Appendix I

Asian Aquaculture, Livelihoods and Knowledge:

A Critical Literature Review

Dinah Rajak
University of Sussex

September 2003

An output of DFID supported AFGRP research project R8119:

The Impact of Aquatic Animal Health Strategies on the Livelihoods of Poor People in Asia

Asian Aquaculture, Livelihoods and Knowledge: A Critical Literature Review

Dinah Rajak

Preface

This literature review is part of a larger research project on the impact of aquatic animal health strategies on the livelihoods of poor people in Asia. This project, supported by DFID (Research grant R8119) is part of the Aquaculture and Fish Genetics Research Programme and is being jointly undertaken by the Institute of Aquaculture at Stirling University, the University of Sussex, Research Institute for Aquaculture No.2 in Ho Chi Minh City, the Aquaculture and Fisheries Science Institute at Cantho, the Aquatic Animal Health Research Institute in Bangkok, the College of Fisheries, Mangalore, and the University of Liverpool.

This review should be read in conjunction with the review of the scientific literature on aquatic animal health strategies. It aims to provide a broad analytical framework within which to contextualise the more specific case study findings from the primary research undertaken in Thailand, South West India and Vietnam as part of the project.

The literature reviewed in this paper derives from a variety of sources including policy documents, empirical case studies and project reports. It draws significantly from anthropological approaches to understandings of 'farmer's knowledge' and the relationship between knowledge and practice; and from debates within the wider arena of social science and development studies concerning processes of technology transfer, the impact of research and the construction of technical knowledge within the context of rural livelihoods.

TABLE OF CONTENTS

Acronyms

AAH	Aquatic animal health
ACIAR	Australian Centre for International Agriculture Research
ADB	Asian Development Bank
ADCP	Aquaculture Development and Coordination Programme
AIT	Asian Institute of Technology
APO	Asian Productivity Organization (Tokyo)
ASPAC	Asian and Pacific Council
DFID	Department for International Development (UK)
DoF	Department of Fisheries
EC	European Commission
FAO	Food and Agriculture Organisation of the United Nations
ICLARM	International Centre for Living Aquatic Resource Management
IDS	Institute of Development Studies
IDRC	International Development Research Centre
IIRR	International Institute of Rural Reconstruction
NACA	Network of Aquaculture Centres for Asia-Pacific
NORAD	Norwegian Agency for International Development
ODI	Overseas Development Institute
PRUS	Poverty Research Unit at Sussex
TNC	Trans National Company
UNRISD	United Nations Research Institute for Social Development
WWF	World Wildlife Fund

I. INTRODUCTION

The FAO Technical Conference on Aquaculture, held in Kyoto in 1976 focused heavily on the role of technology and science, stating one of its key strategies as:

> To bring science into what had until then been very much a discipline that was based on tradition (Beveridge *et al* 2001: 41).

The Bangkok Conference on Aquaculture in the Third Millennium a quarter of a century later, reveals a marked change in thinking about policy, research and practice in the field of aquaculture. The emphasis has shifted from elevating science and technology as the future of aquaculture, to a broader focus on rural development, addressing issues of sustainability, integrating aquaculture into poverty reduction strategies and concern for rural livelihoods[1]. NACA's 3rd Five-Year Work programme 2001-2005 qualifies this, stating that,

> As an economic activity, the exercise to derive higher returns has since been joined by schemes to distribute benefits equitably (NACA 2001: 1).

This new mission is laid out in the Bangkok Declaration and Strategy's Key Strategic Elements which include:

> Investing in people through education and training...improving information flow and communication...improving food security and alleviating poverty...integrating aquaculture into rural development (Aquaculture Development Beyond 2000: Bangkok Declaration and Strategy 2000: 3.1-3.6).

Nevertheless technology transfer and science are still high on the agenda. Following shifts in thinking about technology and knowledge in the wider field of development, the new approach seems to be moving on from the traditional paradigm of technology transfer for development with calls to,

> Transform the emphasis of aquaculture from a resource-dependent activity to a knowledge-based activity (NACA 2001: 6),

and,

> Harness and integrate both science-based and indigenous knowledge to improve aquaculture technology, systems and management (ibid).

[1] This shift reflects movements in the development industry in general in the past decades which has been moving away from the dominant paradigm of technology transfer and modernisation to a focus on sustainable livelihoods.

These new priorities and key strategies seem to suggest a greater focus on the socio-political dynamics of aquaculture. However, while the Bangkok Declaration recognises the need to prioritise rural livelihoods and small-scale fish-farming in aquaculture research, policy and programme planning, attempts to integrate social research into aquaculture and fisheries research have, for the most part, produced a flimsy framework in which livelihoods analysis is bolted on to scientific research. This approach sees social analysis reduced to a sustainable livelihoods framework or a naïve description of the socio-cultural context of technical research and interventions. Such naïve approaches to social analysis are clearly demonstrated in much of project literature, which tends to be characterised by crude over-generalisations and broad assumptions that represent a simplistic vision of social structures, practices and rural economies ignoring the politics of power relations and the political realities that shape people's lives. Thus we are told by the World Bank's 1991 Technical Paper on Fisheries and Aquaculture that

> The common villager does not understand the concepts of ownership of a pond or property rights or a pond (World Bank 1991: 19)

People are represented, not as agents or actors within complex networks and social structures but merely as broad categories, 'the poor', 'farmers', 'traders', with a coherent and accessible system of practices and store of knowledge. Often they appear in the literature merely as passive receivers of new technologies, information or project outputs. In this way research has failed to move on from the technology-led approach that has dominated development since its earliest days.

Statements such as the one quoted below are not uncommon in this kind of project writing

> Fishermen are widely acknowledged, through their close association with the sea and marine life as having a keen awareness of their immediate environment, which aids them in successful fishing and for their very survival…the poor adopt [livelihood strategies] to use the assets they can access, to respond to the structures and processes that influence them (IMM Ltd 2002: 9).
>
> One of the problems with this kind of research is that it represents a static picture of people's lives ignoring the temporal trajectories of poverty and the dynamics of social change that define people's lives and activities. Poverty may be seasonal according to crop or fishing cycles. The relative poverty or wealth of a rural household can change within the course of a year or a few years according to environmental, political or social factors: for many people

> poverty and correspondingly lack of it are temporary states (Lipton and Litchfield 2002: 3)[2].

It therefore seems essential, that if both social and technical research is to produce viable strategies which can be of use to farmers it must attempt to confront not only the socio-political context within which farmers operate but also the way in which livelihood strategies are not discrete, static packages which fit comfortably within a linear diagram, but are dynamic, mobile processes. It is perhaps this realisation that, in recent years, has prompted renewed calls from some corners of the development industry for effective inter-disciplinary research programmes which not only aim to situate technical research in a social context, but which have the potential to challenge the traditional models on which scientific research in the field of rural development have been based.

The application of social science to agricultural research is now well documented, however only in recent years has this been followed in the study of aquaculture systems (for examples see Lewis *et al* 1996; Harrison 1994). To quote Lewis *et al*: ‘fish culture is...the perfect case for interdisciplinary treatment: the growth and habits of fish are determined through biological investigation, but they can only prosper when humans intervene, and this requires social investigation.’ (Lewis *et al* 1996: 30). However, at times an uneasy relationship between biological and social science threatens to be more a marriage of convenience in which methods are uncomfortably patched together, failing to bridge epistemological gaps and confront the underlying issues at stake. The privileged status that the positivist approach of biological and natural science holds in current science-led research frameworks has applied this reductionist approach to social analysis distilling the socio-political world to a livelihoods framework and an array of mechanical tools for translating dynamic social realities and processes into digestible data. An investigation of the social impact of aquaculture management strategies, research and intervention on poverty demands an interpretive, ethnographic approach. Such an approach allows us to engage with the way in which knowledge is constructed in different arenas; and to address the complex interweaving of social and economic structures with science/policy/practice

[2] An interesting discussion of different methods of defining and measuring poverty from the economic perspective is presented institutes this paper (Lipton and Litchfield 2002: 3-4).

processes and knowledge/power relations. This involves taking a more critical look at the interactions between various actors involved in these processes, from researcher to extension worker, farmer to government planner. This has serious implications for the practice of research and intervention and has begun to have an effect in recent shifts in development thinking (this is demonstrated in the recent DFID draft policy paper on *Research for Poverty Reduction* (Surr *et al*.[3] 2002: 3).

The purpose of this literature review is not to provide an exhaustive and comprehensive review of the recent literature on aquaculture but to point to issues, themes and questions raised by the literature that may provide useful conceptual and methodological tools for investigating the impact of aquaculture strategies, specifically those concerned with aquatic animal health (AAH), on livelihoods and poverty. This review aims to provide an analytical framework within which to view the case study findings from the situation appraisals. Chapter II focuses on approaches to studying the role of aquaculture and aquaculture research in rural economy and livelihoods. The intersections of poverty, aquaculture and practice are explored through the central themes of motivation, risk and vulnerability, and the specific significance of aquatic animal disease. Chapter III moves on to look at questions concerning impact and the ways in which development research programmes have attempted to address the issue of impact assessment. This involves an analysis of the role of research in development and the links between research, innovation and technology transfer.

The process of technology transfer is explored in Chapter IV, which reviews critical perspectives on the conventional models of technical innovation and change upon which development research and interventions have been based. The concept of knowledge is, of course, central to ideas about technology transfer and the question of impact on poverty. This chapter addresses questions concerning the construction of knowledge in development research and practice: 'who knows what', 'how is 'farmers' knowledge seen', 'how is knowledge generated', and 'how does knowledge relate to practice'. This chapter moves on to look beyond the generation of strategies

[3] This draft paper highlights the need to 'go beyond dissemination' to more pro-active uptake' (Surr *et al* 2002: vi) of strategies, implicit in this is a renewed focus on impact of strategies produced through development research.

to the channels through which information is communicated. It looks at the various frameworks and media mobilised for the communication of information and the ways in which people engage with chosen sites and paths of communication. Chapter V is concerned with gender and aquaculture. Looking specifically at the relationship between gender and technical strategies, it highlights the way in which research and interventions in the field of aquaculture need to re-evaluate current thinking on technology transfer from a gendered perspective.

Technology transfer, the dynamics of innovation and farming practices are viewed within the broader context of global commodity and value chains and the relationship between knowledge, extension systems and the market. Finally, Chapter VI looks specifically at the Asian shrimp industry, the way in which transnational corporate interests have impacted on the practice of aquaculture and occupy a central role in research on aquatic animal health and the surrounding mechanisms of technology transfer.

II. APPROACHES TO AQUACULTURE, LIVELIHOODS AND POVERTY

In his attempts to break down the academic dichotomy between fisheries and aquaculture, Kai Lorenzen calls for the conventional notion that 'aquaculture' is the 'pastime of rich investors' while fisheries support 'millions of poor fishers' to be dismantled saying,

> To millions of people involved in inland fish production, particularly in Asia, aquaculture and fisheries are but the endpoints of a continuum, and much of their food and income derives from systems that combine aspects of both. Hatchery produced juveniles are stocked into communal or public water bodies, often leading to new use rules and thereby transforming both technological and institutional aquatic resource use. On the other hand, self-recruiting fish and invertebrates, whether indigenous or introduced, contribute substantially th the catch from many rural aquaculture systems. Systems such as these have been much neglected by research and extension. (Lorenzen 2002: 12).

Similarly, Edwards asserts that, 'the promotion of aquaculture for rural development has had a poor record' and is 'commonly equated with intensive culture of salmon in developed countries and culture of shrimp in developing countries[4]; both of which carried out mainly by better-off farmers to provide a high-value product for wealthy consumers. However, he goes on to state that aquaculture does in fact 'contribute to the livelihoods of the poor, particularly in areas of Asia where it is a traditional practice' (Edwards 2000: 1). Edwards describes this form of rural aquaculture as

> Low-cost production with extensive and semi-intensive technologies most appropriate for the limited resource base of small-scale households...fertiliser and feed may be derived from on-farm by-products...By contrast, intensive systems invariably depend on relatively high-cost nutritionally complete diets (ibid).

However, Edwards seems to advocate the traditional 'technical fix' solution to what he perceives as the constraints to the expansion of aquaculture for rural development: 'recent adoption of new technology suggests that, with adequate support, aquaculture could...contribute significantly to rural development' (ibid). Both Lorenzen's adherence to the 'systems' approach as the natural order of the natural and social

[4] Edwards points out that while 'shrimp and salmon receive most publicity' this focus does not reflect the available statistics on aquaculture production: shrimp and salmon, in fact 'comprise less than 10%

world, and Edwards' commitment to technology transfer have the effect of distilling socio-economic and political realities into digestible manageable units. While this provides a pragmatic approach to dealing with 'livelihoods' and 'the social' it tends to result in a simplistic and naïve vision of complex relationship between institutions, social structures and individual agency which determine action and behaviour. This approach to rural development and technology will be discussed further in Chapter IV.

Aquaculture has undoubtedly emerged as a vital source of food and alternative livelihood activity for many rural households, as has been demonstrated in numerous studies on the role of aquaculture in rural livelihoods (see for example, Edwards, Gartner and Pullin 1988; ICLARM and IIRR 2001; Lightfoot and Pullin 1991; Phuong *et al* 2002). However less attention has been paid to the role of farming knowledge and management strategies in achieving sustainable livelihoods, food security within the household and poverty reduction. In the past the link between technology and poverty reduction has often been assumed and studies have based on simplistic approaches to poverty in which 'the poor have been treated as a large, amorphous, anonymous statistical category' (Castillo 1988: 20).

The link between technology and poverty has been further complicated by the lack of agreement about what 'poverty' means. This problem was addressed by Harrison in her study of aquaculture in Zamibia:

> Fish farmers in Luapula, Zambia, do not apply new technology knowledge and dig ponds to raise their income. They do so, for example, to fill seasonal gaps in their diet, to create an asset that may generate income later or to lay claim to a particular piece of land. Do these constitute poverty reduction? They may do for some if a reasonably broad definition of poverty reduction is drawn (for example, including fulfilment of basic needs, building up of assets, better control of resources), but their poverty would be unaffected it is taken to mean level of income (Crewe and Harrison 1998: 111).

As has been highlighted above, poverty (or lack of it) cannot be viewed as a static condition, nor the poor as a homogenous group. Such notions are called into question when investigating the impact of a specific strategy or intervention and we are

---

of global aquaculture production by weight compared with 50% for carps and tilapias which contribute most to domestic food supply in developing countries' (Edwards 2000: 2).

required to ask, who is the target of such a project and how are different people affected by it. This requires what Scoones and Thompson term 'the analysis of difference' – understanding how social difference (due to age, gender, status, wealth, political influence and so on) affects perceptions, actions, and access to and control over resources, including ideas and information (Scoones and Thompson 2000: 5).

Micro-level research into household and the various livelihoods activities and strategies adopted within the household provides one way of approaching the complex relationship between poverty, technical knowledge and farming practices. However there is a need to view these practices within the wider concept of market relations (both domestic and global), economic structures and socio-political changes as increasingly, many of the key factors and decisions influencing prices, capital flows, technological change, and innovation are global. Thus 'exclusively local focuses run the risk of ignoring the most important trends and forces' (Kaimowitz 2002: 125).
As Lewis *et al* put it, there is a need to,

> (Move) the outsider's conception of rural, agrarian society away from usual fixation with households, landholdings...and other village level relations...to the actor-oriented methodological principle that structure and process are also created by the activities of people themselves going about their normal business of survival, accumulation and social reproduction...the fish culture system represents one among many interlaced networks which integrate rural actors on a regional basis (Lewis *et al* 1996: 129-130).

2.1 Questions of Motivation

The level of uptake of a specific strategy depends on the extent to which the strategy and the inputs it requires coordinates with a farmers motivation for culturing fish. While it is indeed true to say that some farmers want to earn income from their ponds, 'the decision to adopt fish farming does not arise unambiguously from this' (Crewe and Harrison 1998: 124). A number of studies reveal that strategies that require significant investments of labour, time or cash are unlikely to appeal to small-scale farmers with few assets for whom aquaculture is chiefly a source of fish for the household (Castillo 1988; Barnett 1994; ICLARM and IIRR 2001). It follows that one of the crucial questions in assessing impact is: 'who is the target of such a strategy' and, 'to what extent is this technology relevant for the target group' (Surr *et al* 2002: 3).

Concerned by the way in which motivation and decision-making with regard to farming activities is often overlooked by planners and researchers, Lewis *et al* note that, a farmer's desire to increase yield must not be assumed:

> Many pond owners see fish culture as a hobby in which food fish are a production bonus for which little or no capital or inputs are necessary. Many operators are content to maintain ponds at the low level of production and perceive high risks to any intensification (i.e. loss due to theft or disease) (Lewis *et al* 1996: 152).

It is the potentially unrealistic image of the 'fish farmer' described by Lewis *et al* that, at times, drives planning and research. While researchers and planners target their output of technical strategies towards 'fish farmers', the farmers themselves may not perceive themselves as 'fish farmers', but regard fish farming as just one activity in a portfolio of livelihood strategies, consequently determining their interest in new aquacultural strategies and changes in practice.

Thus, motivation must be empirically studied according to the socio-political, economic and environmental context in which aquaculture is practiced. Technical strategies are often premised on the assumption that a desire for efficiency in production is the chief motivation for aquaculturalists. Farmers might, in fact, be motivated more by the need for reliability, flexibility and diversity, the need to 'routinize the irregular' (Rayner 2002), and consequently be more interested in low-cost, practices than expensive technical investments to boost yield. In this way motivation is tightly bound up with risk management. Furthermore, planners and researchers, at times, fall into the trap of assuming members of a household, group of farmers or village share a common motivation. Conflict and differing interests are ignored. The promotion of a specific strategy or technical innovation may well benefit certain farmers at the expense of other people inside and outside the unit that has been marked out as the intended 'beneficiaries'. This issue will be discussed further with specific reference to gender in Chapter V.

2.2 Risk Management

The practice of new technologies and the implementation of AAH strategies is not cost free. They require inputs of time, cash, labour that are often not available to the poorest households. While the techniques are essentially stable, the context within which they make such demands on a household's labour, time, cash is not. Thus, within the context of a market slump in the price of cultured tilapia or the absence of traders in the area to whom farmers can sell their harvest, for example, it would make little sense for a farmer to invest any surplus cash in fish health management strategies with the intention of boosting his/her yield, rather than save the money or invest it in another direction. The varying marketability of fish and fish products will form a decisive factor for the levels of financial (and other) expenditure on management strategies and inputs into production that a farmer will be willing to invest (European Commission 1994: 23). In this way a farmer may be reluctant to expend time or money on disease control in the pond if the market value for the species s/he has stocked has dropped and the income generated at harvest will not justify the investment on health management.

Furthermore, farming practices and technologies, and the market, do not operate as two distinct spheres, but are mutually dependent and influenced by each other. While new techniques have the capacity to mitigate against risk and to increase predictability they can, at the same time, adversely affect the market value of a product. Fegan's comparison with the poultry industry is informative on this point:

> In the early years, very little technology was involved and production levels increased through *ad hoc* development. However, the increased production led to an increase in the incidence of disease and losses. As this occurred, continued research into genetics, nutrition and disease led to the development of specifically selected strains, better feeds and improved disease control strategies...these led to increased production, decreased price and increased costs, the industry has developed to where it now produces a large volume-low margin product which is highly predictable (Fegan 1996: 27)[5].

[5] The findings from the fieldwork carried out in Phichit Province, Thailand (2002) as part of this research project revealed a similar pattern in the development of a hybrid catfish which is more resistant to disease. While this has resulted in a rise in yields of catfish and greater predictability, the increased production has been reflected in the decreasing market price for catfish as the market has been saturated with catfish, leaving farmers with a narrowing profit margin and a desire to seek more profitable species to farm.

While aquacultural and agricultural strategies derived from research and promoted by extension are often premised on predictability, management practices have been responding continually to ecological, economic and political instabilities, and to social and institutional change (Fairhead and Leach 2002b: 75; Chase Smith, Pinedo, Summers and Almeyda 2001: 36). As Fairhead and Leach note,

> At times, scientific methods and models that hold true under certain conditions (e.g. laboratories) may be caught out in real life situations by unanticipated variables (Fairhead and Leach 2002a: 10).

Mehta, Leach and Scoones make an important distinction between risk and uncertainty:

> Uncertainty describes a situation where we don't know what we don't know. This is...distinct from risk, where probabilities of outcomes can be calculated (Mehta, Leach and Scoones 2001: 2).

In the face of such uncertainty, people adopt more flexible approaches to daily life, 'allowing them to patch together new livelihood strategies continuously, depending' for example, 'on the timing, intensity and duration of flooding in conjunction with other variables such as market conditions' (Chase Smith, Pinedo, Summers and Almeyda 2001: 42).

The development and communication of aquatic animal health strategies and models for pond management have the potential to overlook the context of vulnerability and change in which resource-poor farmers have little margin for taking risks with experimental or expensive techniques (ICLARM and IIRR 2001: 7). While studies such as that of Weemaes (1997) point out that semi- and intensive aquaculture bring much higher profits than rice farming, they often neglect to qualify this with discussion of the much greater investments and risk involved in the practice of semi- and intensive aquaculture, which makes it less accessible as a activity to small-scale farmers looking to diversify and boost their income.

Through their study of aquaculture and trading systems in Bangladesh, Lewis *et al* revealed the way in which knowledge is deployed within the network of fish production and trading in order to manage risk and can translate directly into greater security or economic power:

> The network contains many risks for the different actors. The food fish pond operator faces difficulties in maintaining pond security[6] as fish grow over a period of six months to two years, has very little reliable information on the quality of the fingerlings purchased from the fry traders and is susceptible to outbreaks of disease. There is also evidence to suggest that a large proportion of the fingerlings sold...are in poor condition and are quickly lost to predators or disease (Lewis *et al* 1996: 117-118).

However, knowledge and farming practices do not operate in a vacuum. Strategies for improving yield or reducing risk from disease need to address the full constellation of social factors, economic relations and access to resources and credit[7] which determine a households relative security or vulnerability. Thus Crewe and Harrison point to an example from Kerala, South India:

> In Kerala, South India…improvements to fishing technology would have achieved little on their own in the face of low prices by wholesale fish-sellers. Strengthening a fishing cooperative led to negotiation for better terms (especially prices and debt repayments) and a more profitable industry (Crewe and Harrison 1998: 111).

2.3 Labour and Employment

Aquatic animal health research and strategies have clearly had a significant impact on intensive, commercial aquaculture, most visibly in the shrimp industry (see Chapter VI). Indeed much of research and development in the field of aquatic health management and disease could, arguably, be said to target this sector. However the question of impact on poverty within the arena of large-scale aquaculture relies on the claims made by the industry, some government sources and in some of the literature that the large-scale aquaculture industry provides a high level of employment, and in so doing is a key player in the poverty reduction process. Thus, it would follow that,

---

[6] The case study undertaken in Phichit Province, Thailand, 2002 as part of this project, revealed this problem. Many informants when asked whether their fish suffered from disease replied that they had problems with 'yellow disease' in their ponds – a euphemism for thieves.

[7] Lewis, Gregory and Wood's study of aquaculture in Bangladesh revealed that informal credit is a crucial component in economic and social networks. However, as they point out,

> 'It is often difficult to obtain accurate and detailed information about the role of credit in transactions, the precise details of which tend to remain obscure' (Lewis, Gregory and Wood 1996: 120).

Credit relations should not be viewed simply as financial interactions. They act as channels for the communication of information and represent complex social relations determining control, not only financially, but in terms of access to knowledge.

sustaining the industry, producing strategies to protect it from disease and other such constraints to production, sustains the poor who rely on it for employment. There is much debate in the literature, however, on the extent to which large-scale commercial aquaculture is a significant source of employment, and to what extent it, in fact, does the opposite by displacing local labour and local farmers, and taking over land and other resources, as some authors have argued. Thus Shenhav and Shrum write,

> Theories of the relationship between technology and employment suggest that new agricultural technologies may increase yields but require capital investment that increase local inequalities and dependency on suppliers (Shenhav and Shrum 1995: 643).

Barraclough and Finger-Stich's study of commercial shrimp farming puts the employment numbers at,

> An average of one to three persons working on a full-time basis per hectare of semi-intensive and intensive shrimp pond and up to seven for extensive ponds…This farm level employment includes temporary low-paid construction workers and permanent maintenance labourers (handling, pumping, feeding, pond water treatment and harvesting), supervisors, and guards to prevent the theft of shrimp grow-out ponds)…compared to other production systems taking place in the same coastal areas – mostly rice production – labour requirements for shrimp aquaculture are very low[8] (Barraclough and Finger-Stich 1996: 14).

The figures found in the literature do not show the employment lost with the development of shrimp farms but it seems clear from them that both 'traditional' aquaculture and agriculture generate more employment than commercial shrimp farming does. Added to which 'the type of employment generated by shrimp farms is often not available to local people' (ibid: 15), and many studies have shown that rather than being the product of local farmers expanding into new activities, many shrimp farms are owned by businessmen who lease land from local farmers as well as from the government (ibid). Barraclough and Finger-Stitch (1996: 27) conclude that,

> With the tendency to develop more semi-intensive and intensive modes of shrimp production, labour as a portion of total costs is being reduced by using more energy and technical inputs…Shrimp farms often expand at the expense of agriculture, aquaculture that are better suited in many places for meeting local food and employment requirements…control of local resources has

[8] In support of this Barraclough and Finger-Stich quote a study from Indonesia, according to which rice production employed an average of 76 workdays per hectare per crop cycle, whereas a semi-intensive shrimp farm in the same area employed about 26 workdays per hectare and an extensive shrimp farm about 45 workdays per hectare per crop cycle.

> shifted from communities to external institutions (Barraclough and Finger-Stitch 1996: 27).

As early as 1988, Engle, Crosetti and Nash wrote that,

> Although one of the roles of aquaculture often stated in national policies is to increase employment opportunities, aquaculture itself is not a labour intensive industry. There are good opportunities for employment but aquaculture is not a panacea for countries with large numbers of unemployed (Engle, Crosetti and Nash 1988: 5)

An economic study for a Bangladesh university reports that: 'shrimp farming displaces more jobs than it creates' (Green Peace 1997: 2). This study argues that rice farming absorbs more labour that shrimp farming does[9]. It is this relatively low level of employment generated by shrimp farming, in comparison to lower-profit[10], higher labour-intensive activities such as rice farming that has led many authors to echo Ben Yami's early prediction that 'Aquaculture (shrimp) can hardly be regarded as a mass employer' (Ben Yami 1986).

This view on shifts in labour patterns which have emerged out of the package of rapid growth and technological change in Asian shrimp aquaculture labelled, 'The Blue Revolution', echo many of the concerns about inequity and labour displacement which have been levelled at the earlier Green Revolution[11] in agricultural (for a brief comparison of the Blue and Green Revolutions see Asian Institute of Technology 1994: 12-13). Thus, Barraclough and Finger-Stich, among others, argue that the 'blue revolution' is using large quantities of commercial inputs for producing a single crop, while it neglects the livelihoods of local people and their environmental and social requirements (Barraclough and Finger-Stich 1996: 35).

However this issue of commercial aquaculture and employment is keenly debated in the literature (see also Sano 2000 for a discussion of this). Some studies speak of Shrimp farming's contribution of income generation through creating employment

---

[9] According to this economic study at Chittagong University, 50 workers can work in 40 ha of rice field, while only 5 people can work on the same land for shrimp culture (Green Peace, 1997: 2).
[10] The descriptions 'high' and 'low-profit' here demonstrate a widespread acceptance of the prevailing orthodoxy of profit models derived from macro-economics.
[11] The largest body of literature on the effects of technical change and transfer in farming techniques and production concerns the consequences of the Green Revolution, investigating the effects on production, employment, inequality, health, social structures and the environment (for a discussion of

opportunities. Thus Edwards (1999) claims that intensive aquaculture (including fin fish, shrimp and sea-weeds) promotes the diversification of employment in Thai coastal regions and consequently contributes significantly to poverty reduction in those areas. Meanwhile, the World Bank Technical Paper on 'Fisheries and Aquaculture Research Capabilities and Needs in Asia' states,

> Further development of freshwater and brackish water aquaculture can lead to higher employment and earnings. Research to improve such culture activities is critical (World Bank 1991: 14).

This claim is echoed in Hambrey's study:

> Intensive or semi-intensive shrimp farming, if well planned and managed will generate far more income and employment than any alternatives (Hambrey undated: 3).

This is further supported by Mulak's 1994 study of intensive aquaculture in Java (Mulak 1994) and the conclusions from the case studies undertaken as part of the Shrimp Farming and the Environment Consortium Programme (Shrimp Farming and the Environment 2002: 20). The workshop on Management Strategies for Major Diseases in Shrimp Aquaculture reported that:

> Shrimp farming has emerged as a main source of employment and income for hundreds and thousands of people...Returns from shrimp farming continue to be high, benefiting small-scale farmers and communities, as well as larger-scale entrepreneur (Arthur *et al* 1999: 1)

Burch *et al* describe the way in which the development of the shrimp industry has effected social and economic change which has involved shifts in patterns of employment and livelihoods: 'one of the major outcomes of the shrimp industry is its domination of local economic activities where whole districts become dependent for employment on the activities of shrimp production' (Burch *et al* 2000: 520). However while Burch *et al* concur with those who argue that the actual production of shrimp is a low labour intensive activity, they point out that the surrounding infrastructure of processing plants and feed mills, is a large source of employment:

> The greatest number of people are employed within the processing plants (approximately 2000 workers per plant) followed by the feed mills (between 200 and 400 workers) and at a distant third the farms themselves (perhaps one or two workers for every pond). The replication of standardised factory work

---

this literature see Shenhav and Shrum 1995: 643). There is also a group of authors who feel the negative effects of the Green revolution to have been exaggerated (ibid).

> within the sector is similar to many other labour-intensive capitalist production processes (ibid).

2.4 Impact of Disease in Aquaculture

> ‘Shrimp disease has emerged as one of the key issues affecting sustainability of shrimp farming worldwide (Arthur *et al* 1999: 1)

Since the major outbreak of shrimp disease in Asia in 1992, disease in shrimp farming has become a primary concern that has radically altered the economics of the system and ‘has to be considered according to local prevalence’ (ICLARM and IIRR 2001: 84). Arthur *et al* suggest that,

> Problems arising in shrimp culture are, in part, due to the rapid expansion of shrimp farming, during which limited consideration may have been given to appropriate farm siting and adoption of sustainable farm-level management systems (Arthur *et al* 1999: 1)

The 2000 FAO review of the State of World Fisheries and Aquaculture concludes that,

> Aquaculture still faces a number of problems. Among these are *access to technology and financial resources for the poor*; environmental impacts; and *diseases* (FAO 2000: 2).

The review prioritises managing the health of aquatic animals as an area for further research. Indeed, aquatic animal disease has been put high on the research agenda and increasing attention has been focused on the production of practical AAH strategies. The urgency to seek new methods of control not only at farm level, but nationally and regionally is outlined by Arthur *et al* who write,

> Conventional methods for controlling aquatic animal pathogens, such as chemotherapy, appear less effective in managing newly emerging pathogens, thus, efforts have been made to improve the situation by introducing various management strategies to prevent the occurrence of disease outbreaks. Instead of ‘quick fix’ control methods applied by individual farmers, there have been attempts to combat disease outbreaks through the collective efforts of the affected farmers, national and state agencies, private-sector service providers and other stakeholders. These include: changing management practices, improving research and development efforts, introducing new legislation, initiating dialogue among shrimp farmers through the development of farmers’ societies, and attempting to reduce trans-boundary spread of pathogens (Arthur *et al* 1999: 1).

However, while the shrimp industry has been the most visible area to be hit by disease, the impacts of disease have been felt across the board from large-scale producers of shrimp for export to farmers with one fishpond. Thus Edwards states,

> Disease also impacts poor farming households, e.g. outbreaks of epizootic ulcerative syndrome in South and Southeast Asia, and red spot disease of grass carp cultures in cages and ponds in Vietnam (Edwards 2000: 7).

The ICLARM and IIRR Primer on Integrated Agriculture-Aquaculture systems contends that shrimp disease poses a major constraint even for very extensive operations (ibid) and the APO seminar report on *Improving Management of Aquaculture in Asia* cites 'spread of disease due to poor environmental conditions' and 'lack of knowledge on alleviating measures' (APO 1998: 11) as two of the major problems affecting management of aquaculture in Vietnam.

Johnston's discussion of the effects of EUS in West Bengal reveals the extent to which an outbreak of disease has a multi-layered impact, affecting fish vendors as much as the producers themselves:

> Investigations carried out in five districts of West Bengal reveal that 73% of aquaculture operations were adversely affected by EUS. The outbreak of the disease depressed the fish consumption rate by 28%, 23.3% and 20.5% in urban, sub-urban and rural areas respectively. Consequently the fish trade was also seriously affected. Owing to consumer resistance, the traders did not accept such fish for selling. In rural markets diseased fish were sold at a very low price…another study undertaken in five districts of Kerala revealed that the spread of EUS completely paralysed the inland fish market … fishermen …and women fish vendors (who) were particularly subject to hardship…had to seek alternative employment as agricultural labourers, head loaders and quarry workers, etc., without much success (Das quoted in Johnson 1998: 42)

This highlights the way in which the impacts of disease are felt, not only by farmers, but throughout the chain of production, marketing and consumption. However it also points to the need for greater research into the market, as some research has suggested that the low price of fish affected by disease provides a cheaper source of a high-protein food that would otherwise be unavailable to the poorest groups of people. This requires that research into the impact of disease, and indeed disease control strategies be placed into a broader framework, which looks beyond the boundaries of the farm unit, considering the network of actors and structures involved and affected by aquaculture and the ways in which different people are affected differently both by the introduction of AAH strategies and risks associated with aquaculture. In this way, the narrow sustainable livelihoods approach is insufficient to gain an intricate understanding of these complexities.

III. IMPACT ASSESSMENT

The need to take a more rigorous approach to looking at the impact of technical research in the field of AAH and the uptake of management strategies emerging out of research reflects a wider recognition within development research and planning of the challenge presented by impact assessment. In their study of Strategic Management of Research and Technology Callon, Larédo and Mustar ask 'how is it possible to determine the utility of skills, knowledge and techniques?' emphasising the challenges inherent in studying the impact of strategic knowledge programmes (Callon *et al* 1997: 13). They suggest that a central question to address in such a study of impact and uptake is 'how (has) the programme been able to mobilize certain actors and not others?' (ibid: 22).

Most recently this issue has been addressed in Stirrat's analysis of approaches to Impact Assessment (Stirrat 2002), which highlights that, while impact assessment is an area of growing concern within the field of development, it is characterised by the inadequacy of current methods for impact assessment used by donors and development agencies. What emerges most strikingly from Stirrat's analysis is the way in which, in the absence of sophisticated and rigorous methods for assessing social impact, donors, agencies and programme management fall back into traditional economic models of impact assessment that are underpinned by the crude economic equation: greater yield and greater production equals poverty reduction. To quote Stirrat:

> The 'low productivity' approach to poverty sees poverty as a result of technological barriers. Improvements to technology of production will lead to increases in output which in turn will lead to economic growth and development and thus a decline in poverty. Such an approach underlies much of the past work of the CGIAR group of research institutions and…most technical research concerned with crops and livestock which is concerned with maximising output. Yet the problem with such an approach to poverty is the assumed link between rising levels of productivity and reduced levels of poverty (Stirrat 2002: 5).

The emphasis on increasing production as opposed to poverty reduction is clear from reports such as the APO 1998 seminar on 'Improving Management of Aquaculture in Asia', which comments, in relation to the state of aquaculture in India:

> Aquaculture has now come up from the stage of a traditional and domestic activity to the level of an industrial activity. It is hoped that a well organized research, extension and development efforts will go a long way to achieve the target of high production and productivity of aquaculture system in the country (Asian Productivity Organisation 1998: 6)

This simplistic formulation often proves only to conceal the realities of inequality, poverty and marginalisation that are in fact accentuated increases in production and fails to understand the intricacies and complex realities of social change that are the outcome of research and development. Social impact is a slippery and intangible issue to address, which is possibly the reason that it has received such little attention in previous years. It is not easily quantifiable, nor can it simply be described by the simplistic binary 'negative impact' or 'positive impact'. One challenge involved in studying impact of aquaculture management strategies and technologies is underlined in the APO Report 1998:

> Aquaculture technologies are highly site-specific...time requirement of transferring/adapting a technology is much longer than generally expected...it can be measured in decades rather than years (APO 1998: 23).

As Stirrat points out, however, 'so far, relatively little has been done on assessing impact in terms of a sustainable livelihoods framework' (ibid: 23). However, qualitative methods potentially offer us one approach to impact assessment at a micro-level:

> …The ways in which impacts are measured and compared will have to change. Traditional quantifiable measurements focusing on a few key indicators have the advantage that comparisons can be made between different types of research and between research and other forms of development intervention. The shift towards a sustainable livelihoods approach to poverty coupled with… the use of…non-quantifiable approaches to impact assessment…involves the rejection of the traditional scientific paradigm and a willingness to accept interpretive and evaluative impact assessments (ibid.).

3.1 Research

In their review of uptake and impact of research projects in the field of natural resources, Edwards and Farrington comment that,

> Research often fails to produce useable outputs because of inadequate familiarity with the socio-economic and natural resource conditions facing intended users (Edwards and Farrington 1993: 1).

Technology need for greater focus on uptake and impact been reiterated in the recent DFID draft policy paper on Research for Poverty Reduction (Surr *et al*l 2002: ii, , 14.4). The question of who sets the research agenda is key to looking at the impact of technical strategies on livelihoods. Some authors have argued that, if AAH strategies are to contribute to the reduction of rural poverty, the research that generates them must directly respond to the most pertinent problems that farmers face. This requires investigation into ways in which researchers engage with farmers not only as the subjects of their pre-ordained research agendas but as the source of the demand for the research; as well as a need to address the distance which exists betweens agricultural development researchers and farmers (DFID 1998b:1; Fairhead 1993: 199). This has been viewed as the upstream communication of interests and information from farmer to research institute.

The growing concern that research should lead to tangible benefit has been expressed through the long-running debate over adaptive versus strategic research. The distinction between strategic and adaptive research is described clearly by Edwards and Farrington:

> Strategic research...addresses issues wider that those specific to any given set of field conditions. Adaptive research aims to adjust new technologies to specific agro-ecological and socio-economic conditions (Edwards and Farrington 1993: 5).

The call for a shift from the segmented, discipline-based approach to rural economy and farming practices has prompted some research and programmers to call for research agendas which focus on 'problems' rather than 'sectors' (Surr *et al* 2002: 14.7; Eponou 1993). Edwards argues that,

> Unsurprisingly research-derived, on-station technologies have seldom fitted the diverse and resource-limited contexts of poor farming households. Most aquaculture professionals and service providers currently have a technocratic and fisheries biology worldview which focuses on maximising biological yield rather than meeting local objectives (Edwards 2000: 6).

However he goes on to warn against an approach that favours only adaptive research to the total neglect of strategic research:

> Although systems approaches to adapt known generic technologies to specific and local contexts will have the greatest short-term impact on poverty reduction, it would be unwise for donors to fund only adaptive research. strategic research may be higher risk, but also has a potentially higher pay off in terms of the number of poor who may benefit from the research over a wide area...The major gaps in knowledge include the social and environment/resource aspects of rural aquaculture; the actual and potential contribution of aquaculture to sustainable livelihoods of the poor (Edwards 2000: 7).

Edwards and Farrington also make the significant point that,

> Farmers are only one type of end-user of research outputs...research can serve various types of intermediate users...Apart from farmers, such end-users can include governments,...NGOs...research...may pass through several further cycles...before producing technologies for uptake by end-users (Edwards and Farrington 1993: 65-6).

This, of course, makes tracking the impact of aquatic animal health strategies a difficult and complex task. A further challenge for the task of tracing uptake of research outputs arises from 'the lag in application – which may be several years after the completion' (ibid). Added to this is the difficulty in sourcing a specific pond management practice to a particular AAH strategy communicated to farmers.

3.2 Linking Research and Technology Transfer

In his study of technology transfers to small-scale farmers, Eponou states that,

> Most systems rely heavily on communication mechanisms to link research with technology transfer. This reflects the traditional view of the sequential nature of the roles of the two groups… It is crucial that policymakers recognise research and technology-transfer as two components of the same system (Eponou 1993: xiii).

The result, according to Eponou, is that the products of research often fail not only to reach farmers, but to meet their needs. For this to be achieved the traditional sequential approach must be replaced with a more interactive framework of exchange between researchers, extension services and farmers. In his study Eponou describes three dominant models of research-technology transfer linkages: The Chain-Link

Model and The Linear Model[12], which are characterised by the traditional sequential pattern outlined above; and Participatory Technology Development. He views this last approach as having emerged as a response to the needs of resource-poor farmers. According to the Participatory Technology Model, the emphasis is placed on adaptive research that responds directly to the needs of farmers who are instrumental in setting the research agenda. Thus direct linkages between farmer, technology transfer and research are established.

The World Bank's Fisheries and Aquaculture Report supports Eponou's argument with empirical findings that highlight the failure of linkages between research institutes, extension services and farmers.

> There appears to be very few linkages between the research institutes and the extension services except in a few cases where direct links have been set up, as in the case of CIFA working directly with FFDA on carp seed production and carp culture (World bank 1991: 27)

In conclusion the report asserts firmly that:

> The absence of direct linkages between research producers and those responsible for transferring the results into practice operates as a severe constraint…Direct linkages between researchers and users also appear to be very weak. In large part, this may be due to the lack of relevance of the research to the fishing industry (ibid).

Eponou further notes in his critique on conventional approaches to technology transfer, that 'in agricultural systems where financial resources are scarce, funding linkages (between research and extension) is often the first to be cut' (Eponou 1993: xii). His study goes on to address the issue that research and technology transfer cannot stand alone, but, as instruments of development, must be considered alongside pricing and market policies, public investment and the provision of agricultural credit (Eponou 1993: 5).

[12] A detailed explanation and discussion of the linear model, according to which (applied) science gives rise to technology and technical strategies, can be found in David Edge's article 'Reinventing the Wheel' (Edge 1995: 5).

IV. TECHNOLOGY TRANSFER

The concern with extension and technology transfer was highlighted in the 1991 World Bank technical paper on fisheries and aquaculture (World Bank 1991:19). This demand has continued to be reiterated the literature on aquaculture in the last decade. *****Lipton and Litchfield's recent study of irrigation technology and it's impact on poverty shows that while it has been greatly beneficial in boosting production and consequently income for those farmers who have access to it, the flip side to this is the negative impact which this change has had on those farmers who do not have access to this technology and have, as a result been, squeezed out of the market. This is sometimes referred to as the 'technology gap' problem 'whereby technical improvement ...provides differential advantage to the more skilled and resourced, further diminishing opportunities for the disadvantaged' (DFID 2002: 2). Driven by the belief that technology is neutral, impact studies on technology transfer often seem to overlook the basic fact that 'knowledge and technologies resulting from these processes (research and technology transfer) have the capacity to produce both benefits and burdens for poor people' (Surr *et al* 2002: 10).

There is a large body of comparative literature concerned both with the process of agricultural technology transfer and its social and economic impacts. Lipton and Litchfield's conclusion in their study of the impact of irrigation technology on the livelihoods of small-scale farmers and poverty is informative for the study of aquaculture management strategies and technologies:

> Distribution issues are central to assessing the poverty impact of irrigation. Small users and those in tail-ends of systems need to be able to secure access to (the technology) (Lipton and Litchfield 2002: 42).

It is clear that this must be a primary concern in the construction of technical strategies in the first place.

Michael Lipton and Richard Longhurst' comprehensive study investigates the apparent contradiction of how modern seed varieties 'work' but fail to alleviate poverty. Lipton and Longhurst's conclusion advises us that it is the conception of poverty itself which needs to be addressed: Small farmers do have access to modern varieties of seeds and technical information, the new technologies and strategies do reduce risk and decrease food prices. However they fail to reduce poverty in as much as the poor are increasingly landless workers of near-landless farm labourers and not small farmers (Lipton and Longhurst 1989). The important point here, is that a focus on technical strategies and innovation in aquaculture and aquaculture misses the poorest people.

There is a need to move on from the prevailing dominance of the traditional model of technology transfer that still holds sway in many corners of the field of agriculture development research and planning. This model is described by Scoones and Thompson:

> Conventional institutional models for research and extension are based on the transfer of technology model of agricultural development. centralised research facilities, in research stations or universities, are aimed at producing widely extendable technologies. These are generally propagated through a top-down extension service, providing packages or messages to client farmers (Scoones and Thompson 1993: 23).

This simplistic approach sees technology transfer in terms of a static linear model in which discreet packages of technology or technical knowledge mainly developed in the north are transferred through a chain of in-country research institutes, through a state extension system until eventually being adopted by a innovative entrepreneurial class of farmers with enough surplus cash or credit and an innovative spirit to engage in a new technology or new market. The dominant paradigm of technology transferred to innovative entrepreneurs and 'trickling down' to farmers with less access to resources or information through gradual processes of imitation and diffusion is exemplified in Boyd, Clay and Hargreaves' neat description:

> One useful approach may be to identify and utilize "master producers" or "change agents" as a conduit for information to assist in the extension of BMP's (Best or Better Management Practices) to nearby small producers (Boyd, Clay and Hargreaves 2002: 22).

The perceived trickle down or filter effect then occurs as other, usually poorer, less 'adventurous' farmers gradually learn from 'the innovators' seeing the benefits of this new technology or new strategy and copying the practice of the original innovator possibly in a diluted form. In this way technical know-how diffuses through rural society impacting on farming practices and improving the livelihoods of farmers of all classes – what is sometimes called the 'Multiplier Affect'.

Lewis *et al* refer to this concept as 'enterprise culture' (Lewis *et al* 1996: 43). It is a model in which,

> Competing characterizations of social actors play a role. Are they passive recipients' of technical know-how, or are they 'hidebound traditionalists, reluctant to alter inefficient farming and production methods? (Shenhav and Shrum 1995: 628).

According to this paradigm, the entrepreneur/innovator, Hargreave's 'change agent' or 'master producer', is viewed as the 'key player in the process of increasing production and creating sustainable employment opportunities' (ibid). In this way,

> The pursuit of change (development) is derived almost exclusively from the findings of the research station and transmitted to the farmer through hierarchical, technically-oriented, extension services. farmers are seen as either "adopters" or "rejectors" of technologies, but not as originators of either technical knowledge or improved practice (Scoones and Thompson 1993: 3).

Aquacultural innovations and strategies do not spread according to a simple pattern of diffusion as this traditional model suggests: 'knowledge transmission is not based on simple communication channels, conduits or linkages...it involves human agency and occurs within...networks of different actors, organisations and institutions' (Scoones and Thompson 1993: 16). The oversimplified approach to technology transfer within a framework of 'enterprise culture', derives from an assumption that increasing production is of value to low income people. This can lead to an exaggeration of the benefits of innovations in technology and management. This is underlined in Lewis, Gregory and Wood's study on aquaculture systems in Bangladesh, which found that often people identified as the 'entrepreneurs' are 'innovating primarily for the purposes of survival' (Lewis *et al* 1996: 45). This highlights the crucial question of motivation in studying the uptake of aquacultural management strategies and technologies[13]. Lewis *et al* conclude that,

> Interventions in complex networks, such as the fry trading system in Bangladesh, often miss the crucial point that much of this entrepreneurial activity on the part of the poor is part of a portfolio of economic activities, which is constantly being adjusted and rearranged according to season, locality and available information and opportunity (Lewis *et al* 1996: 44).

[13] The question of motivation and its relationship to impact is discussed more fully in section 2.1.

A common assumption implicit in this model is that farmers trust other farmers as opposed to extensionists, government employers and external researchers. In many cases this may indeed be a valid and significant conclusion that has important implications for extension planning and design[14]. Indeed just a brief look at some of the literature on extension practices in recent years reveals attempts at new and experimental models for extension which seem ultimately to have been inspired by the 'farmer first' paradigm developed in the early 90's and expounded by Robert Chambers. This model favours a decline in the prominence of the state employed extension officer in favour of a greater emphasis on farmer-to-farmer learning, as well as encouraging researchers and planners to learn from farmers. The 'farmer first' approach to knowledge and learning will be explored in more depth in the next section.

4.1 Knowledge

The complex position of knowledge within processes of technology transfer and change in farming practices requires attention. As Lewis, Gregory and Wood's study has shown, access to information can translate directly into economic power:

> The inconsistencies in knowledge and information flows within the network, and in the range of different actors' control, or lack of control, over these flows is of great significance... Imperfect flows of information and uneven distribution of aquaculture knowledge allows information and price choices to be manipulated by those who control the channels of communication and resource flow... Throughout the network, the control of scarce information and knowledge may translate directly into economic gain (Lewis *et al* 1996: 115).

However, research which focuses on questions of knowledge generation has met certain problems and has tended to fall back on the simplistic vision of knowledge as a discreet package which can be transferred or communicated according to the traditional notion of technology transfer. Yet, the 'Farmer First' methodology,

[14] The significance of 'learning from other farmers' is highlighted in Fairhead's account of farming practices in Bwisha, Zaire: There is no forum for open discussion by farmers... no institutionalization that could lead to pooling, exchange and local assessment of their knowledge. This has the positive effect of forcing all farmers to be inquisitive and innovative, but the negative aspect is that advantageous ideas used by one farmer are often not replicated on other farms (Fairhead 1993: 194).

emerging as an alternative to this 'top down' approach seems often to fall into the same trap, this time representing farmer's knowledge as a unitary block.

Lightfoot and Pullin's 1991 paper call for the application of 'Farmer-First' qualitative methods for integrating farm system modelling into research on integrated agriculture-aquaculture systems. (Lightfoot and Pullin 1991). They echo the 1988 ICLARM paper on 'Research and Education for the Development of Integrated Crop-Livestock-Fish Farming Systems in the Tropics' in demanding a 'holistic view of the farm' (Edwards, Gartner and Pullin 1988: 3). Statements such as this have continued to dominate attempts at social research on livelihoods in both agriculture and aquaculture in he last decade. However in so doing such approaches have neglected broader factors beyond the 'holistic' image of the village and failed to place the micro-level within the local, national and global trajectories of commodity chains and the market and have ignored people's mobility and change. This approach assumes a bounded unit of the farm, family or possibly village and so leaves out significant actors and institutions which are key factors in the practice of aquaculture and the transfer of technology. This approach sets up a linear model in which 'The Research Institute', 'The Extension Service' and 'The Farm', 'Household' or 'Village' become discreet units linked by arrows along which knowledge and information flow. Scoones and Thompson explain how such an approach pitches 'scientific knowledge' against 'farmer's knowledge':

> Farmer First promoters sometimes present the view that farming communities often share common goals, interest, and access to resources (including information) and that local knowledge is unitary, systematised and available for assimilation and incorporation with western scientific knowledge. The emphasis is on information transfer and linkage between the different parties, who are seen as knowledge 'producers', 'disseminators' or utilisers' (Scoones and Thompson 1993: 7).

Such an approach 'extracts farming knowledge from its social and political context...assisting the belief that farming is somehow a-social and a-political' (Fairhead 1993: 193). Fairhead also comments on the danger of viewing farmer's knowledge as a coherent system, arguing that 'farmer's knowledge is more empirical and dynamic' (Fairhead 1993: 193) that this systematised perspective allows.

The approach advocated by Scoones and Thompson, in contrast, argues, that 'both local and non-local people hold many divergent, sometimes conflicting interests and goals' and therefore requires both farming research and extension to adopt a more complex methodology which goes beyond the conventional linear model in which research produces 'knowledge' which is translated into 'information' or 'strategies' which are disseminated and adopted as 'best practice':

> (A) wide variety of actual practices arises not out of a...'plan', but through a series of ...responses to uncertain ecological and social circumstances...They may also involve acts of secrecy and reactions to perceived threats...where an individual or group presents false or misleading information in order to protect ideas or innovations (Scoones and Thompson 1993: 15).

In this way knowledge is 'bound up with action' (ibid), so that what people do is not the same as what they consciously know: to quote Fairhead 'one cannot simply interpret local people's knowledge from what they do, nor vice versa' (Fairhead 1993: 198). As Barnett has pointed out,

> 'Much of the know-how to operate, maintain and adapt production technology is 'tacit knowledge' which forms part of the experience of particular individuals and is not easily transferred or codified' (Barnett1994: 5).

In view of such unplanned practices and sometimes hidden strategies, Scoones and Thompson urge that 'it is vital that formal science engages with farmers' experimental performance' (Scoones and Thompson 1993: 15).

4.2 Tools of Transfer: Extension, Training and The Media

Over the last decade a mass of literature and studies have been produced around the topic of extension. Extension structures and mechanisms have emerged as the chief focus for research into improvement and innovation in farming practices. The crucial role of extension workers as agents in processes of technical innovation and technology transfer has been highlighted. Some studies have shown how local level implementers, such as extension agents... can exert considerable influence on science/policy/practice process: that is 'in the ways they interpret directives, deal with contradictory instructions and ideas, take initiative and exercise discretion' (Fairhead and Leach 2002a: 8). Fairhead and Leach's study of the researcher/extentionist relationship in the field of forestry in Trinidad is informative in highlighting the potential for disparity between the 'hard science' of researchers and the promotion of practical strategies which is the extensionist's remit (Fairhead and Leach 2002b: 78).

The on-going debate surrounding extension practices has revealed, not only the futility of seeking a single, universally applicable model for extension, but also the 'dangers of giving priority to extension structures over functions and of neglecting how extension interacts with other services and information sources' (DFID 1998a: 1). There has been increasing criticism of the "top-down" technology development and extension approach, typified by the Training and Visit system, compatible with centralized institutions, which offers a 'standard-sized conveyer belt supply of packages or messages of farmers' (Scoones and Thompson 2000: 9). This system, which has developed out of the traditional technology transfer paradigm, tends to focus on those farmers identified as 'innovators', 'entrepreneurs' or 'change agents':

> Often extension agents focus on 'leading or progressive farmers' – those with the greatest access to resources on the farm or with sufficient income to purchase these off farm. Extension agents do this because it is easier to show a complete, complex system on a single farm (ICLARM and IIRR 2001: 7).

These farmers are often used to 'demonstrate' the gains to be achieved from the strategy or technology. However, as the ICLARM and IIRR Primer explains, this focus on resource-rich farmers in technology extension efforts tends to marginalize poorer farmers,

> Resource-rich farmers often control the distribution of inputs to poor farmers. Helping rich farmers to expand may reduce access to resources by poor farmers, making it yet more difficult for them to adopt a new system that may improve their livelihood (ICLARM and IIRR 2001: 7).

The World Bank's finding from extension and research study in India in the field of aquaculture and fisheries displays this top-down approach to extension as it speaks of 'getting the fishermen' to adopt certain strategies:

> The extension workers…generally have extremely large areas to cover, are not often equipped with transport means…and are not particularly well trained especially in fisheries…There are, in addition, certain non-governmental operations engaged in technology transfer...Although they are not generally engaged in research they are capable of taking research results produced by others and *getting* the fishermen to put them into practice (World Bank 1991: 26-27, italics added)

A review of farmer-managed trials and extension of rural aquaculture in the Mekong Delta, Vietnam (Phuong, Long, Varaldi, Jeney and Pekar 2002: 275) presents some interesting findings. The authors argue that a variety of studies looking at extension in this region have suggested that what is required in terms of technical support to fish farmers is 'relatively small incremental changes to existing farming systems' rather than 'attempting' to introduce turn-key, alien technologies which usually fail'. Such attempts to introduce new aquaculture technologies and management strategies have often proceeded with no concern about local knowledge, practices, preferences and resource use and therefore are destined to fail. (Barraclough and Finger-Stich 1996: 35). The approach of AIT's *Aqua Outreach* programme reveals the same critical attitude towards conventional models of extension and technology transfer:

> Knowledge merely disseminated to small-scale farmers in a conventional, top-down mode of technology transfer following in-laboratory and on-station research by scientists is rarely effective. This is because it usually fails to match the resource profiles of small-scale farms, which are diverse and complex. A wider perspective on research to develop and disseminate technology *appropriate* for the widely varying resource contexts of farmers is required (AIT 1998: 10).

AIT's approach to outreach and extension follows the 'appropriate technology' model of technology transfer fashionable in current thinking on technology transfer. The concept of *Appropriate Technology* is a recurring theme in discussions of technology choice and change, and transfer of technical knowledge. As a term it refers to the idea that 'technology should be designed and assessed, adopted and adapted, with some concept of basic needs in mind' (Shenhav and Shrum 1995: 645). Thus it plays an increasingly important role in discussions about linkages between research, extension and 'end-users' or target groups.

Alam and Kamp's study of an experimental 'farmer field school' for aquaculture in Bangladesh echoes this stating that:

> 'In most cases the fundamental issue being addressed in the extension message is a technology couched in pre-determined practices which the farmers are then required to…replicate in their own ponds' (Alam and Kamp 1998: 11)

The field school model, on the other hand, appears to present an alternative to this imposition of generic strategies and specific technologies irrespective of context, focusing more on providing a wide understanding of aquatic eco-systems and adaptive methods for management (ibid). Indeed new and experimental models for extension support, like the ‘farmer field school’ are emerging alongside the critiques of the prevailing ‘top-down’ approach.

In their paper on research, innovation and interactions with NGO’s, John Farrington and Anthony Bebbington have demonstrated the valuable prospects for generating effective alliances between NGO’s and public sector research as a way of strengthening extension machinery (Farrington and Bebbington 2000). They conclude that efficient extension support requires an ‘enhaned client orientation, and an awareness hat users’ needs can best be served by ‘problem’ or issue-oriented approaches to technology development and dissemination’ (ibid: 213). Röling goes further, arguing for a total restructuring of existing extension systems if they are to be transformed from supply-led, technology-driven structures to organisations that are demand-led and client-driven (Röling 2000: 245).

In Vietnam, where aquaculture extension is a relatively recent development, long-standing farmers associations which for many years have been a site of information exchange and support can provide extension services with focal points for their activities (Lovatelli 1997: 19). Similarly, a recent study in Gujarat, India presents one of a growing number of cases of village-based extension systems found in various countries. Village extension volunteers offer services, such as soil and water conservation planning, as part of an extension structure run by and paid for by local people to meet their needs (Shah 2000: 248).

The literature is virtually unanimous in stating that in most of the target countries the efficiency of national extension service is low due to severe constraints on funds and facilities (Phuong, Long, Varaldi, Jeney and Pekar 2002: 275; APO 1998: 6). However, some authors have held up the Thai extension system as a model claiming that Thailand’s wide network of extension workers are responsible for ‘getting its 26,000-farm shrimp industry to address critical virus disease and coastal water pollution problems’ (Corbin 1997: 3). Yet, as will be discussed further in Chapter VI, shrimp aquaculture, as Thailand’s eighth largest commodity export (Ministry of Commerce 1996), has benefited from a high level of technical, financial and institutional support not only from government, but from large corporations and international donors, to which small-scale, in-land aquaculturalists have not had access:

> Aquaculture primarily meeting local food requirements has received little support compared to commercial aquaculture, including shrimp farming' (Barraclough and Finger-Stich 1996: 1); whereas 'shrimps are almost exclusively produced for export to meet the demands of high purchasing power consumers in Japan, the United States and Western Europe (Csavas 1992: 15). Consumption in these countries has almost trebled during the last decade, but with many fluctuations in demand, supply and price (Barraclough and Finger-Stich 1996: 1).

Some studies have demonstrated how, in the absence of effective extension and training services, farmers rely on information on management strategies from agricultural suppliers and company representatives:

> Sellers of drugs and chemicals, for example, often take advantage of farmers…not yet…knowledgeable…(about) when and which drugs or chemicals may be usefully applied…(with) the pressure from suppliers of inputs…it is extremely difficult for farmers…to detect the real, as opposed, to perceived benefits of chemical use. This results in an increase in chemical sales and application due to dissemination of anecdotal information. Shrimp farmers have been sold, among other things, powdered oxygen and detergent for use in pond by unscrupulous salesmen (Fegan 1996: 26).

This unofficial 'privatisation' or 'commercialisation' of extension shows how the process of technology transfer does not follow a discreet, linear path, but is embedded in the complex web of social and market relations. Fegan goes on to suggest that the exchange of information from supplier to farmer flourishes due to the 'wide gap in communication between academics or technical experts and farmers' (ibid): it is not only the extension worker-farmer relationship which matters; the connections between researcher and farmer, and researcher and extension worker must also come under close scrutiny.

This has been highlighted in the IDRC's study of *The Role of Science and Technology in Viet Nam*, which identified the crucial role of research institutes as 'powerful sources of new farm-level technologies', stating that,

> 'The applied orientation of staff will ensure that their findings are passed on to the local extension services and directly to farmers through demonstrations and training programs' (Annerstadt, Bezanson, Chung, Hopper, Oldham and Sagasti 1999: 111).

However they note that constraints are placed on the communication of new agricultural and aquacultural technologies and strategies due to an extension service which is 'often isolated from the mainstream of agricultural research' (ibid). They add that training on farming practices needs to be supported by communication of market information, prices and harvest expectations if it is to have a greater impact.

Lewis, Gregory and Wood's work on aquaculture trading systems in Bangladesh addresses the way in which the social and economic complexity of market relationships is frequently underestimated by the planners and investigates the potential for mobilising market relationships in the service of extension (Lewis *et al* 1996: 45). This study investigated the possible role of the fingerling trader as an extension agent of improved fish culture practices, 'supplying his customers (food fish pond holders) with information about stocking and pond management', what they call, 'indigenising extension' (Lewis *et al* 1996: 149). The study found that fingerling traders were often asked by grow-out pond owners for information on pond management. However 'many areas of their fish culture knowledge were found to be low, offering considerable potential for improving food fish productivity if training on better practices could be adopted' (Lewis *et al* 1996: 151). They highlight the advantages of such a system stating that.

> When one considers that a single trader might be dealing with hundreds of food fish producers in a very season, the scope for information dissemination is potentially very large... More specific incentives to traders in their role as informal extension agents were explored by the project. For example if traders were to support a pond operator with advice over a season, they might formally arrange to receive a percentage of the catch (Lewis *et al* 1996: 156).

The authors go on to inform us that the results of the pilot project were very promising. This strategy appeared to generate a 'highly efficient system of agricultural extension in terms of the extent of contact with the target group' (Lewis *et al* 1996: 157). However, a longer period of time and more in-depth follow-up study would be necessary for assessing the impact of this approach to extension on practice and livelihoods.

In recent years the importance of mass media such as radio and television as tools for the communication of farming strategies and information has been recognised. A number of recent studies and projects have highlighted how these channels have successfully been mobilised to reach a broad sector of farmers. The effectiveness of rural radio as a channel for the communication of information on agriculture and aquaculture is revealed in IDRC's study of science and technology in Viet Nam (Annerstadt, Bezanson, Chung, Hopper, Oldham and Sagasti 1999: 116).

The authors of this study add that

> 'Television programs directed at farmers are now being tried and appear to be very effective... Videotapes that extension workers can leave in the villages for people to further study also appear to be effective ways to demonstrate new production technologies' (ibid).

Similarly Indev's recent report comments on an initiative in Karnataka State, India, promoting 'community radio as a tool for development' (Indev May 2000). The 'Namma Dhwani' community radio project set up at Bdhikote village, around 95km from Bangalore involved local people recording programmes in Kannada on relevant issues such as organic farming, sericulture... and water problems. These programmes are stored as audio cassettes and played back at community meetings. In addition, live broadcasts of such programmes are done once a week at the local market where people from the surrounding area gather. According to the report 'the radio programmes act as a tool for widespread information dissemination on locally relevant issues and also serve as a platform for community discussion' (Indev May 2000)[15]. However, just as there is a tendency to view technology as neutral, so the media is often represented uncritically as an a-politcal, a-social channel of communication. The fact that people have access to television or radio should not be translated into evidence that these channels are effective tools of transfer. Located research concerned with the way in which people engage with radio and television is required.

However, attempts to assess the impact of such tools on farmers' livelihoods meet the same challenges as investigating the impact of the strategies themselves. While audience levels, access or reception can be assessed, a link between exposure to

[15] Following recent trends in development planning, another initiative has explored the potential of internet systems as an information tool for farmers. Indev reports that: 'the click and mortar model was first established in Madhya Pradesh for soya farmers. An internet kiosk was set up in the house of an influential farmer known as the choupal sanchalak. The site provides farmers with real-time information market, prices, global prices and the best farming practices…the content was rewritten in some cases by the farmers themselves for user-friendliness' (Indev July 2002).

information and changes in practice or behaviour cannot be assumed. This is clear in the case of extension manuals and materials such as the Integrated Agriculture-Aquaculture Primer produced by ICLARM and IIRR states its purpose as:

> IIRR and ICLARM valued the idea of developing a publication on integrated agriculture-aquaculture to help improve the quality of life of farmers on smallholdings...This resulted in the publication of the 'Farmer-proven integrated agriculture-aquaculture: a technology information kit.

The primer goes on to demonstrate the efficacy of such a tool stating that,

> The 2000 printed copies were distributed to extentionists, farmers, university students, scientists, decionmakers in governmental, non-governmental and local organisations, and bilateral donors. Feedback from users revealed that the kit was used in training courses and communications such as posters and lectures. It was highly sought after (ibid).

However, while this shows the wide dissemination of the kit, no comment is made concerning the impact of this initiative on livelihoods and practices. As has been the pattern in the past, follow-up studies of both research and extension activities have failed to address the crucial questions of uptake and impact.

V. GENDER AND AQUACULTURE

> The now widespread recognition of women's contribution to agriculture labour in the continent has been replicated in some ways when it comes to the farming of fish. As with agriculture this is less frequently translated into action when it comes to organizing extension support (Crewe and Harrison 1998: 117).

Crewe and Harrison's statement in the case of Africa is equally true for the Asian context. This is particularly significant in the field of technology transfer and the generation of technical knowledge in which often a 'perceived dichotomy between technical men and non-technical women' (ibid) prevails, underpinning both the structure and practices of extension systems and government planning in the field of aquaculture.

This appears as a prevailing theme in the literature. The Symposium on, *Women in Asian Fisheries* held as part of the 5th Asian Fisheries Forum 1998 reported that,

> Knowledge of the contributions of women in the fisheries sector is only evolving slowly and still lags behind that of other rural sectors in Asian countries…Women in the sector are marginalized in planning and policy-making. Studies in Malaysia and other countries showed…that more than 80% or rural women's activities were carried out in or close to home. New technologies…in the sector tended to marginalize these backyard activities (Symposium on Women in Asian Fisheries 1998: 8-9)

Equally, Sriputtinibondh and Sunternratana's paper on 'Thai Fisheries Development and Gender Issues' argues that, while women have been playing a very important role in aquaculture, particularly subsistence aquaculture in North-Easter Thailand, credit and training facilities are targeted towards men and difficult for women to access, adding that 'less than ten percent of the farmers trained by the Department of Fisheries in Thailand are women' (Sriputtinibondh and Sunternratana 2002: 10). However they qualify this by saying that when it comes to post-harvest technology – often perceived as the traditional domain of women[16]- including preservation and cooking there are more training and support services available to women. Without easy access to extension and training programmes on pond management women often have to rely on information provided through their husbands, commercial agents (eg. from drugs companies or agricultural suppliers), or other informants (European Commission 1994: 32).

The purpose of Sriputtinibondh and Sunternratana's paper is to highlight a project supported by the Thai government under the title 'Technology Transfer for Gender and Aquaculture in North-East Thailand' (May 2002-May2003) which, they say, is the first step in addressing the issue of gender inequity in the area of extension and technical services offered for aquaculturalists. However such an initiative has a long way to go, as the authors state,

> Gender is still a new thing at the DoF in Thailand… Despite some activities focusing on women supposed to improve post-harvest technology…an implementation plan, programme or project that directly empowers women in the fisheries sector is not clearly defined… The DoF lacks data and research on gender and fisheries development and the division of labour of men and women working in fisheries activities. Without (this)…it is difficult to integrate gender in a programme or project (Sriputtinibondh and Sunternratana 2002: 10).

[16] See the proceedings of the 1988 ADCP/NORAD workshop on women in aquaculture for a discussion of perceptions of post harvest activities including preserving and processing as a traditionally 'female sphere' (Engle, Crosetti and Nash 1988: 57-67

Nevertheless, their hope is that this project will initiate such activities as the training of trainers in gender analysis that will ultimately lead to a restructuring of extension services and address the crucial area of technology transfer and gender.

The report into women's participation in fish nursing in the Cantho area, conducted by Cantho University is equally revealing. This study found that women in the sample families devoted a considerable portion of time from their daily schedule to maintaining the nursery (an average of three hours per day were spent cleaning tanks and ponds, preparing feed and feeding). The report states that

> Fish nursing is a high-profit activity. It was both a secondary and seasonal job for the women, but earnings from it contributed much to household income (Huong, Minh and Tuan 1996: 40).

However, the report goes on to point out that,

> Noteworthy is that none of the women in fish nursing had been trained in aquaculture, and in fact had gained their knowledge only from experience (ibid:41)

Again the authors point to the same problems of inadequate technical and credit services available to women:

> Women face technical problems… Capital investment – the need for money to start the business appears to plague them most…all of the women in the sample households aspire to reduce their working time spent on fish nursing so that they can have more time for study and…attend training courses on fish nursing.

Crewe and Harrison note, with reference to the Zambian context, that although few women in Luapula Province own fish ponds in their own right, this does not mean that they do not participate in aquaculture (Crewe and Harrison 1998: 117). This point, which is often missed by planners and extensionists, is supported by the literature on gender and aquaculture in the Asian context. With specific reference to Thailand, Sriputtinibondh and Sunternratana write that,

> It has been found that subsistence aquaculture is mostly carried out by women. It has also been observed these subsistence[17] aquaculturalists are still not able to commercialise their operations (Sriputtinibondh and Sunternratana 2002: 9).

[17] Conventional perceptions that men inhabit the commercial sphere while household economy is the traditional domain of women underwrite the dichotomy between commercial and subsistence activities. Although this issue is not explored in detail here, there is a need for a deconstruction of this binary framework and re-evaluation of what the terms 'subsistence' and 'commercial' constitute.

The EC Directorate General for Development, *Fisheries and Aquaculture Guidelines for the Incorporation of Gender in Project/Programme Design* states that because the daily feeding and management of the pond is often considered a household activity, women's inputs…are hardly taken into account' (European Commission 1994: 16).

Furthermore, while women are often the primary managers of the pond, carrying out the daily maintenance of the fish including feeding and health care, they are prevented from accessing credit and technical support services as in many cases they are not the 'legal' owners (ibid: 28). This highlights the difficulties of approaching the issue of ownership, management practices and decision-making. The impact of AAH strategies on farming practices and livelihoods depends on the capacity of extension services and other sources of technical support to address the complex issue of decision-making and motivation in the household and farm management. There may be greater social or time constraints to women attending extension training courses or farmers' meetings which need to be addressed in the provision of extension services (European Commission 1994: 31, Engle, Crosetti and Nash 1988: 12). This has inspired a demand for a greater number of women to be trained as extension agents and for services and workshops that target women in aquaculture. In view of the restricted mobility and time constraints often faced by women, a need for on-site activities or mobile extension and credit units has been underlined in discussion of such 'women-targeted' services (European Commission 1994: 32). The potential to mobilise existing informal and formal female groups and networks has also been noted:

> In order to increase access for women to extension service and to expedite the capacity of extension services to affiliate with female target groups, local female extension workers and link workers may have to be recruited, trained and equipped to identify existing professional groupings, o organise women into groups, to work together with these groups on issues prioritised by them and to mediate services from male extension staff. In addition, male extension workers are to be made aware of gender issues and to be motivated to address women's needs (ibid).

As has been discussed above, technical support services cannot stand alone. Women require cash or credit to invest in such strategies, credit to which, without adequate collateral, they may be denied by agriculture and state banks as they cannot claim ownership to the land and ponds they manage. Informal credit, despite the often crippling interest rates, thus provides a more accessible and flexible source of the cash for women needed to invest in technology inputs for aquaculture (European Commission 1994: 28). Equally problematic are initiatives that offer 'targeted credit' to female entrepreneurs. However, credit targeted for farms and businesses run by women will not result in an improvement of the economic position of other categories of women, such as those who work as unpaid labour within the household but are excluded from decisions concerning production and investment (ibid). It is therefore necessary in addressing the potential impact of projects which aim to promote certain farming practices or pond management strategies to consider the question of credit, and who has the resources available to them to exploit such strategies.

Crewe and Harrison argue that women's involvement in fish farming is used 'to equate farmer motivations with household motivations, as if they were one and the same thing, implying mutual and compatible interests within the household' (Crewe and Harrison 1998: 117). It may often be the case that decisions concerning pond management, investment in health strategies, and harvest times are the result of shared motivation, but this cannot be assumed. The incorporation of gender, not only into extension practice, but also into research agendas and design, and the production of management strategies, involves studying empirically the separate, and potentially conflicting, economic strategies that may be adopted men and women. In order to strengthen the link between the production and promotion of AAH strategies, and uptake there is a need for both the research framework and extension practices to be informed by insights into differing motivation and interests and decision-making processes within the household (Sriputtinibondh and Sunternratana 2002: 9-10).

However, it is not a matter simply of broadening extension systems to include women and making AAH technologies available to women involved in fish farming. As is stated forcefully in the forward to the EC's Guidelines on the incorporation of gender in project/programme design for fisheries and aquaculture,

> Where women and men are equally important economic agents, fulfilling different but complementary roles in fish production, processing and marketing an intervention in one field of activities will necessarily have an impact on other activities in the production-marketing chain, and consequently entail effects on the…patterns of division of labour and income generation between men and women (European Commission 1994: 7).

Again this reveals the assumption behind much planning that female and male interests within the household are one and the same and that technical innovations will unambiguously benefit both men and women. As the guidelines go on to point out:

> Evaluations have shown that fisheries development programmes with a strong focus on technology, often resulted in a worsened situation for women in terms of increased work load…and less control over income. Benefits accrued by men through the interventions did not, or only partially *trickle across* to their families, but were rather spent on investments or used for personal consumption. As a consequence technology oriented programmes did not contribute to the improvement of the nutritional and living conditions of target households…there has been a general realisation that the transfer of modern technology by itself has not been very effective and certainly not a sustainable way of alleviating poverty and guaranteeing food security (ibid: 8)

The gendered effects of technology transfer in both agriculture and aquaculture are often overlooked or dealt with naively by both researchers and planners. Only a limited number of studies have looked specifically at the gendered effects of technology change and the promotion of innovative technical strategies. Crewe and Harrison refer to the 'association between technology…manufacture and maleness' (Crewe and Harrison 1998: 108) which often underpins technical research and development programmes.

This is particularly the case when thinking about large-scale and commercial aquaculture enterprises in which new technologies, as in the field of agriculture, can boost production but may often have the adverse impact of displacing labour, a consequence which has been shown to be born significantly by women (Burch *et al* 2000).

VI. SHRIMP FARMING IN ASIA

In the past decade the development of shrimp aquaculture as a commercial industry has been supported by governments, research centres, and international donors and agencies, who have hailed it as a great source of food and revenue for Asian countries. Concern for the ecological implications of intensive commercial shrimp farming has grown and produced a number of interesting studies focused on the environmental question. However, the social impact of the intensification of shrimp farming has been largely overlooked and the literature that exists tends to deal with the social impact and context in a relatively uncritical manner. Recently, however, a growing debate has emerged over the extent to which shrimp farming, while generating substantial revenue through the export market, actually offers anything in the way of food security, employment and poverty reduction for people and the role shrimp aquaculture plays in rural livelihoods. Barraclough and Finger-Stich's study of the ecological and social implications of commercial shrimp farming in Asia argues that,

> It makes only a very small contribution towards meeting the needs for food. Shrimp exports bring substantial foreign exchange to poor countries and may contribute to regional and national short-term economic growth. Shrimp farming also generates improved incomes for some producers and labourers.… Aquaculture development has been heavily promoted and subsidized by international and national lending agencies that often cite global food security needs as a justication…This is fallacious for the major portion of shrimp aquaculture which caters to luxury demand. The shrimp industry has become the main beneficiary of these subsidies and institutional supports (Barraclough and Finger-Stich 1996: 1)

Shrimp culture has long been practised in Asia, traditionally within the context of extensive systems of polyculture production. This system usually describes an area of land close to estuaries or brackish water defined with embankments; wild post-larvae are collected and deposited in the culture area with water exchange achieved through tidal fluctuation. Stocking rates are usually low and the system relies on natural pond matter for feed, thus relatively low yields are generated[18] (Burch *et al* 2000: 517). However as Burch *et al* state 'in recent years…social and economic shifts within the

[18] The statistics presented in World Shrimp Farming 1996 indicate that extensive shrimp farming yields up to approx. 500 kilograms per hectare per crop (live weight) whereas semi-intensive and intensive systems have the potential to yield up to 5,000kg/ha/crop. Most farms, however, tend to average 2,000 and 3,000 kg/ha/crop (World Shrimp Farming 1996: 94, 96).

production, consumption and trade systems have led to more intensive systems' (ibid: 517).

As the shrimp industry has experienced significant growth in production levels, it has generated enormous revenue for a number of groups within the Asian agricultural sector. Burch *et al* point to a number of factors in the context of Thailand which have converged in recent years to boost the intensification of shrimp farming[19]:

> Official encouragement to expand shrimp aquaculture dates from 1972 when the Thai government began to offer financial assistance and the Department of Fisheries adopted a policy of promoting coastal aquaculture by encouraging farmers to upgrade their farming methods…Further incentives over 1986-1991, in the form of US$84 million in assistance sought to encourage the expansion of the shrimp aquaculture section during the period of the Sixth National Development Plan (Burch *et al* 2000: 517).

Skladany and Harris add that the World Bank and the Bank of Thailand 'acted as catalysts for private investment' (Skladany and Harris 1995: 170) providing funds for infrastructure building and encouraging technology transfers. Burch *et al* tell us that the mass of Thailand's shrimp technology was (and still is to a large extent) introduced by the leading transnational corporation in the shrimp industry, the CP Group, in a joint venture with a Japanese company and Taiwanese[20] technicians (Burch *et al* 2000: 517).

The significant rise in prices paid for tiger shrimp in the US, Europe and Japan motivated many farmers to establish ponds and, whether through the contract farming system or working via agents, take up this new activity. However the extent to which small-scale farmers have become involved in the shrimp market and shared in its high profits is keenly debated. Barraclough and Stitch argue that,

> The trend towards intensive shrimp aquaculture is encouraged by high profits from farmed shrimp. These profits result in growing economic power of large producers and of shrimp feed and processing industries (Barraclough and Finger-Stich 1996: 2).

Burch *et al* echo this stating,

[19] See also Skaldany and Harris 1995: 171-174 on the shift towards intensification of shrimp aquaculture in Thailand.
[20] The contribution of Taiwan is important for it was in Taiwan that intensive shrimp farming systems were first developed until the industry collapsed in 1988 due in a large part to disease (Bort, Ovares and Stonich 1997: 165).

> Contrary to the claims of the industry and the Thai government, the existence of a large number of small-scale, independent shrimp farmers is highly exaggerated[21]…It is likely that local villagers do not participate in shrimp farm *ownership* but rather in the provision of wage labour[22] or as tenant farmers (Burch *et al* 2000: 521).

The authors support this argument with the findings from a 1992 government survey of Ranod District, Songkla Province (one of the main centres of shrimp production in Southern Thailand) which revealed that 42% of farms were corporate-owned, 19% were contract-related, and 39% private enterprises. This seems to indicate that close to two thirds of farms were at the time part of a corporate managed system and were not owned by 'small-scale entrepreneurial locals' (ibid). Further support for this argument is found in the ICLARM and IIRR Primer on Integrated Agriculture-Aquaculture Systems, which states that:

> After shrimp production became established, outside interests have become influential and extract much of the value from shrimp culture (ICLARM and IIRR 2001: 84).

However, recent research has revealed how in many cases large enterprises do not own the shrimp production units themselves. A study of Amphoe Hua Sai and Ranot , two districts of southern Thailand reported that around 3000 shrimp farmers controlled 20, 876 Rais (about 3,367 hectares) in ponds and 93% of the farms were operated by the owner (Barraclough and Finger-Stich 1996: 17). While large enterprises have maintained oligopolistic control over the feed and pharmaceutical production sector, in 1990 only approximately 10% of the total number of shrimp farms were owned by large enterprises. The large corporations preferred to promote cooperative systems in which the shrimp farmer was only one member. In this way large enterprises could closely control production practices (monitoring and prescribing inputs) and production while passing on many of the risks of fluctuating shrimp crops to small 'independent' farmers: to quote Lewis *et al*,

> It is the distribution of power within the network, based on capital, information and knowledge, which determines access and allows the more

[21] Such a claim is made in the 'Thematic Review on Management strategies for major Diseases in Shrimp Aquaculture': 'Small-scale farmers owning less that 5 ha of land located in rural coastal areas undertake most shrimp farming in Asia' (Arthur, Philips, Reantaso and Subasinghe 1999: 1). SImilarly Tookwinas states that 'Marine shrimp farms in Thailand are generally small-scale, with most culture areas being approximately 0.16-1.6ha' (Tookwinas 1999: 10).
[22] See further discussion of changes in employment patterns and aquaculture as a source of employment in section 2.3.

> economically secure actors to transfer risks successfully to the less secure network participants (Lewis *et al* 1996: 153).

Despite the risks involved, the financial incentives to enter the shrimp business remain very high. Thai shrimp farmers in the Ranot District, most of whom were previously growing rice, increased their income by as much as ten times (NACA 1994: 22). The risk of low yields due to disease is somewhat mitigated by diversification of livelihood activities since, despite perceptions that shrimp farming is a full-time activity, it is estimated that for all of Thailand 70% of all shrimp farmers have other sources of income: 32% as traders, 16% as fishermen, 8% as rice farmers, 7 % as labourers and a further 7% as government employers (ibid).

The distribution of resources and benefits from shrimp farming varies significantly from one social context to the next. In Thailand for example, where land ownership has generally been widely distributed, small- and medium-sized shrimp farmers who were previously cultivators and fishermen had the potential to move into shrimp aquaculture and in this way improve their incomes significantly (Barraclough and Finger-Stich 1996: 16). Nevertheless the cultivation of shrimp requires large amounts of natural, financial and technical resources (FAO/NACA 1994: 29). Shrimp farmers, producing for international markets have to adopt more intensive technologies in order to remain competitive as there are sharp limits to the land and water resources still available for extensive production. This requires access to financial resources and expensive technology. According to Barraclough and Fingerstich's study these are provided most of the time by urban entrepreneurs supported by foreign investors and industries' (Barraclough and Fingerstich 1996: 16).

As Burch *et al* point out, what is unusual in the Thailand experience is that the transformation of farmed shrimp into a global commodity has been acheived through a southern TNC – Charoen Pokphand, commonly known as the CP Group[23] – and not an established 'northern' agro-food conglomerate' (Burch, Goss and Rickosn 2000:

[23] The CP Group has expanded from the production base to retail (acquiring the Kentucky Fried Chicken franchise and some 715 Seven Eleven stores in Thailand which acquire all their poultry – and nearly all their other product lines from the CP Group), as well as moving into telecommunications, real state, petrochemicals and entertainment ventures. Within agriculture, it has interests in fertilizers, pesticides and agro-chemicals, vehicles, tractors, livestock operations in poultry and swine, and more, in Thailand and beyond (Burch *et al* 2000: 516).

514). The unprecedented growth of the Asian shrimp farming as a global commercial industry, and the emergence of the CP Group as the key player in research, development and technology transfer at all levels of the industry, are crucial factors in the generation and role of aquatic animal health strategies in Asian aquaculture.

Burch, Goss and Rickson's study investigates the way in which the CP Group 'engaged in the full cycle of production (from the inputs of feed and farm technology to the marketing of products overseas)... dominates the industry and shapes the organisational relations of production at every level' (Burch *et al* 2000: 519). CP Group's dominance in the shrimp industry has followed a similar pattern to that of the Group's involvment in the poultry market, when they 'began to organise the production of poultry in a system of vertical integration[24] in which the Group ultimately came to provide all the inputs (day old chicks, animal feed, medicines, credit, extension services), and processed and marketed outputs' (ibid: 515). The shrimp industry is characterised by a similar system of vertical integration that is generally coordinated and controlled by the companies that supply feeds and laboratory services to associated practitioners. This is exemplified by the case of the CP Group who control 65% of the shrimp feed market alone (making it the largest shrimp feed producer in the world) and are responsible for the expansion of shrimp aquaculture to emerging exporters such as Vietnam, China, and India, in which CP claim an 80% share of the shrimp feed market. (Burch *et al* 2000: 518-519)[25].

The transformation of shrimp farming into a global export industry controlled, to a large extent, by transnational corporations has, arguably, been behind the striking increase in research in the field of shrimp aquaculture. According to Burch *et al* the areas of research that dominate the industry literature are disease, feed, pollution and, to a lesser extent, a range of issues raised by 'green' groups. The CP Group has been at the forefront of this movement to mobilise resources with the mission of producing

[24] Barraclough and Finger-Stich present a similar case of *Aquastar*, a large Thai corporation active in the shrimp industry, demonstrating how with the support of government and banks, multi-national capital is used for vertically integrating the shrimp production chain (Barraclough and Finger-Stich 1996: 18).
[25] See Burch, Goss and Rickson's (2000: 518) diagram of the organisational relationships and inter-dependent structures involved in such a system, which extends through all levels of production from technical research to feed and pharmaceutical supply, and from hatcheries producing post-larvae to marketing agents of the 'finished product'.

a base of technical research with which to support the shrimp industry. These research-orientated activities have resulted in the publication of newsletters and the provision of technical services that have offered farmers an important source of information and strategies adapted from research. However, Burch *et al* warn,

> These activities are hardly philanthropic: they are indicative of CP's strategy within the shrimp sector and are symptomatic of the ways in which the company seeks solutions to the constraints placed upon the further expansion of the industry (ibid).

Nevertheless it is important to note that these activities, orientated towards the development of technical knowledge to support shrimp aquaculture, mark a significant shift towards 'south-to-south' relationships in technology transfer:

> CP has been one of the most dynamic agents in this process of transfer in the Asia-Pacific region. Thailand was itself the recipient of technology transfers from Taiwan, and now CP in turn provides the full range of know-how and inputs in joint-venture projects it has established throughout the region (ibid).

This is demonstrated clearly in the case of research focusing on disease control in shrimp production. Many studies have noted that disease is by far the most pressing 'techno-science' issue confronted by the shrimp industry (Boyd, Clay and Hargreves 2002: 8; Arthur *et al* 1999: 2, Shrimp Farming and the Environment 2002: 40, Boonyaratpalin 1996: 80) and this realisation has spawned a growing body of research and literature concerned with the effects of disease on shrimp production and strategies for control (for example the focus on disease in papers presented at the Proceedings of 1996 Workshop, Towards Sustainable Shrimp Culture in Thailand and the Region, (Smith 1996)). Barraclough and Finger-Stich write that 'intensive shrimp farms imply high stocking densities making them very prone to the propagation of pollution and disease' (Barraclough and Finger-Stich 1996: 2).

Burch *et al* state that

> Disease virtually wiped out the Taiwanese shrimp industry in 1988…while in 1993 Chinese producers lost 80% of their crop within a two month period. In 1991 one report identified seven diseases that had been detected in shrimp in Thailand (Burch *et al* 2000: 521).

The CP Group, collaborating with the Thai government and other industry players has recently created the 'Shrimp Culture and Research Development Company' with the aim of 'act(ing) as the major research arm in Thailand for the pursuit of advanced genetic codes for higher shrimp production levels and greater disease tolerance' (ibid). CP has also established mobile diagnostic units offering advice and disease control strategies to farmers within their production circuits. However it appears that a large proportion of the beneficiaries of these services are those farmers who are already under the umbrella of the CP network. Burch *et al* describe the strategic nature of the technical services provided by CP to independent farmers:

> By offering farmers a scientific service 'free' of charge they create two significant relationships. First, CP maintains an active knowledge of the farming systems throughout its diagnostic region which allows it to prepare for many eventualities such as the onset of disease. This also allows the Group a fairly good view of the shrimp themselves – which at harvest time gives the company agents the greatest amount of information (as compared to other processing companies) when choosing stock to acquire for processing. Second, the provision of these services acts as an incentive for farms to maintain further relations with CP (through feed and technology inputs…) Company representatives act as direct contacts with shrimp farmers providing information and technical know-how, and in this way, establishing a positive relationship ('making friends') which can be cultivated for commercial purposes (ibid: 522).

The dominance of the shrimp industry has led some authors to write critically of the way in which support for in-land small-scale fin-fish aquaculture, which is less capital intensive, but is more efficient in producing protein to meet the local population's requirements[26], is often diminished as shrimp farming has been favoured and supported by both government, corporations and international donors. It has been argued that, while donors justify their investments in aquaculture with claims that it provides rural people with a ready source of protein and an alternative livelihood activity, in practice, funds and technical support for aquaculture have focused on the production of farmed shrimp which is a luxury export commodity[27] (Barraclough and Finger-Stich 1996: 19). Thus in-land small-scale aquaculturalists have been sidelined in the provision of adequate extension services, and adaptive research and transfer of viable management strategies and technologies focused on meeting their needs, in

[26] Calls from some corners of the development sector and research arena to address at a regional level the balance between food security for the domestic market and the need to earn foreign exchange currency through export of higher value products such as shrimp are yet to be met (Bacon *et al* 2000: 3).

[27] Barraclough and Fingerstich claim that, 'almost half of Asian aquacultural production is from fresh-water. In 1992, crustaceans accounted for only 4.7 per cent of total volume of Asian aquaculture, while the largest share (48.2%) came from finfish mainly produced inland…Shrimp excepted, the greatest part of Asian aquaculture production remains in domestic markets' (Barraclough and Finger-Stich 1996: 2).

favour of shrimp farming which demands ‘Green Revolution’ kinds of technologies and the commercialisation of land and labour.

The World Bank’s 1991 study of fisheries and aquaculture research and extension in India seems to support the argument that the primary target of technical research in this field has, in the past been, large-scale commercial aquaculture and not small-scale rural farmers:

> In the past, research was focussed on export commodities, the development of large-scale operations and technologies for improving fish harvesting capacity. Training and education has largely been devoted to these areas (World Bank 1991: 28)

Current research has, as yet, failed to address the demands emerging out of the rapid growth of the shrimp industry in Asia, the complexity of economic and social relations within the industry, and the diversity of actors involved at various levels. There is a growing need for research to distinguish the various levels of actors who are involved and affected by the rapid development of the shrimp industry and to address the question of who are the real recipients of technical strategies in the field of shrimp aquaculture.

VII. CONCLUSION

In their essay on technology transfer in developing countries Shenhav and Shrum write that,

> Studies of social impacts of technology in LDC's have yielded considerable information on particular types of situations, but there are too few comparative studies to allow a systematic assessment of social effects (Shenhav and Shrum 1995: 644-5).

As we have seen, this is clearly the case for technical research and innovation concerned with the practice of aquaculture. While livelihoods analysis has become an automatic bolt-on to scientific research concerned with aquaculture, traditional paradigms of technology transfer and economic models for increasing production continue to underpin research agendas and intervention strategies. According to such models farmers appear as stereotyped characters: 'innovators' and 'maximisers', 'passive recipients' or 'rejectors' of technical strategies. The focus is on processes of 'adaption', 'adoption' and 'diffusion' by which the benefits of research eventually 'trickle down' to the people seen as being at the tail end of the system. Knowledge is viewed as a systematised package, technology as neutral and unambiguously beneficial.

This review has attempted to deconstruct these dominant models and show that such a linear approach, reliant on linkages between various points in a chain, is incompatible with the complex socio-economic realities, power relations and conflicting interests which operate within the 'network' of actors involved in aquaculture. Recent studies have begun to undermine the orthodoxy of the conventional approach, highlighting the potentially negative impact that technical strategies and innovative technologies can have on poorer members of a community. Other studies have looked critically at the naïve representation of the household as a nuclear unit with shared objectives, and highlighted the need to broaden the horizons of situated research beyond the immediate focus of the village, farm or household and its 'portfolio' of livelihoods activities. A study of the impact of aquatic animal health strategies on livelihoods and poverty demands a more complex engagement with the intersections of science, policy and development planning on the one hand, and the relationship between knowledge, power and practice on the other. Aquaculture undoubtedly plays a major role in the livelihoods of many people in Asia. Aquaculture research and the generation of aquatic animal health strategies clearly play a vital part in sustaining and improving the benefits derived from the practice of aquaculture. Nevertheless, this review has demonstrated the pressing need to look more critically, not only at the way in which such strategies impact on poverty and livelihoods, but also at the models of technology transfer upon which research and interventions are based.

REFERENCES

Alam, R. and Kemp, K. 1998. 'A "Farmer Field School" for Aquaculture', Aquaculture Asia, Vol. III, No. 4, 11-15.

Almeyda, A. 2001. 'Tropical Rhythms and Collective Action: Community-Based Fisheries Management in the Face of Amazonian Unpredictability' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 36-47.

American Fisheries Society 2002. 'Imported Catfish Labelling Law Signed', Fisheries, American Fisheries Society, Vol. 27, No. 1, Jan 2002.

Annerstedt, J., Bezanson, K., Chung, K., Hopper, D., Oldham, G. and Sagasti, F. 1999. Viet Nam at the Crossroads. The Role of Science and Technology, Ottowa: International Development Research Centre.

Aquaculture Development Beyond 2000: The Bangkok Declaration and Strategy April 2000. NACA and FAO.

Arthur, JR., Bueno, P., Hough, C., McGladdery, SE., Phillips, M. and Subasinghe, R. (eds) 2001. Aquaculture in the Third Millenium, Bangkok, Thailand: NACA and FAO.

Arthur, JR., Phillips, MJ., Reantaso, MB. And Subasinghe, RP. (eds) 1999. Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture, World Bank, NACA, WWF, FAO, Consortium Program on Shrimp Farming and the Environment, http://www.enaca,org/shrimp/case/global/CEBU/FinalCEBU.pdf.

Asian Development Bank 2000. Rural Asia: Beyond the Green Revolution, http://www.adb.org/documents/books/rural-asia/rura-asia.pdf.

Asian Institute of Technology 1994. Partners in Development: The Promotion of Sustainable Aquaculture, AIT.

Asian Institute of Technology 1998. 'Completing the Problem-Solving Cycle in Aquaculture the AIT *Aqua Outreach*', Aquaculture Asia, Vol. III, No. 3, 10-17.

Asian Productivity Organization 1998. Improving Management of Aquaculture in Asia, Report of an APO Seminar, 8-16 May, 1996, Taipei, Republic of China, APO, Tokyo.

Bacon, GB. And Hinds, LO. 2000. 'Regional and Inter-regional Cooperation for Sustainable Development', Aquaculture Asia, Vol. V, No. 3, 2-10.

Barnett, A. 1994. 'Knowledge Transfer and Developing Countries: the Tasks for Science and Technology in the Global Perspective in 2010', Science and Public Policy, Vol. 21, No. 1, 2-12.

Barraclough, S. and Finger-Stich, A. 1996. Some Ecological and Social Implications of Commercial Shrimp Farming in Asia, UNRISD, March 1996.

Ben-Yami, M. 1986. 'Aquaculture: The Importance of Knowing its Limitations', Ceres, Vol. 19, No. 4, 15-19.

Beveridge, M., Bueno, P., Kongkeo, H. and Subasinghe, R. 2001. 'The Bangkok Conference on Aquaculture in the Third Millenium: Outputs and the Challenges ahead', Research for Sustainable Development, Bulletin Vol. 14, No. 1-4, 41-42.

Boonyaratpalin, S. 1996. 'Viral Diseases of Farmed Shrimp – Present Status and Future Research', Towards Sustainable Shrimp Culture in Thailand and the Region, Proceedings of a Workshop held at Hat Yai, Songkhla, Thailand, 28 Oct-1 Nov 1996, ACIAR, 80-82 http://www.aciar.gov.au.publications/proceedings/90/ACIAR-proceedings-90.pdf.

Bort, J., Ovares, L. and Stonich, S. 1997. 'Globlisation of shrimp mariculture: the impact on social justice and environmental quality in Central America', Society and Natural Resources, Vol. 10, No. 2, 161-179.

Boyd, CE., Clay, JW. And Hargreaves, JA. 2002. 'Codes of Practice and Conduct for Marine Shrimp Aquaculture' Report prepared under the World Bank, NACA and FAO Consortium Program on Shrimp Farming and the Environment.

Burch, D., Goss, J. and Rickson, RE. 2000. 'Agri-Food Restructuring and Third World Transnationals: Thailand, the Cp Group and the Global Shrimp Industry', World Development Vol. 28 No. 3, 513-530.

Callon, M., Larédo, PH. and Mustar, PH. 1997. 'Introduction' in Callon, M., Larédo, PH. and Mustar, PH. (eds) The Strategic Management of Technology, Paris: Economica International, 9-25.

Cameron, H. and Georghiou, L. 1997. 'Managerial Performance – the Process Evaluation' in Callon, M., Larédo, PH. and Mustar, PH. (eds) The Strategic Management of Technology, Paris: Economica International, 227-250.

Castillo, GT. 1988. 'Finding Connections between Farm and Household', Transfer of Technology to Small-Scale Farms, Papers Presented at the 9th Meeting of the Technical Advisory Committee, Food and Fertilizer Technology Centre for the Asian and Pacific Region, ASPAC.

Chase Smith, R., Pinedo, D., Summers, PM. and Almeyda, A., 2001. 'Tropical Rhythms and Collective Action: Community-Based Fisheries Management in the Face of Amazonian Unpredictability' in Mehta, L., Leach, M. and

Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 36-47.

Corbin, JS. 1997. 'Government as Cheerleader, Gatekeeper and Facilitator for Sustainable Aquaculture Development', Aquaculture Asia, Vol. II, No. 2, 2-7.

Crewe, E. and Harrison, E. 1998. Whose Development ? An Ethnography of Aid, London and New York: Zed Books.

Csavas, I., 1992. 'Impact of Aquaculture on the Shrimp Industry', Infofish shrimp 92', Hong Kong, 6-18.

DFID and ODI 1998a.'Agriculture Extension', Keysheets for Sustainable Livelihoods DFID and ODI, http://www.odi.org.uk/keysheets/blue_2_agext_rev.pdf

DFID and ODI 1998b.'Agriculture Research', Keysheets for Sustainable Livelihoods, DFID and ODI, http://www.odi.org.uk/keysheets/blue_1_agres_rev.pdf

DFID April 2002. DFID AFGRP Draft Annual Report 2001/2002.

Edge, D., 1995. 'Reinventing the Wheel' in Jasanoff, S., Markle, GE., Petersen, JC. and Pinch, T. (eds) Handbook of Science and Technology Studies, California, London and New Delhi: Sage Publications, 3-25.

Edwards, DT. and Farrington, J. 1993. 'Review of the Factors Influencing the Uptake And Impact of a Sample of 21 UK-Supported Renewable Natural resource Research Projects', Network Paper 43, Agriculture Administration (Research And Extension) Network, ODI.

Edwards, P. 1999. 'Aquaculture and Poverty: Past, Present and Future Prospects on Impact', A Discussion paper prepared for the Fifth Fisheries Development Donor Consultation, Rome, Italy, 22-24 February, 1999.

Edwards, P. 2000. 'Aquaculture, Poverty Impacts and Livelihoods', ODI Natural Resource Perspectives No. 56, ODI, http://www.odi.org.uk/nrp/56.html.

Edwards, P., Gartner, JA. And Pullin, RSV. 1988. Research and Education for the Development of Integrated Crop-Livestock-Fish Farming Systems in the Tropics, Manila, Philippines: International Centre for Living Aquatic Resources Management.

Engle, CR., Crosetti, D. and Nash, CE. 1987. 'Women in Aquaculture', Proceedings of the ADCP/NORAD Workshop on Women in Aquaculture Rome, FAO, 13-16 April 1987.

Eponou, T. 1993. 'Partners in Agriculture Technology. Linking Research and Technology Transfer to Serve Farmers', ISNAR Research Report.

European Commission, Directorate General for Development 1994. 'Fisheries and Aquaculture – Operational Guidelines for the Incorporation of Gender in Project/ Programme Preparation and Design'.

FAO/NACA 1994. Bangladesh Country Paper: Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Draft Report, TCP/RAS/2253, Bangkok, 21-26 February.

FAO 2000. The State of World Fisheries and Aquaculture, http://www.fao.org/DOCREP/003/X8002E/X8002E00.htm.

Fairhead, J. 1993. 'Representing Knowledge: the 'New Farmer' in Rsearch Fashions' in Pottier, J. (ed.) Practising Development. Social Science Perspectives, London and New York: Routledge, 187-205.

Fairhead, J. and Leach, M. 2002a. 'Introduction: Changing Perspectives on Forests: Science/Policy Processes in Wider Society' in Amanor, K., Fairhead, J. and Leach, M. Science and the Policy Process: Perspectives from the Forest, IDS Bulletin Vol 33, No. 1, Jan 2002, 1-12.

Fairhead, J. and Leach, M. 2002b. '"Sustainable" Timber Production and Science/Policy Processes in Trinidad' in Amanor, K., Fairhead, J. and Leach, M. Science and the Policy Process: Perspectives from the Forest, IDS Bulletin Vol 33, No. 1, Jan 2002, 75-84.

Farrington, J. and Bebbington, AJ. 2000. 'From research to Innovation: Getting the Most from Inetraction with NGO's' in in Scoones, I. and Thompson, J. (eds) Beyond Farmer First. Rural People's Knowledge, Agriculture Research and Extension Practice, London: Intermediate Technology Publications, 203-213.

Fegan, D. 1996. 'Sustainable Shrimp Farming in Asia: Vision or Pipedream?', Aquaculture Asia, Vol. I, No. 2, 22-39.

Green Peace 1997. Shrimp-The Devastating Delicacy: The Explosion of Shrimp Farming and the Negative Impacts on People and the Environment, http://www.greenpeaceusa.org/reports/biodiversity/shrimp/shrmp02.html

Hambrey, J. (Undated). 'Mangrove, Fisheries and Economic Valuation', . http://www.agri-aqua.ait.ac.th/mangroves/Haarintr.html.

Harrison, E. 1994. 'Fish farming in Africa: What's the Catch?', ODA.

Huong, DT., Minh, LT. And Tuan, NA. 1996. 'Women in Cantho City are Profitably Involved in Fish Nursing Activities', Aquaculture Asia, Vol. I, No. 2, 40-43.

ICLARM and IIRR 2001. 'Integrated Agriculture-Aquaculture. A Primer', FA) Fisheries Techincal Paper 407, FAO, ICLARM, IIRR, Rome 2001.

IMM 2002. 'Literature Review of Reef Dependent Livelihoods and the Poor', Report prepared for DFID, IMM ltd, University of Exeter.

Indev May 2000. Indev Report, May 2002, http://www.indev.org/news/news.html.

Indev June 2000. Indev Report, June 2002, http://www.indev.org/news/news.html.

Johnston, M. 1998. 'Keep Records of Disease Events and Losses!', Aquaculture Asia, Vol. III, No. 2, 42-43.

Kaimowitz, D. 2002. 'Towards a Pro-Poor Forest Science' in Amanor, K., Fairhead, J. and Leach, M. Science and the Policy Process: Perspectives from the Forest, IDS Bulletin Vol 33, No. 1, Jan 2002, 123-126.

Le Thi Van Hue, 2001. 'Institutional Arrangements for Community-Based Mangrove Forest Management in Giao Lac Village, Giao Thuy District, Nam Dinh Province, Vietnam' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 71-77.

Lewis, D., Gregory, R. and Wood, GD. 1996. Trading the Silver Seed. Local Knowledge and Market Moralities in Aquacultural Development, London: Intermediate Technology Publications.

Lightfoot, C. and Pullin, RSV. 1991. 'Why Asian FSRE Needs Qualitative Methods for Integrating Agriculture with Aquaculture', Journal of Asian Farming Systems Association Vol. 1, No. 2, 201-215.

Lipton, M. and Longhurst, R. 1989. New Seeds and Poor People, Baltimore, MD: Johns Hopkins University Press.

Lipton, M. and Litchfield, J. 2002. 'The Impact of Irrigation on Poverty', Poverty Research Unit at Sussex, FAO.

Lorenzen, K. 2002. 'A Scientist in No-Man's Land: Bridging the Gap between Fisheries and Aquaculture', Aquaculture News, No. 28, 12-13, University of Stirling.

Lovatelli, A. 1997. 'Status of Aquaculture in Vietnam', Aquaculture Asia, Vol. II, No. 3, 18-26.

Marlowe, GA., 1988. 'Transfer of Technology for Vegetable Crops to the Small-Scale Farms', Transferof Technology to Small-Scale Farms, Papers Presented at the 9th Meeting of the Technical Advisory Committee, Food and Fertilizer Technology Centre for the Asian and Pacific Region, ASPAC.

Mehta, L., Leach, M. and Scoones, I. 2001. 'Editorial' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 1-10.

Ministry of Commerce 1996. Trade Statistics and Economic Indicators of Thailand 1995, Department of Business Economics (Bangkok), Ministry of Commerce, Thailand.

Ministry of Commerce 1997. Trade Statistics and Economic Indicators of Thailand 1996, Department of Business Economics (Bangkok), Ministry of Commerce, Thailand.

Mulak, C., 1994. Social and Environmental Impacts of Shrimp Culture in West Java, Indonesia, Ph.D. thesis, Auburn University, USA.

NACA 1994. Impact of Aquaculture on the Environment: Study 1, Sixth Meeting of the Governing Council, Beijing, Vhina, 26-29 October 1994.

NACA 2001. The 3rd Five-Year Work Programme of the Network of Aquaculture Centres in Asia-Pacific.

Phuong, NT., Long, DN., Varadi, L., Jeney, Z. and Pekar, F. 2002. 'Farmer-Managed Trials and Extension of Rural Aquaculture in the Mekong Delta, Vietnam' in Edwards, P., Demaine, H. and Little, DC. Rural Aquaculture, Oxford and New York: CABI Publishing, 275-285.

Poverty Research Unit at Sussex 2002. 'The WTO and Poverty Reduction', PRUS Newsletter, Issue 2, Winter 2002.

Rayner, S. 2002. 'Managing Risks of Technological Innovation', Paper Delivered at IDS, May 22nd, 2002.

Röling, N. 2000. 'Facilitating Sustainable Agriculture: Turning Policy Models Upside Down' in Scoones, I. and Thompson, J. (eds) Beyond Farmer First. Rural People's Knowledge, Agriculture Research and Extension Practice, London: Intermediate Technology Publications, 245-248.

Sano, A. 2000. 'Social Actors in the Global Market: Socio-Economic Impacts of Shrimp Aquaculture in South Sulawesi in Indonesia', Working Paper Series No. 316, Institute of Social Studies, The Hague.

Scoones, I. and Thompson, J. 2000 (1st pub. 1994). 'Introduction' in Scoones, I. and Thompson, J. (eds) Beyond Farmer First. Rural People's Knowledge, Agriculture Research and Extension Practice, London: Intermediate Technology Publications, 1-15.

Scoones, I. and Thompson, J. 1993. Challenging the Populist Perspective: Rural People's Knowledge, Agriculture Research and Extension Practice, Institute of Development Studies Discussion Paper 332, Sussex: IDS.

Shah, P. 2000. 'Village-managed Extension Systems: Implications for Policy and Practice' in Scoones, I. and Thompson, J. (eds) Beyond Farmer First. Rural People's Knowledge, Agriculture Research and Extension Practice, London: Intermediate Technology Publications, 248-252.

Shenhav, Y. and Shrum, W. 1995. 'Science and Technology in Less Developed Countries' in Jasanoff, S., Markle, GE., Petersen, JC. and Pinch, T. (eds) Handbook of Science and Technology Studies, California, London and New Delhi: Sage Publications, 627-652.

Shrimp Farming and the Envrionment, 2002. Shrimp Farming and the Environment, A Consortium Program, World Bank, NACA, WWF, FAO, Consortium Program on Shrimp Farming and the Environment, http://www.enaca.org/shrimp/case/Draftsynthesisreport-21-june-pdf

Skladany, M. and Harris C. 1995. 'On Global Pond: International Development ND Commodity Chains in the Shrimp Industry' in Mcmichael, P. (ed.) Food and Agrarian Orders in the World Economy, Westport: Praeger, 169-191.

Smith, PT. 1996. Towards Sustainable Shrimp Culture in Thailand and the Region, Proceedings of a Workshop held at Hat Yai, Songkhla, Thailand, 28 Oct-1 Nov 1996, Australian Centre for International Agriculture Research, http://www.aciar.gov.au.publications/proceedings/90/ACIAR-proceedings-90.pdf.

Sriputtinibondh, N. and Sunternratana, U. 2002. 'Thai Fisheries Development and Gender Issues', Mekong Fish Catch and Culture, Mekong Fisheries Network Newsletter, Vol. 7, No. 4, 9-11.

Stirrat, RL. 2002. 'Impact Assessment', DRAFT.

Surr, M., Barnett, A., Duncan, A., Speight, M., Bradley, D., Rew, A. and Toye, J. 2002. Research for Poverty reduction: DFID Research Policy Paper, DFID.

Symposium on Women in Asian Fisheries, 13 Nov 1998. 'Women Do Fish!', Aquaculture Asia, Vol. IV, No. 1, 8-9.

Tookwinas, S. 1999. 'Shrimp Culture in Thailand – Present Status and Future Directions for Research', Towards Sustainable Shrimp Culture in Thailand and the Region, Proceedings of a Workshop held at Hat Yai, Songkhla, Thailand, 28 Oct-1 Nov 1996, ACIAR, 10-15 http://www.aciar.gov.au.publications/proceedings/90/ACIAR-proceedings-90.pdf.

Weemaes, S. 1997. 'Brachishwater Aquaculture in District Maros, South Sulawesi, MA Thesis, University of Utrecht, The Netherlands.

World Bank 1991. 'Fisheries and Aquaculture Research Capabilities and Needs in Asia – Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region', World Bank Technical Paper Number 47, Fisheries Series, Washington DC: World Bank.

World Shrimp Farming 1996. Annual Report, Shrimp News International, San Diego.

Appendix II

CONTENTS

ABSTRACT

A SYSTEMATIC REVIEW OF AQUATIC ANIMAL HEALTH INTERVENTIONS IN ASIA

LUCY BARNARD

Background: The expansion in global aquaculture has led to an increasing interest in aquatic animal health. The impact of aquatic animal health research on production and the livelihoods of small-scale aquaculturists is unclear.

Objectives: To conduct a systematic review of aquatic animal health interventions reported from India, Thailand and Vietnam between 1993 and 2003 as part of an assessment of the impact of aquaculture on the livelihoods of poor people.

Search strategy: Sources included Web of Science, CAB Direct, BIOSIS and Aquatic Sciences and Fisheries Abstracts (ASFA), conference proceedings, journals, books, theses and bibliographies. Companies, research institutes, GOs and NGOs conducting research in the target countries were also approached.

Selection criteria: Studies must have been conducted in the target countries, provided detailed methods, and included a control group and statistical analysis. Interventions must have aimed to influence the health, (growth, survival, production, quality, disease occurrence), of fish or shrimp/prawn. Abstracts only were excluded.

Data collection and analysis: Two reviewers independently assessed the studies and one extracted the data. Studies were divided into eight groups; water quality, light/photoperiod, polyculture, stocking density, genetics, feed and nutrition, and disease. Analysis was descriptive for most topics, but for studies on stocking density, multilevel models were used to assess the variation in the data accounted for at four levels:- different studies, experiments, replicates and species.

Main results: A total of 254 studies were included; 185 from India, 58 from Thailand and 10 from Vietnam. Research output fluctuated slightly over the decade, peaking in 1999. An average of 23 studies was retrieved each year. Feed and nutrition was the most common topic, (138 studies), followed by water quality (48), and stocking density (21). There were relatively few reports (21), of interventions targeted at specific diseases. Polyculture, genetics and light formed a minor component of reports. 30 studies fitted more than one category and 41 were uncategorized. More studies were conducted on species of fish than shrimp. Carp and *Penaeus* sp. were the most frequent target species. Survival, mean harvest weight and mean weight gain were the most common outcome measures. Hierarchical modelling showed that for data on the effect of stocking density on growth rate, 74.6% of the variance was associated with the individual study design.

Reviewers' conclusions: There was considerable diversity in the categories of intervention carried out and heterogeneity of study design within categories. No particular strategy or focus of research effort was apparent. The heterogeneity of reports within a category made the value of meta-analysis questionable. Problems were also encountered in assessing abstracts and studies because of inadequate or

inaccurate information. The lack of field trials made the impact of aquatic animal health research on productivity and livelihoods difficult to assess.

Acknowledgements

I would like to thank the following people for their valuable help in identifying and obtaining literature for this review: Dr James Turnbull, Dr Margaret Crumlish, Miss Jutaporn Bundit, Miss Penny Beaton (Institute of Aquaculture, University of Stirling, UK), Dr Temduong Somsiri, Dr Supranee Chinabut (Aquatic Animal Health Research Institute (AAHRI), Bangkok, Thailand), Mr Deepak Kumar Nayak, Mr Prakish Patel, Dr Kalkuli Shankar (College of Fisheries, Mangalore, India), Mr NQT Vuong, Dr Hao (Research Institute for Aquaculture No. II, Vietnam), and Miss TT Dung (College of Fisheries, Ho Chi Minh City, Vietnam).

Thank you to my supervisor Professor Kenton Morgan for his help and guidance in carrying out this systematic review, and for dedicating a significant amount of his time to being the second assessor of papers.

I would also like to thank my family and friends for their continued support and encouragement throughout the last eighteen months. Special thanks to Matt for his immense patience and understanding, and without whose support this would not have been possible.

CHAPTER 1. INTRODUCTION

The aim of this study is to conduct a systematic review of aquatic animal health interventions in the Asian countries of India, Thailand and Vietnam. This process will identify what types of interventions have been carried out and on what species, and will provide a baseline of information that will facilitate the identification of areas where research is lacking. This review forms part of a larger DFID funded project, (R8119), investigating the impact of aquatic animal health strategies on the livelihoods of poor people in Asia.

1.1 Systematic reviews

Systematic reviews are designed to provide an unbiased compilation of all intervention trials that have been conducted on a specific health issue and include a meta-analysis of the pooled results to give a quantitative estimation of the intervention efficacy. They provide a baseline of information and an evidence base from which future research can progress.

Systematic reviews are carried out according to a specific protocol that defines the background and objectives of the review, the question being asked, the search strategy used to identify studies and the criteria for inclusion of studies in the review. To date, the Cochrane Collaboration is the largest organisation on a global scale that is involved in producing and maintaining systematic reviews, (Clarke, 2003).

The Cochrane Collaboration was established in October 1992, but its development dates back to the 1970s. In 1972, Dr Archie Cochrane published a book titled, 'Effectiveness and Efficiency: random reflections on health services', (Cochrane, 1972). This publication highlighted the problems in the dissemination of healthcare research at the time. In particular that,

i) knowledge of the effectiveness of treatments or interventions came from studies that were identified and collected using a haphazard process, without searching all available sources,

ii) some readers or reviewers selected studies that reinforced or agreed with their ideas or beliefs,

iii) there were time constraints of searching the entire literature,

iv) there were publication and language biases associated with the failure to include unpublished data, the tendency for negative results not to be published and the selection of English language journals, and

v) only studies that showed significant results were selected.

When examined in the context of human healthcare, Cochrane argued that the conclusions drawn from studies of human healthcare were unlikely to be a true reflection of current knowledge, owing to the deliberate or accidental exclusion of a substantial number of research findings. He concluded that this could be misleading and, in extreme cases, promote treatments that had detrimental effects, and cause misuse of limited monetary and human resources.

Interest generated by this publication led to the development of a register of randomised controlled trials in perinatal medicine and systematic reviews of trials relating to pregnancy and childbirth. This involved collaboration between a number of institutes. Following the publication of the results, funding was received in February 1992, for a ‘Cochrane centre’, to conduct systematic reviews of human healthcare interventions. Since its establishment, a total of 50 Cochrane Collaborative Review Groups, (CRGs), have been set up. Each reviews interventions relating to a specific area of human health and medicine, e.g. the epilepsy group and skin group.

A detailed handbook outlining the procedures involved in carrying out a systematic review is available, (Clarke and Oxman, 2002). The majority of systematic reviews specify that the studies must be randomised controlled trials. A randomised controlled trial is a trial where participants are randomly allocated to a treatment group, e.g. by random numbers tables. If participants are allocated using other criteria, e.g. age, trials are simply called controlled trials. Randomised controlled trials (RCTs) usually involve the use of single or double blinding also, where the participants and/or those administering the treatment are not aware of the treatment they have received or delivered. Randomised controlled trials are considered high quality studies. The principle behind them is to ensure that the differences between groups of participants are kept to a minimum so that any differences between them can be attributed to the intervention of interest. Chance effects will always be present, but the use of this type of study design minimises these effects and reduces any sources of bias. By pooling the results of multiple randomised controlled trials, systematic reviews reduce these effects further and allow results to be generalised more easily (Mukhopadhyay et al, 1996; George and Rubin, 2003; Henderson et al, 2003).

The aim of a systematic review is to identify both published and unpublished sources, with the aim of eliminating any publication bias. Identifying published literature involves conducting a search of electronic databases using Boolean search strategies of key words and synonyms relating to the review question. The aim of these Boolean search strategies is to minimise the number of false positive studies, i.e. studies that do not fulfil the criteria for inclusion. Searching unpublished literature can include hand searching of journals, books, theses and conference proceedings, citation chasing, (i.e. where the list of references in studies are hand searched), and contacting private companies, research institutes or government departments for any documents that are not in the public domain or that are not easily accessible.

Once all studies have been identified they are screened for inclusion according to a prespecified set of objective criteria, (usually by more than one reviewer), and an assessment of study quality is made. Factors such as the adequacy of allocation concealment of participants and blinding of people recording the outcome measures are sometimes used as measures of quality, (Conde-Agudelo et al, 2004; Edwards et al, 2004). In some cases, quality scores or scales are used, (Beckles Willson et al, 2004; Green et al, 2004). Following this, if a sufficient number of studies have been identified and they are suitably homogeneous, in terms of the interventions tested and the outcomes measured, then a meta-analysis of the pooled results is conducted. This provides an overall estimate of the effectiveness of interventions on a specific measure of the specified disease or condition, and also identifies which interventions have been beneficial or detrimental, with respect to the outcome measure being analysed. Where studies contain too much heterogeneity, a qualitative summary of the results is given in addition or instead, (Moher et al, 2004; van Tulder et al, 2004). Once a review has been conducted it is published on the Cochrane Collaboration website and updates are made as necessary, (Cormac et al, 2004; Young and Jewell, 2004).

The Cochrane Collaboration has primarily been concerned with generating systematic reviews of human healthcare interventions. In recent years, the use of systematic reviews has spread to other disciplines, to include the arts and social sciences and policy, (The Campbell Collaboration, 2004; Hemsley-Brown et al, 2003; Murphy et al, 2003; Pirrie, 2003; Torgerson et al, 2003). Its uptake in the field of veterinary science has also been relatively recent, (Curran et al, 2002; Hirst et al, 2002; Olivry et al, 2003). Until now, systematic reviews conducted in veterinary science have all focused on terrestrial animals as the target participants. To date, no systematic reviews have been carried out in aquaculture and aquatic animal health.

1.2 Aquaculture

Due to an increasing global population, strains on food security, particularly in developing countries, have put an enormous strain on agricultural industries. Aquaculture has played a pivotal role in providing sufficient food resources and it is currently the world's fastest growing area of food production. It has also been responsible for export and employment opportunities and has become an important income source, especially in low-income food-deficit countries, (Gryseels, 2001).

In the past, capture fisheries, involving the harvesting of fish from water bodies without any supplementary feed or provision of fertilisers, and fishing of wild stocks, have been the main source of fish and other aquatic animal production. However, over the last decade, problems of sustainability have been highlighted by depletion of fish stocks, damage to the aquatic environment, (Fluharty, 2000; Koslow et al, 2000; Caddy, 1999), and the ever-increasing demand for aquatic animal products. Gryseels, (2001), stated that global capture fisheries could sustain an annual production level of 100 million tonnes, but only if such factors were addressed and the resources utilised efficiently.

In response to the strain on capture fisheries, the aquaculture industry has experienced phenomenal global growth. The definition of aquaculture as given by the United Nations Food and Agriculture Organisation (FAO) states that,

"Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated."

It is therefore considered a very different method of production to that of simply harvesting stocks after a set time period or collecting wild stocks.

On a global scale, the aquaculture industry has been increasing at a rate of approximately 10% per year in developing countries and 3.7% per year in developed countries since 1970, (FAO, 2002). The percentage contribution of aquaculture to world fish production levels almost doubled between 1990 and 1998, from 13% to 25%, (Gryseels, 2001). FAO estimated that world production of aquatic animals was 125 million tonnes in 1999, of which 92.3 were from capture fisheries and 32.9 from aquaculture, (World Aquaculture Outlook, 2002). This compares to just 2 million tonnes from aquaculture production in the 1960s. FAO also predicts that by 2010, aquaculture production will have reached 40 million tonnes, (World Aquaculture Outlook, 2002).

Aquaculture is an important industry across all continents. Asia, however, is the global leader, containing 11 of the top 20 producing countries, (World Aquaculture Outlook, 2002). This includes many of the low-income food-deficit countries that together contribute 75% of the global fish production from aquaculture. In the year 2000, FAO reported that aquaculture production from low-income food-deficit countries was approximately 7 million tonnes and was worth approximately $9 billion, (FAO, 2002), highlighting its importance to these countries.

After China, India is the biggest global producer of aquaculture products. In 2000, India produced 2,095,000 tonnes with a value of $2,166,000. The diversification of India's aquaculture practices, to include rice-cum-fish culture and more intensive shrimp culture has also made the country more competitive in the global market, by the production of both protein, (fish), and cash, (shrimps), crops, (Jana et al, 2003).

Another very important Asian aquaculture producing country is Thailand. This country is the biggest global exporter of aquaculture and fisheries products, accounting for 8% of the world value, (World Aquaculture Outlook, 2002). Between 1981 and 1994, Thailand's marine shrimp exports increased from approximately 20,000 tonnes to 165,000 tonnes, highlighting the rapid growth in the industry. Part of this growth can be attributed to the spread of intensive farming of marine shrimp in 1989, (Kwei Lin, 1995), where previously, farming had been extensive. In 2000, aquaculture production had risen to 707,000 tonnes but its value was more than that of India's produce, at $2,431,000.

In Vietnam, growth in aquaculture production has been relatively slow, however Lovatelli, (1997), stated that based on land area, it was one of the largest countries involved in shrimp farming in Southeast Asia. Many different types of farming are practiced including traditional extensive farming, rice-shrimp farming, salt-shrimp alternation, integrated shrimp-mangrove farming and improved extensive and semi-intensive culture, (Binh and Kwei Lin, 1995). This diversification may have been a contributing factor to the success of the industry with respect to the utilisation of different environments. Figures from FAO, (2002), showed that aquaculture production in Vietnam in the year 2000 was 526,000 tonnes and was valued at $1,096,000.

One noticeable trend is that although Vietnam had a level of production that was less than 200,000 tonnes smaller than Thailand, the value of the produce was less than half that obtained by Thailand, indicating that perhaps Vietnam is in need of more development in the industry to make it more competitive in the global market.

Although India, Thailand and Vietnam are all very successful aquaculture producers, there remain clear differences between them. India is the biggest producer with a very large domestic market, Thailand is the biggest exporter and Vietnam, although relatively new to the industry, has enormous potential for developing a large domestic and export market.

Despite impressive growths in individual country's aquaculture industries, the continent of Asia, (excluding China), has had a deficit of fisheries products over the past 25 years, (from 1976 to 2000), as the import value of its produce has always been above the export value. In 2000, the deficit was approximately $8 billion, (FAO, 2002). Future production and aquaculture practice will need to improve if this deficit is to be reduced.

1.3 Aquatic animal health

The increase in the global aquaculture industry has lead to the pressure of producing countries to be internationally competitive. In some cases, this means exporting or importing a substantial amount of produce. In agriculture, the World Trade Organisation, (WTO), has introduced guidelines for the international trade of animal and plant products, (WTO, 2004). An International Aquatic Animal Health Code has been introduced by the Office International des Epizooties, (OIE), also known as the World Organisation for Animal Health. The aim of this code is to ensure the safe transportation of aquatic animals and to prevent transfer of pathogenic agents between importing and exporting countries, (OIE, 2004(b)). This code requires that the international trade in aquatic animals can only go ahead if a procedure of certification is carried out between the exporting and importing country or countries. Each country has the responsibility to communicate to the other country information regarding the disease status of the species of interest within the country and the measures taken to control this. This information will then determine whether or not an importing or exporting country will receive certification.

The introduction of such measures has coincided with an increase in reported aquatic disease prevalence across all aquaculture-producing countries, (Bower, 2003; Ghittino et al, 2003; Villena, 2003), including India, Thailand and Vietnam. From the 2003 OIE disease prevalence data, the number of diseases reportable to the OIE was 22 for Thailand, 22 for Vietnam and 25 for India. These had all increased from the year 2000, when the number of reportable diseases was 20 for each country, (OIE, 2003).

Other factors that have threatened the aquaculture industry, particularly in developing countries, have included the lack of strict guidelines regarding the use of chemicals, the lack of management regulations for land use, (Kwei Lin, 1995), and the emphasis on profit maximisation. In 2002, export restrictions were placed on Thai shrimp products because they contained high residues of chloramphenicol and other antibiotics, (foodmarketexchange.com, 2003), used in response to increased incidences of shrimp disease. This resulted in decreased demand and revenue. Coupled with the fact that many areas that have been used for aquaculture practice in developing countries have been unsustainable and have resulted in the abandonment of ponds, there is clearly a need to increase awareness of how aquaculture practice can be improved. Aquatic animal health issues are central to this, as many of the causes of the abandonment of ponds have been linked with disease problems and poor water quality, leading to financial difficulties for farmers, (Australian Marine Conservation Society, 2003). The combinations of all of these factors that act as constraints to continued aquaculture production, makes research into aquatic animal health problems very important if such practices are to remain sustainable. This is particularly the case for developing countries in Asia.

The aim of this systematic review is therefore to identify all types of aquatic animal health interventions that have been conducted on species of fish and shrimp over the last ten years in the Asian countries of India, Thailand and Vietnam. Information gathered from these studies will be important in highlighting what research has been conducted, what areas of research need to be further developed and on what species of fish and shrimp, and finally what the status of each target country is in terms of research outputs. This review is part of a collaboration with institutes in Scotland, India, Thailand and Vietnam.

CHAPTER 2. SEARCH STRATEGY, INCLUSION CRITERIA AND PAPERS RETRIEVED.

2.1 INTRODUCTION

Many aspects of aquaculture practice can influence the health of animals being cultured. Examples include stocking density, feed and nutrition, disease status and the quality of water animals are maintained in. This heterogeneity of factors affecting aquatic animal health has led to a wealth of worldwide research, (Corsin et al, 2001; Villena, 2003; Irianto and Austin, 2002; Brock and Bullis, 2001; Watanabe, 2002). Its aim is to improve aquatic animal health, welfare and productivity and indirectly to enhance the livelihoods of those involved in aquaculture. However, there is no current estimate of the impact of these research studies on aquatic animal health and farmers' livelihoods.

In this systematic review we ask the question, 'Have aquatic animal health interventions had any effect on aquaculture production in India, Thailand and Vietnam?'

As a result, the null hypothesis (H_o) being tested in this review is: - Aquatic animal health interventions have had no significant effect on aquaculture production in India, Thailand and Vietnam. In this chapter we describe the search strategy, inclusion criteria and the papers retrieved.

2.2 MATERIALS AND METHODS

2.2.1 Review protocol

The process of systematic review involves developing a defined protocol. This entails identifying the participants of interest, types of study design to be included, types of interventions, and outcome measures of interest, (Clarke and Oxman, 2002(a)). For this review the protocol was developed in collaboration with Prof K.L. Morgan and Dr J.F. Turnbull and is shown below:-

Participants: i) The countries India, Thailand and Vietnam

ii) All farmed species of freshwater, marine and brackish water fish and shrimp/prawn.

iii) All systems of aquaculture, (including intensive, semi-intensive and extensive).

Study design: i) All types of study design.

ii) All languages.

iii) Published and unpublished material.

iv) Studies conducted in the last ten years (i.e. 1993 to 2003 inclusive).

Interventions: Manipulations to:

i) Water quality parameters, including temperature.

ii) Light/photoperiod.

iii) Polyculture/monoculture conditions, including multiple species and different developmental stages of the same species.

iv) Stocking density.

v) Genetics, including cross-breeding.

vi) Feed and nutrition.

vii) Disease related aspects, including immunisations, drug trials, clinical trials and any other intervention to exotic or indigenous pathogens, bacterial, viral, protozoan or fungal diseases.

Outcomes: The interventions of interest must have aimed to have an effect on:

i) The production, survival, quality or growth of the species concerned, including the feed conversion ratio (FCR) and specific growth rate (SGR).

ii) Disease prevalence, incidence or occurrence.

iii) The level of disease susceptibility.

2.2.2 Collection of documents

The process of systematic review requires the identification and collection of all relevant documents. Two methods, broadly classified as electronic and non-electronic were used to do this. These will be described separately, as each involved very different processes.

2.2.2.1 Electronic search:

Four electronic databases were selected using the topics of publications within each database as the main criterion. These were:

i) ISI Web of Science (WOS)

ii) Aquatic Sciences and Fisheries Abstracts (ASFA)

iii) CAB Direct (CAB)

iv) BIOSIS Previews (BIOSIS)

Before searching each database, the journals and other sources indexed by each one were listed in order to identify any differences.

2.2.2.1.1 Search strategy

The aim of the search strategy was to search each database effectively and identify all relevant documents. Boolean logic with a series of key words was used to do this. Boolean logic is the use of AND, OR and NOT functions between words or categories of words. Construction of the final search strategy involved the following steps. Firstly, five key words from the review were identified. These were, 'aquatic', 'animal', 'health', 'intervention' and 'Asia'. From these, a list of synonyms was made with input from collaborators on the project, (Prof K.L. Morgan, Dr M. Crumlish, Dr J.F. Turnbull and Mr D.K. Nayak).

The number of words selected from this list was based on the maximum allowance for the Web of Science database. Different combinations of words from each category, with brackets enclosing each of the five categories of words, were entered into the full search option and run on the database. Web of Science was used for the initial selection of synonyms because it is one of the most widely used databases and indexes journals covering a wide range of subjects.

To ensure that plurals or alternative endings to the synonyms were not being missed, all words were truncated in groups of 5 at a time (using the star (*) function). The additional studies were logged and this was used to select words for truncation in the final search strategy.

The same process was carried out for ASFA, CAB Direct and BIOSIS, using different combinations of the synonyms selected for the Web of Science search strategy. The words that were truncated in the Web of Science (and ASFA) search strategy remained truncated for maximum consistency. Again the total number of hits and the number of false positive hits were logged for each search run, with the aim of reducing the maximum number of false positives.

Each search used the full search option, all languages, a time scale limited to 1993-2003 and the results presented in order of relevance. Selection of the final search strategy was based on the elimination of the maximum number of false positive studies (i.e. not relevant to the review topic).

To remove any duplicated studies and reduce the amount of reading, the individual abstracts from each database were compared. This was done using a careful process to ensure all possible comparisons were made. The Web of Science abstracts were used as the baseline for comparison. ASFA abstracts were compared with these and duplicates removed. CAB Direct abstracts were then compared with those from Web of Science and those unique to ASFA and duplicates again removed. Finally, BIOSIS abstracts were compared with Web of Science and those unique to ASFA and CAB

Direct. Retrospectively, the number of unique studies in each database and those identified in two, three and all four databases was calculated.

In order to ensure that all foreign language papers were being identified, each database helpline was contacted to check that abstracts identified by the English language search strategies did not exclude foreign language documents. This confirmed that any foreign abstracts within the database are translated into English as well.

Titles and abstracts of all studies identified by each database search were obtained and stored separately.

2.2.2.1.2 Comparing search strategies

To compare the results obtained from each database with the use of alternative database search strategies, the CAB Direct and BIOSIS search strategies were run on both Web of Science and ASFA using the same database limits of 1993 to 2003 on 13/2/04. In addition, the CAB Direct search strategy was used in BIOSIS.

2.2.2.2 Non-electronic searching:

This was carried out primarily for unpublished or 'grey literature'. It involved searching sources such as conference proceedings, company reports, proceedings of meetings, and PhD, MPhil and MSc theses from research institutes, universities and commercial companies involved in aquaculture and aquatic animal health. The methods used in each case are described below.

2.2.2.2.1 Conference proceedings

A list of conferences held in the past 10 years on the subject of aquatic animal health was created using the search engine ‘Google’ and by following internet links from individual websites. Email and postal addresses of organisers or society officials were obtained where available. Additional conferences identified from the search of the electronic databases were added to the list. Where possible, documents and proceedings from each conference were obtained from Internet websites. For the remainder, email messages were sent, where possible, requesting information about where proceedings could be obtained or who should be contacted. In addition, conference resources at the Institute of Aquaculture, Stirling in the form of hard copies of full proceedings, were hand searched for relevant material. Photocopies of potential studies (either as abstracts or full papers) were made.

2.2.2.2.2 Postgraduate theses

MSc and PhD theses resources at the Institute of Aquaculture were searched, first by identifying potentially relevant titles from an available list, and then hand searching through those selected to identify theses for inclusion in the review.

2.2.2.2.3 Research institutes, universities and commercial companies

a) Letters and questionnaires:

The search for documents at international research institutes, universities and commercial companies involved sending a letter requesting relevant documents on aquatic animal health research and a questionnaire to commercial companies, GOs, NGOs, universities and research institutes in each of the target countries and to a selection of contacts outside India, Thailand and Vietnam thought to be conducting research within one or more of these target countries. Full details of this will reported in chapter 3.

b) Reports from collaborating and associated institutes:

These were collected by local hand searches by staff at collaborating institutes. These were conducted by Mr Deepak Kumar Nayak and Mr Prakish Patel at the College of Fisheries, Mangalore, India, Dr Temdoung Somsiri at the Aquatic Animal Health Research Institute (AAHRI), Bangkok, Thailand, Mr D.Q.T. Vuong at the Research Institute for Aquaculture Number 2 (RIA II), Vietnam, Miss T.T. Dung at Can Tho University, Vietnam, and Miss L.E. Barnard at the Institute of Aquaculture, University of Stirling, UK.

Each research assistant collected available documents from their respective institutes as well as CIFA (Central Institute of Freshwater Aquaculture) and institutes in Cochin in India, and the Research Institute for Aquaculture number 1 (RIA I), Research Institute for Aquaculture number 2 (RIA II), Fisheries Ministry Centre of Information, the Fisheries University of Nha trang, and Hai Phong Research Institute in Vietnam.

The titles and where possible the abstract and full paper of theses, journals, technical papers and any additional resources available were collected, according to the review specifications. These were sent electronically to the UK.

2.2.2.2.4 Hand searching

Relevant books, magazines and journals available from library resources at the University of Liverpool, UK, were hand searched and all potentially useful studies obtained.

2.2.2.2.5 Citation chasing

All references contained in each primary study identified were searched and potentially relevant papers and documents obtained either online or by inter-library loan. Due to time constraints, references of primary papers only were searched. Any papers obtained as a result of citation chasing did not have their references searched.

2.2.3 Criteria for inclusion

2.2.3.1 Specification

Minimum criteria for the inclusion of papers in the review were established and selected in collaboration with Prof K.L. Morgan and Dr J.F. Turnbull. These were:-

1) The study must have been conducted within India, Thailand or Vietnam.

2) The intervention must have aimed to have an effect on growth, survival, production or quality of a species of fish or shrimp/prawn, or on disease occurrence, incidence or prevalence.

3) Details of the methods must have been given and a control group must have been used.

4) Statistical analysis must have been carried out.

To be included, a study had to fulfil all the specified criteria. If one or more criteria were not met, the study was excluded. The deadline for inclusion was set as the 17/12/03; all papers not obtained by this date were excluded.

2.2.3.2 Application

All abstracts were assessed independently using the specified criteria by two reviewers; Prof. Morgan and Miss L.E. Barnard. Documents in Thai and Vietnamese were assessed for inclusion by the respective research assistant using the same criteria. Abstracts were either marked as included, excluded or uncertain. The latter did not provide adequate information on which to base a decision. The full papers of 'included' and 'uncertain' abstracts were obtained either electronically from the University of Liverpool electronic journal resources, or by inter-library loan. Once obtained, they were re-assessed independently by the same two reviewers using the same criteria. Any disagreements were discussed and the decision adjusted as necessary.

2.3 RESULTS

2.3.1 Electronic search

2.3.1.1 Database sources

There were no obvious differences in the types of journals indexed by each database. ASFA however contained a much higher number of books, conference proceedings, technical papers and theses.

2.3.1.2 Electronic search strategies

2.3.1.2.1 Synonyms

The list of synonyms of the five keywords totalled 100. Of these, 11 were in the category of ‘aquatic’, 13 in the category of ‘animal’, 37 in the category of ‘health’, 33 in the category of ‘intervention’, and 6 in the category of ‘Asia’, (see appendix 1), inclusive of the keywords themselves.

2.3.1.2.2 Database limitations

Web of Science was subject to a 50-word limit, as search strategies longer than this timed out. The process of truncation resulted in a total of five truncated words within this search strategy. The ASFA database was not subject to any word limit, thus it was possible to apply the same search strategy as Web of Science to this database. CAB Direct was subject to a 26-word limit. As a result of this, different combinations of words from the 50 Web of Science search strategy words were selected and a full search run. BIOSIS was subject to a 35-word limit. Again, the same process as for CAB Direct was carried out to reach a final search strategy using the full search option. The final search strategy selected for Web of Science, comprising 50 words, was:

(aqua* OR fresh* OR marine OR brackishwater OR farm*) AND (fish OR shrimp OR prawn OR crustacean OR fry OR postlarvae OR fingerling*) AND (health OR infection OR pathogen OR bacterial OR parasitic OR virus OR survival OR growth OR reproduction OR production OR disease OR microbe OR fungi OR mortality OR performance OR stress OR status) AND (intervention OR vaccination OR water OR feed OR nutrition OR polyculture OR monoculture OR genetic OR stocking OR treatment OR immunisation OR therapy OR prophylactic OR trial OR strategy OR bath OR temperature) AND (Thailand OR Vietnam OR India* OR Asia)

This search was run on 03/04/03. This search strategy was also applied to the ASFA database on 28/04/03. The search strategy used on CAB Direct was:

(aqua* OR fresh* OR marine OR brackishwater OR farm*) AND (fish OR shrimp OR prawn OR fingerling*) AND (survival OR growth OR production OR disease OR mortality OR performance) AND (vaccination OR feed OR polyculture OR monoculture OR stocking OR immunisation OR treatment OR temperature) AND (Thailand OR Vietnam OR India*)

This search was run on 30/04/03. The search strategy used on BIOSIS was also run on 30/04/03 and was:

(aqua* OR fresh* OR marine OR brackishwater OR farm*) AND (fish OR shrimp OR prawn OR crustacean OR fry OR postlarvae OR fingerling*) AND (health OR infection OR pathogen OR survival OR growth OR reproduction OR production OR disease OR mortality OR performance OR stress OR status) AND (genetic OR monoculture OR feed OR polyculture OR stocking OR immunisation OR treatment OR temperature) AND (Thailand OR Vietnam OR India*)

2.3.1.3 Electronic search results

2.3.1.3.1 Papers included

The ASFA database identified the largest number of studies, (473), followed by CAB Direct with 245 and BIOSIS with 225. Web of Science identified the least studies, (198). The overall number of studies identified was 1141, (Table 1).

Table 1. Number of papers unique to each database and identified in multiple databases.

Database	**Number of papers**				
	Total	**Unique**	**In 2 databases**	**In 3 databases**	**In 4 databases**
WoS	**198**	88	65	23	22
ASFA	**473**	370	62	19	22
CAB	**245**	172	30	21	22
BIOSIS	**225**	133	47	23	22
Total	**1141**	**763**	**204**	**86**	**88**

67% (763/1141) of the papers were unique to one database. ASFA had the highest proportion of studies that were unique to that database, (78%), and Web of Science the lowest, (44%). Removal of duplicates by inter-database comparisons yielded a total of 913 papers. A summary of the numbers removed at each stage is shown in Table 2.

Table 2. Number of duplicated papers removed from each database following each inter-database comparison.

Database	Number of papers				
	Identified by search	Removed after comparison with WoS	Removed after comparison with ASFA	Removed after comparison with CAB	Remaining after removal of duplicates
WoS	198	N/A	N/A	N/A	198
ASFA	473	89	N/A	N/A	384
CAB	245	29	7	11	198
BIOSIS	225	54	11	27	133
Total	**1141**	**172**	**18**	**38**	**913**

2.3.1.3.2 Comparing search strategies

The CAB Direct search strategy had the minimum number of words making it the candidate for a unified search strategy across all databases. Use of this strategy in Web of Science identified 77 (39%) papers identified on the date of the original search. In ASFA 187 (40%), and in BIOSIS, 212 (94%) of the papers were identified. Therefore, if the CAB Direct search strategy had been used on all four databases for maximum consistency, this would have resulted in the loss of 420 papers, (121 from Web of Science, 286 from ASFA and 13 from BIOSIS).

2.3.1.3.3 Assessment of abstracts for inclusion

From a total of 913 abstracts, 89 (10%) were initially selected for inclusion, 649 (71%) for exclusion, and 175 (19%) required the full paper to make a decision, (Table 3).

Table 3. Numbers of studies selected for inclusion and exclusion and those requiring the full paper.

Database	Total abstracts	Included	Excluded	Full paper required	Included after all assessments
WoS	198	21	164	13	20
ASFA	384	12	323	49	20
CAB	198	25	79	94	52
BIOSIS	133	31	83	19	31
Total	**913**	**89**	**649**	**175**	**123**

The most common reasons for exclusion included the study being conducted outside the target countries of India, Thailand and Vietnam, the study just being observational with no intervention, a lack of statistical analysis, no control group, or the paper being a review.

In total, 123 papers from all four databases were selected for inclusion. ASFA had the highest proportion of false positive hits, and CAB Direct had the lowest as shown by a comparison of the proportions of papers from each database included in the final review, (Table 3). CAB Direct was highest with 26%, followed by BIOSIS (23%), Web of Science (10%) and ASFA (5%).

Interestingly, ASFA made up just 16% of the papers finally selected, despite having the highest number of initial papers, (384). CAB Direct made up 42% of the total included papers despite having a much lower initial total of 198. In comparison, BIOSIS made up 25% of the total included papers and Web of Science 16%.

There was huge variation across databases in the number of abstracts that did not provide adequate information, with CAB Direct having the highest proportion of references that required the full paper, (47%). ASFA and BIOSIS had very similar proportions of 13% and 14% respectively, and Web of Science had the lowest with 7%.

2.3.1.3.4 Retrieval of papers

A number of papers were reported by the inter-library loans office to only be available overseas. As this required a foreign application, taking up to six months to arrive, these would not have met the final inclusion date criterion, so the orders were cancelled and the papers excluded from the review. Other papers that did not arrive before the cut-off date were also excluded. Such occurrences explain the lower number of included studies after assessment of all papers for Web of Science compared to the number before all assessments.

2.3.2 Non-electronic searching

2.3.2.1 Conference proceedings

A list of 140 conferences was made using web-based resources. Thirty-five (25%) had a contact email address and seven (5%) had proceedings available online. There were 10 responses to the email request for information on where conference proceedings could be obtained. Some emails failed, implying the addresses were no longer in use. From the initial list of 140 conferences, just five (4%) contributed papers to the final review.

Proceedings from nine conferences were hand searched at the Institute of Aquaculture, Stirling, and 141 papers and abstracts obtained for assessment. Of these, 76, (54%), were abstracts only and 65, (46%), were papers. All the abstracts were automatically excluded from the review, as they did not provide sufficient information for review. Of the 65 papers, 8 (12%) were selected for inclusion. However, four of these papers were duplicates from another part of the search and were excluded, and the other four were not obtained until after the deadline for data extraction and were also excluded. Proceedings from five conferences were obtained from library resources, hand searched and 56 papers obtained for assessment. Of these, 40 (71%) were included and 16 (29%) were excluded.

2.3.2.2 Postgraduate theses

From a total list of 300 titles of PhD and MSc theses at the Institute of Aquaculture, Stirling, 82 (27%) were selected for assessment on the basis of the title only. Following assessment, 9, (11%), MSc theses were selected for inclusion. However, owing to time constraints and the prohibition of photocopying these theses, data extraction could not be carried out and all were excluded from the final review.

2.3.2.3 Hand searching

A total of 24 journals located in the University of Liverpool library, were hand searched for potential studies (see appendix 2). As a result, 53 articles were obtained for assessment and 25 (47%) were selected for inclusion.

2.3.2.4 Citation chasing

A total of 203 references were selected from the reference lists of all primary papers included for review.

Table 4. The source of studies identified by citation chasing, the number obtained and the number included.

Source of study	No. identified	No. obtained	No. included
Inter-library loan	200	105	38
Electronic journal	3	3	0
Total	**203**	**108**	**38**

Three were available online from library electronic resources and 200 were ordered via inter-library loan (Table 4). Of these, 105 (53%) documents were received before the deadline. Of the remaining 95 (47%), 20 (21%) were untraceable references, 45 (47%) required a foreign application and were therefore cancelled, (reported by the inter-library loans office as having no UK locations), 12 (13%) arrived after the deadline for data extraction, 9 (9%) references were incorrect, (as reported by the inter-library loans office as the item having been identified but not containing the specified article), and 9 (9%) were simply not delivered. Following assessment, 38 (35%) were selected for inclusion.

2.3.2.5 Reports from collaborating and associated institutes

2.3.2.5.1 India

Of 111 papers identified, 42 (38%) were from searches of the resources at CIFA (Central Institute of Freshwater Aquaculture) and 69 (62%) from searches in Cochin. Titles and abstracts of these papers were sent electronically to the UK for assessment, following which 40 (36%) papers were selected. Of these, 55% were from CIFA sources and 45% from Cochin sources. However these were selected after the deadline of 17/12/03 and were not included in the final review.

2.3.2.5.2 Thailand

Searches of the literature at AAHRI, Bangkok, Thailand, resulted in a total of 224 potential documents for inclusion from a variety of resources including PhD and MPhil theses, technical papers, journal articles and magazine articles. Again, the titles and abstracts of all these documents were sent electronically to the UK for assessment for inclusion. Following assessment, 66 (29%) were selected for inclusion and a data extraction form was sent to Dr Somsiri for completion for each selected study (see chapter 4). Of these, 37 (56%) were returned via email, but due to some studies having missing information, a total of 26 were finally selected for inclusion.

2.3.2.5.3 Vietnam

From RIA II, Vietnam, 32 potential studies were obtained. As the abstracts of these papers were in Vietnamese, Mr Vuong assessed these studies for inclusion in the review. Following this, two (6%) were selected for inclusion, but as the information for the data extraction stage was received after the deadline, these studies were excluded.

At Can Tho University, Vietnam, a manual search of documents at 9 institutes and universities identified a total of 98 potential papers for inclusion. However, owing to time constraints and the need for translation of most of the papers, there was not enough time to assess them and extract the necessary data, thus they were excluded.

2.3.2.6 Documents obtained in response to the questionnaire

A total of 73 documents were received of which 2, (3%), were selected for inclusion.

Full details will be reported in chapter 3.

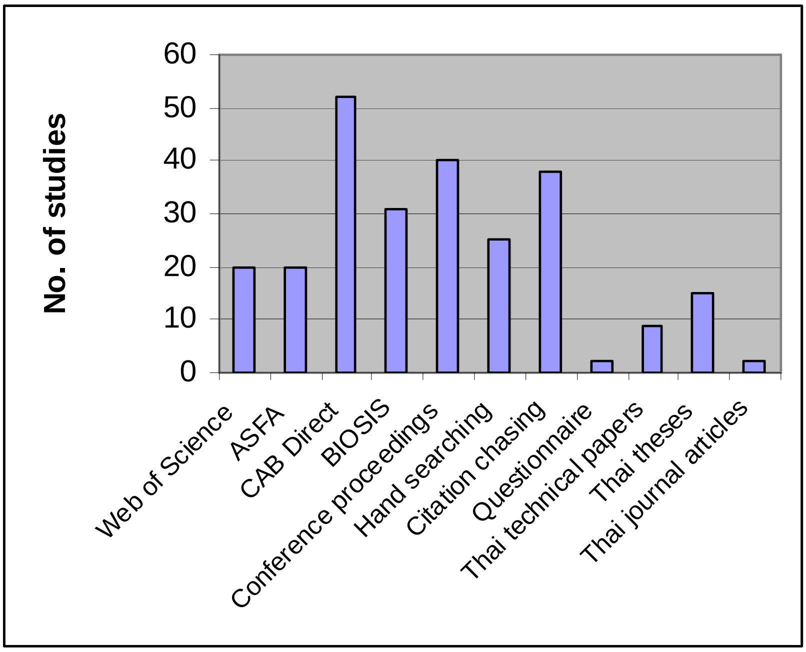
2.3.3 Time limitations and document retrieval

Across all sources searched a total of 161 studies were excluded because they were not obtained before the cut-off date. Sixty-three of these (39%) were papers that had been selected for inclusion. Of these, forty (63%) were documents hand searched at collaborating and associated research institutes in India, two (3%) from the same institutes in Vietnam, 12 (19%) from papers ordered by inter-library loan from citation chasing, and 9 (14%) from papers ordered by inter-library loan from the electronic database search results. A further 98 papers (61%) from hand searches in Vietnam were excluded before the assessment stage due to time constraints.

2.3.4 Summary of study sources

A total of 254 of 1651 potential studies identified, (15%), were selected for inclusion in the review. Of these, 123 (48%) were from electronic sources and 131 (52%) from non-electronic sources, (Figure 2.1).

Fig. 2.1. Distribution of included studies from the different sources searched.



CAB Direct contributed the highest proportion of studies to the final review, (20%). This was followed by conference proceedings, citation chasing and hand searching of journals, (16%, 15% and 10% respectively). The Web of Science and ASFA electronic databases contributed an equal proportion of 8% each. Studies identified from theses, technical papers and journal articles in Thailand sources, and those obtained from responses to the letter and questionnaire contributed the least to the final number of studies included, at 6%, 4%, 1% and 1% respectively.

2.4 DISCUSSION

This is the first systematic review to be carried out in the field of aquatic animal health. Although the review was confined to reports from 3 countries for a 10-year period, the process has revealed a number of constraints to the successful application of the Cochrane approach (Clarke and Oxman, 2002) to reviews of aquatic animal health in Asia.

The 10-year period covered by this review was within that of all the electronic databases yet over 50% of the papers included in the review came from reports identified by other means. This has several important implications. It is possible that classical peer reviewed research in aquaculture in Asia and, in particular, developing countries contributes less to the industry than other methods e.g. on-farm trial and error. Hence more research may exist on the form of company reports and technical papers. Ineffective dissemination of research and 'societal indifference to research', as highlighted in other countries, (Mohammed, 1995), may also have had an effect. The rapid development of the aquaculture industry in the three target countries may have taken the emphasis away from research output and dissemination to the optimisation of the quality, production and export potential of the species being produced. A study by Abdullah, (1995), showed that Southeast Asian countries showed a tendency to depend on knowledge provided from publications from the UK and America, and that the lack of dissemination of research from countries within this continent may hinder important industrialisation in all areas of development. Confidentiality and competitiveness between producers may contribute to this further.

Despite the abundance of literature in the non-electronic form, there were a number of technical problems involved in identifying and obtaining these documents. Many of the conferences identified did not have contact email addresses to which to send a request for information, nor a website on which proceedings were available online. As a result, many proceedings and consequently potential studies may have been missed.

It should be noted however, that the initial list of conferences included a number that were held outside the target countries of India, Thailand and Vietnam and many that were ambiguous in terms of the subjects covered. It was unclear as to whether or not any relevant research within the target countries had been presented, but these conferences were still added to the list. It is possible that only a small proportion of these conferences may have had any relevance to this review. The location of these conferences and the small proportion of available proceedings having full papers rather than abstracts supports this. If this were the case, the proportion of relevant studies not identified by the search may have been small. A means of improving this situation would be to create a depository for all conference proceedings in aquaculture libraries in each country, (perhaps multiple ones for larger countries), where a complete resource would be readily available for searching. If this information were also available in electronic form for the individual depositories, electronic searching would further improve the efficiency of identifying relevant proceedings. This would reduce the time taken to search for and identify relevant studies from months to days.

The reference lists of primary studies produced a large number of studies that were untraceable by the inter-library loans office or which required a foreign application. Reading the reference lists of primary studies was time consuming and the high proportion of untraceable or unobtainable references reduced the overall efficiency of the review process. It may also have resulted in the exclusion of a substantial number of potentially relevant studies.

Possible reasons for references being untraceable may include incorrect citation or the source of the reference not being indexed in the resources searched by or available to the inter-library loans office. In the latter case, this indicates the need to improve dissemination routes of research findings or to increase the sources indexed by information centres, libraries and databases. Incorrect citation of references may have implications for the assessment of studies for quality. Study quality is sometimes assessed by the citation rate of papers either solely or in conjunction with other measures, (Walter et al, 2003; Healy and Catell, 2003). If studies were incorrectly cited, this would reduce the extent to which they were referenced by later studies and could result in a misrepresentation of their quality.

There were also problems in the collection of papers identified by collaborating research institutes. The research assistants in the target countries carried out assessment for inclusion of foreign language papers and this may have introduced a source of bias. The ideal method would have been to translate all documents in a foreign language into English and email them to the UK so that the same two reviewers carried out all assessments. However, it would be difficult to allocate time to translation before the number of foreign language studies selected for inclusion was known. This method was therefore not possible and the method used was the most efficient in minimising the time delay.

Time itself proved another important constraint to the review process. Retrieval of some papers, conference proceedings and postgraduate theses was time consuming and many fell outside the inclusion time limit. Where reviews are conducted under strict time constraints, obtaining foreign applications may be beyond the scope of the review. This indicates the need to improve the dissemination of research outputs and make the necessary resources available in more countries. This may require increasing or changing the formats in which the research is presented. If the method of inter-library loan were used in a future review, a minimum time period of six months would be required to obtain foreign applications.

Similarly, for sources hand searched in each of the target countries, time restrictions limited the number of institutes searched, this being especially the case in India. To allocate time to this method, consideration of the number of institutes, the distance between them and the number of people available to carry out the search would have to be taken. The time lag between receiving the abstracts or titles of collected papers from each research assistant, assessing them for inclusion and requesting the relevant information will have added to the delay.

Of the studies that could be obtained, the most common initial retrieval was the abstract. Some of these provided insufficient information to make a reliable assessment for inclusion. The high proportion of these ambiguous abstracts and their use in a preliminary screening procedure for systematic reviews has important implications for their structure and content. If abstracts do not provide information on, for example, the study design, statistics and outcome measures, (depending on the specific criteria), they may be excluded from the review, despite having this information in the full paper.

Abstracts may also misrepresent the study design, outcomes and results. Specific problems of abstract quality have been previously reported. These include differences between data and figures quoted in the abstract and those in the main paper, information in the abstract that is not present in the paper, (Pitkin et al, 1999), and the omission of important results or conclusions from the abstract that are present in the paper, (Winker, 1999). Pitkin et al, (1999) found that 18% to 68% of abstracts had problems relating to the former two issues in 44 papers from five journals. Therefore, it appears that the problem of deficient information from abstracts identified in this review is a general problem that needs to be addressed in order to facilitate the systematic review process.

A possible means of standardising abstracts or improving the quality of them would be if peer-reviewed journals provided abstract templates to authors to ensure adequate information was included. Systematic reviews conducted by the Cochrane Collaboration for example, all have abstracts structured in the same format. They are divided into sections on the background to the review, the objectives, the search strategy used to identify papers and the criteria by which they are selected, details of the collection and analysis of data and the main results of the review, and overall conclusions, (Cochrane Colloboration, 2004). A study by Pitkin and Branagan, (1998) tested the effect of providing instructions regarding the accuracy of abstracts to authors of papers under revision on the resulting abstract accuracy. The results indicated that this intervention had no effect. In response to this and other research conducted on the issue of abstract quality, the editors of the Journal of the American Medical Association implemented a set of quality criteria for assessing abstracts of submitted papers, which resulted in the improvement of abstract quality via the elimination of discrepancies between the abstract and the main body of the article, (Winker, 1999). In addition, a study by Taddio et al, (1994), comparing nonstructured and structured abstracts, found a significantly higher mean quality score in those abstracts that were structured. Alternatively, or in addition to this, it may be useful if there were general guidelines for abstract writing available to authors in an easily accessible format.

In addition to the problem of abstract quality, general restrictions in the use of electronic databases were identified. Although electronic databases greatly facilitate the retrieval of relevant scientific information, this review highlighted the importance of using more than one database and of the lack of standardisation of search strategies across databases.

The lack of overlap in search results and the high proportion of unique studies in each database highlighted the importance of using different databases in this study. A similar result was found in a study by Hirst et al, (2002), when searching the databases ISI Web of Science, MEDLINE PubMed, CAB Abstracts and BIOSIS Previews in a systematic review of literature on cattle lameness. This lack of overlap, in the present study may be a result of the different search strategies used. However, as the search strategies only differed by a few words, this variation is much higher than expected. Differences in the journals indexed in each database could not account for this. ASFA on the other hand, has many additional resources indexed, i.e. conference proceedings, books and technical reports for example, compared to primarily journals for the other databases. This may account for the high proportion of abstracts not being repeated in the other databases and the high overall number of abstracts from ASFA.

To be consistent, the most desirable method would have been to apply the same search strategy to all four databases. However it became apparent that some databases could not compute search strategies that were too complex, e.g. search strategies containing more words than the maximum allowance, or with too many truncated words were timed-out and couldn't be processed in Web of Science search engine.

The inability of some databases to process complex search strategies has been found in other recent studies, (Murphy et al, 2003), highlighting this as a general limitation of electronic databases. This was not just a reflection of the word limit on each database, because even when the word limit was adhered to some of the more complex search strategies were still not processed. This has significant implications for the ability to develop standardised search strategies and may result in a failure to identify all relevant studies. The use of a single search strategy, although it would have improved the consistency and comparability of search results, would have resulted in the loss of a large proportion of potentially useful papers. This problem could be resolved by simply expanding the word limits on scientific databases to allow for the use of more lengthy or complex search strategies. Also, some of the papers identified when the different search strategies were used on each database differed from those identified by the original strategy. This has implications for the effectiveness of a single strategy in identifying all of the potentially relevant papers.

Overall, this review has highlighted the need to not only search multiple electronic databases in reviews in aquaculture but also to carry out an extensive search of the non-electronic literature. Such sources make a considerable contribution to the wealth of existing research, however the amount of time involved in identifying and obtaining these studies may be unpredictable and it is important to allocate a proportion of time to this process. Creating depositories for conference proceedings on a country-by-country basis, improving the dissemination of other non-electronic literature sources and increasing the word allowances on electronic databases to facilitate the standardisation of complex search strategies would all improve the efficiency of the systematic review process in aquatic animal health.

CHAPTER 3. RESPONSE TO THE LETTER AND QUESTIONNAIRE: RESPONSE RATES, DOCUMENTS AND THE EFFECT OF REPLY COUPONS

3.1 INTRODUCTION

One of the challenges of the systematic review process is to obtain information that is unpublished or not in circulation. In some systematic reviews private companies and research institutes operating in the area relevant to the review specifications are approached. This is usually in the form of a letter or postal questionnaire, (Cave et al, 2003; Lee et al, 2003; Oakley-Browne et al, 2003).

Questionnaires are widely used in epidemiological studies as a cost effective means of obtaining data on exposure variables thought to be associated with disease or other conditions, (Correa et al, 1994; Wood et al, 1998; Erdogan et al, 2001). In the UK, it is standard procedure to provide a stamped addressed envelope for return postage of completed questionnaires, a procedure shown to be effective in increasing response rates, (Edwards et al, 2002). Sending reminder cards and duplicate questionnaires is also common practice, (Doherr et al, 1998). Obtaining a high response rate is important not only for obtaining enough data but also to achieve representative and valid results, (Cetinkaya et al, 1997).

The emergence of new diseases, increased international transport and the development of a global economy have focused attention on an international approach to investigating these factors, (Diamond, 2003).

The use of ‘international questionnaires’, (i.e. those dispatched to multiple countries), is a potential option for obtaining epidemiological data but presents a number of practical difficulties, e.g. language. Furthermore, methods such as the provision of stamped addressed envelopes to maximise the response rate are hampered by the difference in postage rates and stamps for the respective countries.

In an attempt to overcome this, the Universal Postal Union (UPU) have created an ‘International Reply Coupon’, available from most large post offices in the UK and other member countries of the UPU. These coupons can be purchased individually for £0.60p (EUR 0.85, $1.05), and used for full or part-payment of postage at any post office worldwide, with the exception of Taiwan, (which is not a member of the UPU). The UPU was founded in 1874 and currently has 189 member countries. The international reply coupon was introduced in 1906, with the main users being developed countries, (Universal Postal Union, 2004). As a member country of the UPU, all post offices must accept these coupons, but it is not an obligation to sell them, (Universal Postal Union, 2004).

In this chapter the process of potentially identifying sources of unpublished data and obtaining relevant studies from previously unsearched research institutes, universities and commercial companies located within the target countries is described. In addition, the effect of providing an international reply coupon on the response rate to a trans-national questionnaire was also tested.

3.2 MATERIALS AND METHODS

3.2.1 Study design

A randomised controlled trial was carried out to test the effect of an international reply coupon on the response rate to a trans-national questionnaire designed to obtain unpublished data on interventions aiming to influence aquatic animal health.

3.2.2 Target population

All research institutes, universities and commercial feed, seed, equipment and pharmaceutical companies, government organisations, (GOs), and non-government organisations, (NGOs), which might be carrying out relevant research in the target countries of India, Thailand and Vietnam were potential participants in this study. Universities and research institutes outside the target countries with a known interest in aquatic animal health, and which may have conducted research in one or more of the target countries, were also included. A list of names and addresses of target institutions was obtained in collaboration with the University of Stirling, UK, (Miss Penny Beaton), the Aquatic Animal Health Research Institute (AAHRI), Thailand, (Dr. Temdoung Somsiri), the Research Institute for Aquaculture Number 2 (RIA II), Vietnam, (Mr DQT Vuong), Can Tho University, Vietnam, (Miss TT Dung), and the College of Fisheries, Mangalore, India, (Mr Deepak Kumar Nayak and Mr Prakish Patel).

All of the contacts names and postal addresses were entered into a spreadsheet (Excel, Microsoft).

3.2.3 Letter and questionnaire

A letter and short questionnaire were sent to each of the organisations, (see appendix 3). The aim of the letter was to describe the purpose of the review and request any relevant non-electronic literature, including proceedings of meetings or conferences, MSc/MPhil/PhD theses or articles.

The aim of the questionnaire was to identify which organisations were involved in aquatic animal health research, on which species they conduct research and in which area of aquatic animal health they were active. Additional questions included the country in which research was conducted, where it was published, if potential information or documents existed and whether they were willing to provide this information. All questions asked were multiple-choice for quick completion.

Letters and questionnaires sent to India and to organisations outside the target countries were in the English language. Those sent to Thailand and Vietnam were translated. This involved a process of initial translation, independent back-translation into English, and further refinement to ensure consistency in their content.

The letter and questionnaire was translated into Thai by Dr Temduong Somisiri at AAHRI, back-translated by Miss Jatuporn Bundit at the Institute of Aquaculture, University of Stirling, and refined by Dr Somsiri. For Vietnamese, translation was done by Mr Binh at Can Tho University, and back-translated and refined by Flavio and Tram Corsin.

A one-month deadline for returning questionnaires and/or documents was given.

To investigate the effect of providing an international reply coupon the list of contact organisations was stratified by country and randomly assigned (using random number tables) to those that would receive a coupon and those that would not. One coupon was provided for each selected contact together with instructions on how to use them. The coupon itself did not have Thai and Vietnamese translations of the instructions. To control for the addition of a separate Thai and Vietnamese instruction sheet, the selected Indian and international organisations received an English version of instructions, despite these being on the coupon, (see appendix 4). The instructions were translated, back-translated and refined using the process described previously.

Organisations names, addresses and whether or not they had been selected for receipt of an international reply coupon were entered into an Excel (Microsoft) spreadsheet.

When dispatching the letters and questionnaires, the addresses were entered on to each using Microsoft Mail Merge to enable identification of the source of returned questionnaires and any documents sent with them.

Organisations were offered three methods of returning documents and questionnaires to encourage maximum compliance; fax, scan and email, or posting in a pre-addressed envelope enclosed with the letter. A standard A4 envelope was used to send out the letter and questionnaire but Tyvek envelopes, (Tyvek®), were included for the reply to allow for the posting of bulky or large numbers of documents. All envelopes were sent by airmail, apart from those sent to UK contacts.

Two weeks after the first mailing, a postcard-sized reminder was sent to all contacts that hadn't yet responded. This reminder card was pale blue in colour to attract attention. The text was short, in the appropriate language, and simply requested that contacts returned the questionnaires and/or documents as soon as possible if they hadn't done so already, (see appendix 5).

Two weeks later a second set of letters and questionnaires was dispatched to all contacts that hadn't responded. This included a second set of international reply coupons where applicable. A deadline of one month for their return was again given.

3.2.4 Data handling

An Excel (Microsoft) spreadsheet was used to record the list of names and addresses of the target organisations, the international reply coupon information, the date of dispatch of the original letter and questionnaire, the reminder card and the second letter and questionnaire if sent. The type and number of returned documents was also recorded.

Email contact was recorded and responded to. Any queries that couldn't be dealt with were forwarded to collaborators at the Institute of Aquaculture, Stirling, (Dr. J.F. Turnbull and Dr. M. Crumlish).

A separate spreadsheet (Excel, Microsoft) was used to record data from the questionnaire. Hard copies of all questionnaires, documents and email responses were stored.

3.2.5 Assessment of documents for inclusion

All documents received were assessed by the same two reviewers using the same procedure described previously.

3.2.6 Statistical analysis

Between country differences in response rates were compared using chi-squared analysis.

.

3.3 RESULTS

3.3.1 Number and distribution of organisations identified

The total number of research institutes, universities, commercial companies, GOs and NGOs identified was 346. There were 86 (25%) in India, 186 (54%) in Thailand, 34 (10%) in Vietnam, and 58 (17%) in 12 other countries.

3.3.2 Response rate

Of 346 letters and questionnaires dispatched, 70 were returned, giving a response rate of 20%. Of the 70 replies, 67 (96%) were returned by airmail in the return envelope provided, one by email and two by fax. Organisations in Vietnam gave the highest response rate (35%) and those in Thailand the lowest, (17%), however there was no statistical difference between the response rate in any of the countries, (X^2 = 6.010, 3 df, p = 0.111), (Table 5). Overall Thai organisations made up the highest proportion of respondents with 41% (29/70) of the total.

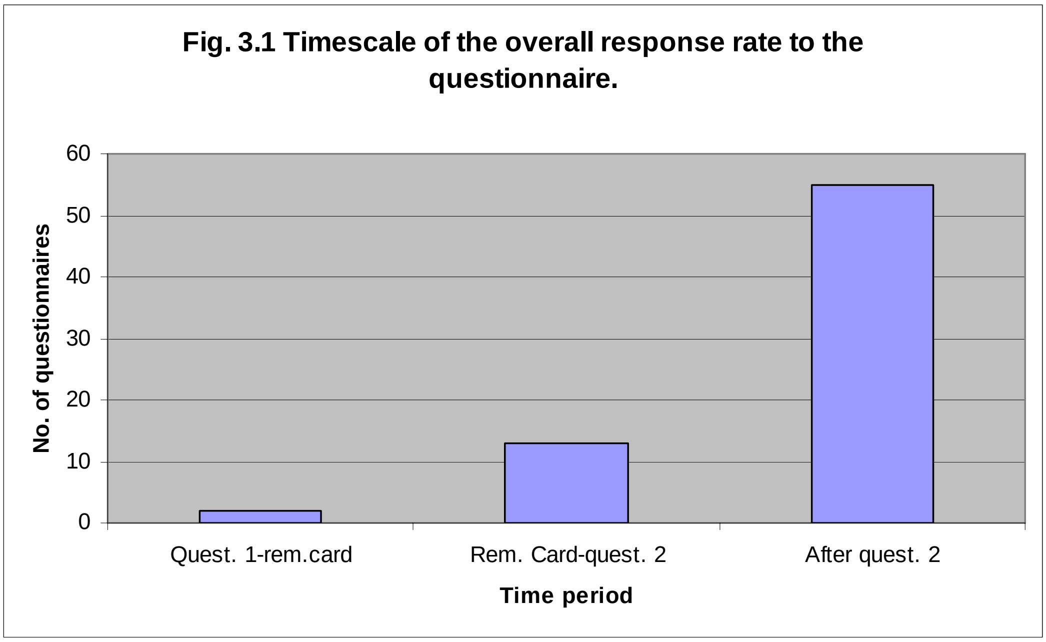
Table 5. Response rates of contacts to the questionnaire, stratified by country.

Country	**Response rate (No. replies/no. sent)**			
	Overall	**Companies**	**Research institutes**	**NGOs and GOs**
India	21 (16/86)	14 (6/42)	20 (8/41)	67 (2/3)
Thailand	17 (29/168)	13 (19/150)	56 (10/18)	0
Vietnam	35 (12/34)	38 (9/24)	30 (3/10)	0
Other	22 (13/58)	0	24 (8/34)	21 (5/24)
Total	**20 (70/346)**	**16 (34/216)**	**28 (29/103)**	**26 (7/27)**

Stratifying by organisation, the highest response rate was from research institutes, (28%), and the lowest from commercial companies, (16%), (Table 3). In India, NGOs and GOs had the highest response rate, (67%) and companies the lowest, (14%), whereas in Thailand, research institutes gave the highest response rate, (56%). In Vietnam, the response rate of companies was slightly higher than for research institutes, and for contacts from other countries response rates were similar between research institutes and NGOs and GOs.

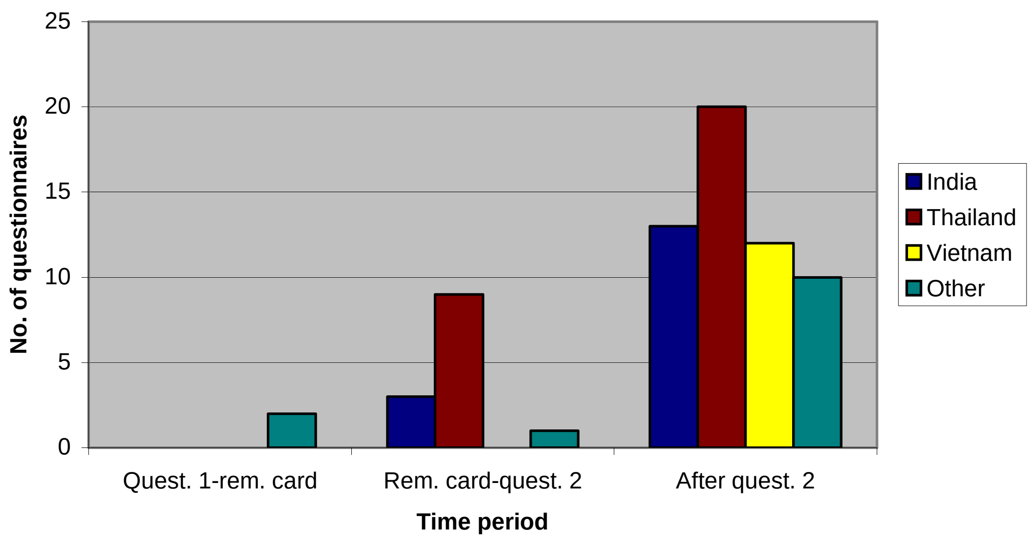
3.3.3 Timescale of responses

With the exception of 'other countries', the number of returned questionnaires increased over time. This was monitored over three time periods:- first mailing to reminder card mailing, mailing the reminder card to mailing the second questionnaire, and the period after the second questionnaire was dispatched, (Figure 3.1).



The first completed questionnaires were received four days after the first mailing. These were from organisations outside the target countries. At the time the reminder card was sent out, no replies had been received from India, Thailand or Vietnam, (Figure 3.2). The overall response rate at this stage was 1%, (2/346). The first response from a target country was from Thailand at 14 days, followed by Vietnam at 30 days and India at 33 days. A small proportion of completed questionnaires, (19%, 13/70), were received between the reminder card and second questionnaire, with the exception of Vietnam, but the majority, (79%, 55/70), arrived after dispatching the second questionnaire.

Fig. 3.2 Timescale of questionnaire responses, stratified by country.



There were differences between countries in the time-span between sending out the first questionnaire and receiving the last completed questionnaire. It was shortest for Vietnam, (50 days), followed by other countries, (66 days). India had the second longest time-span of 70 days but Thailand had a much longer delay of 150 days owing to one questionnaire arriving one month after the previous questionnaire.

The timescale between receipt of the first and last completed questionnaires also showed variation between countries. Questionnaires from Vietnam were received over the shortest time period of 21 days, followed by India at 42 days, countries outside the targets at 62 days and finally Thailand at 93 days, again having the longest time period.

3.3.4 Effect of international reply coupons on response rate

Overall there was no difference in the response rate of organisations that had received an international reply coupon, (20%, 34/173), compared to those who had not, (21%; 36/173), (X^2 = 1.498, 3 df, p = 0.683). There was no statistical difference between the response of individual countries, although the response rate was slightly higher from Thai organisations that had not received a reply coupon, (Table 6). For ‘other countries’ this trend was reversed.

Table 6. Effect of an international reply coupon on the overall and country specific response rate.

Country	Response rate %		
	Overall	**With reply coupon**	**Without replay coupon**
India	21 (16/86)	19 (8/43)	19 (8/43)
Thailand	17 (29/168)	14 (12/84)	20 (17/84)
Vietnam	35 (12/34)	35 (6/17)	35 (6/17)
Other	22 (13/58)	28 (8/29)	17 (5/29)
Total	**20 (70/346)**	**20 (34/173)**	**21 (36/173)**

3.3.5 Documents received

Of the 70 respondents, 25 (36%) enclosed one or more documents. The overall number of documents received was 73, (Table 7). These included journal articles, synopses of theses, magazine and newspaper articles, company reports and posters and were sent by companies, research institutes and GOs or NGOs. There were differences between countries in the proportion of respondents that returned documents, (X^2 = 12.903, 3 df, p = 0.005), with 75% (12/16) from India, 14% (4/29) from Thailand, 34% (4/12) from Vietnam, and 38% (5/13) from outside countries. Just over half of the documents received, (51%, 37/73), were from India and 34%, (25/73), were from countries other than India, Thailand and Vietnam.

Table 7. Numbers of documents sent in response to the letter and questionnaire from different countries.

Country	Overall total number (%)		
	Respondents	Returning documents	Documents returned
India	16 (21%)	12 (75%)	37
Thailand	29 (17%)	4 (14%)	6
Vietnam	12 (35%)	4 (34%)	5
Other	13 (22%)	5 (38%)	25
Total	**70 (20%)**	**25 (36%)**	**73**

More companies and research assistants sent documents, (Table 8). None were received from government and non-government organisations within the target countries.

Two thirds of the documents (66%) were from research institutes and 69% (33/48) of these were from the target countries, the highest proportion being from India. Commercial companies contributed 20.5% of documents, with 77% (37/48) of these from India only. NGOs and GOs contributed 13.5% of documents and all of these were from outside the target countries.

Table 8. Numbers of documents sent in response to the letter and questionnaire from different groups of organisations, stratified by country.

Country	No. responses from companies			No. responses from research institutes			No. responses from NGOs and GOs		
	Overall	With documents	Docu-ments	Overall	With documents	Docu-ments	Overall	With documents	Docu-ments
India	6	6	8/37	8	6	29/37	2	0	0/37
Thailand	19	2	2/6	10	2	4/6	0	0	0/6
Vietnam	9	4	5/5	3	0	0/5	0	0	0/5
Other	0	0	0/25	8	2	15/25	5	3	10/25
Total	**34**	**12**	**15/73**	**29**	**10**	**48/73**	**7**	**3**	**10/73**

3.3.6 Effect of international reply coupons on document return

The inclusion of a postage reply coupon had no effect on the proportion of respondents returning documents. 5% (9/173) of contacts sent a postage reply coupon returned documents compared to 9% (16/173) that did not receive one. Although the response to the return of documents was slightly higher in the group that did not receive a coupon, this difference was not statistically significant, ($p>0.05$). Of all respondents that sent documents with their completed questionnaires, 9 (36%) had been provided with a coupon and 16 (64%) had not. Stratifying by country, there was little variation between countries in the proportion that had and had not received a coupon, and chi-squared analysis showed no significant difference between countries in the number of respondents that sent documents and had received a coupon, (X^2 = 0.844, 3 df, $p = 0.839$).

3.3.7 Questionnaire responses

3.3.7.1 Proportion of respondents conducting research on aquatic animal health

Sixty-nine of the 70 respondents indicated whether they were involved in aquatic animal health research. All respondents from India and Vietnam conducted research on aquatic animal health, as did a high proportion of those from Thailand (72%), (Table 9). For the respondents outside the target countries however, the proportion was less than 50%.

Table 9. Numbers and percentages of respondents conducting research on aquatic animal health stratified by country.

Country	Percentage involved in research
India	100 (16/16)
Thailand	72 (21/29)
Vietnam	100 (11/11)
Other	46 (6/13)
Total	**77 (54/69)**

3.3.7.2 Proportion of respondents carrying out field and/or clinical trials

Sixty-three of the 70 respondents indicated whether or not they carried out field and/or clinical trials, of which 84%, (53) said that they did. Responses from each of the target countries were all over 90%, (Table 10).

Table 10. Numbers and percentages of respondents involved in field and/or clinical trials stratified by country.

Country	Percentage involved in field and/or clinical trials
India	94 (15/16)
Thailand	91 (22/24)
Vietnam	91 (10/11)
Other	54 (7/13)
Total	**84 (53/63)**

3.3.7.3 Proportion of respondents possessing potential studies

Almost three-quarters (72%) of the 64 respondents that answered this question indicated that they had information that could be included in this review. Stratifying by country, all Indian respondents indicated that they had information compared to approximately two thirds for both Thailand (61%) and Vietnam (67%), and 58% for other countries, (Table 11).

Table 11. Numbers and percentages of respondents with potential information, stratified by country.

Country	Percentage with information
India	100 (16/16)
Thailand	61 (15/24)
Vietnam	67 (8/12)
Other	58 (7/12)
Total	**72 (46/64)**

3.3.7.4 Proportion of respondents indicating compliance

Fifty-eight of the 70 respondents indicated whether or not they were willing to provide any information for use in this review. Just 2% said that they were not willing. Of the remainder 54% said they were and 44% said they were but some information was confidential, (Table 12). Stratifying by country, Thailand was the only country where any of the respondents indicated they were not willing to provide information, (4%). The rest of the Thai respondents and all from India and Vietnam were split between those that were willing and those with some confidential information. All respondents from other countries said they were willing to provide information without the restriction of confidentiality.

Table 12. Numbers and percentages of respondents indicating their willingness to provide information for use in the review stratified by country.

Country	Percentage willing	Percentage willing (but some confidential)	Percentage not willing
India	47 (8/17)	53 (9/17)	0
Thailand	55 (12/23)	41 (10/23)	4 (1/23)
Vietnam	36 (4/11)	64 (7/11)	0
Other	100 (7/7)	0	0
Total	**54 (31/58)**	**44 (26/58)**	**2 (1/58)**

3.3.7.5 The geographical location of research

Some respondents made multiple responses to this question so the number of responses (76) was higher than the number of respondents. A fairly even proportion of responses indicated that aquatic animal health research was carried out in India (29%) and Thailand (34%), with 20% in Vietnam, (Table 13). The rest of Asia was highlighted in 6.5% of responses and 10.5% of responses indicated that some research was conducted in the rest of the world.

Table 13. Numbers and percentages of responses indicating the area in which research is carried out, stratified by country.

Country	Percentage of research				
	India	Thailand	Vietnam	Rest of Asia	Rest of World
India	100 (16/16)	0	0	0	0
Thailand	0	85 (23/27)	0	7.5 (2/27)	7.5 (2/27)
Vietnam	0	0	92 (12/13)	8 (1/13)	0
Other	30 (6/20)	15 (3/20)	15 (3/20)	10 (2/20)	30 (6/20)
Total	**29 (22/76)**	**34 (26/76)**	**20 (15/76)**	**6.5 (5/76)**	**10.5 (8/76)**

3.3.7.6 Target species of aquatic animal health research

Multiple responses were made to this question so the total (114) far exceeded the number of respondents. Almost half of these responses, (48%, 55/114) indicated that fish were the subject of research, (of which 53% were freshwater species), compared to 37% (42/114) on shrimp and prawns, (Table 14). Research on shellfish, crabs and amphibians formed a small proportion of all responses, (15% combined). Stratifying by country, India showed a similar trend with 49% of responses indicating research on fish and 33% on shrimp. For Thailand and Vietnam the proportion of research on shrimp (48% and 50% respectively), was slightly higher than for fish (41% and 41% respectively). For countries outside the targets a much higher proportion of research was carried out on fish (63%) than on shrimp (17%).

Table 14. Numbers and percentages of responses indicating on what species research is carried out, stratified by country.

Country	Percentage of research				
	Fish				Shrimp/prawns
	Total	Freshwater	Brackishwater	Marine	
India	49 (19/39)	26 (10/39)	13 (5/39)	10 (4/39)	33 (13/39)
Thailand	41 (12/29)	31 (9/29)	7 (2/29)	3 (1/29)	48 (14/29)
Vietnam	41 (9/22)	18 (4/22)	9 (2/22)	14 (3/22)	50 (11/22)
Other	63 (15/24)	25 (6/24)	17 (4/24)	21 (5/24)	17 (4/24)
Total	**48 (55/114)**	**8 (29/114)**	**11 (13/114)**	**11 (13/114)**	**37 (42/114)**

3.3.7.7 Topics of research

Again, some respondents gave multiple responses to this question so a total of 150 responses overall were made. Feed and nutrition were indicated as being the most common types of research in 23% of responses. Water quality and pharmaceuticals followed in 20% and 17% of responses respectively. Research into stocking density, polyculture, water temperature and light and genetics made up a smaller proportion of responses, (Table 15). Stratifying by country, feed and nutrition was the most common type of research in both Thailand and Vietnam, (20% and 38% of responses respectively). For India however, there was a fairly even proportion of research conducted on feed and nutrition (20%), water quality (24%) and pharmaceuticals (22%). For countries outside the targets, feed and nutrition, water quality and polyculture were the most common topics of research, (20%, 20% and 16% respectively).

Table 15. Numbers and percentages of responses indicating the different types of research that are carried out, stratified by country.

Country	Percentage of research							
	Feed and nutrition	**Water quality**	**Pharma-ceuticals**	**Stocking density**	**Polyculture**	**Genetics**	**Temperature and/or light**	**Other**
India	20 (10/49)	24 (12/49)	22 (11/49)	12 (6/49)	8 (4/49)	2 (1/49)	2 (1/49)	8 (4/49)
Thailand	20 (10/50)	14 (7/50)	14 (7/50)	16 (8/50)	2 (1/50)	6 (3/50)	8 (4/50)	20 (10/50)
Vietnam	38 (10/26)	23 (6/26)	23 (6/26)	0	8 (2/26)	0	0	8 (2/26)
Other	20 (5/25)	20 (5/25)	4 (1/25)	8 (2/25)	16 (4/25)	8 (2/25)	8 (2/25)	16 (4/25)
Total	**23 (35/150)**	**20 (30/150)**	**17 (25/150)**	**11 (16/150)**	**7 (11/150)**	**4 (6/150)**	**5 (7/150)**	**13 (20/150)**

3.3.7.8 Methods of research presentation

A total of 122 responses were made to this question as many respondents indicated multiple methods of research presentation. Overall, a fairly even proportion of research was presented in the form of company reports (29%), scientific publications (27%), and proceedings of meetings (24%), (Table 16). Theses were used to a lesser extent, (20%). Stratifying by country, India used scientific publications more frequently (31%) than the other methods which were used to an almost equal extent. For Thailand, scientific publications, theses and proceedings of meetings were all used in 23% of responses, with company reports accounting for the remaining 31%. For Vietnam, 50% of responses indicated the use of company reports to present research with the other forms each used to a lesser extent. Scientific publications and proceedings of meetings were the most common methods used in countries outside the targets, (37% and 30% respectively).

Table 16. Numbers and percentages of responses indicating where research was presented stratified by country.

Country	Percentage of research			
	Scientific publications	**Company reports**	**Proceedings of meetings**	**Theses**
India	31 (11/36)	25 (9/36)	22 (8/36)	22 (8/36)
Thailand	23 (10/43)	31 (13/43)	23 (10/43)	23 (10/43)
Vietnam	12.5 (2/16)	50 (8/16)	25 (4/16)	12.5 (2/16)
Other	37 (10/27)	19 (5/27)	30 (8/27)	15 (4/27)
Total	**27 (33/122)**	**29 (35/122)**	**24 (30/122)**	**20 (24/122)**

3.3.7.9 Assessment of documents for inclusion in the review

Of the 73 documents received, two were selected for inclusion in the review. The most common reasons for exclusion were the absence of a control group, no description of statistical analysis used, or the study being conducted outside India, Thailand and Vietnam, (this was frequently the case with documents from contacts outside these target countries). In addition, one study was terminated before completion resulting in exclusion from the review.

3.4 DISCUSSION

The poor response rate to this letter and questionnaire, despite the use of reminder cards and duplicate questionnaires, indicates that a large amount of research may have been unidentified.

Possible reasons for the poor response rate may have been related to the time taken to complete the questionnaire and search for documents, as requested by the letter. As the questionnaire only consisted of eight multiple-choice questions however, this is unlikely to have been a constraint. In contrast, many responses indicated that information existed but it was not sent with the questionnaire. This suggests that time to search for documents may have reduced the compliance of some contacts.

The difference in the timescale of response rates between the target countries and contacts outside the target countries may be accounted for by the significant delay between posting and receiving items in India, Thailand and Vietnam, (approximately five days each way). This is supported by the fact that the first two responses from contacts outside the target countries were within the UK.

It is unclear from this study whether the reminder cards and duplicate questionnaires had an effect on the response rate, as this may have been a function of time. However, the majority of replies were received after posting the second questionnaire.

Provision of an international reply coupon had no significant effect on the response rate of contacts. There may have been a number of reasons for this. Firstly, there were three reports that the coupons had not been accepted at the local post office. These included users not realising they could not be used to pay for postage over a certain value and post offices not recognising them, (despite being member countries of the UPU).

The actual value of the coupon may have affected response rates. However, each coupon was worth £0.60p in exchange value, equivalent to 45.2 Indian Rupees, 39.0 Thailand Bhat and 15.5 Vietnam Dong, (as on 13/10/03). The postal website for each target country indicated that the cost of sending a 10g letter by airmail to the UK and Europe is 15.0 Indian Rupees, (Indiapost, 2003), 17.0 Thailand Bhat, (Thailand guidebook, 2003), and 10.7 Vietnam Dong, so the coupon was sufficient for at least 20g. This would account for the questionnaire and some documents and is unlikely to have been a limiting factor. The evidence suggested that respondents who did not receive a reply coupon returned more documents although this was not statistically significant.

Those contacts that did not receive an international reply coupon may have been deterred by the lack of provision of payment. Those that did receive a coupon may have required a bigger financial incentive, other than covering postal costs. A number of recent studies indicate the significant effect that monetary incentives had on the response rate to a postal questionnaire, (Roberts et al, 2000; Leung et al, 2002), with lack of payment as a reason for non-response being highlighted elsewhere, (Key et al, 2002). Confidentiality restrictions and competitiveness between producers may have been a more influential factor on response rates, thereby removing any effect of the coupons.

A possible alternative method to the one used in this study may have been to send letters and questionnaires out from a centralised point in each target country, i.e. a collaborating research institute, and returned there also. This would have reduced postage costs both outgoing and for the respondents, however it would demand a high level of coordination to send them out, log the return date and organise reminder cards and duplicate questionnaires. In addition, it would not have been possible to have a centralised point, other than the UK, for contacts outside the target countries.

A very small number of documents overall were received in response to the letter, making inference from statistical analysis difficult. The difference between countries in those that sent documents possibly indicates a difference in compliance of countries in contributing research findings. In this case, India had the highest proportion of respondents that sent documents, followed by Vietnam, suggesting more willingness to comply compared to organisations in Thailand. However, the list of contacts from each country varied in the proportion of organisations that were research institutes, commercial companies and NGOs and GOs. If compliance rates between these types of organisations varied, this would result in a misrepresentation of the difference between the whole countries. Variation in the response rates of the different types of organisations supports this idea, as more research institutes and commercial companies than NGOs and GOs sent documents. This could be explained by the different aims of each organisation type and restrictions regarding confidentiality. Alternatively, subjective assessment of documents may have contributed to the difference between the numbers of documents considered to be relevant from each organisation type.

After assessing the documents for inclusion, 97% were excluded. As a proportion of those excluded were done so for having been conducted outside the target countries or for not being relevant to the review subject, it may have been necessary to make clearer the specifications of the review. However, this high proportion of excluded studies may indicate the need for improvements in the quality of aquatic animal health research being carried out by organisations.

In addition to the low response rate, the identification of institutes to which the letter and questionnaire were sent may have led to unrepresentative results from the questionnaire. For India the list of contacts did not appear to be exhaustive, as highlighted by the list for Thailand having almost double the number of contacts despite being a much smaller country. This suggests that many of the target organisations were not approached for information, both in the form of the questionnaire and for potentially relevant documents. The number of contacts for Vietnam was also small, (34), and also suggests an incomplete list. Possible reasons for this discrepancy between countries may have been the constraint of time in identifying and obtaining names and full postal addresses of all relevant contacts. Alternatively, the use of different sources to identify contacts within each country may have led to differences in the ability to identify and obtain postal addresses. For lists to be complete, this would have required a significant amount of time and extensive searching of a wide range of resources, which would not have been possible for this review. The creation of a searchable international database containing the names and contact addresses of institutes and companies involved in aquaculture would facilitate this task.

The large proportion of respondents that said they were willing to provide information appears to be contradicted by the small number that actually sent documents. The proportion of responses that indicated some information was confidential could account for some of this, however, as only four respondents said they were not willing to provide information, the low number of respondents who actually sent documents is therefore very surprising.

The focus of this review on fish and shrimp in India, Thailand and Vietnam appears to be correct in relation to the important species that are influenced by aquatic animal health problems. The larger number of organisations that conduct research on them reflects this. It also suggests that species of fish and shrimp are of more economic importance compared to the other species, and therefore research on aquatic animal health is more urgent, relevant or more readily funded.

The distribution of research topics indicates a difference in the types of aquatic animal health problems that affect each country. Variation in the proportion of responses from different types of organisations will have affected this to some extent. But it may also be related to the different species that are cultured in each country. Interestingly, the topic of feed and nutrition was the most popular within all countries, suggesting this area of research was considered most important in improving aquaculture production. Water quality and pharmaceuticals were the next most common areas of research, suggesting that these areas receive more funding or are of more interest in the research community compared to other subject areas.

Responses indicate that approximately 75% of research outputs exist in the non-electronic literature in the form of theses, conference proceedings and company reports. This suggests that the amount of research from these sources is under represented in this review.

However only 2 of the 73 studies, (3%), identified in this report were included in the review suggesting that they are of a poorer quality than those identified by other means. For example, the inclusion rate from electronic studies was 14%. Chi-squared analysis showed that this difference was statistically significant, ($X^2 = 7.129$, df = 1, p = 0.008).

Overall a considerable amount of effort and expense went into trying to identify unpublished studies held by commercial companies, research institutes, GOs and NGOs. This resulted in the inclusion of only 2 reports. This process, costing approximately £500, was therefore not cost-effective. Dispatching questionnaires from a centralised point within India, Thailand and Vietnam may have improved the response rate but would require a high degree of coordination and organisation. For 'other countries' it would also not be possible to have a centralised point other than within the UK. Leaving a longer time between first mailing and mailing of the reminder cards and second questionnaires may have been more effective by providing more time for contacts to search for documents. An international searchable database of names and addresses of relevant organisations involved in aquatic animal heath and aquaculture would significantly reduce the time taken to create the initial list of contacts and would provide a more complete list. If this process were to be repeated, a time allowance of approximately 4 to 5 months would be required. This would allow for one month between mailings, a one-month deadline after dispatch of the last questionnaire, and a two-week period for assessment of documents. If the method of dispatching questionnaires from a centralised point were used, an extra month may be required to arrange transportation of documents to the UK for assessment.

CHAPTER 4. TOPICS OF RESEARCH, SOURCES OF STUDIES, AND THE TEMPORAL AND GEOGRAPHICAL DISTRIBUTION

4.1 INTRODUCTION

In carrying out this systematic review to test the hypothesis that:- Aquatic animal health interventions have had no significant effect on levels of aquaculture production in India, Thailand and Vietnam, we retrieved 254 papers for inclusion in the review. As part of the review protocol, potential interventions were grouped into 7 broad categories. These were water quality, light or photoperiod, polyculture, stocking density, genetic interventions, feed and nutrition and disease.

One approach to dealing with heterogeneous studies that is commonly used to analyse results in Cochrane systematic reviews is sub-group analyses. This involves breaking the studies down into particular categories, e.g. by disease status, to make the results used in a meta-analysis more comparable. As highlighted in the Cochrane Handbook however, (Clarke and Oxman, 2002(c)), conclusions drawn from this type of analysis must be tentative as there may be differences between studies, other than the factor on which their grouping has been based, which may account for variation in results.

Additional approaches used to deal with heterogeneity include omitting certain studies, e.g. of a low quality or different study design, or using a random effects approach, where a single variance is used to represent heterogeneity, (Clarke and

Oxman, 2002(c)). Many studies utilising the systematic review process have used these methods, (Volmink et al, 1996; Apelberg et al, 2001; Petti, 2003).

For this review, allocation of studies to one of the specified categories acts as a form of sub-grouping, making comparisons between studies more meaningful. The aim of this chapter is to present information about the distribution of studies included in this review by target countries, years of publication and the specified areas of research.

4.2 MATERIALS AND METHODS

4.2.1 Definition of categories of intervention

Seven broad categories of intervention were defined in consultation with the collaborators in this review. These were:-

***Water quality*:** This category included a wide variety of manipulations to water quality including:-

i) Levels of suspended solids and waste.

ii) Heavy metals, biocides, pesticides, terrestrial agrochemicals and organic compounds.

iii) The use of aquatic fertilisers.

iv) Temperature, pH and salinity levels.

Stocking density: The number of animals per unit volume of water or per tank or pond for example.

Feeding trials: A wide range of factors need to be taken into consideration when optimising a feeding regime. This category included:-

i) Optimising the FCR (feed conversion ratio).

ii) Altering the method, frequency, timing and distribution of feed.

iii) Changing the size and sinking rate of the feed.

iv) Changing the type of feed altogether.

v) The balance of dietary constituents, e.g. levels or ratios of protein, vitamins, minerals, lipids and other nutrients.

Diseases: Interventions to disease can take a variety of forms. These can include immunisations, drug trials, the provision of immunostimulants, or any other intervention that will reduce the incidence, occurrence or prevalence of a particular disease, infection or condition. A list of fish and shrimp/prawn diseases that are currently prevalent within India, Thailand and Vietnam, (as of 2003), from data from OIE (Office International des Epizooties), (OIE, 2004(a)), can be found in the appendix, (6). All identified diseases will be considered as a target of intervention in this review.

Genetics: Interventions in this category included cross breeding as well as sex-reversal techniques.

Polyculture: This included stocking of different species of fish or shrimp together as well as fish and shrimp combined. It also included stocking of different developmental stages of the same species.

Light: As well as photoperiod manipulation, (i.e. the duration of exposure to light), this category also included the alteration of shading provided and the light intensity.

4.2.2 Data extraction

A data extraction form was prepared and used to classify papers and characterise the study design, the type of statistical analysis, the outcome measures and main results, (see appendix 7). Where possible, tick boxes were used to reduce the length of time taken to complete each form. The title, authors, source, (i.e. electronic, conference proceedings, questionnaire, hand searching etc.), year of publication and species used were also recorded.

Study design information included the number and description of comparators or treatments (including the control), the number of replicates, the type (e.g. tanks) and total number of units, the number of animals, and their developmental stage.

Data on statistical analysis required a specification of how the results were presented, (i.e. means with standard deviations etc.), whether or not analysis of variance had been carried out and what other forms, if any, of statistical analysis had been used.

Outcome measures were listed, with tick boxes for the most common measures, and the units of measure recorded. For each of the common measures used, the maximum value observed, regardless of whether or not it was significant, was recorded in a table along with the comparator number with which it was obtained. This allowed the identification of any trends. Finally, any recording of water quality and sediment parameters was noted.

4.2.3 Data recording

Once each form was completed the data were entered into tables, stratified by topic. Three tables were created for each topic. The first contained information on the study design, presentation of results and statistical analysis. The second contained information on the type, number and units of measure of each comparator. The third table contained the maximum values of each of the most common outcome measures used, the comparator with which it was recorded, and a list of the other additional measures used.

4.2.4 Documents identified from collaborating and associated institutes

It was not possible to complete the data extraction forms in the UK for the documents identified by the research assistants in India, Thailand and Vietnam. Time restrictions limited their translation and transmission. As all the documents collected in Vietnam were in Vietnamese, forms for assessment for inclusion were emailed to the collaborating research assistants for completion and return. The Thai and Indian abstracts were in English, thus each was assessed by the two UK reviewers. Research assistants in all three countries were then sent a copy of the data extraction form along with notes for guidance on its completion. They were asked to complete a form in English for each study selected for inclusion and return them by email before 17/12/03. This provided similar information as that for each paper identified from the searches conducted within the UK.

4.3 RESULTS

4.3.1 Data extraction and collation

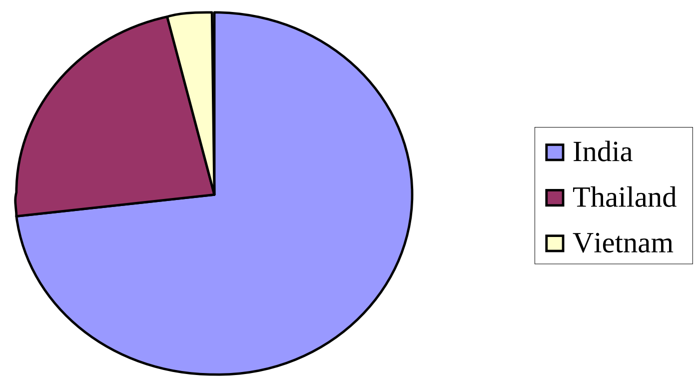
4.3.1.1 Extracting data

Details on the study design proved difficult to decipher in a large proportion (27%) of studies. This was resolved by discussion between the two assessors. The most common problems were establishing the number of replicates, the total number of units and animals used, and details of the comparators. If discussion resulted in an agreeable value for the ambiguous information, this was entered into the form and consequently the table. If an agreement could not be reached, ‘unclear’ was entered into both the form and table.

4.3.1.2 Countries of origin of study

The country of origin was specified for 253 (99.6%) studies. There was a striking difference between the number of studies conducted within each target country, with 73% from India, 23% from Thailand and 4% from Vietnam, (Figure 4.1).

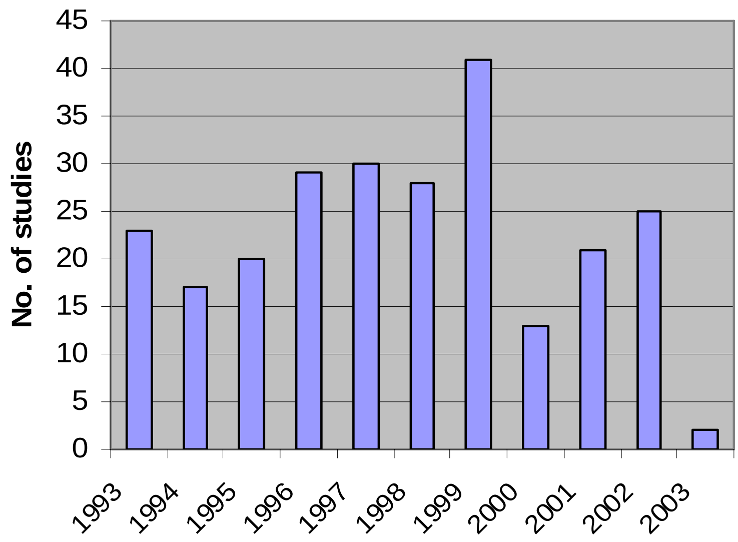
Fig. 4.1. Geographical distribution of included studies



4.3.1.3 Years of publication

The year of publication was obtained for 249 (98%) studies. The distribution by year is shown in figure 4.2. The average number of studies conducted in each target year of publication was 23, ranging from 2 in 2003 to 41 in 1999.

Fig. 4.2. The year of publication of studies selected for inclusion.



There were slightly fewer publications in 1994 in comparison to the middle of the 10-year period in 1996-9. Overall it appears that there has been a sustained amount of research on aquatic animal health in the target countries over this selected time period.

4.3.1.4 Study topics

Of 254 studies included in the review, 224 (88%) fell into a single category and 30 (12%) fell into more than one category, (Table 17). Where studies were allocated to multiple categories, the appropriate information from each study was entered into each category table, therefore the results were used more than once. Of these papers, 29 (97%) were allocated to 2 different categories and 1 (3%) to 3 categories. The total number of data sets used was therefore 285.

Table 17. Numbers of studies in each general topic category, both single and multiple.

No. studies	Single category only	Multiple categories	Total
Feed and nutrition	115	23	**138**
Water quality	36	12	**48**
Stocking density	11	10	**21**
Disease	9	12	**21**
Polyculture	7	3	**10**
Genetics	2	1	**3**
Light	3	0	**3**
Other	32	9	**41**
Total	**224**	**30**	**254**

The feed and nutrition category had the highest number of studies, (138; 48% (138/285)), indicating that this has been the most active area of research in India, Thailand and Vietnam in the past ten years. This was followed by water quality (48;

17% (48/285)). Stocking density and disease both contained an equal number of studies (21; 7% each (21/285)), with polyculture containing slightly fewer (10; 4% (10/285)). Finally, genetics and light contained the fewest studies, with three each.

The proportion of studies that fell within a single category varied between topics. Feed and nutrition and water quality had the highest proportion with 83% and 75% respectively. Stocking density and disease had the lowest with 52% and 43% respectively.

Of the multiple category studies, the most common combination of topics was feed and nutrition and other, (8, 27%), followed by feed and nutrition and either disease or stocking density, (5; 17%). The remaining combinations occurred less frequently and are summarised in Table 18.

Table 18. Topic categories of studies selected for inclusion that fell into more than one category.

Reference	Feed and nutrition	Water Quality	Stocking density	Disease	Poly-culture	Genetics	Light	Other
Basavaraja et al, 1997(a)	*							*
Basavaraja et al, 1997(b)	*							*
Jayaprakas and Sindhu, 1996	*							*
Murugesan et al, 1998	*							*
Sambhu and Jayaprakas, 1997(a)	*							*
Sambhu and Jayaprakas, 1997(b)	*							*
Sehgal and Saxena, 1997	*							*
Sobhnana and Nandeesha, 1994	*							*
Chucherd, 1995	*			*				
Kamertmanee, 1997	*			*				
Sahoo and Mukherjee, 2002(a)	*			*				
Sahoo and Mukherjee, 2002(b)	*			*				
Sahoo and Mukherjee, 1999	*			*				
Anh and Son, ?	*		*					
Keshavanth et al, 2001	*		*					
Mohanty, 2001(a)	*		*					
Mohanty, 2001(b)	*		*					
Sampath and Raj, 1995	*		*					
Dhawan and Kaur, 2002	*	*						
James and Chandrakala Vadivu, 2000	*	*						
Venkadesh and Palavesam, 1999	*	*						
Vijayakumaran, 1999	*	*						
Balasubramanaian and Bai, 1996		*	*					
Saha et al, 1997		*	*					
Sasikumar and Vadhyar, 1999		*	*					
Yi and Kwei Lin, 2001		*	*					
Basavaraju et al, 2002					*	*		
Kwei Lin and Diana, 1995			*		*			
Yi et al, 2003		*			*			
Ruangpanich and Boonliptanon, 1993	*	*						*

4.3.1.5 Countries of origin of study topics

In India and Thailand the most frequent topic of research was feed and nutrition, (62% and 40% respectively), (Table 19). The proportion of studies categorised as water quality or ‘other’ was similar in both countries. Interestingly the proportion of studies on disease research in Thailand, (19%), was nearly four times that in India (5%). Stocking density showed a similar pattern. The proportion of studies from Thailand in this category (12%) was nearly twice that from India (7%).

Table 19. Numbers of studies in each topic category conducted in each target country.

Topic	India	Thailand	Vietnam	Unknown	Total
Feed and nutrition	114	23	1	0	**138**
Water quality	37	12	0	0	**48**
Stocking density	13	7	1	0	**21**
Disease	10	11	0	0	**21**
Polyculture	5	3	1	1	**10**
Genetics	2	1	0	0	**3**
Light	2	1	0	0	**3**
Other	26	7	8	0	**41**
Total	**185**	**58**	**10**	**1**	**254**

The proportion of studies on polyculture, light and genetics was very small in both Thailand and India. In Vietnam the majority of studies (80%) were on topics outside those specified, with one study on polyculture and one on the multiple topics of feed and nutrition and stocking density. Chi-squared analysis showed a significant difference ($p<0.05$) between countries in the proportion of studies conducted on feed and nutrition and on ‘other’ subject areas. There was no significant difference ($p>0.05$) between countries in the remaining topic categories.

4.3.1.6 Year of publication of study topics

The number of reports for each topic appears to have been sustained over the last decade, with no sharp increases or decreases, (Table 20).

Table 20. Numbers of studies from each topic category conducted in each target year of publication.

Topic	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Unknown	Total
Feed and nutrition	17	7	11	14	21	17	21	4	12	11	1	2	**138**
Water quality	3	6	2	8	5	3	10	2	3	4	1	1	**48**
Stocking density	0	1	2	5	3	0	2	2	4	1	0	1	**21**
Disease	0	2	4	1	1	1	4	2	1	3	0	2	**21**
Polyculture	1	0	1	0	0	2	1	0	0	4	1	0	**10**
Genetics	0	0	1	0	0	1	0	0	0	1	0	0	**3**
Light	1	0	1	0	0	0	1	0	0	0	0	0	**3**
Other	3	2	1	3	6	6	7	3	4	6	0	0	**41**
Total	**23**	**17**	**20**	**29**	**30**	**28**	**41**	**13**	**21**	**25**	**2**	**5**	**254**

The only slight variations have been on the subject of feed and nutrition, which appears to have had a slight increase in the number of studies carried out in the middle of the 10-year period, (43% from1997-9). The small sample sizes of polyculture, genetics and light however make it difficult to see any trend for these subjects.

4.3.1.7 Information sources of study topics

Stratifying by topic category there was some variation in the information source of the studies, (Table 21). For feed and nutrition, stocking density and ‘other’ the distribution of studies obtained from electronic and non-electronic sources was fairly equal, (50%, 57% and 47% of studies from electronic sources respectively). For polyculture the majority (90%) were from electronic databases. A higher proportion of studies on water quality, disease, genetics and light interventions however came from non-electronic sources, (65%, 62%, 67% and 67% respectively).

Table 21. Numbers of studies from each topic category identified from each source searched.

Topic	Number of studies										
	Web of Science	**ASFA**	**CAB**	**BIOSIS**	**Conf-erence proc-eedings**	**Hand searching – Journal article**	**Citation chasing**	**Quest-ionnaire documents**	**Thai Technical papers**	**Thai Theses**	**Thai Journal articles**	**Total**
Feed and nutrition	7	9	37	16	24	15	17	0	6	5	2	**138**
Water quality	1	6	7	3	7	5	12	0	3	4	0	**48**
Stocking density	2	2	4	4	5	1	2	0	1	0	0	**21**
Disease	1	1	2	4	2	0	3	2	0	6	0	**21**
Polyculture	3	1	1	4	1	0	0	0	0	0	0	**10**
Genetics	1	0	0	0	0	0	2	0	0	0	0	**3**
Light	0	0	1	0	1	0	0	0	0	1	0	**3**
Other	8	3	5	4	6	7	6	0	1	1	0	**41**
Total	**20**	**20**	**52**	**31**	**40**	**25**	**38**	**2**	**9**	**15**	**2**	**254**

There were no major differences between the number of studies identified by each electronic database on the topics of stocking density, disease, polyculture, genetics and light. However, over half, (54%), of feed and nutrition studies identified from electronic sources were from CAB Direct, with over three quarters (76%) of water quality studies coming from CAB Direct and ASFA. For studies on other subject areas, 45% were from Web of Science.

Each topic area showed more variation in the numbers of studies from non-electronic sources. For feed and nutrition a high proportion of non-electronic studies were from conference proceedings (35%), citation chasing (25%) and hand searching of journal articles (22%).

Of the 31 studies on water quality that were from non-electronic sources, 39% were identified by citation chasing and 23% were from conference proceedings, with hand searching of journal articles, Thai theses and technical papers all contributing a fairly even number.

For stocking density studies, over half (56%) of those from non-electronic sources were from conference proceedings, with the remainder being from citation chasing, hand searching of journal articles and Thai technical papers. A fairly even number of studies on disease were from conference proceedings, citation chasing and documents obtained in response to the questionnaire, however 46% of non-electronic studies were from Thai theses.

4.3.1.8 Sources and years of publication

Overall, there appears to be no specific trend for the majority of sources in the years of publication of the studies obtained, (Table 22).

Table 22. Numbers of studies from each target year of publication identified from each source searched.

Study source	Number of studies										
	Web of Science	**ASFA**	**CAB**	**BIOSIS**	**Conf-erence proc-eedings**	**Hand searching – Journal article**	**Citation chasing**	**Quest-ionnaire documents**	**Thai Technical paper**	**Thai Theses**	**Thai Journal article**	**Total**
1993	0	3	1	0	9	7	0	0	3	0	0	**23**
1994	0	1	0	2	0	0	8	0	1	5	0	**17**
1995	1	2	2	1	2	3	5	0	1	3	0	**20**
1996	1	1	8	4	4	3	3	0	3	2	0	**29**
1997	0	1	11	5	0	6	5	0	0	2	0	**30**
1998	1	3	16	2	1	0	4	0	0	1	0	**28**
1999	1	2	7	1	21	2	7	0	0	0	0	**41**
2000	2	3	2	2	0	0	2	0	0	2	0	**13**
2001	6	2	3	6	0	0	3	0	1	0	0	**21**
2002	8	2	2	7	0	4	1	0	0	0	1	**25**
2003	0	0	0	1	0	0	0	0	0	0	1	**2**
Unknown	0	0	0	0	3	0	0	2	0	0	0	**5**
Total	**20**	**20**	**52**	**31**	**40**	**25**	**38**	**2**	**9**	**15**	**2**	**254**

A few exceptions to this trend do become apparent however. CAB Direct shows a noticeable peak in the number of included studies in the middle of the decade, particularly 1997 and 1998. A very high number of studies obtained from conference proceedings (53%) were from 1999, following which there were none. In addition, Web of Science showed a slight peak in the last few years, (70% from 2001-2), and the theses from Thailand showed an opposite trend with more studies being from the beginning of the target decade, (80% from 1994-7).

4.3.1.9 Sources and countries of study

Each target country differed in the proportion of studies included from each source searched, (Table 23).

Table 23. Numbers of studies conducted in each target country identified from each source searched.

Country of study	Web of Science	ASFA	CAB	BIOSIS	Conf-erence proc-eedings	Hand searching – Journal article	Citation chasing	Quest-ionnaire documents	Thai Tech-nical paper	Thai Theses	Thai Journal article	Total
India	8	19	50	24	31	21	32	0	0	0	0	**185**
Thailand	4	0	1	7	8	4	6	2	9	15	2	**58**
Vietnam	7	1	1	0	1	0	0	0	0	0	0	**10**
Unknown	1	0	0	0	0	0	0	0	0	0	0	**1**
Total	**20**	**20**	**52**	**31**	**40**	**25**	**38**	**2**	**9**	**15**	**2**	**254**

For India, 55% of studies were from electronic sources. CAB Direct contributed the highest proportion, followed by BIOSIS, ASFA and finally Web of Science. Of the non-electronic sources, an even proportion of studies were from conference proceedings and citation chasing, with slightly fewer from hand searching of journal articles.

In contrast to India, just 21% of studies from Thailand were obtained from electronic sources. Of the electronic databases, BIOSIS contributed the highest number of studies, followed by Web of Science and CAB Direct. ASFA did not contribute any studies. Thai theses made the highest contribution of studies from the search of non-electronic sources (33%), with the other sources ranging from 2 (4%) to 9 (20%).

Vietnam showed a different pattern. With the exception of one study (from conference proceedings), all included studies were identified by electronic databases, the majority of which were from the Web of Science.

4.3.1.10 Countries of study and years of publication

There was variation between the three target countries in the distribution of included studies by year, (Table 24).

Table 24. Numbers of studies from each target year of publication conducted in each of the target countries.

Year of study	India	Thailand	Vietnam	Total
1993	16	7	0	**23**
1994	7	10	0	**17**
1995	11	9	0	**20**
1996	18	11	0	**29**
1997	27	3	0	**30**
1998	25	2	1	**28**
1999	38	2	1	**41**
2000	8	3	2	**13**
2001	14	5	2	**21**
2002	20	2	3	**25**
2003	0	2	0	**2**
Unknown	2	2	1	**5**
Total	**185**	**58**	**10**	**254**

In India, data suggest that research on aquatic animal health was highest in the middle of the study period, (1997-99). In Thailand, a higher number were conducted at the beginning of the 10-year study period, between 1993 and 1996, with a decreased but fairly even proportion in the following years. An opposite trend occurred in Vietnam.

4.4 DISCUSSION

There were geographical differences between the number of studies included from each of the target countries, with 73% from India, 23% from Thailand and 4% from

Vietnam. Insufficient time to complete the search may have accounted for this variation. Although many sources within Vietnam and India were hand searched at collaborating and associated research institutes, there was insufficient time to extract the relevant data from studies selected for inclusion in the review. Without this time restriction fewer studies from Vietnam particularly may have been excluded. The number of studies included from the electronic search only, which was not constrained by time, indicates that 82% of studies were from India, 10% from Thailand and 8% from Vietnam. This suggests that the ranking of the countries would have been the same, but numerically the inclusion of hand searched studies within Thailand may have affected the geographical distribution of studies.

Alternatively, this difference between the target countries could be the result of real differences in their size, wealth and aquaculture industries. One explanation for the results is that India is a bigger country both physically and in population size, compared to Thailand and Vietnam. However, looking at the absolute wealth of each of the target countries, (World Bank, 2003(a),(b),(c)), the gross domestic product (GDP) per capita, (an indication of the wealth of the country), of Thailand is considerably greater than that of India and Vietnam. In proportional terms however, Vietnam has experienced the biggest growth, with a 196.6% increase in GDP per capita from 1992 to 2002. A summary of this information is shown in Table 25.

Furthermore, in 1992 and 2002, there appears to be no relationship between the number of papers published and the GDP per capita. Ratios varied from 0.00097 in Thailand in 2002 to 0.057 in India in 1992. This ratio has remained constant in India in spite of a 72.7% increase in GDP per capita, whereas in Thailand it has fallen from 0.0036 to 0.00097.

Table 25. The wealth and economic status of India, Thailand and Vietnam in 1992 and 2002.

Data from World Bank, (2003(a),(b),(c)) and Geographic.com (2004(a),(b)).

Country	1992			2002			% growth ($000 GDP/capita)
	GDP $Billions	GDP /capita $000	Papers/$ capita GDP*	GDP $Billions	GDP /capita $000	Papers/$ capita GDP*	
India	244.2	0.282	0.057	510.2	0.487	0.041	72.7
Thailand	111.5	1.963	0.0036	126.4	2.052	0.00097	4.5
Vietnam	9.9	0.147	0	35.1	0.436	0.0069	196.6

*Figures calculated from the number of studies in each country from 1993.

The decrease in research output from Thailand may be partly attributable to the fall in exports that occurred as a result of the detection of high levels of antibiotic residues in shrimp stocks in 2002, (Food Market Exchange, 2003).

Interestingly, the percentage contribution of agriculture to the GDP of each country has shown a different trend. For all three countries this value has decreased between 1992 and 2002. This suggests that the amount of research would decrease as a consequence of the diminishing importance of this industry in monetary terms. But, the percentage contribution of agriculture for India and Thailand has remained much higher than for Vietnam at both ends of the 10-year period. Vietnam, whose aquaculture industry is still in its developing stages, might have had less money to allocate to aquaculture research in the past 10 years compared to Thailand and India. Research councils or other funding bodies may have allocated their resources to areas that make up a higher proportion of GDP. The overall wealth and structure of the economy in each country therefore doesn’t explain fully the variation in aquatic animal health research.

Another explanation for the difference between countries is that research conducted within India may be more widely distributed, available and accessible. Between-country differences were found in the types of sources used, supporting this suggestion. However, these results could be biased by the inclusion of studies collected by research assistants in Thailand. Those from India and Vietnam were excluded due to time constraints. In Vietnam, research outputs were generally published in peer-reviewed scientific journals which are subsequently made available online. This is encouraging in that Vietnamese research is becoming accessible to a wider number of users.

There was considerable variation in the topics of aquatic animal health studied. Feed and nutrition was the subject with the greatest number of reports, (48%), followed by water quality, (16%). Other subjects had relatively few studies. However, this distribution may not necessarily reflect the true situation. When compared to the results obtained from the aquatic animal health questionnaire, (see chapter 3), feed and nutrition was highlighted as the area of research in just 23% of responses. However the questionnaire results may have provided an unrepresentative sample due to the low response rate.

Possible reasons for the high amount of feed and nutrition research may be that the growth of the aquaculture industry has necessitated a wider variety of feeds or feeds more appropriate for particular species. In addition, cost effectiveness is a very important aspect of aquaculture practice and there may be demand for low cost feed. Feed and nutrition can influence the susceptibility of animals to disease so its optimisation may be preferable to the development of disease treatments.

The most surprising outcome is the relative lack of research on disease. A wide range of diseases are currently present in the target countries, thus the assumption would be that research efforts would focus on identifying appropriate treatment and prevention strategies. With just 21 studies identified, 7 of which studied additional factors, there appears to be a great need for more research in this area.

The number of studies in this review that fit into multiple topics highlights the complexity of aquatic animal health. Many factors can simultaneously have an effect on aquaculture production and aquatic animal health and this has implications for intervention studies.

In this review, the topics of feed and nutrition and disease were frequently studied together. This association between nutrition and disease has been investigated in other areas of aquaculture and agriculture, (Prince et al, 1995; Edwards, 2000; Galyean et al, 1999), highlighting it as a recognised problem. Feed and nutrition was also studied in conjunction with several other topics, such as stocking density and water quality, indicating its widespread effects in combination with other variables.

There were between-country differences in the types of research carried out. Feed and nutrition, water quality and polyculture appear to be of more importance or interest in India compared to Thailand and Vietnam, whereas the proportion of studies that were in the categories stocking density, disease and genetics was greater in Thailand than in India. Thailand is the biggest exporter of aquaculture products and the influence of international regulations regarding the transportation and disease status of aquatic animals may be greater than the other two countries. Increased revenue from exports may also allow for more research on disease, and the research on stocking density may be an attempt to intensify the production of valuable cash crops.

One surprising trend was the distribution of disease studies by year. It might be assumed that the increase in disease problems over the past decade, (Flegel and Alday-Sanz, 1998; Kasornchandra et al, 1998; Shariff, 1998), might have prompted more research, in particular on species of great economic importance. However, the amount of research has remained almost constant. The cost of developing and testing new treatments and vaccines, in comparison to research on other topics, may have been a possible reason for this. Alternatively, organisations that fund aquatic animal health research might perceive the cost-benefit ratio of other topics of intervention e.g. feed and nutrition to be higher.

The low number of disease studies obtained from conference proceedings is also surprising. The rise in disease problems within the target countries over the past few years would be expected to attract interest from conference organisers, as conferences tend to present research on up to date and current problems and issues of importance. However, some research on disease presented at conferences will have subsequently been published in peer-reviewed journals and therefore counted as being from electronic sources.

The data suggest that the strategy required to search for studies will be dependent on the topic of interest. Studies on feed and nutrition were obtained from all sources, apart from questionnaire documents, suggesting that all types of organisations carry out such research. A high proportion of selected studies were from CAB Direct. There is no obvious reason for this, other than the fact that CAB Direct might index sources that are more relevant to this topic compared to the other databases. Over half of the studies, (52%), were from non-electronic sources, the highest being from conference proceedings, indicating this to be a popular avenue for presenting this type of research.

Of the studies on water quality, just 35% were from electronic databases. This could indicate that journals indexed on these databases accept only a small proportion of studies on this subject, possibly for reasons associated with interest to the reader, relevance to the journal, or the findings of the research. For example, studies have provided conflicting evidence that papers finding a negative effect or no effect at all of an intervention would be less likely to be accepted for publication (Hojat et al, 2003; Abbot and Ernst, 1998). This explanation however, could also be applied to any of the other topics.

The problems of data extraction from some papers associated with e.g. absence or ambiguity of descriptions of the interventions used, the number of replicates and animals reinforce the observations of Estrada et al, (2000). In assessing the validity of published studies they also found that basic information on the methods used were not given either in the abstract or the main paper. This highlights a need to improve the reporting of the design of studies. This is a particularly important issue for systematic reviews, where an assessment of the quality of studies is usually made using some form of quality score. These scores are sometimes used to weight the results of studies in statistical analysis, (Clarke and Oxman, 2002(b)). Incomplete reporting of studies may result in a misrepresentation of their quality and therefore the efficacy of the treatment being tested.

In conclusion, in this review India produced the greatest number of studies on a wide range of aquatic animal health topics. In contrast there were relatively few from Vietnam, with Thailand somewhere in between. The number of studies overall has remained fairly consistent over the last 10 years, but there has been relatively little on the subject of disease. This highlights an important area for the focus of future research efforts. To improve the availability and accessibility of studies, a greater proportion on all subject areas need to be made available on electronic databases. In addition, there needs to be improvements in the reporting of studies, in particular on the study design, to enable reproduction and increase their reliability and validity.

CHAPTER 5. FEED AND NUTRITION: SPECIES, INTERVENTIONS AND OUTCOME MEASURES

5.1 INTRODUCTION

Feed and nutrition play a central role in the health of all animals, and aquatic species are no exception. Manipulation of nutrients can improve growth rate, influence immunocompetence and affect susceptibility to disease. Deficiencies of nutrients can also limit growth and in some cases they are associated with specific diseases, for example vitamin deficiencies, (Fisher et al, 1996; Wahli et al, 1998; Puangkaew et al, 2004).

A vast range of factors are involved in the feed and nutrition of aquatic species. Some of these include the specific formulation of feeds, the feeding schedule, the use of growth promoters and the effects of toxins. Consequently feed and nutrition research of aquatic animals has received a large amount of interest on a global scale, (Boonyaratpalin, 1997; Kasumyan and Doving, 2003; Manning et al, 2003).

The importance of nutrition and growth in aquaculture production has led to an increase in the number of commercial organisations involved in the development and production of feeds for aquatic species in Asia, (Hasan, 2001). This industry is therefore a very important source of GDP (Gross Domestic Product) in each country. With feeds and fertilisers accounting for 60% to 80% of production costs of aquaculture, (Hasan, 2001), it is important that the feeding regime is correct and that the nutritional requirements of the species are met.

Problems involved in feed and nutrition research revolve around the production of different species. Each species will have specific requirements, limiting the use of a standard feed for all species. Hasan, (2001), presents the range of dietary protein, energy and amino acid requirements of different fish species. Also, species are farmed at different stages of development so nutrition of the individual species will depend heavily upon what is to be optimised. For example if animals are farmed at an early stage optimising growth might be the aim. However, if animals are farmed at a more mature stage the focus may be on optimising survival and immunocompetence. Age-dependent effects have also been documented in nutrient utilisation in fish, (Kolkovski, 2001), with alterations in the digestive tract from larvae to juveniles requiring diets of different formulation.

The aim of this chapter is to present information about the range of intervention trials that have been conducted on the different areas of feed and nutrition. It will also identify in which countries research has been more active and on what species. Information about the types of outcome measures used will also be given.

5.2 MATERIALS AND METHODS

Studies allocated to this category were sub-categorised within the topic of feed and nutrition. If they fitted into more than one sub-category, information from the study was used separately for both.

5.3 RESULTS

5.3.1 Numbers of studies

There were 138 papers on feed and nutrition, four of which fitted into two subcategories, giving a total of 142 studies across all subcategories, (Table 26).

Table 26. Subcategories of feed and nutrition studies, stratified by country.

Subcategory		India	Thailand	Vietnam	Total
Feed formulation	Variation in quantities of ingredients	43	7	0	**50**
	Variation in type of ingredients or feeds	25	6	1	**32**
Vitamins and amino acids		23	5	0	**28**
Feeding regime		9	1	0	**10**
Hormones		8	0	0	**8**
Growth promoters		3	1	0	**4**
Toxic ingredients and feeds		3	0	0	**3**
Substrates		2	1	0	**3**
Other		2	2	0	**4**
Total		**118**	**23**	**1**	**142**

Studies that reported differences in feed formulation were the most common subcategory (58%; 82/142). Quantitative changes in food components accounted for 61% (50/82) of these and the remainder involved qualitative changes in ingredients or types of food. Studies on the use of vitamins and amino acids were also common, accounting for 20% of the reports. The effects of feeding regimes, in-feed hormones, growth promoters, toxic ingredients and the use of substrates formed a minor component of the reports.

Most of the reports (83%) came from India. There was only one report from Vietnam, with the remainder from Thailand. Chi-squared analysis showed no significant difference, ($p>0.05$), between the distribution of studies in each subcategory from India and Thailand.

5.3.2 Species of study

A total of 40 species were used as the target for study. This included 33 species of fish and seven species of shrimp and prawn. Over three-quarters of nutritional interventions involved fish (80%; 114/142), (Table 27). The major species used were carp, tilapia, and catfish. The most common group was carp, (Catla, rohu, mrigal, common carp, silver carp and grass carp), (71 studies; 50% of all studies; 62% of fish studies), compared to much smaller and approximately equal numbers for tilapia, (Nile and Mozambique), and catfish, (*Clarias batrachus, Clarias gariepinus, Heteropneutes fossilis, Mystus keletius, Ompok bimaculatus* and the hybrid catfish *Clarias macrocephalus* X *C. gariepinus)*. Species that did not fit into these groups were allocated to an 'other' category and included 25 studies across all sub-categories.

Table 27. Subcategories of feed and nutrition studies stratified by fish and shrimp species.

Subcategory		Number of studies								Total species
		Total Fish	**Carp**	**Tilapia**	**Catfish**	**Other spp.**	**Total Prawn**	**Penaeus**	**Macro-brachium**	
Feed formulation	Variation in quantities of ingredients	**40**	27	1	3	9	**10**	7	3	**21**
	Variation in type of ingredients or feeds	**21**	12	0	2	7	**11**	8	3	**22**
Vitamins and amino acids		**26**	15	3	4	4	**2**	1	1	**13**
Feeding regime		**8**	5	1	1	1	**2**	2	0	**8**
Hormones		**8**	6	0	0	2	**0**	0	0	**4**
Growth promoters		**3**	3	0	0	0	**1**	0	1	**4**
Toxic ingredients or feeds		**3**	2	1	0	0	**0**	0	0	**3**
Substrates		**3**	1	1	0	2	**0**	0	0	**3**
Other		**2**	0	2	0	0	**2**	0	2	**3**
Total		**114**	**71**	**9**	**10**	**25**	**28**	**18**	**10**	**40**

Shrimp or prawns were used in 28 (20%) studies. Of these, 18 (64%) used *Penaeus* spp. compared to 10 (36%) using *Macrobrachium* spp.

5.3.3 Outcome measures

The outcomes used can be broadly classified into those related to total yield, (i.e. total harvest weight, gross yield and net yield), growth, (i.e. mean weight at harvest, mean weight gain, mean daily weight gain and specific growth rate), and survival or mortality, (Table 28). Feed conversion ratio (FCR) was an additional measure.

Table 28. Numbers of feed and nutrition studies using different outcome measures, stratified by sub-topic.

Outcome measure	Number of studies								
	Variation in quantities of ingredients	Variation in type of ingredients or feeds	Vits + amino acids	Feeding regime	Hormones	Growth promoters	Toxic ingredients or feeds	Sub-strates	Other	Total
Total harvest weight	3	2	1	3	1	0	0	0	1	**11**
Mean harvest weight	38	18	21	8	8	3	3	3	4	**106**
Mean weight gain	35	13	23	2	5	1	3	0	1	**83**
Mean daily weight gain	10	10	3	3	0	0	3	0	4	**33**
Specific growth rate	29	11	18	4	4	4	1	1	1	**73**
Gross yield	0	1	0	2	0	0	0	1	1	**5**
Net yield	1	1	0	5	0	0	0	3	1	**11**
Survival.	32	20	24	7	7	2	2	3	3	**100**
FCR	32	15	16	7	1	1	3	1	1	**77**
Other	49	25	22	10	7	3	3	0	4	**123**

Mean harvest weight and survival were the most common measures used across all feed and nutrition studies, in 106 (75%) and 100 (70%) studies respectively. Although less commonly used than these two measures, mean weight gain, FCR and specific growth rate were all fairly even, with 83 (58%), 77 (54%) and 73 (51%) studies respectively. The main production measures of total harvest weight, gross production and net production were least commonly used, with 11 (8%), 5 (4%) and 11 studies (8%) respectively. A high proportion of studies, 123 (87%) used additional outcomes that did not fit into these categories and were insufficient in number to form new categories, (e.g. blood parameters and body condition measures).

5.3.4 Details of comparators

5.3.4.1 Feed formulation

Studies in this sub-category were broadly classified into variation in the quantities of ingredients and variation in the type of ingredients or feeds.

5.3.4.1.1 Variation in quantities of ingredients

Species: Forty (80%) studies used one or more species of fish and the remainder used shrimp. Carp, (rohu, mrigal, common carp, grass carp, catla and the medium carp, (*Osteobrama belangeri*)), were used in 68% of fish studies, (27/40). One study was conducted on the Nile tilapia, and one each on the hybrid catfish, (*Clarias macrocephalus X C. gariepinus*), *Clarias gariepinus* and *Ompok bimaculatus.* The remaining 9 (23%) fish studies were targeted at the sea bass, mullet, mahseer, *Channa striata*, *Channa punctatus*, red snapper and barramundi.

Of the 10 (20%) studies that used prawns or shrimp, 7, (70%), were either *Penaeus monodon* or *Penaeus indicus*, and 3, (30%), either *Macrobrachium rosenbergii* or *Macrobrachium malcolmsonii*.

Interventions: A total of 9 (23%) fish studies investigated the effects of increasing the percentage incorporation of the macronutrients, protein, lipid or carbohydrate, (Jafri and Jafri, 1995; Jafri et al, 1995; Sakthivel and Baskaran, 1995; Gangadhara et al, 1997; Samantaray and Mohanty, 1999; Venkadesh and Palavesam, 1999; Marimuthu and Sukumaran, 2001; Satpathy et al, 2001; Pongmaneerat et al, 2002). A further 4 (10%) studies looked at, energy (expressed in calories), (Hassan and Jafri, 1996;

Chawpaknum and Bowonsupakijkul, 2001), n-3HUFA (highly unsaturated fatty acids), (Wattanakowat et al, 1993), or potassium chloride, (Saxena and Talwar, 1996).

Three (8%) studies varied the ratios of various ingredients or parameters, including the carbohydrate: lipid ratio and the ratio between a reference diet and coconut oil cake, linseed oil cake or karanja oil, (Saha and Ray, 1993; Jantrarotai et al, 1994; Jafri and Jafri, 1998).

The remaining 24 (60%) studies all involved the manipulation of the quantities of a specific ingredient or ingredients, inlcuding salseed meal, (a product of the nuts of the Asian Sal tree), *Spirulina platensis*, (a microalgae), silkworm pupa and sardine oil. Of the shrimp studies, 3 (25%), looked at the effects of altering the percentage of lipid, protein or carbohydrate, (Ali, 1993; Ali, 1996; Shivaram and Raj, 1997).

Another 3 (25%) looked at cholesterol or phospholipids (in the form of a soy lecithin supplement), (Chandge and Raj, 1997; Samuel et al, 1997; Srivastava and Parihar, 1997). One study looked at the effects of altering the lipid: carbohydrate ratio and protein: energy ratio, (Chuntapa et al, 1999), one at alterations in the ratio of clam meat: tapioca, (Nair and Sherief, 1993), and one at the ratio between alpha starch and cellulose powder, (Hemambika and Raj, 1999).

Of the other two studies, one provided a feed of *Artemia* supplemented with a range of herbal medicinal ingredients, (Citarasu et al, 2002), and the other a diet with various amounts of mantis shrimp, (Sridhar et al, 1999).

Outcome measures: A large proportion of fish studies used measures of weight as an outcome. Thirty-three, (83%), measured the mean weight at harvest and 25 (63%) measured the mean weight gain. The specific growth rate was also a common measure, (28; 70%), followed by the FCR and survival rate in 25 and 21 studies respectively (63% and 53%). Mean daily weight gain and total harvest weight, gross yield and net yield were used to a lesser extent.

The majority of studies, (93%), used additional measures such as the RNA and DNA content in the muscle of animals, the mean length at harvest, the composition of the carcass in terms of the percentage moisture, carbohydrate, lipid and ash, and the protein efficiency ratio amongst many others.

Of the shrimp studies, survival and mean weight gain were the most common measures used (90% of studies each), followed by FCR and mean harvest weight, (80% and 60% respectively). Mean daily weight gain and specific growth rate were used to a lesser extent and the production measures of total harvest weight, gross and net yield were not given in any studies at all. Additional measures were recorded in 90% of shrimp studies and included the body composition of animals, protein efficiency ratio and the gain in length.

5.3.4.1.2 Variation in type of ingredients or feeds

Species: In this group, a total of 22 species were used. Approximately two thirds (66%) of studies used species of fish, of which 12 (57%) used one or more of the carp species catla, rohu, common carp, hybrid common carp, mrigal, grass carp and silver carp. No studies looked at tilapia species, but one study each used the catfish *Clarias gariepinus* and *Clarias batrachus*. Of seven (33%) studies using species outside these broad groups, species included the Malabar grouper, angelfish, zebrafish, goldfish, *Channa micropeltes*, barramundi and pearlspot.

For the 11 (34%) studies using species of prawn or shrimp, eight (72%) used Penaeus sp., to include *Penaeus monodon, Penaeus indicus, Penaeus merguiensis* and *Metapenaeus monoceros*. The latter two species were used in the same study, but in separate experiments, and neither was used in any additional studies. The other three (28%) studies used either *Macrobrachium rosenbergii* or *Macrobrachium malcolmsonii.*

Interventions: The 21 fish studies showed great variation, thus it is not possible to summarise them all. Examples of different types of ingredients used include different carbohydrates, e.g. glucose, fructose, sucrose, dextrin and raw potato starch, different protein sources, e.g. fishmeal, meat meal, soyabean meal, groundnut meal and sunflower meal. Some used different feeds altogether and these included cassava leaves and peanut vines, juvenile tilapia, *Sigara* sp. (an aquatic insect) and clam meat, and soybean, moong, cowpea and guar, amongst others. Overall, 13 (61%) studies used artificial or commercially formulated ingredients or feeds only, 5 (22%) used natural or whole feeds or ingredients only, and 3 (17%) used feeds or ingredients of both types.

The 11 shrimp studies also showed variation in the comparators used. Three (27%) looked at the effects of providing different types of feed as well as manipulating an additional variable, eg. providing either squid, beef liver, crab or squilla as feed to eye-stalk ablated and non-ablated shrimp, (Murugesan et al, 1998; Vijayakumaran, 1999; Wangsawebool, 2000). One study tested various feed ingredients both individually and in combination, including *Artemia*, *Brachionus plicatilis*, (a rotifer), Moina sp., (water flea), and an artificial feed, (Soundarapandian and Kannupandi, 2000). A further two (18%) studies looked at the effects of diets with or without astaxanthin and norflaxin nicotinate respectively on the response to an injection with a strain of the Vibrio bacteria, (Chucherd, 1995; Kamnertmanee, 1997). The remaining 5 (45%) compared different types of feeds and these included the carbohydrates glucose, fructose, galactose, sucrose, maltose, starch and glycogen, *Artemia*, earthworm, oyster and pellet feeds, (Ali, 1993; Gokulakrishnan and Bandyopadhyay, 1995; Soundarapandian et al, 1998; Ali, 2002; Pawase and Shenoy, (a)).

Outcome measures: The most common measure in fish studies was the mean weight at harvest, used in 13 (62%) studies. This was followed by survival (52%), and the specific growth rate and FCR, (48% each). Additional growth measures of mean daily weight gain and mean weight gain were used to a slightly lesser degree, (38% and 33% respectively). Total productivity measures were minimal. Of 18 (86%) studies that used additional measures also, some of these included the composition of the carcass, the protein efficiency ratio and the gut enzyme activities.

Shrimp studies showed a similar pattern. Survival was the most common measure, (82%), followed by the mean weight gain (55%), mean weight at harvest and FCR, (45% each). The specific growth rate however was only calculated in one study. Only one study also used any measure of production, (net yield). Approximately two thirds

(64%) of studies presented outcomes for additional measures, including body composition, final length and metabolic rate.

5.3.4.2 Vitamins and amino acids

Species: Almost all of these interventions, (93%), involved species of fish, (Table 23). Two studies used species of shrimp and one reported the intervention of an amino acid (methionine) supplement in *Penaeus monodon*, (Gopal et al, 1999), and the other, vitamin C, (in the form of ascorbyl-2-phosphate), in *Macrobrachium rosenbergii*, (Hari et al, 2002).

The most common group of fish used was again carp, (catla, rohu and common carp). Tilapia species included the Nile tilapia and Mozambique tilapia, (3 studies), and catfish species included *Clarias batrachus* and *Heteropneustes fossilis*, (4 studies). Other species used include the sea bass, barramundi, grouper and pearlspot.

Interventions: Of the fish studies, 14 (54%) investigated the effects of increasing the amount of a specific amino acid, and two of these involved multiple amino acids. Most of these (10 studies, 71%) used at least one of the essential amino acids methionine, (Khan and Jafri, 1993; Murthy and Varghese, 1998; Gopal et al, 1999; Mukhopadhyay and Ray, 1999(a)), lysine, (Khan and Jafri, 1993; Murthy and Varghese, 1997(b); Satheesha and Murthy, 1999; Mukhopadhyay and Ray, 1999(a)), trytophan, (Khan and Jafri, 1993; Murthy and Varghese, 1997(a)), valine, (Murthy and Varghese, 1997(c)), phenylalanine, (Murthy and Varghese, 1996(a)), isoleucine, (Murthy and Varghese, 1996(b)), and threonine, (Murthy and Varghese, 1996(a)). The non-essential amino acids investigated included L-carnitine, (Kumar and Jayaprakas, 1996; Jayaprakas and Sambhu, 1998; Keshavanath and Renuka, 1998), arginine, (Khan and Jafri, 1993; Murthy and Varghese, 1995), histidine, (Murthy and Varghese, 1995), and cystine, (Mukhopadhyay and Ray, 1999(a)). Two studies used both essential and non-essential amino acids.

Of the 12 (46%) vitamin interventions, 7 (58%) involved B vitamins, 3 (25%) C vitamins and 2 (17%) E vitamins. B vitamin interventions included deleting vitamins B1 (thiamine), B2 (riboflavin), pantothenic acid and inositol from the diet and increasing the amounts of biotin, pyridoxine, (vitamin B6), or niacin, (vitamin B3), (Boonyaratpalin and Wanakowat, 1993; Boonyaratpalin et al, 1993(a); Mohamed and Ibrahim, 2001; Mohamed, 2001(a); Mohamed, 2001(b); Mohamed et al, 2000; Sommani and Jindathip, 2003). C vitamin interventions involved the supplementation with or removal of, for example, L-ascorbyl-2-phosphate or ascorbic acid, (Boonyaratpalin et al, 1993(b); Reddy and Ramesh, 1996; Sommani and Jindathip, 2003). One of two studies using vitamin E involved studying the effects of supplementary levels in the diet, (in the form of alpha-tocopherol), on fish that had or had not been immunocompromised with an aflatoxin injection, (Sahoo and Mukherjee, 2002(a)). The other involved altering the level of incorporation of vitamin E in the diet only, (de la Cruz Camacho, 1998).

Outcome measures: In all fish studies, the emphasis appears to have been on promoting growth, (Table 24), as 21 (81%) and 19 (73%) studies measured the mean weight gain and the mean weight at harvest respectively. In addition 17 (65%) studies measured the specific growth rate and three (12%) measured the mean daily weight gain. There was also strong emphasis on measuring the survival (22 studies, 85%) and to a lesser extent the FCR, in 15 (58%) studies.

Both shrimp studies measured the mean weight at harvest, mean weight gain and survival, and the specific growth rate and FCR were calculated in one study each.

There was practically no emphasis on total production outcomes. Only one study measured the total harvest weight of animals, and no studies measured the gross or net yield. A total of 22 (79%) studies used measures in addition to those specified, and some examples of these include the length of the animal at harvest, the protein efficiency ratio, the composition of the carcass in terms of amino acids for example, and the optimum requirements of the specific vitamin or amino acid tested.

5.3.4.3 Feeding regime

Species: Fish were used in 80% of studies, with carp being the most common group, (i.e. rohu, mrigal, catla and common carp either individually or in combination). One study each investigated Nile tilapia, the catfish *Mystus keletius*, and goldfish. Both prawn studies used *Penaeus monodon*.

Interventions: Of the fish studies, three (38%) looked at the effects of altering the timing of feeding, (Sampath and Raj, 1995; James and Chandrakala Vadivu, 2000; Premila and Sampath, 2001). Four (50%) tested the effects of providing feeds of high or low protein value, or feeds with a plant or animal protein source, in varying regimes, (Nandeesha et al, 1993; Nandeesha et al, 1994; Saha and Ray, 1998(a); Saha and Ray, 1998(c)). The final study, (Diana et al, 1994), looked at the effects of providing different levels of satiation feeding, and the difference between providing feed only, fertiliser only or a combination of the two.

For the two shrimp studies, both looked at the effects of using a standardised feeding programme compared to a commercial programme with animals stocked at different densities, (Mohanty, 2001(a); Mohanty, 2001(b)).

Outcome measures: There was no obvious trend in the use of weight, growth or production measures of animals across all studies. For fish, the most common measures used were the mean weight at harvest (100%), survival and FCR (88%). The net yield followed these (63%), with the remaining five measures being used to a lesser extent. All studies used measures additional to those specified. Examples of these include the protein efficiency ratio, the apparent net protein utilisation and the percentage protein retention.

For the two shrimp studies, both measured the total harvest weight, mean weight at harvest, mean daily weight gain, net yield, survival and FCR. The condition factor of animals was also measured in both studies.

5.3.4.4 Hormones

Species: All eight of these studies were conducted on species of fish. The most common group (75%) used was carp, (i.e. the common carp and mrigal). No studies used tilapia or catfish. One study each was conducted on pearlspot, (*Etroplus* *suratensis* Bloch), and green chromide, (*Etroplus suratensis*). The use of hormones was not investigated in any species of shrimp or prawn.

Interventions: Four studies looked at the effects of providing increasing amounts of natural reproductive hormones. These included testosterone propionate, (Sambhu and Jayaprakas, 1997(a)), human chorionic gonadotrophin (HCG) and testosterone propionate alone or in combination, (Jayaprakas and Sindhu, 1996), L-thyroxine (thought to affect testicular development and spermatogenesis), (Sambhu and Jayaprakas, 1997(b)), and estrone, (a feminisation hormone), (Sehgal and Saxena, 1997). The aim of using such hormones is to create a population of animals of the faster-growing sex, through sterility or the production of monosex animals (Donaldson, 1996; Lakra and Ayyappan, 2003). The remaining studies used either synthetic hormones or substances that influenced the activity of natural hormones. One study used increasing amounts of 3,5,5'-triiodothyronine (T3) in the diet, a substance that enhances the activity of gonadotrophic hormones, (Ansal and Kaur, 1998), and one sprayed various amounts of the synthetic oestrogen diethylstilbestrol on to the feed and compared its effects to a hormone free diet, (Basavaraja et al, 1997(a)). One study each used increasing quantities of the sex-reversal hormone norethindrone, (Basavaraja et al, 1997(b)), and mibolerone, (another hormone involved in masculinisation), (Sobhnana and Nandeesha, 1994).

Outcome measures: All studies measured the mean weight at harvest, and all but one the survival. A fairly even proportion of studies measured the mean weight gain and the specific growth rate, (63% and 50% respectively). Total harvest weight and FCR were used to a lesser extent. Neither mean daily weight gain nor gross or net yield were used in any of the studies.

All but one study provided data on additional outcome measures and some examples of these include the sex composition of the population or sample, the gonado-somatic index, (calculated by dividing the weight of the gonads of an animal by the body weight and multiplying by 100), and the RNA: DNA ratio.

5.3.4.5 Growth promoters

Species: No one species was used in more than one study. Of the 4 studies, 3 used the carp, mrigal, rohu and common carp and 1 used the shrimp *Macrobrachium rosenbergii*.

Interventions: The studies conducted on mrigal and rohu looked at the effects of altering the percentage concentration of 'Livol', a herbal growth promoter, (Jayaprakas and Euphrasia, 1997; Euphrasia and Jayaprakas, 1999). The study on common carp also used this growth promoter, and in addition, 'Bioboost forte' and Amchemin-AQ', (a manufactured feed product), each at a different percentage level of incorporation, (Shadakshari and Manissery, 1999). The study on *Macrobrachium* rosenbergii, measured the effect of a steroid given either in the diet or by injection, (Cheinwichai, 1994).

Outcome measures: All studies calculated the specific growth rate, and the 3 fish studies the mean weight at harvest. Two fish studies also measured survival and one the mean weight gain. The FCR was only calculated in the shrimp study, this being the only other measure in addition to the specific growth rate.

Additional measures, as used in the fish studies only, included the protein efficiency ratio, the mean length at harvest and the RNA and DNA content in the liver and muscle tissue.

5.3.4.6 Toxic ingredients or feeds

Species: All 3 studies were conducted on species of fish. One focused on the medium carp, *Osteobrama belangeri*, one on rohu, and one on the Mozambique tilapia. No studies were carried out on any species of shrimp or prawn.

Interventions: One of these studies investigated the effects of increasing the proportion of either cobalt chloride or zinc chloride in the diet, (Azad, 1997). The second study looked at the effects of replacing 20% of a reference diet with a biogas plant effluent, (Gopal et al, 1996). The final study increased the level of solvent extracted glanded cottonseed, *Gossypium herbaceum*, in the diet, (Usmani et al, 1997).

Outcome measures: All studies reported on the mean weight at harvest, mean weight gain and mean daily weight gain. In addition, two studies each recorded survival and the FCR, and one the specific growth rate.

Some of the additional measures used across all three studies included the composition of the carcass of animals and the protein and glycogen levels in the brain, liver and muscle tissue of fish.

5.3.4.7 Substrates

Species: All three studies investigating the use of substrates to enhance the availability of feed were conducted on fish. The Nile tilapia was used in one study, the mahseer in another and the fringe-lipped carp, (*Labeo fimbriatus*), and mahseer together in another.

Interventions: Keshavanath et al, (2002), investigated the use of different densities of bamboo poles in the presence or absence of a pelleted feed. Shrestha and Knud-Hansen, (1994), tested different densities of upright baffles for periphyton attachment. Keshavanath et al, (2001), investigated the use of different types of substrate, including PVC pipes and bamboo poles, with different stocking densities of fish.

Outcome measures: All three studies measured mean weight at harvest, net yield and survival. The specific growth rate, gross yield and FCR were each measured in one study.

5.3.4.8 Other

Species: Of the remaining four studies that did not fit into any of the above categories, two used the Nile tilapia and two used *Macrobrachium* spp., including *Macrobrachium rosenbergii* and *Macrobrachium lamarrei lamarrei*.

Interventions: The two tilapia studies conducted interventions to the size of the feed, (Bhujel et al, 2001), and the size of fish at first feeding, (Diana et al, 1996). The two *Macrobraachium* spp. studies looked at the effects of the presence or absence of supplemental feeding with a monthly fertilisation programme, (Chandrasekaran et al, 1998), and the addition of a variety of food colours to a basal feed, (Papand et al, 1999).

Outcome measures: Both of the fish studies measured the mean weight at harvest and the mean daily weight gain. Total harvest weight, gross yield, survival and FCR were used to a lesser extent in one study each. Additional measures, as used in both studies, included the weight of fish at first feeding and the seed output.

For the shrimp, both studies measured the mean weight at harvest, the mean daily weight gain and survival. The mean weight gain, specific growth rate, net yield and FCR were also used in one study each. Additional measures included the final length, daily gain in length and the protein efficiency ratio.

5.4 DISCUSSION

Feed and nutrition studies constituted a very high proportion of the studies included in this review. The growth in aquaculture production has brought about a dramatic growth in the feed industry. In 1995 global aquaculture feed production was approximately 16.8 million metric tonnes, (Gill, 1996), rising to around 18.2 million metric tonnes in 1996, (Gill, 1997). However estimates have varied dramatically, some of which suggest much lower volumes, (Tacon, 2004). Global production of aquaculture feeds is estimated to increase from approximately 12 million metric tonnes per year in 2000 to approximately 68 million metric tonnes in 2025, (Barlow, 2000), indicating the continued growth of the sector.

A high proportion of the studies were conducted in India, with most of the remainder from Thailand. Just one was from Vietnam. As developments in the feed and nutrition industry will have been in conjunction with aquaculture development, Vietnam will inevitably have experienced a slower increase in the number of companies involved in feed and nutrition and consequently research. It is also possible that feed products developed in India and Thailand have been exported and used in other Asian countries, reducing the need for research in countries such as Vietnam. Alternatively, the types of aquaculture practiced in these countries may have influenced the amount of feed and nutrition research conducted. India and Thailand, whose aquaculture industries are more established compared with Vietnam, may be moving towards more semi-intensive and intensive methods of production. Vietnam on the other hand still mainly carries out extensive farming, with a small amount of semi-intensive. In intensive production, formulated supplementary feeds are more widely used than natural feeds. The latter are used more in extensive systems. As more effort is put into the formulation of supplementary feeds, this may be a possible reason for the higher amount of research in India and Thailand.

A large proportion of feed and nutrition studies were conducted on species of fish, of which two thirds were carp. Although shrimp were used in less than a quarter of studies, the majority involved species of *Penaeus*. A possible reason for the lack of research on shrimps is that they have a relatively under-developed digestive and immune system, limiting the potential for optimisation of digestive processes. It is also possible that the appearance of farmed fish is a more important factor compared to shrimps. Feed and nutrition of fish will have a significant effect on various aspects of their composition and therefore the consumer preference. A study by Haard, (1992), highlighted the importance, (amongst other factors), of the diet of the fish in contributing to their flavour, nutrition and appearance post-harvest.

The most common measures from these studies were the mean harvest weight and survival, followed by the mean weight gain and FCR. The emphasis therefore appears to be on optimising the growth of animals and the cost-effectiveness of production. Although total harvest weight, gross yield and net yield were not directly measured in the majority of studies, mean harvest weight and survival measures would allow production to be calculated.

A high proportion of feed and nutrition studies (58%) involved the manipulation of aspects of feed formulation. This included the use of different quantities of specific ingredients as well as different ingredients and feeds altogether. A lot of research has been conducted on optimising the amount of specific parameters, in particular carbohydrate and lipid levels, in a variety of species, (Lim et al, 1997; Gaylord et al, 2003; Stone, 2003). These macronutrients have been used increasingly over time, as they are a more cost-effective way of providing the required amount of dietary energy. This is because they serve ‘protein sparing functions’, (Hasan, 2001), thereby reducing the cost of the feed by decreasing the amount of more expensive protein required.

Also common amongst studies on feed formulation was the use of locally available and natural ingredients and products. This has particular importance in developing countries. If aquaculture production is to become more intensive to meet increasing demands, countries such as India, Thailand and Vietnam will have to make aquaculture feed production more sustainable. In recent years the dependence of the industry on fish oil and fishmeal in providing the necessary lipids and proteins has resulted in a shortage of these products, (Watanabe, 2002). In combination with the increase in agriculture, where fish products are used in the feeds of livestock, (Hasan, 2001), competition will require the use of other readily available ingredients. The relatively high number of studies utilising local feeds is encouraging, however the lack of information regarding how and where these products can be obtained in developing countries, (Hasan, 2001), may limit the uptake of this practice. If successful though, it will play a major role not only in local aquaculture production but also in maintaining the livelihoods of local producers of these ingredients, both of which will improve the local economy.

There were a relatively high proportion of studies carried out on vitamin and amino acid manipulation. This is quite surprising as a statement by Hasan, (2001), indicated that this is the least researched area of aquatic animal nutrition. However, as India particularly may be moving towards more intensive systems of aquaculture in which vitamin deficiencies are more common, (Hasan, 2001), this may have prompted more research. This research was almost completely carried out on species of fish. This can indicate one of two things, that these parameters are particularly limiting in fish or that they play a less important role in shrimp development. The wealth of research in other countries on the effects of vitamins and amino acids in shrimp however contradicts this idea, (Teshima et al, 2002; Cavalli et al, 2003; Shiau and Wu, 2003). The complete absence of studies investigating dietary minerals, (which would have been included in this subcategory), could be due to the ability of aquatic organisms to absorb these macromolecules from the water in addition to feeds, (Hasan, 2001). Therefore many confounding factors affecting the ability to measure dietary mineral uptake will exist and limit the effectiveness of an intervention trial.

All hormone research involved fish only, mainly carp. All interventions aimed to manipulate the sex of the animals by the use of reproductive hormones, either natural or synthetic, in the diet. This may be a more cost-effective means of optimising production of the more profitable sex, (male or female depending on the species), compared to genetic manipulation. However studies investigating dietary hormone supplementation overall were relatively few. This may be a reflection of the little information known about the effect of hormones on nutrient utilisation. MacKenzie et al, (1998), highlighted the need for more research into how nutrients affect the endocrine system of fish on a cellular and molecular basis. Also, in some countries, including India, the use of hormones to produce populations of monosex animals that are ultimately consumed by humans has been banned, (Dunham et al, 2001), and this may consequently have been a major influence on the funding of this type of research.

Relatively few studies have been carried out on the use of growth promoters. Although not strictly classified as growth promoters, steroids were grouped in this category for their growth promoting effects, as the other hormone studies focused on sex manipulation. These products might be quite expensive, and for improving the growth of animals, manipulating the feed formulation might be more cost-effective. Controversy surrounding their use may also receive adverse public reaction leading to decreased demand for products.

There have also been relatively few studies carried out on the effects of toxic components of feeds. Improvements in the aquaculture and agriculture industries or increased awareness of environmental issues may have seen a reduction in the occurrence of effluent discharges and spillages for example. A reduction in these problems may have caused a reduction in the need for research on the effects of toxic ingredients on aquatic species. However, as freshwater pollution, industrial pollution and agrochemical use have all increased in South-east Asia over the past 10 years, (United Nations, 2002), this is unlikely. One area of feed toxicity that has not received any research is the effect of overloading the water with feed. If excess feed is left to accumulate this can lead to eutrophication, (Pathak et al, 2000), and adverse water quality conditions. Substances that received attention included cobalt chloride and zinc chloride, compounds known to have adverse effects on the physiology, enzyme activity and development, amongst other measures, of a wide range of organisms, (Palit et al, 1991; Plowman et al, 1991; Hemalatha and Banerjee, 1997). Solvent extracted glanded cottonseed, a substance that has an inhibitory effect on digestive enzymes and causes a lowering of appetite, (Usmani et al, 1997), was also tested.

Overall, the large amount of research into the feed and nutrition of aquatic animals in Asia reflects its cost and importance in maximising aquaculture production. Nutrition of aquatic animals is central to their health in a number of ways, as highlighted by the diverse range of topics on which intervention trials have been carried out. The most commonly investigated subject is feed formulation, with the effects of growth promoters, hormones and toxic feeds having received relatively little attention. For research outputs to be effective, it may be necessary to develop a set of legislative guidelines regarding the manufacture and use of aquaculture feeds. Tacon et al, (1995), suggested the development of such control measures on a country-by-country basis so that consideration can be taken of the types of aquaculture systems used and the resources available.

CHAPTER 6. WATER QUALITY: SPECIES, INTERVENTIONS AND OUTCOME MEASURES

6.1 INTRODUCTION

Problems relating to the quality of water in aquaculture systems are very diverse. A careful balance of nutrients and other factors is essential to maintain the optimum culture conditions required for health. These factors include temperature, salinity, pH, hardness and the balance between nitrogen, oxygen and phosphorus amongst many others.

The application of fertilisers is also important in boosting the productivity of a system. The use of aquatic fertilisers and other commercial water treatment products in the three target countries has increased dramatically, and is reflected in the range of organic and inorganic products available on the market, (Pathak et al, 2000; Tonguthai, 2000). Feed and fertilisers account for 60-80% of the total cost of aquaculture production, (Hasan, 2001), making the use of the correct product of particular importance for developing countries.

Another important factor influencing water quality is toxicity. The increase in intensification of aquaculture has led to increased environmental problems. One of the major problems is contamination of surrounding water bodies or neighbouring aquaculture systems by effluent discharged from ponds that contain high nutrient loads and chemical residues, (Pathak et al, 2000), which can lead to eutrophication, (where increased productivity from excess nutrient loading leads to decreased levels of dissolved oxygen), or disease in affected animals. Industrial waste and spillages have also been implicated in causing toxic water quality conditions. All of these factors can affect the disease susceptibility of aquatic animals and therefore have serious implications for productivity. Consequently, a lot of research has been carried out into effluent treatment and how their toxic effects can be minimised, and in some cases this has led to the development of guidelines, (Boyd, 2003; Lin and Yi, 2003; Naylor et al, 2003).

Basic management practice can be vital in preventing some of these problems, e.g. not over-stocking fish or shrimp and providing adequate aeration and circulation, however there is still a need to carry out intervention trials to maximise the potential of aquaculture, especially for developing countries. As water quality problems will be closely related to the type of farming system being used and the species being cultured, the outputs from research will be influential at all levels of production.

The aim of this chapter is to summarise the types of interventions that have been carried out on the different topics of water quality, in which of the target countries and on what species. Again the outcome measures used will be summarised for each group of studies.

6.2 MATERIALS AND METHODS

Studies in this category were sub-categorised based on the interventions carried out. Any studies that could not be allocated to a specific sub-category were put in an ‘other’ group.

6.3 RESULTS

6.3.1 Numbers of studies

There were 48 papers in this category. They were broadly classified into 7 subcategories. Of these, 3 fitted into more than one subcategory giving a total of 51 across all subcategories, (Table 29).

Table 29. Numbers of water quality studies conducted on different sub-topics, stratifying by country.

Subcategory	India	Thailand	Vietnam	Total
Toxicity	17	1	0	**18**
Fertilisers	10	4	0	**14**
Salinity	4	3	0	**7**
Water flow, circulation and aeration	2	4	0	**6**
Temperature	1	1	0	**2**
Hardness	1	0	0	**1**
Other	2	1	0	**3**
Total	**37 (36)**	**14 (12)**	**0**	**51**

The most common category was the application of toxic substances to water, (35%). Fertilisers accounted for 27% of studies and salinity and water flow, circulation and aeration effects for 14% and 12% respectively. Water temperature and hardness formed a minor component of studies.

Almost three quarters of the studies (73%) were conducted in India, with the remainder (27%) from Thailand. There was a difference between countries in the distribution of studies on toxicity, (X^2=6.389, df=1, p=0.011), and water flow, circulation and aeration, (X^2=5.445, df=1, p=0.020).

6.3.2 Species of study

A high proportion of studies (85%) involved species of fish, compared to 17% involving shrimp, (Table 30). Some studies used both fish and shrimp in the same study, accounting for the higher combined total number of studies.

Table 30. Numbers of water quality studies conducted on different groups of fish and shrimp species, stratifying by sub-topic.

Sub-category	Number studies								Total species
	Fish	Carp	Tilapia	Catfish	Other spp.	Prawn	Penaeus	Macro-brachium	
Toxicity	**18**	8	4	5	2	**1**	1	0	**10**
Fertilisers	**13**	9	5	0	0	**1**	1	0	**9**
Salinity	**3**	0	0	1	2	**5**	5	0	**8**
Water flow, circulation and aeration	**6**	2	4	1	0	**0**	0	0	**5**
Temperature	**1**	0	0	0	1	**1**	1	0	**2**
Hardness	**1**	0	0	0	1	**0**	0	0	**1**
Other	**2**	1	0	0	1	**1**	0	1	**3**
Total studies	**44**	**20**	**13**	**7**	**7**	**9**	**8**	**1**	**22**

Across all subcategories, 22 different species were used; 16 fish and 6 shrimp. Carp, (catla, rohu, mrigal, scale carp, common carp, silver carp and grass carp), were the most common group of fish used (45% of fish studies), followed by tilapia, (Nile and Mozambique), (30%). Catfish, (*Heteropneustes fossilis* and the hybrid catfish), were used to a lesser extent in 16% of fish studies. In addition, 7 (16%) used species outside these groups. Three studies across all subcategories used fish species from more than one group, accounting for the category totals adding up to more than the overall number of studies. Of the shrimp studies, the majority (89%) used species of *Penaeus* or *Metapenaeus* as the target of intervention, compared to just one with *Macrobrachium*.

6.3.3 Outcome measures

Survival, the most common measure, was used in 50% of studies, (Table 31). Mean weight at harvest, mean daily weight gain and net yield were all used to a similar degree, in 29%, 21% and 27% of studies respectively. Mean weight gain, total harvest weight, FCR, specific growth rate and gross yield were all used to a lesser extent and in decreasing numbers of studies. Therefore there appeared to be no specific trend in the types of outcomes that are of particular interest.

Table 31. Numbers of water quality studies using different outcome measures, stratifying by sub-topic.

Outcome measure	Subcategory							Total
	Toxicity	Fertilisers	Salinity	Water flow, circulation and aeration	Temperature	Hardness	Other	
Total harvest weight	1	4	0	2	0	0	0	**7**
Mean harvest weight	1	8	3	3	0	0	0	**15**
Mean weight gain	0	3	1	5	0	0	0	**9**
Mean daily weight gain	3	1	2	5	0	0	0	**11**
Specific growth rate	0	2	1	0	0	0	0	**3**
Gross yield	0	0	0	2	0	0	0	**2**
Net yield	0	7	0	6	0	0	1	**14**
Survival	3	11	5	5	1	0	1	**26**
FCR	0	1	1	3	0	0	0	**5**
Other	16	6	2	2	0	1	1	**28**

A total of 28 studies, (60%), used measures in addition to those specified and examples of these measures will be provided in the relevant sections.

6.3.4 Details of comparators

6.3.4.1 Toxicity

Species: All 18 studies were carried out on species of fish, with one exception, which used *Penaeus monodon* and hybrid catfish together. Of the other studies, 8 (44%) used one or more of the carp, catla, rohu, mrigal, scale carp and common carp, including one study that looked at common carp in combination with the catfish, *Heteropneustes fossilis*. Four (22%) studies looked at species of catfish, which included again the hybrid catfish and *Heteropneustes fossilis*. Four (22%) studies were conducted on the Mozambique tilapia and two (11%) used *Channa punctatus*, a species falling outside these groups.

Interventions: Five (28%) studies investigated the toxic effects of the heavy metal cadmium using various methods. These looked at the effects of various concentrations of cadmium alone, (Vincent et al, 2002), or in combination with poultry litter, (Ghosal and Kaviraj, 1996), the drug Essentiale (Nattermann, Cologne, FRG), protective against biochemical toxicity, (Kothari et al, 1999), the pesticide dimethoate, (Sastry and Gupta, 1994), or potassium permanganate, (sometimes used to treat fish pathogens) and cobalt chloride, (Das and Kaviraj, 1994).

Four (22%) studies investigated the effects of toxic effluents. In two cases, the percentage 96hour LC50 concentrations of tannery effluent were increased, and in one study an additional variable was the exposure time in days, (Ambrose et al, 1994; Ambrose et al, 1994). A third studied distillery effluent, (Kumar and Gopal, 2001), and the fourth, sublethal concentrations of sewage, (Rajan, 1997).

Two (11%) studies looked at the effects of exposure to increasing sublethal concentrations of urea, (Babu et al, 1997; Balasubramanian et al, 1999).

The remaining studies looked at various comparators. James and Sampath, (1995), studied the effect of ammonia either alone or in combination with copper, and Koydon, (1994), with different salinities. Rani et al, (1998), also studied the effects of increased concentrations of ammonium chloride. The effect of exposure to copper with increasing amounts of the chelating agent EDTA was also studied, (James et al, 1998). Two studies looked at the effects of the insecticides delamethrin, a synthetic pyrethroid, (Kumar et al, 1999), and chlordecone, (Srivastava and Srivastava, 1995). A final study tested different methods of removing unwanted fish from ponds, including the use of the piscicides mahua oil cake and bleaching powder, (Shyam et al, 1993).

Outcomes: Survival and mean daily weight gain were used in three (17%) studies each, and the mean harvest weight and total harvest weight in one (6%) study each. A large proportion, (16, 89%), used measures alternative or in addition to those specified, including haematological parameters, the tissue content of specific toxic substances, 96hour LC50 values, and the metabolic rate.

6.3.4.2 Fertilisers

Species: All but one study (93%) was conducted on species of fish. Nine (69%) were on one or more of the carp, catla, rohu, mrigal, common carp, grass carp and silver carp. Four (31%) used either the Nile or Mozambique tilapia. One study used common carp, rohu and Nile tilapia together.

Interventions: The single study looking at fertiliser effects in shrimp was conducted on *Penaeus monodon* and looked at the use of different substances for liming and their effects at a range of salinities, (Arifin, 1996).

Five (38%) fish studies looked at the effects of administering increasing concentrations of various types of animal manure. Two used chicken manure, (Knud-Hansen et al, 1993; Ghosal and Kaviraj, 1996), two involved the use of cow dung, (Garg and Bhatnagar, 1996; Borah et al, 1999), and in the other pig manure was tested as a fertiliser and as a feed ingredient, (Dhawan and Kaur, 2002).

Other fertilisers used across 4 studies included biogas plant effluent, water hyacinth compost, sugarcane bagasse, (a plant substrate), paddy straw and Mussoorie rockphosphate (MRP) and single super phosphate (SSP), (Balasubramanian and Bai, 1996; Jana and Chakrabarty, 1997; Ramesh et al, 1999; Umesh et al, 1999; Sahu et al, 2002). Two (15%) studies looked at the effects of different rates of fertilisation with a mixture of triple superphosphate and urea, (and in one experiment cow dung also), but delivering the same total input overall, (Knud-Hansen and Batterson, 1994; Garg and

Bhatnagar, 2000). A final study looked at the difference between fertilised and unfertilised water, and water with a suspension of 'Phen' or 'Roiet' soil, (Mhoryadee, 1997).

Outcomes: Those measured in the shrimp study were the mean harvest weight and survival. The most common measure in the fish studies was survival, in 79% of studies. This was followed by net yield and mean harvest weight, in 54% and 62% of studies respectively. Total harvest weight and mean weight gain were used in 31% and 23% of studies respectively, with mean daily weight gain, specific growth rate and FCR being used to a lesser extent. Six (46%) studies looked at additional outcome measures, including the length at harvest, 96hour LC50 values and the distribution of weight classes.

6.3.4.3 Salinity

Species: Overall 8 different species were used. Five, (63%), were shrimp and 3, (37%), were fish. A higher proportion (63%) of studies were conducted on species of shrimp, in contrast to the previous subcategories. Two studies were on *Penaeus indicus*, one on *Penaeus monodon,* one on mixtures of *Penaeus monodon, Penaeus merguiensis, Metapenaeus monoceros* and *Metapenaeus dobsoni* and one investigated both *Penaeus monodon* and the hybrid catfish together. No species of Macrobrachium were investigated. The two additional fish studies used grouper and mullet.

Interventions: Just one of the shrimp studies looked at the effects of altering the salinity level alone, (Pawase and Shenoy, (b)). The other 4 (80%) looked at the effect of salinity in conjunction with additional factors, including different forms of liming, altered water temperatures and stocking densities, feed types and ammonia levels, (Koydon, 1994; Arifin, 1996; Sasikumar and Vadhyar, 1999; Vijayakumaran, 1999).

The two fish studies involved investigating a range of salinity levels either alone, (Parnichsuke et al, 1996), or in combination with the use of feeds containing different protein concentrations respectively, (Venkadesh and Palavesam, 1999).

Outcomes: Survival was the most common measure used in shrimp studies (80%). Mean harvest weight was used in 2 (40%) studies and mean weight gain, mean daily weight gain and FCR to a lesser extent. One study only used additional measures including the protein efficiency ratio, metabolic rate and energy budgets amongst others. Of the two studies involving fish only, mean harvest weight, mean daily weight gain, specific growth rate and survival were measured in one study each. Production measures were not used in any of the studies.

6.3.4.4 Water flow, circulation and aeration

Species: All 6 studies in this category were conducted on species of fish. Two used the carp catla, rohu and mrigal as the targets of intervention, and three used the Nile tilapia. One study used both Nile tilapia and Hybrid catfish, (*Clarias macrocephalus X C. gariepinus*), together, hence the group totals come to more than the number of studies. No water flow, circulation and aeration studies were reported from shrimp species.

Interventions: Four (67%) studies looked at the effects of providing different rates of water flow or aeration. Two tested different aeration rates and water flow rates, (Barte, 1996; Saha et al, 2001). One tested the effects of different rates with different stocking densities of fish, (Saha et al, 1997), and one looked at the effects of stocking one to four cages in a pond and providing artificial aeration from a paddle wheel in ponds that contained four cages, (Yi and Kwei Lin, 2001). The other two (33%) studies looked at the effects of water circulation either by daily mixing, (Szyper and Hopkins, 1996), or comparing non-integrated and integrated pen-cum-pond systems with natural or artificial, (by use of a pump), water circulation, (Yi et al, 2003).

Outcomes: All studies measured the net yield of fish. Mean weight gain, mean daily weight gain, and survival were used in 5 (83%) studies each. The FCR, mean weight at harvest, total harvest weight and gross yield were used less frequently. Two studies also looked at other measures, including the length at harvest and the percentage moisture, nitrogen and phosphorus content of fish, common measures of body composition.

6.3.4.5 Temperature

Species: One study each was conducted on the Malabar grouper, (*Epinephelus malabaricus*) and *Penaeus indicus*.

Interventions: In the Malabar grouper study, the effects of culturing fish at three different temperatures; 26^{o}C, 29-30^{o}C and 31-33^{o}C was studied, (Ruangpanich and Boonliptanon, 1993). The *Penaeus indicus* study looked at the effects of two different temperatures, (30+/-1^{o}C and 23+/-2^{o}C), in combination with different salinities and stocking densities, (Sasikumar and Vadhyar, 1999).

Outcomes: Survival was the only outcome measure used in studies investigating water temperature.

6.3.4 6 Hardness

Species: The goldfish was the species on which the single study investigating water hardness effects was conducted.

Interventions: Four different concentrations of $CaCo_3$, (92, 250, 550 and 860ppm), were tested, (James and Chandrakala Vadivu, 2000).

Outcomes: This study recorded the feeding and conversion rate and the gross conversion efficiency.

6.3.4.7 Other

Species: Two studies were conducted on species of fish. These were the carp, rohu and barramundi. The single shrimp study was on *Macrobrachium malcolmsonii.*

Interventions: The rohu study looked at the effects of using four different levels of cobalt chloride, (Adhikari and Ayyappan, 2002), and the barramundi study used three different levels of pH, (Thompolkrang and Predalumpaburt, 1996). For

Macrobrachium malcomsionii, the performance of animals reared in diluted fresh seawater, recent hatchery wastewater and one-year-old hatchery wastewater was compared, (Kanaujia et al, 1998).

<u>*Outcomes:*</u> For rohu, net yield was measured, and for the barramundi, survival. In the *Macrobrachium malcolmsonii* study, measures included the day the first post-larvae appeared, the number of post-larvae produced, and the production of postlarvae per litre.

6.4 DISCUSSION

Studies investigating water quality constituted a relatively high proportion of all included studies in the review, (16%). Almost three quarters of them were from India and the remainder from Thailand. As maintaining optimal water quality conditions are a ubiquitous problem encountered in all aquaculture systems, it is not surprising that a fairly large amount of research has been carried out on this topic. The lack of intervention trials from Vietnam however contradicts this and indicates an important need for more research.

The majority of studies, (85%), involved species of fish. It is not clear why there has been a relative lack of research on shrimps, but a possible reason may be that measures used to monitor the effects of toxins or nutrient imbalances in the water may be more easily observed in fish. However, as survival was the most common outcome measure used overall, this suggestion is not supported. Alternatively, the longer culture period for some fish than shrimp, dictated by the size to be attained before harvest, may require that water quality conditions be maintained at an optimal level for a longer duration. Research into water quality in fish culture may therefore be more cost-effective.

The most common topic studied was toxicity, most frequently on the effects of heavy metals and effluents. Cadmium received a relatively high amount of research interest. This heavy metal has been associated with decreased survival and growth in fish and shrimp as well as accumulation and damage in tissues and organs, and disruption of various metabolic functions, (Bambang et al, 1995; Couture and Kumar, 2003; Thophon et al, 2003). Surprisingly, intervention trials on other heavy metals that have been shown to have toxic effects in a variety of species, e.g. magnesium, iron and zinc, (Chinni et al, 2002; Handy, 2003; Rogers et al, 2003), have not been conducted in any of the target countries.

The effects of distillery and sewage effluent were investigated in two studies. However, none directly looked at the effects of effluent run-off from one pond or unit on the productivity and water quality of another. The effect of rearing shrimp in fresh or stored hatchery wastewater was investigated in one study from the ‘other’ group. Despite toxicity being the most common subject, synonyms relating to this area of aquatic animal health were omitted from the electronic search strategies. Consequently, the proportion of research on this subject may have been underrepresented in this review, and may account for the general paucity of studies on shrimp.

The limited research on piscicides may be related to changes in the types of systems used. Intensification of production has in some areas moved it away from extensive to more semi-intensive or intensive practices where there is more control over what enters the system. Consequently, the need to remove unwanted species of fish will have diminished.

Research into the use of aquatic fertilisers also received a relatively high amount of interest. Animal manures were the main forms of fertilisers used as well as some plant substrates. These readily available ‘natural’ substances will be inexpensive and thus cost-effective for increasing production. The limited use of more costly commercial fertilisers in intervention trials reinforces this point. Use of these products may also be subject to stricter regulations due to the possible adverse effects they may have on the environment, making them a less sustainable option, an issue that has become a central focus in global aquaculture, (Phillips et al, 2001).

The effects of salinity were mainly researched in combination with other variables, with the exception of one study that manipulated salinity levels only. This is an area that requires more research in India, Thailand and Vietnam, particularly as research conducted in other countries has indicated that tolerance to salinity levels is species-specific, (Kumlu et al, 2001).

All interventions relating to water flow and aeration of systems were conducted on species of fish. Variation in the types of systems used to rear fish and shrimp may account for some of this, as well as providing support for the high proportion of studies on water quality in Thailand being on this topic. This is because the use of recirculation systems is increasing in more intensive aquaculture practice, (Funge-Smith and Phillips, 2001), which is used to a greater extent in Thailand compared to India and Vietnam. The most commonly investigated effects were the rates of water flow, with some interest in circulation. Water aeration however received little attention. This is surprising as oxygen uptake and regulation in aquatic animals is crucial and can have serious effects on their survival, metabolism and susceptibility to disease, (Cheng et al, 2003; Dabrowski et al, 2003; Evans et al, 2003).

The very limited research on water temperature, hardness and pH is also surprising and highlights other areas where intervention trials are needed in India, Thailand and Vietnam. These parameters also have effects on the metabolic functioning of aquatic animals, disease susceptibility, and susceptibility to toxic metals and compounds, and have received research interest in other countries, (Pyle et al, 2002; Aritaki et al, 2004; Cogun and Kargin, 2004; Foott et al, 2004).

Overall, water quality has been a fairly active area of research. The lack of studies from Vietnam however highlights this as an area requiring urgent attention. With the majority of research having been carried out on fish, there is also a need for a more diverse range of factors relating to water quality to be investigated in shrimp. There also needs to be a focus on the effects of basic water quality parameters such as pH and temperature, as the attention so far has been predominantly on the use of fertilisers and the effects of toxic substances. The use of natural products for fertilisation however is encouraging in relation to the promotion of sustainability in aquaculture in Asia.

CHAPTER 7. DISEASE: SPECIES, INTERVENTIONS AND OUTCOME MEASURES

7.1 INTRODUCTION

Diseases of aquatic animals are an increasing problem on a global scale, (Chen, 1996; Shariff, 1998; Ghittino et al, 2003). As with terrestrial animals, diseases can be infectious or non-infectious. These include viral and bacterial diseases and metazoan and protozoan parasitic infections.

In India, Thailand and Vietnam new diseases of aquatic animals are continuing to be identified, as indicated by the growing number of diseases being reportable to the OIE. Between 2000 and 2003, two new diseases of farmed fish species were added to the list of reportable diseases for Thailand and Vietnam, (OIE, 2004(a)). These were viral haemorrhagic septicaemia and red sea bream iridoviral disease.

The increase in international trade of aquaculture products, particularly from Thailand, has made the control and reduction of disease of major importance. In Thailand, losses from shrimp diseases rose from $30 million US in 1992 to $600 million US in 1997, (Subasinghe et al, 2001). For India the losses have been higher, totalling $17.6 million US in 1994 alone, (Subasinghe et al, 2001). To improve or maintain the international competitiveness of countries affected by disease, research into their treatment and management is therefore crucial.

The implementation of restrictions and regulations regarding the disease status of aquatic animals has also contributed to this. Many codes have now been implemented regarding the transportation of aquatic animals internationally, (Turner, 1988; OIE, 2000). There also exist regional and national codes. For example, Thailand implemented the Code of Conduct for Marine Shrimp Farming. Such regulations have an impact on disease in aquaculture and emphasise the need for ongoing research to reduce this impact and limit monetary losses, particularly for developing countries.

Interventions to reduce the effects of disease can take a variety of forms including epidemiological, husbandry or systems approaches where the production process as a whole is taken into consideration, (Subasinghe et al, 2001). Treatments can include the use of chemotherapeutant agents by oral or immersion methods. Prevention can include not only vaccination and the use of immuno-modulators but also husbandry and management practices that prevent disease entering a farm and spreading between ponds and farms. A more recent development is the use of probiotics, microorganisms that have a beneficial effect on the bacteria within the intestine of an animal.

The aim of this chapter is to present information on the types of interventions and the species and diseases studied.

7.2 MATERIALS AND METHODS

Studies were allocated to different sub-categories based on the comparators used. Studies that did not fit into any specific groups were allocated to an ‘other’ category.

7.3 RESULTS

7.3.1 Numbers of studies

Twenty-one studies were categorised as disease related. All were from either India or Thailand (Table 32), with an almost equal distribution between two, (48% and 52% respectively). The reports fell into 3 subcategories in which the use of immuno-modulators, specific disease treatments and probiotics was described (Table 32). Two reports did not fit into these three groups and were placed in a fourth 'other' subcategory.

Table 32. Subcategories of studies classified as disease related stratified by country.

Subcategory	India	Thailand	Vietnam	Total
Immuno-modulators	5	4	0	**9**
Treatments for specific diseases	3	5	0	**8**
Probiotics	2	0	0	**2**
Other	0	2	0	**2**
Total	**10**	**11**	**0**	**21**

A similar proportion of studies reported the effects of immuno-modulators and specific disease treatments, (43% and 38% respectively). The immuno-modulators included immuno-stimulants and immuno-suppressors. Two studies reported on the use of probiotics.

7.3.2 Species of study

Almost two thirds (62%) of the studies in the disease related category involved species of shrimp (Table 33).

Table 33. Frequency of disease related studies stratified by species.

Sub-category	**Number of studies**								**Total species**
	Fish					**Prawns**			
	Total Fish	**Carp**	**Tilapia**	**Cat-fish**	**Other spp.**	**Total Prawn**	**Penaeus**	**Macro-brachium**	
Immuno-modulators	**5**	5	0	0	0	**4**	4	0	**2**
Treatments for specific diseases	**3**	1	0	2	0	**5**	4	1	**7**
Probiotics	**0**	0	0	0	0	**2**	2	0	**1**
Other	**0**	0	0	0	0	**2**	2	0	**1**
Total	**8**	**6**	**0**	**2**	**0**	**13**	**12**	**1**	**8**

Of the 13 shrimp studies, 12 (92%) were conducted on *Penaeus monodon* and one on *Macrobrachium rosenbergii.* The use of immuno-modulators was reported in a third of these studies, specific disease treatments accounted for a further third and the remainder fell into the probiotic and other categories.

Of the 8 fish studies, carp (rohu and catla) were used in 6 and catfish (*Clarias macrocephalus*, *Clarias gariepinus* and a hybrid of the two) in the remainder. Two thirds (63%) of these studies reported on the use of immuno-modulators and the other third (37%) specific disease treatments. No studies on the use of probiotics in fish culture were reported.

A higher proportion (56%) of immuno-modulator studies involved species of fish, whereas a higher proportion (63%) of studies on specific disease treatments involved shrimp.

7.3.3 Outcome measures

Survival was the most common outcome measure used, in 62% of studies, (Table 34).

Table 34. Numbers of disease studies using different outcome measures, stratified by sub-topic.

Outcome measure	Subcategory				Total
	Immuno-modulators	Treatments for specific diseases	Probiotics	Other	
Total harvest weight	0	0	1	0	**1**
Mean weight at harvest	4	0	1	1	**6**
Mean weight gain	1	0	2	0	**3**
Mean daily weight gain	0	0	1	0	**1**
Specific growth rate	0	1	1	0	**2**
Gross yield	0	0	0	0	**0**
Net yield	0	0	0	0	**0**
Survival	3	7	2	1	**13**
FCR	2	1	1	0	**6**
Other	9	4	2	1	**16**

Mean weight at harvest and FCR were used in six studies each, (29%), followed by mean weight gain in three studies, (14%). Specific growth rate, mean daily weight gain and total harvest weight were used to a lesser extent, and the production measures of gross and net yield were not used at all. Additional measures, as used in 16 (76%) studies, included blood parameters and antibody titres.

7.3.4 Details of comparators

7.3.4.1 Shrimp: Immuno-modulators

The use of immuno-modulators in shrimp is summarised in Table 35. Two *Penaeus monodon* studies examined the dose response effects of immunostimulants or prophylactics in the diet. One of these used a commercial form of B-Glucan (MacroGard®) and the other used lactoperoxidase, an immunoprophylactic against *Vibrio* sp. The other two shrimp studies carried out challenge tests, including an immersion treatment with the immunostimulant B-Glucan (MacroGard®) followed by, in one experiment, an injection with *Vibrio harveyi*, and providing increasing amounts of peptidoglycan followed by an injection with either yellow head baculovirus or a sterile lobster haemolymph medium.

Table 35. Immuno-modulator treatments reported.

Immuno-modulator	Route	Challenge	Reference
Lactoperoxidase	Oral	N/A	Visitvithayagorn, 2000
B-Glucan	Oral	N/A	Supamattaya and Pongmaneerat, (a)
B-Glucan	Immersion	*Vibrio harveyi*	Supamattaya and Pongmaneerat, (b)
Peptidoglycan	Oral	Yellow head baculovirus	Boonyaratpalin and Boonyaratpalin, 1995

7.3.4.2 Shrimp: Treatments for specific diseases

Three studies on specific diseases conducted intervention trials on the influence of exposure to various factors on the effects of Vibriosis, (Table 36). Two involved treatment and one involved oral and immersion vaccination.

Table 36. Specific shrimp disease treatments reported.

Disease	Treatment	Route	Challenge	Reference
Vibriosis	Norfloxacin nicotinate	Oral	Bacterial injection	Kamnertmanee, 1997
Vibriosis	Romet-30®	Unknown	Vibriosis bacteria injection	Rochanasiri, 1995
Vibriosis	Bacterin	Immersion and oral	Vibrio pathogen or photobacterium	Vici et al, 2000
Lagenidium	Trifluralin (Treflon)	Immersion	N/A	Ramasamy et al, 1996
Unknown	Oxolinic acid	Unknown	Unknown	Suetorsak, 1994

One of these treatment studies investigated the effect of norfloxacin nicotinate, (a fluoroquinolone antimicrobial), on a bacterial challenge, and in the other Romet-30® (a combination of sulfadimethoxine and ormetaprim), was used. In the vaccine study, shrimp were bathed in a bacterin solution every seven days and provided with a bacterin yeast feed, following which half were challenged with either a strain of Vibrio sp. or a photobacterium.

In addition, one study investigated the effects of a treatment for the fungi Lagenidium in infected animals, using increasing dosages of the anti-fungal agent, trifluralin (Treflon). The fifth study investigated the effects of increasing amounts of oxolinic acid, a quinolone antimicrobial agent.

7.3.4.3 Shrimp: Probiotics

Both studies using probiotics were conducted on *Penaeus indicus*. One of these studies, (Ravi et al, 1998), investigated the effects of increasing amounts of the probiotic 'NS Series Super SPO', (NU Genes Technologies, USA), provided in the water. The second study, (Uma et al, 1999), provided increasing supplementation with the probiotic Lactosacc®, (Vet-Care Altech Company Ltd., India), a micro-encapsulated bacteria containing a strain of the yeast *Saccharomyces* sp., following which animals were then challenged with the *Vibrio alginolyticus* bacterium by immersion.

7.3.4.4 Shrimp: Other

Both of the studies in this category were conducted on *Penaeus monodon.* One study looked at the difference between feeding a normal diet or one supplemented with the antioxidant astaxanthin on the effects of either a *Vibrio haemolyticus* or *V. alginolyticus* injection, (Chucherd, 1995). The second study compared the effects of stocking animals that had been identified as positive for white spot syndrome virus with those that were negative, (Withyachumnarnkul, 1999).

7.3.4.5 Fish: Immuno-modulators

Five of the nine studies (56%) were conducted on species of fish, all of which used the carp rohu.

Three investigated the effects of using immunostimulants and suppressors. One studied the effect of different types of immunostimulant, (including Beta-1,3 glucan, ascorbic acid, alpha-tocopherol and levamisole), on animals either positive or negative for the immunosupressor aflatoxin B1, (Sahoo and Mukherjee, 2002(b)). Fish were then challenged with *Edwardsiella tarda* bacterin. In a similar study, animals either given a single aflatoxin injection or left immunosupressor-free, were supplemented or not with alpha-tocopherol, (vitamin E - an immunostimulant), (Sahoo and Mukherjee, 2002(a)). Samples of fish from each group were then challenged by intraperitoneal injection with either pathogenic *Aeromonas hydrophila* or *Edwardsiella tarda.* The third study looked at the immunosuppressive effects of increasing concentrations of aflatoxin, followed by intraperitoneal injection with formalin-killed *Edwardsiella tarda*, (Sahoo and Mukherjee, 2001).

In the other two studies animals exposed to immunostimulants or suppressors were challenged with various bacteria or viruses. One looked at the effects of administering the immunostimulant chitosan and the immunosuppressor cortisol either alone or combined in fish positive or negative for the bacterium *Edwardsiella tarda*, (Sahoo and Mukherjee, 1999). The other looked at the effects of exposure to formalin-killed *E. tarda*, levamisole hydrochloride, (an immunostimulant), the probiotic 'Bioboost' and ascorbic acid alone, in combination, or with a dose of sheep red blood cells, (Sahoo et al, 1999).

7.3.4.6 Fish: Treatments for specific diseases

Of the three (38%) studies that looked at specific treatments, one used the carp catla and rohu, and two used catfish species including *Clarias gariepinus, Clarias macrocephalus* and a hybrid of these two.

One study immersed animals in various antibiotics, including chloromphenicol, oxytetracycline, ampicillin and chloramine, and compared the effects on growth and survival to a non-exposed group, (Sultana, 1994). Another used a challenge method in which animals exposed to increasing concentrations of *E. tarda* were challenged with a set concentration of this bacterium for increasing time periods, (Swain et al, 2002). The third study compared the effect of parenteral vaccination with an *Aeromonas hydrophila* bacterin with unvaccinated animals on challenge with virulent *A. hydrophila*, (Areechon and Karoon, 1995).

7.3.5 Outcome measures

7.3.5.1 Immuno-modulators

Mean weight at harvest was used in two of the five fish studies (40%). For the shrimp studies, survival was the most common measure (75% of studies). FCR, mean harvest weight and mean weight gain were all used to a lesser extent. None of the production measures, (total harvest weight, gross and net yield), were used across all studies, nor were mean daily weight gain and specific growth rate. All nine studies used additional measures, which included bacterial antibody titres and the protein, albumin and globulin content of the blood amongst others.

7.3.5.2 Treatments for specific diseases

In the studies on shrimp, survival was measured in 80%. For fish, survival was the most common measure, with specific growth rate and FCR being used to a lesser degree. No production measures were used in any of the studies. Measures additional to those specified were used in 50% of studies. These included antibody titres, LD50 values and percentage moulting rates (of shrimp).

7.3.5.3 Probiotics

Due to the small sample size, it is difficult to see which outcome measures are the most commonly used, however one or both of the studies used all measures apart from the gross and net yield. Additional measures across both studies included the mean length at harvest, the mean length gain and the mean assimilation efficiency.

7.3.5.4 Other

One study each recorded the mean weight at harvest and the survival. Additional measures, as used in one of the studies, included those related to the failure of populations within ponds exposed to different conditions.

7.3.6 Study design and the use of randomisation

Only one study, (Withyachumnarnkul, 1999), was a field trial carried out in on-farm conditions in earthen ponds. This study investigated the effects of stocking WSSV positive or negative shrimp. All the remaining studies, (20; 95%), were conducted under experimental conditions where the units of study were tanks or aquaria, pools, concrete ponds or experimental troughs. Only one clinical trial was conducted also, (Ramasamy et al, 1996), which involved the use of a population of shrimp infected with the fungus *Lagenidium* sp. and comparing the performance of anti-fungal treated and untreated animals. This however was conducted in experimental conditions using concrete tanks. No clinical field trials were conducted.

Details on the randomisation procedures used could not be obtained for 6, (29%), studies because these were only available in Thai and insufficient time prevented extraction of this information. Of the remaining 15 studies, 9, (60%), did not state if there were any randomisation procedures carried out in the study. Three, (20%), studies stated that animals were randomly allocated to treatment groups only, with a fourth randomly selecting animals for bacterial agglutination titres also. A fifth study randomly selected animals for antibody titres as well. All of these studies involved fish. The final study, (also the only field trial), randomly stocked ponds with shrimp either positive or negative for WSSV, and shrimp from individual ponds were also randomly sampled for PCR to detect their disease status. No randomised clinical field trials were therefore conducted.

7.4 DISCUSSION

Studies on aspects relating to diseases of aquatic animals contributed a relatively small proportion to the overall number selected for this review, (14%). This is surprising considering the increase in aquatic animal disease in Asia that has occurred, and the impact it has on trade and profitability of the industry, (Subasinghe, 1997; Subasinghe et al, 2001). Despite the growth in aquaculture, the income or GDP generated from this in India, Thailand and Vietnam may not have been sufficient to fund comparatively expensive disease research. Instead it may be that research into the nutrition of aquatic animals is a more cost-effective use of money. Subasinghe et al, (2001), stated that the rate of expansion in the aquaculture industry has surpassed the amount of research and uptake of outputs from this research in health management. The results from this review appear to highlight the same problem.

A similar number of studies came from India and Thailand, but none at all from Vietnam. Overall Thailand had the greatest proportion of disease related studies. This may be because Thailand, being the biggest exporter of aquaculture products in Asia, is subject to more regulations and restrictions regarding the international transportation of animals. Consequently more research may be required to minimise disease occurrence in these export crops, whereas in India, internal transportation and movement of aquatic animals may limit the impact of disease on the market and profitability of the industry.

In contrast, Vietnam whose aquaculture industry is less established than India's and Thailand's, may have allocated the limited resources available to expanding and improving the sustainability of the industry rather than to disease research. Moves towards more semi-intensive methods of production may have received more attention than preventing the spread of diseases. However, as aquatic animal disease is a big problem in Vietnam too, with losses of approximately $300,000 per year for rice-shrimp farmers, (Subasinghe et al, 2001), there is an obvious need for increased research into aspects of disease in this country.

Another interesting trend identified from the studies was that approximately two thirds were on shrimp. This suggests that disease is perceived as having more impact in these animals compared to fish. However, the OIE list of notifiable aquatic animal diseases, (OIE, 2004(a)), indicates a greater number of diseases in fish than shrimp in India, Thailand and Vietnam. It is possible that the greater amount of disease research in shrimps in the target countries is because these species are more valuable crops than fish. In 1996, world aquaculture figures from FAO, (FAO, 1999), indicated that although fish production was higher than that of crustaceans, the relative value of the latter species was much greater. Consequently funding will be better spent on disease research in shrimp.

One of the most common diseases studied in this review was Vibriosis in shrimp. This disease is a big problem in all three target countries as shown by its presence on each country's OIE list of notifiable diseases. A study by Vaseeharan and Ramasamy, (2003), found that *Vibrio harveyi* and *Vibrio anguillarum* were the predominant forms of bacteria in the water of *Penaeus monodon* hatchery systems in India. Despite this, the inability to vaccinate against shrimp pathogens, (Subasinghe et al, 2001), has limited the treatment of this disease. Consequently, the interventions being investigated in this review involved methods alternative to vaccination. Bechteler and Holler, (1995), stated that antibiotics were the only means of preventing Vibriosis and that more research is required into the immune system of shrimps before a vaccine can be developed. Quite surprisingly, there were no intervention trials on treatments for white spot disease syndrome, a disease that has caused widespread losses for shrimp farmers across all of the target countries and has received a lot of general research interest, (Corsin et al, 2002; Madhusudhan et al, 2002; Menasveta, 2002).

The immune system of shrimp, being relatively under-developed, means that immuno-modulation is seen as a more effective option. Substances sometimes used for this include glucans and killed bacterial cells. In this review, two shrimp studies on immuno-modulators carried out challenge experiments following administration of a particular stimulant. Smith et al, (2003), however analysed the validity of a range of studies investigating the effects of immuno-stimulants in shrimp and concluded that more research is required as well as the need to consider other methods of treatment. Bachere, (2000), also highlights the lack of knowledge of the physiology of shrimp and in turn their immunology, areas crucial for disease control.

In fish, similar immuno-modulators were used to those in shrimp. However, as fish have a more developed immune system, vaccination is possible in these species. Two studies in this review looked at the effects of vaccination against *Edwardsiella tarda* and *Aeromonas hydrophila*. These are bacterial diseases of fish that cause edwardsiellosis or haemorrhagic septicaemia and motile Aeromonas septicaemia respectively and are characterised by a variety of pathological changes, including internal lesions of vital organs and necrosis or haemorrhaging of the skin, (Shakitla et al, 1999; Darwish et al, 2000) They have become increasingly prevalent in India, Thailand and Vietnam, and are therefore of great economic importance. Vaccination is therefore a very cost-effective method of control.

One study looked at the effects of a wide range of antibiotics. Indiscriminate use of these substances since their introduction, both in shrimp and fish farming, and the rise in antibiotic resistance in a wide range of species has generated a lot of research interest in their use, (Depaola et al, 1995; Petersen and Dalsgaard, 2003). A similar problem has been seen with terrestrial animals, where increased antibiotic use has been associated with widespread resistance in agriculture on a global scale, prompting much research (Docic and Bilker, 2003; Langford et al, 2003; Esaki et al, 2004). In aquatic environments however, this problem may be exacerbated by more contact between animals and by administering large quantities of antibiotics to large groups without taking into consideration the health status of individual animals. The effect that residues of these substances in farmed animals had on trade, particularly in Thailand in 2002, (Food Market Exchange, 2003), has lead to a decrease in antibiotic usage.

Interestingly, the use of probiotics was only reported in shrimp. This is perhaps surprising, as use of these substances in fish has been researched in many other countries, (Robertson et al, 2000; Lara-Flores et al, 2003; Nikoskelainen et al, 2003). Possible reasons for the small amount of research in this area overall may be related to the difficulties in keeping these bacteria alive in dry feed formulations, and the little knowledge of what happens to probiotics in the gastrointestinal tract, (Gatesoupe, 1999).

The lack of clinical trials and trials carried out in field conditions highlights an important need to improve the design and quality of studies investigating aspects of disease in aquatic animals. The majority of studies were conducted in experimental or laboratory conditions, which limits their validity and application in aquaculture practice. Also surprising was the limited use of randomisation procedures. Only a small proportion of studies mentioned the use of randomisation, of which an even smaller number randomly allocated animals to treatment groups. Cochrane systematic reviews focus mainly on randomised controlled trials, (Clarke and Oxman, 2002). The poor quality of study designs and the lack of randomisation in aquatic animal disease intervention trials in the three target countries therefore limits the ability to carry out a systematic review specifying this type of study design.

Overall, there appears to have been a shortage of studies on disease in Vietnam, with Thailand contributing the most to disease research in relation to the proportion of research allocated to this subject. Vibriosis has been the most common disease researched, with other diseases of great economic importance having received little or no attention. A high proportion of studies from the target countries have been carried out on shrimp and this may reflect the higher relative value of these species. There is a clear need for more intervention trials into a wider range of aquatic animal diseases and on a wider range of species. Vietnam in particular will need to contribute to this and the use of randomised clinical and field trials will have to be improved.

CHAPTER 8. ADDITIONAL INTERVENTION TOPICS: POLYCULTURE, GENETICS, LIGHT AND OTHER.

8.1 INTRODUCTION

Aquatic animal health issues span a wide range of topics. A consequence of this diversity however, is that some subjects receive relatively little research interest. This chapter describes studies, which numerically, form a minor component of the review.

Polyculture, the process of rearing different developmental stages or species of fish or shrimp or both together, has been advocated as a method of promoting sustainable aquaculture, (FAO, 2001), particularly in developing countries. Stocking different species that utilise different niches can improve an aquaculture system by stabilising the aquatic environment and/or reducing feed requirements, (Brzeski and Newkirk, 1997). In addition, farming multiple species will provide added revenue for the farmer.

Another method used to improve aquatic animal health is genetics. This is a relatively new area, particularly in developing countries. Many different types of genetic intervention exist, ranging from genetic crosses between different species, to genetic selection and manipulation and the production of disease resistant strains. Although relatively new to aquaculture, it has been widely used in agriculture, (Elsen, 2003; Wheeler, 2003; Rohrer, 2004).

Photoperiod and other aspects of light manipulation are also included in this group of studies. This can involve altering the exposure time of animals to light, manipulating the intensity of the light or changing the ratio of shade and light available. The aims of such interventions might be to induce spawning or influence spawning behaviour, (Ridha and Cruz, 2000; Hansen et al, 2001).

The aim of this chapter is to present information on the range of interventions that have been carried out on topics that have received relatively little attention in India, Thailand and Vietnam in comparison to feed and nutrition, water quality and disease. Again, the species that have been used and the outcome measures will be summarised.

8.2 MATERIALS AND METHODS

Topics that only contained a few studies were not separated into sub-categories. Studies that fell in the 'other' group were sub-categorised according to the type of intervention carried out and the species, treatments and outcome measures summarised accordingly.

8.3 RESULTS

8.3.1 Polyculture

8.3.1.1 Numbers of studies

The 10 studies on this topic could not be subdivided into smaller categories. Five

(50%) were conducted in India, three (30%) in Thailand and one (10%) in Vietnam. For one study, the country in which the study was conducted was not clear.

8.3.1.2 Species of study

All studies involved species of fish and two used species of shrimp in addition. Across all studies, 10 different species were used, nine of which were fish and one a shrimp, (Table 37).

Table 37. Numbers of polyculture studies conducted on different groups of fish and shrimp species.

Number of studies								Total species
Fish	**Carp**	**Tilapia**	**Catfish**	**Other spp.**	**Prawn**	**Penaeus**	**Macro-brachium**	
10	7	4	1	1	**2**	0	2	**10**

Carp were the most common species of fish used (70% of studies) and included the common carp, rohu, catla, mrigal, grass carp and silver carp. Four (40%) used Nile tilapia, and one used hybrid catfish. The silver barb was also used in one study. Three of these studies used species from more than one group of fish, therefore the total from each group adds up to more than the total number of studies. *Macrobrachium malcolmsonii* was used in two studies, but only with species of fish.

8.3.1.3 Interventions

Four studies used combinations of the Indian major carp, Rohu, Catla and Mrigal alone or in combination with the exotic common, silver and grass carp, (Jena et al, 1998; Basavaraju et al, 2002; Gjerde et al, 2002; Reddy et al, 2002).

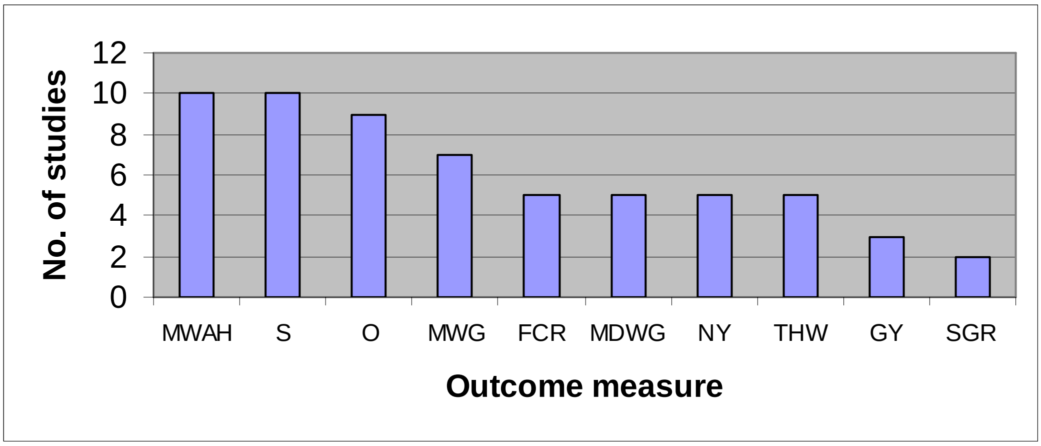
Three studies tested various combinations of catfish and tilapia (Kwei Lin and Diana, 1995; Rothuis et al, 1998; Yi et al, 2003), and in one of these, (Rothuis et al, 1998), silver barb were also used. Yi et al, (2003), looked at the difference between an integrated pen-cum-pond system containing hybrid catfish and tilapia with natural or artificial water circulation, with a non-integrated system containing hybrid catfish only. Interestingly, one study compared the co-culture of the lotus plant and Nile tilapia with the monoculture of each species individually, (Yi et al, 2002).

The first of two studies looking at polyculture of fish and shrimp, was Mohire et al, (1993), who compared the culture of catla, rohu, silver carp and common carp alone, and *Macrobrachium rosenbergii* alone, with polyculture of all of these species together. The second, (Naik and Murthy, 1999), again used *Macrobrachium rosenbergii*, and compared monoculture with polyculture with the carps catla and rohu.

8.3.1.4 Outcome measures

All studies recorded mean weight at harvest and survival, (Figure 8.1). Mean weight gain was used in seven (70%) studies, and FCR, mean daily weight gain, net yield and total harvest weight in half of the studies each. Gross yield and specific growth rate were the least commonly used measures.

Fig. 8.1. Numbers of polyculture studies that used each outcome measure.



Key:

MWAH:	Mean weight at harvest	MDWG:	Mean daily weight gain
S:	Survival	NY:	Net yield
O:	Other	THW:	Total harvest weight
MWG:	Mean weight gain	GY:	Gross yield
FCR:	Feed conversion ratio	SGR:	Specific growth rate

All but one study used measures in addition to those specified, including the length at harvest, the protein efficiency ratio and the percentage moisture, nitrogen and phosphorus content of animals.

8.3.2 Genetics

8.3.2.1 Numbers of studies

Two of the three studies were conducted in India and the other in Thailand. No studies from Vietnam were selected for inclusion.

8.3.2 2 Species of study

All three genetics studies were conducted on species of fish, (Table 38).

Table 38. Numbers of genetics studies conducted on different groups of fish and shrimp species.

Number of studies								Total species
Fish	**Carp**	**Tilapia**	**Catfish**	**Other spp.**	**Prawn**	**Penaeus**	**Macro-brachium**	
3	2	1	0	0	**0**	0	0	**5**

Across these three studies, a total of five species of fish were used, including the carp catla, rohu, the fringe-lipped carp and the common carp. The Nile tilapia was used in one study.

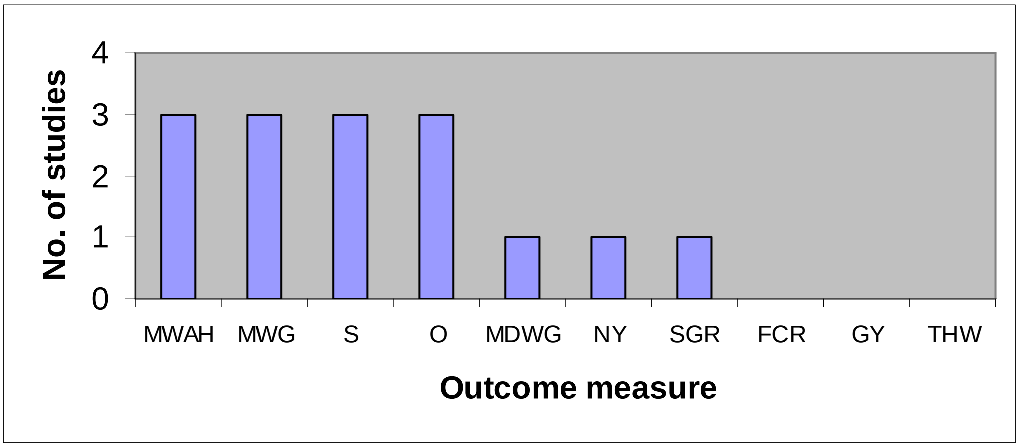
8.3.2.3 Interventions

The three interventions were a comparison of diploid and triploid common carp in monoculture or polyculture, (Basavaraju et al, 2002), various crosses between catla and fringe-lipped carp with pure strains of each species, (Basavaraju et al, 1995), and genetically male or sex-reversed male Nile tilapia produced from pure strains or from various crosses, (Tuan et al, 1998).

8.3.2.4 Outcome measures

All three studies measured mean weight at harvest, mean weight gain and survival, (Figure 8.2).

Fig. 8.2. Numbers of genetics studies that used each outcome measure.



Key:

MWAH:	Mean weight at harvest	MDWG:	Mean daily weight gain
S:	Survival	NY:	Net yield
O:	Other	THW:	Total harvest weight
MWG:	Mean weight gain	GY:	Gross yield
FCR:	Feed conversion ratio	SGR:	Specific growth rate

No studies measured total harvest weight, gross yield or FCR. All three studies also recorded additional measures, including the sex of animals, the gonadosomatic index and the feed conversion efficiency.

8.3.3 Light

8.3.3.1 Numbers of studies

Two of the three studies were conducted in India and one in Thailand.

8.3.3.2 Species of study

Two studies were conducted on species of fish and one on shrimp, (Table 39).

Table 39. Numbers of light studies conducted on different groups of fish and shrimp species.

Number of studies								Total species
Fish	**Carp**	**Tilapia**	**Catfish**	**Other spp.**	**Prawn**	**Penaeus**	**Macro-brachium**	
2	1	0	1	0	**1**	0	1	**5**

In one of the fish studies the carp catla, rohu and mrigal were used and in the other, the catfish *Clarias macrocephalus* and *Clarias gariepinus*, totalling five species overall. The shrimp *Macrobrachium malcolmsonii* was also used in one study.

8.3.3.3 Interventions

Each of the three studies used different comparators. Chughtai, (1995), looked at the effects on catfish of increasing the percentage plant cover of water with the water spinach *Ipomoea aquatica*, from 0% up to 75%. The other two studies looked at the effect of providing supplementary light. Kanaujia et al, (1999), using *Macrobrachium malcolmsonii*, compared exposure to natural daylight for 11 hours a day with exposure to a higher photointensity of 2000-4000 lux, by means of fluorescent tubes. Rao and Singh, (1993), looked at the effects on carps of providing additional light to give a 14-hour exposure.

8.3.3.4 Outcome measures

Results on mean weight at harvest, mean weight gain, mean daily weight gain, net yield and survival or mortality of animals were provided in the catfish study only.

The other two studies used measures alternative to those specified and included the number of dead animals accumulated, the gonadosomatic index and the number of berried female shrimp.

8.3.4 Other

8.3.4.1 Numbers of studies

The 41 studies that did not fit into any of those already mentioned were broadly classified into seven subcategories, (Table 40).

Table 40. Numbers of 'other' studies conducted on different sub-topics, stratifying by country.

Subcategory	India	Thailand	Vietnam	Total
Reproduction and hatching	9	4	2	**15**
Hormones	7	0	0	**7**
Integrated farming	0	0	5	**5**
Stress	1	1	0	**2**
Anaesthetics	2	0	0	**2**
Substrates	1	0	0	**1**
Other	6	2	1	**9**
Total	**26**	**7**	**8**	**41**

The topic of reproduction and hatching contained the highest proportion of studies (37%), followed by hormones (17%). Five studies, (12%), were conducted on the use of integrated farming systems. Studies on substrate effects, stress and anaesthetics formed a small component of studies. Nine studies (22%) did not fit into any of these categories and were allocated to an 'other' group.

A high proportion of studies, (63%), were conducted in India, and an almost even proportion in Thailand and Vietnam, (17% and 20% respectively). There was no significant difference using chi-squared analysis, ($p>0.05$), between countries in the distribution of studies across the different subcategories.

8.3.4.2 Species of study

Across all studies, 24 species were used, 20 (83%) of which were fish and 4 (17%) of which were prawns, (Table 41). Carp species included the common carp, mrigal, rohu, catla, silver carp and grass carp. Catfish species included *Clarias gariepinus, Clarias macrocephalus, Heteropneustes fossilis* and *Pangasius bocourti.* The Nile tilapia was also used.

Table 41. Numbers of 'other' studies conducted on different groups of fish and shrimp species, stratifying by sub-topic.

Sub-category	Number of studies								Total species
	Fish	Carp	Tilapia	Catfish	Other spp.	Prawn	Penaeus	Macro-brachium	
Reproduction and hatching	**13**	4	4	4	2	**2**	2	0	**10**
Hormones	**7**	5	0	0	2	**0**	0	0	**5**
Integrated farming	**5**	5	5	1	5	**0**	0	0	**8**
Stress	**2**	0	1	0	1	**0**	0	0	**2**
Anaesthetics	**1**	1	0	0	0	**1**	1	0	**2**
Substrates	**0**	0	0	0	0	**1**	0	1	**1**
Other	**6**	2	2	0	2	**4**	1	3	**12**
Total	**34**	**17**	**13**	**5**	**12**	**8**	**4**	**4**	**24**

From 41 studies, 34 (83%) involved species of fish and 8 (20%) involved species of prawn. One study used species from both groups, accounting for the higher number of studies combined. Of the studies on fish, 17 (50%) used at least one species of carp, 13 (38%) used a species of tilapia and 5 (15%) a species of catfish. In addition, 12 (35%) studies used species that were not from any of these groups. The group totals add up to more than the number of studies as many studies used species from more than one group of fish. Of the 8 studies on prawns, four (50%) each used species of *Penaeus* and *Macrobrachium*.

8.3.4.3 Outcome measures

The most common outcome measure used across all studies was survival (61%), followed by mean weight at harvest, (54%), (Table 42).

Table 42. Numbers of 'other' studies using different outcome measures, stratifying by sub-topic.

Outcome measures	Subcategory							Total
	Reproduction and hatching	Hormones	Integrated farming	Stress	Anaesthetics	Substrates	Other	
Total harvest weight	0	1	1	0	0	0	2	**4**
Mean weight at harvest	5	7	4	1	1	1	3	**22**
Mean weight gain	2	5	0	0	0	1	2	**10**
Mean daily weight gain	4	0	4	0	0	0	1	**9**
Specific growth rate	1	3	3	0	0	0	0	**7**
Gross yield	2	0	4	0	0	0	2	**8**
Net yield	3	0	4	0	0	1	3	**11**
Survival	5	7	4	1	1	1	6	**25**
FCR	0	0	0	0	0	0	1	**1**
Other	13	7	1	2	2	1	6	**36**

Net yield, mean weight gain, mean daily weight gain, gross yield and specific growth rate were all used to a similar, (although lesser), extent in between 7 and 11 studies each, (17% to 27%). The least commonly used outcomes were total harvest weight and FCR. Additional outcome measures were used in 36 studies, (88%), and included the sex ratio or composition, the gonadosomatic index, (a measure of sexual maturity), and the percentage moulting rate of shrimp.

8.3.4.4 Details of comparators

8.3.4.4.1 Reproduction and hatching

Species: Thirteen of these studies were conducted on species of fish. Of these, 4 (31%) used one or more of the carps, rohu, catla, mrigal and common carp, 4 used Nile tilapia, 4 (31%) used the catfish, *Heteropneustes fossilis, Pangasius bocourti* or *Clarias macrocephalus*, (the Thai walking catfish), and two used the Deccan mahseer and striped gouramy respectively, including one study that used both Nile tilapia and rohu.

Of two studies on shrimp, one used *Penaeus semisulcatus* and one used *Penaeus monodon*.

Interventions: Two of the studies on carps were concerned with embryo storage. One involved equilibrating embryos in different concentrations of methanol and storing them in differing concentrations of methanol alone or with trehalose at different temperatures and durations, (Ahammad et al, 2002). The other study compared the effects of storage in a range of substances, including chilled or natural water, methanol, methanol and sucrose, glycerol, glycerol and sucrose, dimethylsulfoxide

(DMSO, a cryoprotectant that stops crystals of ice forming when cells are frozen), and DMSO and sucrose, (Ahammad et al, 1998). Gupta and Rath, (1993), looked at the performance of carp produced from fresh milt and that of fish produced from milt that had been cryopreserved.

The study involving Nile tilapia and rohu, (Little et al, 2000), investigated the effects of different broodfish exchange procedures of Nile tilapia in spawning hapas. Each exchange varied in time, whether or not animals had undergone a period of conditioning and whether or not rohu were also stocked.

Of the other three studies on Nile tilapia, one investigated different methods of exchanging fish in relation to the conditioning and spawning cycle, (Little et al, 1993). Two involved the use of broodfish. Dan and Little, (2000(b)), conducted four separate experiments. The first two involved stocking different strains of Nile tilapia individually or communally in different types of units, and the second two involved stocking monosex Nile tilapias that were small or large in size in deep hapas. Little et al, (1996), compared the effects of increasing the number of days conditioning before the exchange of females in spawning hapas amongst other comparators.

In the catfish studies, one investigated the effects of photothermal treatment on the response to sGnRHa and the effects of repeated administration of this hormone, (Alok et al, 1998). Another study compared the use of different ‘preparatory steps’ and ‘resolving steps’, involving respectively the administration of different numbers of HCG injections at a fixed dose and different doses of HCG a certain period of time after the last preparatory step, (Cacot et al, 2002). The third study involved three experiments across which the use of cold-shocks and heat-shocks for inducing fertilisation and the use of UV-irradiated and normal sperm with or without supplemental hormone injections were investigated, (Na-Nakorn, 1995). In the fourth study, (Francis, 1999), five different methods of inducing spawning were compared including an injection of pituitary extract, HCG, both together, leutinising hormone releasing hormone, (LHRH), and ovaprim.

In the mahseer study, (Basavaraja et al, 2002), different durations of milt equilibration were compared, each with different concentrations of DMSO. The study on the stripped gouramy, (Pandey, 1998), looked at the use of biocides to inhibit reproduction by comparing the outcomes from fish reared in dechlorinated tap water with and without the biocide 'emisan', with fish that had been killed without any of these exposures.

Both of the studies on shrimp investigated eyestalk ablation. Removal of the eyestalk leads to increased ovulation through the reduction of ovarian inhibitory hormone, which is produced by glands in the eyestalk. Kathiresan and Moorthy, (1996), compared the performance of prawns with ablated eyestalks with those that had intact eyestalks, and each either treated with UV or not. Murugesan et al, (1998), also compared the performance of prawns either eyestalk ablated or intact, each fed five different feeds.

Outcomes: In the studies on fish, the most common outcome measure was survival, although only used in 5 studies, (45%). Mean weight at harvest, net yield and mean daily weight gain were used in 3 studies each, (27%), and gross yield in two, (18%).

All but one study used measures alternative or in addition to those specified, including the gonadosomatic index, the spawning interval and the serum levels of sex steroids.

Both shrimp studies measured mean weight gain, with one study using mean harvest weight and mean daily weight gain also. The other study used measures alternative to those specified including the linear growth of animals, (ie. the length increase per animal), the protein and carbohydrate, DNA and RNA content of tissues and the DNA: RNA ratio.

8.3.4.4.2 Hormones

Species: All 7 studies were conducted on fish. Five studies (63%) were conducted on the common carp or mrigal, one on green chromide and one on pearlspot.

Interventions: Four of the studies, all on carp, involved the use of hormones for the purposes of sex-reversal. One looked at the effect of increasing concentrations of diethylstilbestrol, an oestrogen, (Basavaraja et al, 1997(a)), one at estrone, a naturally occurring oestrogen, (Sehgal and Saxena, 1997), and one at mibolerone, a synthetic androgen, (Sobhnana and Nandeesha, 1994). Basavaraja et al, (1997(b)), looked at increasing concentrations of the sex-reversal hormone norethindrone in the diet of animals for a period of 50 days, following which a hormone-free diet was delivered.

The other three studies focused on the growth promoting potential of hormones. Jayaprakas and Sindhu, (1996), compared a basal diet with one supplemented with HCG (Human Chorionic Gonadotrophin), testosterone propionate and both. The study on green chromide, (Sambhu and Jayaprakas, 1997(b)), consisted of two trials looking at the effects of administering increasing concentrations of the hormone L-thyroxine in the water and the feed respectively. The study involving pearlspot, (Sambhu and Jayaprakas, 1997(a)), investigated the effects of providing increasing concentrations of testosterone propionate in the diet.

Outcomes: All seven of these studies measured the mean weight of animals at harvest and survival. Mean weight gain, specific growth rate and total harvest weight were used to decreasing extents, in 5 (71%), 3 (43%) and one (14%) studies respectively. No studies recorded mean daily weight gain, FCR or gross and net yield. All studies used measures alternative to those mentioned, including the gonadosomatic index, the sex composition of animals, and the digestive enzyme activity in e.g. the stomach and gut.

8.3.4.4.3 Integrated farming systems

Species: Five studies were conducted using Vietnamese rice fields as the unit of study. Across the five studies, eight species of fish were used, with every study using a minimum of three species from multiple groups, (i.e. carp, tilapia and other), with the exception of catfish, which were not used at all. Species included the silver barb, common carp, silver carp, rohu, Nile tilapia, snakeskin gourami, giant gourami and *Clarias* sp.

Interventions: Two studies, (Rothuis et al, 1999; Vromant et al, 2001), looked at the effects of altering the rice seeding rate of rice fields in combination with the presence or absence of fish polyculture. The other three studies in this category all used the results from either three or eight experiments using rice fields to conduct a multiple regression of factors affecting the target species growth rate for example, (Vromant et al, 2001; Vromant et al, 2002(a); Vromant et al, 2002(b)). Variables included the rice seeding rate of fields and the stocking density of fish, in study designs such as a 2x2 factorial design, completely randomised design, (CRD), and completely randomised block design, (CRBD).

Outcomes: Mean weight at harvest, mean daily weight gain, gross and net yield, and survival were all used in all but one study each. Specific growth rate was calculated in three studies and total harvest weight in just one. Mean weight gain and FCR were not used in any of the five studies. All however, used additional measures such as the condition factor of animals and the yield of species of non-stocked fish.

8.3.4.4.4 Stress

Species: One study each of two investigating stress effects were conducted on the Nile tilapia and the tropical fish, *Liza parsia*.

Interventions: MacNiven and Little, (2001), stocked Nile tilapia fry at different densities with different amounts of supplementary feed, with one group receiving a two-minute bath treatment in 250ppm formalin prior to this. Each group was then challenged with 24ppt salinity and 500ppm formalin, acting as stressors. Mohapatra and Shanmugam, (1998), conducted three separate experiments on *Liza parsia* each involving the use of the dichlorvos Nuvan in the water, an organophosphate pesticide sometimes used to treat sea lice, and which causes biochemical stress. Dose response effects over time were investigated, including the use of different concentrations of 96-hour LC50 values.

<u>*Outcomes:*</u> One study used both mean weight at harvest and survival of animals. Both studies used alternative measures that included the final length, the condition factor of animals and the alkaline phosphotase and acid phosphotase ratio in the bloodstream, (a measure used as a biochemical stress indicator).

8.3.4.4.5 Anaesthetics

<u>*Species:*</u> Of the two studies investigating the effects of anaesthetics, one used the common carp as the target species and the other used the shrimp *Penaeus monodon*.

<u>*Interventions:*</u> Mohammad, (1999), looked at the effects of administering increasing concentrations of four different anaesthetics to the common carp, including 2-phenoxyethanol, quinaldine, MS-222, and benzocaine. In contrast, Salin and Jayasree-Vadhyar, (2001), looked at the anaesthetic effects on *Penaeus monodon* of reducing the water temperature from 25^{o}C to 14^{o}C over different time periods. These included 8 hours, (slow rate), 4 hours, (moderate rate), and 2 hours, (fast rate).

<u>*Outcomes:*</u> In *Penaeus monodon* mean harvest weight and survival were recorded but none of the other measures specified were used in either study. Both however, used additional measures including the induction time, (time taken to stop swimming), and recovery time and the percentage weight loss of animals after revitalisation from an anaesthetic.

8.3.4.4.6 Substrates

Species: The one study examining substrate effects was conducted on *Macrobrachium rosenbergii*.

Interventions: Nair et al, (1999), compared the effects of using 0, 26 and 40 PVC hideout tubes per tank to reduce antagonistic behaviour amongst individuals.

Outcomes: Mean weight at harvest, mean weight gain and survival were measured. The percentage moulting rate and percentage occupancy rate of substrates were some of the additional measures used.

8.3.4.4.7 Additional studies

Species: Of 9 studies that did not fit into any of the specified groups, 5 (56%) were conducted on fish, 3 (33%) on shrimp, and 1 on both fish and shrimp, including Nile tilapia and *Penaeus monodon* (target species). Of the fish studies, two used carp, including one on the common carp only and one on silver carp, catla, rohu, grass carp, mrigal and common carp together. One study each used the Nile tilapia, Malabar grouper, *Epinephelus malabaricus*, and the climbing perch. Of the three studies that used shrimp species only, two were on *Macrobrachium rosenbergii* and one was on *Macrobrachium malcolmsonii*.

<u>*Interventions:*</u> The 5 studies on fish all looked at very different comparators. Borah et al, (1998), compared an integrated system of pig, chicken and fish culture, with non-integrated units of fish, pigs and chickens separately. Dan and Little, (2000(a)), carried out two studies using three strains of the Nile tilapia, (Thai, GIFT and Viet). The first was a comparison between overwintered and new-season mixed-sex and monosex strains communally, and the second between the same strains stocked separately. Ramaneswari and Rao, (1999), looked at the effects of exposure over time to three different larvicides on common carp, including 'Abate', 'Baytex' and 'Pyrethum'. Ruangpanich and Boonliptanon, (1993), compared the effects of grading larvae of the malabar grouper prior to stocking with no grading. Details of two other experiments conducted by the latter authors have been provided in chapters 5 and 6. Finally, Singh and Varma, (1999), investigated the effects on climbing perch of a 'maximum tolerable limit' dose of the pesticide formulation 'lindane' and a 50% 'maximum tolerable limit' dose.

Of the two studies on *Macrobrachium rosenbergii*, one (Ranjeet and Kurup, 2002), investigated different methods of grading larvae, by hatching order and size. The second study (Sureshkumar and Kurup, 1999) looked at the effect of altering the colour of the bag in which prawns were packed. The effects of altering the oxygen: water ratio at four different stocking densities was also investigated. In *Macrobrachium malcolmsonii* (Soundarapandian et al, 1997), the effects of rearing animals in different types of unit including round and rectangular fibreglass tanks, plastic lined zinc barrels, plastic barrels and cement tanks was tested. The study using both fish and shrimp species, (Yacoob, 1994), stocked shrimp in a pond at different densities each with and without the stocking of 20 tilapia in a cage in the same pond.

Outcomes: In fish studies mean harvest weight and survival were used in two each (40%), and mean daily weight gain and net yield in one each. Additional measures, as used in 4 (80%) studies included LC50 values and chromosome characteristics amongst others.

As the study involving both fish and shrimp used shrimp as the target species, the outcomes have been included in this group. All 4 shrimp studies measured survival, with gross and net yield each being used in two studies (50%). Total harvest weight, mean harvest weight, mean weight gain and FCR were all used to a lesser extent. Two studies used additional measures, which included the percentage hatching rate of animals and the sex ratio.

8.4 DISCUSSION

All of the subject areas covered in this chapter have received relatively little attention in all three of the target countries, particularly Vietnam. This suggests that research into feed and nutrition, water quality and disease are more readily funded in comparison. Interventions on the latter subjects could be more cost-effective in the benefits gained from research outputs, the initial amount of funding required, or how widespread the problem of interest is.

In the case of polyculture, (the combination of species in a single water body), improvements or developments in the feed formulation of aquatic animals, as indicated by the large amount of research carried out on this subject, may have reduced the need to practise this type of farming. For example, in some of the studies selected for this review, species of fish that fed off different substances were cultured together to exploit the different ecological niches and maximise the production of the system. The existence of feeds that produce optimal growth of these species may have displaced the role of polyculture. The association of polyculture with increased disease occurrence may also have had an effect, (Kautsky et al, 2000).

Another possible explanation for the low number of studies is that species that are not conducive to polyculture, i.e. carnivorous and/or aggressive, are more profitable species for India, Thailand and Vietnam. These include the shrimp *Macrobrachium* sp., which may account partly for the lack of studies using shrimp only. However, carp and tilapia, herbivorous species, were the most common groups of fish used in polyculture studies selected for this review, and in Vietnam for example, carp production accounted for 29% of total fish production in 1996, with tilapia also being an important species, (World Fish Centre, 2002). The limited use of polyculture of fish and shrimp together in India, Thailand and Vietnam may be because resource-poor farmers are restricted in what they can produce by the types of facilities available and the type and size of rearing units. Also, increased costs would be incurred from additional supplementary feeds and the need for multiple treatments if a disease outbreak occurred.

The expense of interventions to aquatic animal health will also be a limiting factor for developing countries. This is likely to be the major reason for the very low number of studies related to genetic interventions in India and Thailand, and none at all from Vietnam. Genetic interventions are however relatively new to the field of aquaculture, particularly gene transfer, with the use of genetic selection having only really increased since 1970, (Dunham et al, 2001), and with Vietnam in particular still becoming an established producer, research efforts may be more focused on other areas. Public and consumer perception of genetic manipulation in fish and shrimp may also have affected its uptake.

All three of the selected studies involved fish, specifically carp and tilapia. A review by Hulata, (2001), highlighted less uptake of genetic improvement of stocks in crustaceans compared to fish, as well as between-species differences amongst fish in the use of genetic applications in general. The lack of any research on shrimp may mean that genetic interventions are more difficult in these animals. Behavioural issues may complicate crosses between species or strains for example. Alternatively, increased production, or improved health or quality of shrimp may be more cost-effective by the use of other interventions.

Genetic crosses between species or strains of a species were used in two of the three studies. This being a relatively cheap form of genetic intervention may account for its use as well as the fact that more modern genetic manipulations can take between 10 and 20 years from experimentation to affecting the industry, (Hulata, 2001). No trials were identified on the use of genetics to create disease-resistant strains. The expense of this type of intervention and the limited research in India, Thailand and Vietnam on a vast range of aquatic animal diseases may have hindered this. Part of the reason for its limited uptake in aquaculture in developing countries may also be the constraints of acquiring funding and training scientists, (Dunham et al, 2001).

Interventions involving light manipulation were diverse and included investigating the effects of photointensity, photoperiod duration and shade provided by plant cover in the three different studies. Some of the aquaculture systems used in Asia, i.e. outdoor ponds or units may be less conducive to light manipulation. In contrast, indoor systems may facilitate more effective control, which may explain the large amount of research on this subject that has been carried out in more developed countries, (Bjornsson et al, 2000; Howell et al, 2003; Campos-Mendoza et al, 2004).

For the remaining studies the range of topics was still very broad, highlighting further the multitude of factors that can affect aquatic animal health. Interventions involving reproduction and hatching, hormones and stress were all carried out on fish only, however the process of eyestalk ablation was used only in shrimp. This gives a good example of the use and effectiveness of different types of interventions for different species.

All of the studies using ricefields for integrated farming systems were carried out in Vietnam. These systems of farming are practiced to a much lesser extent in India and Thailand, and provide a very important source of income for rice farmers, who can still utilise the land when rice crops are harvested, (Binh and Kwei Lin, 1995). This method of farming also offers advantages in the form of sustainability and diversification, (Rothuis et al, 1998).

Overall, it is difficult to make comparisons between the groups of studies in this chapter because the types of interventions varied widely and the sample size was small. Although there has been limited research on polyculture, light and genetics in

India, Thailand and Vietnam, genetic research is likely to become a very important application in aquaculture in the future.

CHAPTER 9. STOCKING DENSITY: SPECIES, INTERVENTIONS, OUTCOME MEASURES AND STATISTICAL ANALYSIS OF RESULTS

9.1 INTRODUCTION

Increasing the stocking density i.e. the number of fish per unit volume of water is a method which can potentially increase the productivity of an individual pond. However, increased stocking density requires a higher level of feeding and management and may be accompanied by an increased risk of injury, behavioural abnormalities and disease spread. In terrestrial animals it has been implicated as a contributing factor to welfare. Increased stocking density has been associated with an increase in the incidence of leg problems in broiler chickens, (Hall, 2001), and an increase in tailing biting in pigs, (Moinard et al, 2003).

In aquaculture, increased stocking density has been found to be a determinant of mortality in white sturgeon exposed to white sturgeon iridovirus (WSIV) and white sturgeon herpesvirus-2 (WSHV-2), (Georgiadis et al, 2000), and of an increased stress response, in the form of elevated plasma cortisol concentrations, in Nile tilapia, (Barcellos, 1999).

An important aspect of aquaculture production is optimising the complex interaction which exists between growth rates, body weights, feed conversion ratios, survival and production costs in order to either maximise the income from the pond or produce an adequate amount of food at the minimal cost. Economically, often a trade-off exists between these factors. There is a negative relationship between feed conversion and body size, (Spaargaren, 1999), and also between additional factors such as survival and net production.

Examples from shrimp culture include, a higher survival rate, mean weight at harvest and weight gain at lower stocking densities but also a lower harvest biomass of *Macrobrachium rosenbergii*, (Marques et al, 2000).

The aim of a systematic review is to merge results from a number of studies for meta-analysis. Meta-analysis has been a method used to quantitatively summarise data across multiple studies since its first use in 1904, (Rosenthal and DiMatteo, 2001). The aim of meta-analysis is to combine the results of different studies that have used different participants and study designs to produce an estimate of a specific outcome that can be more widely generalised, (Sutton et al, 2001).

This process is relatively straightforward when a reasonable amount of data is available from studies that have investigated the effects of a specific intervention or condition and when the same outcomes have been recorded. However many systematic reviews have been conducted where heterogeneity between studies has prevented the use of meta-analysis, (Hopkins et al, 2004; Riley et al, 2004; Park et al, 2003). The diversity of interventions identified in this review, both overall and within each of the eight categories, has hindered the use of meta-analysis to provide a quantitative summary of the data.

An interesting question posed of heterogeneous studies is, ‘at what degree of heterogeneity is the process of meta-analysis untenable?’ In this chapter hierarchical statistical modelling is used to identify the sources of variation in the results of the studies included in the review using stocking density as an example. Stocking density was selected as the interventions used had the least heterogeneity of all the topics and was therefore the most amenable to statistical analysis.

9.2 MATERIALS AND METHODS

9.2.1 Data extraction

All studies underwent the same process of data extraction described for previous topics. Information on the study design, treatments and outcome measures used were obtained and the study duration in days was also recorded. Where the duration was specified in months rather than days, an approximation of the number of days was made using the assumption that one month was equal to 30 days. In addition, a full table of results for each study was created, containing the value and units of measure for each outcome with each treatment or comparator.

The stocking densities tested in each study were converted, where necessary, into kg fish/m^3 to standardise them. This was based on the number of fish stocked, the average weight of fish at stocking, and the size of the units used for rearing.

9.2.2 Selection of outcome measures for statistical analysis

Specific growth rate (SGR) and daily mortality were the outcome measures selected for statistical analysis. SGR results for all studies that had measured it were recorded in a table. Where possible, this outcome was calculated for the remaining studies as follows, (Hopkins, 1992):-

$$(\ln W_T - \ln W_t) / (T - t)$$

$$\text{i.e. } \ln_{\text{final weight}} - \ln_{\text{weight at stocking}} / \text{time}$$

Daily mortality was calculated from the percentage survival data provided in the papers as follows:-

$$(100 - \%\text{survival}) / \text{duration of experiment in days}$$

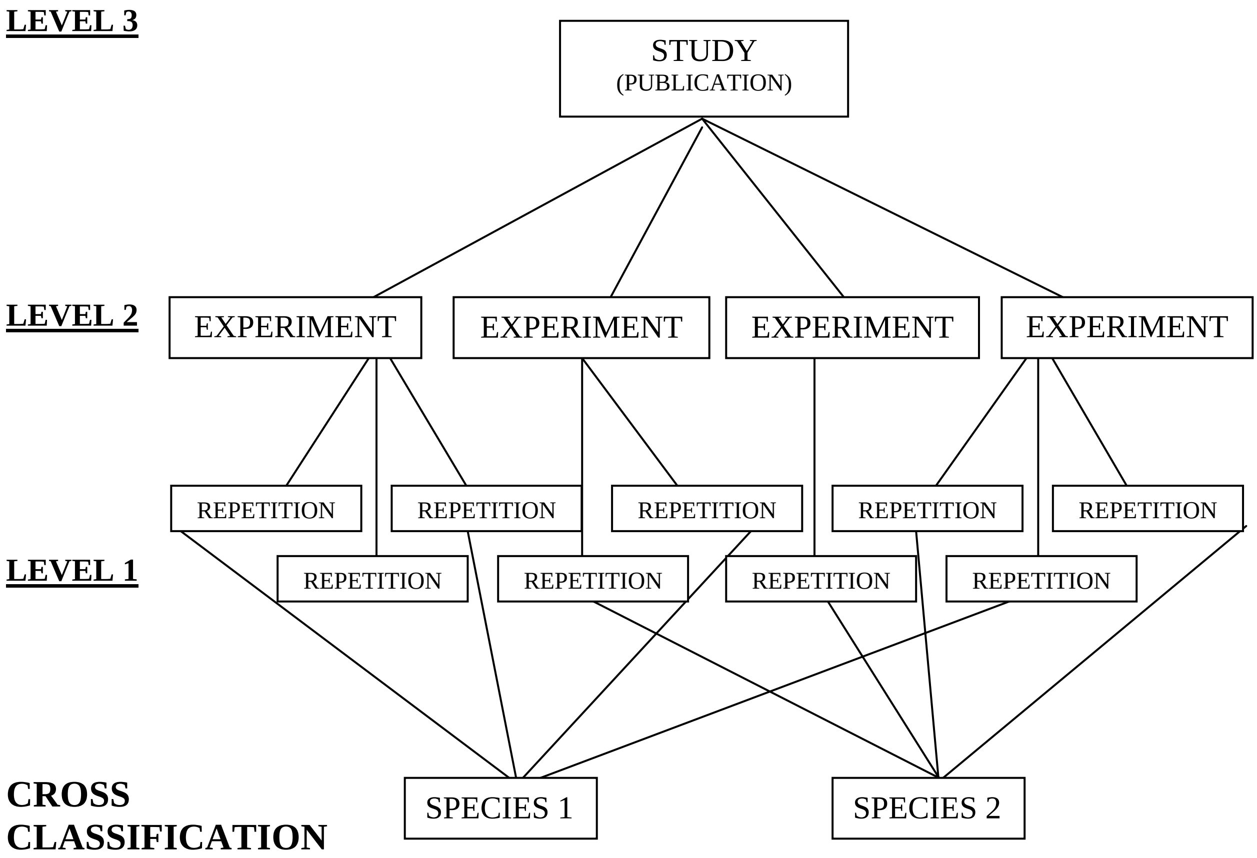
Studies were grouped according to the use of fish or shrimp species.

Other outcome measures were not used for analysis because they were not directly comparable between studies and could not be converted into standard measures or units.

9.2.3 Statistical analysis

The initial aim of these analytical methods was to identify the sources of variation in the data. The results of the studies in this review may be considered as multilevel or hierarchically structured data. Data are clustered at a number of different levels and each of these levels contributes to the variance within the data. At the highest level there is the STUDY or publication, where there is variation associated with the experimenter and the facilities available etc. Within each publication a number of EXPERIMENTS or experimental designs may be used, forming the second level of clustering. Finally there are the results of individual REPETITIONS of experiments, which may have the same study design. This hierarchical clustering is shown diagrammatically in Fig 9.1.

Fig. 9.1. Diagram of the hierarchical structure of included studies.



In addition, there is also clustering at the level of SPECIES. As different studies sometimes use the same species, this type of clustering is called cross-classification (Fig 9.1), (Rasbash and Goldstein, 1994; Goldstein and Sammons, 1997).

The variance associated with each of these different levels can be estimated by using random effects intercept only models. This was carried out in MLwiN.

Multi-level models are derived from the ordinary regression equation:-

$$y= a + bx + e$$

where:

y = the outcome or dependent variable

x= the predictor or independent variable

a = the intercept (where the slope meets the y axis)

b = the slope of the regression line

e = the *residual* (i.e. the difference between the value of the outcome predicted by the regression equation and the real value of the outcome seen in the data used to develop the regression line).

This regression equation is used to model data at one level and the *variance of the residual* is equivalent to the variation at this level.

If there is more than one level e.g. where experiments are one of a number of replicates, then regression equations may be developed for each replicate. These equations can be summarised as:-

$$y_{ij} = a + bx_{ij} + e_{ij} + u_j$$

where:

y_{ij} = the outcome variable which varies across both level 1 (i) and level 2 (j)

x_{ij} = the predictor or independent variable also varying across levels 1(i) and 2 (j)

a = a constant

b = the slope (which in this case is constant across all levels but which can be modified to account for differences in slope at different levels)

u_j = the level 2 (j) residual

e_{ij} = the level 1 residual which also varies across level 2 (j)

The variables u_j and e_{ij} are known as random variables and are the hallmark of a multilevel model. These models are often referred to as *random effects models.* It is assumed that these variables are uncorrelated and that they are normally distributed with a mean of zero so that it is sufficient to estimate their variances σ^2_u and σ^2_e.

This equation can be adapted for three or four levels using subscripts k and l and residuals v and w.

In MLwiN, the notation of this equation is adapted by the introduction of a predictor or independent variable x_o which assumes a value of 1, and by the use of β_0 and β_1 instead of a and b such that for a three level model:-

$$y_{ijk} = \beta_0 x_o + \beta_1 x_{ijk} + e_{0ij} x_o + u_{0j} x_o + v_{0k} x_o$$

By collecting $\beta_{0,}$ e_{0ij} x_o and u_{0j} x_o this becomes:-

$$y_{ijk} = \beta_{0ijk} x_o + \beta_1 x_{ijk}$$

where:

$$\beta_{0ijk} = \beta_0 + e_{0ij} + u_{0j} + v_{0k}$$

The intercept only (i.e. no predictor or independent variables) form of this model is:-

$$y_{ijk} = \beta_{0ijk} x_o$$

This was used in studies of stocking density to estimate the variance in SGR at level 1, (the individual result) level 2 (the experiment) and level 3 (the study).

Estimates were determined using iterative least squares, (Goldstein, 1995; MLwiN, 2001).

The same approach was used for daily mortality, however a binomial distribution using the logit function was used rather than a normal distribution. This is because daily mortality, being a proportion, means that the underlying probability of death (π) lies between 0 and 1. In the model, these proportions were calculated by dividing daily mortality by 100. Modelling binomial data with a logit function is known as logistic regression.

If π_{ijk} is the probability of death in the i^{th} repetition of the j^{th} experiment in the k^{th} study then the probability of death is defined as:-

$$\text{logit}\,(\pi_{ijk}) = \beta_{1jk}x_1$$

where:

$\beta_{1kj} = \beta_1 + v_{1k} + u_{1jk}$

v_{1k} is the variance associated with the study

u_{1jk} is the variance associated with the jth experiment in the kth study

The full model can be written as:-

$$y_{ijk}=\pi_{ijk} + e_{0ijk}x_0$$

where:

y_{ijk} are the observed responses

In modelling these proportions in MLwiN, the variable "denom" is an abbreviation of denominator which in this case was the number of fish stocked, (either taken directly from the report or calculated based on stocking density figures and pond size). This variable is recognised by the software macro and has a special function where death is not recorded at the level of the individual fish but as a proportion of fish in the replicate of the experiment.

In MLwiN the distributional form of the equation is used:-

$$y_{ijk} \sim Binomial\ (denom_{ijk},\ \pi_{ijk})$$

9.2.4 Estimation of the variation associated with species

As indicated above, the structure of these data is not simply hierarchical. A number of different species were used in these studies, with the same species sometimes being used in different studies. Species, an important potential source of variation, is not nested within repetition, experiment or study. This is called a cross-classification structure.

In this cross classification, repetitions are nested within experiment but in some cases, different species are used in different experiments in the same study or in different experiments in different studies. These experiments are nested within study.

A model of this can be written as:-

$$y_{i(jk)l} = \alpha + \boldsymbol{u}_j + \boldsymbol{u}_l + \boldsymbol{e}_{i(jk)} + \boldsymbol{e}_{jl} + \boldsymbol{e}_{kl}$$

where:

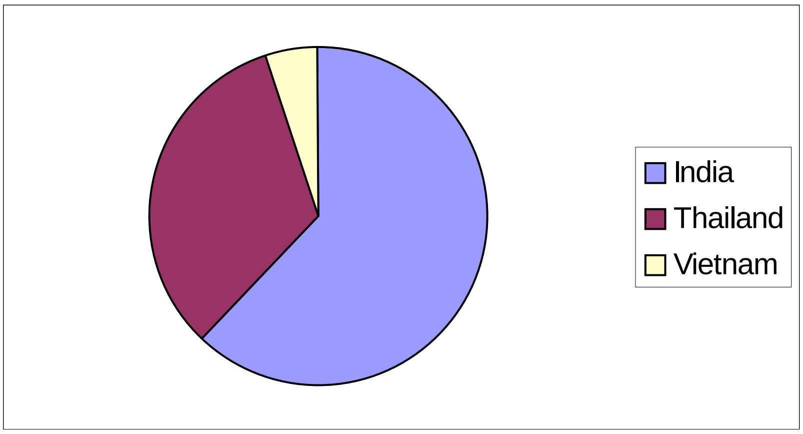
i refers to the repetition, *j* the experiment, *k* the species and *l* the study.

9.3 RESULTS

9.3.1 Number of studies

Of 21 studies selected for inclusion, 62%, were carried out in India, 33% in Thailand and 5% in Vietnam, (Figure 9.2).

Fig. 9.2. Geographical distribution of stocking density studies.



9.3.2 Species

Thirteen studies, (62%), used species of fish and 8, (38%), used species of shrimp, (Table 43). Across all studies, a total of 19 different species were used, including 14 fish species and five shrimp species. A total of four studies used multiple species of fish, accounting for the higher number than overall number of studies. In no cases were fish and shrimp investigated together in one study.

Table 43. Numbers of fish and shrimp species used in stocking density studies.

Number of studies								Total species
Fish					Shrimp			
Total	Carp	Tilapia	Catfish	Other	**Total**	Penaeus	Macrobrachium	
13	3	6	3	2	**8**	4	4	**19**

Tilapia were the most common group of fish used in 6, (46%), studies, followed by carp, (catla, common carp, grass carp, mrigal, rohu, silver carp and hybrid common carp), and catfish, (African catfish and *Mystus keletius*), in 3 studies each, (23%). Mahseer and mullet were used in one study each.

Penaeus and *Macrobrachium* species were used in an equal proportion of shrimp studies.

9.3.3 Interventions

Of the 13 fish studies, 9 investigated different stocking densities for a single species. Ambali and Little, (1996), increased the density of Nile tilapia in conditioning hapas from 0.6-0.8 to 2.3-2.5 kg fish/m^2. Knud-Hansen and Kwei Lin, (1996), and Yi et al, (1996), also investigated increasing densities of Nile tilapia, ranging from 0.8 to 2.4 fish/m^2, and 30 to 70 fish/m^3 respectively. In a study using Mozambique tilapia, Balasubramanian and Bai, (1996), tested a stocking density of 30,000 fish/ha with different fertilisers, with a density of 60,000 fish/ha.

Two studies that used catfish only, compared densities of 1.66 to 6.40 kg fish/m^3, (Hengsawat et al, 1997), and 1 to 16 fish/dm^3 each with different feeding frequencies, (Sampath and Raj, 1995).

Anh and Son carried out 9 different experiments, 5 on the hybrid common carp, and 2 each on grass carp and mrigal. For each, different stocking densities were tested each with different types of cages and feed.

Wattanakul et al, (1994), conducted 3 separate experiments on the mullet, where stocking densities were increased from 500 to 1500 fish/m^2, 100 to 300 fish/m^2, and 5 to 20 fish/m^2 respectively. In a study by Keshavanath et al, (2001), the density of mahseer in compartments was increased from 0 to 12 fish, with the use of different substrate types also being investigated at each density.

The remaining 4 studies all used integrated systems, involving multiple species or multiple types of unit. Jena et al, (2002), using 6 species of carp, (catla, rohu, mrigal, silver carp, grass carp and common carp), tested two different stocking densities each with combinations of 3 or 6 species. Saha et al, (1997), also using catla, rohu and mrigal, investigated densities ranging from 0.2 to 0.4 million fish/ha each with three different rates of water flow. Kwei Lin and Diana, (1995), investigated the difference between a 2: 1 and 4: 1 stocking ratio of hybrid catfish in cages and Nile tilapia in ponds, and Yi and Kwei Lin, (2001), using a similar system, looked at the effects of increasing the number of cages containing Nile tilapia in ponds containing the same species.

Of 4 studies using species of *Penaeus*, 3, (Mohanty, 2001(a); Mohanty, 2001(b); Mohanty and Panda, 2000), reported the same experiment, involving the use of 6 different stocking densities of *Penaeus monodon* each with different feeding schedules. The study on *Penaeus indicus*, (Sasikumar and Vadhyar, 1999), investigated stocking densities ranging from 200 to 500 postlarvae/l, each with different salinities and water temperatures.

The two studies on *Macrobrachium rosenbergii* investigated different ranges of stocking densities. One study, (Nagarathinam et al, 2000), looked at two densities of 5 and 10 prawns/m^2, and the other, (Vasudevappa et al, 1999), used a range of 50 to 250 prawns/m^2. Kanaujia et al, (1997), compared stocking densities of 30,000 and 50,000 prawns/0.02 ha using *Macrobrachium malcolmsonii*, and Singh and Qureshi, (1997), investigated densities of between 100 and 350 prawns/m^2 using *Macrobrachium lamarrei lamarrei.*

9.3.4 Outcome measures

Net yield and survival were the most common outcome measures used across all studies, (81% each), closely followed by mean harvest weight, (71%), (Table 44).

Table 44. Outcome measures used in fish and shrimp studies of stocking density.

Outcome measure	Number of studies		
	Fish	Shrimp	Total
Total harvest weight	5	3	**8**
Mean harvest weight	10	5	**15**
Mean weight gain	5	2	**7**
Mean daily weight gain	6	4	**10**
Specific growth rate	1	2	**3**
Gross yield	4	1	**5**
Net yield	11	6	**17**
Survival	9	8	**17**
FCR	5	4	**9**
Other	1	0	**1**

Of the studies on fish, the most common measures were net yield, mean harvest weight and survival, (85%, 77% and 69% respectively). Mean daily weight gain, total harvest weight, mean weight gain, FCR and gross yield were all used to a fairly equal extent, (46%, 38%, 38%, 38% and 31% respectively). Specific growth rate was used to a lesser extent and one study used additional measures that included the daily instantaneous growth rate and the daily instantaneous mortality rate.

For shrimp studies, survival was the most common measure, (100% of studies), followed by net yield and mean harvest weight, (75% and 63% respectively). Mean daily weight gain and FCR were used in 50% of studies each, with total harvest weight, mean weight gain, specific growth rate and gross yield being used to a lesser extent. No studies used any measures additional to these.

9.3.5 Selection of sample for analysis

The number of studies using species of shrimp was too small for statistical analysis.

Consequently, all subsequent analysis was carried out on results from fish studies only. Of 13 studies only one recorded SGR, however values for this outcome could be calculated using other results for 10 other studies, giving a total of 11 studies for analysis. Individual replicates within each experiment within each study were used as separate data points, giving a total of 178. Of these 11 studies, the mortality per day was also calculated from survival figures. Data on the study, species and experiment were entered into an Excel (Microsoft) spreadsheet using numerical coding. For each point, stocking density in kg fish/m^3 and the SGR and mortality per day value were also recorded as well as the values of measures required to calculate these.

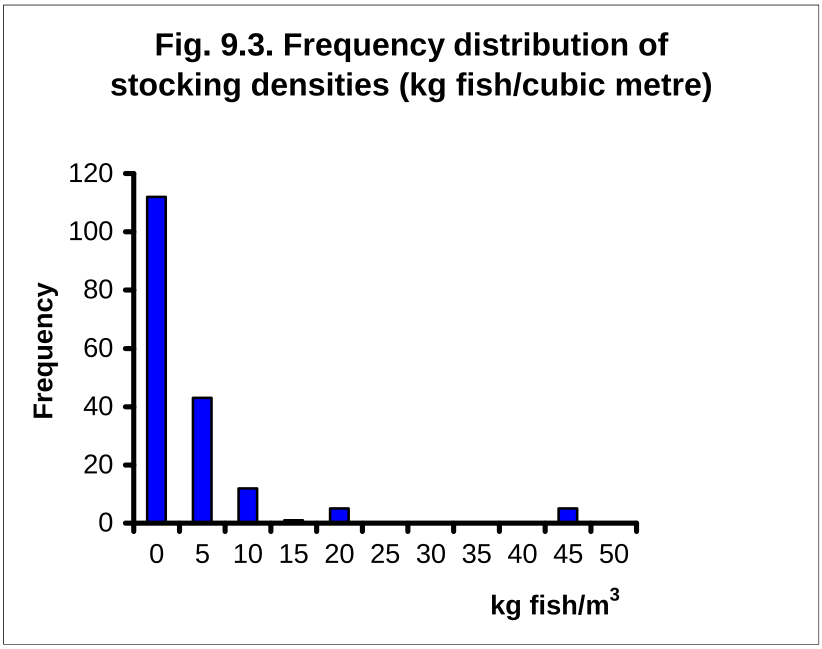
9.3.6 Descriptive statistics of studies involving fish

9.3.6.1 Results

The species and stocking densities used in each study, and the SGR and percentage mortality per day recorded or calculated for each was summarised. A total of 176 individual data points were obtained for SGR, and 153 for mortality per day. Survival, (from which mortality per day was calculated), was not recorded in one of the 11 studies.

9.3.6.2 Stocking density

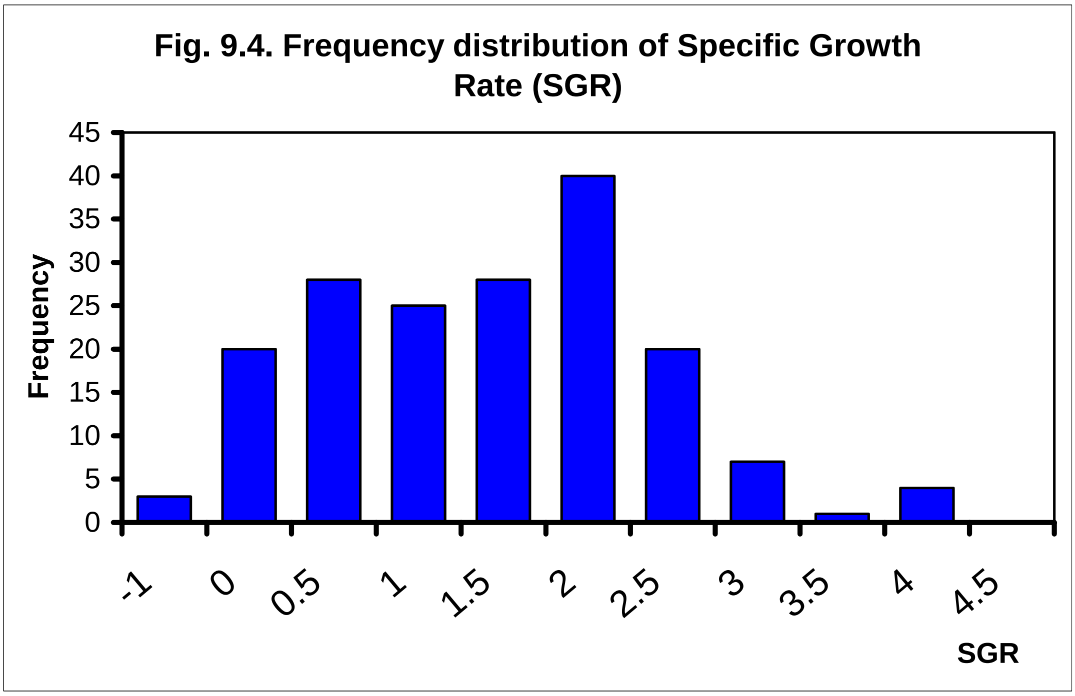
Figure 9.3 illustrates the frequency distribution of stocking densities tested in kg fish/m^3 in the 11 studies selected for analysis.



The mean stocking density was 5.69 +/- 8.72 kg fish/m^3, ranging from 0.0003 to 48 kg fish/m^3. The majority of densities investigated however, (63%), were less than 5 kg fish/m^3, with 24% between 5 and 10 kg fish/m^3.

9.3.6.3 Specific Growth Rate

Figure 9.4 illustrates the frequency distribution of SGR values calculated across the 11 studies.



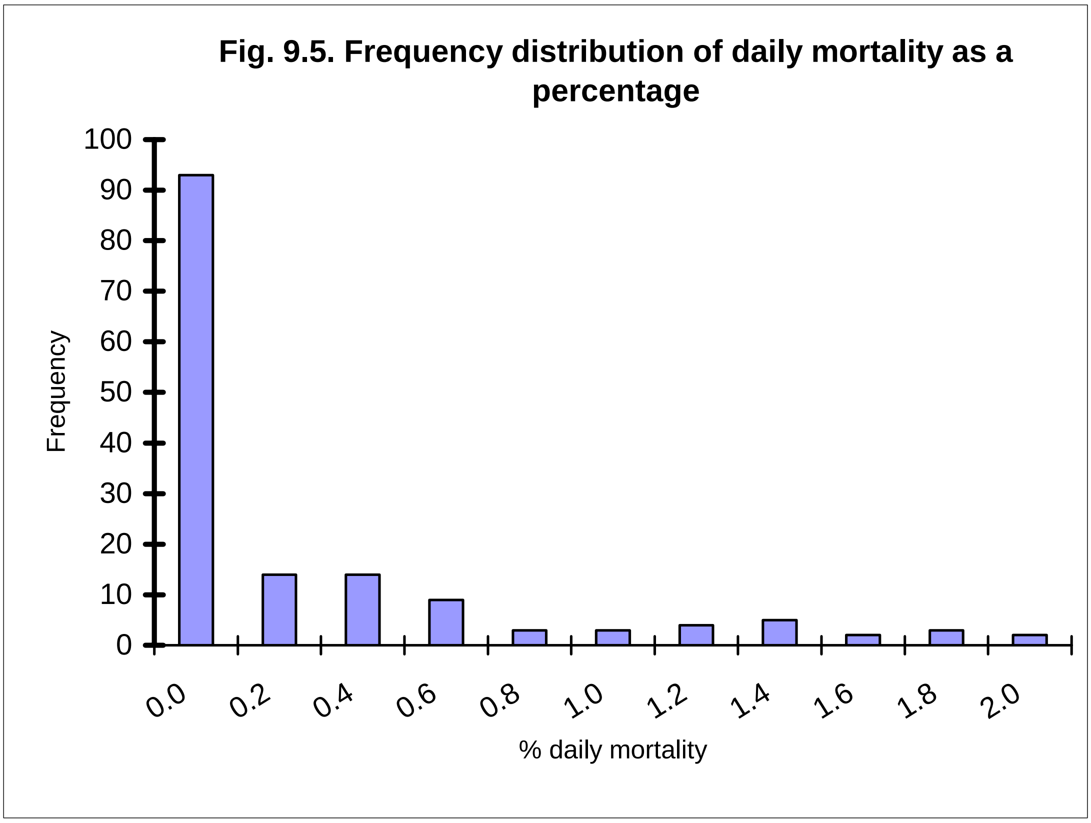
Mean SGR was 1.68+/-0.97, with a range from –0.16 to 4.40. Results showed a normal distribution with a slight skew to the left. It was therefore not necessary to transform them for subsequent analysis.

9.3.6.4 Daily mortality

The distribution of percentage daily mortality values was skewed to the left, (Figure 9.5), with the majority (61%) between 0 and 0.2%. The median value was 0.134%

with an interquartile range of 0.068% to 0.516%. Mean percentage mortality per day was 0.38+/-0.501%, and it ranged from 0.0089% to 2.093%, (Fig. 9.5).

.

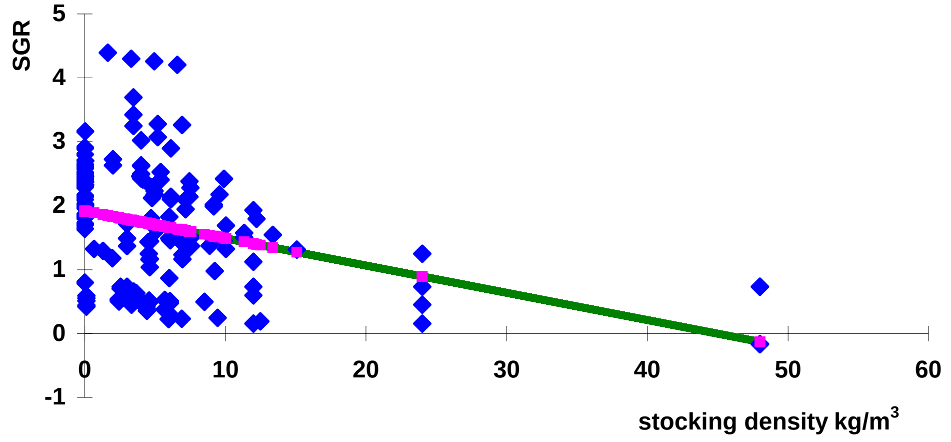


9.3.7 Exploring the effects of stocking density

9.3.7.1 Regression analysis

Before analysis, the relationship between stocking density and the selected outcomes was investigated using scatter plots. Plotting SGR against stocking density in kg fish/m^3, (Fig. 9.6), demonstrated a possible negative relationship, with SGR decreasing with increasing stocking density.

Fig. 9.6. Scatter Plot and Regression Line of Stocking Density against Specific Growth Rate



Regression analysis was carried out and the summary output is shown below. From the intercept and X variable1 regression coefficients the fitted line for these data was:-

SGR= 1.98 - 0.065 x STOCKING DENSITY

The estimated standard error of the slope coefficient was 0.104, with a t statistic of 19.04 and p value of 0.0093, (Table 45). This indicates that the slope is significantly greater than 0. Although there is a significant negative relationship between SGR and stocking density, only 6.45% of the variation in SGR was explained by stocking density (R squared value), indicating the model fit to be poor. The standard error of the regression was 0.927. The correlation between SGR and stocking density (Multiple R) was 0.254.

Table 45. Output of regression analysis between SGR and stocking density.

Regression Statistics	
Multiple R	0.253992
R Square	0.064512
Adjusted R Square	0.058842
Standard Error	0.926504
Observations	167

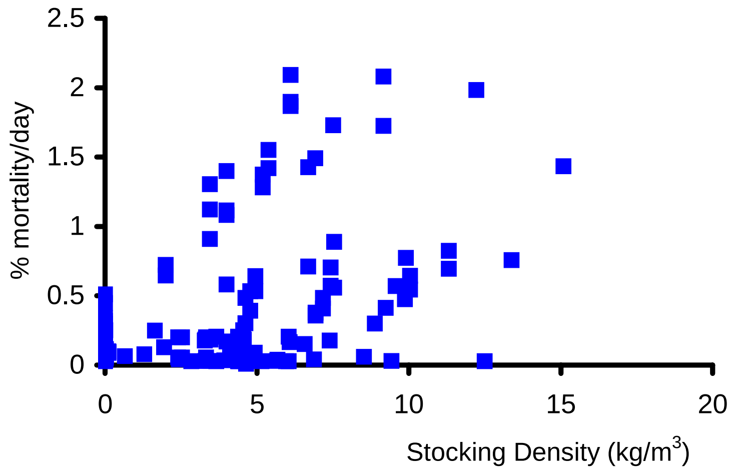
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9.767452	9.767452	11.37855	0.000926
Residual	165	141.6375	0.858409		
Total	166	151.405			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.980799	0.104052	19.03655	1.74E-43	1.775353	2.186244	1.775353	2.186244
X Variable 1	-0.06536	0.019375	-3.37321	0.000926	-0.10361	-0.0271	-0.10361	-0.0271

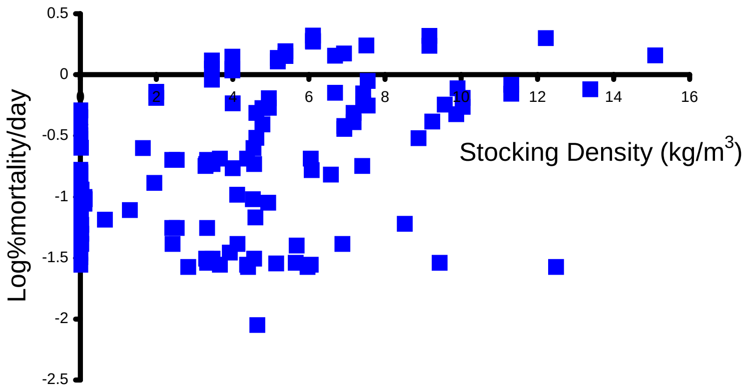
Plotting percentage mortality per day against stocking density showed a lot of variation and no distinct relationship between the two, (Fig. 9.7). There was, however, some clustering of mortality values between 0 and 0.5% per day around stocking densities of less than 5 kg fish/m^3.

Fig. 9.7. Scatter Plot of Stocking Density Against Percentage Mortality per Day



No distinct relationship was shown with log percentage mortality per day either, (Fig. 9.8).

Fig. 9.8. Scatter Plot of Stocking Density Against Log Percentage Mortality per Day



9.3.7.2 Cross classification models

9.3.7.2.1 SGR

Intercept only cross classification models enabled estimates of the variance associated with study, experiment, repetition and species to be calculated. The output from this model is shown below.

Table 46. The variance and intra-class correlation coefficient of SGR at each level.

Level	**Variable**	**Variance**	**Standard Error**	**Intra - class correlation coefficient**
Level 1	Repetition	0.123	0.015	9.98%
Level 2	Experiment	0.143	0.047	11.6%
Level 2 Cross classification	Species	0.047	0.038	3.8%
Level 3	Study	0.919	0.440	74.6%

The intra-class correlation coefficients indicate that most of the variance was associated with the study rather than the individual experiment or repetition. Species however, only accounted for a small proportion of the variance in the model (3.8%). Attempts to add other explanatory variables to this model resulted in failure of convergence and the simpler three level hierarchical model was used to explore the relationship between stocking density and SGR.

The results of the intercept model were qualitatively similar to those from the cross-classification model and are shown below, where *i* is the repetition, *j* the experiment and *k* the study.

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$
$$y_{ijk} = \beta_{0ijk}x_0$$
$$\beta_{0ijk} = 1.837(0.300) + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\begin{bmatrix} v_{0k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_v) \ : \ \Omega_v = \begin{bmatrix} 0.895(0.420) \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_u) \ : \ \Omega_u = \begin{bmatrix} 0.156(0.050) \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_e) \ : \ \Omega_e = \begin{bmatrix} 0.136(0.017) \end{bmatrix}$$

$$-2{*}loglikelihood(IGLS) = 247.381(176 \text{ of } 178 \text{ cases in use})$$

Adding stocking density into this model resulted in the following output:-

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$
$$y_{ijk} = \beta_{0ijk}x_0 + -0.023(0.004)x_{1ijk}$$
$$\beta_{0ijk} = 1.807(0.289) + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\begin{bmatrix} v_{0k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_v) \ : \ \Omega_v = \begin{bmatrix} 0.832(0.390) \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_u) \ : \ \Omega_u = \begin{bmatrix} 0.141(0.044) \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_e) \ : \ \Omega_e = \begin{bmatrix} 0.112(0.014) \end{bmatrix}$$

$$-2{*}loglikelihood(IGLS) = 216.258(176 \text{ of } 178 \text{ cases in use})$$

In summary the equation for this model of the relationship between SGR and stocking density is:-

SGR (y)=1.81 – (0.023 x stocking density) + 0.832 + 0.141 + 0.112

The –2* loglikelihood (IGLS) value is an estimate of the unexplained variation in the model. The statistical significance of adding stocking density (centred) into the model can be assessed by comparing values from the two models. This difference was 31.12, indicating the change in deviance between the two models. This is also the equivalent of a χ^2 value for the explanatory variable (stocking density). There was only one parameter change between the two models, giving one degree of freedom. The deviance was therefore highly significant, ($p<0.001$), confirming that this model is a better fit to the data.

This model produced an average prediction of SGR from a particular stocking density. The departures of individual studies and experiments from this average were estimated by plotting the residuals. A caterpillar plot of the residuals at study level showed that, with the exception of a study at each end of the plot, the confidence intervals around the residuals crossed or were near to zero. This suggests that most of the studies did not differ significantly from the average line at the 5% level, (Figure 9.9).

Fig. 9.9. A Caterpillar plot of the residuals at study level.

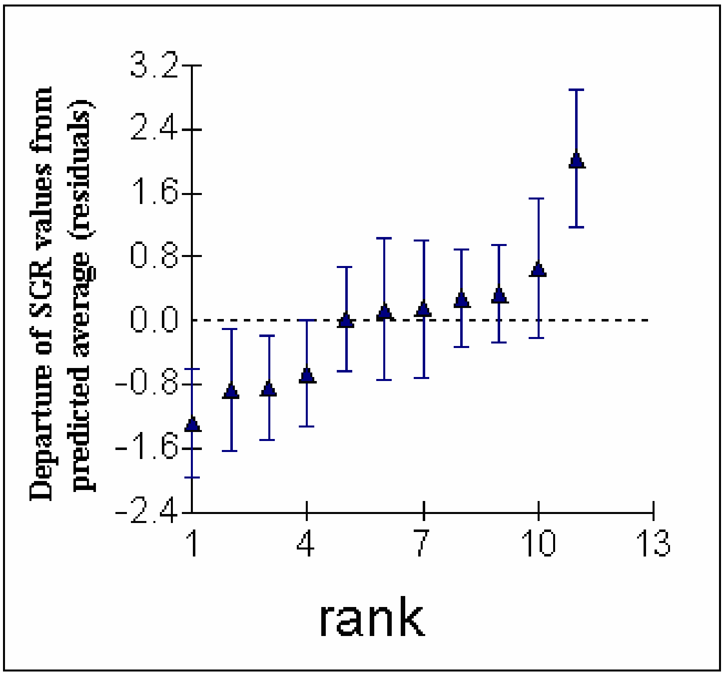
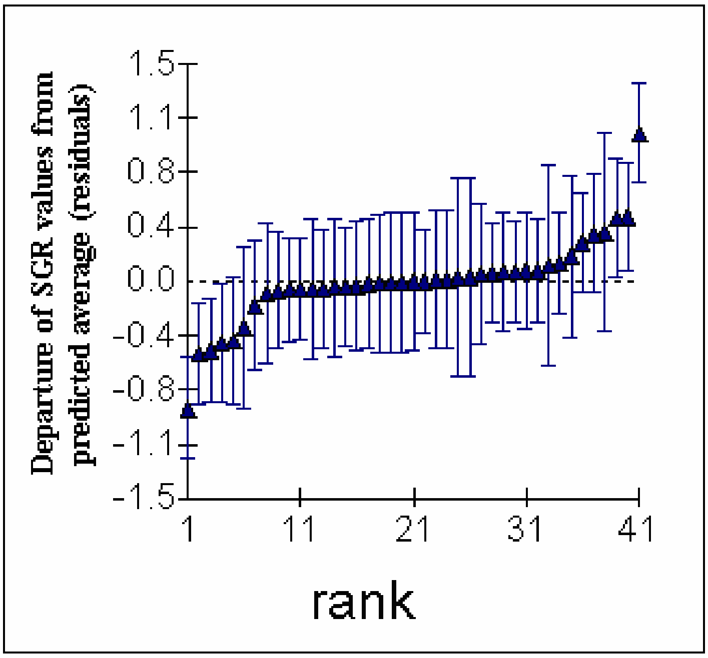


Fig. 9.10. A caterpillar plot of the residuals at experiment level.



At the experiment level, the majority of confidence intervals overlapped zero, indicating a more marked effect, (Figure 9.10).

9.3.7.2.2 Daily mortality

The variance in mortality associated with study, experiment, repetition and species in the cross classification model is shown in Table 47.

Table 47. The variance and intra-class correlation coefficient of daily mortality at each level.

Level	Variable	Variance	Standard Error	Intra - class correlation coefficient
Level 1	Repetition	Not estimated assumed to be $\pi^2/3=3.29$	Not estimated	-
Level 2	Experiment	0.224	0.104	5.3%
Level 2 Cross-classification	Species	0.001	0.003	0.002%
Level 3	Study	0.745	0.515	17.5%

Again most of the variance was associated with the study. The average daily mortality using this model can be calculated from $(1+\exp(\beta_{1jk}))^{-1}$ which in this case was $(1+\exp(-6.762))^{-1}$ i.e. 0.0012 or 0.12% mortality per day. Attempts to add stocking density to this model were unsuccessful as there was failure of convergence.

The addition of stocking density to a three level model produced the following:-

$$\left.\begin{array}{l} y_{ijk} \sim \text{Binomial}(n_{ijk}, \pi_{ijk}) \\ y_{ijk} = \pi_{ijk} + e_{0ijk}x^*_0 \end{array}\right\}$$

$$\text{logit}(\pi_{ijk}) = \beta_{1jk}x_1 + 0.031(0.004)x_{2ijk}$$

$$\beta_{1jk} = -6.657(0.336) + v_{1k} + u_{1jk}$$

$$\left[v_{1k}\right] \sim \text{N}(0,\ \Omega_v) \ :\ \Omega_v = \left[0.653(0.458)\right]$$

$$\left[u_{1jk}\right] \sim \text{N}(0,\ \Omega_u) \ :\ \Omega_u = \left[0.219(0.102)\right]$$

$$x^*_0 = x_0[\pi_{ijk}(1 - \pi_{ijk})/n_{ijk}]^{0.5}$$

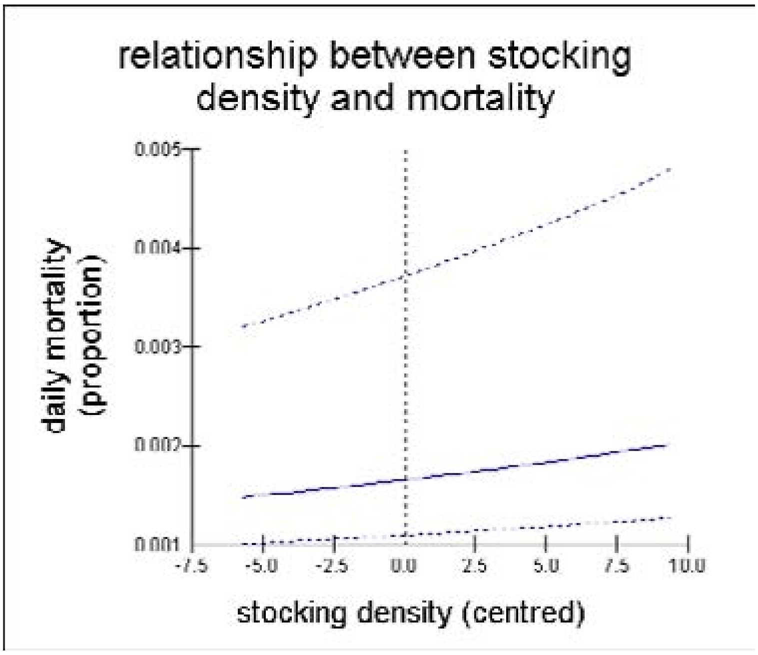
$$\left[e_{0ijk}\right] \sim (0,\ \Omega_e) \ :\ \Omega_e = \left[1.000(0.000)\right]$$

The average daily mortality was $(1+\exp(-6.657))^{-1}$ i.e. 0.0013 or 0.13% per day. The OR (odds ratio) associated with an increase in stocking density of $1 kg/m^3$ was $e^{0.031}$ i.e. 1.36 (CI 1.02-1.48). The relationship between stocking density and mortality is expressed by the equation:-

$$\mathbf{ln\ \left(\frac{p}{1-p}\right) = -\ 6.657 + (0.031\ x\ stocking\ density)}$$

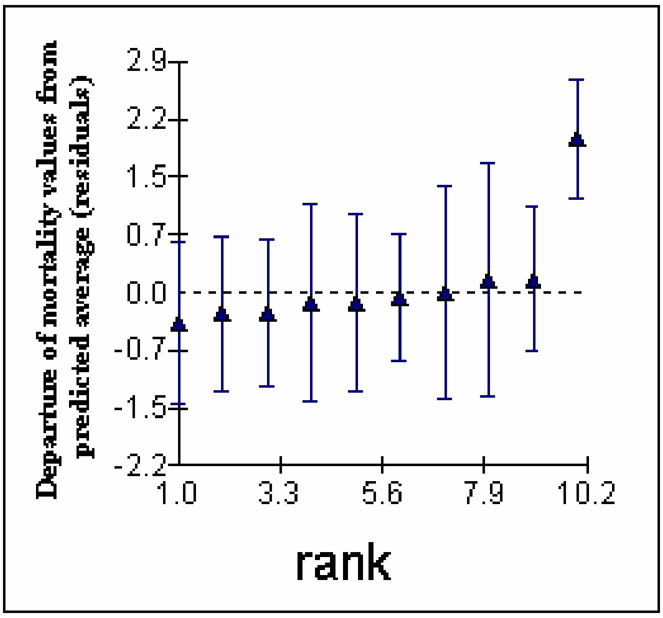
It is shown in Figure 9.11.

Fig. 9.11. The relationship between stocking density and daily mortality.



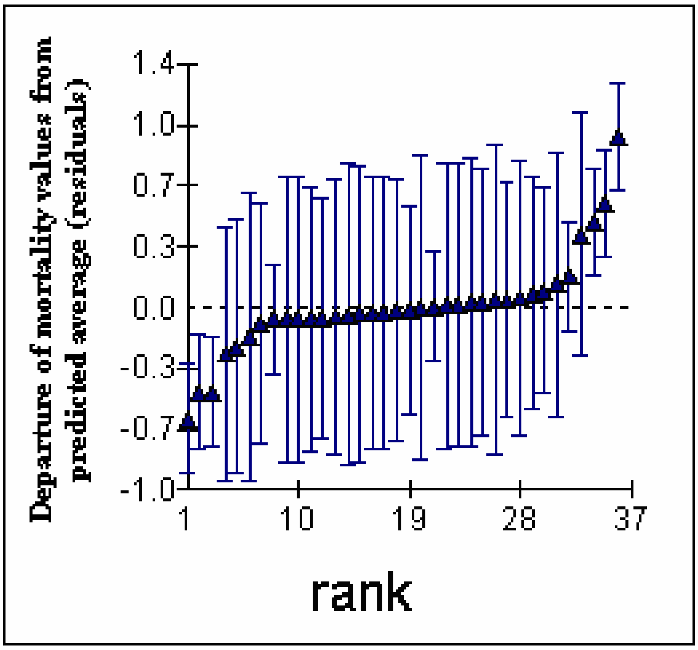
A caterpillar plot of the residuals at the level of the study revealed that only one of the studies had confidence intervals which did not cross zero, (Fig. 9.12).

Fig. 9.12. A caterpillar plot of residuals at study level.



A similar picture was seen when the residuals at the level of the experiment were plotted, (Fig. 9.13). Six experiments had confidence intervals which failed to cross zero.

Fig. 9.13. A caterpillar plot of residuals at experiment level.



4 DISCUSSION

The aim of this chapter was to determine whether or not a meta-analysis of the results from studies on stocking density could be carried out and if so, whether the results were meaningful. This topic was chosen not only for the manageable number of papers, but also for the quantitative and therefore comparable measures of both the independent variable (stocking density) and outcome measures of biological significance (survival and growth rate).

A meta-analysis of results from shrimp studies was not possible for a number of reasons. Three of the eight studies reported the same experiment in the separate papers, (Mohanty, 2001(a); Mohanty, 2001(b); Mohanty and Panda, 2000), and in two of these large sections of text were identical. As each paper was published in similar journals, there is no evidence to suggest that that author was attempting to disseminate the findings to a wider range of people. Instead, this may be a consequence of pressures to publish, particularly as many international journals require, (for copyright purposes), a certification that the data has not previously been published. Meta-analysis was further limited by the use of different shrimp species in five of the remaining six studies, resulting in a descriptive analysis only.

For the thirteen studies on fish, a number of factors had to be taken into consideration. A total of fourteen different species of various developmental stages were used as well as combinations of species in four studies. In addition, different measures of the independent variable stocking density were used. The most common measure was the number of fish per volume of water, however the weight of fish and the number per unit e.g. pond were also used. Standardisation of these measures to kg of fish per m^3 was carried out. However approximations of some values used to calculate this were necessary, e.g. to determine the depth of water bodies where m^2 or hectares were used or to determine the total weight of fish stocked where numbers and average weights at stocking were reported.

SGR and daily mortality were the outcome measures selected to investigate the influence of stocking density. Despite being a measure of growth rate that can be standardised, only one study recorded SGR. However for ten additional studies this value could be calculated from other measures. Survival was more commonly used than mortality, so further re-calculations to obtain mortality values was required, using time in days as a denominator to standardise study durations. Approximation was also necessary here as some studies reported duration in months. Two of the thirteen studies were excluded as neither of these outcome measures could be calculated.

It is clear from this that there is a need for raw data from these studies to be made available. If, for example, raw data tables were published separately or were made available on a searchable database, this would increase the amount of data that could be pooled for statistical analysis of any form, thereby increasing the power of analyses and in turn the generalisability of results. If individual animal data was available, this would be more useful than group means only. Re-calculations introduce the possibility for error, especially if the data from which these were made were incorrect or incomplete in the original paper.

It has already been made clear that the aquatic animal health interventions identified have been very diverse in the interventions that have been used, the target species of each study, the study design of these experiments and the outcomes that have been used, including the units of measure. One criticism of the meta-analysis process, and an argument against its use in this review, is the ‘apples and oranges’ argument, (Rosenthal and DiMatteo, 2001). This states that it is inappropriate to combine results from studies that have asked different questions and have used different variables and methods of sampling. However, the reverse of this is that the methods used in a study could be included as a covariate in a method of meta-regression, (Rosenthal and DiMatteo, 2001), i.e. an analysis of factors other than the independent variable that have an effect on the dependent variable of interest.

However, the studies in this review show variation in the number and types of covariates, even within subcategories within each general topic that could be used in such an analysis. For example, some studies looked at the effects of two different factors, such as feed and fertilisation, therefore if a meta-regression of feed studies was to be conducted, fertilisation would act as a covariate, but in this study only. In contrast, some covariates that were consistent across all studies were the species used, (if studies were divided into those that used fish and shrimp), developmental stage of animals, the unit of study, e.g. the tank or pond, and the study or author.

Another means of quantitatively analysing heterogeneous data and studies is to carry out subgroup analyses, (Oxman and Guyatt, 1992), involving the division of studies or data into smaller groups to make the comparisons more meaningful. However, as the number of studies identified in each subcategory within each topic in this review is small, and further subdivision would create further problems for the power values of statistical analysis, this approach would not have been appropriate.

The heterogeneity across all studies selected for this review spanning all topics caused problems in the application of statistical analysis to analyse and compare results obtained from these studies. This prevented the ability to provide information on which types of interventions have been effective and in which species.

Although just eleven studies on stocking density were used in the analysis, the number of different experiments and replicates within these studies resulted in a total of 178 data points, (aggregated at the level of the water body i.e. tank, cage or pond). To account for the hierarchical structure and therefore lack of independence of data points, specific multi-level analysis was required.

In this chapter, hierarchical random intercept models were used to determine the variance of linear and logistic regression models associated with different hierarchical levels of data. In both linear and logistic models the largest component of variance was associated with the individual study, suggesting that the experimental designs used in these studies were too different to be combined in a meta-analysis. It was however still possible to show that there was a negative association of stocking density with growth rate and a positive association with mortality. However, it would be inappropriate and misleading to identify and recommend an optimal stocking density based on these results. This is because the different repetitions or replicates of experiments, the individual experiments within a study and the overall study or author in particular, all contributed to the variation in SGR and mortality values of fish. Combined with variation from different species, it would not be appropriate to generalise from this data. If data from aquatic animal health intervention studies were to be combined in future analyses, it may be useful to specify a maximum level of variance associated with the study, beyond which a meta-analysis of results would not be meaningful or valid.

The range of stocking densities tested across studies suggests that there are currently no specific densities that have been identified as an optimum for aquaculture in Asia that would provide guidelines for intervention studies. Also, the range of densities makes it difficult to identify an optimum that would be relevant to all species and systems, even in the small sample of studies in this review.

An interesting point to note is that all of the stocking densities used in these studies were well below some of those used in more intensive systems. For example, a review by Ellis et al, (2002), found that the maximum recommended stocking densities for rainbow trout varied up to 267 kg fish/m^3. This is over 200 kg fish/m^3 greater than the highest density tested in the fish stocking density studies from this review. This suggests that stocking density is unlikely to be the main limiting factor to growth rate and survival in these studies, and feed for example may play a more significant role.

In conclusion, stocking density has been shown to have some effect on the SGR and mortality of fish. However, the method of statistical analysis used to demonstrate this has revealed that the heterogeneity between even a small sample of studies has a large influence on the results obtained. This identified problem questions the ability to combine larger groups of studies on aquatic animal health interventions in Asia in a meta-analysis, especially as the sample of studies selected for analysis were considered to be the least heterogeneous of all those included in the review

CHAPTER 10. GENERAL DISCUSSION AND CONCLUSIONS

The overall aim of the DFID-funded project R8119 was to assess the impact of aquatic animal health strategies on the livelihoods of rural poor in Asia. To contribute towards poverty alleviation of aquaculture farmers, an aquatic animal health intervention needs to be cost effective and increase productivity in a sustainable manner. From studies included in this review, there was no evidence for the use of large-scale field trials, where the cost of the intervention and the degree of training and organisation required was taken into consideration in the context of rural aquaculture production. A large proportion of studies were experimental, tank-based interventions carried out at research institutes, therefore limiting the extent to which research outputs from these studies will directly affect aquaculture producers. There is a need to adopt more widespread use of field trials to investigate aquatic animal health interventions in India, Thailand and Vietnam.

The aim of a systematic review is to obtain as many studies as possible on a specific subject or intervention according to a set of inclusion criteria. The results of these studies are then pooled and a meta-analysis conducted. The extent to which these aims could be met by this review was unknown at the start, as there was no estimate of the volume of aquatic animal health research that existed or of the diversity of interventions. Many issues in this review prevented the complete fulfilment of these aims.

Part of the reason for the inability to carry out meta-analysis may be attributed to the review question. This review addressed a very broad range of interventions across a very broad subject area. If the question had focused on one topic of aquatic animal health interventions, e.g. feed and nutrition or disease, this may have enabled the specification of methods of delivery or categories of intervention from which studies could be grouped for comparisons and more testable hypotheses generated.

One major constraint to this review was funding being limited to one year. In consideration of this limited time allowance, a more specific question would have facilitated a more extensive search of the literature, resulting in a more complete collection of studies and a larger sample size for analysis. However, the extent to which additional time would affect the number of studies identified and obtained is unknown. Also, some subject areas were found to have had very few studies carried out on them in the three target countries, e.g. genetics and light, thus it would not have been productive to carry out a systematic review solely on these areas. This review has therefore been useful in identifying these subject areas.

One of the inclusion criteria was that studies must have been published between 1993 and 2003. This may have resulted in a biased representation of what aquatic animal health problems each country has been affected by. It is possible that intervention trials conducted before this time period may have resolved certain problems and removed the need to carry out any further research.

The breadth of the review question also limited the development of a search strategy for the electronic databases containing all possible synonyms for the key words. This may have resulted in some studies, containing the omitted synonyms, not being identified. Further, the topic of toxicity and toxicology was not incorporated into any of the search strategies. This subject area was not included because the application of toxic substances and their subsequent effects were not considered to be an intervention that may be beneficial to aquatic animal health. Studies that were identified were done so only because the abstracts contained other words included in the search strategies. These studies highlighted the need to incorporate this subject area into aquatic animal health research, as they related either to defining the boundaries of doses of therapeutic products or chemicals, or to the effects of toxic substances that may be present in industrial or pond effluent that may discharge into water bodies used for aquaculture.

To facilitate the standardisation of complex search strategies across databases, currently limited by restrictions on the size and complexity of search strategies, increasing the word allowance of database search engines would significantly improve the ability to do this, and would make the search more consistent and easier to repeat.

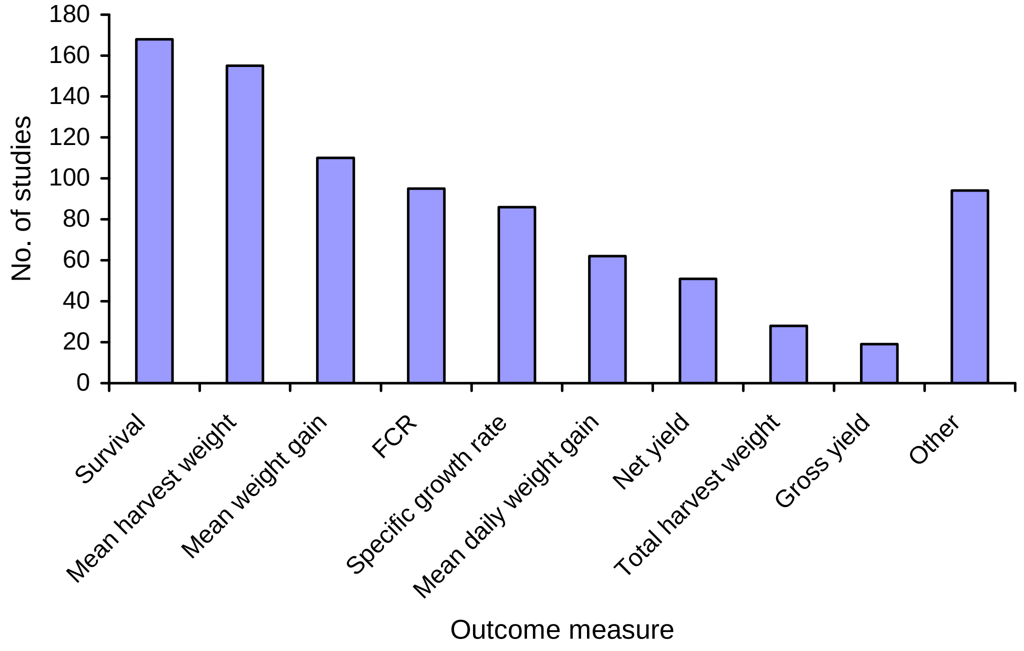
There were inconsistencies between search results highlighted by the lack of overlap between database searches. These factors combined highlight the need to search multiple databases when conducting any literature review and improvements need to be made to the dissemination of this information to researchers utilising this method.

Heterogeneity across included studies did not allow for a meta-analysis of the combined results. Even when studies were divided into broad categories and further into sub-categories, differences in the species and developmental stages used, the units of study, the interventions carried out and the outcomes measured, (including the units), still did not facilitate this process. The standardisation of units of measure for specific outcomes regularly used in aquatic animal health studies would help to improve the potential for comparison, as would the use of standard measures overall. However it is likely that heterogeneity from other sources would still prevent this.

In the previous chapter, an example of how statistical analysis of a different type might be carried out on studies of stocking density interventions on fish and shrimp was demonstrated. However, the sample size was very small for each of the outcome measures analysed, and the use of different species, (even within groups of fish and shrimp), and varied stocking densities limits the extent to which these results can be generalised. In addition, this sort of analysis would be more difficult for studies in the other categories of interventions, as the majority of interventions were different, making comparisons between them less meaningful than for stocking density.

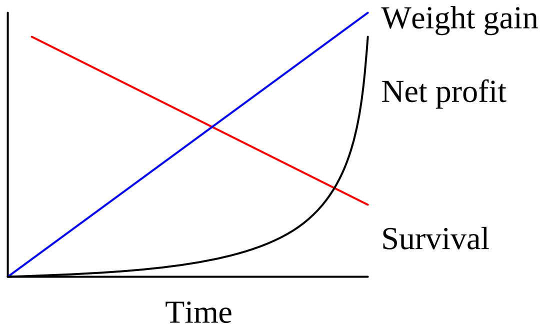
A very diverse range of outcome measures were used across all studies, (Figure 10.1). This was an additional constraint to the use of meta-analysis. Survival and mean harvest weight were the most common outcome measures used, with production measures of net yield, gross yield and total harvest weight being used to a lesser extent.

Fig. 10.1. Frequency distribution of outcome measures used across all studies



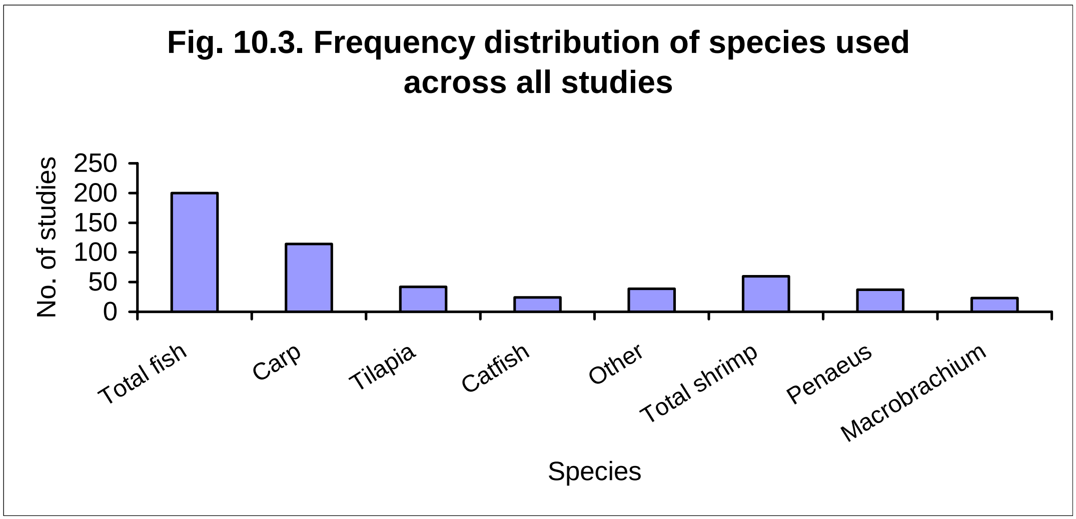
Standardisation of growth and production measures used in aquatic animal health research, particularly within a specific subject area, would help to facilitate this type of analysis. Standard measures that might be used could include survival and the growth rate of animals per day, allowing for outcomes to be standardised by time. If information on the original weight and number of animals stocked was provided, this would allow for all additional growth and production measures in figure 10.1 to be calculated. The most important outcomes for the farmer, in relation to poverty alleviation through improved aquaculture production, are survival and growth rate also, as these will determine net production. Figure 10.2 illustrates theoretically the relationship that may occur between the weight gain and survival of animals and the profit achieved by the farmer from the stock.

Fig. 10.2. Theoretical relationship between weight gain and survival of cultured animals and the net profit obtained from the harvest.



This relationship can be complex, e.g. a trade-off may exist between the price achieved on a harvest and the survival of the stock, as increased culture time may produce a high weight of animals that achieve a high price, but will accrue a greater level of mortality. If aquatic animal health intervention studies focused on optimising these parameters, they may be of more direct relevance to farmers.

Across all studies, 78% involved species of fish and 23% involved species of shrimp, (with a few using both), (Figure 10.3). Carp were used in the highest proportion of fish studies, (57%), followed by tilapia, (21%), then catfish, (12%). Additional species were used in 20% of studies, and in some cases, fish from more than one group were used together. A higher proportion of shrimp studies were on *Penaeus* sp. (61%) compared to *Macrobrachium* sp. (39%).



In view of poverty alleviation, carrying out research on a more diverse range of species, (not just those of the highest economic importance), would be relevant to a wider range of aquaculture producers.

This review has highlighted a paucity of studies selected for inclusion from Vietnam. In Thailand, the number of studies was higher although still fairly low. India on the other hand contributed the highest number of studies, higher than the other two countries combined. The possible implications of this are that there is less research being carried out in Vietnam and Thailand compared to India, or that this research is of a lower quality and was therefore not selected for inclusion in the review. Alternatively, dissemination of research outputs may be more effective in India compared to Vietnam and Thailand, and if this is the case there is a need to improve the situation in the latter two countries. The poor response rates from all three of the countries to the letter and questionnaire indicate that compliance of all types of organisations needs to improve however if this is to be achieved.

A country-specific searchable database containing names and contact details of all commercial companies, government organisations, non-government organisations, research institutes and universities involved in aquatic animal health would have improved the efficiency of the identification process. Time delays were accrued during the translation and back-translation of letters and questionnaires. However, this process proved very valuable for the identification of inconsistencies and mistakes in initial translation and efforts should be made to adopt this process as standard practice.

A very poor response rate to the letter and questionnaire was achieved, despite the use of a reminder card, a second letter and questionnaire and the provision, for 50% of contacts, of a postage payment coupon. This will have resulted in the loss of potentially important documents from a range of institutes. Sending out the letters and questionnaires from a centralised point in each of the target countries, may have improved the response rate, as may the provision of postage payment of a higher value.

A useful means of obtaining information on aquatic animal health conferences would be a searchable electronic database containing the names of all conferences. There is a need for improvement in the dissemination of conference proceedings, as highlighted by the small proportion available online and the poor response rate of conference organisers contacted by email, and an effective way of doing this would be to make more available online.

From the electronic search results, approximately one fifth of the abstracts did not provide adequate information regarding the criteria for inclusion and the full paper had to be obtained. A similar problem was also found in some conference proceedings and theses abstracts. There is a clear need for the standardisation of the structure of abstracts. In the case of private company documents, this would be more difficult and not necessarily appropriate, as such documents often take a different format and are not generally available for public use. A standardised abstract should include information on the study design, intervention carried out, outcome measures, and results obtained, including the type(s) of statistical analysis conducted. The promotion of this type of standardisation would, if successful, improve or simplify the process of systematic review.

A very important issue highlighted from this review is the lack of research on diseases of fish and shrimp. Only a very limited number of diseases were studied, and for the majority of notifiable diseases, no studies at all were selected. A greater amount of disease research, in particular clinical trials, needs to be conducted in all three countries and on a wider range of species.

Of the additional topics, the highest number of studies was on feed and nutrition, indicating this to be most active area of aquatic animal research or that these studies are of a higher quality compared to other subject areas. Efforts need to focus on those areas where little research has been done, in this case, on light and genetics interventions particularly.

Attempts to statistically analyse the effects of stocking density of fish on SGR and mortality values highlighted the influence of different studies, experiments, replicates and species on the variation seen in the data. This questions the validity of combining results from different studies and limits the extent to which findings can be generalised and used in aquaculture practice.

In conclusion, problems relating to the diversity and quality of aquatic animal health research in India, Thailand and Vietnam may limit the extent to which outputs from current aquatic animal health interventions will directly affect the livelihoods of aquaculture farmers in these countries.

REFERENCES TO TEXT

Abbot, N.C., and Ernst, E. 1998. Publication bias: direction of outcome less important than scientific quality. *Perfusion*. **11** (4): 182-184.

Abdullah, S. 1995. Scientific and technical information – Impetus for development in Southeast Asia. *International Forum on Information and Documentation.* **20** (2): 3-13.

Apelberg, B.J., Aoki, Y. and Jaakkola, J.J.K. 2001. Systematic review: Exposure to pets and risk of asthma and asthma-like symptoms. *Journal of Allergy and Clinical Limmunology.* **107** (3); 455-460.

Aritaki, M., Ohta, K., Hotta, Y., Tagawa, M. and Tanaka, M. 2004. Temperature effects on larval development and occurrence of metamorphosis-related morphological abnormalities in hatchery-reared spotted halibut *Verasper variegatus* juveniles. *Nippon Suisan Gakkaishi.* **70** (1): 8-15.

Australian Marine Conservation Society. 2003. Aquaculture bonds in the Northern Territory: A summary of the issues for the Ministerial Advisory Committee on Aquaculture in the Northern Territory.

Bachere, E. 2000. Shrimp immunity and disease control. *Aquaculture*. **191** (1-3): 3-11.

Bambang, Y., Charmantier, G., Thuet, P. and Trilles, J.P. 1995. Effect of cadmium on survival and osmoregulation of various developmental stages of the shrimp *Penaeus japonicus* (Crustacea, Decapoda). *Marine Biology.* **123** (3): 443-450.

Barcellos, L.J.G., Nicolaiewsky, S., de Sauza, S.M.G. and Lulhier, F. 1999. The effects of stocking density and social interaction on acute stress response in Nile tilapia *Oreochromis niloticus* (L.) fingerlings. *Aquaculture Research.* **30** (11-12): 887-892.

Bechteler, C. and Holler, D. 1995. Preliminary trials about the immunisation of prawns (*Penaeus monodon*) against Vibriosis. *Berliner und Munchener Tierarztliche Wochenschrift.* **108** (12): 462-465.

Beckles Willson, N., Elliott, T.M. and Everard, M.L. 2004. Omega-3 fatty caids (from fish oils) for cystic fibrosis (Cochrane Review). *The Cochrane Library, Issue 1.*

Binh, C.T. and Kwei Lin, C. 1995. Shrimp culture in Vietnam. *World Aquaculture.* **26** (4): 27-33.

Bjornsson, B.T., Hemre, G.I., Bjornevik, M. and Hansen, T. 2000. Photoperiod regulation of plasma growth hormone levels during induced smoltification of underyearling Atlantic salmon. *General and Comparative Endocrinology.* **119** (1): 17-25.

Boonyaratpalin, M. 1997. Nutrient requirements of marine food fish cultured in Southeast Asia. *Aquaculture.* **151** (1-4): 283-313.

Bower, S.M. 2003. Update on emerging abalone diseases and techniques for health assessment. *Journal of Shellfish Research.* **22** (3): 805-810.

Box, G.E.P. 1953. Non-normality and tests on variances. *Biometrika* **40**: 318-335.

Boyd, C.E. 2003. Guidelines for aquaculture effluent management at the farm-level. *Aquaculture.* **226** (1-4): 101-112.

Brock, J.A., and Bullis, R. 2001. Disease prevention and control for gametes and embryos of fish and marine shrimp. *Aquaculture.* **197** (1-4): 137-159.

Brzseki, V. and Newkirk, G. 1997. Integrated coastal food production systems – A review of current literature. *Ocean and Coastal Management.* **34** (1): 55-71.

Caddy, J.F. 1999. Fisheries management in the twenty-first century: will new paradigms apply? *Reviews in Fish Biology and Fisheries.* **9** (1): 1-43.

Campos-Mendoza, A., McAndrew, B.J., Coward, K. and Bromage, N. 2004. Reproductive response of Nile tilapia (*Oreochromis niloticus*) to photoperiodic manipulation; effects on spawning periodicity, fecundity and egg size. *Aquaculture.* **231** (1-4): 299-314.

Cavalli, R.O., Batista, F.M.M., Lavens, P., Sorgeloos, P., Nells, H.J. and De Leenheer, A.P. 2003. Effect of dietary supplementation of vitamins C and E on maternal performance and larval quality of the prawn *Macrobrachium rosenbergii*. *Aquaculture.* **227** (1-4): 131-146.

Cave, C.B., Bryant, J. and Milne, R. 2003. Recombinant growth hormone in children and adolescents with Turner syndrome (Cochrane Review). *The Cochrane Library*, Issue 4.

Cetinkaya, B., Edorgan, H.M. and Morgan, K.L. 1997. Relationships between the presence of Johne's disease and farm and management factors in dairy cattle in England. *Preventive Veterinary Medicine*. **32** (3-4): 253-266.

Chen, S.N. 1996. Current status of trade in cultured shrimps. *Revue Scientifique et Technique de l'Office International des Epizooties.* **15** (2): 517-521.

Cheng, W.T., Liu, C.H. and Kuo, C.M. 2003. Effects of dissolved oxygen on haemolymph parameters of freshwater giant prawn, *Macrobrachium rosenbergii* (de Man). *Aquaculture.* **220** (1-4): 843-856.

Chinni, S., Khan, R.N. and Yallapragada, P.R. 2002. Acute toxicity of lead on tolerance, oxygen consumption, ammonia-N excretion, and metal accumulation in *Penaeus indicus* postlarvae. *Ecotoxicology and Environmental Safety*. **51** (2): 79-84.

Clarke, M. 2003. Systematic reviews and the Cochrane Collaboration. http://www.cochrane.org/docs/whycc.htm.

Clarke, M. and Oxman, A.D., editors. Cochrane Reviewers Handbook 4.1.5 [updated April 2002]. In: The Cochrane Library, Issue 2, 2002. Oxford: Update Software, Updated quarterly.

Clarke, M, Oxman, A.D, editors. Formulating the problem. Cochrane Reviewers Handbook 4.1.5 [updated April 2002]; Section 4. In: The Cochrane Library, Issue 2. 2002(a). Oxford: Update Software. Updated quarterly.

Clarke M, Oxman, AD, editors. Assessment of study quality. Cochrane Reviewers Handbook 4.1.5 [updated April 2002]; Section 6. In: The Cochrane Library, Issue 2, 2002(b). Oxford: Update Software. Updated quarterly.

Clarke M, Oxman, AD, editors. Analysing and presenting results. Cochrane Reviewers Handbook 4.1.5 [updated April 2002]; Section 8. In: The Cochrane Library, Issue 2, 2002(c). Oxford: Update Software. Updated quarterly.

Cochran, W.G. 1947. Some consequences when the assumptions for the analysis of variance are not satisfied. *Biometrics* **3**: 22-38.

Cochrane, A.L. 1972. Effectiveness and Efficiency. Random Reflections on Health Services. London: Nuffield Provincial Hospitals Trust.

Cochrane Collaboration. 2004. Cochrane Reviews: abstracts and full-text access. http://www.cochrane.org/reviews/index.htm

Cogun, H.Y. and Kargin, F. 2004. Effects of pH on the mortality and accumulation of copper in tissues of *Oreochromis niloticus. Chemosphere.* **55** (2): 277-282.

Conde-Agudelo, A., Diaz-Rossello, J.L. and Belizan, J.M. 2004. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants (Cochrane Review). *The Cochrane Library, Issue 1.*

Cormac, I., Jones, C., Campbell, C. and Silveira da Mota Neto, J. 2004. Cognitive behaviour therapy for schizophrenia (Cochrane Review). *The Cochrane Library, Issue 1.*

Correa, A., Stewart, W.F., Yeh, H-C. and Santos-Burgoa, C. 1994. Exposure measurement in case-control studies: reported methods and recommendations. *Epidemiologic Reviews*. **16**: 18-32.

Corsin, F., Turnbull, J.F., Hao, N.V., Mohan, C.C., Phi, T.T., Phuoc, L.H., Tinh, N.T.N., and Morgan, K.L. 2001. Risk factors associated with white spot syndrome virus infection in a Vietnamese rice-shrimp farming system. *Diseases of Aquatic Organisms.* **47** (1): 1-12.

Corsin, F., Phi, T.T., Phuoc, L.H., Tinh, N.T.N., Hao, N.V., Mohan, C.V., Turnbull, J.F. and Morgan, K.L. 2002. Problems and solutions with the design and execution of an epidemiological study of white spot disease in black tiger shrimp (*Penaeus monodon*) in Vietnam. *Preventive Veterinary Medicine.* **53** (1-2): 117-132.

Couture, P. and Kumar, P.R. Impairment of metabolic capacities in copper and cadmium contaminated wold yellow perch (*Perca flavescens*). *Aquatic Toxicology*. **64** (1): 107-120.

Curran, M.M. and MacLeHose, H.G. 2002. Community animal health services for improving household wealth and health status of low income farmers. *Tropical Animal Health and Production*. **34** (6): 449-470.

Dabrowski, K., Rinchard, J., Ottobre, J.S., Alcantara, F., Padilla, P., Ciereszko, A., De Jesus, M.J. and Kohler, C.C. 2003. Effect of oxygen saturation in water on reproductive performances of pacu *Piaractus brachypomus. Journal of the World Aquaculture Society.* **34** (4): 441-449.

Darwish, A., Plumb, J.A. and Newton, J.C. 2000. Histopathology and pathognesis of experimental infection with *Edwardsiella tarda* in channel catfish. *Journal of Aquatic Animal Health.* **12** (4): 255-266.

Depaola, A., Peeler, J.T. and Rodrick, G.E. 1995. Effect of oxytetracycline-medicated feed on antibiotic resistance of gram-negative bacteria in catfish ponds. *Applied and Environmental Microbiology*.**61** (6): 2335-2340.

Diamond, B. 2003. SARS spreads new outlook on quarantine models. *Nature Medicine*. **9** (12): 1441-1444.

Docic, M. and Bilker, G. 2003. Differences in antibiotic resistance in *Escherichia coli* from East-European swine herds with or without prophylactic use of antibiotics. *Journal of Veterinary Medicine Series B – Infectious Diseases and Veterinary Public Health.* **50** (1): 27-30.

Doherr, M.G., Carpenter, T.E., Wilson, W.D. and Gardner I.A. 1998. Application and evaluation of a mailed questionnaire for an epidemiologic study of Corynebacterium pseudotuberculosis infection in horses. *Preventive Veterinary Medicine*. **35** (4): 241-253.

Donaldson, E.M. 1996. Manipulation of reproduction in farmed fish. *Animal Reproduction Science.* **42** (1-4): 381-392.

Dunham, R.A., Majumdar, K., Hallerman, E., Bartley, D., Mair, G., Hulata, G., Liu, Z., Pongthana, N., Bakos, J., Penman, D., Gupta, M., Rothlisberg, P. and Hoerstgen-Schwark, G. 2001. Review of the status of aquaculture genetics. In Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E., and Arthur, J.R. eds.

Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 137-166. NACA, Bangkok and FAO, Rome.

Edwards, H.M. 2000. Nutrition and skeletal problems in poultry. *Poultry Science.* **79**: 1018-1023.

Edwards, P., Roberts, I., Clarke, M., DiGuisepps, C., Pratap, S., Wentz, R. and Kwan, I. 2002. Increasing response rates to postal questionnaires: systematic review. *British Medical Journal.* **324** (7347): 1183-1191.

Edwards, P, Roberts, I, Clarke, M., DiGuiseppi, C., Pratap, S., Wentz, R. and Kwan I. 2004. Methods to influence response to postal questionnaires (Cochrane Methodology Review). *The Cochrane Library, Issue 1.*

Ellis, T., North B., Scott, A.P., Bromage, N.P., Porter, M.and Gadd, D. 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of Fish Biology*. **61**: 493-531.

Elsen, J.M. 2003. Utilisation of genomic information in livestock improvement. *Outlook on Agriculture.* **32** (4): 241-245.

Erdogan, H.M., Cetinkaya, B., Green, L.E., Cripps, P.J. and Morgan, K.L. 2001. Pre**v**alence, incidence, signs and treatment of clinical listeriosis in dairy cattle in England. *The Veterinary Record*. **149** (10): 289-293.

Esaki, H., Morioka, A., Ishihara, K., Kojima, A., Shiroki, S., Tamura, Y. and Takahashi, T. 2004. Antimicrobial susceptibility of Salmonella isolated from cattle, swine and poultry (2001-2002): report from the Japanese Veterinary Antimicrobial Resistance Monitoring Program. *Journal of Antimicrobial Chemotherapy*. **53** (2): 266-270.

Estrada, C.A., Bloch, R.M., Antonacci, D., Basnight, L., Patel, S.R., and Wiese, W. 2000. Reporting and concordance of methodologic criteria between abstracts and articles in diagnostic test studies. *Journal of General Internal Medicine.* **15**: 183-187.

Evans, J.J., Shoemaker, C.A. and Klesius, P.H. 2003. Effects of sublethal dissolved oxygen stress on blood glucose and susceptibility to *Streptococcus agalactiae* in Nile tilapia *Oreochromis niloticus. Journal of Aquatic Animal Health.* **15** (3): 202-208.

FAO. 1999. World review of fisheries and aquaculture. Fisheries resources: trends in production, utilization and trade. In: FAO. 1999. The state of world fisheries and aquaculture, 1998. FAO, Rome, (Italy), and
http://www.fao.org/docrep/w9900e/w9900e02.htm#P0_0

FAO. 2001. Aquaculture issues in the Bangkok Declaration: Improving environmental sustainability. In: FAO. 2001. The Bangkok Declaration and the strategy for aquaculture development beyond 2000: The aftermath. FAO, Regional Office for Asia and the Pacific, Bangkok, Thailand.

FAO. 2002. The state of world fisheries and aquaculture 2002. http://www.fao.org/DOCREP/005/Y7300E/y7300e05.htm.

Fisher, J.P., Fitzsimons, J.D., Combs, G.F. and Spitsbergen, J.M. 1996. Naturally occuring thiamine deficiency causing reproductive failure in Finger Lakes Atlantic salmon and great lakes lake trout. *Transactions of the American Fisheries Society*. **125** (2): 167-178.

Flegel, T.W. and Alday-Sanz, V. 1998. The crisis in Asian shrimp aquaculture: Current status and future needs. *Journal of Applied Ichthyology*. **14** (3-4): 269-273.

Fluharty, D. 2000. Habitat protection, ecological issues, and implementation of the Sustainable Fisheries Act. *Ecological Applications*. **10** (2): 325-337.

Food Market Exchange. 2003. Shrimp: A review of the news in 2002. http://www.foodmarketexchange.com/datacenter/industry/article/idf_shrimp_review2002.php

Foott, J.S., Hannon, R. and Stone, R. 2004. Effect of water temperature on non-specific immune function and ceratomyxosis in juvenile chinook salmon and steelhead from the Klamath River. *California Fish and Game*. **90** (2): 71-84.

Funge-Smith, S. and Phillips, M.J. 201. Aquaculture systems and species. *In*: Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R., eds. *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February, 2000. pp. 193-219. NACA, Bangkok and FAO, Rome.

Galyean, M.L., Perino, L.J., and Duff, G.C. 1999. Interaction of cattle health/immunity and nutrition. *Journal of Animal Science*. **77** (5): 1120-1134.

Gaylord, T.G., Schwartz, M.H., Davitt, G.M., Cool, R.W., Jahneke, M.L. and Craig, S.R. 2003. Dietary lipid utilisation by juvenile summer flounder *Paralichthys dentatus*. *Journal of the World Aquaculture Society*. **34** (2): 229-235.

Geographic.com. 2004(a). http://www.theodora.com/wfb/1992/wfb_1992.html

Geographic.com. 2004(b). http://www.theodora.com/wfb/2002/index.html

George, A. and Rubin, G. 2003. A systematic review and meta-analysis of treatments for impetigo. *British Journal of General Practice*. **53** (491): 480-487.

Georgiadis, M.P., Hedrick, R.P., Johnson, W.O., Yun, S. and Gardner, I.A. 2000. Risk factors for outbreaks of disease attributable to white sturgeon iridovirus and white sturgeon herpesvirus-2 at a commercial sturgeon farm. *American Journal of Veterinary Research*. **61** (10): 1232-1240.

Ghittino, C., Latini, M., Agnetti, F., Panzieri, C., Lauro, L., Ciappelloni, R. and Petracca, G. 2003. Emerging pathologies in aquaculture: effects on production and food safety. *Veterinary Research Communications.* **27**: 471-479 Supplement 1.

Gill, C. 1996. World feed panorama: more growth in key countries of Asia and Latin America. *Feed International.* **17** (1): 4-5.

Gill, C. 1997. World feed panorama: high cost feedstuffs: global impact, response. *Feed International***.** **18** (1): 6-16.

Goldstein, H. 1995. Multilevel statistical models. London, Edward Arnold: New York, Wiley.

Goldstein, H., and Sammons, P. 1997. The influence of secondary and junior schools on sixteen year examination performance: a cross-classified multilevel analysis. *School effectiveness and school improvement*, **8**: 219-230.

Green, S., Buchbinder, R. and Hetrick, S. 2004. Physiotherapy interventions for shoulder pain (Cochrane Review). *The Cochrane Library, Issue 1.*

Gryseels, G. 2001. International fisheries research and sustainable food security. *World Aquaculture.* **32** (4): 12-15, 66.

Haard, N.F. 1992. Control of chemical-composition and food quality attributes of cultured fish. *Food Research International*. **25** (4): 289-307.

Hall, A.L. 2001. The effect of stocking density on the welfare and behaviour of broiler chickens reared commercially. *Animal Welfare.* **10** (1): 23-40.

Handy, R.D. 2003. Chronic effects of copper exposure versus endocrine toxicity: two sides of the same toxicological process? *Comparative Biochemistry and Physiology A – Molecular and Integrative Physiology.* **135** (1): 25-38.

Hansen, T., Karlsen, O., Taranger, G.L., Hemre, G.I., Holm, J.C. and Kjelson, O.S. 2001. Growth, gonadal development and spawning time of Atlantic cod (*Gadus morhua*) reared under different photoperiods. *Aquaculture.* **203** (1-2): 51-67.

Hasan, M.R. 2001. Nutrition and feeding for sustainable aquaculture development in the third millennium. *In*: Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R., eds. *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February, 2000. pp. 193-219. NACA, Bangkok and FAO, Rome.

Healy, D., and Cattell, D. 2003. Interface between authorship, industry and science in the domain of therapeutics. *British Journal of Psychiatry*. **183**: 22-27.

Hebert, R.S., Smith, C.G., Wright, S.M. 2003. Minimal prevalence of authorship misrepresentation among internal medicine residency applicants: Do previous estimates of 'misrepresentation' represent insufficient case finding? *Annals of Internal Medicine.* **138**: 390-392.

Hemalatha, S. and Banerjee, T.K. 1997. Histopathological analysis of acute toxicity of zinc chloride on the respiratory organs of air-breathing catfish *Heteropneustes* (Saccobranchus) *fossilis* (Bloch). *Veterinarski Arhiv.* **67** (1): 11-24.

Hemsley-Brown, J. and Sharp, C. 2003. The use of research to improve professional practice: a systematic review of the literature. *Oxford Review of Education.* **29** (4): 449-470.

Henderson, W.R., Dhingra, V.K., Chittock, D.R., Fenwick, J.C. and Ronco, J.J. 2003. Hypothermia in the management of traumatic brain injury – A systematic review and meta-analysis. *Intensive Care Medicine.* **29** (10): 1637-1644.

Hirst, W.M., Le Fevre, A.M., Logue, D.N., Offer, J.E., Chaplin, S.J., Murray, R.D., Ward, W.R., and French, N.P. 2002. A systematic compilation and classification of the literature on lameness in cattle. *The Veterinary Journal.* **164**: 7-19.

Hojat, M., Goneela, J.S., and Caelleigh, A.S. 2003. Important judgement by the 'gatekeepers' of science: falability and accountability in the peer review process. *Advances in Health Sciences Education.* **8** (1): 75-96.

Hopkins K.D. 1992. Reporting fish growth: A review of the basics. *Journal of the World Aquaculture Society.* **23** (3): 173-179.

Hopkins, M.L., Fung, M.F.K., Le, T. and Shorr, R. 2004. Ovarian cancer patients and hormone replacement therapy: a systematic review. *Gynecologic Oncology.* **92** (3): 827-832.

Howell, R.A., Berlinsky, D.L. and Bradley, T.M. 2003. The effects of photoperiod manipulation on the reproduction of black sea bass, *Centropristis striata. Aquaculture.* **218** (1-4): 651-669.

Indiapost. 2003. Indiapost: International service. http://www.indiapost.org/foreigntariff.html

Irianto, A., and Austin, B. 2002. Probiotics in Aquaculture. *Journal of Fish Diseases.* **25** (11): 633-642.

Jana, B.B. and Jana, S. 2003. The potential and sustainability of aquaculture in India. *Journal of Applied Aquaculture.* **13** (3-4): 283-316.

Kasornchandra, J., Boonyaratpalin, S. and Itami, T. 1998. Detection of white-spot syndrome in cultured penaeid shrimp in Asia: Microscopic observation and polymerase chain reaction. *Aquaculture.* **164** (1-4): 243-251.

Kasumyan, A.O. and Doving, K.B. 2003. Taste preferences in fishes. *Fish and Fisheries.* **4** (4): 289-347.

Kautsky, N., Ronnback, P., Tedengren, M. and Troell, M. 2000. Ecosystem perspectives on management of disease in shrimp pond farming. *Aquaculture.* **191** (1-3): 145-161.

Key, C., Layton, D. and Shakir, S.A.W. 2002. Results of a postal survey of the reasons for non-response by doctors in a Prescription Event Monitoring study of drug safety. *Pharmacoepidemiology and Drug Safety*. **11**: 143-148.

Kolkovski, S. 2001. Digestive enzymes in fish larvae and juveniles – implications and applications to formulated diets. *Aquaculture*. **200** (1-2): 181-201.

Koslow, J.A., Boehlert, G.W., Gordon, J.D.M., Haedrich, R.L., Lorance, P. and Parin, N. 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. *ICES Journal of Marine Science.* **57** (3): 548-557.

Kumlu, M., Eroldogan, O.T., Aktas, M. and Saglamtimur, B. 2001. Larval growth, survival and development of *Metapenaeus monoceros* (Fabricus) cultured in different salinities. *Aquaculture Research.* **32** (2): 81-86.

Kwei Lin, C. 1995. Progression of intensive marine shrimp culture in Thailand. In: Browdy, C.L. and Hopkins, J.S. (eds). Swimming through troubled water. Proceedings of the special session on shrimp farming, Aquaculture 1995. World Aquaculture Society, Baton Rouge, Louisiana, USA.

Lakra, W.S. and Ayyappan, S. 2003. Recent advances in biotechnology applications to aquaculture. *Asian-Australasian Journal of Animal Sciences.* **16** (3): 455-462.

Langford, F.M, Weary, D.M. and Fisher, L. 2003. Antibiotic resistance in gut bacteria from dairy calves: A dose response to the level of antibiotics fed in milk. *Journal of Dairy Science.* **86** (12): 3963-3966.

Lara-Flores, M., Olvera-Novoa, M.A., Guzman-Mendez, B.E. and Lopez-Madrid, W. 2003. Use of bacteria Streptococcus faecium and Lactobacillus acidophilus, and the yeast Saccharomyces cerevisiae as growth promoters in Nile tilapia (*Oreochromis niloticus*). *Aquaculture.* **216** (1-4): 193-201.

Lee, B., Bhuta, T., Craig, J. and Simpson, J. 2003. Methenamine hippurate for preventing urinary tract infections (Cochrane Review). *The Cochrane Library*, Issue 4.

Leung, G.M., Ho, L.M., Chan, M.F., Johnston, J.M. and Wong, F.K. 2002. The effects of cash and lottery incentives on mailed surveys to physicians: A randomised trial. *Journal of Clinical Epidemiology*. **55**: 801-807.

Lim, C., Ako, H., Brown, C.L. and Hahn, K. 1997. Growth response and fatty acid composition of juvenile *Penaeus vannamei* fed different sources of dietary lipid. *Aquaculture.* **151** (1-4): 143-153.

Lin, C.K. and Yi, Y. 2003. Minimising environmental impacts of freshwater aquaculture and reuse of pond effluents and mud. *Aquaculture.* **226** (1-4): 57-68.

Lovatelli, A. 1997. Status of aquaculture in Vietnam. *Aquaculture Asia.* **2** (3): 18-24.

MacKenzie, D.S., VanPutte, C.M. and Leiner, K.A. 1998. Nutrient regulation of endocrine function in fish. *Aquaculture.* **161** (1-4): 3-25.

Madhusudhan, M., Morgan K.L. and Mohan, C.V. 2002. Estimation of prevalence of white spot syndrome virus (WSSV) by polymerase chain reaction in *Penaeus monodon* postlarvae at time of stocking in shrimp farms of Karnataka, India: a population-based study. *Diseases of Aquatic Organisms.* **49** (3): 235-243.

Manning, B.B., Li, M.H., Robinson, E.H., Gaunt, P.S., Camus, A.C. and Rottinghaus, G.E. 2003. Response of channel catfish to diets containing T-2 toxin. *Journal of Aquatic Animal Health.* **15** (3): 229-238.

Marques, H.L.D., Lombardi, J.V. and Boock, M.V. 2000. Stocking densities for nursery phase culture of the freshwater prawn *Macrobrachium rosenbergii* in cages. *Aquaculture.* **187** (1-2): 127-132.

McGuiness, K.A. 2002. Of rowing boats, ocean liners and tests of the ANOVA homogeneity of variance assumption. *Austral Ecology* **27**: 681-688.

Menasveta, P. 2002. Improved shrimp growout systems for disease prevention and environmental sustainability in Asia. *Reviews in Fisheries Science.* **10** (3-4): 391-402.

MLwiN Help version 2.0.011 - June 2001. ©Institute of Education.

Mohammed, Z. 1995. Research in library and information science in a developing country – Nigeria. *Library and Information Science Research.* **17** (3): 295-303.

Moher, M., Hey, K. and Lancaster, T. 2004. Workplace interventions for smoking cessation (Cochrane Review). *The Cochrane Library, Issue 1.*

Moinard, C., Mendl, A., Nicol, C.J. and Green, L.E. 2003. A case-control study of on-farm risk factors for tail biting in pigs. *Applied Animal Behaviour Science.* **81** (4): 333-355.

Mukhopadhyay, S., Singh, M., Cater, J.I., Ogston, S., Franklin, M. and Olver, R.E. 1996. Nebulised antipseudomonal antibiotic therapy in cystic fibrosis: A meta-analysis of benefits and risks. *Thorax.* **51** (4): 364-368.

Murphy, N. and Krimsky, S. 2003. Implicit precaution, scientific inference, and indirect evidence: the basis for the US Environmental Protection Agency's regulation of genetically modified crops. *New Genetics and Society*. **22** (2): 127-143.

Murphy, L.S., Reinsch, S., Najm, W.I., Dickerson, V.M., Seffinger, M.A., Adams, A., and Mishra, S.I. 2003. Spinal palpation: The challenges of information retrieval using available databases. *Journal of Manipulative and Physiological Therapeutics*. **26** (6): 374-382.

Naylor, S., Brisson, J., Labelle, M.A., Drigo, A. and Corneau, Y. 2003. Treatment of freshwater fish farm effluent using constructed wetlands: the role of plants and substrate. *Water Science and Technology*. **48** (5): 215-222.

Nikoskelainen, S., Ouwehand, A.C., Bylund, G.,, Slaminen, S. and Lilius, E.M. 2003. Immune enhancement in rainbow trout (*Onchorhynchus mykiss*) by potential probiotic bacteria (Lactobacillus rhamnosus). *Fish and Shellfish Immunology*. **15** (5): 443-452.

Oakley-Browne, M.A., Adams, P. and Mobberley, P.M. 2003. Interventions for pathological gambling (Cochrane Review). *The Cochrane Library*, Issue 4.

OIE. 2000. International Aquatic Animal Health Code and Diagnostic Manual for Aquatic Animal Diseases (OIE 2000). http://www.oie.int/eng/publicat.htm

OIE. 2003. http://www.rr-asia.oie.int/aadr/cbc/2003.

OIE. 2004(a). OIE: Regional aquatic animal disease report (country by country). http://www.rr-asia.oie.int/aadr/cbc/cbc_top.html.

OIE. 2004(b). http://www.oie.int/eng/normes/en_acode.htm.

Olivry, T. and Mueller, R.S. 2003. Evidence-based veterinary dermatology: a systematic review of the pharmacology of canine atopic dermatitis. *Veterinary Dermatology*. **14**: 121-146.

Oxman, A.D. and Guyatt, G.H. 1992. A consumers guide to subgroup analyses. *Annals of Internal Medicine*. **116** (1): 78-84.

Palit, S., Sharma, A. and Talukder, G. 1991. Cytotoxic effects of cobalt chloride on mouse bone-marrow cells in vivo. *Cytobios*. **68** (273): 85-89.

Park, H.L., O'Connell, J.E and Thomson, R.G. 2003. A systematic review of cognitive decline in the general elderly population. *International Journal of Geriatric Psychiatry*. **18** (12): 1121-1134.

Pathak, S.C., Ghosh, S.K. and Palanisamy, K. 2000. The use of chemicals in aquaculture in India. In: Arthur, J.R., Lavilla-Pitigo, C.R. and Subasinghe, R.P. eds. *Use of Chemicals in Aquaculture in Asia*. Proceedings of the Meeting on the Use of Chemicals in Aquaculture in Asia, 20-22 May 1996, Tigbauan, Iloilo, Philippines.

Southeast Asian Fisheries Development Centre, Aquaculture Department, Tigbauan, Iloilo, Philippines.

Petersen, A. and Dalsgaard, A. 2003. Antimicrobial resistance of intestinal Aeromonas spp. and Enterococcus spp. in fish cultured in integrated broiler-fish farms in Thailand. *Aquaculture*. **219** (1-4): 71-82.

Petti, S. 2003. Pooled estimates of world leukoplakia prevalence: a systematic review. *Oral Oncology*. **39** (8): 770-780.

Phillips, M.J., Boyd, C. and Edwards, P. 2001. Systems approach to aquaculture management. *In*: Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R., eds. *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February, 2000. pp. 193-219. NACA, Bangkok and FAO, Rome.

Pirrie, A. 2003. Spoilsport: on sport and attainment. *Educational Research.* **45** (2): 181-188.

Pitkin, R.M., and Branagan, M.A. 1998. Can the accuracy of abstracts be improved by providing specific instructions? A randomised controlled trial. *Journal of the American Medical Association, JAMA.* **280** (3): 267-269.

Pitkin, R.M., Branagan, M.A., and Burmeister, L.F. 1999. Accuracy of data in abstracts of published research articles. *Journal of the American Medical Association, JAMA.* **281** (12): 1110-1111.

Plowman, M.C., Peracha, H., Hopfer, S.M. and Sunderman, F.W. 1991. Teratogenicity of cobalt chloride in *Xenopus laevis*, assayed by the FETAX procedure. *Teratogenesis, Carcinogenesis and Mutagenesis*. **11** (2): 83-92.

Prince, D.L., Bayer, R.C., Gallagher, M.L., and Subramayam, M. 1995. Reduction of shell disease with an experimental diet in a Nova-Scotian lobster pound. *Journal of Shellfish Research.* **14** (1): 205-207.

Puangkaew, J., Kiron, V., Somamoto, T., Okamoto, N., Satoh, S., Takeuchi, T. and Watanabe, T. 2004. Nonspecific immune response of rainbow trout (*Onchorynchus mykiss* Walbaum) in relation to different status of vitamin E and highly unsaturated fatty acids. *Fish and Shellfish Immunology*. **16** (1): 25-39.

Pyle, G.G., Swanson, S.M. and Lehmkuhl, D.M. 2002. The influence of water hardness, pH, and suspended solids on nickel toxicity to larval fathead minnows (*Pimephales promelas*). *Water Air and Soil Pollution.* **133** (1-4): 215-226.

Rasbash, J. and Goldstein, H. 1994. Efficient analysis of mixed hierarchical and cross classified random structures using a multilevel model. Journal of Educational and Behavioural statistics **19**: 337-50.

Ridha, M.T. and Cruz, E.M. 2000. Effect of light intensity and photoperiod on Nile tilapia, *Oreochromis niloticus* L. seed production. *Aquaculture Research.* **31** (7): 609-617.

Riley, R.D., Heney, D., Jones, D.R., Sutton, A.J., Lambert, P.C., Abrams, K.R., Young, B., Wailoo, A.J. and Burchill, S.A. 2004. A systematic review of molecular and biological tumor markers in neuroblastoma. *Clinical Cancer Research.* **10** (1): 4-12.

Roberts, P-J., Roberts, C., Sibbald, B. and Torgerson, D.J. 2000. The effect of a direct payment or a lottery on questionnaire response rates: a randomised controlled trial. *Journal of Epidemiology and Community Health*. **54**: 71-72.

Robertson, P.A.W., O'Dowd, C., Burrells, C., Williams, P. and Austin, B. 2000. Use of Carnobacterium sp. as a probiotic for Atlantic salmon (*Salmo salar* L.) and rainbow trout (*Onchorynchus mykiss*, Walbaum). *Aquaculture.* **185** (3-4): 235-243.

Rogers, J.T., Richards, J.G. and Wood, C.M. 2003. Ionoregulatory disruption as the acute toxic mechanism for lead in the rainbow trout (*Oncorhynchus mykiss*). *Aquatic Toxicology*. **64** (2): 215-234.

Rohrer, G.A. 2004. An overview of genomics research and its impact on livestock reproduction. *Reproduction Fertility and Development.* **16** (1-2): 47-54.

Rosenthal, R. and DiMatteo, M.R. 2001. Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology.* **52**: 59-82.

Rothuis, A.J., Nhan, D.K., Richter, C.J.J. and Ollevier, F. 1998. Rice with fish culture in the semi-deep waters of the Mekong Delta, Vietnam: a socio-economical survey. *Aquaculture Research.* **29** (1): 47-57.

Shakitla, L., Sheeba, L., Omprakasam, M. and Manohar, L. 1999. Bacterial haemorrhagic septicaemia in *Cirrhina mrigala*, infected experimentally with *Aeromonas hydrophila. Journal of Environmental Biology.* **20** (1): 55-59.

Shariff, M. 1998. Impact of diseases in aquaculture in the Asia-Pacific region as exemplified by epizootic ulcerative syndrome (EUS). *Journal of Applied Ichthyology.* **14** (3-4): 139-144.

Shiau, S.Y. and Wu, M.H. 2003. Dietary vitamin B-6 requirement of grass shrimp, *Penaeus monodon. Aquaculture.* **225** (1-4): 397-404.

Smith, V.J., Brown, J.H. and Hauton C. 2003. Immunostimulation in crustaceans: does it really protect against infection? *Fish and Shellfish Immunology*. **15** (1): 71-90.

Spaargaren, D.H. 1999. Optimal harvest size in shrimp cultures. *Crustaceana.* **72** (3): 297-306.

Stone, D.A.J. 2003. Dietary carbohydrate utilisation by fish. *Reviews in Fisheries Science.* **11** (4): 337-369.

Subasinghe, R. 1997. Fish health and quarantine. In: FAO Fisheries Department. Review of the state of world aquaculture. FAO Fisheries Circular No. 886 FIRI/C886 (Rev. 1). Rome. 1997.

Subasinghe, R.P., Bondad-Reantaso, M.G. and McGladdery, S.E. 2001. Aquaculture development, health and wealth. In: Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R. eds. *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 167-191. NACA, Bangkok and FAO, Rome.

Sutton, A.J., Abrams, K.R. and Jones, D.R. 2001. An illustrated guide to the methods of meta-analysis. *Journal of Evaluation in Clinical Practice.* **7** (2): 135-148.

Tacon, A.G.J. 2004. Selected developments and trends: Aquafeeds and feeding strategies. In: FAO Fisheries Department Review of the State of World Aquaculture. FAO Fisheries Circular No. 886 FIRI/C886 Rev. 1 and http://www.fao.org/docrep/003/w7499e/w7499e16.htm

Tacon, A.G.J., Phillips, M.J. and Barg, U.C. 1995. Aquaculture feeds and the environment – The Asian experience. *Water Science and Technology.* **31** (10): 41-59.

Taddio, A., Pain, T., Fassos, F.F., Boon, H., Ilersich, A.L., and Einarson, T.R. 1994. Quality of nonstructured and structured abstracts of original research articles in the British Medical Journal, the Canadian Medical Association Journal and the Journal of the American Medical Association. *Canadian Medical Association Journal.* **150** (10): 1611-1615.

Teshima, S., Alam, M.S., Koshio, S., Ishikawa, M. and Kanazawa, A. 2002. Assessment of requirement values for essential amino acids in the prawn, *Marsupenaeus japonicus* (Bate). *Aquaculture Research.* **33** (6): 395-402.

Thailand guidebook. 2003. Post office in Thailand: Air mail. http://www.thailandguidebook.com/postoffice/airmail.html

The Campbell Collaboration. 2004. http://www.campbellcollaboration.org/.

Thophon, S., Kruatrachue, M., Upatham, E.S., Pokethitiyook, P., Sahaphong, S. and Jaritkhuan, S. 2003. Histopathological alterations of white seabass, *Lates calcarifer*, in acute and subchronic cadmium exposure. *Environmental Pollution.* **121** (3): 307-320.

Tonguthai, K. 2000. The use of chemicals in aquaculture in Thailand. *In*: Arthur, J.R., Lavilla-Pitigo, C.R. and Subasinghe, R.P., eds. *Use of Chemicals in Aquaculture in Asia.* 2000. Southeast Asian Fisheries Development Centre, Aquaculture Department, Tigbauan, Iloilo, Philippines.

Torgerson, C.J., Porthouse, J. and Brooks, G. 2003. A systematic review and meta-analysis of randomised controlled trials evaluating interventions in adult literacy and numeracy. *Journal of Research in Reading.* **26** (3): 234-255.

Turner, G. (ed.). 1988. Codes of Practice and Manual for Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms. EIFAC Occasional Paper No. 23. European Inland Fisheries Advisory Commission. Food and Agriculture Organisation of the United Nations, Rome, Italy.

United Nations. 2002. Environmental governance for sustainable development in Asia and the Pacific. United Nations Development Programme: Economic and Social Commission for Asia and the Pacific. http://www.gm-unccd.org/FIELD/Multi/ESCAP/Env.pdf**.**

Universal Postal Union. 2004. International reply coupons. http://www.upu.int/irc/en/index.html.

Usmani N, Jafri AK, Alvi AS. 1997. Effect of feeding glanded cottonseed meal on the growth, conversion efficiency and carcass composition of Labeo rohita (Hamilton) fry. *Journal of Aquaculture in the Tropics*. 73-78.

Van Tulder, M.W., Scholten, R.J.P.M., Koes B.W. and Deyo, R.A. 2004. Non-steroidal anti-inflammatory drugs for low back pain (Cochrane Review). *The Cochrane Library, Issue 1.*

Vaseeharan, B. and Ramasamy, P. 2003. Abundance of potentially pathogenic micro-organisms in *Penaeus monodon* larvae rearing systems in India. *Microbiological Research.* **158** (4): 299-308.

Villena, A.J. 2003. Applications and needs of fish and shellfish cell culture for disease control in aquaculture. *Reviews in Fish Biology and Fisheries.* **13** (1): 111-140.

Volmink, J., Lancaster, T., Gray, S. and Silagy, C. 1996. Treatments for postherpetic neuralgia – A systematic review of randomised controlled trials. *Family Practice.* **13** (1): 84-91.

Wahli, T., Verlhac, V., Gabaudan, J., Schuep, W. and Meier, W. 1998. Influence of combined vitamins C and E on non-specific immunity and disease resistance of rainbow trout, *Onchorynchus mykiss* (Walbaum). *Journal of Fish Diseases.* **21** (2): 127-137.

Walter, G., Bloch, S., Hunt G., and Fisher, K. 2003. Counting on citations: a flawed way to measure quality. *Medical Journal of Australia.* **178**: 280-281.

Watanabe, T. 2002. Strategies for further development of aquatic feeds. *Fisheries Science.* **68** (2): 242-252.

Wheeler, M.B. 2003. Production of transgenic livestock: Promise fulfilled. *Journal of Animal Science*. **81**: 32-37 Supplement 3.

Winker, M.A. 1999. The need for concrete improvement in abstract quality. *Journal of the American Medical Association, JAMA.* **281** (12): 1129-1130.

Wood, J.L.N., Milne, E.M. and Doxey, D.L. 1998. A case-control study of grass sickness (equine dysautonomia) in the United Kingdom. *Veterinary Journal*. **156** (1): 7-14.

World Aquaculture Outlook. 2002.

World Bank. 2003(a). India at a glance. http://www.worldbank.org/data/countrydata/aag/ind_aag.pdf

World Bank. 2003(b). Thailand at a glance. http://www.worldbank.org/data/countrydata/aag/tha_aag.pdf

World Bank. 2003(c). Vietnam at a glance. http://www.worldbank.org/data/countrydata/aag/vnm_aag.pdf

World Fish Centre. 2002. Implementation status of the research components (March – August 2002): Component 1 – Profile of key aquaculture technologies and fishing practices: Vietnam. *In*: Fish Supply and Demand in Asia: Progress report 2002. World Fish Centre, and http://www.worldfishcenter.org/demandsupply/inception_reportaug02/ir_aug02_profileofkatfp_vietnam.asp

World Trade Organisation. 2004. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm

Young, G. and Jewell, D. 2004. Interventions for preventing and treating pelvic and back pain in pregnancy (Cochrane Review). *The Cochrane Library, Issue 1.*

REFERENCES TO INCLUDED STUDIES

Adhikari, S. and Ayyappan, S. 2002. Fertilisation of freshwater fish ponds with cobalt and its absorption and desorption in the pond sediment. *The Israeli Journal of Aquaculture – Bamidgeh.* **54** (3): 110-115.

Ahamad Ali, S. 1993. Evaluation of different carbohydrates in the diet of the prawn *Penaeus indicus*. *Journal of Aquaculture in the Tropics.* **8**: 13-23.

Ahamad Ali, S. 1996. Carbohydrate nutrition under different dietary conditions in prawn *Penaeus indicus*. *Journal of Aquaculture in the Tropics.* **11**: 13-25.

Ahammad, M.M., Bhattacharyya, D. and Jana, B.B. 1998. Effect of different concentrations of cryprotectant and extender on the hatching of Indian major carp embryos (*Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala*) stored at low temperature. *Cryobiology.* **37**: 318-324.

Ahammad, M.M., Bhattacharyya, D. and Jana, B.B. 2002. The hatching of common carp (Cyprinus carpio L.) embryos in response to exposure to different concentrations of cryoprotectant at low temperatures. *Cryobiology.* **44**: 114-121.

Ali, S. and Sahu, N.P. 2002. Response of *Macrobrachium rosenbergii* (de Man) juveniles to fish silages as substitutes for fish meal in dry diets. *Asian Fisheries Science.* **15** (1): 59-69.

Alok, D., Krishnan, T., Talwar, G.P. and Garg, L.C. 1998. Multiple induced spawnings of the Indian catfish *Heteropneustes fossilis* (Bloch) within a prolonged spawning season. *Journal of the World Aquaculture Society.* **29** (2): 252-258.

Ambali, A.J.D. and Little, D.C. 1996. Studies on the effect of manipulating hapa size on broodstock conditioning of *Oreochromis niloticus* in fertilised earthen ponds. *The Third International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings.* **41**: 223-228. Pullin RSV, Lazard J, Legendre M, Kothias JBA, Pauly D (Eds). ICLARM, Philippines.

Ambrose, T., Arunkumar, L.C. and Vincent, S. 1994. Impact of tannery effluent on food utilisation in the freshwater fish *Cirrhinus mrigala* (Ham.). *Environment and Ecology.* **12** (2): 416-418.

Ambrose, T., Kumar, L.C.A., Lambert, V.S. and Lambert, R.S. 1994. Biochemical responses of *Cyprinus carpio communis* to toxicity of tannery effluent. *Journal of Ecobiology.* **6** (3): 213-216.

Anh, B.T. and Son, N.H. Cage rearing of fry to fingerling of carp species in large reservoirs in Northern Vietnam. Reservoir and culture-based fisheries: biology and management. p 347-358.

Ansal, M.D. and Kaur, K. 1998. Relative efficacy of dietary administration of 3,5,3'-triiodothyronine (T3) to different stages of an Indian major carp, *Cirrhina mrigala* (Hamilton): growth and economics. *Aquaculture Research.* **29**: 835-841.

Areechon, N. and Karoon, B. 1995. Comparative studies on resistance and immunological response of a hybrid catfish and the parent species to Aeromonas hydrophila. Proceedings of the Second Symposium on Diseases in Asian Aquaculture, 25-29 October, 1993, Phuket, Thailand. p 451-457. Shariff M, Arthur JR, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society.

Arifin, Z. 1996. Efficacy of liming and liming materials for shrimp pond management. Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Ashraf, M. and Fairgrieve, W. 1998. Effects of artificial feeds on the spawning success, fecundity and egg fertilisation rate in Chinese and Indian major carps. *Pakistan Journal of Zoology.* **30** (3): 185-189.

Azad, I.S. 1997. Growth performance of advanced fry of 'Pengba' Osteobrama belangeri (Val.) fed with cobalt and zinc supplemented diets. *Journal of Aquaculture in the Tropics.* 133-138.

Babu, C.S., Reddy, K.P.O. and Neeraja, P. 1997. Influence of urea on ATPase, acid and alkaline phosphatase activities in fingerlings of fish, *Labeo rohita*. *Journal of Aquaculture in the Tropics.* 239-242.

Balasubramanian, P.R. and Bai, R.K. 1996. Biogas plant-effluent as an organic fertiliser in monosex, monoculture of fish (*Oreochromis mossambicus*). *Bioresource Technology.* **55**: 119-124.

Balasubramanian, P., Saravanan, T.S. and Palaniappan, M.K. 1999. Biochemical and histopathological changes in certain tissues of *Oreochromis mossambicus* (Trewaves) under ambient urea stress. Bulletin *of Environmental Contamination and Toxicology.* **63**: 117-124.

Barte, M.B. 1996. The effect of aeration on water quality and fish growth in the intensive culture of Nile tilapia. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Basavaraja, N., Gangadhar, B. and Udupa, K.S. 1997(a). Effect of diethylstilbestrol-incorporated diet on sex ratio and body composition of common carp, *Cyprinus carpio*. *Journal of Aquaculture in the Tropics.* 209-218.

Basavaraja, N., Gangadhar, B. and Udupa, K.S. 1997(b). Successful induction of sterilisation and growth improvement in common carp *Cyprinus carpio* through dietary administration of the androgen norethindrone. *Asian Fisheries Science.* **10**: 29-40.

Basavaraja, N., Hegde, S.N., Akash, N. and Udupa, K.S. 2002. The fertility of cryopreserved Deccan Mahseer, Tor khudree (Sykes) spermatozoa. *Asian Fisheries Science.* **15** (3): 193-202.

Basavaraju, Y., Devaraj, K.V. and Ayyar, S.P. 1995. Comparative growth of reciprocal carp hybrids between *Catla catla* and *Labeo fimbriatus. Aquaculture.* **129**: 187-191.

Basavaraju, Y., Mair, G.C., Kumar, H.M.M., Kumar, S.P., Keshavappa, G.Y. and Penman, D.J. 2002. An evaluation of triploidy as a potential solution to the problem of precocious sexual maturation in common carp, *Cyprinus carpio*, in Karnataka, India. *Aquaculture.* **204** (3-4): 407-418.

Basudha, C.H. and Vishwanath, W. 1997. Formulated feed based on aquatic weed azolla and fish meal for rearing medium carp *Osteobrama belangeri* (Valenciennes). *Journal of Aquaculture in the Tropics.* **12**: 155-164.

Bazaz, M.M. and Keshavanath, P. 1993. Effect of feeding different levels of sardine oil on growth, muscle composition and digestive enzyme activities of mahseer, *Tor khudree. Aquaculture.* **115**: 111-119.

Bhujel, R.C., Yakupitiyage, A., Turner, W.A. and Little, D.C. 2001. Selection of a commercial feed for Nile tilapia (*Oreochromis niloticus*) broodfish breeding in a hapa-in-pond system. *Aquaculture.* **194** (3-4): 303-314.

Boonyaratpalin, S. and Boonyaratpalin, M. 1995. Effects of peptidoglycan (PG) on growth, survival and immune response, and tolerance to stress in black tiger shrimp, *Penaeus monodon.* Proceedings of the Second Symposiium on Diseases in Asian Aquaculture, 25-29th October, 1993, Phuket, Thailand. p. 469-477. Shariff M, Arthur JR, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society.

Boonyaratpalin, M. and Wanakowat, J. 1993. Effect of thiamin, riboflavin, pantothenic acid and inositol on growth, feed efficiency and mortality of juvenile seabass. Fish Nutrition in Practice. Fourth International Symposium on Fish Nutrition and Feeding, Biarritz (France), June 24-27, 1991. p 819-828. Kaushik SJ, Luquet P (Eds). INRA, Paris.

Boonyaratpalin, M., Suraneeranat, P. and Tunipibal, T. 1996. Replacement of fishmeal with various types of soybean products in seabass diet. NICA technical paper No. 19. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Boonyaratpalin, M., Wannagowat, J. and Borisut, C. 1993(a). Effect of vitamin B1, B2, pantothenic acid and inositol deficiencies in juvenile seabass, *Lates calcarifer*. NICA technical paper No. 1. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Boonyaratpalin, M., Wannagowat, J. and Borisut, C. 1993(b). L-ascorbyl-2-phosphate-Mg as a dietary vitamin C source for grouper. NICA technical paper No.

17. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Borah, B.C., Bhagowati, A.K. and Baruah, U.K. 1999. Techno-economic feasibility of cow-manure recycling in fish pond. *Indian Journal of Hill Farming.* **12** (1-2): 1-7.

Borah, B.C., Bhagowati, A.K., Baruah, U.K., Gogoi, H.K. and Nath, S. 1998. Integrated poultry-pig-fish farming. *Journal of the Inland Fisheries Society of India.* **30** (1): 39-46.

Borthakur, S. and Sarma, K. 1998. Effect of some non-conventional fish meal replcaers on the growth, feed conversion and body composition of *Clarias batrachus* (Linn.) fingerlings. *Environment and Ecology.* **16** (3): 694-698.

Bureau, D.P., de la Noue, J. and Jaruratjamorn, P. 1995. Effect of dietary incorporation of crop residues on growth, mortality and feed conversion ratio of the African catfish, *Clarias gariepinus* (Burchell). *Aquaculture Research.* **26**: 351-360.

Cacot, P., Legendre, M., Dan, T.Q., Tung, L.T., Liem, P.T., Mariojouls, C. and Lazard, J. 2002. Induced ovulation of *Pangasius bocourti* (Sauvage, 1880) with a progressive hCG treatment. *Aquaculture.* **213** (1-4): 199-206.

Chandge, M.S. and Raj, R.P. 1997. Cholesterol requirements of juvenile Indian white prawn *Penaeus indicus* H. Milne Edwards. *Journal of Aquaculture in the Tropics.* 227-237.

Chandrasekaran, V.S., Singh, V.K. and Singh, R. 1998. Pond culture of the freshwater prawn in the Tarai region of Uttar Pradesh. Ecological Agriculture and Sustainable Development: Proceedings of an International Conference on Ecological Agriculture: Towards Sustainable Development, Chandigarh, India, 15-17 November, 1997. **1**: 279-284. Dhaliwal GS, Arora R, Randhawa NS, Dhawan AK (Eds).

Chawpaknum, C. and Bowonsupakijkul, S. 2001. Dietary energy requirement for *Ompok bimaculatus* (Bloch). *Thai Fisheries Gazette.* **56** (1): 41-47.

Cheinwichai, W. 1994. Effects of steroid sapogenins on growth rate and moulting of giant freshwater prawn, *Macrobrachium rosenbergii* (de Man). Thesis submitted in partial fulfilment of the degree of Master of Science, Interdisciplinary graduate programme, Kasetsart University, Bangkok, Thailand.

Chucherd, N. 1995. Effects of astaxanthin on growth, survival rate and tolerance to pathogenic bacteria of black tiger shrimp in low salinity conditions. Thesis submitted in partial fulfilment of the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Chughtai, M.A. 1995. Effects of water spinach (Impoea aquatica) on nutrient regime and fish growth. Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Chuntapa, B., Piyatiratitivorakul, S., Nitithamyong, C., Viyakarn, V. and Menasveta, P. 1999. Optimal lipid:carbohydrate and protein:energy ratios in semi-purified diets for juvenile black tiger shrimp *Penaeus monodon* Fabricus. *Aquaculture Research.* **30**: 825-830.

Citarasu, T., Babu, M.M., Sekar, R.R.J. and Marian, M.P. 2002. Developing artemia enriched herbal diet for producing quality larvae in *Penaeus monodon*, Fabricus. *Asian Fisheries Science.* **15** (1): 21-32.

Dan, N.C. and Little, D.C. 2000(a). The culture performance of monosex and mixed-sex new-season and overwintered fry in three strains of Nile tilapia (*Oreochromis niloticus*) in northern Vietnam. *Aquaculture.* **184** (3-4): 221-231.

Dan, N.C. and Little, D.C. 2000(b). Overwintering performance of Nile tilapia *Oreochromis niloticus* (L.) broodfish and seed at ambient temperatures in northern Vietnam. *Aquaculture Research.* **31** (6): 485-492.

Das, B.K. and Kaviraj, A. 1994. Individual and interactive lethal toxicity of cadmium, potassium permanganate and cobalt chloride to fish, worm and plankton. *Geobios.* **21** (4): 223-227.

Das, S.K., Manissery, J.K. and Varghese, T.J. 1994. Growth response of Indian major carps *Catla catla* and *Labeo rohita* to formulated diets containing leaf powders as protein source. *Fishery Technology*. **31** (2): 102-107.

de la Cruz Camacho, M.V. 1998. The effect of vitamin E on salinity tolerance, growth, body composition and flesh quality of Nile tilapia (*Oreochromis niloticus*). Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Dhawan, A. and Kaur, S. 2002. Effect of pig dung on water quality and polyculture of carp species during winter and summer. *Aquaculture International.* **10**: 297-307.

Dhawan, A. and Singh, R. 1993. Efficacy of different protein ingredients used in practical feeds on the growth and reproductive potential of common carp. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 23-26.

Diana, J.S., Kwei Lin, C. and Jaiyen, K. 1994. Supplemental feeding of tilapia in fertilised ponds. *Journal of the World Aquaculture Society.* **25** (4): 497-506.

Diana, J.S., Lin, C.K. and Yi, Y. 1996. Timing of supplemental feeding for tilapia production. *Journal of the World Aquaculture Society.* **27** (4): 410-419.

Ebanasar, J. and Jayaprakas, V. 1996. Food utilisation of Channa micropeltes fed three diets of animal origin. *Indian Journal of Experimental Biology.* **34**: 1261-1264.

Euphrasia, C.J. and Jayaprakas, V. 1999. Growth responses of the Indian major carp *Cirrhinus mrigala* to Livol (IHF-1000). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 303-305. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Francis, T. 1999. Effect of different hormones on the maturity of *Heteropneustes fossilis* (Bloch). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 513-515. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Gangadhara, B., Nandeesha, M.C., Varghese, T.J. and Keshavanath, P. 1997. Effect of varying protein and lipid levels on the growth of rohu, *Labeo rohita*. *Asian Fisheries Science.* **10**: 139-147.

Garg, S.K. and Bhatnagar, A. 1996. Effect of varying doses of organic and inorganic fertilisers on plankton production and fish biomass in brackish water fish ponds. *Aquaculture Research*. **27**: 157-166.

Garg, S.K. and Bhatnagar, A. 2000. Effect of fertilisation frequency on pond productivity and fish biomass in still water ponds stocked with *Cirrhinus mrigala* (Ham.). *Aquaculture Research*. **31**: 409-414.

Garg, S.K., Kalla, A. and Bhatnagar, A. 2002. Evaluation of raw and hydrothermically processed leguminous seeds as supplementary feed for the growth of two Indian major carp species. *Aquaculture Research.* **33**: 151-163.

Ghosal, T.K. and Kaviraj, A. 1996. Influence of poultry litter on the toxicity of cadmium to aquatic organisms. *Bulletin of Environmental Contamination and Toxicology*. **57**: 1009-1015.

Ghosh, B.C., Ghosh, R., Mittra, B.N., Mitra, A. and Jana, M.K. 1994. Influence of organic and inorganic fertilization on the growth and nutrition of rice and fish in a dual culture system. *Journal of Agricultural Science.* **122**: 41-45.

Gjerde, B., Reddy, P.V.G.K., Mahapatra, K.D., Saha, J.N., Jana, R.K., Meher, P.K., Sahoo, M., Lenka, S., Govindassamy, P. and Rye, M. 2002. Growth and survival in two complete diallele crosses with five stocks of rohu carp (*Labeo rohita*). *Aquaculture.* **209**: 103-115.

Gokulakrishnan, P. and Bandyopadhyay, S. 1995. Formulation and characterisation of some pelleted feeds for *Penaeus monodon. Fishery Technology*. **32** (1): 19-24.

Gopal, C., Natarajan, M., Swamy, D.N., Madhavan, P., Nair, K.G.R., Radhakrishna, A.G. and Safiullah, A. 1999. Quantitative dietary requirement of methionine for *Penaeus monodon.* The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 313-315. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Gopal, V., Prabakaran, S. and Balasubramanian, P.R. 1996. Effect of a biogas-plant effluent-based pelleted diet on the growth of *Oreochromis mossambicus* fingerlings. *Bioresource Technology*. **58**: 315-317.

Gupta, S.D. and Rath, S.C. 1993. Cryogenic preservation of carp milt and its utilisation in seed production. The Third Indian Fisheries Forum Proceedings, 11-44 October, 1993, Pantnagar. p 77-79.

Hari, B. and Kurup, B.M. 2002. Vitamin C (ascorbyl 2 polyphosphate) requirement of freshwater prawn *Macrobrachium rosenbergii* (de Man). *Asian Fisheries Science.* **15** (2): 145-154.

Hassan, M.A. and Jafri, A.K. 1996. Influence of feeding varying levels of dietary energy on growth, utilisation efficiency, and carcass composition of fry of the Indian major carp, *Cirrhinus mrigala* (Hamilton). *Journal of Aquaculture in the Tropics.* **11**: 143-152.

Hemambika, M. and Raj, R.P. 1999. Effect of dietary starch levels on digestive enzyme activity in *Penaeus indicus.* The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 287-289. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Hengsawat, K., Ward, F.J. and Jaruratjamorn, P. 1997. The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages. *Aquaculture.* **152**: 67-76.

Jafri, E. and Jafri, A.K. 1995. Growth response of fingerling Indian major carp, *Labeo rohita* (Ham.) to various sources of dietary carbohydrate. *Journal of Aquaculture in the Tropics.* **10**: 287-296.

Jafri, E. and Jafri, A.K. 1998. Growth rate, feed conversion, and body composition of *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala* fry fed diets of various carbohydrate-to-lipid ratios. *Journal of the World Aquaculture Society.* **29** (1): 84-91.

Jafri, A.K., Anwar, M.F., Usmani, N., Samad, R. and Alvi, A.S. 1995. Influence of dietary lipid levels on the growth and body composition of fingerlings of an Indian major carp, *Cirrhinus mrigala* (Ham.). *Journal of Aquaculture in the Tropics.* **10**: 151-157.

James, R. and Chandrakala Vadivu, S. 2000. Optimum requirements for maximum growth in juveniles of gold fish *Carassius auratus. Environment and Ecology.* **18** (4): 877-883.

James, R. and Sampath, K. 1995. Sublethal effects of mixtures of copper and ammonia on selected biochemical and physiological parameters in the catfish *Heteropneustes fossilis* (Bloch). *Bulletin of Environmental Contamination and Toxicology.* **55**: 187-194.

James, R., Muthukrishnan, J. and Sampath, K. 1993. Effects of food quality on temporal and energetics cost of feeding in *Cyprinus carpio* (Pisces: Cyprinidae). *Journal of Aquaculture in the Tropics.* **8**: 47-53.

James, R., Sampath, K. and Selvamani, P. 1998. Effect of EDTA on reduction of copper toxicity in Oreochromis mossambicus (Peters). *Bulletin of Environmental Contamination and Toxicology*. **60**: 487-493.

Jana, B.B. and Chakrabarty, D. 1997. Relative status and contribution of sediment phosphorus and nitrogen in carp culture system fertilised with various combinations of rockphosphate. *Aquaculture Research.* **28**: 247-255.

Jantrarotai, W., Sitasit, P. and Rajchapakdee, S. 1994. The optimum carbohydrate to lipid ratio in hybrid Clarias catfish (*Clarias macrocephalus x C. gariepinus*) diets containing raw broken rice. *Aquaculture.* **127**: 61-68.

Jayaprakas, V. and Euphrasia, C.J. 1997. Growth performance of *Labeo rohita* (Ham.) to Livol (IHF-1000), a herbal product. *Proceedings of the Indian National Science Academy, Part B.* **63** (1-2): 21-30.

Jayaprakas, V. and Sambhu, C. 1998. Influence of dietary L-carnitine on growth and lipid metabolism in pearlspot, *Etroplus suratensis* (Bloch). *Indian Journal of Experimental Biology.* **36**: 1044-1048.

Jayaprakas, V. and Sindhu, B.S. 1996. Effect of hormones on growth and food utilisation of the Indian major carp, *Cirrhinus mrigala. Fishery Technology.* **33** (1): 1-27.

Jena, J.K., Mukhopadhyay, P.K. and Aravindakshan, P.K. 1999. Evaluation of a formulated diet for raising carp fingerlings in field conditions. *Journal of Applied Ichthyology.* **15**: 188-192.

Jena, J.K., Aravindakshan, P.K., Chandra, S., Muduli, H.K. and Ayyappan, S. 1998. Comparative evaluation of growth and survival of Indian major carps and exotic carps in raising fingerlings. *Journal of Aquaculture in the Tropics.* **13** (2): 143-150.

Jena, J.K., Ayyappan, S., Aravindakshan, P.K., Dash, B., Singh, S.K. and Muduli, H.K. 2002. Evaluation of production performance in carp polyculture with different stocking densities and species combinations. *Journal of Applied Ichthyology.* **18**: 165-171.

Kamnertmanee, S. 1997. Efficacy of norflaxin nicotinate against vibriosis infection in black tiger shrimp (*Penaeus monodon* Fabricus). Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Kanaujia, D.R., Mohanty, A.N. and Das, K.M. 1998. Recycling of used water for the seed production of *Macrobrachium malcolmsonii* (H. Milne Edwards). *Journal of Aquaculture in the Tropics.* **13** (3): 223-232.

Kanaujia, D.R., Mohanty, A.N. and Tripathi, S.D. 1997. Growth and production of Indian river prawn *Macobrachium malcolmsonii* (H. Milne Edwards) under pond conditions. *Aquaculture.* **154**: 79-85.

Kanaujia, D.R., Mohanty, A.N. and Tripathi, S.D. 1999. Year-round breeding and seed production of India river prawn *Macrobrachium malcolmsonii* (H. Milne Edwards) under controlled conditions. *Journal of Aquaculture in the Tropics.* **14** (1): 27-36.

Kathiresan, K. and Moorthy, P. 1996. Alleviation of UV-B induced effects by eye-stalk ablation in *Penaeus semisulcatus* De Haan. *Indian Journal of Experimental Biology*. **34**: 1161-1163.

Kavita, K. and Sharma, L.L. 1999. Use of herb (Asparagus racemous wild) supplemented diet for promoting growth in the fry of *Labeo rohita.* The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 241-243. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Keshavanath, P. and Renuka, P. 1998. Effect of dietary L-carnitine supplements on growth and body composition of fingerling rohu, *Labeo rohita* (Hamilton). *Aquaculture Nutrition.* **4**: 83-87.

Keshavanath, P., Manjappa, K. and Gangadhara, B. 2002. Evaluation of carbohydrate rich diets through common carp culture in manured tanks. *Aquaculture Nutrition.* **8**: 169-174.

Keshavanath, P., Gangadhar, B., Ramesh, T.J., van Dam, A.A., Beveridge, M.C.M. and Verdegem, M.C.J. 2002. The effect of periphyton and supplemental feeding on the production of the indigenous carps *Tor khudree* and *Labeo fimbriatus. Aquaculture.* (1-4): 207-218.

Keshavanath, P., Gangadhar, B., Ramesh, T.J., van Rooij, J.M., Beveridge, M.C.M., Baird, D.J., Verdegem, M.C.J. and van Dam, A.A. 2001. Use of artificial substrates to enhance production of freshwater herbivorous fish in pond culture. *Aquaculture Research.* **32**: 189-197.

Khan, M.A. and Jafri, A.K. 1993. Quantitative dietary requirement for some indispensable amino acids in the Indian major carp, *Labeo rohita* (Hamilton) fingerlings. *Journal of Aquaculture in the Tropics.* **8**: 67-80.

Knud-Hansen, C.F. and Batterson, T.R. 1994. Effect of fertilisation frequency on the production of Nile tilapia (*Oreochromis niloticus*). *Aquaculture.* **123**: 271-280.

Knud-Hansen, C.F. and Kwei Lin, C. 1996. Strategies for stocking Nile tilapia (*Oreochromis niloticus*) in fertilised ponds. The Third International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings. **41**: 70-76. Pullin RSV, Lazard J, Legendre M, Kothias JBA, Pauly D (Eds). ICLARM, Philippines.

Knud-Hansen, C.F., Batterson, T.R. and McNabb, C.D. 1993. The role of chicken manure in the production of Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management.* **24** (4): 483-493.

Kothari, S., Pandya, C. and Mahajan, P. 1999. Role of a drug 'Essentiale' against cadmium toxicity in the intestine of *Oreochromis mossambicus* (Trewavas). The

Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 135-137. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Koydon, S. 1994. Efficacy of formalin in reducing ammonia in water and its effects on black tiger prawn (*Penaeus monodon* Fabricus) and hybrid catfish. Thesis submitted in partial fulfilment of the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Kumar, S. and Gopal, K. 2001. Impact of distillery effluent on physiological consequences in the freshwater teleost *Channa punctatus. Bulletin of Environmental Contamination and Toxicology*. **66**: 617-622.

Kumar, S.S. and Jayaprakas, V. 1996. Role of dietary L-carnitine on the monosex culture of male Mozambique tilapia *Oreochromis mossambicus* (Peters). *Proceedings of the Indian National Science Academy, Part B.* **62** (4): 247-258.

Kumar, S., Lata, S. and Gopal, K. 1999. Deltamethrin induced physiological changes in freshwater catfish *Heteropneustes fossilis. Bulletin of Environmental Contamination and Toxicology.* **62**: 254-258.

Kwei Lin, C. and Diana, J.S. 1995. Co-culture of catfish (*Clarias macrocephalus x C. gariepinus*) and tilapia (*Oreochromis niloticus*) in ponds. *Aquatic Living Resources.* **8**: 449-454.

Little, D.C., Macintosh, D.J. and Edwards, P. 1993. Improving spawning synchrony in the Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management.* **24**: 399-405.

Little, D.C., Macintosh, D.J. and Edwards, P. 1996. Selective broodfish exchange of *Oreochromis niloticus* in large breeding hapas suspended in earthen ponds. The Third International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings. **41**: 92-99. Pullin RSV, Lazard J, Legendre M, Amon JB, Pauly D (Eds). ICLARM, Philippines.

Little, D.C., Coward, K., Bhujel, R.C., Pham, T.A. and Bromage, N.R. 2000. Effect of broodfish exchange strategy on the spawning performance and sex steroid hormone levels of *Oreochromis niloticus* broodfish in hapas. *Aquaculture.* **186**: 77-88.

MacNiven, A.M. and Little, D.C. 2001. Development and evaluation of a stress challenge testing methodology for assessment of Nile tilapia (*Oreochromis niloticus*, Linn.) fry quality. *Aquaculture Research.* **32** (9): 671-679.

Marimuthu, K. and Sukumaran, N. 2001. Effect of dietary lipid levels on growth and survival of fingerlings of the Indian major carp *Cirrhinus mrigala. Fishery Technology.* **38** (1): 48-50.

Mathew, P.M. and Sherief, P.M. 1999. Effects of some dietary protein source on growth and survival of angelfish and zebrafish. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 255-257. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Mhoryadee, R. 1997. Effect of turbidity on pond fish culture. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Mohamed, J.S. 2001(a). Dietary biotin requirement determined for Indian catfish, *Heteropneustes fossilis* (Bloch), fingerlings. *Aquaculture Research.* **32**: 709-716.

Mohamed, J.S. 2001(b). Dietary pyridoxine requirement of the Indian catfish, *Heteropneustes fossilis. Aquaculture.* **194**: 327-335.

Mohamed, J.S. and Ibrahim, A. 2001. Quantifying the dietary niacin requirement of the Indian catfish, *Heteropneustes fossilis* (Bloch), fingerlings. *Aquaculture Research.* **32**: 157-162.

Mohamed, J.S., Ravisankar, B. and Ibrahim, A. 2000. Quantifying the dietary biotin requirement of the catfish, *Clarias batrachus. Aquaculture International.* **8***:* 9-18.

Mohamed, S.J. 1999. Comparative efficacy of four anaesthetics on common carp *Cyprinus carpio* L. *Acta Ichthyologica et Piscatoria.* **29** (2): 91-97.

Mohanty, R.K. 2001(a). Feeding management and waste production in semi-intensive farming of *Penaeus monodon* (fab.) at different stocking densities. *Aquaculture International.* **9**: 345-355.

Mohanty, R.K. 2001(b). Feeding management in semi-intensive farming of *Penaeus monodon* (Fab.). *Journal of Aquaculture in the Tropics.* **16** (4): 349-357.

Mohanty, R.K. and Panda, R.K. 2000. Performance evaluation of semi-intensive culture practice of black tiger shrimp, *Penaeus monodon. International Journal of Tropical Agriculture.* **18** (1): 63-68.

Mohanty, S.N., Swain, S.K. and Panigrahi, A. 1999. Energy budgets of different sizes of rohu (*Labeo rohita* Ham.) fry fed two diets. *Journal of Aquaculture in the Tropics.* **14** (3): 217-226.

Mohapatra, B.C. and Shanmugam, S. 1998. ALP-ACP ratio for indicating biochemical stress in tropical fish *Liza parsia. Current and Emerging Trends in Aquaculture.* p 186-190. Thomas PC (Eds). Daya Publishing House, New Delhi.

Mohire, K.V., Basavaraju, Y., Keshavappa, G.Y., Devaraj, K.V. and Iyyar, S.P. 1993. Experimental culture of Macrobrachium rosenbergii (de Man) in concrete ponds. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 41-44.

Mondal, T.K. and Ray, A.K. 1999. The nutritive value of Acaia auriculiformis leaf meal in compounded diets for *Labeo rohita* fingerlings. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 295-298. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Mukhopadhyay, N. and Ray, A.K. 1996. The potential of deoiled sal (*Shorea robusta*) seed meal as a feedstuff in pelleted feed for Indian major carp, rohu, *Labeo rohita* (Hamilton) fingerlings. *Aquaculture Nutrition.* **2**: 221-227.

Mukhopadhyay, N. and Ray, A.K. 1997. The apparent total and nutrient digestibility of sal seed (*Shorea robusta*) meal in rohu, *Labeo rohita* (Hamilton), fingerlings. *Aquaculture Research.* **28**: 683-689.

Mukhopadhyay, N. and Ray, A.K. 1999(a). Improvement of quality of sesame *Seasamum indicum* seed meal protein with supplemental amino acids in feeds for rohu *Labeo rohita* (Hamilton) fingerlings. *Aquaculture Research.* **30**: 549-557.

Mukhopadhyay, N. and Ray, A.K. 1999(b). Utilisation of copra meal in the formulation of compound diets for rohu, *Labeo rohita*, fingerlings. *Journal of Applied Ichthyology*. **15**: 127-131.

Murthy, H.S. and Varghese, T.J. 1995. Arginine and histidine requirements of the Indian major carp, *Labeo rohita* (Hamilton). *Aquaculture Nutrition.* **1**: 235-239.

Murthy, H.S. and Varghese, T.J. 1996(a). Dietary requirements of the Indian major carp, *Labeo rohita* (Hamilton), for total aromatic amino acids. *The Israeli Journal of Aquaculture*. **48** (2): 78-83.

Murthy, H.S. and Varghese, T.J. 1996(b). Quantitative dietary isoleucine requirement for growth and survival of Indian major carp, *Labeo rohita* (Hamilton) fry. *Indian Journal of Experimental Biology*. **34**: 1141-1143.

Murthy, H.S. and Varghese, T.J. 1997(a). Dietary tryptophan requirement for the growth of rohu, *Labeo rohita. Journal of Applied Aquaculture.* **7** (2): 71-79.

Murthy, H.S. and Varghese, T.J. 1997(b). Dietary requirements of juveniles of the Indian major carp, *Labeo rohita*, for the essential amino acid lysine. *The Israeli Journal of Aquaculture – Bamidgeh.* **49** (1): 19-24.

Murthy, H.S. and Varghese, T.J. 1997(c). Quantitative dietary requirements of the Indian major carp *Labeo rohita* for the essential amino acid valine. *Indian Journal of Animal Sciences.* **67** (11): 1028-1030.

Murthy, H.S. and Varghese, T.J. 1998. Total sulphur amino acid requirement of the Indian major carp, *Labeo rohita* (Hamilton). *Aquaculture Nutrition.* **4**: 61-65.

Murugesan, P., Rajagopal, S. and Ajmal Khan, S. 1998. Utility of eyestalk ablation in farming and broodstock development of the shrimp *Penaeus monodon* Fabricus. *Indian Journal of Experimental Biology*. **36**: 699-702.

Na-Nakorn, U. 1995. Comparison of cold and heat shocks to induce diploid gynogenesis in Thai walking catfish (*Clarias macrocephalus*) and performances of gynogens. *Aquatic Living Resources.* **8**: 333-341.

Nagarathinam, N., Kumar, J.S.S. and Sundararaj, V. 2000. Influence of stocking density on growth, production and survival of *Macrobrachium rosenbergii* (de Man) in a monoculture grow-out pond. *Indian Journal of Fisheries.* **47** (2): 103-108.

Naik, A.T.R. and Murthy, H.S. 1999. Use of plant and animal protein based diet on growth and body composition of freshwater prawn and carps reared in cement cisterns. *Indian Journal of Nutrition and Dietetics.* **36**: 384-389.

Nair, C.M. and Sherief, P.M. 1993. Effects of diets containing different proportions of clam meat and tapioca on growth of *Macrobrachium rosenbergii. Journal of Aquaculture in the Tropics.* **8**: 239-244.

Nair, K.K.C., Branislav, M., Rosenthal, H., Jayalakshmi, K.V. and Nost, J. 1999. Experimental studies on the cannibalistic habit of Macrobrachium rosenbergii (de Man). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 227-232. Joseph MM, Menon NR, Nair NU (Eds). AFS, Indian branch.

Nandeesha, M.C., De Silva, S.S. and Krishnamurthy, D. 1993. Evaluation of mixed feeding schedules in two Indian major carps, catla (*Catla catla*) and rohu (*Labeo rohita*). Fish Nutrition in Practice. The Fourth International Symposium on Fish Nutrition and Feeding, Biarritz (France), June 24-27, 1991. p 753-765. Kaushik SJ, Luquet P (Eds). INRA, Paris.

Nandeesha, M.C., De Silva, S.S., Murthy, D.K. and Dathatri, K. 1994. Use of mixed feeding schedules in fish culture: field trials on catla, *Catla catla* (Hamilton-Buchanan), rohu, *Labeo rohita* (Hamilton), and common carp, *Cyprinus carpio* L. *Aquaculture and Fisheries Management.* **25** (6): 659-670.

Nandeesha, M.C., Gangadhara, B., Manissery, J.K. and Venkataraman, L.V. 2001. Growth performance of two Indian major carps, catla (*Catla catla*) and rohu (*Labeo rohita*) fed diets containing different levels of Spirulina platensis. *Bioresource Technology.* **80**: 117-120.

Nandeesha, M.C., Gangadhar, B., Varghese, T.J. and Keshavanath, P. 1998. Effect of feeding Spirulina platensis on the growth, proximate composition and organoleptic quality of common carp, Cyprinus carpio L. *Aquaculture Research.* **29**: 305-312.

Pandey, A.C. 1998. Reproduction in the female stripped gouramy *Colisa fasciatus* (Bl. and Schn.) in response to sublethal concentration of emisan. *Journal of Environmental Biology.* **19** (1): 9-13.

Papand, H., Sahu, N.P. and Jain, K.K. 1999. Attractability of coloured feed to *Macrobrachium rosenbergii* (de Man) post larvae. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 265-266. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Parnichsuke, P., Na-anan, P. and Sirisuay, S. 1996. The effect of salinity on survival rate of 1-15 days old grouper larvae, *Epinephelus coioides.* NICA technical paper No. 11. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Patra, B.C., Maity, J., Debnath, J. and Patra, S. 2002. Making aquatic weeds useful II: *Nymphoides cristatum* (Roxb.) O. Kuntze as feed for an Indian major carp *Labeo rohita* (Hamilton). *Aquaculture Nutrition.* **8** (1): 33-42.

Pawase, A.S. and Shenoy, S. (a). Growth experiments on Penaeus merguiensis and Metapenaeus monoceros from Ratnagiri using different pelleted feeds. *Current and Emerging Trends in Aquaculture.* p 244-260. Thomas PC (Eds). Daya Publishing House, New Delhi.

Pawase, A.S. and Shenoy, S. (b). Salinity effect on growth of some important penaeid prawns of Ratnagiri. *Current and Emerging Trends in Aquaculture.* p 30-34. Thomas PC (Eds). Daya Publishing House, New Delhi.

Pongmaneerat, J. and Boonyaratpalin, M. 1995. Use of plant proteins in diet for seabass (*Lates calcarifer*). NICA Technical paper. **14**. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Pongmaneerat, J., Chainark, P., Chindamaikul, T. and Borisut, C. 2002. Optimum dietary protein level for red snapper (*Lutjanus argentimaculatus* Forskal). *Thai Fisheries Gazette*. **56** (6): 413-421.

Premila, C.L. and Sampath, K. 2001. Optimum feeding frequency as a function of body weight in *Cirrhinus mrigala. Environment and Ecology*. **19** (4): 893-899.

Rajan, M.R. 1997. Survival, feed utilisation and growth of *Cirrhinus mrigala* (Ham.) in domestic waste waters. *Environment and Ecology*. **15** (2): 291-295.

Ramaneswari, K. and Rao, L.M. 1999. Effect of some larvicides on the juveniles of *Cyprinus carpio* (Linn.). The Fourth Indian Fisheries Forum Proceedings, 24-28 Nowember, 1996, Kochi. p 121-123. Joseph MM, Menon NR, Nair NU (Eds). AFS, Indian branch.

Ramasamy, P., Rajan, P.R., Jayakumar, R., Rani, S. and Brennan, G.P. 1996. Lagenidium callinectes (Couch, 1942) infection and its control in cultured larval Indian tiger prawn, *Penaeus monodon* Fabricus. *Journal of Fish Diseases.* **19**: 75-82.

Ramesh, M.R., Shankar, K.M., Mohan, C.V. and Varghese, T.J. 1999. Comparison of three plant substrates for enhancing carp growth through bacterial biofilm. *Aquacultural Engineering.* **19**: 119-131.

Rani, E.F., Elumalai, M. and Balasubramanian, M.P. 1998. Toxic and sublethal effects of ammonium chloride on a freshwater fish *Oreochromis mossambicus. Water, Air and Soil Pollution.* **104**: 1-8.

Ranjeet, K. and Kurup, B.M. 2002. Management strategies associating batch-graded and size-graded postlarvae can reduce heterogeneous individual growth in *Macrobrachium rosenbergii* (de Man). *Aquaculture Research.* **33** (15): 1221-1231.

Rao, A.P. and Singh, C.S. 1993. Effect of additional photoperiod on spawning time in Indian major carps reared in earthen ponds. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 89-93.

Ravi, V., Khan, S.A. and Rajagopal, S. 1998. Influence of probiotics on growth of Indian white prawn *Penaeus indicus. Journal of Scientific and Industrial Research.* **57**: 752-756.

Ray, A.K. and Das, I. 1993. Incorporation of dried aquatic weed (*Salvinia cuculata*) meal in the pelleted feed for rohu, *Labeo rohita* (Ham.) fingerlings. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 9-12.

Ray, A.K. and Das, I. 1995. Evaluation of dried aquatic weed, Pistia stratiotes, meal as a feedstuff in pelleted feed for rohu, *Labeo rohita*, fingerlings. *Journal of Applied Aquaculture.* **5** (4): 35-44.

Reddy, H.R.V. and Ramesh, T.J. 1996. Dietary essentiality of ascorbic acid for common carp *Cyprinus carpio* L. *Indian Journal of Experimental Biology*. **34**: 1144-1146.

Reddy, P.V.G.K., Gjerde, B., Tripathi, S.D., Jana, R.K., Mahapatra, K.D., Gupta, S.D., Saha, J.N., Sahoo, M., Lenka, S., Govindassamy, P., Rye, M. and Gjedrem, T. 2002. Growth and survival of six stocks of rohu (*Labeo rohita*, Hamilton) in mono and polyculture production systems. *Aquaculture.* **203** (3-4): 239-250.

Rochanasiri, J. 1995. Efficacy of Romet-30 against vibriosis in black tiger shrimp (*Penaeus monodon* Fabricus). Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Rothuis, A.J., Nam, C.Q., Richter, C.J.J. and Ollevier, F. 1998. Polyculture of silver barb, *Puntius gonoinotus* (Bleeker), Nile tilapia, *Oreochromis niloticus* (L.), and common carp, *Cyprinus carpio* L., in Vietnamese ricefields: fish production parameters. *Aquaculture Research*. **29** (9): 661-668.

Rothuis, A.J., Vromant, N., Xuan, V.T., Richter, C.J.J. and Ollevier, F. 1999. The effect of rice seeding rate on rice and fish production, and weed abundance in direct-seeded rice-fish culture. *Aquaculture.* **172** (3-4): 255-274.

Ruangpanich, N. and Boonliptanon, P. 1993. Some factors effect to the growth and survival rate of grouper larvae, *Epinephalus malabaricus.* NICA Technical paper. **20**. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Saha, A.K. and Ray, A.K. 1993. Nutrient digestibility of three oil cakes by the fingerlings of an Indian major carp *Labeo rohita* (Ham.). The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 1-4.

Saha, A.K. and Ray, A.K. 1998(a). Performance of rohu, *Labeo rohita* (Hamilton), fingerlings maintained on alternate feeding of plant and animal protein based diets. *Acta Ichthyologica et Piscatoria.* **28** (1): 3-13.

Saha, A.K. and Ray, A.K. 1998(b). Cellulase activity in rohu fingerlings. *Aquaculture International.* **6**: 281-291.

Saha, A.K. and Ray, A.K. 1998(c). Performance of *Labeo rohita* (Ham.) fingerlings with alternate feeding of low and high protein diets. Proceedings of the National Symposium on Technological Advancements in Fisheries and its Impact on Rural Development (held at Cochin by the University of Science and Technology, December 5-7, 1995). p 114-119.

Saha, A.K. and Ray, A.K. 1998(d). Evaluation of Chuni, a commercially available low-cost cattle fodder, in the diet for rohu, *Labeo rohita* (Hamilton), fingerlings. *Aquaculture Research.* **29**: 761-768.

Saha, C., Mohapatra, B.C. and Giri, S.S. 1997. Growth studies of three major carps of India in flow-through aquaculture systems. *Journal of Aquaculture in the Tropics.* p 97-102.

Saha, C., Mohapatra, B.C., Ghosh, A.S. and Ayyappan, S. 2001. Studies on the effect of flow rates while nursing Indian major carps in flow-through aquaculture systems. *Journal of Aquaculture in the Tropics.* **16** (3): 221-229.

Sahoo, P.K. and Mukherjee, S.C. 1999. Influence of the immunostimulant, chitosan on immune responses of healthy and cortisol-treated rohu (*Labeo rohita*). *Journal of Aquaculture in the Tropics.* **14** (3): 209-215.

Sahoo, P.K. and Mukherjee, S.C. 2001. Immunosuppressive effects of aflatoxin B1 in Indian major carp (*Labeo rohita*). *Comparative Immunology, Microbiology & Infectious Diseases.* **24**: 143-149.

Sahoo, P.K. and Mukherjee, S.C. 2002(a). Influence of high dietary alpha-tocopherol intakes on specific immune response, nonspecific resistance factors and disease resistance of healthy and aflatoxin B1-induced immunocompromised Indian major carp, *Labeo rohita* (Hamilton). *Aquaculture Nutrition.* **8**: 159-167.

Sahoo, P.K. and Mukherjee, S.C. 2002(b). The effect of dietary immunomodulation upon Edwardsiella tarda vaccination in healthy and immunocompromised Indian major carp (*Labeo rohita*). *Fish and Shellfish Immunology.* **12** (1): 1-16.

Sahoo, P.K., Mohanty, J. and Mukherjee, S.C. 1999. The effect of three immunomodulators on haematological parameters and immunity level in rohu (*Labeo rohita*) fingerlings. *Journal of Aquaculture in the Tropics.* **14** (2): 127-135.

Sahu, A.K., Sahoo, S.K. and Giri, S.S. 2002. Efficacy of water hyacinth compost in nursery ponds for larval rearing of Indian major carp, *Labeo rohita. Bioresource Technology.* **85**: 309-311.

Sakthivel, M. and Baskaran, P. 1995. Effects of dietary carbohydrate on growth, feed conversion, protein utilisation and body carcass of a common air-breathing freshwater teleost fish, *Channa punctatus* (Bloch). *Journal of Aquaculture in the Tropics.* **10**: 119-127.

Salin, K.R. and Jayasree-Vadhyar, K. 2001. Effect of different chilling rates for cold anaesthetisation of *Penaeus monodon* (Fabricus) on the survival, duration and sensory quality under live storage in chilled sawdust. *Aquaculture Research.* **32**: 145-155.

Samantaray, K. and Mohanty, S.S. 1999. Growth of *Channa striata* (Bloch) fingerlings under varying dietary protein and culture conditions. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 441-443. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Sambhu, C. and Jayaprakas, V. 1997(a). Dietary administration of testosterone propoinate on growth, proximate composition and residual content of pearlspot, *Etroplus suratensis* (Bloch) (Cichlidae). *Indian Journal of Marine Sciences.* **26**: 173-179.

Sambhu, C. and Jayaprakas, V. 1997(b). Growth promoting potential of L-thyroxine in green chromide, *Etroplus suratensis* (Bloch) (Cichlidae-Pisces). *Journal of Aquaculture in the Tropics.* **12**: 305-318.

Sampath, K. and Raj, A. 1995. Effects of feeding frequency and stock density on total production, final mean body weight, and food utilisation in the freshwater catfish *Mystus keletius* (Valenciennes). *Acta Hydrobiologica.* **37** (3): 171-178.

Samuel, M.J., Soundarapandian, P. and Kannupandi, T. 1997. Impact of dietary cholesterol on the growth and conversion efficiency of the freshwater prawn *Macrobrachium malcolmsonii* (H. Milne Edwards). *The Israeli Journal of Aquaculture – Bamidgeh.* **49** (1): 3-11.

Sasikumar, G. and Vadhyar, J. 1999. Effect of packing density, salinity and temperature on the survival and duration of oxygen packed seed of *Penaeus indicus* during transportation. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 211-214. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Sastry, K.V. and Gupta, A. 1994. Level of cadmium in water, soil and tissues of fish *Channa punctatus. Environment and Ecology.* **12** (4): 869-873.

Satheesha, S.K. and Murthy, H.S. 1999. Dietary requirement of the Indian major carp, *Catla catla* for the essential amino acid lysine. *Indian Journal of Animal Sciences.* **69** (4): 277-279.

Satpathy, B.B., Mukherjee, D. and Ray, A.K. 2001. Effects of dietary inclusion of the beta-adrenergic agonist, salbutamol, on growth performance and whole-body composition of rohu *Labeo rohita* (Hamilton) fingerlings fed diets containing two protein levels. *Aquaculture Research.* **32**: 739-747.

Saxena, P.K. and Talwar, P. 1996. Effect of dietary potassium on the growth and flesh quality of Indian major carp, *Cirrhinus mrigala* (Ham.). *Indian Journal of Experimental Biology*. **34**: 135-137.

Sehgal, G.K. and Saxena, P.K. 1997. Effect of estrone on sex composition growth and flesh composition in common carp, *Cyprinus carpio communis* (Linn.). *Journal of Aquaculture in the Tropics.* p 289-295.

Sethuramalingam, T.A., Haniffa, M.A. and Arockiasamy, S. 1999. Efficacy of plant protein diets on the growth performance of *Labeo rohita.* The Fourth Indian Fisheries Forum Proceedings, 24-28 Novemeber, 1996, Kochi. p 319-321. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian Branch.

Shadakshari, G.S. and Manissery, J.K. 1999. Effect of Bioboost Forte, Livol and Amchemin-AQ on the growth of common carp *Cyprinus carpio* (Linn.). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 271-273. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Sharma, O.P., Rai, H.O. and Kishan, R. 1997. Effect of agrimin on feed conversion, specific growth rate and protein efficiency ratio of the Indian major carp, *Labeo rohita* (Ham.). *Uttar Pradesh Journal of Zoology*. **17** (1): 13-16.

Shiranee, P. and Natarajan, P. 1995. Impact of compounded feeds on the growth, muscle composition and organoleptic characteristics of pearlspot *Etroplus suratensis* (Bloch). *Journal of Aquaculture in the Tropics.* **10**: 231-243.

Shiranee, P., Natarajan, P. and Dhevendren, R. 1993. The role of gut and sediment bacterial flora in the nutrition of cultured pearlspot (*Etroplus suratensis*, Bloch). *The Israeli Journal of Aquaculture – Bamidgeh.* **45** (2): 45-58.

Shivananda, M.H. and Varghese, T.J. 1996. Quantitative dietary requirement of threonine for the growth of the Indian major carp, *Labeo rohita* (Hamilton). *Journal of Aquaculture in the Tropics.* **11**: 1-7.

Shivaram, C.M. and Raj, R.P. 1997. Dietary lipid requirements of the juveniles of Indian white prawn *Penaeus indicus* H. Milne Edwards. *Journal of Aquaculture in the Tropics.* p 165-180.

Shrestha, M.K. and Knud-Hansen, C.F. 1994. Increasing attached microorganism biomass as a management strategy for Nile tilapia (*Oreochromis niloticus*) production. *Aquacultural Engineering*. **13**: 101-108.

Shyam, R., Tripathy, N.K. and Khan, H.A. 1993. Effect of the piscicides mahua oilcake and bleaching powder on benthic productivity in carp nursery ponds. *Journal of Aquaulture in the Tropics.* **8**: 25-32.

Shyama, S. and Keshavanath, P. 1993. Growth response of *Tor khudree* to silkworm pupa incorporated diets. Fish Nutrition in Practice. Fourth International Symposium on Fish Nutrition and Feeding, Biarritz (France), June 24-27, 1991. Kaushik SJ, Luquet P (Eds). INRA, Paris.

Shyama, S. and Keshavanath, P. 1999. Effect of silkworm pupa incorporated diets on the growth of mahseer. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 501-503. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Singh, R. and Das, A. 1993. Incorporation of molasses with mustard meal and rice polish for the development of cost effective feed for carps. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pantnagar. p 19-21.

Singh, H. and Qureshi, T.A. 1997. Production of fresh water prawn, *Macrobrachium lamarrei lamarrei* (H. Milne Edwards, 1837) at different stocking densities. *Pakistan Journal of Zoology*. **29** (2): 101-105.

Singh, K.K. and Varma, M.C. 1999. Pesticide induced heteropycnosis of chromosome in climbing perch *Anabas testudineus* (Bloch.). *Environment and Ecology*. **17** (2): 366-371.

Sobhnana, K.S. and Nandeesha, M.C. 1994. Standardisation of mibolerone dosage for production of female-free common carp (*Cyprinus carpio var. communis* L.) and the impact of the hormone on growth and flesh composition. *Journal of Aquaculture in the Tropics*. **9**: 133-139.

Sommani, A. and Jindathip, R. 2003. Effect of vitamin C on growth, mortality and deformities of Nile tilapia larvae. *Thai Fisheries Gazette*. **56** (1): 29-33.

Soundarapandian, P. and Kannupandi, T. 2000. Effect of feed on larvae of *Macrobrachium malcolmsonii* (H. Milne Edwards) reared in synthetic brackishwater. *Indian Journal of Experimental Biology*. **38**: 287-289.

Soundarapandian, P., Kannupandi, T. and Samuel, M.J. 1998. Effect of feeds on digestive enzymes of juveniles of *Macrobrachium malcolmsonii* (H. Milne Edwards). *Indian Journal of Experimental Biology*. **36**: 720-723.

Soundarapandian, P., Samuel, M.J. and Kannupandi, T. 1997. A simple method for the seed production of freshwater prawn *Macrobrachium malcolmsonii* (H. Milne Edwards). *Journal of Aquaculture in the Tropics*. p 261-266.

Sridhar, M., Vijayagopal, P. and Raj, R.P. 1999. A preliminary study of the effect of mantis shrimp as an ingredient in *Penaeus indicus* postlarval diets. *Journal of Aquaculture in the Tropics.* **14** (4): 269-276.

Srivastava, A.K. and Srivastava, A.K. 1995. Time-related and dose-dependent biochemical effects of the insecticide Chlordecone (Kepone) in the freshwater Indian catfish *Heteropneustes fossilis*. *Zoological Studies*. **34** (2): 106-110.

Srivastava, P.P. and Parihar, A.S. 1997. Preliminary growth studies on the use of soylecithin in the diet of freshwater prawn, *Macrobrachium rosenbergii*, post-larvae. *National Academy Science Letters*. **20** (1-2): 22-26.

Srivastava, P.P., Shrangare, U.P., Jain, K.K. and Sinha, P.S.R.K. 1997. Studies on the growth, in early growing stage, of common carp (*Cyprinus carpio*) on dietary supplementation of vitamin H. *Proceedings of the National Academy of Sciences, India*. **67** (1): 21-29.

Suetorsak, S. 1994. Residues and effects on growth and disease of oxolinic acid in *Penaeus monodon* Fabricus. Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Sultana, S. 1994. Effects of antibiotics on early life stages and the subsequent growth and survival of African catfish (*Clarias gariepinus*). Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Supamattaya, K. and Pongmaneerat, J. (a). The effect of MacroGard on growth, feed conversion, survival and immune response of black tiger shrimp *Penaeus monodon.* Reprinted from research on the effect of MacroGard on growth performance and health condition of black tiger shrimp (*Penaeus monodon*).

Supattamaya, K. and Pongmaneerat, J. (b). Effect of MacroGard (immersion grade) on immunity and disease resistance in black tiger shrimp (*Penaeus monodon*). Reprinted from research on the effect of MacroGard on growth performance and health condition of black tiger shrimp (*Penaeus monodon*).

Sureshkumar, S. and Kurup, B.M. 1999. Packing methods for mother prawns of *Macrobrachium rosenbergii* (de Man) for safe transportation. The Fourth Indian Fisheries Forum Proceedings, 24-28 Novemebr, 1996, Kochi. p 69-71. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Swain, P., Nayak, S.K., Sahu, A., Mohapatra, B.C. and Meher, P.K. 2002. Bath immunisation of spawn, fry and fingerlings of Indian major carps using a particulate bacterial antigen. *Fish and Shellfish Immunology.* **13**: 133-140.

Swamy, H.V.V. and Devaraj, K.V. 1999. Digestibility of soybean and soybean products in the diets of *Catla catla* (Ham.). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 307-309. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Szyper, J.P. and Hopkins, K.D. 1996. Effects of pond depth and mechanical mixing on production of *Oreochromis niloticus* in manured earthen ponds. The Third International Symposium on Tilapia in Aquaculture, ICLARM Conference Proceedings. **41**: 152-159. Pullin RSV, Lazard J, Legendre M, Kothias JBA, Pauly D (Eds). ICLARM, Philippines.

Thompolkrang, P. and Predalumpaburt, Y. 1996. Acute toxicity of pH from water of swampy forest to seabass (*Lates calcarifer*) Bloch fingerlings (3-5 inches). NICA technical paper No. 2. National Institute of Coastal Aquaculture, Department of Fisheries, Songkla, Thailand.

Tuan, P.A., Little, D.C. and Mair, G.C. 1998. Genotypic effects on comparativfge growth performance of all-male tilapia *Oreochromis niloticus. Aquaculture.* **159**: 293-302.

Uma, A., Abraham, T.J., Jeyaseelan, M.J.P. and Sundararaj, V. 1999. Effect of probiotic feed supplement on performance and disease resistance of Indian white shrimp *Penaeus indicus* H. Milne Edwards. *Journal of Aquaculture in the Tropics.* **14** (2): 159-164.

Umesh, N.R., Shankar, K.M. and Mohan, C.V. 1999. Enhancing growth of common carp, rohu and Mozambique tilapia through plant substrate: the role of bacterial biofilm. *Aquaculture International.* **7**: 251-260.

Usmani, N., Jafri, A.K. and Alvi, A.S. 1997. Effect of feeding glanded cottonseed meal on the growth, conversion efficiency and carcass composition of *Labeo rohita* (Hamilton) fry. *Journal of Aquaculture in the Tropics.* p 73-78.

Vasudevappa, C., Swamy, B., Swamy, V. and Keshavappa, G.Y. 1999. Standardisation of rearing of post-larvae of *Macrobrachium rosenbergii* to juvenile stage. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 205-206. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Venkadesh, B. and Palavesam, A. 1999. Influence of dietary protein levels and salinity on food intake, growth, food conversion and protein metabolism of the mullet *Mugil cephalus* (Linnaeus). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 57-59. Joseph MM, Menon NR, Nair NU (Eds). Asian Fisheries Society, Indian branch.

Vici, V., Bright Singh, I.S. and Bhat, S.G. 2000. Application of bacterins and yeast Acremonium dyosporii to protect the larvae of *Macrobrachium rosenbergii* from vibriosis. *Fish and Shellfish Immunology.* **10** (6): 559-563.

Vijayakumaran, M. 1999. Effect of salinity and quality of feed on food conversion efficiency in the post larvae of the prawn *Penaeus indicus* (H. Milne Edwards). The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. p 193-195. Joseph MM, Menon NR, Unnikrishnan Nair N (Eds). Kerala AFS, Indian branch.

Vincent, S., Ambrose, T. and Selvanayagam, M. 2002. Impact of cadmium on food utilisation of the Indian major carp, *Catla catla* (Ham.). *Journal of Environmental Biology.* **23** (2): 209-212.

Visitvithayagorn, N. 2000. Efficacy of lactoperoxidase for control of Vibrio sp. in black tiger shrimp (*Penaeus monodon* Fabricus). Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Vromant, N., Chau, N.T.H. and Ollevier, F. 2001. The effect of rice-seeding rate and fish stocking on the floodwater ecology of the trench of a concurrent, direct-seeded rice-fish system. *Hydrobiologia.* **457**: 105-117.

Vromant, N., Nam, C.Q. and Ollevier, F. 2001. Growth performance of *Trichogaster pectoralis* Regan in intensively cultivated rice fields. *Aquaculture Research.* **32:** 913-921.

Vromant, N., Nam, C.Q. and Ollevier, F. 2002(a). Growth performance of *Barbodes gonionotus* (Bleeker) in intensively cultivated rice fields. *Aquaculture.* **212**: 167-178.

Vromant, N., Nam, C.Q. and Ollevier, F. 2002(b). Growth performance and use of natural food by *Oreochromis niloticus* (L.) in polyculture systems with *Barbodes gonionotus* (Bleeker) and *Cyprinus carpio* (L.) in intensively cultivated rice fields. *Aquaculture Research.* **33**: 969-978.

Wangsawebool, C. 2000. Effect of using chlorella in nursed postlarvae (P5-P15) of black tiger shrimp (*Penaeus monodon* Fabricus) fed by living and nonliving food. Thesis submitted in partial fulfilment of the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Wattanakowat, J., Boonyaratpalin, M. and Watanabe, T. 1993. Essential fatty acid requirement of juvenile seabass. Fish Nutrition in Practice. The Fourth International Symposium on FIsh NUtrition and Feeding, Biarritz (France), June 24-27, 1991. p 807-817. Kaushik SJ, Luquet P (Eds). INRA, Paris.

Wattanakul, W., Yachiro, R., Ruengpanit, N. and Onlamai, P. 1994. Experiment on nursing and rearing of mullet, *Liza subviridis.* Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science, Kasetsart University, Bangkok, Thailand.

Withyachumnarnkul, B. 1999. Results from black tiger shrimp *Penaeus monodon* culture ponds stocked with postlarvae PCR-positive or -negative for white-spot syndrome virus (WSSV). *Diseases of Aquatic Organisms.* **39**: 21-27.

Yacoob, S.Y. 1994. Eutrophication problem in shrimp (*Penaeus monodon*) ponds and the biological control using Nile tilapia (*Oreochromis niloticus*). Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Asian Institute of Technology, Bangkok, Thailand.

Yi, Y. and Kwei Lin, C. 2001. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system. *Aquaculture.* **195**: 253-267.

Yi, Y., Kwei Lin, C. and Diana, J.S. 1996. Influence of Nile tilapia (*Oreochromis niloticus*) stocking density in cages on their growth and yield in cages and in ponds containing the cages. *Aquaculture.* **146**: 205-215.

Yi, Y., Kwei Lin, C. and Diana, J.S. 2002. Recycling pond mud nutrients in integrated lotus-fish culture. *Aquaculture.* **212**: 213-226.

Yi, Y., Kwei Lin, C. and Diana, J.S. 2003. Hybrid catfish (*Clarias macrocephalus x C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) culture in an integrated pen-cum-pond system: growth performance and nutrient budgets. *Aquaculture.* **217**: 395-408.

APPENDIX 1. Initial list of synonyms for electronic search strategy.

Aquatic:
Marine
Saltwater
Freshwater
Brackish-water
Aquaculture
Fishery
Oceanic
Pelagic
Coastal
Vac (Vietnamese term)

Animal:
Fish
Shrimp
Prawns
Finfish
Crayfish
Crustacea(n)(ns)
Fry
Fingerlings
Broodfish
Seed
Larvae
Postlarvae

Health:
Disease
Infection
Bacterial
Viral
Parasitic
Fungal
Microbial
Pathogens
Abnormality
Malnutrition
Survival
Growth
Hatchability
Mortality
Performance
Reproduction
Stress
Weight
Epidemiology
Physiology
Condition
Fitness
Strength

Interventions:
Vaccination
Treatment
Injection
Medication
Water quality
Water exchange
Feeding
Nutrition
Diet
Supplements
Nutrients
Light
Temperature
Polyculture
Monoculture
Genetic selection
Genetic manipulation
Protection
Immunisation
Selection
Stocking
Transport
Movement
Prevention
Quarantine
Exposure
Trial
Experiment
Introduction
Modification
Manipulation
Therapy

Asia:
India
Thailand
Vietnam
Asia-Pacific
Indian sub-continent

Vigour
Form
State
Contamination
Disorder
Contagion
Poison
Irregular
Susceptible
Weakness
Prosperity
Proliferation
Productivity

APPENDIX 2. List of hand searched journals.

Aquaculture, Volume 111 (1-4), 1993.
Aquaculture and Fisheries Management, Volume 23 (4), 1993.
Aquaculture and Fisheries Management, Volume 25 (3), 1994.
Aquaculture and Fisheries Management, Volume 25 (6), 1994.
Aquaculture Research, Volume 30 (5), 1999.
Bulletin of Environmental Contamination and Toxicology, Volume 54 (4), 1995.
Environment and Ecology, Volume 17 (2), 1999.
Journal of Aquaculture in the Tropics, Volume 8, 1993.
Journal of Aquaculture in the Tropics, Volume 12 (3), 1997.
Journal of Aquatic Animal Health, Volume 4 (3), 1992.
Journal of Aquatic Animal Health, Volume 5 (2), 1993.
Journal of Aquatic Animal Health, Volume 8 (3), 1996.
Journal of Fish Biology, Volume 43 (2), 1993.
Journal of Fish Diseases, Volume 16 (2), 1993.
Journal of Fish Diseases, Volume 18 (4), 1995.
The British Journal of Nutrition, Volume 69 (1), 1993.
The Journal of Nutrition, Volume 123 (1), 1993.
Transactions of the American Fisheries Society, Volume 123 (4), 1994.
World Aquaculture, Volume 32 (4), 2001.

APPENDIX 3. Letter and questionnaire dispatched to organisations involved in aquatic animal health and aquaculture.

Miss Lucy Barnard
Leahurst Field Station
Chester High Road
Neston
South Wirral
CH64 7TE
Fax: 0151 7946028
Email: L.E.Barnard@liv.ac.uk

Dear Sir/Madam,

Have your work recognised internationally.

The DFID funded project (R8119) is investigating the impact of aquatic animal health strategies on the livelihoods of poor people in Asia. A major project output will be the first systematic review on aquatic animal health interventions, in India, Thailand and Vietnam, and their effects on production.

I have access to a wide range of sources including international peer reviewed papers, and conference proceedings, however I am concerned that valuable information that is not widely available or accessible, or that is only produced in the local language, will be missed. This is where I need **your** help.

Do you have: any papers, reports, proceedings of meetings, theses (MSc or PhD), articles, newsletters, published AND unpublished, both existing and emerging, dating 1993 to 2003 on the following subjects;

- fish, shrimp or prawn health interventions. This means any changes that have been made to nutrition, water quality, genetics, poly and monoculture, temperature, as well as immunisations and drug trials. Outcomes must have had an effect on production, survival, growth or quality of the species, to include also disease prevention or reduction in disease prevalence, incidence or occurrence.

I am primarily interested in studies and trials that have been conducted within India, Thailand and Vietnam. If you have any such documents, please can you send them to me either by scanning and emailing, faxing, or photocopying and sending a hard copy in the return envelope provided. If your material fits the criteria, it will be included in the review which will be freely available on the DFID website by March 2004. You will however be contacted and informed of the exact date.

In addition, could you please fill in the enclosed questionnaire and return it in the envelope provided, together with any hard copies of documents.

If you think you can help, please contact me either by email, fax or post by 31st July 2003.

I look forward to hearing from you.

Yours faithfully,

Lucy Barnard

Please fill in this short questionnaire by ticking the boxes that are most applicable to you.

1) Do you conduct research on aquatic animal health?

☐ Yes ☐ No

If yes, what organisms do you conduct research on?

☐ Marine fish	☐ Freshwater fish
☐ Brackish water fish	☐ Prawns/shrimp
☐ Crabs	☐ Amphibians
☐ Shellfish	

2) Do you conduct field and/or clinical trials?

☐ Yes ☐ No

3) What is your focus of research?

☐ Drug/pharmaceutical trials	☐ Feed/nutrition trials
☐ Stocking manipulations	☐ Mono/Polyculture trials
☐ Temperature/light manipulations	☐ Water quality trials
☐ Genetics related	☐ Other (please specify) ………………………….. …………………………..

4) Where is your focus of research?

☐ India ☐ Thailand ☐ Vietnam
☐ Rest of Asia (please specify)……………………………………………
☐ Rest of world (please specify)……………………………………………

5) Where is your research written up?

☐ Company reports	☐ Scientific publications
☐ Theses (MSc/MPhil/PhD)	☐ Proceedings of meetings

6) Do you have information that could be included in this study?

☐ Yes ☐ No

7) Are you willing to provide this information?

- ☐ Yes
- ☐ Yes we can provide some information but we hold other information that is confidential.
- ☐ No

In order to be able to notify participants of the final report of the study, please could you provide a contact name and address for future correspondence.

Name:……………………………………………………………………………...

Address:…………………………………………………………………………...

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

Signature:…………………………………………. Date:…………………………….

Please return this form in the envelope provided along with any hard copies of documents, by 31st July 2003.

Thank you for your cooperation on this project

APPENDIX 4. Instruction sheet for use of international reply coupons provided for 50% of organisations who received the letter and questionnaire.

DFID Department for International Development

A F G R P
aquaculture and fish genetics research programme

UNIVERSITY OF STIRLING

THE UNIVERSITY of LIVERPOOL

This international response coupon can be exchanged at any local Post Office for contribution towards return postage.

Please use it to send hard copies of documents back to the UK in the envelope provided.

Thank you for your cooperation.

APPENDIX 5. Reminder card dispatched to non-responding organisations sent a letter and questionnaire.

Front:

Aquatic Animal Health Questionnaire

Back:

This is a reminder that, as yet, we haven't received your questionnaire and/or documents relating to the DFID funded Aquatic Animal Health Interventions in Asia project. Even if you have not conducted relevant research, we would be very grateful if you could fill in your questionnaire and return it to us, with any relevant documents, in the envelope provided. If you have sent your questionnaire and/or documents in the last few days, please ignore this reminder.

THANK YOU FOR YOUR COOPERATION.

Miss Lucy Barnard
Leahurst Field Station
Neston, Wirral
CH64 7TE
UNITED KINGDOM

APPENDIX 6. OIE (Offices des Epizooties International) 2003 fish and shrimp disease prevalence data for India, Thailand and Vietnam.

Finfish diseases (Indigenous):	Epizootic haematopoietic necrosis
	Infectious haematopoietic necrosis
	Oncorhynchus masou virus disease
	Viral haemorrhagic septicaemia
	Infectious pancreatic necrosis
	Viral encephalopathy and retinopathy
	Epizootic ulcerative syndrome (EUS)
	Bacterial kidney disease (BKD)
	Red seabream iridoviral disease
Finfish diseases (Exotic):	Spring viraemia of carp
	Viral haemorrhagic septicaemia
Crustacean diseases (Indigenous):	Yellowhead disease
	Infectious hypodermal and haematopoietic necrosis
	White spot disease
	Taura syndrome
	Spawner-isolated mortality virus disease

APPENDIX 7. Data extraction form for included studies.

Title of study:……………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

Author(s):………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

Year of publication (1993-2003):………………………………………………
(see note 1)

Country of study (please tick): ☐ India ☐ Thailand ☐ Vietnam
(see note 2)

Source of document (please tick): ☐ Online/electronic ☐ Hand searching ☐ Other……………………………
(see note 3)
…………………………………

Type of document (please tick): ☐ Journal article ☐ Conference proceedings ☐ Thesis (MSc/MPhil/PhD) ☐ Newspaper/magazine article ☐ Proceedings of meetings ☐ Other……………………………
…………………………………
……………….

Study topic (please tick): ☐ Feed/nutrition ☐ Water quality ☐ Disease ☐ Genetics ☐ Stocking density ☐ Temperature ☐ Light ☐ Polyculture ☐ Other……………………………………….
(see note 4)
……………………………………………..

What species were used in the study?:…………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
Target species:…………………………………………………………………
(see note 5 and 6)

What was the unit of study? (please tick): ☐ Earthen pond

(see note 7)

- ☐ Cement pond
- ☐ Hapa
- ☐ Cages (floating)
- ☐ Aquarium/tank
- ☐ Trough
- ☐ Cement cistern
- ☐ Ricefields
- ☐ Other…………………………...

………………………………………
………………………………………

Number of treatments/comparators:…………………………………………………

Please specify what each treatment/comparator was (including the control) and the number of animals used in each treatment:
(see note 8)

	Number of animals
Comparator 1:…………………………………………….. …………………………………………………………	☐
Comparator 2:…………………………………………….. …………………………………………………………	☐
Comparator 3:…………………………………………….. …………………………………………………………	☐
Comparator 4:…………………………………………….. …………………………………………………………	☐
Comparator 5:…………………………………………….. …………………………………………………………	☐
Comparator 6:…………………………………………….. …………………………………………………………	☐
Comparator 7:…………………………………………….. …………………………………………………………	☐
Comparator 8:…………………………………………….. …………………………………………………………	☐
Additional comparators:………………………………….. ………………………………………………………… …………………………………………………………	☐

No. of replicates:………………………………………………………………………..
(see note 9)

Total number of units used:…………………………………………………………..
(see note 10)

Total no. of animals used:……………………………………………………………
(see note 11)

Developmental stage of animals:………………………………………………………
(see note 12)

Have results been presented as means +/- standard deviation, standard error, or 95% confidence limits? (please tick):

- ☐ Yes – standard deviations
- ☐ Yes – standard errors
- ☐ Yes – 95% confidence limits
- ☐ No

If no, how have they been presented? (please tick):

- ☐ Means only
- ☐ Percentages
- ☐ Ranges
- ☐ Graphs
- ☐ Median + inter-quartile range
- ☐ Other…………………………………………………
…………………………………………………………

Have the results been statistically analysed using analysis of variance? (please tick): (see note 13)

- ☐ Yes
- ☐ No

What other forms of statistical test, if any, have been carried out? (please tick): (see note 14)

- ☐ Student's t-test
- ☐ Least significant difference test
- ☐ Duncan's multiple range test
- ☐ Chi-squared test
- ☐ Tukey's Honest Significant Difference test
- ☐ Regression analysis
- ☐ Mann-Whitney U test
- ☐ Kruskal-Wallis test
- ☐ Other…………………………………………………
…………………………………………………………
…………………………………………………………

Please tick all applicable boxes of fish/prawn outcome measures (not water quality) used and state the units where necessary, eg. kg/ha (please tick): (see note 15)

Units

- ☐ Total harvest weight……………………………………
- ☐ Mean weight at harvest…………………………………
- ☐ Mean weight gain………………………………………
- ☐ Mean daily weight gain…………………………………
- ☐ Specific growth rate……………………………………..
- ☐ Gross yield/production…………………………………
- ☐ Net yield/production……………………………………
- ☐ Survival…………………………………………………
- ☐ FCR……………………………………………………..
- ☐ Other……………………………………………………

…………………………………………………………
…………………………………………………………

Please complete the table below by stating the highest, maximum or best absolute value for each outcome measure used, and with which treatment/comparator this was (please tick):
(see note 16)

Outcome measure	Highest/maximum/best absolute value	Treatment/comparator
Total harvest weight		
Mean weight at harvest		
Mean weight gain		
Mean daily weight gain		
Specific growth rate		
Gross yield/production		
Net yield/production		
Survival		
FCR		
Other		
Other		
Other		

Were recordings of water quality parameters taken? (please tick):

□ Yes □ No

If yes, what parameters were sampled? (please tick):

□ Temperature □ pH □ Dissolved oxygen
□ Hardness □ Salinity □ Free CO2
□ Ammonia-nitrogen □ Nitrite-nitrogen
□ Nitrate-nitrogen □ Other……………………………………
…………………………………………..
…………………………………………..
…………………………………………..

Were recordings of sediment parameters taken? (please tick):

□ Yes □ No

If yes, what parameters were sampled? (please tick):

□ pH □ Organic carbon
□ Available phosphorus □ Available nitrogen
□ Other………………………………………………………………
…………………………………………………………………………..

APPENDIX 8. Excluded references and reasons for their exclusion.

ELECTRONIC REFERENCES	
Reference	**Reason for exclusion**
Abbas G. 2000. Influence of NPK fertilisation of carp ponds in polyculture rearing: a preliminary investigation. *Indian Journal of Animal Sciences.* **70** (7): 771-776.	Outside target countries
Abdalla AAF, McNabb CD, Batterson TR. 1996. Ammonia dynamics in fertilised fish ponds stocked with Nile tilapia. *Progressive Fish-Culturist.* **58** (2): 117-123.	Outside target countries
Achuthankutty CT. 1998. Shrimp farming in estuarine environment: Points to ponder. Proceedings of the Workshop on Environmental Impact Assessment of Aquaculture Enterprises, Chennai, December 10-12, 1997. p 32-38.	Review
Achuthankutty CT, Sreepada RA. 1998. Brackishwater shrimp farming: Possible impacts on an estuarine ecosystem. *Advances in aquatic biology and fisheries.* Prof. N. Balakrishnan Nair felicitation volume: 175-189.	Overview
Ackman RG, McLeod C, Rakshit S, Misra KK. 2002. Lipids and fatty acids of five freshwater food fishes of India. *Journal of Food Lipids.* **9** (2): 127-145.	Observational study
Acosta BO, Williams MJ. 2001. The role of an International Research Organisation in tilapia aquaculture Tilapia: Production, marketing and technological developments: Proceedings of the Tilapia 2001 International Technical and Trade Conference on Tilapia, 28-30 May, Kuala Lumpur, Malaysia. p 49-58.	Overview
Adamczewska AM, Morris S. 2000. Locomotion, respiratory physiology, and energetics of amphibious and terrestrial crabs. *Physiological and Biochemical Zoology.* **73** (6): 706-725.	Outside target species
Aerts JCJH, Hassan A, Savenije HHG, Khan MF. 2000. Using GIS tools and rapid assessment techniques for determining salt intrusion:STREAM, a river basin management instrument. *Physics and Chemistry of the Earth Part B - Hydrology Oceans and Atmosphere.* **25** (3): 265-273.	Not related to aquatic animal health
Aggarwal SG, Chandrawanshi CK, Patel RM, Agarwal S, Kamavisdar A, Mundhara GL. 2001. Acidification of surface water in central India. *Water Air and Soil Pollution.* **130** (1-4): 855-862.	Observational stuy
Aguirre Guzman G. Acencio Valle F. 2000. Infectious disease in shrimp species with aquaculture potential. *Recent Research Developments in Microbiology*. **4** (1): 333-348.	Review

Ahmed M, Rab A, Bimbao MAP. 1993 Household socioeconomics, resource use and fish marketing in two thanas of Bangladesh. ICLARM technical reports, Manila. **40**: 82 pp.	Outside target countries; not related to aquatic animal health
Ahmed M, Rab MA, Gupta MV. 1995. Impact of improved aquaculture technologies: Results of an extension program on the farming systems of Bangladesh. *Asian Fisheries Science.* **8** (1): 27-39.	Outside target countries
Akolkar P, Trivedi RC. 1998. Suitability of Chlorella pyrenoidosa and Daphnia magna as reference cultures for toxicity evaluation of waste waters in tropical conditions. First National Workshop on Development and Use of Environmental Reference Material. p 76-82.	Outside target species
Aksornkoae S. 1993. Ecology and management of mangroves. International Union for Conservation of Nature and Natural Resources (IUCN), Bangkok (Thailand). 191 pp.	Overview
Alceste CC, Jory DE. 2000. Tilapia - Considerations for tilapia production in salt water. *Aquaculture Magazine.* **26** (5): 58-61.	Overview
Ali SA. 2001. Nutritional requirements in the diet of Indian white shrimp (*Penaeus indicus*) - a review. A*pplications in Fisheries and Aquaculture.* **1** (1): 151-154.	Review
Alongi DM, Tirendi F, Trott LA. 1999. Rates and pathways of benthic mineralization in extensive ponds of the Mekong delta, Vietnam. *Aquaculture.* **175** (3-4): 269-292.	Observational study
Alongi DM, Johnston DJ, Xuan TT. 2000. Carbon and nitrogen budgets in shrimp ponds of extensive mixed shrimp-mangrove forestry farms in the mekong delta, Vietnam. *Aquaculture Research.* **31** (4): 387-399.	Observational study
Alongi DM, Chong VC, Dixon P, Sasekumar A, Tirendi F. 2003. The influence of fish cage aquaculture on pelagic carbon flow and water chemistry in tidally dominated mangrove estuaries of peninsular Malaysia. *Marine Environmental research.* **55** (4): 313-333.	Outside target countries
Alongi DM, Dixon P, Johnston DJ, Van Tien D, Xuan TT. 1999. Pelagic processes in extensive shrimp ponds of the Mekong delta, Vietnam. *Aquaculture.* **175** (1-2): 121-141.	Observational study
Alonso-Rodriguez R, Paez-Osuna F. 2003. Nutrients, phytoplankton and harmful algal blooms in shrimp ponds: A review with special reference to the situation in the Gulf of California. *Aquaculture.* **219** (1-4): 317-336.	Review
Alsayed A, Ghaddaf, M. 1993. Upwelling and fish mortality, in the northern Gulf of Aden. *Indian Journal of Marine Sciences.* **22** (4): 305-307.	Outside target countries

Amaraneni SR. 2002. Persistence of pesticides in water, sediment and fish from fish farms in Kolleru Lake, India. *Journal of the Science of Food and Agriculture.* **82** (8): 918-923.	Observational study
Ambasankar K, Ali SA. 2002. Effect of dietary phosphorus on growth and phosphorus excretion in Indian white shrimp. *Journal of Aquaculture in the Tropics.* **17** (2): 119-126.	Obtained after time limit
Amsler K. 1995. Manatee: the twilight of the mermaids. *Oceanorama. Institut oceanographique Paul Ricard, Marseille.* **24**: 21-24.	Not related to aquatic animal health; outside target species
An NT. 2002. Presentation of the GAMBAS project. Shrimp farming sustainability in the Mekong delta environmental and technical approaches: Proceedings of the workshop held in Travinh (Vietnam), 5-8 March, 2002, organised by the Nha Trang Institute of Oceanography. p 1.	Overview
Angell CL. 1997. Site selection towards sustainable shrimp aquaculture in Myanmar. FAO, Bangkok (Thailand). 36 pp.	Overview
Anil AC, Kurian J. 1996. Influence of food concentration, temperature and salinity on the larval development of *Balanus amphritrite. Marine Biology.* **127** (1): 5-124.	Outside target species
Anon. 1996. Seedstock shortages in Veitnam? *Shrimp News International.* **21** (3): 8-9.	Overview
Anon. 1997. The blight of Asian farms. *Fish Farming International.* **24** (3): 32.	Overview
Anon. 1997. Weaning diet may add new species. *Fish Farming International.* **24** (12): 36.	Outside target countries
Anon. 1999. Research and training off to a good start. *Abbassa Update.* **2** (1): 4 pp.	Overview
Anon. 2000. Taiwan's offshore potential: First symposium outlines country's cage culture. *Fish Farming International.* **27** (1): 26.	Outside target countries; overview
Ansari ZA, Abidi SAH. 1994. Impact of aquaculture on coastal marine environment. *Environment and Applied Biology, Society of Biosciences, Muzaffarnagar (India).* p 31-40.	Review
Arumugam PT. 2000. The role of recent technologies in traditional integrated farming in Malaysia: application to Australia. Proceedings of the National Workshop on Wastewater Treatment and Integrated Aquaculture. p 54-	Outside target countries; review

61.	
Ashworth AC, Kuschel G. 2003. Fossil weevils (Coleoptera: Curculionidae) from latitude 85 degree S Antarctica. *Palaeogeography Palaeoclimatology Palaeoecology*. **191** (2): 191-202.	Not related to aquatic animal health
Athithan S, Ramadhas V. 1997. Bioconversion efficiency and growth in the white shrimp, *Penaeus indicus* (Milne Edwards) fed with decomposed mangrove leaves. *Indian Journal of Ecology*. **24** (2): 196-198.	No statistical analysis
Athithan, S., Francis, T., Ramanathan, N., Ramadhas, V. 2001. A note on monoculture of Penaeus monodon in a hardwater seasonal pond. *Naga*. **24** (3-4): 14-15.	No control group
Ayyappan S, Jena JK. 2001. Sustainable freshwater aquaculture in India. *Sustainable Indian fisheries.* p 88-133.	Review
Azad IS, Shekhar MS, Mishra SS, Santiago TC, Rao LH. 2002. Detection of WSV specificity to different tissues of tiger shrimp (*Penaeus monodon*), from the east coast of India, by polymerase chain reaction and histopathology. *Journal of Aquaculture in the Tropics.* **17** (3): 175-184.	Observational study
Azim ME, Verdegem MCJ, Wahab MA, van Dam AA, Beveridge MCM. 2001. Periphyton boosts production in pond aquaculture systems. *World Aquaculture.* **32** (4): 57-60.	Overview
Azim ME, Verdegem MCJ, Wahab MA, van Dam AA, Beveridge MCM. 2001. Evaluation of three species polyculture of major Indian carps under the periphyton-based pond aquaculture systems. Aquaculture 2001: Book of abstracts. p. 33.	Abstract only
Azim ME, Wahab MA, van Dam AA, Beveridge MCM, Huisman EA, Verdegem MCJ. 2001. Optimization of stocking ratios of two Indian major carps, rohu (Labeo rohita Ham.) and catla (Catla catla Ham.) in a periphyton-based aquaculture system. *Aquaculture.* **203** (1-2): 33-49.	Outside target countries
Azim ME, Wahab MA, Verdregem MCJ, van Dam AA, van Rooij JM, Beveridge MCM. 2002. The effects of atrificial substrates on freshwater pond productivity and water quality and the implications for periphyton-based aquaculture. *Aquatic Living Resources.* **15** (4): 231-241.	Outside target countries
Azim ME, Verdegen MCJ, Khatoon H, Wahab MA, van Dam AA, Beveridge MCM. 2002. A comparison of fertilization, feeding and three periphyton substrates for increasing fish production in freshwater pond aquaculture in Bangladesh. *Aquaculture.* **212** (1-4): 227-243.	Outside target countries
Azim ME, Verdegem MCJ, Rahman MM, Wahab MA, van Dam AA, Beveridge MCM. 2002. Evaluation of polyculture of Indian major carps in periphyton-based ponds. *Aquaculture.* **213** (1-4): 131-149.	Obtained after time limit
Azuma T. 2001. Can water-flow induce an excellent growth of fish; effects of water flow on the growth of	Outside target countries

juvenile masu salmon, *Onchorynchus masou. World Aquaculture.* **32** (4): 26-29.	
Baconawa ET. 1993. The fish-crop-livestock farming project. Integrated agriculture-aquaculture farming systems. Book Series, Philippine Council for Aquatic and Marine Research and Development. **15**: 37-42.	Overview
Bader JA, Shoemaker CA, Klesius PH, Connolly MA, Barbaree JM. 1998. Genomic subtyping of Edwardsiella ictaluri isolated from diseased channel catfish by arbitrarily primed polymerase chain reaction. *Journal of Aquatic Animal Health.* **10** (1): 22-27.	Outside target countries
Bador, R., Scura, E D., Naivosoa, R. 1998. The use of feeding trays in the semi-intensive grow-out of Penaeus monodon: A tool to better understand shrimp feeding behaviour in ponds. Aquaculture '98: Book of Abstracts. p 27.	Abstract only; no control group
Bagchi D, Verma HM. 2001. Evaluation study of Fish Farmers Development Agencies (FFDAs) in Rajasthan. Research study - Agro-Economics Research Centre, Sardar Patel University. **116**. 59 pp.	Not related to aquatic animal health
Baghel DS, Saxena V. 2002. Composite fish culture in Tarai region of Uttaranchal. *Geobios.* **29** (2-3): 101-104.	No control group
Bailey R, Cole B. Spawning the tinfoil barb, Barbodes schwanenfeldi, in Hawaii. Hawaii Sea Grant.	Outside target countries
Bakthavathsalam R, Vishnupriya SR, Panimalar S, Kavitha S, Perianayaki D. 2003. Diurnal and weekly variations of some physico-chemical factors of a natural carp culture pond. *Environment and Ecology.* **21** (1): 227-233.	Observational study
Balamurugan S, Subramanian P. 2001. Copepod (Crustacea: Copepoda) fauna diversity, in some ponds around the Bharathidasan Univeristy, in relation to aquaculture context, Tiruchirappalli, Tamil Nadu, India. Aquaculture 2001: Book of Abstracts. p 41.	Abstract only; observational study
Balasubramanian T, Viswakumar M, Venugopal P. 1995. Ecological evaluation of two prawn culture fields in the Cochin Backwater based on premonsoon diurnal observations. *Journal of the Marine Biological Association of India.* **37** (1-2): 212-220.	Observational study
Banerjee GD. 1994. Prawn culture - a profitable avocation - a case study. *National Bank News Review (Bombay).* **10** (1): 7-10.	Review
Banerji SR. 1997. Unattended issues in scientific promotion of inland fisheries. *Fishing Chimes.* **17** (6): 23-24.	Overview

Barbier E, Cox M. 2002. Economic and demographic factors affecting mangrove loss in the coastal provinces of Thailand, 1979-1996. *Ambio*. **31** (4): 351-357.	Observational study
Bardygula-Nonn LG, Black MB, Baranyai PS, Glonek T, Early TA. 1996. Naturally spawning chinook salmon (*Onchorynchus tshawytscha*) from the effluent of a wastewater treatment plant. *Journal of Freshwater Ecology*. **11** (4): 439-445.	Outside target countries
Barlow, C. 1998. Barramundi *Lates calcarifer* aquaculture in Australia. Aquaculture '98: Book of Abstracts. p 31.	Outside target countries; abstract only
Barlow C, Williams K, Rimmer M. 1996. Sea bass culture in Australia. *INFOFISH International*. **2** (26-29): 31-33.	Outside target countries; review
Barman BK, Little DC, Edwards P. 2002. Small-scale fish culture in Northwest Bangladesh: a participatory appraisal focusing on the role of tilapia. *Rural Aquaculture*. p 227-244. Edwards P, Little DC, Demaine H (Eds).	Outside target countries
Bart AN, Yen PT. 2001. Improved performance of domesticated giant prawn *Macrobrachium rosenbergii* in Vietnam. Aquaculture 2001: Book of abstracts. p. 45.	Abstract only
Bartley DM, Rana K, Immink AJ. 2000. The use of inter-specific hybrids in aquaculture and fisheries. *Reviews in Fish Biology and Fisheries*. **10** (3): 325-337.	Review
Baruah UK, Bhagowati AK, Talukdar RK, Saharia PK. 2000. Beel fisheries of Assam: Community-based co-management imperative. *Naga*. **23** (2): 36-41.	Overview
Basavaraju Y, Mair GC, Tuan PA, Edwards P, Penman DJ, Kumar MHM, Kumar PS. 2001. A case for indigenous common carp in traditional rice-fish aquaculture systems in northern Vietnam. 6th Asian Fisheries Forum Book of Abstracts. p 165.	Abstract only
Basu TK, Bhattacharyya B. 1996. Linear programming in fish nutrition studies. *Environment and Ecology*. **14** (3): 704-706.	No intervention
Beckmann R. 1999. New and better paths to farmed fish nutrition. *Partners in Research for Development*. **12**: 42-46.	Review
Begum NN, Chakraborty SC, Zaher M, Abdul MM, Gupta MV. 1994. Replacement of fishmeal by low-cost	Outside target countries

animal protein as a quality fish feed ingredient for Indian major carp, Labeo rohita, fingerlings. *Journal of the Science of Food and Agriculture.* **64** (2): 191-197.	
Bello-Olusoji OA, Somers MJ. 1997. Assessment of the African river prawn *Macrobrachium vollenhovenii* (Herklots, 1857) in some lentic and lotic environments in Nigeria. *African Journal of Ecology.* **35** (1): 80-81.	Outside target countries
Benetti DD, Nakada M, Minemoto Y, Hutchinson W, Shotton S, Tindale A. 2001. Aquaculture of yellowtail amberjacks Carangidae: Current status, progress and constraints. Aquaculture 2001: Book of Abstracts. p 56.	Abstract only; overview
Bentsen HB, Eknath AE, Palada-de Vera MS, Danting JC, Bolivar HC, Reyes RA, Dionisio EE, Longalong FM, Circa AV, Tayamen MM, Gjerde B. 1998. Genetic improvement of farmed tilapias: growth performance in a complete diallele cross experiment with eight strains of *Oreochromis niloticus. Aquaculture.* **160** (1-2): 145-173.	Outside target countries
Berg H. 2002. Rice monoculture and integrated rice-fish farming in the Mekong Delta, Vietnam - economic and ecological considerations. *Ecological Economics.* **41** (1): 95-107.	Observational study
Berger B, Vierbuchen M. 2001. Opisthorchiasis simulating malignoma. *Zeitschrift fur Gastroenterologie.* **39** (2): 173-175.	Outside target countries; not related to aquatic animal health
Beveridge MCM, Stewart JA. 1998. Cage culture: Limitations in lakes and reservoirs. Inland fishery enhancements. FAO fisheries technical paper. **374**: 263-278. Bhartiya MT. 1996. Aquaculture industry: A review. *Seafood Export Journal.* **27** (1): 5-8.	Overview
Bhartiya MT. 1996. Aquaculture industry: A review. *Seafood Export Journal.* **27** (11): 5-8.	Review
Bhasker N, Setty TMR. 1994. Incidence of Vibrios of publc-health significance in the farming phase of tiger shrimp (*Penaeus monodon*). *Journal of the Science of Food and Agriculture.* **66** (2): 225-231.	Observational study
Bhatta R. 2000. Sustainable development of coastal resources: Brackish water shrimp farming in Karnataka. Environmental problems of coastal areas of India. p 173-189.	Overview
Bhatta R, Bhat M. 1998. Impacts of aquaculture on the managment of estuaries in India. *Environmental Conservation.* **25** (2): 109-121.	Observational study
Bhattacharya A, Sarkar SK. 2003. Impact of overexploitation of shellfish: Northeastern coast of India. *Ambio.* **32** (1): 70-75.	No intervention; not related to aquatic animal health

Bhattacharya S, Dasgupta S, Datta M, Basu D. 2002. Biotechnology input in fish breeding. *Indiana Journal of Biotechnology*. **1** (1): 29-38.	Overview
Bhattacharyya S, Sen U, Bhattacharyya SP, Mukherjee D. 2002. High performance liquid chromatographic separation of steroids from ovarian follicles of fresh water perch Anabas testudineus: Identification and characterization of the maturation-inducing hormone. *Journal of Experimental Zoology*. **292** (6): 565-572.	Observational study
Bhaumik U, Saha SK, Mitra A. 2001. Desired extension approaches for enhancement of inland fish production. *Applications in Fisheries and Aquaculture*. **1** (1): 107-109.	Overview
Bhowmik ML, Chattopdhyay A, Manna NK. 1997. Biological treatment of sewage with reference to reduction of microbial load, nutrients and fish growth. *Journal of Interacademicia*. **1** (2): 121-125.	Obtained after time limit
Billard R. 1999. Biological diversity in pond fish culture. Proceedings of the 5th Indo-Pacific Fish Conference, Noumea - New Caledonia, 3-8 November, 1997. p 471-479.	Overview
Bisht D, Bisht GS, Khulbe RD. 2000. Fusarium - A new threat to fish population in reservoirs of Kumaun, India. *Current Science*. **78** (10): 1241-1245.	Observational study
Bisht GS, Bisht D, Joshi C, Khulbe RD. 1996. Potential threat to reservoir fishery by fungi in Kumaun Himalaya. *Current Science*. **71** (9): 720-723.	Observational study
Blazer VS, Lilley JH, Schill WB, Kiryu Y, Densmore CL, Panyawachira V, Chinabut S. 2002. Aphanomyces invadans in Atlantic menhaden along the East Coast of the United States. *Journal of Aquatic Animal Health*. **14** (1): 1-10.	Outside target countries
Bluem V, Paris F. 2001. Aquatic modules for bioregenerative life support systems based on the CEBAS biotechnology. *Acta Astronautica*. **48** (5-12): 287-297.	Not related to aquatic animal health
Blum V, Andriske M, Eichhorn H, Kreuzberg K, Schreibman MP. 1995. A controlled aquatic ecological life-support system (CAELSS) for combined production of fish and higher-plant biomass suitable for integration into a lunar or planetary base. *Acta Astronautica*. **37**: 361-371.	Overview
Bocci M. 1999. Modelling the growth of Nile Tilapia (Oreochromis niloticus)feeding on natural resources in enclosures in Laguna de Bay (Philippines). *Ecological Modelling*. **119** (2-3): 135-148.	Outside target countries

Bolivar RB, Eknath AE, Bolivar HL, Abella TA. 1993. Growth and reproduction of individually tagged Nile tilapia (*Oreochromis niloticus*) of different strains. *Aquaculture.* **111** (1-4): 159-169.	Outside target countries
Boonyaratpalin M. 1997. Nutrient requirements of marine food fish cultured in Southeast Asia. *Aquaculture.* **151** (1-4): 283-313.	Review
Boonyaratpalin M. 1998. Nutirtion of *Penaeus merguiensis* and *Penaeus indicus. Reviews in Fisheries Science.* **6** (1-2): 69-78.	Review
Bordalo AA, Nilsumranchit W, Chalermwat K. 2001. Water quality and uses of the Bangpakong River (Eastern Thailand). *Water Research.* **35** (15): 3635-3642.	Not related to aquatic animal health
Borrill R. 1996. All aspects of the production and marketing of duck meat and eggs: A study tour to the USA, China and other Far East countries. 62 pp.	Not related to aquatic animal health
Boulle D. 1998. The new threat looming for Indian Ocean coral reef fisheries. *Window newsletter.* **9** (2): 1-2.	Not related to aquatic animal health; overview
Bovet P, Larue D, Fayol V, Paccaud F. 1998. Blood thiamin status and determinants in the population of Seychelles (Indian Ocean). *Journal of Epidemiology and Community Health.* **52** (4): 237-242.	Not related to aquatic animal health
Bowen BW, Bass AL, Rocha LA, Grant WS, Robertson DR. 2001. Phylogeography of the trumpetfishes (Aulostomus): Ring species complex on a global scale. *Evolution.* **55** (5): 1029-1039.	Review
Bowles DE, Aziz K, Knight CL. 2000. Macrobrachium (Decapoda : Caridea : Palaemonidae) in the contiguous United States: A review of the species and an assessment of threats to their survival. *Journal of Crustacean Biology.* **20** (1): 158-171.	Outside target countries; review
Boyd CE, Teichert-Coddington D. 2001. Inland shrimp farming and the environment. Aquaculture 2001: Book of Abstracts. p 70.	Abstract only
Brennan, D., Clayton, H., Thanh Be, Tran. 2000. Economic characteristics of extensive shrimp farms in the Mekong Delta. *Aquaculture Economics and Management.* **4** (3-4): 127-139.	Observational study
Briggs MRP, Funge-Smith SJ. 1994. A nutrient budget of some intensive marine shrimp ponds in Thailand. *Aquaculture and Fisheries Management.* **25** (8): 789-811.	Observational study

Brock JA. 1993. A synopsis of pathology, diseases and production problems of cultured Macrobrachium, with an emphasis on experiences in Hawaiian prawn farming. CRC Handbook of mariculture. Crustacean aquaculture. **1** (2): 361-391. CRC Press, Boca Raton, Fl (USA).	Outside target countries
Brockmeyer RE jr, Rey JR, Virnstein RW, Gilmore RG, Earnest L. 1997. Rehabilitation of impounded estuarine wetlands by hydrologic reconnection to the Indian River Lagoon, Florida (USA). *Wetlands Ecology and Management.* **4** (2): 93-109.	Outside target countries; not related to aquatic animal health
Browdy CL, Hopkins JS. 1995. Swimming through troubled water. Proceedings of the special session on shrimp farming, San Diego, California, USA, 1-4 February, 1995. 253 pp.	Multiple papers
Brundrit G, Waldron H. 2000. Sea-level fluctuations as an index of upwelling. Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks. **171**: 81.	Outside target countries; not related to aquatic animal health
Bruton MN. 1995. Have fishes had their chips - The dilemma of threatened fishes. *Environmental Biology of Fishes.* **43** (1): 1-27.	Review
Buchet V. 1998. Aquaculture in the French West Indies. *Aquaculture Insulaire et Tropicale.* **20**: 95-98.	Outside target countries
Bueno PB. 1999. Priorities for regional research on sustainable shrimp aquaculture. Towards sustainable shrimp culture in Thailand and the region. Proceedings of a workshop held at Hat Yai, Songkhla, Thailand, 28 October - 1 November, 1996. p 148-151. Smith PT (Eds).	Overview
BuiXuan M, Ogle B, Preston TR. 1997. Studies on duck production in the Mekong Delta, Vietnam. Integrated farming in human development. Proceedings of a workshop Tune, Landboskole, Denmark, 25-29 March, 1996. p 104-119. Dolberg F, Petersen PH (Eds).	Not related to aquatic animal health
Bullard SA, Overstreet RM. Potential pathological effects of blood flukes (Digenea: Sanguinicolidae) on pen-reared marine fishes. Proceedings of the fifty-third annual Gulf and Caribbean Fisheries Institute. **53**: 10-25.	Overview
Cagauan AG, Branckaert RD, Cvan H. 2000. Integrating fish and azolla in to rice-duck farming in Asia. *Naga.* **23** (1): 4-10.	Outside target countries
Campbell RE, Lilley JH, Taukhid, Panyawachira V, Kanchanakhan S. 2001. In vitro screening of novel	Outside target countries

treatments for Aphanomyces invadans. *Aquaculture Research.* **32** (3): 223-233.	
Carbone F, Accordi G. 2000. The Indian Ocean coast of Somalia. *Marine Pollution Bulletin.* **41** (1-6): 141-159.	Outside target countries; not related to aquatic animal health
Catling PM, Spicer KW, Biernacki M, Doust JL. 1994. The biology of Canadian weeds. 103. Vallisneria americana michx. *Canadian Journal of Plant Science.* **74** (4): 883-897.	Outside target countries; not related to aquatic animal health
Cavalli RO, Tamtin M, Lavens P, Sorgeloos P, Nelis HJ, De Leenheer AP. 2001. The content of ascorbic acid and tocopherol in the tissues and eggs of wild Macrobrachium rosenbergii during maturation. *Journal of Shellfish Research.***20** (3): 939-943.	Observational study
Cayre P, Marsac F. 1993. Modelling the yellowfish tuna (Thunnus albacares) vertical distribution using sonic tagging results and local environmental parameters. *Aquatic Living Resources.* **6** (1): 1-14.	Outside target countries
Central Inland Capture Fisheries research Institute, Barrackpore, India. 1997. Epizootic ulcerative syndrome in fishes: Its present status in India. *Bulletin of the Central Inland Capture Fisheries Research Institute Barrackpore.* **2**: 22 pp.	Review
Central Inalnd Capture Fisheries Research Institute, Barrackpore (India). 1997. Ecology-based fisheries management in Aliyar Reservoir. *Bulletin of the Central Inland Capture FIsheries Research Institute, Barrackpore.* **72**: 36 pp.	Review
Central Inland Capture Fisheries Research Institute, Barrackpore (India). 2000. Guidelines for small reservoir fisheries management. *Bulletin of the Central Inland Capture Fisheries Research Institute, Barrackpore.* **93**: 31 pp.	Guidelines
Central Institute of Brackishwater Aquaculture, Madras India. 2000. Shrimp feed processing and production technology. *Buletin of the Central Institute of BRackishwater Aquaculture.* **13**: 20 pp.	Overview
Central Institute of Brackishwater Aquaculture, Madras India. Marine protein resource availability as raw materials for prawn feeds.	Observational study
Chaitanawisuti N, Kritsanapuntu A. 2000. Growth and production of hatchery-reared juvenile spotted babylon Babylonia areolata Link 1807 cultured to marketable size in intensive flowthrough and semi-closed recirculating water systems. *Aquaculture Research.* **31** (5): 415-419.	Outside target species
Chaitanawisuti N, Piyatiratitivorakul S. 1994. Studies on cage culture of red snapper, *Lutjanus argentimaculatus*, with special emphasis on growth and economics. *Journal of Aquaculture in the Tropics.* **9** (4):	Observational study

269-278.	
Chakraborty C, Chatterjee TK. 1999. Effects of stocking density and light intensity on growth and survival in larval rearing of freshwater prawn *Macrobrachium rosenbergii* (de Man). *Environment and Ecology*. **17** (2): 288-290.	No statistical analysis
Chakraborty C, Chatterjee TK, Chakraborty SK. 1999. Water quality of larval rearing system of giant freshwater prawn *Macrobrachium rosenbergii* (de Man). *Environment and Ecology*. **17** (2): 432-435.	Observational study
Chakraborty A, Oinam S, Karmakar R, Chatterjee M. 1998. Vanadium toxicology - an assessment of general health, haematological aspects and energy response in an Indian catfish Clarias batrachus (Linn). *Biometals*. **11** (2): 95-100.	No control group
Chakraborty A, Otta SK, Joseph B, Kumar S, Hossain MS, Karunasagar I, Venugopal MN, Karunasagar I. 2002. Prevalence of white spot syndrome virus in wild crustaceans along the coast of India. *Current Science*. **82** (11): 1392-1397.	Observational study
Chalorkpunrut P, Taebsri S. 1996. Studies on growth and survival rates of sepat siam (*Trichogaster pectoralis* Regan) postlarvae fed with various artificial feeds. *Khon Kaen Agriculture Journal*. **24** (1): 41-43.	Obtained after time limit
Chamberlain GW. Sustainability of world shrimp farming. Global Trends: Fisheries Management. American Fisheries Society Symposium. **20**: 195-209.	Reveiw
Chand BK. 1999. Studies on effects of hideouts on survival and production rate of *Macrobrachium rosenbergii*. *Indian Journal of Animal Health*. **38** (1): 65-68.	No statistical analysis
Chand BK. 2000. Effect of aeration on water quality, growth and production of prawn in commercial farming. *Indian Journal of Animal Health*. **39** (1): 43-47.	Obtained after time limit
Chand BK, Patra BC, Das SK. 2002. Growth and production of freshwater prawn and carp under polyculture system. *Journal of Interacademicia*. **6** (2): 210-215.	Obtained after time limit
Chand BK, Goswani A, Biswas BK, Biswas PK, Biswas A. 2002. Growth and production of carps under composite farming in different village ponds. *Environment and Ecology*. **20** (1): 139-142.	Observational study
Chandrika V. 1999. Incidence of antagonistic Bacillus spp. - An eco-friendly aquatic probiotic from aquaculture	Observational study

ponds. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi, Kerala. p 147-150.	
Chang AKW. 2001. Analysis of the performance of a formulated feed for redclaw crayfish *Cherax quadricarinatus* compared to a commercial prawn feed. Aquaculture 2001: Book of Abstracts. p 109.	Abstract only
Chapman FA, Colle DE, Rottmann RW, Shireman JV. 1998. Controlled spawning of the neon tetra. *Progressive Fish-Culturist.* **60** (1): 32-37.	Outside target countries
Chapman G, Fernando CH. 1994. The diets and related aspects of feeding of Nile tilapia (Oreochromis niloticus L.) and common carp (Cyprinus carpio L.) in lowland rice fields in northeast Thailand. *Aquaculture.* **123** (3-4): 281-307.	Observational study
Chara J, Pedraza G, Conde N. 1999. The productive water decontamination system: A tool for protecting water resources in the tropics. *Livestock Research for Rural Development.* **11**: 1.	Overview
Chareontesprasit N, Jiwyam W. 1996. Dietary protein requirement on growth for climbing perch (*Anabas testudineus*). *Khon Kaen Agriculture Journal.* **24** (3): 116-120.	Obtained after time limit
Chareontesprasit N, Jiwyam W, Khongsai S, Tiebsri S. 1997. Optimal dietary protein level and stocking density of climbing perch (*Anabas testudineus*) in cage culture. *Khon Kaen Agriculture Journal.* **25** (1): 42-47.	Obtained after time limit
Charles PM. 1997. Environmental influence on the reproduction of *Macrobrachium lamarrei. Uttar Pradesh Journal of Zoology*. **17** (2): 89-100.	Observational study
Chatterjee S, Ghosh R. 1995. Toxicity of carbofuran technical 75DB to the fertilisation of eggs of catfish, *Heteropneustes fossilis* (Bloch). *Bulletin of Environmental Contamination and Toxicology*. **55** (1): 111-115.	Outside target countries
Chatterjee DK, Saha PK, Adhikari S, Mondal AK. 1997. Exploitation efficiency of added nitrogen and its effect on pond environment in freshwater carp culture. *Journal of Aquaculture in the Tropics.* **12** (2): 123-131.	Observational study
Chaudhari DN, Thirunavukkarasu AR. 1993. Changes in haemolymph constituent in the resting (or non-active) and activity stressed *Penaeus indicus* H. Milne Edwards. Mariculture Research Programme under the Postgraduate Programme in Mariculture, Part 2, CMFRI, Cochin, Special publication. **53**: 112-114.	Outcome measures not related to aquatic animal health
Chauhan R. 2000. Comparative performance of mirror and grass carps in monoculture under sub temperate conditions. *Uttar Pradesh Journal of Zoology*. **20** (1): 103-104.	Obtained after time limit

Chauhan R. 2001. Production potential of exotic carps in composite culture under sub-temperate conditions. *Uttar Pradesh Journal of Zoology*. **21** (3): 225-228.	Observational study
Cheng HS, Shieh YH. 2000. Investigation on subclinical aspects related to intestinal parasitic infections among Thai laborers in Taipei. *Journal of Travel Medicine.* **7** (6): 319-324.	Not related to aquatic animal health
Chinabut S. 1998. Epizootic ulcerative syndrome: Information up to 1997. *Fish Pathology.* **33** (4): 321-326.	Overview
Chinabut S. 2002. A case study of isopod infestation in tilapia cage culture in Thailand. FAO Fisheries Technical Paper. **406**: 201-202.	Observational study
Chinabut S. 2002. Jaundice disease in catfish, a case study demonstrating a decline in incidence as a result of research output. FAO Fisheries Technical Paper. **406**: 77-80.	Overview; no intervention
Chiu Liao, I., Chien, Yew-Hu. 1994. Culture of Kuruma prawn (*Penaeus japonicus* Bate) in Asia. *World Aquaculture.* **25** (1): 18-33.	Overview
Chowdhury R, Bhattacharjee H, Angell C. 1993. A manual for operating a small-scale recirculation freshwater prawn hatchery. Bay of Bengal Programme for Fisheries Development, Madras (India). 36 pp.	Manual
Christensen MS. 1993. An economic analysis of loating cage culture of tinfoil barb, Puntius schwanenfeldii, in East Kalimantan, Indonesia, using chicken manure and other fresh feeds. *Asian Fisheries Science.* **6** (3): 271-281.	Outside target countries
Chu JCW, Leung KMY, Wu RSS. 1996. Nutritional study on the areolated grouper (Epinephelus areolatus) cultured in open sea cages. Proceedings of the Pacon Conference on Sustainable Aquaculture '95. p 79.	Abstract only
Clarke WC, Saunders RL, McCormick SD. Smolt production. Principles of salmonid culture. *Developments in Aquaculture and Fisheries Science.* **29**: 517-568.	Review
Clifford, H C III. 1999. A review of diagnostic, biosecurity and management measures for the exclusion of white spot virus disease from shrimp culture systems in the Americas. Aquaculture '99. **1**: 134-171.	Outside target countries; review
Collins TM, Trexler LC, Nico LG, Rawlings TA.. 2002. Genetic diversity in a morphologically conservative invasive taxon: Multiple introductions of swamp eels to the southeastern United States. *Conservation Biology.*	Outside target countries

16 (4): 1024-1035.	
Corpron, K. 1994. The Asian shrimp feed market. *Shrimp News International.* **19** (7): 14-18.	Overview
Corsin F, Phi TT, Phuoc LH, Tinh NTN, Hao NV, Mohan CV, Turnbull JF, Morgan KL. 2002. Problems and solutions with the design and execution of an epidemiological study of white spot disease in black tiger shrimp (*Penaeus monodon*) in Vietnam. *Preventive Veterinary Medicine.* **53** (1-2): 117-132.	Outcome measures not related to aquatic animal health
Corsin F, Thakur PC, Padiyar PA, Madhusudhan M, Turnbull JF, Mohan CV, Hao NV, Morgan KL. 2002. Feeding farmed shrimp with shrimp waste: The lessons for aquaculture from BSE. 56th Annual Conference of the Association of Veterinary Teachers and Research Workers on Current Topics in Veterinary Science, Scarborough, England, UK, March 25-27, 2002.	Obtained after time limit
Corsin F, Turnbull JF, Hao NV, Mohan CV, Phi TT, Phuoc LH, Tinh NTN, Morgan KL. 2001. Risk factors associated with white spot syndrome virus infection in a Vietnamese rice-shrimp farming system. *Diseases of Aquatic Organisms.* **47** (1): 1-12.	Observational study
Cowan VJ, Lorenzen K, Funge-Smith SJ. 1999. Impact of culture intensity and monsoon season on water quality in Thai commercial shrimp ponds. *Aquaculture Research.* **30** (2): 123-133.	Observational study
Cowley JA, Dimmock CM, Wongteerasupaya C, Boonsaeng V, Panyim S, Walker PJ. 1999. Yellow head virus from Thailand and gill-associated virus from Australia are closely related but distinct prawn viruses. *Diseases of Aquatic Organisms.* **36** (2): 153-157.	Observational study
Csavas, I. 1994. The history of shrimp farming in Thailand. *Shrimp News International.* **19** (7): 12-14.	Overview
Csavas, I. 1996. Transferring sustainable technologies - the Asian experience. Proceedings of the Pacon conference on sustainable aquaculture '95. p 111.	Overview
Csavas I, Watanabe T, Liao IC, Chien YH, Chen SN, Wu JL. 1998. Improving management of aquaculture in Asia: Report of APO seminar, Taipai, Republic of China, 8-16 May, 1996. 266 pp. Asian Productivity Organisation.	Multiple papers
Culberson SD, Piedrahita RH. 1996. Aquaculture pond ecosystem model: Temperature and dissolved oxygen prediction - Mechanism and application. *Ecological Modelling.* **89** (1-3): 231-258.	Observational study

Custer TW, Sparks DW, Sobiech SA, Hines RK, Melancon MJ. 1996. Organochlorine accumulation by sentinel mallards at the Winston-Thomas sewage treatment plant, Bloomington, Indiana. *Archives of Environmental Contamination and Toxicology*. **30** (2): 163-169.	Outside target countries
Dalmin G, Kathiresan K, Puroshothaman A. 2001. Effect of probiotics on bacterial population and health status of shrimp in culture pond ecosystem. *Indian Journal of Experimental Biology*. **39** (9): 939-942.	Obtained after time limit
Dalsgaard A. 1998. The occurence of human pathogenic Vibrio spp. and Salmonella in aquaculture. *International Journal of Food Science and Technology*. **33** (2): 127-138.	Observational study
Dalsgaard A, Huss HH, Hkittikun A, Larsen JL. 1995. Prevalence of vibrio-cholerae and Salmonella in a major shrimp production area in Thailand. *International Journal of Food Microbiology*. **28** (1): 101-113.	Observational study
Dalsgaard A, Echeverria P, Larsen JL, Serichantalergs RSO, Huss HH. 1995. Application of ribotyping for differentiating Vibrio cholerae non-O1 isolated from shrimp farms in Thailand. *Applied and Environmental Microbiology*. **61** (1): 245-251.	Observational study
Dalsgaard A, Serichantalergs O, Shimada T, Sethabutr O, Echeverria P. 1995. Prevalence of Vibrio-cholerae with heat-stable enterotoxin (NAG-ST) and cholera-toxin genes - Restriction-fragment-length-polymorphisms of NAG-ST genes among Vibrio-cholerae O-serogroups from a major shrimp production area in Thailand. *Journal of Medical Microbiology*. **43** (3): 216-220.	Observational study
Dalsgaard A, Bjergskov T, Jeppesen VF, Jorgensen LB, Echeverria P, Dalsgaard I. 1996. Prevalence and characterization of Vibrio cholerae isolated from shrimp products imported into Denmark. *Journal of Food Protection.* **59** (7): 694-697.	Outside target countries
Dan NC, Olesen I. 2002. Genetic studies of farmed tilapia in fresh and brackish water in Vietnam. *Aquaculture.* **204** (3-4): 199-200.	Abstract only
Danting MJC, Eknath AE, Bentsen HB. 1995. Evaluation of growth performance testing methods for strain comparisons of Nile tilapia (*Oreochromis niloticus*). *Aquaculture.* **137** (1-4): 332.	Outside target countries
Das BK. 1999. Environmental pollution of Udaisagar lake and impact of phosphate mine, Udaipur, Rajasthan, India. *Environmental Geology*. **38** (3): 244-248.	Not related to aquatic animal health

Das, D., Sahu, N P., Reddy, A K. 1999. Indian and Thai magur culture: Present status, perspectives and constraints. *Fishing Chimes*. **19** (8): 11-15.	Review
Das P, Mishra A, Srivastava SK. 1996. Status on research in applied carp genetics and breeding in India. *Journal of Aquaculture in the Tropics.* **11** (4): 307-317.	Review
Das P, Barat A, Manna GK, Roy SC. 1995. Application of genetics in fisheries can help blue revolution in India. *Perspectives in Cytology and Genetics.* p 25-33.	Review
Datta AK, Bhowmik ML, Mandal SC, Tripathi SD. 1996. Rearing of Labeo bata in sewage-fed fish culture pond. *Journal of the Indian Fisheries Association.* **26**: 105-109.	No control group
Davis WP, Taylor DS, Turner BJ. 1995. Does the autecology of the mangrove Rivulus fish (Rivulus-marmoratus) reflect a paradigm for mangrove ecosystem sensitivity. *Bulletin of Marine Science.* **57** (1): 208-214.	Review
De NC. 1993. Seasonal dynamics of Camallanus anabantis infections in the climbing perch, Anabas testudineus, from the freshwater swamps near Kalyani town, West Bengal, India. *Folia Parasitologica.* **40** (1): 49-52.	Observational study
de Iongh HH, van Zon JCJ. 1993. Assessment of impact of the introduction of exotic fish species in north-east Thailand. *Aquaculture and Fisheries Management.* **24** (3): 279-289.	Observational study
de la Pena MR. 2001. Use of juvenile instar Diaphanosoma celebensis (Stingelin) in hatchery rearing of asian sea bass Lates calcarifer (Bloch). *Israeli Journal of Aquaculture – Bamidgeh.* **53** (3-4): 128-138.	Outside target countries
de Silva SS. 2001. Reservoir and culture-based fisheries: biology and management. Proceedings of an International Workshop held in Bangkok, Thailand, 15-18 February 2000. 384 pp. de Silva SS (Eds).	Multiple papers
Dehadrai PV. 1997. Aquaculture research and development in India. *Recent advances in biosciences and oceanography.* p 123-130.	Overview
Dehadrai PV. 1997. Aquaculture and environment. *Recent advances in biosciences and oceanography.* p 63-66.	Overview
Deniz H. 2000. Marine aquaculture in Turkey and potential finfish species. Recent advances in Mediterranean aquaculture finfish species diversification. Proceedings of the Seminar of the CIHEAM Network on Technology	Outside target countries; overview

of Aquaculture in the Mediterranean (TECAM), jointly organised by CIHEAM and FAO, Zaragoza (Spain), 24-28 May, 1999. **47**: 349-358.	
Deolalikar AV, Ghosh KK. 1996. Research in fisheries related disciplines particularly in ICAR Fisheries Institutes in the decade 1981-1990. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pant Nagar, Uttar Pradesh. p 239-247.	Observational study
Devaraj, M. 2001. Integrated coastal mariculture, seafarming and stock proposal of a project concept for adoption in the Gulf of Mannar and the contiguous sea areas. Perspectives in mariculture. p 273-292.	Overview
Devaraj M, Sundararaj V, Prince Jeyaseelan MJ. 1994. A report on rare and vulnerable ichthyofaunal elements from a South Indian estuarine mangrove ecosystem. Threatened fishes of India. Proceedings of the National Seminar on Endangered fishes of India held at National Bureau of Fish Genetic Resources, Allahabad, 25-26 April, 1992, Nature Conservators, Muzaffarnagar (India). p 261-269.	Not related to aquatic animal health; observational study
Devaraj M, Srinath K, Immanuel S, Pushkaran KN, Ananthalakshmi TN. 1997. Demonstration of ornamental fish farming in a coastal village. *Marine Fisheries Information Service Technical and Extension Series.* **148**: 5-7.	Overview
Devaraj M, Raj RP, Vivekanandan E, Balan K, Sathiadhas R, Srinath M. 1996. Coastal fisheries and aquaculture management in the east coast of India. Marine Fisheries Information Service Technical and Extension Series. **141**: 1-9.	Observational study
Devi CHB, Vishwanath W. 1993. Nutritive value and growth responses of formulated aquatic fern Azolla based diets on advanced fry of endemic medium carp Osteobrama belangeri (Val.). *Journal of Freshwater Biology*. **5** (2): 159-164.	No statistical analysis
Dey, M M.. 2001. Tilapia production in South Asia and the Far East. Tilapia: Production, marketing and technologicla developments: Proceedings of the Tilapia 2001 International Technical and trade Conference on tilapia, 28-30 May 2001, Kuala Lumpur, Malaysia. p 17-26.	Observational study
Dey MM, Gupta MV. 2000. Socioeconomics of disseminating genetically improved Nile tilapia in Asia: an introduction. *Aquaculture Economics and Management.* **4** (1-2): 5-11.	Overview
Dey MM, Paragus FJ. 2001. Economics of tilapia farming in Asia. Tilapia:production, marketing and technological developments: proceedings of the Tilapia 2001 International Technical and Trade Conference on	Overview

Tilapia, 28-30 May 2001, Kuala Lumpur, Malaysia. p 33-44.	
Dey MM, Paraguas FJ, Bhatta R, Alam MF, Koeshendrayana S, Piumsumbun S, Miao W, Dung LTC, Ahmed M. 2001. Socioeconomics of freshwater fish farming in Asia. 6th Asian Fisheries Forum: Book of Abstracts. p 303.	Abstract only
Dhevendaran K, Anithakumari YK. 2002. L-asparaginase activity in growing conditions of Streptomyces spp. associated with Therapon jarbua and Villorita cyprinoids of Veli Lake, South India. *Fishery Technology*. **39** (2): 155-159.	Outcome measures not related to aquatic animal health
Diamant A, Banet A, Paperna I, van Westernhagan H, Broeg K, Kruener G, Koerting W, Zander S. 1999. The use of fish metabolic, pathological and parasitological indices in pollution monitoring II. The Red Sea and Mediterranean. *Helgoland Marine Research*. **53** (3-4): 195-208.	Outside target countries
Diamant A. 1998. Red drum Sciaenops ocellatus (Sciaenidae), a recent introduction to Mediterranean mariculture, is susceptible to Myxidium leei (Myxosporea). *Aquaculture*. **162** (1-2): 33-39.	Outside target countries
Dierberg FE, Kiattisimkul W. 1996. Issues, impacts, and implications of shrimp aquaculture in Thailand. *Environmental Management*. **20** (5): 649-666.	Overview
Dillon RT, Wethington AR, Rhett JM, Smith TP. 2002. Population of the European freshwater pulmonate Physa acuta are not reproductively isolated from American Physa heterostropha or Physa integra. *Invertebrate Biology*. **121** (3): 226-234.	Outside target countries
Dua VK, Sharma SK, Srivastava A, Sharma VP. 1997. Bioenvironmental control of industrial malaria at Bharat Heavy Electricals Ltd., Hardwar, India - results of a nine-year study (1987-95). *Journal of the American Mosquito Control Association*. **13** (3): 278-285.	Not related to aquatic animal health
Duangsawasdi M. Fisheries development in Thailand. Priorities in aquatic resources research in the Asia-Pacific region, ICLARM conference proceedings. **62**: 22-23.	Overview
Duong LT, Rothuis A. 1997. Rice-fish culture in the Mekong Delta, Vietnam. *WES Newsletter*. **5**: 11-13.	Overview
Durville P, Bosc P, Conand C, Dufour V. 2000. Comparative growth in rearing conditions of three species of juvenile Lutjanidae in Reunion Island. *Cybium*. **24** (3): 263-271.	Outside target countries

Dutta D, Jana PK, Bandyopadhyay P. 2001. Growth analysis of rice (Oryza sativa L.) under rice-cum-prawn culture system. *Research on Crops.* **2** (1): 17-20.	Outcome measures not related to aquatic animal health
Dutta D, Jana PK, Bandyopadhyay P, Maity D. 1999. Production potential and economic analysis of rice-prawn culture-cum-paira grasspea (Lathyrus sativus L.) cropping sequence in coastal area of West Bengal. *Journal of Interacademicia.* **3** (3-4): 317-322.	Outcome measures not related to aquatic animal health
Dutta SPS, Kaul V, Sharma J, Kour H. 1997. An incidence of fish kill in Behlol Nullah, tributary of River Tawi Jammu. *Journal of Environmental Biology.* **18** (3): 263-266.	Observational study
Dwivedi SN, Choubey AK. 1998. Indian Ocean large marine ecosystems: Need for national and regional framework for conservation and sustainable development. Large marine ecosystems of the Indian Ocean: Assessment, sustainability and management. p 361-367.	Overview
Edwards P. 1999. Aquaculture and poverty: past, present and future prospects of impact. A discussion paper prepared for the Fifth Fisheries Development Donor Consultation, Rome, Italy, 22-24 February, 1999. 5th Fisheries Development Donors Consultation. FAO, Rome, 22-24 February. p 1-52.	Not related to aquatic animal health; overview
Edwards, P., Hiep, D D., Anh, P M., Mair, G. 2000. Traditional culture of indigenous common carp in rice fields in northern Vietnam - Does it have a future role in poverty reduction? *World Aquaculture.* **31** (4): 34-40.	Observational study
Eknath AE, Tayamen MM, Palada-De Vera MS, Danting JC, Reyes, RA, Dionisio EE, Capili JB, Bolivar HL, Abella TA. 1993. Genetic improvement of farmed tilapias: The growth performance of eight strains of *Oreochromis niloticus* tested in different farm environments. *Aquaculture.* **111** (1-4): 171-188.	Outside target countries
Eknath AE, Tayamen MM, Paladadevera MS, Danting JC, Reyes RA, Dionisio EE, Capili JB, Bolivar HL, Abella TA, Circa AV, Bentsen HB, Gjerde B, Gjedrem T, Pullin RSV. 1993. Genetic improvements of farmed tilapias - the growth performance of 8 strains of Oreochromis niloticus tested in different farm environments. *Aquaculture*. **111** (1-4): 171-188.	Outside target countries
El-Sayad AM, Bary KA. 1994. Life cycle and fecundity of rabbitfish, Siganus canaliculatus (Teleostei: Signidae) in the Arabian Gulf. *Oebalia.* **20**: 79-88.	Outside target countries
Elmatbouli M, Hoffman RW. 1994. Sinuolinea-tetraodoni NSP, a myxosporean parasite of fresh-water pufferfish Tetraodon-palembangensis from southeast-Asia - Light and electron-microscope observations.	Outside target countries; observational study

Diseases of Aquatic Organisms. **19** (1): 47-54.	
Emata AC. 2001. Natural spawning and egg production of tank- and cage-reared mangrove red snapper Lutjanus argentimaculatus in the Philippines. Aquaculture 2001: Book of Abstracts. p 210.	Outside target countries; abstract only
Enright L. 1995. Aquaculture degrades Khao Sam Roi Yot National Park. Coastal Management in the Tropics, Asia. **4**: 24-25.	Case study; not related to aquatic animal health
Coral reefs of India: State-of-the-art report. 1998. ENVIS Publication Series. 52 pp.	Not related to aquatic animal health
Epstein PR. 1993. Algal blooms in the spread and persistence of cholera. *Biosystems.* **31** (2-3): 209-221.	Outside target countries; not related to aquatic animal health
Falaye AE, Ogunsanmi AO, Opadokun IO. 1999. Growth, haematology, plasma biochemistry and tissue pathology of Indian carp (Cirrhinus mrigala) fed five diets in which soybean milk residue was substituted for groundnut cake at low to high levels. *Tropical Veterinarian.* **17** (3-4): 199-210.	Outside target countries
FAO Regional Office for Asia and the Pacific, Bangkok (Thailand). 1999. Rural aquaculture in India. RAP Publication, Bangkok. **21**: 84.	Review
FAO Technical Cooperation Programme, Rome (Italy). 1998. Assistance for responsible movement of live aquatic animals. FAO, Bangkok (Thailand). 3 pp.	Overview
FAO, Rome (Italy). 1999. Fish and fisheries at higher altitudes. Asia. FAO Fisheries Technical Paper. Rome. **385**: 304 pp.	Review
FAO Regional Office for Asia and the Pacific, Bangkok (Thailand). Aquaculture in Cambodian area and rehabilitation project (CARERE 2).	Outside target countries
FAO Fisheries Department, Rome (Italy) Inalnd Water Resources and Aquaculture Service. 1997. Review of the state of world aquaculture. FAO Fisheries Circular. **886**: 163 pp.	Review
Report of the eighth session of the committee for the development and management of the fishery resources of the gulfs. Muscat, Sultanate of Oman, 17-21 December, 1994 FAO Fisheries Report. 1996. **536**: 32 pp.	Outside target countries; overview

Fast AW, Shang YC, Wanitprapha K, Hanvivatanakit P. 1995. Marine shrimp culture and trawling in Thailand during 1985/86: Characterisations and financial comparisons. *Journal of Aquaculture in the Tropics.* **10** (4): 319-336.	Observational study
Fathimulla F. 2000. Preliminary assessment of health impacts for the Newport Chemical Agent Disposal Facility. *Drug and Chemical Toxicology, an International Journal for Rapid Communication.* **23** (1): 55-66.	Outside target countries; not related to aquatic animal health
Fegan DF, Clifford HC, Griffith DW. 2001. Health management strategies for virus diseases in shrimp farms. Aquaculture 2001: Book of Abstracts. p 220.	Abstract only
Felix S. 1995. Mystery disease outbreak - a turning point to the shrimp aquaculture industry in India. *Seafood Export Journal.* **26** (4): 33-35.	Overview
Ferguson HW, Turnbull JF, Shinn A, Thompson K, Dung TT, Crumlish M. 2001. Bacillary necrosis in farmed *Pangasius hypophthalmus* (Sauvage) from the Mekong Delta, Vietnam. *Journal of Fish Diseases.* **24** (9): 509-513.	Observational study
Fernandez CH, Sukumaran NS. 1995. Effect of crystalline amino acids on the growth performance of Indian white shrimp, *Penaeus indicus* (Milne Edwards). *Journal of Aquaculture in the Tropics.* **10** (3): 245-260.	Obtained after time limit
Fishelson L, Bresler V, Abelson A, Stone L, Gefen E, Rosenfeld M, Mokady O. 2002. The two sides of man-induced changes in littoral marine communities: Eastern Mediterranean and the Red Sea as an example. *Science of the Total Environment.* **296** (1-3): 139-151.	Observational study
Flaherty M, Szuster B, Miller P. 2000. Low salinity inland shrimp farming in Thailand. *Ambio.* **29** (3): 174-179.	Overview
Flegel TW. 2001. The shrimp response to viral pathogens. Aquaculture 2001: Book of Abstracts. p 228.	Abstract only
Flegel TW, Alday-Sanz V. 1998. The crisis in Asian shrimp aquaculture: current status and future needs. *Journal of Applied Ichthyology - Zeitschrift fur Angewandte Ichthyologie.* **14** (3-4): 269-273.	Review
Flegel TW, Sriurairatana S, Wongteerasupaya C, Boonsaeng V, Panyim S, Withyachumnarnkul B. 1995. Progress in characterisation and control of yellow-head virus of Penaeus monodon. Swimming through troubled water. Proceedings of the special session on shrimp farming, World Aquaculture Society, Baton Rouge, LA (USA). p 76-83.	Review

Fouda MM. 1995. Fish resources of Dhofar khawrs (coastal lagoons) in the Sultanate of Oman. *Fisheries Management and Ecology*. **2** (3): 209-225.	Outside target countries
Fisheries Research and Development Corporation, Canberra (Australia). 1997. Fishmeal replacement in aquaculture feeds for prawns, sub program 93/120: final report to the Fisheries Research and Development Corporation. FRDC, Canberra, A.C.T. (Australia). 168 pp.	Outside target countries
Frias-Torres S. 2002. Oceanic transport and life history of the tropical western Atlantic opossum pipefish, *Microphis brachyurus lineatus*. *Dissertation Abstracts International, Part B: Science and Engineering*. **63** (3): 1207.	Not related to aquatic animal health; overview
Fromard F, Le Cong Kiet. 2002. Mangrove swamps in South Vietnam: recent history, current dynamics, and prospects. *Bois et Forets des Tropiques*. **273**: 31-42.	No intervention
Funge-Smith S. 1999. Small-scale rural aquaculture in Lao PDR (Part 1). FAO Aquaculture Newsletter. **22**: 3-9.	Overview
Funge-Smith SJ, Briggs MRP. 1998. Nutrient budgets in intensive shrimp ponds: implications for sustainability. *Aquaculture*. **164** (1-4): 117-133.	Observational study
Gammon JR. 1995. Environmental assessment and fish populations of the Wabash River and its tributaries. *Natural Areas Journal*. **15** (3): 259-266.	Outside target countries
Gauthier-Clerc M, Le Maho Y, Clerquin Y, Bost CA, Handrich Y. 2002. Seabird reproduction in an unpredictable environment: how King penguins provide their young chicks with food. *Marine Ecology - Progress Series*. **237**: 291-300.	Not related to aquatic animal health
George JP, Langer RK, Swamy RP. 1993. Problems and prospects of carp seed production in South Gujarat, water quality management - a case study. Proceedings of the National Seminar on Aquaculture Development in India - Problems and Prospects, 27-29 November, 1990, Kerala University, Thiruvanathapuram (India). p 139-144.	Case study; obtained after time limit
Ghosh M. 1997. Principal fatty acids of phospholipid classes of an Indian fresh water fish (C-pabda). *Journal of Food Lipids*. **4** (3): 189-197.	Observational study

Ghosh SK, Ponniah AG. 2001. Freshwater fish habitat science and management in India. *Aquatic Ecosystem Health and Management.* **4** (4): 367-380.	Overview
Ghosh SK, Santra SC, Mukherjee PK. 1993. Phenological studies in aquatic macrophytic plants of lower Gangetic Delta, West Bengal, India. *Feddes Repertorium.* **104** (1-2): 93-111.	Outside target species – macrophytic plants
Gopakumar K. 2001. Fisheries of India, problems and prospects. *Applications in Fisheries and Aquaculture.* **1** (1): 113-115.	Review
Gopakumar K. 2003. Indian aquaculture. *Journal of Applied Aquaculture.* **13** (1-2): 1-10.	Review
Gopal B, Sah M. 1995. Inventory and classification of wetlands in India. *Vegetatio.* **118** (1-2): 39-48.	Not related to aquatic animal health; observational study
Gopalakrishnan A, Basheer VS. 2000. Peninsular food fishes: taxonomic ambiguities. Endemic fish diversity of Western Ghats. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **1**: 186-187.	Not related to aquatic animal health; overview
Gopalakrishnan A, Lal KK, Ponniah AG. 1999. Conservation of the Nilgiri rainbow trout in India. *Naga.* **22** (3): 16-19.	Review
Gothberg A, Greger M, Bengtsson BE. 2002. Accumulation of heavy metals in water sppinach (Ipomoea aquatica) cultivated in the Bangkok region, Thailand. *Environmental Toxicology and Chemistry.* **21** (9): 1934-1939.	Not related to aquatic animal health
Graczyk TK, Fried B. 1998. Echinostomiasis: A common but forgotten food-borne disease. *American Journal of Tropical Medicine and Hygiene.* **58** (4): 501-504.	Not related to aquatic animal health
Graslund S, Bengtsson BE. 2001. Chemicals and biological products used in south-east Asian shrimp farming, and their potential impact on the environment - a review. *Science of the Total Environment.* **280** (1-3): 93-131.	Review
Graslund S, Holmstrom K, Wahstrom A. A field survey of chemicals and biological products used in shrimp farming. *Marine Pollution Bulletin.* **46** (1): 81-90.	Observational study
Grubh RB, Lazarus S, Grubh AR. 2000. Conservation of the endangered freshwater fishes of Kanyakumari District, Tamil Nadu. Endemic fish diversity of Western Ghats. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **1**: 174-176.	Overview

Guerrero RD III, Guerrero LA. 1993. Technologies for commercial production of sex-reversed tilapia in Asia. Proceedings of the First International Symposium on Aquaculture Technology and Investment Opportunities. p 618-627.	Review
Guillaume J, Kaushik D, Bergot P, Metailler R. 2001. Springer-Praxis Books in Aquaculture and Fisheries, Nutrition and Feeding of Fish and Crustaceans. INRA-IFREMER.	Review (book)
Gunamalai V, Subramoniam T. 2002. Synchronisation of molting and oogenic cycles in a continuously breeding population of the sand crab Emerita asiatica on the Madras Coast, South India. Journal of Crustacean Biology. **22** (2): 398-410.	Outside target species
Gupta A. 1997. Study of coastal water pollution in Tamil Nadu. *Journal of Ecotoxicology and Environmental Monitoring.* **7** (2): 89-93.	Observational study
Gupta MV, Acosta BO. 2001. Networking - a way for accelerating aquaculture genetics research. 6th Asian Fisheries Forum Book of Abstracts. p 1.	Abstract only; overview
Gupta P, Khan HA. 1994. Mahseer fisheries in India. Threatened fishes of India. Proceedings of the national seminar on endangered fishes of India held at National Bureau of Fish Genetic Resources, Allahabad, 25-26 April, 1992, Nature Conservators, Muzaffarnagar (India). p 181-190.	Review
Gupta SD. 1998. Advances in the seed production technology of major carps. Current and emerging trends in aquaculture: Proceedings of the national seminar, 14-16 February, 1995. p 160-163. Thomas PC (Eds).	Review
Hai PG. 2002. Public policy for shrimp farming in Vietnam. Shrimp farming sustainability in the Mekong delta environmental and technical approaches: Proceedings of the workshop held in Travinh (Vietnam), 5-8 March, 2002, organised by the Nha Trang Institute of Oceanography. p 24.	Overview
Hall MR. Genetics and reproduction of penaeid prawns: Natural resources and closed lifecycle improvement. Aquaculture and Fisheries Resources Management. Conference proceedings, Taiwan Fisheries Research Institute. **4**: 33-36.	Review
Halver JE. 2001. The second 25 years in fish nutrition R & D (a personal view of topics, trials and travels in Asia). 6th Asian Fisheries Forum Book of Abstracts. p 88.	Abstract only; overview

Halwart M. 1998. Trends in rice-fish farming. FAO Aquaculture Newsletter. **18**: 3-11.	Review
Hambrook JA. 1999. Habitat design for mussel restoration in fish creek, Cedar Creek, and West branch of St. Joseph River, Ohio, Indiana, and Michigan. IAGLR '99. International Association for Great Lakes Research: Great Lakes, Great Science, Great Cities. Program and Abstracts. A-42.	Outside target countries; outside target species
Hardy RW. 2001. Fish feeds and nutrition. *Aquaculture Magazine*. **27** (3): 51-54.	Review
Hardy RW. 2000. World's largest feed company. *World Aquaculture*. **31** (3): 12-15.	Not related to aquatic animal health
Harikrishnan, M., Kurup, B M. 1998. Present status and future prospects of farming of Macrobrachium rosenbergii (de Man) in Kuttanad, Kerala. Technological advancements in fisheries. Proceedings of the National Symposium on Technological Advancements in Fisheries and its Impact on Rural Development held at Cochin by the School of Industrial Fisheries, Cochin University of Science and Technology during December 5th to 7th, 1995. p 60-68.	Overview
Haroon AKY, Pittman KA. 1997. Rice-fish culture: feeding, growth and yield of two size classes of Puntius gonionotus Bleeker and Oreochromis spp. in Bangladesh. *Aquaculture*. **154** (3-4): 261-281.	Outside target countries
Hasan BMA, Das BK. 2002. Growth of Penaeus monodon under different agro-climatic condition in India and Saudi Arabia. *Journal of Interacademicia*. **6** (1): 85-90.	Observational study
Hasan MR, Haq MS, Das PM, Mowlah G. 1997. Evaluation of poultry-feather meal as a dietary protein source for Indian major carp, *Labeo rohita*, fry. *Aquaculture*. **151** (1-4): 47-54.	Obtained after time limit
Hassan MA, Jafri AK. 1994. Optimum feeding rate, and energy and protein maintenance requirements of young *Clarias batrachus* (L.), a cultivable catfish species. *Aquaculture and Fisheries Management*. **25** (4): 427-438.	Obtained after time limit
Hassan MA, Jafri AK, Alvi AS, Samad R, Usmani N. 1995. Dietary energy and protein interaction - an approach to optimising energy:protein ratio in Indian major carp, *Cirrhinus mrigala* (Hamilton), fingerlings. *Journal of Aquaculture in the Tropics*.**10** (3): 183-191.	Obtained after time limit
Hatai K, Chukanhom K, Lawhavinit C, Kunitsune M, Imai S. 2001. Some biological characteristics of Tetrahymena corlissi isolated from guppy in Thailand. *Fish Pathology*. **36** (4): 195-199.	No statistical analysis

Hatch U, Agbayani R, Belleza E. 1996. Economic analysis of prawn (Penaeus monodon) culture in the Philippines, 2: Grow-out operations. *Asian Fisheries Science.* **9** (2): 127-141.	Outside target countries
Hazarika R, Das M. 1998. Toxicological impact of BHC on the ovary of the air-breathing catfish Heteropneustes fossilis (Bloch). *Bulletin of Environmental Contamination and Toxicology.* **60** (1): 16-21.	No statistical analysis
Hein L. 2002. Toward improved environmental and social management of Indian shrimp farming. *Environmental Management.* **29** (3): 349-359.	Review
Ho J. 2001. Invasions of sea lice (Caligidae, Copepoda) to fishes cultured in ocean cages in Japan and Taiwan. 6th Asian Fisheries Book of Abstracts. p 97.	Outside target countrie; abstract only
Hoang T. 2001. The banana prawn - the right species for shrimp farming? *World Aquaculture.* **32** (4): 40-44.	Outside target countries; overview
Hoq ME, Islam MM, Hossain MM. 1996. Polyculture of freshwater prawn (Macrobrachium rosenbergii) with Chinese and Indian carps in farmers ponds. *Journal of Aquaculture in the Tropics. Calcutta.* **11** (2): 135-141.	Outside target countries
Hossain MA, Amin AR, Islam MS, Hoqe MM, Amin MR. Comparative growth performances of riverine and hatchery produced Indian major carps (*Catla catla* Ham., *Labeo rohita* Ham., and *Cirrhinus mrigala* Ham.). *Bangladesh Journal of Zoology*. **27** (1): 65-73.	Obtained after time limit
Huggett JA, Richardson AJ. 2000. A review of the biology and ecology of Calanus agulhensis off South Africa. *ICES Journal of Marine Science.* **57** (6): 1834-1849.	Outside target countries
Hulata G. 1995. A review of genetic-improvement of the common carp (Cyprinus-carpio L) and other cyprinids by crossbreeding, hybridization and selection. *Aquaculture.* **129** (1-4): 143-155.	Review
Hulata G. 2001. Genetic manipulations in aquaculture: a review of stock improvement by classical and modern technologies. *Genetica.* **111** (1-3): 155-173.	Review
Hussain MG, Islam MS, Hossain MA, Wahid MI, Kohinoor AHM, Dey MM, Mazid MA. 2002. Stock improvement of silver barb (*Barbodes gonionotus* Bleeker) through several generations of genetic selection. *Aquaculture.* **204** (3-4): 469-480.	Outside target countries
Huy PT, Phuc PD, Vinh NN, Sollows JD. 2001. Cage fish trials in Ea Soup Reservoir, Vietnam. p 367-374. de Silva SS (Eds).	No statistical anlaysis
Hwang KP. 1998. Human intestinal capillariasis (Capillaria philippinensis) in Taiwan. *Acta Paediatrica Sinica.* **39** (2): 82-85.	Outside target countries; not related to aquatic animal health
ICLARM - The World Fish Centre, Penang (Malaysia). 2000. Improving the productivity of Tilapia farming in Asia. *Impacts.* **1** (2): 1-2.	Obtained after time limit
Biological pollution: The control and impact of invasive exotic species. Proceedings of a symposium held at the University Place Conference Centre, Indiana University - Purdue University at Indianapolis, October 25-26,	Outside target countries; overview

1991. Indiana Academy of Sciences, Indianapolis (USA). 1993. 261 pp.	
Integrated Fish Farming Project in the Northeastern Region of Thailand, Amphoe Muang (Thailand); Bank for Agriculture and Agricultural Cooperation, Amphoe Muang (Thailand); Belgian Administration for Development Cooperation (Belgium). 1998. Rearing pigs in integrated fish farming, Part 1: General aspects. BAAC, Amphoe Muang (Thailand). 127 pp.	Outside target species; overview
IFREMER Paris, Issy-les-Moulineaux (France) DRV/RA. 1998. Assessment of tropical shrimp aquaculture impact on the environment in tropical countries, using hydrobiology, ecology and remote sensing as helping tools for diagnosis. IFREMER, Issy-les-Moulineaux (France). 263 pp.	Observatioanl study
Ignatius B, Rathore G, Jagadis I, Kandasami D, Victor ACC. 2001. Spawning and larval rearing technique for tropical clown fish Amphiprion sebae under captive condition. *Journal of Aquaculture in the Tropics.* **16** (3): 241-249.	Obtained after time limit
India, National Bank for Agriculture and Rural Development. 1994. Inland fishery schemes in Azamgargh and Deoria districts, Uttar Pradesh: an ex-post evaluation study report. Evaluation Study Series - Regional Office, Lucknow, National Bank for Agriculture and Rural Development. **3**: 38 pp.	Not related to aquatic animal health
India, National Bank for Agriculture and Rural Development. 1994. Brackishwater prawn culture in Puri district (Orissa). Evaluation Study Series - Regional Office, Bhubaneswar, National Bank for Agriculture and Rural Development. **3**: 93 pp.	Observational study
International Union for Conservation of Nature and Natural Resources, Gland (Switzerland) Species Survival Commission. 2000. Biology and conservation of freshwater cetaceans in Asia. Occasional Paper, IUCN Species Survival Commission. **23**: 160 pp.	Outside target species
International Union for Conservation of Nature and Natural Resources, Nairobi (Kenya) Regional Office for Eastern Africa. 1998. Report of the western Indian Ocean Turtle Excluder Device training workshop. IUCN EARO, Nairobi (Kenya). 35 pp.	Overview of training workshop, outside target species
Jain AK. 1998. Fisheries resource management in Rajasthan: An overview of present status and future scope. *Fishing Chimes*. **17** (11): 9-14.	Overview
Jain KK, Srivastava PP, Sinha A. 1996. Water hyacinth: A potential source for fish feed and its impact on feed economics. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pant Nagar, Uttar Pradesh. p 13-17.	No statistical analysis
Jamu Dm, Piedrahita RH. 2002. An organic matter and nitrogen dynamics model for the ecological analysis of integrated aquaculture/agriculture systems: I. Model development and calibration. *Environmental Modelling and Software*. **17** (6): 571-582.	Observational stuy
Jana BB, Jana S. 2003. The potential and sustainability of aquaculture in India. *Journal of Applied Aquaculture.* **13** (3-4): 283-316.	Review
Jana BB, Bandopadhyay B, Jana S. 2000. Influence of some environmental factors on the growth of tiger shrimp *Penaeus monodon* (Fabricus) during summer and monsoon crops in six brackishwater ponds of West Bengal,	Obtained after time limit

India. *Journal of Aquaculture in the Tropics.* **15** (3): 229-241.	
Jana PK, Dutta D, Bandyopadhyay P, Maity D. 2000. Performance of Paira grasspea (*Lathyrus sativus* L.) as influenced by residual effect of treatments applied to dual culture (rice + prawn). *Indian Agriculturist.* **44** (1-2): 83-85.	Not related to aquatic animal health
Janakiram K. 2003. Freshwater pearl culture technology development in India. *Journal of Applied Aquaculture.* **13** (3-4): 341-349.	Outside target species
Janakiram P, Jayasree L, Madhavi R. 2000. Bacterial abundance in modified extensive and semi-intensive shrimp culture ponds of *Penaeus monodon*. *Indian Journal of Marine Sciences.* **29** (4): 319-323.	Observational study
Jankowski T. 2001. The freshwater medusae of the world - a taxonomic and systematic literature study with some remarks on other inland water jellyfish. *Hydrobiologia.* **462**: 91-113.	Review
Jantrarotai W. 1995. The estimation of the economic protein requirement of hybrid Clarias catfish. *Kasetsart Journal, Natural Sciences.* **29** (1): 38-44.	Obtained after time limit
Jasmine GI, Pillai SP, Athithan S. 1993. Effect of feed stimulants on the biochemical composition and growth of Indian white prawn *Penaeus indicus*. From Discovery to Commercialisation, European Aquaculture Society, Oostende (Belgium), 1993, Special Publication. **19**: 139.	Obtained after time limit
Jawad LA, Smith PJ. 2002. Phosphoglucomutase genotypes and spawning time in two species of anchovy, Thryssa hamiltoni and T. mystex, from the northwest Arabian Gulf. *Fisheries Research.* **59** (1-2): 273-277.	Outside target countries
Jayaprakas V, Lal TSB. 1996. Factors affecting the motility and short-term storage of spermatozoa of the Indian major carps, *Labeo rohita* and *Cirrhinus mrigala*. *Journal of Aquaculture in the Tropics.* **11** (1): 67-78.	Outcome measures not related to aquatic animal health
Jayaraman R. 1997. Carp culture in Thanjavar District, Tamil Nadu, India: An economic analysis. *Asian Fisheries Science.* **9** (4): 275-288.	Observational study
Jayasree L, Janakiram P, Madhavi R. 2001. Aspergillus sp. isolated from Penaeus monodon with red disease from culture ponds of Andhra Pradesh. *Journal of Aquaculture in the Tropics.* **16** (1): 37-43.	Observational study
Jefferson TA. 2000. Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters. *Wildlife Monographs.* **144**: 1-65.	Outside target countries; outside target species
Jeney Z, Hao NV, Trong QT, Nguyen Thi Mui, Pham Thi Bich Hong, Thanh NM, MacRae IH. 2002. Preliminary results of the fish health survey in rural aquaculture of Tien Giang Province, Vietnam. FAO Fisheries Technical Paper. **406**: 323-332.	Observational study
Jensen JG. 2001. Managing fish, flood plains and food security in the Lower Mekong Basin. *Water Science and Technology.* **43** (9): 157-164.	Overview
John KR, George MR, Richards RH, Frerichs GN. 2001. Characteristics of a new reovirus isolated from epizootic ulcerative syndrome infected snakehead fish. *Diseases of Aquatic Organisms.* **46** (2): 83-92.	Observational study
Johnson MC, Maxwell JM, Loh PC, Leong JAC. 1999. Molecular characteization of the glycoproteins from two warm water rhabdoviruses: snakehead rhabdovirus (SHRV) and rhabdovirus of penaeid shrimp (RPS)/spring	Observational study

viremia of carp virus (SVCV). *Virus Research.* **64** (2): 95-106.	
Johnston D, Trong NV, Tien DV, Xuan TT. 2000. Shrimp yields and harvest characteristics of mived shrimp-mangrove forestry farms in southern Vietnam: factors affecting production. *Aquaculture.* **188** (3-4): 263-284.	Observational study
Johnston D, Lourey M, Van Tien D, Luu TT, Xuan TT. 2002. Water quality and plankton densities in mixed shrimp-mangrove forestry farming systems in Vietnam. *Aquaculture Research.* **33** (10): 785-798.	Observational study
Jory D, Cabrera T, Dugger D, Fegan D, Berger C, Orrantia J, Wainberg A, Perez H, Castaoeda J, McIntosh R, Moya M, Jackson C, Vargas W, Evans L. 2001. A global review of shrimp feed management: Status and perspectives. Aquaculture 2001: Book of Abstracts. p 318.	Abstract only; review
Joseph KO, Gupta BP, Alavandi SV, Mishra SS, Sivakumar G. 1996. Impact of shrimp farming on the environment - A case study. Proceedings of the National Workshop on Transfer of Technology for Sustainable Shrimp Farming, held at Madras, India, 9-10 January, 1995. p 127-134.	Observational study
Kainongsuang S. 2000. Effects of rock salt concentrations on growth, survival rates and reproduction of red tilapia (Tilapia nilotica Linn.). Abstracts of Master of Science Theses (fisheries Science), 1985-1990, Faculty of Fisheries, Kasetsart University, Bangkok (Thailand). p 3-4.	Obtained after time limit
Kaiser H, Britz P, Endemann F, Haschick R, Jones CLW, Koranteng B, Kruger DP, Lockyear JF, Oellermann LK, Olivier AP, Rouhani Q, Hecht T. 1997. Development of technology for ornamental fish aquaculture in South Africa. *South African Journal of Science.* **93** (8): 351-354.	Outside target countries
Kanaujia DR. 1998. Emerging technologies in the seed production of *Macrobrachium malcolmsonii* (H.M. Edwards). Current and emerging trends in aquaculture: Proceedings of the national seminar, 14-16 February, 1995. p 148-159. Thomas PC (Eds).	Observational study
Kanchanaphum P, Wongteerasupaya C, Sitidilokratana N, Boonsaeng V, Panyim S, Tassanakajon A, Withyachumnarnkul B, Flegel TW. 1998. Experimental transmission of white spot syndrome virus (WSSV) from crabs to shrimp *Penaeus monodon*. *Diseases of Aquatic Organisms.* **34** (1): 1-7.	Observational study
Kannan K, Tanabe S, Iwata H, Tatsukawa R. 1995. Butylins in muscle and liver of fish collected from certain Asian and Oceanian countries. *Environmental Pollution.* **90** (3): 279-290.	Observational study
Karunasagar I, Karunasagar I. 1999. Diagnosis, treatment and prevention of microbial diseases of fish and shellfish. *Current Science.* **76** (3): 387-399.	Review
Kasornchandra J, Khongpradit R, Ekpanithanpong U, Boonyaratpalin S. 1999. Progress in the development of shrimp cell cultures in Thailand. *Methods in Cell Science.* **21** (4): 231-235.	Overview
Kathiresan K. 2000. A review of studies on Pichavaram mangrove, southeast India. *Hydrobiologia.* **430** (1-3): 185-205.	Review
Katiha PK. 1999. Marketing and distribution of fish seed towards development of inland fisheries in India. *Agricultural Economics Research Review.* **12** (1): 15-24.	\not related to aquatic animal health
Katz T, Herut B, Genin A, Angel DL. 2002. Gray mullets ameliorate organically enriched sediments below a fish farm in the oligotrophic Gulf of Aqaba (Red Sea). *Marine Ecology Progress Series.* **234**: 205-214.	Outcome measures not related to aquatic animal health

Kaur MDAK. 1998. Relative efficacy of dietary administration of 3,5,3'-triiodothyronine (T3) to different stages of an Indian major carp, *Cirrhinus mrigala* (Hamilton): growth and economics. *Environment and Ecology*. **29** (11): 835-841.	Obtained after time limit
Kaushal DK, Kumar S, Gopalakrishnayya CH. 2000. Limno-chemical parameters vis-a-vis productivity in Pong reservoir, Himachal Pradesh. *Indian Journal of Animal Sciences*. **70** (10): 1094-1098.	Observational study
Kautsky N, Ronnback P, Tedengren M, Troell M. 2000. Ecosystem perspectives on management of disease in shrimp pond farming. *Aquaculture*. **191** (1-3): 145-161.	Review
Keenan CP. 2000. Should we allow human-induced migration of the Indo-West Pacific fish, barramundi Lates calcarifer (Bloch) within Australia? *Aquaculture Research*. **31** (1): 121-131.	Outside target countries
Kelly K. 1999. The use of chemicals in the live fish export industry. *Queensland Fisherman*. **17** (3): 22.	Review
Keshavanath P, Gangadhar B, Ramesh TJ, Beveridge MCM, Baird DJ, Verdegem MCJ, van Dam A. 2001. Performance of Torr khudree in fed and non-fed tanks with different densities of bamboo substrate. Aquaculture 2001: Book of abstracts. p. 327.	Abstract only
Kestemont P. 1995. Different systems of carp production and their impacts on the environment. *Aquaculture*. **129** (1-4): 347-372.	Review
Khajuria CK, Prasad GVR. 1998. Taphonomy of a Late Cretaceous mammal-bearing microvertebrate assemblage from the Deccan inter-trappean beds of Naskal peninsular, India. *Palaeogeography Palaeoclimatology Palaeoecology*. **137** (1-2): 153-172.	Not related to aquatic animal health
Kim JH, Hayward CJ, Heo GJ. 2002. Nematode worm infections (Camallanus cotti, Camallanidae) in guppies (Poecilia reticulate) imported to Korea. *Aquaculture*. **205** (3-4): 231-235.	Outside target countries
Kim JH, Hayward CJ, Joh SJ, Heo GJ. 2002. Parasitic infections in live freshwater tropical fishes imported to Korea. *Diseases of Aquatic Organisms*. **52** (2): 169-173.	Outside target countries
Kino H, Inaba H, Nguyen VD, Le Van C, Dang TS, Hoan TH, Nguyen DT, Le Dinh C, Sano M. 1998. Epidemiology of clonorchiasis in Ninh Binh Province, Vietnam. *Southeast Asian Journal of Tropical Medicine and Public Health*. **29** (2): 250-254.	Not related to aquatic animal health
Klemetsen A, Amundsen PA, Dempson JB, Jonsson B, Jonsson N, O'Connell MF, Mortensen E. 2003. Atlantic salmon Salmo salar L., brown trout Salmo trutta L. and Arctic charr Salvelinus alpinus (L.): a review of aspects of their life histories. *Ecology of Freshwater Fish*. **12** (1): 1-59.	Outside target countries; review
Kole RK, Banerjee H, Bhattacharyya A. 2001. Monitoring of market fish samples for endosulfan and hexachlorocyclohexane residues in and around Calcutta. *Bulletin of Environmental Contamination and Toxicology*. **67** (4): 554-559.	Observational study
Konar D, Ghosh SH, Kundu AL, Bairagya CN, Datta SK. 1996. Studies on paddy-cum-fish culture under different land situations. *Journal of the Indian Fisheries Association*. **26**: 85-91.	Obained after time limit
Kongkeo H. 1997. Comparison of intensive shrimp farming systems in Indonesia, Philippines and Taiwan and Thailand. *Aquaculture Research*. **28** (10): 789-796.	Observational study

Koopmanschap E, Vullings W, van Mensvoort MEF, Le QT, Tromp M. 1999. Remote sensing as a tool for identification of aquacultural systems and mangrove species in the coastal part of the Mekong Delta, Vietnam. Proceedings of an International Workshop on the Rehabilitation of Degraded Coastal Systems, 19-24 January, 1998, Special publication, Phuket Marine Biological Centre (Thailand). **20**: 49-59.	Overview
Kornilova GN, Tsarin SA. 1993. New data on the distribution and ecology of Diaphus coeruleus (Myctophidae). *Voprosy Ikhtiologii*. **33** (4): 573-575.	Outside target countries
Krishnan, L. 1998. Status of seed production and culture of brackish water fin fishes in India. Technological Advancements in Fisheries. Proceedings of the national Symposium on Technological Advancements in Fisheries and its Impact on Rural Development held at Cochin by the School of Industrial Fisheries, Cochin University of Science and Technology during December 5th to 7th, 1995. p 29-36.	Review
Kulshreshtha SD. 1996. Prospects of integrating aquaculture with other farming systems for rural development in Rajasthan, India. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pant Nagar, Uttar Pradesh. p 235-237.	Overview
Kumar P, Lakra WS. 1996. Somatic chromosomes of the black tiger prawn, Penaeus monodon (Penaeidae: Crustacea). *Bulletin of Marine Science*. **5** (3): 556-559.	Observational study
Kumar A, Pandey CK, Kumar N. 1999. Induced breeding of silver carp, Hypophthalmichthys molitrix Val. at 1676m altitude in Central Himalayas. *Journal of Applied Zoological Researches*. **10** (2): 165-166.	No control group
Kumar JSS, Nagarathinam N, Sundaraj V. 2000. Production characteristics of *MAcrobrachium rosenbergii* and *M. malcolmsonii* under controlled monoculture system. *Journal of Aquaculture in the Tropics*. **15** (3): 207-217.	Observational study
Kumar P, Sharma B, Sinha RK, Mishra AP. 2002. Efficacy of endosulfan on mortality of a freshwater air-breathing catifhs, Heteropneustes fossilis (Bloch) during different developmental stages. *Uttar Pradesh Journal of Zoology*. **22** (2): 179-184.	Obtained after time limit
Kumar KS, Kannan K, Paramasivan ON, Sundaram VPS, Nakanishi J, Masunaga S. 2001. Polychlorinated dibenzo-p-dioxins, dibenzofurans, and polychlorinated biphenyls in human tissues, meat, fish and wildlife samples from India. *Environmental Science and Technology*. **35** (17): 3448-3455.	Not related to aquatic animal health
Kumaresan S, Sethuraman A, Subramanian A. 1999. Some aspects of soil and water quality management in a modified extensive shrimp farm with special reference to iron and copper. Water quality issues in aquaculture. Proceedings of the National Seminar on Water Quality Issues in Aquaculture Systems, December 18-19, 1996. p 37-41.	Observational study
Kumari A, Sinha RK, Gopal K. 2001. Organochlorine contamination in the fish of the river Ganges, India. *Aquatic Ecosystem Health and Managaement*. **4** (4): 505-510.	Observational study
Kumblad L, Olsson A, Koutny V, Berg H. 2001. Distribution of DDT residues in fish from the Songkhla Lake, Thailand. *Environmental Pollution*. **112** (2): 193-200.	Observational study
Kungsuwan A, Arakawa O, Promdet M, Onoue Y. 1997. Occurence of paralytic shellfish poisons in Thai freshwater puffers. *Toxicon*. **35** (8): 1341-1346.	Observational study

Kwei Lin C. 1995. Progression of intensive marine shrimp culture in Thailand. Swimming through troubled water. Proceedings of the special session on shrimp farming, San Diego, California, USA, 1-4 February, 1995. p 13-23.	Overview
Lahav E, Ra'anan Z. 1997. Salinity tolerance of genetically produced tilapia (Oreochromis) hybrids. *Israeli Journal of Aquaculture Bamidgeh*. **49** (3): 160-165.	Outside target countries
Lakra WS. 2002. Fish and shellfish genetics in India: An overview. *Aquaculture*. **204** (3-4): 224.	Review
Lakshmanan L. 1996. Sustainable technologies for industrial shrimp culture and industry's role in transfer of technology. Proceedings of the National Workshop on Transfer of Technology for Sustainable Shrimp Farming, held at Madras, India, 9-10 January, 1995. p 154-159.	Overview
Lala S, Roy AK. 1993. Application of pure oxygen in fish culture. *Seafood Export Journal*. **25** (2): 13-18.	Observational study
Langer RK, Somalingam J. 1996. Experimental culture of freshwater prawn in ponds at Powerkheda, Hoshangabad. The Third Indian Fisheries Forum Proceedings, 11-14 October 1993, Pant Nagar, U.P. p 65-66.	No control group
Larsson J, Folke C, Kautsky N. 1994. Ecological limitations and appropriation of ecosystem support by shrimp farming in Colombia. *Environmental Management*. **18** (5): 663-676.	Outside target countries
Laubier, A., Laubier, L. 1993. Marine crustacean farming: Present status and perspectives. *Aquatic Living Resources*. **6** (4): 319-329.	Review
Lawrence, A L., More, W., Bray, W A., Royo, M. 2001. Successful intensive culture of Litopenaeus vannamei on a white spot syndrome virus-contaminated farm in Panama. Aquaculture 2001: Book of Abstracts. p 753.	Outside target countries; abstract only
Lazard J, Cacot P. 1997. Aquaculture systems in Vietnam: An overview, challenges and prospects for research. *Cahiers Agricultures*. **6** (5): 127-136.	Review
Le Corre M. 2001. Breeding seasons of seabirds at Europa Isalnd (southern Mozambique Channel) in relation to seasonal changes in the marine environment. *Journal of Zoology*. **254** (2): 239-249.	Not related to aquatic animal health
Lebel L, Tri NH, Saengnoree A, Pasong S, Buatama U, Thoa LK. 2002. Industrial transformation and shrimp aquaculture in Thailand and Vietnam: Pathways to ecological, social, and economic sustainability? *Ambio*. **31** (4): 311-323.	Not related to aquatic animal health
Lee CE. 1999. Rapid and repeated invasions of fresh water by the copepod Eurytemora affinis. *Evolution*. **53** (5): 1423-1434.	Not related to aquatic animal health
Lee SY. 1993. The management of traditional tidal ponds for aquaculture and wildlife conservation in southeast-Asia - Problems and prospects. *Biological Conservation*. **63** (2): 113-118.	Outside target countries
Lee C-S, O'Bryen P. 2001. Review on current finfish hatchery production technology. Aquaculture 2001: Book of Abstracts. p 359.	Abstract only; review
Lehane L, Lewis RJ. 2000. Ciguatera: recent advances but the risk remains. *International Journal of Food Microbiology*. **61** (2-3): 91-125.	Not related to aquatic animal health; overveiw
Leung P, Tran LT, Fast AW. 2000. A logistic regression of risk factors for disease occurence on Asian shrimp farms. *Diseases of Aquatic Organisms*. **41** (1): 65-76.	Observational study

Levsen A, Jakobsen PJ. 2002. Selection pressure towards monoxeny in Camallanus cotti (Nematoda, Camallanidae) facing an intermediate host bottleneck situation. *Parasitology*. **124**: 625-629.	Not related to aquatic animal health
Lewis RJ. 2001. The changing face of ciguatera. *Toxicon*. **39** (1): 97-106.	Not related to aquatic animal health
Liao IC. Achievements and prospects of fisheries research in Taiwan. Aquaculture and Fisheries Resource Management conference proceedings, Taiwan Fisheries Research Institute. **4**: 15-32.	Outside target countries; review
Lien LV, Thien N, Ly LV. 1996. Byproducts from food industries: Processing and utilisation for animal feed in Vietnam. Exploring approaches to research in the animal sciences in Vietnam: A workshop held in Hue, Vietnam, 31 July - 3 August, 1995. p 149-152. Pryor WJ (Eds).	Not related to aquatic animal health
Lightner DV, Redman RM. 1998. Strategies for the control of viral diseases of shrimp in the Americas. *Fish Pathology*. **33** (4): 165-180.	Outside target countries
Lin CK, Kaewpaitoon K. 2000. An overview of freshwater cage culture in Thailand. Cage culture inAsia: Proceedings of the First International Symposium on Cage Culture in Asia. p 253-257.	Overview
Lin CK, Ruamthaveesub P, Wanuchsoontorn P. 1993. Integrated culture of the green mussel (Perna viridis) in wastewater from an intensive shrimp pond: Concept and practice. *World Aquaculture*. **24** (2): 68-73.	Outside target species
Lipton AP. 1993. Cryptocaryon-irritans (protozoa, ciliata) infection among aquarium-held marine ornamental fish and its control. *Current Science*. **65** (7): 571-572.	Obtained after time limit
Lipton AP. 1994. Disease challenges and their management in intensive fish farming. *Seafood Export Journal, Cochin*. **25** (16): 11-22.	Review
Lirdwitayaprasit T, Vicharangsan T, Sawetwong N. 1994. Occurences of red tide phenomena in the inner Gulf of Thailand during 1991-1993. NRCT-JSPS Joint seminar on marine science, Chulalongkorn University, Bangkok (Thailand). p 106-110.	Not related to aquatic animal health; observational study
Little DC, Edwards P. Alternative strategies for livestock-fish integration with emphasis on Asia. *Ambio*. **28** (2): 118-124.	Overview
Little DC, Surintaraseree P, Innes Taylor N. 1996. Fish culture in rainfed rice fields of northeast Thailand. *Aquaculture*. **140** (4): 295-321.	Observational study
Lo CF, Kou GH. 2001. Molecular characteristics of shrimp white spot syndrome virus. 6th Asian Fisheries Forum Book of Abstracts. p 157.	Abstract only; review
Lo CF, Hsu HC, Tsai MF, Ho CH, Peng SE, Kou GH, Lightner DV. 1999. Specific genomic DNA fragment analysis of different geographical clinical samples of shrimp white spot syndrome virus. *Diseases of Aquatic Organisms*. **35** (3): 175-185.	Observational study
Loc NT, Ogle B, Preston TR. 1997. Village pig production in CEntral Vietnam: results of a participatory rural appraisal survey and on-farm feeding trials with protein supplementation of traditional diets. Integrated farming in human development. Proceedings of a workshop Tune, LAndboskole, Denmark, 25-29 March, 1996. p 120-134. Dloberg F, Petersen PH (Eds).	Not related to aquatic animal health
Lorenzen K. 1995. Population dynamics and management of culture-based fisheries. *Fisheries Management and*	No intervention

Ecology. **2** (1): 61-73.	
Lourdes M, Cuvinaralar A. 1994. Survival and heavy-metal accumulation of 2 Oreochromis-niloticus (L) strains exposed to mixtures of zinc, cadmium and mercury. *Science of the Total Environment.* **148** (1): 31-38.	Outside target countries
Lu X. Aquaculture in China and its effect on global markets. Global trends: Fisheries management. American Fisheries Society Symposium. **20:** 185-194.	Outside target countries; overview
Lucien-Brun, H. 1997. Evolution of world shrimp production: Fisheries and aquaculture. *World Aquaculture.* **28** (4): 21-33.	Review
Lutz CG. 2000. Genetics and breeding: Transgenic Fish: Recent reports. *Aquaculture Magazine*. **26** (1): 69-71.	Review
Luu LT, Trang PV, Cuong NX, Demaine H, Edwards P, Pant J. 2002. Promotion of small-scale pond aquaculture in the Red River delta, Vietnam. *Rural Aquaculture.* p 55-75. Edwards P. Little DC, Demaine H (Eds).	Overview
Macpherson CNL, Gottstein B, Geerts S. 2000. Parasitic food-borne and water-borne zoonoses. *Revue Scientifique et Technique de l'Office International des Epizooties*. **19** (1): 240-258.	Not related to aquatic animal health
Madhavi R, Jhansilakshmibai K, Murugesh M. 1996. Parasite fauna of fingerlings of Channa spp. used for treatment of asthma patients. *Current Science.* **70** (5): 350-351.	Not related to aquatic animal health
Madhu K, Madhu R. 1999. Economics of three different shrimp culture practices and influence of seed and feed on production. *Flora and Fauna (Jhansi).* **5** (2): 68.	Outcome measures not related to aquatic animal health
Madhu R, Madhu K. 1997. Effect of hydrological parameters on the production of lab-lab in the aquaculture ponds at Cochin. *Flora and Fauna (Jhansi).* **3** (1): 12-18.	Obtained after time limit
Maeda M, Kasornchandra J, Itami T, Suzuki N, Hennig O, Kondo M, Albaladejo JD, Takahashi Y. 1998. Effect of various treatments on white spot syndrome virus (WSSV) from Penaeus japonicus (Japan) and P-monodon (Thailand). *Fish Pathology*. **33** (4): 381-387.	Outside target countries
Magnussen OM. 2000. Post-harvest technology of farmed fish. Cage aquaculture in Asia: Proceedings of the First International Symposium on Cage Aquaculture in Asia. p 281-287.	Outside target countries; overview
Mahanta PC, Kapoor D. 1994. Endangered, vulnerable and rare carp species of Ganga River system. Threatened fishes of India. Proceedings of the National Seminar on Endangered Fishes of India, held at National Bureau of Fish Genetic Resources, Allahabad, 25-26 April, 1992, Nature Conservators, Muzaffarnagar (India). p 21-24.	Overview
Mahapatra BK, Datta NC. 1999. Food preference and growth performance of the exotic catfish Clarias gariepinus (Burchell). *Environmenet and Ecology*. **17** (1): 207-210.	No statistical analysis
Mahmud Y, Halder GC, Mazid MA. 1993. Pond culture of giant freshwater prawn with different supplemental feeds. *Bangladesh Journal of Zoology*. **21** (1): 133-142.	Outside target countries
Main KL, Fulks W. 1993. Current issues in diseases of cultured penaeid shrimp: Results of an Asia/United States workshop. From discovery to commercialisation, European Aquaculture Society, Oostende (Belgium), Special publication. **19**: 146.	Overview

Maitland PS. 1995. World status and conservation of the Arctic charr Salvelinus alpinus (L.). Proceedings of the Third International Charr Symposium, June 13-18, 1994, Trondheim, Norway. p 113-127.	Overview
Maity SG, Das SK, Mukherjee S, Santosh V, Shankar SK. 1997. Creutzfeldt-Jakob diseases: Report of a case from West Bengal. *Journal of the Indian Medical Association.* **95** (10): 564-565.	Not related to aquatic animal health
Majumdar KC, Ravinder K, Nasaruddin K. 1997. DNA fingerprinting in Indian major carps and tilapia by Bkm 2(8) and M13 probes. *Aquaculture Research.* **28** (2): 129-138.	Observational study
Mal BC. 1996. Performance of Hawaii-type automated fish feed dispenser. *Aquacultural Engineering.* **15** (2): 81-90.	Not related to aquatic animal health
Malloy KD, Targett TE. 1994. The use of RNA:DNA ratios to predict growth limitation of juvenile summer flounder (Paralichthys dentatus) from Delaware and North Carolina estuaries. *Marine Biology.* **118** (3): 367-375.	Outside target countries
Manfrin A, Friso S, Perin R, Porcellato E, Qualtieri K, Bovo G. 1999. Non O1 Vibrio cholerae in aquarium water of fishes imported from extra E.U. countries. *Bollettino Societa Italiana di Patologia Ittica.* **11** (26): 25-32.	Observational study
Marsden JE, Chotkowski MA. 2001. Lake trout spawning on srtificial reefs and the effect of zebra mussels: Fatal attraction? *Journal of Great Lakes Research.* **27** (1): 33-43.	Outside target countries
Marsden JE. 1994. Spawning by stocked lake trout on shallow, near-shore reefs in southwestern Lake Michigan. *Journal of Great Lakes Research.* **20** (2): 377-384.	Outside target countries
Marte CL. 2001. Marine fish breeding and larviculture research at the Aquaculture Department, Southeast Asian Fisheries Development. 6th Asian Fisheries Forum Book of Abstracts. p 167.	Abstract only
Masae A, Bussabong. 2001. Institutional and legal aspects of fisheries and resource management and implications at local level in Thailand. 6th Asian Fisheries Forum Book of Abstracts. p 168-169.	Not related to aquatic animal health; abstract only
Masood, E. 1997. Aquaculture: A solution, or source of new problems? *Nature.* **386** (6621): 109.	Overview
Mathews SS, Menon NG. 1993. Ecological characteristics of prawn culture fields in the Cochin area. Mariculture Research under the Postgradute Programme in Mariculture, Part 5, CMFRI, Cochin (India), 1993, CMFRI Special publication. **56**: 149-152.	Observational study
Mathur N, Srivastav AK. 1999. Influence of temperature in fresh water fish Heteropneustes fossilis (b.) in relation to tapeworm infestation. *Flora and Fauna (Jhansi).* **5** (1): 23-24.	Obtained after time limit
McClanahan T, Mangi S. 2001. Coral and algal response to the 1998 El Nino coral bleaching and mortality on Kenya's southern reef lagoons. Coral reef degradation in the Indian Ocean: Status reports and project presentations, 2000. p 160-165.	Outside target countries; observational study
McClanahan TR, Muthiga NA, Mangi S. 2001. Coral and algal changes after the 1998 coral bleaching: interaction with reef management and herbivores on Kenyan reefs. *Coral Reefs.* **19** (4): 380-391.	Not related to aquatic animal health
McDermott JJ. 2001. Status of the Nemertea as prey in marine ecosystems. *Hydrobiologia*. **456**: 7-20.	Not related to aquatic animal health; outside target species
McIntosh D, Fitzsimmons K. 2003. Characterization of effluent from an inland, low-salinity shrimp farm: what contribution could this water make if used for irrigation. *Aquacultural Engineering.* **27** (2): 147-156.	Observational study

McIvor CC, Ley JA, Bjork RD. 1994. Changes in freshwater inflow from the Everglades to Floride Bay including effects on biota and biotic processes: A review. Everglades. The Ecosystem and its Restoration. St. Lucie Press, Boca Raton, Florida, USA. P. 117-146.	Outside target countries; not related to aquatic animal health
McKinnon AD, Trott LA, Alongi DM, Davidson A. 2002. Water column production and nutrient characteristics in mangrove creeks receiving shrimp farm effluent. *Aquaculture Research.* **33** (1): 55-73.	Ouside target countries
Meksumpun C, Meksumpun S. 1999. Polychaete-sediment relations in Rayong, Thailand. *Environmental Pollution.* **10** (3): 447-456.	Observational study
Men BX, Ogle B, Lindberg JE. 2001. Effect of choice feeding on the nutrient intake and performance of broiler ducks. *Asian-Australasian Journal of Animal Sciences.* **14** (12): 1728-1733.	Outside target species
Menasveta P. 2001. Development of shrimp culture systems for disease prevention and environmental sustainability. 6th Asian Fisheries Forum Book of Abstracts. p 172.	Abstract only
Menasveta P. 2002. Improved shrimp growout systems for disease prevention and environmental sustainability in Asia. *Reviews in Fisheries Science.* **10** (3-4): 391-402.	Review
Menon NN, Balchand AN, Menon NR. 2000. Hydrobiology of the Cochin backwater system - a review. *Hydrobiologia.* **430** (1-3): 149-183.	Review
Merican ZO. 1998. Recent trends in aquaculture feed manufacturing in the Asian region. Aquaculture '98: Book of Abstracts. p 364.	Abstract only; review
Metcalfe-Smith JL, Staton SK, West EL. 2000. Status of the wavy-rayed Lampmussel, Lampsilis fasciola (Bivalvia : Unionidae), in Ontario and Canada. *Canadian Field-Naturalist.* **114** (3): 457-470.	Outside target countries; outside target species
Michel A. 2001. From shrimp to fish. 6th Asian Fisheries Book of Abstracts. p 174.	Abstract only
Miles DJC, Kanchanakhan S, Lilley JH, Thompson KD, Chinabut S, Adams A. 2001. Effect of macrophages and serum of fish susceptible or resistant to epizootic ulcerative syndrome (EUS) on the EUS pathogen, Aphanomyces invadans. *Fish and Shellfish Immunology.* **11** (7): 569-584.	Outside target countries
Miller PJ, Flaherty M, Szuster B. 1999. Inland shrimp farming in Thailand. *Aquaculture Asia.* **4** (1): 27-32.	Overview
Milstein A, Wahab MA, Rahman MM. 2002. Environmental effects of common carp *Cyprinus carpio* (L.) and mrigal *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polycultures. *Aquaculture Research.* **33** (14): 1103-1117.	Outside target countries
Mims SD. 2001. Aquaculture of paddlefish in the United States. *Aquatic Living Resources.* **14** (6): 391-398.	Outside target countries; review
Mims SD. 2001. Paddlefish culture in the United States. Aquacultrue 2001: Book of Abstracts. p 438.	Outside target countries; abstract only
Minh LT, Huong DT, Tuan NA. 1996. Women in Cantho City are profitably involved in fish nursing activities. *Aquaculture Asia.* **1** (2): 40-41.	Observational study
Minton JW, Walsh LS, Lee PG, Forsythe JW. 2001. First multi-generation culture of the tropical cuttlefish Sepia pharaonis Ehrenberg, 1831. *Aquaculture International.* **9** (5): 379-392.	Observational study
Mishra SA, Pradhan P, Dutta NC, Chakraborty SK. 2001. Studies on the performance of 'Ovatide' - On breeding of Indian major carps. *Journal of the Indian Fisheries Association.* **28**: 125-129.	No control group; no statistical analysis

Ministry of Fisheries (Vietnam), Research Institute for Aquaculture No. 1; South Australian Research and Development Institute, Henley Beach (Australia). 2001. Technological and socio-economic evaluation of integrated aquaculture systems in the highland ranges of Vinh Phuc Province, north Vietnam. Ministry of Fisheries, Dinh Bang, Bac Ninh (North Vietnam). 46 pp.	Observational study
Mitra A, Patra KC. 2001. Semi-intensive culture of *Penaeus monodon* fabricus under mono- and polyculture systems. Aquaculture 2001: Book of abstracts. p. 444.	Abstract only
Mohan CV. 1996. Health management strategy for a rapidly developing shrimp industry: An Indian perspective. Health Management in Asian Aquaculture. Proceedings of the Regional Expert Consultation on Aquaculture Health Management in Asia and the Pacific. Serdang, Malaysia, 22-24 May 1995., FAO, Rome (Italy). FAO fisheries technical paper. no. 360. p 75-87.	Review
Mohan CV, Cordin F, Thakur PC, Padiyar PA, Madhusudan M, Turnbull JF, Hao NV, Morgan KL. 2002. Usefulness of dead shrimp specimens in studying the epidemiology of white spot syndrome virus (WSSV) and chronic bacterial infection. *Diseases of Aquatic Organisms.* **50** (1): 1-8.	Observational study
Mohanta KN. 2000. Development of giant freshwater prawn broodstock. *Naga*. **23** (3): 18-20.	Observational study
Mohanty SK, Mohanty RK. 2001. Studies on the management of biopond system in a semi-intensive shrimp farm. *Perspectives in Mariculture*. p 77-84.	Obtained after time limit
Mohanty RK, Patnaik PN. 2001. Brackishwater shrimp monoculture: a low input-based ecofriendly approach. *Perspectives in mariculture*. p 67-76.	Observational study
Mondal SK, De AB. 2002. A fatal oomycotic disease of the fresh water fish Aplocheilus panchax in India caused by Aphanomyces laevis. *Mycopathologia.* **154** (1): 21-24.	Observational study
Moravec F, Wolter J, Korting W. 1999. Some nematodes and acanthocephalans from exotic ornamental freshwater fishes imported into Germany. *Folia Parasitologica.* **46** (4): 296-310.	Outside target countries
Motongwa H. 1998. An economic overview of the Kenyan marine fisheries. African Fishes and Fisheries Diversity and Utilisation. p 145.	Outside target countries; overview
Marine Products Export Development Authority, Cochin (India). 1995. Shrimp aquaculture in India: Current problems and remedial measures. *Fishing Chimes.* **15** (9): 21-22.	Review
Mukherjee MD. 1996. Pisciculture and the environment: An economic evaluation of sewage-fed fisheries in East Calcutta. *Science, Technology and Development.* **14** (2): 73-99.	Not related to aquatic animal health; review
Mukherjee M. 1996. Antidote to combat white spot disease in culture ponds. *Fishing Chimes.* **16** (5): 30-31.	Overview
Mukhi SK, Chandroka V, Madhavi B, Nayak BB. 2001. Incidence of beta-haemolytic streptococcal infection associated with mass mortalities of cultured tilapia, Oreochromis mossambicus in brackish water ponds India. *Journal of Aquaculture in the Tropics.* **16** (4): 373-383.	Observational study
Mukhopadhyay MK. 1997. Present status of fish production in the beels of West Bengal with suggestion for fish yield optimisation. Fisheries enhancement of small reservoirs and floodplain lakes in India. Bulletin of the Central Inland Capture Fisheries Research Institute, Barrackpore (India). **75**: 193-197.	Overview

Mukhopadhyay PK, Rangacharyulu PV, Mitra G, Jana BB. 2003. Applied nutrition in freshwater prawn, *Macrobrachium rosenbergii*, culture. *Journal of Applied Aquaculture.* **13** (3-4): 317-340.	Review
Mukul. 1994. Aquaculture boom: who pays? *Economic and Political Weekly.* **29** (49): 3075-3078.	Not related to aquatic animal health
Mulla MS, Rodcharoen J, Ngamsuk W, Tawatsin A, Pan-Urai P, Thavara U. 1997. Field trials with Bacillus sphaericus formulations against polluted water mosquitoes in a suburban area of Bangkok, Thailand. *Journal of the American Mosquito Control Association.* **13** (4): 297-304.	Not related to aquatic animal health
Muniandy S, Sheela S. 1993. Studies on the effects of pesticides on food intake, growth and food conversion efficiencies of a fish Lepidocephalichthyes thermalis. *Comparative Physiology and Ecology.* **18** (3): 92-95.	Outside target countries
Murthy HS. 1998. Freshwater prawn culture in India. *INFOFISH International.* **5**: 30-36.	Review
Musick JA, Berkeley SA, Cailliet GM, Camhi M, Huntsman G, Nammack M, Warren ML Jr. 2000. Protection of marine fish stocks at risk of extinction. *Fisheries.* **25** (3): 6-8.	Outside target countries; overview
Muthukaruppan A, Sivakami S. 1993. Biochemical aspects of ovarian maturation in Liza parsia (Hamilton-Buchanan). Mariculture Research under the Postgraduate Programme in Mariculture, Part , CMFRI, Cochin (India), Special publication. **53**: 160-167.	Observational study
Myers-Kinzie ML. 1999. Factors affecting survival and recruitment of unionid mussels in small midwestern streams. Dissertation Abstracts International, Part B: Science and Engineering. **59** (12): 6181.	Outside target countries; abstract only
Nagarajan K, Kumar RS. 2002. Effect of sago effluent on selected physiological aspects of the fresh water fish *Labeo rohita. Journal of Ecotoxicology and Environmental Monitoring.* **12** (3): 233-238.	Obtained after time limit
Nagdali SS, Gupta PK. 2002. Impact of amss mortality of a mosquito fish, Gambusia affinis on the ecology of a fresh water eutrophic lake (Lake Maini Tal, India). *Hydrobiologia*. **468** (1-3): 45-52.	Observational study
Naik SD, Jalihal DR. 1998. Biological observations on the pufferfishes of south Konkan coast with special reference to the net-damaging species Lagocephalus spadiceus (Osteichthyes, Tetraodontidae). *Indian Journal of Marine Sciences.* **27** (3-4): 426-432.	Observational study
Nair CM. 1993. Freshwater prawn seed production technology developments. *Seafood Export Journal.* **25** (4): 33-37.	Overview
Nair KCC, Madhupratap M, Gopalahrishnan TC, Haridas P, Gauns M. 1999. The Arabian Sea: Physical environment, zooplankton and myctophid abundance. *Indian Journal of Marine Sciences.* **28** (2): 138-145.	Outside target countires; not related to aquatic animal health
Nandeesha MC, Bhadraswamy G, Patil JG, Varghese TJ, Sarma K, Keshavanath P. 1993. Preliminary results on induced spawning of pond-raised mahseer, Tor khudree. *Journal of Aquaculture in the Tropics.* **8** (1): 55-60.	No control group
Nandi NC, Das AK. 1995. Epizootiology of epistylis infestation in shrimp farms of West Bengal. *Seafood Export Journal.* **26** (11): 17-19.	Observational study
Narayana PL. 1998. State of aquaculture in India. *Aquaculture International.* **6** (2-3): 7-8.	Overview
Nerland K. 1997. Background on Thailand's soybean import policy. *Oilseeds: World Markets and Trade.* **5**: 10-14.	Not related to aquatic animal health
New MB. 1995. Status of freshwater prawn farming: A review. *Aquaculture Research.* **26**: 1-54.	Review

New, M B., Csavas, I. 1993. Aquafeeds in Asia - A regional overview. Farm-made aquafeeds. Proceedings of the regional expert consultation on farm-made aquafeeds, 14-18 December 1992, Bangkok, Thailand. FAO regional office for Asia and the Pacific, Bangkok (Thailand). p 1-23.	Overview
Nguyen CD, Ingrid O. 2002. Genetic studies of farmed tilapia in fresh and brackish water in Vietnam. *Aquaculture.* **204** (3-4): 199-200.	Overview
Nguyen SH, Bui AT, Le LT, Nguyen TTT, De Silva SS. 2001. The culture-based fisheries in small, farmer-managed reservoirs in two provinces of northern Vietnam: an evaluation based on three production cycles. *Aquaculture Research.* **32** (12): 975-990.	Observational study
Nhan NTH, Hon NV. 1999. Supplementing rice by-products with foliage of Trichanthera gigantea in diets of growing and lactating pigs and fattening ducks. *Livestock Research for Rural Development.* **11**: 3.	Not related to aquatic animal health
Ninawe AS. 1994. Freshwater prawn farming: Developments in India. *Indian Farming.* **44** (6): 13-16.	Overview
Ninawe AS. 1997. Growth hormone gene in transgenic fish production. *INFOFISH International.* **2**: 29-32.	Review
New South Wales Fisheries, Sydney (Australia). 2000. Replacing fishmeal in aquaculture diets. New South Wales Fisheries Final Report Series. **25**: 13 pp.	Overview
Obura DO. 2001. Kenya. *Marine Pollution Bulletin.* **42** (12): 1264-1278.	Outside target countries; not related to aquatic animal health
Ogle DH. 1998. A synopsis of the biology and life history of ruffle. *Journal of Great Lakes Research.* **24** (2): 170-185.	Not related to aquatic animal health
Ogrelius M, Larson A. 1993. Marketing of tuna in South India. Fisheries development series. National Swedish Board of Fisheries. Goteberg (Sweden). **69**: 59 pp.	Not related to aquatic animal health
Oh BS, Kim SY. 1995. Effect of feeds on the growth of the Korean mitten crab, Eriocheir japonicus (De Haan). Bulletin of National Fisheries Research and Development Agency (Korea). **50**: 147-155.	Outside target countries; ouside target species
Okemwa EN. 1998. Application of the large marine ecosystem concept to the Somali Current. Large marine ecosystems of the Indian Ocean: Assessment, sustainability and management. p 73-99.	Outside target countries; not related to aquatic animal health
Okemwa E. 1995. Application of the large marine ecosystem concept to the Somalia Current. Status and future of large marine ecosystems of the Indian ocean. A report of the International Symposium and Workshop. IUCN, Gland (Switzerland).	Outside target countries; not related to aquatic animal health
Okemwa EN. 1998. Issues relevant for management of large larine ecosystems, with special reference to the Western Indian Ocean. *African Fishes and Fisheries Diversity and Utilisation.* p 153-154.	Overview
Otta SK, Karunasagar I, Karunasagar I. 2003. Detection of monodon baculovirus and whitespot syndrome virus in apparently healthy Penaeus monodon postlarvae from India by polymerase chain reaction. *Aquaculture.* **220** (1-4): 59-67.	Observational study
Otta SK, Shubha G, Joseph B, Chakraborty A, Karunasagar I, Karunasagar I. 1999. Polymerase chain reaction (PCR) detection of white spot syndrome virus (WSSV) in cultured and wild crustaceans in India. *Diseases of Aquatic Organisms.* **38** (1): 67-70.	Observational study

Padmakumar KG, Krishnan A, Nair JR. 1993. Utilisation of duck droppings for fish production. A study on mixed farming of ducks and carps in wetlands of Kuttanad, Kerala. Proceedings of the National Seminar on Aquaculture Development in India - Problems and Prospects, 27-29 November, 1990, Kerala University, Thiruvanathapuram (India). p 67-72.	Obtained after time limit
Padmavathi P, Durga Prasad MK. 1997. Impact of unwanted fish on the water quality, plankton and fish production in a carp culture pond in the environs of Lake Kolleru. *Journal of Environmental Biology*. **18** (1): 79-93.	Observational study
Paez-Osuna F. 2001. The environmental impact of shrimp aquaculture: Causes, effects and mitigating alternatives. *Environmental Management.* **28** (1): 131-140.	Review
Palanisamy K, Ghosh SK. 1996. Intensive fish culture - The technology options and their comparative economics. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pant Nagar, Uttar Pradesh. p 213-215.	Overview
Palaniselvam V, Kathiresan K. 1998. Potential of a marine cyanobacterium Phormidium tenue (Menegh.) Gomont as a shrimp feed supplement. *Seaweed Research and Utilisation.* **20** (1-2): 75-78.	Obtained after time limit
Pan C, Chien Y. 2003. Concentration and composition of astaxanthin in black tiger prawn *Penaeus monodon* postlarvae fed Artemia sp. nauplii or mauxia shrimp Acetes intermedius. *Journal of the World Aquaculture Society*. **34** (1): 57-65.	Outside target countries
Pandey AC. 2000. Aquatic pollution and fish reproduction: a bibliographical review. *Indian Journal of Fisheries*. **47** (3): 231-236.	Review
Pandey AC, Kumar R, Sharma MK. 2000. Prospects of exotic catfish (Clarias gariepinus Burchell, 1822) farming and interrelationship between body weight and various abiotic factors in a farmer's pond, Uttar Pradesh (India). *Journal of Environmental Biology*. **21** (4): 325-328.	Observational study
Pandian TJ, Kirankumar S. 2003. Recent advances in hormonal induction of sex-reversal in fish. *Journal of Applied Aquaculture*. **13** (3-4): 205-230.	Review
Panigrahi AK, Chakrabarti A. 2000. Common diseases among cultured fishes in West Bengal and their control. *Journal of Interacademicia*. **4** (1): 145-156.	Overview
Panigrahi AK, Chand BK. 1999. Impact of bottom grazing fishes in enhancing the yield of fish in pig-fish integration system. *Indian Journal of Animal Health*. **38** (2): 165-169.	Obtained after time limit
Paria T, Konar SK. 1999. Present status of the impounded waters of district Birbhum (West Bengal) for sustainable fish production. *Environment and Ecology*. **17** (4): 931-935.	Observational study
Paria T, Konar SK. 1999. Management of fish ponds and its relation to fish diseases in West Bengal, India. *Environment and Ecology*. **17** (4): 962-970.	Observational study
Paria T, Konar SK. 1999. Management of pond resources for fish production in Bankura district, Wst Bengal. *Environment and Ecology*. **17** (2): 306-309.	Observational study
Paria T, Konar SK. 2000. Impact of environmental degradation on fish production in the impounded water of	Observational study

Purulia district, West Bengal. *Environment and Ecology*. **18** (3): 566-572.	
Paria T, Konar SK. 2000. Environmental impact on pond ecosystem in Jalpaiguri district, West Bengal. *Environment and Ecology*. **18** (3): 624-629.	Observational study
Pascoe S, Wattage P, Naik D. 2002. Optimal harvesting strategies: practice versus theory. *Aquaculture Economics and Management*. **6** (5-6): 295-308.	No intervention
Pathak SC. 2000. Status of cage aquaculture in India. Cage Culture in Asia: Proceedings of the First International Symposium on Cage Aquaculture in Asia. p 47-51.	Overview
Pathak AK, Sarkar UK. 2000. Aquatic resource zone mapping for North East wetlands. Fish biodiversity of North-East India. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **2**: 105-108.	Observatoinal study; overview
Patil R, Jeyasekaran G, Shanmugam SA. 2001. Occurence and activity of marine actinomycetes against shrimp bacterial pathogens. *Applictions in Fisheries and Aquaculture*. **1** (1): 79-81.	Observational study
Patterson WP. 1998. North American continental seasonality during the last millenium: high-resolution analysis of sagittal otoliths. *Palaeogeography Palaeoclimatology Paleoecology*. **138** (1-4): 271-303.	Outside target countries; not related to aquatic animal health
Paulraj R, Rajagopalan M, Vijayakumaran M, Vivekanandan E, Sathiadhas R. 1998. Environmental and social issues in coastal aquaculture: A case study. *Bay of Bengal news*. **2** (11): 15-18.	Observational study
Pauly D. 1994. A framework for latitudinal comparisons of flatfish recruitment. *Netherlands Journal of Sea Research*. **32** (2): 107-118.	Observational study
Pe T, Smith PT. 1999. In search of variables contributing to production of shrimp and identifying shrimp farming provinces in Thailand. ACIAR Technical Report Series. **47**: 69-83.	Observational study
Pearson MD, Hirono I, Aoki T, Miranda R, Inglis V. 2000. Virulence properties of motile aeromonads isolated from farmed frogs Rana tigerina and R. rugulosa. *Diseases of Aquatic Organisms*.**40** (3): 185-193.	Outside target species
Pearson MD, Chinabut S, Karnchanakharn S, Somsiri T. 1994. Jaundice disease in the farmed catfish hybrid, Clarias macrocephalus (Gunther) X C. gariepinus (Burchell), in Thailand. *Journal of Fish Diseases*. **17** (4): 325-336.	Observational study
Pechmanee T. 1993. Seabass (Lates calcarifer) farming in South East Asia and Australia. From discovery to commercialization. Special Publication, European Aquaculture Society, Oostende (Belgium). **19**: 295.	Overview
Pechmanee T. 1997. Status of marine larviculture in Thailand. *Hydrobiologia*. **358**: 41-43.	Overview
Petersen A, Dalsgaard A. 2001. Integrated fish-poultry farms select for antimicrobial resistant bacteria in the fish gut. 41st Annual Meeting of the Interscience Conference on Antimicrobial Agents and Chemotherapy, Chicago, Illinois, USA, September 22-25, 2001; Abstracts of the Interscience Conference on Antimicrobial Agents and Chemotherapy. **41**: 148.	Observational study
Petersen A, Dalsgaard A. 2003. Antimicrobial resistance of intestinal Aeromonas spp. and Enterococcus spp. in fish cultured in integrated broiler-fish farms in Thailand. *Aquaculture*. **219** (1-4): 71-82.	Observational study
Petersen A, Andersen JS, Kaewmak T, Somsiri T, Dalsgaard A. 2002. Impact of integrated fish farming on antimicrobial resistance in a pond environment. *Applied and Environmental Microbiology*. **68** (12): 6036-6042.	Observational study

Petr T. 1994. Intensification of resevoir fisheries in tropical and subtropical countries. *Internationale Revue der Gesamten Hydrobiologie*. **79** (1): 131-138.	Review
Petr T. 1998. Fisheries in reservoirs in the arid and semiarid zones of Asia. *International Review of Hydrobiology*. **83**: 591-598.	Review
Phang SM, Shaharuddin S, Noraishah H, Sasekumar A. 1996. Studies on Gracilaria changii (Gracilariales, Rhodophyta) from Malaysian mangroves. *Hydrobiologia*. **327**: 347-352.	Outside target countries; not related to aquatic animal health
Phillips MJ, Kwei Lin C, Beveridge MCM. 1993. Shrimp culture and the environment: Lessons from the world's most rapidly expanding warm water aquaculture sector. Environment and Aquaculture in Developing Countries, ICLARM, Manila (Philippines). **31**: 171-198.	Review
Phoung NT. 1997. On-farm prepared feed and feeding regimes for Mekong giant catfish Pangasius bocourti cultured in cages in the Mekong River in Vietnam. Report of the Symposium on Social, Economic and Management Aspects of Recreational Fisheries held in connection with the European Inland Fisheries Advisory Commission, nineteenth sesion, Dublin, Ireland, 11-19 June, 1996. p 109.	Obtained after time limit
Phuc PD, Sollows JD. 2001. Status and potential of reservoir fisheries in Dak Lak Province, Vietnam. p 36-42. de Silva SS (Eds).	Review
Phukan RR, Biswas SP. 2000. Historical tanks of Assam. Habitat status and role as potential sanctuaries. Fish biodiversity of North-East India, National Bureau of Fish Genetic Resources, Lucknow (India) publication. **2**: 136-137.	Not related to aquatic animal health
Piepho HP. 1993. Weed-fish interactions at different water levels in irrigated rice fields in northeast Thailand. *International Rice Research Notes.* **18** (1): 54-55.	Outcome measures not related to aquatic animal health
Pierini SV, Warrell DA, De Paulo A, Theakston RDG. 1996. High incidence of bites and stings by snakes and other animals among rubber tappers and Amazonian Indians of the Jurua VAlley, Acre State, Brazil. *Toxicon.* **34** (2): 225-236.	Outside target countries; not related to aquatic animal health
Potipitak K. 1996. Aquaculture extension services review: Thailand. FAO fisheries circular. Rome. **910**: 46 pp.	Review
Prasad GS, Qureshi A, Devi BC, Rao PS. 1996. Recycling cattle farm yard wastes and biogas slurry for fish culture. Proceedings of the Pacon conference on sustainable aquaculture ’95. p. 300-307.	No statistical analysis
Price KS. 1998. A framework for a Delaware inland bays environmental calssification. *Environmental Monitoring and Assessment.* **51** (1-2): 285-298.	Not related to aquatic animal health
Primavera JH. 1993. A critical review of shrimp pond culture in the Philippines. *Reviews in Fisheries Science.* **1** (2): 151-201.	Outside target countries; review
Puste AM, Das DK. 2001. Impact of air pollutant emissions on the ecosystems in the vicinity of industrial areas of Indian sub-tropics. *Water Air and Soil Pollution.* **130** (1-4): 843-848.	Not related to aquatic animal health
Puttaswamy GP, Ramesha KS. 1997. Integrated fish farming with Khaki Campbell ducks. Current Research - University of Agricultural Sciences (Bangalore). **26** (6-7): 97-99.	No control group
Qin Q, Shen H, Shi C, Chang SF, Ngoh GH, Sin YM, Lam TJ. 2001. Antigenic characterisation of a marine fish	Abstract only

iridovirus isolated from grouper Epinephelus tauvina. 6th Asian Fisheries Forum Book of Abstracts. p 203.	
Qureshi TA, Basha SM, Biswas R. 1993. Larval rearing of Indian river prawn, *Macrobrahium malcolmsonii* through synthetic sea water. From discovery to commercialization. Special Publication, European Aquaculture Society, Oostende (Belgium). **19**: 158.	Observational study
Radheyshyam, Chandra S, Sarkar SK. 2001. Mass fry-kills in the farmer's nursery ponds due to outbreak of trichodiniasis disease and its feasible control measures. *Bioved.* **12** (1-2): 27-30.	No control group; no statistical analysis
Rahman A. 2000. Development of beel fishery of Assam with emphasis on in situ conservation. Fish biodiversity of North-East India. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **2**: 148-149.	Overview
Rai SP, Roy AK, Datta AK, Das CR, Ghosh JK. 1996. A record production from an integrated farming system utilising sewage enriched water. *Journal of the Indian Fisheries Association.* **26**: 33-40.	Outside target species
Raina HS, Petr T. 1999. Coldwater fish and fisheries in the Indian Himalayas: Lakes and reservoirs. Fish and fisheries at higher altitudes. FAO Fisheries Technical Paper. **385**: 64-88.	Overview
Rajan PR, Ramasamy P, Purushothaman V, Brennan GP. 2000. White spot baculovirus syndrome in the Indian shrimp Penaeus monodon and P-indicus. *Aquaculture.* **184** (1-2): 31-44.	Observational study
Rajendran N, Kathiresan K. 1996. Effect of effluent from a shrimp pond on shoot biomass of mangrove seedlings. *Aquaculture Research.* **27** (10): 745-747.	Not related to aquatic animal health
Raksakulthai N. 1996. Processing of hybrid Clarias catfish. *INFOFISH International.* **3**: 33-36.	Not related to aquatic animal health
Ramakrishnan M, Elumalai M, Jayakumar R, Balasubramanian MP. 1999. Influence of distillary effluent on feeding energetics of freshwater fish in relation to water temperature. *Cytobios.***98** (389): 175-187.	Obtained after time limit
Ramesh KS, Mohan CV, Shankar KM, Ahmed I. 2000. Piscinoodinium sp. infection in juveniles of common carp (*Cyprinus carpio*), mahseer (*Torr khudree*) and tilapia (*Oreochromis mossambicus*). *Journal of Aquaculture in the Tropics.* **15** (3): 281-288.	Observational study
Ramesh KS, Puttswamy GP, Chandramohan K, Ahmed I, Hanumanthappa H. Stunted carp fingerlings are a boon to seasonal water bodies. *Fishing Chimes.* **20** (4): 25-26.	Obtained after time limit
Ramos JA, Maul AM, Ayrton V, Bullock I, Hunter J, Bowler J, Castle G, Mile R, Pacheco C. 2002. Influence of local and large-scale weather events and timing of breeding on tropical roseate tern reproductive parameters. *Marine Ecology - Progress Series.* **243**: 271-279.	Outside target countries; not related to aquatic animal health
Rani GU, Reddy TC, Ravindranath K. 1993. Economics of brackishwater prawn farming in Nellore district of Andhra Pradesh state, India. *Journal of Aquaculture in the Tropics.* **8** (2): 221-230.	Observational study; outcome measures not related to aquatic animal health
Rao AP. 1995. Giant prawn farming is a profitable venture. *Indian Farming.* **45** (4): 36-38.	Overview
Rao GRM. 1998. Coastal aquaculture in India. Guidelines issued by Ministry of Agriculture, Government of India. Proceedings of the Workshop on Environmental Impact Assessment of Aquaculture Enterprises, Chennai, December 10-12, 1997. p 159-170.	Guidelines
Rao, G R M. 2001. Present status of coastal aquaculture in India. *Applications in Fish Aquaculture.* **1** (1): 143-	Overview

144.	
Rao GS. 1997. Prawn farming in Andhra Pradesh - A retrospect. Marine Fisheries Information Service Technical and Extension Series. **146**: 1-4.	Overview
Rao RJ. 2001. Biological resources of the Ganga River, India. *Hydrobiologia.* **458**: 159-168.	Not related to aquatic animal health
Rao GRM, Ravichandran P. 2001. Sustainable brackishwater aquaculture. Sustainable Indian Fisheries. p 134-151.	Overview
Rao KJ, Ayyappan S. 2000. Hatchery technology of giant freshwater prawn, *Macrobrachium rosenbergii. Fishing Chimes.* **19** (10-11): 112-117.	Overview
Rao SM, Rao VR. 1996. Influence of temperature and rainfall on the helminth infection in the freshwater catfish Mystus seenghala. *Journal of Ecobiology.* **8** (4): 281-284.	Observational study
Rasheed M, Khan AR. 1996. Seasonal population dynamics of some helminth parasites of fishes in Wular Lake, Kashmir. Parasitic diseases - new horizons. Proceedings of the eighth national congress of veterinary parasitology and national symposium on molecular parasitology, 9-11 October, 1996. p 34-40. Banerjee DP, Ghosh JD, Gupta SK (Eds).	Outside target species
Ratafia M. 1995. Aquaculture today: A worldwide status report. *World Aquaculture.* **26** (2): 18-24.	Overview
Rattanarajcharkul R, Rucha W, Sommer S, Menzi H. 2001. Area-wide integration of specialised livestock and crop production in Eastern Thailand. p 295-300.Sangiorgi F (Eds).	Not related to aquatic animal health
Reddy PVGK. 1999. Genetic resources of Indian major carps. FAO Fisheries Technical Paper. **387**: 1-76.	Review
Reddy PVGK, Ayyappan S. 1999. The potentialities of genetics in modern aquaculture with special reference to India. *Fishing Chimes.* **19** (8): 19-20.	Overview
Regunathan C, Nair KP. 1993. A study on the black clam Villorita cyprinoides (Gray) as protein source in prawn diet. Mariculture Research Programme under the Postgraduate Programme in Mariculture, Part 4, CMFRI, Cochin (India), Special publication. **55**: 97-106.	Obtained after time limit
Reilly A, Kaferstein F. 1997. Food safety hazards and the application of the principles of the hazard analysis and critical control point (HACCP) system for their control in aquaculture production. *Aquaculture Research.* **28** (10): 735-752.	Not related to aquatic animal health; review
Riegl B. 2002. Effects of the 1996 and 1998 positive sea-surface temperature anomalies on corals, coral diseases and fish in the Arabian Gulf (Dubai, UAE). *Marine Biology (Berlin).* **140** (1): 29-40.	Outside target countries
Roberts RJ. 2000. Identifying the vibrio suspects. *Fish Farming International.* **27** (1): 12.	Overview
Romana-Eguia MRR, Eguia RV. 1999. Growth of five Asian red tilapia strains in saline environments. *Aquaculture.* **173** (1-4): 161-170.	Outside target countries
Ronnback P, Bryceson I, Kautsky N. 2002. Coastal aquaculture development in eastern Africa and the Western Indian Ocean: Prospects and problems for food security and local economics. *Ambio.* **31** (7-8): 537-542.	Outside target countries; review
Ronnback P. 1999. The ecological footprint: a communicative tool for assessing resource use and development limitations in aquaculture. International workshop on status of the freshwater/coastal/marine living resources	Overview

with particular emphasis on threats and options in coastal areas, 15-18 November, 1999, Montpellier, France. p 30.	
Rosecchi E, Charpentier B. 1995. Aquaculture in lagoon and marine environments. Conservation of Mediterranean Wetlands, Tour du Valat, Arles (France). **3**: 94 pp.	Overview
Rothuis AJ, Nhan DK, Richter CJJ, Ollevier F. 1998. Rice with fish culture in the semi-deep waters of the Mekong Delta, Vietnam: Interaction of rice culture and fish husbandry management on fish production. *Aquaculture Research.* **29** (1): 59-66.	Observational study
Routray P, Routray MD. 1997. Growth potential of grass carp, Ctenopharyngodon idella, Val. in saline water with an aquatic weed Potamogeton pectinatus as feed. *Fishery Technology. Society of Fisheries Technologists (India).* **34** (2): 7-10.	No control group
Roy NC, Wahab MA, Alim MA, Thilsted SH. 2001. To develop an appropriate carp polyculture technology with small indigenous species mola (Amblypharyngodon mola) for rural Bangladesh. 6th Asian Fisheries Forum Book of Abstracts. p 259.	Outside target countries; abstract only
Roy SD, Soundararajan R, Dorairaj K. 1998. Environmental issues and prospects of brackishwater aquaculture in the Andaman. Island Ecosystem and Sustainable Development. p 95-105.	Overview
Ruangpan L, Danayadol Y, Direkbusarkaom S, Siurairatana S, Flege; TW. 1999. Lethal toxicity of Vibrio harveyi to cultivated Penaeus monodon induced by a bacteriophage. *Diseases of Aquatic Organisms.* **35** (3): 195-201.	Observational study
Sadhukhan PC, Ghosh S, Chaudhuri J, Ghosh DK, Mandal A. 1997. Mercury and organomercurial resistance in bacteria isolated from freshwater fish of wetland fisheries around Calcutta. *Environmental Pollution.* **97** (1-2): 71-78.	Observational study
Saha D, Pal J, 2002. In vitro antibiotic susceptibility of bacteria isolated from EUS-affected fishes in India. *Letters in Applied Microbiology*. **34** (5): 311-316.	Outcome measures not related to aquatic animal health
Saha N, Das L. 1999. Stimulation of ureogenesis in the perfused liver of an Indian air-breathing catfish, Clarias batrachus, infused with different concentrations of ammonium chloride. *Fish Physiology and Biochemistry.* **21** (4): 303-311.	In vitro study
Saha N, Ratha BK. 1998. Ureogenesis in Indian air-breathing teleosts: adaptation to environmental constraints. *Comparative Biochemistry and Physiology A - Molecular and Integrative Physiology.* **120** (2): 195-208.	Review
Saha N, Das L, Dutta S. 1999. Types of carbamyl phosphate synthetases and aubcellular localization of urea cycle and related enzymes in air-breathing walking catfish, *Clarias batrachus. Journal of Experimental Zoology.* **283** (2): 121-130.	Observational study
Saha C, Paul BN, Mohapatra BC. 2001. High density fish culture in flow-through system: an ecofriendly approach. *Journal of Ecophysiology and Occupational Health.* **1** (3-4): 245-248.	Obtained after time limit
Saha JN, Jana RK, Govindassamy P, Sahoo M, 1998. Preparation of wet-lab and nursery ponds for rearing spawn of fullsib groups to raise fry/fingerlings for 'selective breeding of rohu, Labeo rohita (Ham.)'. Current and	Guidelines

emerging trends in aquaculture: Proceedings of the national seminar, 14-16 February, 1995. p 131-137. Thomas PC (Eds).	
Saha SB, Bhattacharyya SB, Basu S, MItra A, Zamadar YA, Choudhury A. 1998. Primary production and ecological efficiency of brackishwater shrimp culture in the vicinity of sundarbans mangrove ecosystem. *Journal of Aquaculture in the Tropics.* **13** (2): 151-157.	Observational study
Saharan BS. 1999. Status of fisheries development in Haryana. *Fishing Chimes.* **19** (7): 21-25.	Overview
Sahoo RN, Mohapatra MK, Sahoo B, Das GC. 1995. Acute renal failure associated with freshwater fish toxin. *Tropical and Geographical Medicine.* **47** (2): 94-95.	Not related to aquatic animal health
Sakthivel M, Baskaran P. 1995. Effects of dietary lipid on growth, body carcass and haematological parameters of freshwater fishes. *Journal of Ecobiology.* **7** (3): 161-168.	No statistical analysis
Sakthivel M. 1993. Aquaculture - a potential tool for coastal fishery development and management of living resources of the sea. Sustainable management of coastal ecosystems. p 155-159. Swaninathan MS, Ramesh R (Eds).	Not related to aquatic animal health
Sakthivel M, Ramamurthy S, Alagaraaja K. 1997. Coastal aquaculture in India with special reference to Tamil Nadu - a perspective. National Aquaculture Week 1997: A Special Programme of the Department of Biotechnology, Government of India, AFI, Neelankarai, Chennai (India). p 46-50.	Overview
Salvat B, Aubanel A. 2002. Coral reefs management in French Polynesia. *Revue d'ecologie - la terre et la vie.* .**57** (3-4): 193-251.	Outside target countries; not related to aquatic animal health
Samal UN. 1994. Effect of fluoride pollutants on growth of certain freshwater fishes. *Environment and Ecology.* **12** (1): 218-220.	Observational study
Sangamaheswaran AP, Kumar RS, Jeyaseelan MJP, Sundararaj V. 2001. Bioremediation technology for the treatment of shrimp farm effluent: an ecofriendly approach. *Perspectives in Mariculture.* p 413-420.	Outcome measures not related to aquatic animal health
Sangrudtanakul C. 2000. Effect of pelletised diets containing various levels of protein on growth and survival of climbing perch, Anabas testudineus (Bloch). Abstracts of Master of Science Theses (Fisheries Science) 1985-1990, Faculty of Fisheries, Kasetsart University, Bangkok (Thailand). p 22.	Obtained after time limit
Sanjeeviraj G, Ravikumar B, Gopalakrishnan P. 1997. Effect of eyestalk ablation on moulting and growth of different size groups of Macrobrachium rosenbergii (de Man). Water quality issues in aquaculture. Proceedings of the National Seminar on Water Quality Issues in Aquaculture Systems, Dec 18-19, 1996. p 147-158.	Obtained after time limit
Sarangi N, Soundararajan R, Ram N, Singh I. 1998. Culture of freshwater giant prawn, Macrobrachium rosenbergii, in rainfed ponds in Andamans. *Journal of the Andaman Science Association.* **14** (1): 41-45.	Obtained after time limit
Sarkar SK. 1999. Role of herbicides, 2, 4-D and simazine on the effectiveness of fertilisers and oil cakes in fish production. *Indian Journal of Environment and Ecoplanning.* **2** (3): 303-310.	Obtained after time limit
Sarkar SK. 2002. Studies on the soil characteristic features of sodic soil fish pond ecosystem and their management practices. *Uttar Pradesh Journal of Zoology.* **22** (1): 109-111.	Outcome measures not related to aquatic animal health
Sarkar UK, Kapoor D. 2000. Survey of existing databases for potential economically important fish species of	Observational study

Peninsular India. Endemic fish diversity of Western Ghats. Publication of the NAtional Bureau of Fish Genetic Resources, Lucknow (India). **1**: 259-260.	
Sathe PS, Mourya DT, Basu A, Gogate SS, Banerjee K. 1995. Establishment and characterisation of a new fish cell line, MG-3, from gills of mrigal, *Cirrhinus mrigala. Indian Journal of Experimental Biology*. **33**: 589-594.	Not related to aquatic animal health
Sathiavathy V, Noble A. 1993. Nutritional evaluation of chicken entrails as prawn feed for Penaeus indicus H. Milne Edwards. Mariculture Research under the Postgraduate Programme in Mariculture. Part 4, CMFRI, Cochin (India). **55**: 1-7.	Obtained after time limit
Sato S, Ogata T, Borja V, Gonzales C, Fukuyo Y, Kodama M. 2000. Frequent occurence of paralytic shellfish poisoning toxins as dominant toxins in marine puffer from tropical water. *Toxicon.* **38** (8): 1101-1109.	Outside target countries
Saxena A. 1994. Fish health: Hazards and insurance. International Symposium on Aquatic Animal Health: Program and abstracts, University of California, School of Veterinary Medicine, Davis, California (USA). p 93.	Review
Scarpa J. 2001. Penaeid shrimp culture: Think globally. Aquaculture 2001: Book of Abstracts. p 579.	Abstract only; overview
Schiemer F. 1995. Bottom up vs. top down control in tropical reservoir management. *Tropical Immunology.* **1**: 57-68.	Not related to aquatic animal health
Schmeiser HH, Gminski R, Mersch-Sundermann V. 2001. Evaluation of health risks caused by musk ketone. International Journal of Hygiene and Environmental Health. **203** (4): 293-299.	Not related to aquatic animal health
Scholz T, Salgado-Maldonado G. 2000. The introduction and dispersal of Centrocestus formosanus (Nishigori, 1924) (Digenea: Heterophyidae) in Mexico: A review. *American Midland Naturalist.* **143** (1): 185-200.	Outside target countries; review
Southeast Asian Fisheries Development Centre, Tigbauan (Philippines) Aquaculture Department. 1999. The modular method. Milkfish pond culture. Aquaculture extension manual. Aquaculture Department, Southeast Asian Fisheries Development Centre, Tigbauan. **25**: 18 pp.	Manual
Sehgal KL. 1999. Coldwater fish and fisheries in the Indian Himalayas: Rivers and streams. FAO Fisheries Technical Paper. **385**: 41-63.	Overview
Sehgal KL. 1999. Coldwater fish and fisheries in the Western Ghats, India. Fish and fisheries at higher altitudes. FAO Fisheries Technical Paper. **385**: 103-121.	Overview
Sehgal KL. 1999. Coldwater fish and fisheries in the Indian Himalayas: Culture. Fish and fisheries at higher altitudes. Asia. FAO Fisheries Technical Paper. **385**: 89-102.	Overview
Sehgal HS, Sehgal GK. 2002. Aquacultural and socio-economic aspects of processing carps into some value-added products. *Bioresource Technology*. **82** (3): 291-293.	Not related to aquatic animal health
Selgeby JH. 1994. Ruffe (in Lake Superior). The state of Lake Superior in 1992. Special publication, Great Lakes Fishery Commission. **94** (1): 87-92.	Outside target countries; overview
Selvaraj C. 1997. Yield optimisation insmall reservoirs: A case study in Aliyar Reservoir. Fisheries enhancement of small reservoirs and floodplain lakes in India, Bulletin of the Central Inland Capture Fisheries Research Institute, Barrackpore (India). **75**: 127-131.	Observational study
Senarath U, Visvanathan C. 2001. Environmental issues in brackish water shrimp aquaculture in Sri Lanka.	Outside target countries

Environmental Management. **27** (3): 335-348.	
Seng LT. 1997. Control of parasites in cultured marine finfishes in Southeast Asia - an overview. *International Journal for Parasitology*. **27** (10): 1177-1184.	Overview
Setboonsarng S. 1994. Evolution of freshwater aquaculture in Northeast Thailand: Growth of a new technology. Socioeconomics of aquaculture. Proceedings of International Symposium '93, Keelung, Taiwan, 14-17 December, 1993. **4**: 297-318.	Overview
Setboonsarng S, Edwards P. 1998. An assessment of alternative strategies for the integration of pond aquaculture in to the small-scale farming system of North-east Thailand. *Aquaculture Economics and Management.***2** (3): 151-162.	Obtained after time limit
Shah MS, Rahman MA, Haque MZ, Deppert D. 1994. Effects of stocking density on the gonadal maturation of Indian major carps and Chinese carps. *Bangladesh Journal of Zoology*. **22** (1): 1-8.	Outside target countries
Shaheed K, Somasundaram SSN, Hameed PS, Iyengar MAR. 1997. A study of polonium-210 distribution aspects in the riverine ecosystem of Kaveri, Tiruchirappalli, India. *Environmental Pollution.***95** (3): 371-377.	Not related to aquatic animal health
Shaleesha A. 1998. New dimensions of algal impact in aquaculture: Skeletonema sp. and Chaetoceros sp. *Seaweed Research and Utilisation.* **20** (1): 79-83.	Outside target species
Shamasundar BA. 2001. Fish processing in India. Sustainable Indian fisheries. p 250-271.	Review
Shariff M. 1998. Impact of diseases on aquaculture in the Asia-Pacific region as exemplified by epizootic ulcerative syndrome (EUS). *Journal of Applied Ichthyology - Zeitschrift fur Angewandte Ichthyologie.* **14** (3-4): 139-144.	Overview
Sharma KR, Leung PS. 2000. Technical efficiency of carp production in India: a stochastic frontier production function analysis. *Aquaculture Research.* **31** (12): 937-947.	Observational study
Sharma AP, Singh UP, Chauhan RS, Singh VK. 1998. Intergrated duck-cum-fish culture in Tarai region of Uttar Pradesh. Ecological agriculture and sustainable development: Volume 1. Proceedings of international conference on ecological agricultrue: towards sustainable development, Chandigarh, India, 15-17 November, 1997. **1**: 285-292. Dhaliwal GS, Arora R, Randhawa NS, Dhawan AK (Eds).	No statistical analysis
Sharma B. 1999. Effect of carbaryl on some biochemical constituents of the blood and liver of Clarias batrachus, a fresh-water teleost. *Journal of Toxicological Sciences.* **24** (3): 157-164.	Outcome measures not related to aquatic animal health
Sharma KR, Pingsun L. 2000. Technical efficiency of carp pond culture in South Asia: An application of a stochastic meta-production frontier model. *Aquaculture Economics and Management.* **4** (3-4): 169-190.	Observational study
Shaylaja K, Rengarajan K. 1993. Tolerance limits of salinity, temperature, oxygen and pH by the juveniles of prawn Penaeus indicus H. Milne Edwards. Mariculture Research under the Postgraduate Programme in Mriculture, Part 3, CMFRI, Cochin (India), Special publication. **54**: 64-69.	Obtained after time limit
Shete NB. 1997. Financing aquaculture - problems and solutions. *State Bank of India Monthly Review*. **38** (10): 503-520.	Review
Shetty HPC, Satyanarayana Rao GP. 1996. Aquaculture in India. *World Aquaculture.* **27** (1): 20-24.	Overview

Shiau SY. 2001. Applications of fish nutrition research in aquaculture: the Taiwan experience. *Aquaculture Research*. **32** (8): 639-643.	Outside target countries
Shirai N, Miyakawa M, Tokairin S, Ehara H, Wada S. 2000. The fatty acid composition in edible portion of wild and cultured catfish. *Nippon Suisan Gakkaishi*. **66** (5): 859-868.	Not related to aquatic animal health
Shiva V, Karir G. 1997. Towards sustainable aquaculture: Chenmeenkettu. 133 pp.	Not related to aquatic animal health; overview
Shukla JB, Dubey B. 1996. Effect of changing habitat on species: Application to Keoladeo National Park, India. *Ecological Modelling*. **86** (1): 91-99.	Not related to aquatic animal health
Shyamala DR, Ramalingam K. 2000. Vibriosis outbreak in prawn farms and the growth threshold of endemic pathogen populations. *Uttar Pradesh Journal of Zoology*. **20** (3): 243-247.	Observational study
Siddeek MSM. 2000. Marine fisheries resources, fisheries and marine environmental management, coral reefs and marine parks in the northwest Indian Ocean. Technical paper 1. Report of a Regional Workshop on Fisheries Monitoring, Control and Surveillance. Muscat, Sultanate of Oman, 24-28 October, 1999. FAO/Norway Programme of Assistance to Developing Countries for the Implementation of the Code of Conduct for Responsible Fisheries. Sub-Programme C: Assistance to Developing Countries for Upgrading their Capabilities in Monitoring, Control and Surveillance. p 101-115.	Review
Silvestre G, Pauly D. 1997. Management of tropical coastal fisheries in Asia: an overview of key challenges and opportunities. Status and management of tropical coastal fisheries in Asia. ICLARM conference proceedings. **53**: 8-25.	Overview
Singh N. 1996. Sex ratio of Schizothoraichthys progastus McClelland (Cyprinidae: Teleostei) in relation to three aquatic parameters of glacier-fed hillstream Mandakini in Garhwal hills. *Journal of Animal Morphology and Physiology*. **43** (2): 195-201.	Observational study
Singh AK, Bose SK. 1997. Growth of grass carp (ctenopharyngodon idella Val.) fed on cauliflower leaves. *Journal of Interacademicia*. **1** (1): 75-78.	Obtained after time limit
Singh BN, Kumar K. 1996. Observations on the use of nuvimin (a vitamin trace mnineral poultry and live stock feed supplement) and fish meal in the feeds for spawn and fry of Indian major carps. *Proceedings of the National Academy of Sciences India Section B (Biological Sciences)*. **66** (4): 323-327.	Obtained after time limit
Singh D, Sharma RC. 1998. Biodiversity, ecological status and conservation priority of the fish of the River Alaknanda, a parent stream of the River Ganges (India). *Aquatic Conservation: Marine and Freshwater Ecosystems*. **8** (6): 761-772.	Observational study
Singh VV, Raje SG. 1998. Recurring fish mortalities at Versova stress exigency for new strategies of conservation. *Indian Journal of Marine Science*. **27** (3-4): 502-505.	Observational study
Singh UP, Sharma AP, Upadhyay AK. 1999. Comparative performance of two carp hatchery systems. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi, Kerala. p 237-239.	No statistical analysis
Singh HP, Singh R, Maheshwari RC, Pandey KC. 1993. Biodigested slurry application in agriculture and fisheries. *Indian Journal of Environmental Health*. **35** (2): 123-131.	Review

Sinha M. 2001. Status and future strategies for development of fisheries of inland open waters of India. *Applications in Fisheries and Aquaculture*. **1** (1): 123-127.	Overview
Sinha AK, Sinha C. 1996. Population dynamics of Genarchopsis goppo (Ozaki) - a trematode parasite of freshwater fish Channa orientalis (Schneider) of Jamshedpur, India. *Rivista di Parasitologia*. **57** (1).	Outside target species; observational study
Sirimongkonthaworn R, Fernando CH. 1994. Biology of Clupeichthys-aesaarnensis (Clupeidae) in Ubolratana reservoir, Thailand, with special reference to food and feeding-habits. *Internationale Revue der Gesamten Hydrobiologie*. **79** (1): 95-112.	Observational study
Sivakami R, Premkishore G, Chandran MR. 1996. Occurence and distribution of potentially pathogenic Enterobacteriaceae in carps and pond water in Tamil Nadu, India. *Aquaculture Research*. **27** (5): 375-378.	Observational study
Smith PT, Phillips MJ. 1999. Priorities for shrimp research in Thailand and the region. ACIAR Technical Report Series. **47**: 93-106.	Observational study
Smith MS, Swart JJ. 1998. Flathead mullet (Mugil cephalus) as a potential aquaculture species in the Western Cape. African Fishes and Fisheries Diversity and Utilisation. p 241.	Outside target countries
Smithrithee M. 2000. Marine shrimp culture development appraoch in Amphoe Muang Samut Sakhon, Changwat Samut Sakhon. Abstracts of Master of Science Theses (Fisheries Science) 1985-1990, Faculty of Fisheries, Kasetsart University, Bangkok (Thailand). p 31.	Abstract only; observational study
Sobhanakumar K. 1998. Role of Matsyafed in shrimp and freshwater prawn hatchery development. Technological advancements in fisheries. Proceedings of the National Symposium on Technological Advancements in Fisheries and its Impact on Rural Development held at Cochin by School of Industrial Fisheries, Cochin University of Science and Technology, 1995. p 438-442.	Overview
Societe Francaise d'Ichtyologie, Paris, France. 1999. Proceedings of the 5th Indo-Pacific fish conference, Nounea, New Caledonia, 3-8th November, 1997. 866 pp.	Multiple papers
Society of Fisheries Technologists, Cochin, India. 1998. Advances and priorities in fisheries technology. Proceedings of the symposium 'Advances abd priorities in fisheries technology', 11-13th February, 1998, jointly organised by Society of Fisheries Technologists (India) and Central Institute of Fisheries Technology, Cochin.	Multiple papers
Somvanshi VS. 1998. Fishery resources in the Indian EEZ: Recommendations for deep-sea fisheries development. *Indian Journal of Marine Sciences*. **27** (3-4): 457-462.	Overview
Son NH, Anh BT, Thuy NTT. 2001. Investigation of the fisheries in farmer-managed small reservoirs in Thainguyen and Yenbai provinces, Northern Vietnam. p 246-256. de Silva SS (Eds).	Observational study
Sonnenholzner S, Boyd CE. 2000. Chemical and physical propertie of shrimp pond bottom soils in Ecuador. *Journal of the World Aquaculture Society*. **31** (3): 358-375.	Outside target countries
Srikrishnadhas B, Sundararaj V. 1993. Studies on the growth of marine shrimps in floating cages and pen. Proceedings of the National Seminar on Aquaculture Development in India - Problems and Prospects, 27-29 November, 1990, Kerala University, Thiruvanathapuram (India). p 53-58.	Obtained after time limit
Srinath K, Sridhar M, Kartha PNR, Mahanan AN. 2000. Group farming for sustainable aquaculture. *Ocean and*	Not related to aquatic animal health

Coastal Management. **43** (7): 557-571.	
Srinivas R. 2002. Tips for sustainable shrimp culture. *INFOFISH International.* **1** (28): 30-32.	Overview
Srinivasan M, Haq MAB, Rajasegar M.. 1999. Status of white spot disease in shrimp famrs in Vellar Estuary, Tamil Nadu. The Fourth Indian Fisheries Forum, Proceedings. 24-28 November, 1996, Kochi, Kerala. p 335-336.	Observational study
Srivastava SK, Sarkar UK. 2000. Conservation of stream fishes: Importance of physical habitat studies. Endemic fish diversity of Western Ghats. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **1**: 197-199.	Overview
Strom DG, Graves GA. 2001. A comparison of mercury in estuarine fish between Florida Bay and the Indian River Lagoon, Florida, USA. *Estuaries.* **24** (4): 597-609.	Outside target countries
Su MS, Lee CS, Liao IC. 2002. Technical responses to challenges in milkfish aquaculture. *Reviews in Fisheries Science.* **10** (3-4): 451-464.	Outside target countries; review
Subasinghe RP. 1993. Effects of controlled infections of Trichodina sp. on transmission of epizootic ulcerative syndrome (EUS) to naive snakehead, Ophicephalus striatus Bloch. *Journal of Fish Diseases.* **16** (2): 161-164.	Outside target countries
Subrahmanyam NS, Rao GPS, Somaiya VJ. 2001. First experience of commercial farming of Penaeus monodon (Fabricus) along the Okhamandal coast, Gujarat. *Perspectives in mariculture.* p 321-330.	Observational study
Sudha HR. 2002. Reproductive cycle and environmental factors in Mystus vittatus (Bloch). *Uttar Pradesh Journal of Zoology.* **22** (1): 25-32.	Review
Sudthongkong C, Miyata M, Miyazaki T. 2002. Viral DNA sequences of genes encoding the ATPase and the major capsid protein of tropical iridovirus isolates which are pathogenic to fishes in Japan, South China Sea and Southeast Asian countries. *Archives of Virology.* **147** (11): 2089-2109.	Observational study
Sugunan VV. 2001. Status of culture-based fisheries in small reservoirs in India. p 274-280. de Silva SS (Eds).	Review
Sugunna VV, Sinha M. 2001. Sustainable capture fand culture-based fisheries in freshwaters of India. Sustainable Indian fisheries. p 43-70.	Overview
Sukumaran, N. 1995. Status of shrimp farming in India - Prospects and problems. Sustainable Development of Fisheries in Africa. p 58-59.	Overview
Sukumaran PK. 2002. Growth of major carps in a lentic habitat having permanent Microcystis blooms. *Environment and Ecology.* **20** (1): 191-195.	Observational study
Sureshkumar S, Kurup BM. 1998. Prospects of setting up of backyard hatcheries of Macrobrachium rosenbergii (de Man) for self-employment and rural development. Technological advancements in fisheries. Proceedings of the National Symposium on Technological Advancements in Fisheries and its Impact on Rural Development held at Cochin by School of Industrial Fisheries, Cochin University of Science and Technology, December 5-7, 1995. p 432-437.	Overview
Suvapepun S. 1994. Environmental impacts of mariculture. NRCT-JSPS Joint seminar on marine science, Chulalongkorn University, Bangkok (Thailand). p 25-29.	Review

Swamy HVV, Devaraj KV. Effect of varying levels of solvent extracted soybean meal on nutrient digestion and nutrient accretion by Indian major carp *Catla catla* (Ham.). *Agricultural and Biological Research.* **17** (1-2): 38-50.	Obtained after time limit
Sweetman JW. 1993. Perspectives and critical success factors in the present farming of fish. From discovery to commercialisation, European Aquaculture Society, Oostende (Belgium), Special publication. **19**: 288.	Review
Szyper JP, Kwei Lin C, Little D, Setboonsarng S, Yakupitiyage A, Edwards P, Demaine H. 1996. Techniques for efficient and sustainable mass production of tilapia in Thailand. Proceedings of the Pacon Conference on Sustainable Aquaculture '95. p 349-356.	Overview
Tacon AGJ. 1996. Feeding tomorrow's fish. *World Aquaculture.* **27** (3): 20-32.	Review
Tacon AGJ, De Silva SS. 1997. Feed preparation and feed management strategies within semi-intensive fish farming systems in the tropics. *Aquaculture.* **151** (1-4): 379-404.	Review
Tacon AGJ, Phillips MJ, Barg UC. 1995. Aquaculture feeds and the environment - the Asian experience. *Water Science and Technology.* **31** (10): 41-59.	Review
Takahashi Y, Kondo M, Itami T, Honda T, Inagawa H, Nishizawa T, Soma G, Yokomizo Y. 2000. Enhancement of disease resistance against penaeid acute viraemia and induction of virus-inactivating activity in haemolymph of kuruma shrimp, Penaeus japonicus, by oral administration of Pantoea agglomerans lipopolysaccharide (LPS). *Fish and Shellfish Immunology.* **10** (6): 555-558.	Outside target countries
Tamaru CCA, Tamaru CSC, McVey JP. 1999. Spawning and maturation of aquaculture species. Proceedings of the 28th US-Japan Natural Resources Aquaculture Panel, Kihei, Hawaii, November 10-12. 174 pp.	Multiple papers
Tamse CT, GAcutan RQ, Tamse AF. 1995. Changes induced in the gills of milkfish (*Chanos chanos* Forsskaal) fingerlings after acute exposure to Nifurpirinol (Furanace; P-7138). *Bulletin of Environmental Contamination and Toxicology.* **54** (4): 591-596.	Obtained after time limit
Tan KKT, Lee SM. 2001. Status of pot orchid production in Singapore. *Singapore Journal of Primary Industries.* **29**: 75-78.	Outside target countries; not related to aquatic animal health
Tanaka H. 2001. Eel culture. Aquaculture 2001: Book of Abstracts. p 634.	Outside target countries; abstract only
Tanasomwang V, Nakai T, Nishimura Y, Muroga K. 1998. Vibrio-inhibiting marine bacteria isolated from black tiger shrimp hatchery. *Fish Pathology.* **33** (5): 459-466.	Outcome measures not related to aquatic animal health
Tandon KK, Johal MS, Mahajan M. 1993. Morphometry, length-weight relationship, age and growth of Gudusia chapra (Hamilton, 1822) from two different localities of Rajasthan State, India. *Research Bulletin of the Panjab University Science.* **43** (1-4): 87-104.	Observational study
Tangtrongpiros J, Pasomkit W, Chunsue N. 1998. Motile aeromonas disease in fishes. *Thai Journal of Veterinary Medicine.* **28** (4): 81-88.	Review
Te BQ. 1997. Reviews of diseases of aquatic animals in the last few years and their prophylaxis and treatment. *Khoa Hoc Ky Thuat Thu Y.* **4** (2): 82-87.	Review
Thakur PC, Corsin F, Turnbull JF, Shankar KM, Hao NV, Padiyar PA, Madhusudhan M, Morgan KL, Mohan	Observational study

CV. 2002. Estimation of prevalence of white spot syndrome virus (WSSV) by polymerase chain reaction in Penaeus monodon postlarvae at time of stocking in shrimp farms of Karnataka, India: a population-based study. *Diseases of Aquatic Organisms.* **49** (3): 235-243.	
Thammasart S. 1993. C.P. shrimp successful in Thailand. From discovery to commercialisation, Eurpopean Aquaculture Society, Oostende (Belgium), 1993, Special publication. **19**: 91.	Overview
Thampuran N, Surendran PK, Gopakumar K. 1997. Prevalence of pathogenic vibrios in caostal water and fishes of Cochin (India). Asia Pacific Fishery Commission. Summary report of and papers rpesented at the tenth session of the Working Party of Fish Technology and Marketing. Colombo, Sri Lanka, 4-7 June, 1996. p 25-33.	Observational study
ThanhLuu L. 1994. Inland fisheries in Vietnam under environmental constraints. *FAO Fisheries Report.* **512**: 185-192.	Overview
Thien TM, Trong TD. 1995. Genetic resources of common carp in Vietnam. *Aquaculture.* **129** (1-4): 216.	Overview
Thirunavukkarasu AR, Kailasam M, Chandra PK, Shiranee P, Charles MAAVK, Subburaj R. 2001. Captive broodstock development and breeding of seabass *Lates calcarifer* (Bloch) in India. *Perspectives in mariculture.* p 111-124.	No control group
Thomas SA, Raj RP. 1993. Evaluation of the nutritive value of mangrove leaves as a feed component for juveniles of *Penaeus indicus*. Mariculture Research under the Postgraduate Programme in Mariculture, Part 2, CMFRI, Cochin (India), Special publication. **53**: 87-95.	Obtained after time limit
Thompson KD, Lilley JH, Chinabut S, Adams A. 1997. The antibody response of snakehead, *Channa striata* Bloch, to *Aphanomyces invaderis*. *Fish and Shellfish Immunology.* **7** (5): 349-353.	No statistical analysis
Thongrak S, Prato T, Chiayvareesajja S, Kurtz W. 1997. Economic and water quality evaluation of intensive shrimp production systems in Thailand. *Agricultural Systems.* **53** (2-3): 121-141.	Observational study
Tiewchaloern S, Udomkijdecha S, Suvouttho S, Chunchamsri K, Waikagul J. 1999. Clinostomum trematode from human eye. *Southeast Asian Journal of Tropical Medicine and Public Health.* **30** (2): 382-384.	Not related to aquatic animal health
Tonguthai K, Leong TS. 2000. Diseases of cage cultured fish in marine and brackish water. Cage Aquaculture in Asia: Proceedings of the First International Symposium on Cage Aquaculture in Asia. p 217-224.	Review
Tonguthai K. 1997. Control of freshwater fish parasites: A Southeast Asian perspective. *International Journal for Parasitology.* **27** (10): 1185-1191.	Review
Tookwinas S. 1998. The environmental impact of marine shrimp farming effluents and carrying capacity estimation at Kung Krabaen Bay, eastern Thailand. *Asian Fisheries Science.* **11** (3-4): 303-316.	Observational study
Tookwinas S. 1999. Shrimp culture in Thailand - present status and future directions for research. Towards sustainable shrimp culture in Thailand and the region. Proceedings of a workshop held at Hat Yai, Songkhla, Thailand, 28 October - 1 November, 1996. p 10-15. Smith PT (Eds).	Review
Tookwinas S, Boonyaratpalin M, Choongam C, Poongern J. 1999. On farm quality assurance for shrimp production in Thailand. Papers presented at the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture. p 111-122.	Overview

Tookwinas S, Songsangjinda P, Chankaew K, Phillips M, Yang SS. 2001. Implementation of the Thai code of conduct for shrimp farming: preliminary results from demonstration studies in Thailand. Aquaculture 2001: Book of Abstracts. p 643.	Abstract only
Tripathi SD. 1996. Present status of breeding and culture of catfishes in South Asia. *Aquatic Living Resources.* **9**: 219-228.	Review
Tripathi SD. 2001. New dimensions in Indian aquaculture. *Applications in Fisheries and Aquaculture.* **1** (1): 129-132.	Overview
Tripathi SD, Aravindakshan PK, Ayyappan S, Jena JK, Muduli HK, Chandra S, Pani KC. 2000. New high in carp production in India through intensive polyculture. *Journal of Aquaculture in the Tropics.* **15** (2): 119-128.	Obtained after time limit
Truong, Trong Nghia., Vu, Ngoc Ut, Nguyen, Kim Quang, Rothuis, AJ. 1994. Improvement of traditional shrimp culture in the Mekong Delta. *Naga.* **17** (2): 20-22.	Overview
Tu NV, Giang TT. 2002. Improving the efficiency of aquaculture extension activity in the southeastern provinces of Southern Vietnam. *Rural Aquaculture.* p 285-300. Edwards P, Little DC, Demaine H (Eds).	Not related to aquatic animal health
Tuan NA. 1994. Culturing fish in ricefields as a means of preventing insect infestations: preliminary observations. Role of fish in enhancing ricefield ecology and in integrated pest management. Summary report of the third Asian Rice-Fish Farming Research and Development workshop, Sukamandi Research Institute for Food Crops, Sukamandi, Subang, West Java, Indonesia, 6-11 June, 1993, ICLARM conference proceedings. **43**: 31.	Obtained after time limit
Tucker JW Jr. 2001. Barramundi culture. Aquaculture 2001: Book of Abstracts. p 652.	Abstract only
Tucker JW Jr, 2001. Grouper culture. Aquaculture 2001: Book of Abstracts. p 650.	Abstract only
Tunkijjanukij S. 2000. Dynamic of dissolved oxygen in tiger prawn (Penaeus monodon Fabricus) intensive culture pond. Abstracts of Master of Science Theses (Fisheries Science), Kasetsart University, Bangkok (Thailand), Faculty of Fisheries, 1985-1990. p 21-22.	Outcome measures not related to aquatic animal health
Universite Michel de Montaigne Bordeaux 3, Bordeaux (France) UFR geographie et Amenagement. 2002. Aquaculture in Asia: The dilemnas of development. 135 pp.	Overview
Upare MA. 2000. India: Developing mariculture through credit. *Aquaculture Asia.* **5** (2): 29-31.	Overview
Uthoff D. 1994. Marine shrimp aquaculture in Thailand - succes and problems of an export oriented intensive system. *Naturraum und Landnutzung in Sudostasien.* p 161-183.	Overview
van Dam AA, Huisman EA, Rabbinge R. 1996. Simulation of food and oxygen limitations on the growth of Nile tilapia, Oreochromis niloticus L., in fishponds. *Aquaculture Research.* **27** (6): 463-478.	No intervention
van Dam AA, Azim ME, Verdegem MCJ. 2001. A simulation model for periphyton-based fish production in ponds. 6th Asian Fisheries Forum Book of Abstracts. p 253.	Abstract only
van Dam AA, Beveridge MCM, Azim ME, Verdegem MCJ. 2002. The potential of fish production based on periphyton. *Reviews in Fish Biology and Fisheries.* **12**: 1-31.	Review
Varshney PK, Maheswari UK, Abidi SAH. 1999. Biodiversity of macrobenthos off Thana Creek, Mumbai, west	Observational study

coast of India in relation to prevailing environmental conditions. The Fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi, Kerala. p 113-116.	
Vasudevappa C, Sivasankar N, Patil SA. 1996. Growth of giant freshwater prawn *Macrobrachium rosenbergii* (de MAn) fed on different formulated feeds. The Third Indian Fisheries Forum Proceedings, 11-14 October, 1993, Pant Nagar, Uttar Pradesh. p 33-35.	No statistical analysis
Veerina SS, Nandeesha MC, De Silva SS, Ahmed M. 1999. An analysis of production factors in carp farming in Andhra Pradesh, India. *Aquaculture Research.* **30** (11-12): 805-814.	Observational study
Velammal A, Aiyamperumal B, Venugopalan VK. 1994. Incidence of Vibrio cholerae in Muttom coastal waters, southwest coast of India. *Mahasagar. Dona Paula.* **27**: 117-124.	Observational study
Verghese CP. 1995. Sustained development of brackish water shrimp farming. *Seafood Export Journal. Cochin.* **26** (4): 17-32.	Overview
Verma SK. 1994. Water hyacinth, Eichhornia crassipes (Mart.) Solms. as direct feed for grass carp (Ctenopharyngodon idella, Cuv. and Val.). *Journal of Freshwater Biology.* **6** (4): 323-326.	No statistical analysis
Viet TT, Loi DT, Vinh NN, Phuc PD, Huy PT, Chien TN, An NQ, Sollows JD. 2001. An assessment of the fisheries of four stocked reservoirs in the Central Highlands of Vietnam. p 81-92. de Silva SS (Eds).	Observational study
Vijayakumaran M. 2001. Probiotics in aquaculture. *Perspectives in mariculture.* p 369-380.	Absract only; review
Villegas CT, Lacierda RB. 1997. The aquaculture training needs in the Philippines and Southeast Asia. *SEAFDEC Asian Aquaculture.* **19** (3): 5-6, 27-29.	Observational study
Vinh PQ, Alur MD, Nair PM. 1993. Storage properties of gamma-irradiated semi-dried fish varieties. *Fisheries Technology. Society of Fisheries Technology, Kochi.* **30** (2): 127-129.	Not related to aquatic animal health
Vishwanath W. 2000. Fish fauna of Manipur: Need for documentation and conservation. Fish biodiversity of North-East India. Publication of the National Bureau of Fish Genetic Resources, Lucknow (India). **2**: 73-74.	Overview
Wahab MA, Rahman MM, Milstein A. 2002. The effect of common carp, *Cyprinus carpio* (L.) and mrigal, *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polycultures. *Aquaculture Research.* **33** (8): 547-556.	Outside target countries
Wahab MA, Ahmed ZF, Islam MA, Haq MS, Rahmatullah SM. 1995. Effects of introduction of common carp, Cyprinus carpio (L.), on the pond ecology and growth of fish in polyculture. *Aquaculture Research.* **26** (9): 619-628.	Outside target countries
Wakugami K, Loawhakasetr P. 1999. Development and prospect of EM technology in Thailand. Fifth international conference on Kyusei nature farming, Bangkok, Thailand, 23-26 October, 1997. p 45-48. Senanayake YDA, Sangakkara UR (Eds).	Not related to aquatic animal health
Walker PJ, Cowley JA, Hall MR, Spann KM, Hodgson RA, Withyachumnarnkul B. 2001. Yellow head virus complex viruses: transmission cycles and topographical distribution in the Asia-Pacific region. Aquaculture 2001: Book of Abstracts. p 673.	Abstract only
Walker PJ. Regional cooperation in controlling prawn viral diseases - Application of molecular technologies.	Overview

Aquaculture and Fisheries Resources Management. Conference proceedings. Taiwan Fisheries Research Institute. **4**: 59-62.	
Wanninayake, W M T B., Ratnayake, R M T K., Edirisinghe, U. 2001. Experimental culture of tiger shrimp (Penaeus monodon) in a low slainity environment in Sri Lanka. 6th Asian Fisheries Forum Book of Abstracts. p 265.	Outside target countries; abstract only
Watanabe M, Sasaki K, Nakashimada Y, Kakizono T, Noparatnaraporn N, Nishio N. 1998. Growth and flocculation of a marine photosynthetic bacterium Rhodovulum sp. *Applied Microbiology and Biotechnology*. **50** (6): 682-691.	Not related to aquatic animal health
Watanabe WO, Ellis SC, Ellis EP, Lopez VG, Bass P, Ginoza J, Moriwake A. 1996. Evaluation of first-feeding regimens for larval Nassau grouper Epinephalus striatus and preliminary pilot-scale culture through metamorphosis. *Journal of the World Aquaculture Society*. **27** (3): 323-331.	Outside target countries
Weigel JY. 1993. Coastal aquaculture and environmental movements in Thailand. *Tiers Monde*. **34** (134): 385-403.	Not related to aquatic animal health
Weston DP. 1996. Environmental considerations in the use of antibacterial drugs in aquaculture. *Aquaculture and Water Resource Management*. p 140-165.	Review
Wilkinson C, Linden O, Cesar H, Hodgson G, Rubens J, Strong AE. 1999. Ecoligical and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? *Ambio*. **28** (2): 188-196.	Not related to aquatic animal health
Wisespongpand P, Polypradub P. 1994. Grouper (Epinephelus malabaricus Bloch and Schneider) rearing in net cages at different water depth. *Kasetsart Journal, Natural Sciences*. **28** (4): 545-555.	Not available in English; insufficient time for translation
Wiwanitkit V, Nithiuthai S, Suwansaksri J, Chongboonprasert C, Tangwattakanont K. 2001. Survival of heterophyid metacercariae in uncooked Thai fish dishes. *Annals of Tropical Medicine and Parasitology*. **95** (7): 725-727.	Not related to aquatic animal health
Wong HC, Chen MC, Liu SH, Liu DP. 1999. Incidence of highly genetically diversified Vibrio parahaemolyticus in seafood imported from Asian countries. *International Journal of Food Microbiology*. **52** (3): 181-188.	Observational study
Xie P,Yang Y. 2000. Long-term changes of Copepoda community (1957-1996) in a subtropical Chinese lake stocked densely with planktivorous filter-feeding silver and bighead carp. *Journal of Plankton Research*. **22** (9): 1757-1778.	Outside target countries
Yadava YS. 1999. Code of conduct for responsible fisheries. Significant developments in India. *Bay of Bengal News*. .**2** (13): 26-27.	Code of conduct
Yadava NK, Vaishali. 1993. Recycling of duckery wastes through aquaculture under integrated fish farming systems in India. From discovery to commercialization. Special publication, European Aquaculture Society, Oostende (Belgium). **19**: 285.	Obtained after time limit
Yi Y, Lin CK, Diana JS. 2001. Red tilapia (Oreochromis spp.) culture in brackishwater ponds. 6th Asian	Abstract only

Fisheries Forum Book of Abstracts. p 275.	
Yogamoorthi A. 1994. Biotechnoligical developments and aquaculture prospects. *Seafood Export Journal*. **25** (15): 9-18.	Overview
Yokoyama H, Higano J, Adachi K, Ishihi Y, Yamada Y, Pichitkul P. 2002. Evaluation of shrimp polyculture system in Thailand based on stable carbon and nitrogen isotope ratios. *Fisheries Science*. **68** (4): 745-750.	Outcome measures not related to aquatic animal health
Yoonpundh R, Little D. 1997. Trends in the farming of the snakeskin gourami (Trichogaster pectoralis) in Thailand. *Naga*. **20** (3-4): 18-20.	Observational study
Zaman L, Arakawa O, Shimosu A, Onoue Y. 1997. Occurence of paralytic shellfish poison in Bangladeshi freshwater puffers. *Toxicon*. **35** (3): 423-431.	Outside target countries
Zarillo GA. 1998. A calibrated 3-D hydrodynamic and transport model for managing the salinity regime of the Indian River Lagoon. Oceans '98 - Engineering for sustainable use of the oceans: conference proceedings, 28 September - 1 October, 1998, Nice (France). **1**: 66-71.	Outside target countries; not related to aquatic animal health
NON-ELECTRONIC REFERENCES	
Hand searching of journals	
Reference	**Reason for exclusion**
Abraham TJ, Manley R, Palaniappan R, Dhevendaran K. 1997. Pathogenecity and antibiotic sensitivity of luminous Vibrio harveyi isolated from diseased penaeid shrimp. *Journal of Aquaculture in the Tropics*. P 1-8.	No statistical analysis
Abraham TJ, Manley R, Palaniappan R, Dhevendaran K. 1997. Pathogenicity and antibiotic sensitivity of luminous Vibrio harveyi isolated from diseased penaeid shrimp. *Journal of Aquaculture in the Tropics*. **12** (1): 1-8.	No statistical analysis
Adler PR, Takeda F, Glenn DM, Summerfelt ST. 1996. Utilising byproducts to enhance aquaculture sustainability. *World Aquaculture*. **27** (2): 24-26.	No intervention
Alok D, Krishnan T, Talwar GP, Garg LC. 1993. Induced spawning of catfish, *Heteropneustes fossilis* (Bloch), using D-Lys salmon gonadotropin-releasing hormone analog. *Aquaculture*. **115**: 159-167.	No statistical analysis
Ayyappan S, Jena JK. 2003. Grow-out production of carps in India. *Journal of Applied Aquaculture*. **13** (3-4): 251-282.	Review
Azim ME, Verdegem, MCJ, Wahab MA, van Dam AA, Beveridge MCM. 2001. Periphyton boosts production in pond aquaculture systems. *World Aquaculture*. **32** (4): 57-61.	Review
Balasubramanian S, Rajan MR, Raj SP. 1993. Bacterial filtration by silver carp (*Hypophthalmichthys molitrix*). *Journal of Aquaculture in the Tropics*. **8**: 231-237.	Not related to aquatic animal health
Bandyopadhyay MK. 1999. Earthen spawning pool – A low cost system for commercial spawning of the Indian major carps. *Environment and Ecology*. **17** (2): 461-463.	No statistical analysis
Bromage N, Randall C, Davies B, Thrush M, Duston J, Carillo M, Zanuy S. 2000. Photoperiodism and the control of reproduction and development in farmed fish. *Aquaculture: Fundamental and applied research*. P 81-	Review

102. Lahlon B, Vitiello P (Eds). American Geophysical Union.	
Chapman G, Fernando CH. 1994. The diets and related aspects of feeding of Nile tilapia (*Oreochromis niloticus* L.) and common carp (*Cyprinus carpio* L.) in lowland rice fields in northeast Thailand. *Aquaculture.* **123**: 281-307.	Observational study
Das BK, Ghosal TK, Kaviraj A. 1994. Heavy metal concentration in some brackishwater ponds of Sundarban, India. *Journal of Ecobiology*. **6** (4): 261-264.	Observational study; not related to aquatic animal health
de Graaf GJ, Xuan TT. 1998. Extensive shrimp farming, mangrove clearance and marine fisheries in the southern provinces of Vietnam. *Mangrove and Salt Marshes.* **2**: 159-166.	Review
Edwards P, Kaewpaitoon K, Little DC, Siripandh N. 1994. An assessment of the role of buffalo manure for pond culture of tilapia II Field trial. *Aquaculture.* **126**: 97-106.	Observational study and no statistical analysis
Eknath AE, Dey MM, Rye M, Gjerde B, Abella TA, Sevilleja R, Tayamen MM, Reyes RA, Bentsen HB. 1998. Selective breeding of Nile tilapia for Asia. Proceedings of the 6th World Congress on genetics Applied to Livestock Production, Armidale, Australia, January 11-16th 1998, ICLARM Contribution No. 1397.	Review
Garg SK, Bhatnagar A. 1999. Effect of different doses or organic fertiliser (cow dung) on pond productivity and fish biomass in tillwater ponds. *Journal of Applied Ichthyology*. **15**: 10-15.	No control group
Gatesoupe FJ. 2000. Development of fish larvae and rearing conditions in hatcheries. *Aquaculture: Fundamental and applied research.* P 159-172. Lahlon B, Vitiello P (Eds). American Geophysical Union.	Review
Ghosh BC, Ghosh R, Mittra BN, Mitra A, Jana MK. 1994. Influence of organic and inorganic fertilization on the growth and nutrition of rice and fish in a dual culture system. *Journal of Agricultural Science.* **122**: 41-45.	No statistical analysis
Ignatius B, Jose S. 1999. Optimum level of oxytetracycline as growth promoter in *Macrobrachium rosenbergii* (de Man) post larvae. The fourth Indian Fisheries Forum Proceedings, 24-28 November, 1996, Kochi. P 275-277. Joseph MM, Menon NR, Nair NU (Eds). AFS, Indian branch, Kerala.	No control group
James R, Sampath K. 1998. Effects of feed and water quality (hardness) on growth in red swordtail *Xiphophorus helleri* fry. *Indian Journal of Fisheries.* **45** (3): 307-313.	Obtained after time limit
Jana BB, De UK. 1993. Management-induced variability of the bacterioplankton in fish farming ponds. *Journal of Aquaculture in the Tropics.* **8**: 131-140.	Not related to aquatic animal health
Jana BB, Jana S. 2003. The potential and sustainability of aquaculture in India. *Journal of Applied Aquaculture.* **13** (3-4): 283-316.	Review
Jana BB, Manna AK. 1993. Seasonal changes of lipid content of plankton, benthic invertebrates and carp growing in tropical farm ponds. *Journal of Aquaculture in the Tropics.* **8**: 177-186.	Observatioanl study
Jebakumar SRD, Kumaraguru AK, Jayaraman J. 1993. Accumulation and dissipation of phosphamidon in the tissues of freshwater fish *Oreochromis mossambicus. Comparative Physiology and Ecology*. **188** (1): 12-17.	No statistical analysis
Jena JK, Mukhopadhyay PK, Sarkar S, Aravindakshan PK, Muduli HK. 1996. Evaluation of a formulated diet for nursery rearing of Indian major carp under field conditions. *Journal of Aquaculture in the Tropics.* **11**: 299-305.	No statistical analysis

John G, Ponniah AG, Lakra WS, Gopalakrishnan A, Barat A. 1993. Preliminary attempts to cryopreserve embryos of *Cyprinus carpio* (L) and *Labeo rohita* (Ham.). *Journal of the Inland Fisheries Society, India.* **25** (1): 55-57.	No statistical analysis
Karunasagar I, Karunasagar I, Otta SK. 2003. Disease problems affecting fish in tropical environments. *Journal of Applied Aquaculture.* **13** (3-4): 231-250.	Review
Kaviraj A, Das BK. 1994. Cadmium induced changes in fish and other aquatic organisms. *Journal of Nature Conservator.* **6** (2): 105-122.	Review
Konar D, Ghosh SH, Kundu AL, Bairagya CN, Datta SK. 1996. Studies on paddy-cum-fish culture under different land situations. *Journal of the Indian Fisheries Association.* **26**: 85-91.	No statistical analysis
Kumar SA, Ramkumar NS. 1997. Effect of polluted water on histochemical localization of carbohydrates in a fresgwater teleost, *Channa punctatus* (Bloch) from Hussain Sagar lake, Hyderabad, Andhra Pradesh. *Pollution Research.* **16** (3): 197-200.	Observational study
Little DC, Lin CK, Turner WA. 1995. Commercial scale tilapia fry production in Thailand. *World Aquaculture.* **26** (4): 21-24.	No aquatic animal health intervention
Manjappa K, Gupta TRC, Gowda G, Ramesha AM. 1999. Coffee pulp wash effluents – characteristics and effects on common carp *Cyprinus carpio* (Linn.). The fourth Indian Fisheries Forum Proceedings, 2-28th November, 1996, Kochi, India. P 129-130.	No control group
Mohanty AN, Chatterjee DK, Giri BS. 1993. Effective combination of urea and bleaching powder as a piscicide in aquaculture operations. *Journal of Aquaculture in the Tropics.* **8**: 249-254.	No statistical analysis
Mukhopadhyay PK, Rangacharyulu PV, Mitra G, Jana BB. 2003. Applied nutrition in freshwater prawn, *Macrobrachium rosenbergii*, culture. *Journal of Applied Aquaculture.* **13** (3-4): 317-340.	Review
Murthy HS. 1998. Effect of enriched artemia on metamorphosis and survival of larvae of giant freshwater prawn, *Macrobrachium rosenbergii. Journal of Aquaculture in the Tropics.* **13** (3): 215-222.	No statistical analysis
Nandeesha MC, Bhadraswamy G, Patil JG, Varghese TJ, Sarma K, Keshavanath P. 1993. Preliminary results on induced spawning of pond-raised mahseer, *Tor khudree. Journal of Aquaculture in the Tropics.* **8**: 55-60.	No statistical analysis
Palaniselvam V, Kathiresan K. 1998. Potential of a marine cyanobacterium Phormidium tenue (Menegh.) Gomont as a shrimp feed supplement. *Seaweed Resource Utilisation.* **20** (1-2): 75-78.	Obtained after time limit
Randall DJ, Lin H. 2000. Effects of variations in water pH on fish. *Aquaculture: Fundamental and applied research.* P 31-45. Lahlow B, Vitello P (Eds). American Geographical Union.	Review
Ray AK, Das I. 1994. Apparent digestibility of some aquatic macrophytes in rohu, *Labeo rohita* (Ham.) fingerlings.	Outcome measures not related to aquatic animal health
Reddy PVGK, Gjerde B, Mahapatra KD, Saha JN, Jana RK, Gupta SD, Rye M. 1998. Selective breeding and mating designs for selection in fishes with reference to rohu – Labeo rohita (Hamilton). *Fish Genetic Biodiversity Conservation.* **5**: 449-456.	No statistical analysis
Sharma B, Gopal K. 1995. Changes in lactic acid content and activity of lactate dehydrogenase in *Clarias*	Outcome measures not related to aquatic animal health

batrachus, exposed to carbaryl. *Toxicological and Environmental Chemistry*. **47**: 89-95.	
Soundarapandian P, Samuel MJ, Kannupandi T. 1995. Seasonal variation in production of *Macrobrachium rosenbergii* postlarvae reared at ambient temperatures in a hatchery. *World Aquaculture*. **26** (3): 38-40.	Observational study
Srivastava AK, Srivastava AK. 1995. Renal changes in selenium-exposed freshwater Indian catfish, *Heteropneustes fossilis* (Bloch). *Acta Hydrobiologica*. **37** (3): 177-181.	No statistical analysis
Wahab MA, Rahman MM, Milstein A. 2001. The effect of common carp, *Cyprinus carpio*, and mrigal, *Cirrhinus mrigala*, as bottom feeders in Indian carp polyculture. *World Aquaculture*. **32** (4): 50-52, 69.	Review
Wilson RP. 1994. Utilisation of dietary carbohydrate by fish. *Aquaculture*. **124**: 67-80.	Review
Yakupitiyage A. 1993. Constraints to the use of plant fodder as fish feed in tropical small-scale tilapia culture systems: An overview. Fish nutrition in Practice. 14th International Symposium on Fish Nutrition and Feeding, Biarritz (France), June 24-27th, 1991. p 681-689. Kaushik SJ, Luquet P (Eds). INRA, Paris.	Review
Zohar Y. 1996. New approaches for the manipulation of ovulation and spawning in farmed fish. Bu*lletin of the National Research Institute for Aquaculture*. Supplement 2: 43-48.	Review
Questionnaire documents	
Reference	**Reason for exclusion**
Anantharaman P, Kannan R, Kannan L. 1996. Microalgae and aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Anitha F. 2002. Effect of crowding as a social stress on immune response and serum cortisol level in *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Anon. A field report on Nagai-Quaid-e-Milleth district. Peace Trust.	No intervention
Anon. Prawn farming in Nagai Quaid-E-Milleth district. Peace Trust.	No intervention
Aquaculture Authority. 1999. Guidelines: Adopting improved technology for increasing production and productivity in traditional and improved traditional systems of shrimp farming. Aquaculture Authority, Government of India, Ministry of Agriculture, Department of Animal Husbandry and Dairying, New Delhi, India.	No intervention
Aquaculture Authority. 2001. Shrimp aquaculture and the environment – An environment impact assessment report, submitted to the supreme court of India. Aquaculture Authority, Government of India, Chennai, India.	No intervention
Aquaculture Authority. 2001. Guidelines: Effluent treatment system in shrimp farms. Aquaculture Authority, Governement of India, Chennai, India.	No intervention
Aquaculture Authority. 2002. *Aquaculture Authority News*. **1** (1): 1-16.	No intervention
Aquaculture Authority. 2002. *Aquaculture Authority News*. **1** (2): 1-24.	No intervention
Aquaculture Authority. 2003. *Aquaculture Authority News*. **1** (3): 1-24.	No intervention

Balasubramani SP. 2002. Immunomodulation by the fruit extract of Indian gosseberry, *Phyllanthus emblica* (Linn) in *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Baskar JP. 1994. Press note: Environment and social issues of Nagai Quaid-E-Milleth district by promotion of prawn culture farming. Bhagwati Environment Development Institute.	No intervention
Bhasha P. 1994. Plea to put prawn farming proposals on hold. *Indian Express, Bombay*. 4/7/1994.	No intervention
Brindha Devi V. 2001. Comparative efficacy of crude extract and water soluble fraction of *Murraya koenigii* as immunostimulants for *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Bunnajirakul S, Steinhagen D, Hetzel U, Korting W, Drommer W. 2000. A study of sequential histopathology of *Trypanoplasma borreli* (Protozoa: Kineplastida) in susceptible common carp *Cyprinus carpio. Diseases of Aquatic Organisms.* **39**: 221-229.	Outside target countries
Caers M, Utting SD, Coutteau P, Millican PF. 2002. Impact of the supplementation of a docosahexaenoic acid-rich emulsion on the reproductive output of oyster broodstock, *Crassostrea gigas. Marine Biology*. **140**: 1157-1166.	Outside target countries
Coutteau P, Geurden I, Camara MR, Bergot P, Sorgeloos P. 1997. Review on the dietary effects of phospholipids in fish and crustacean larviculture. *Aquaculture.* **155**: 149-164.	Outside target countries
Hameed MS. 1996. Present status of capture and culture fisheries in India. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Hebbar R, Hebbar N. 2000. Letter. Oceancare Aquaculture Consultants and Laboratory.	No intervention
Hi-Line Aqua Co. Probiotics – concepts and successful performances.	No statistical analysis
Irwin GJ, Jeyalakshmi G, Daniel T. 1996. Processing, suitability and evaluation of leaf protein concentrate in the feed for aquatic organisms. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Jameson JD, Santhnam R. 1996. Ornamental fish culture and its prospectives. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Kasim HM. 1996. Shellfish culture: its problems and prospects. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Krishnan NT. 1996. The role of aquatic insects in aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only

Kumar VGHS, Gowda TPH. 1996. Dissolved oxygen modelling of Manakudy estuary with reference to H_2S discharge. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Kumar BR, Natarajan P, Dhevendran K. 1996. Bacterial and pathological aspects of fin erosion disease of certain freshwater and brackishwater fishes. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Kumar TTA, Sankar G, Kannan L, Duraisamy A. 1996. Remote sensing and aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Lavens P, Sorgeloos P. 2000. Experiences on importance of diet for shrimp postlarval quality. *Aquaculture*. **191:** 169-176.	Outside target countries
Lazarus S. 1996. Shrimp farming – its problems and prospects. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Lipton AP, Selvin J, Huxley AJ. 2003. Efficacy of *Ulva* incorporated therapeutic diet in managing bacterial diseases of *Penaeus monodon*. National conference on aquaculture nutrition, NATP and CMFRI Kochi, 12-14th March, 2003. p 58-59.	Abstract only
Lipton AP, Subhash SK, Raj RP, Rani AA. 2003. Influence of environmental factors and microbial load on the spat settlement of pearl oyster, *Pinctada fucata*. First Indian congress and exposition. P 52-54.	Outside target species
Marian MP, Christopher MSM, Lazarus S. 1996. Live feed culture – problems and prospects. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Educa-0tion and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Merchie G, Lavens P, Sorgeloos P. 1997. Optimisation of dietary vitamin C in fish and crustacean larvae: a review. *Aquaculture*. **155**: 165-181.	Outside target countries
Muthuraman AL. 2002. Features and operational results of an effluent treatment system in a scampi farm. *Fishing Chimes*. **22** (9): 29-33.	No intervention
Muthuraman AL. Scampi culture operational results in Tanparc.	No intervention
Muthuraman A, Kochumoideen MK. 2000. Hardness of freshwater: a criteria for choosing scampi seeds for stocking in freshwater farms. National seminar on conservation of biodiversity and coastal aquaculture, technical session IV. P 47.	Abstract only
Nagarajan T. 1996. Seaweed culture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Neeraja N, Murugesan AG, Sukumaran N. 1996. Role of probiotics in aquaculture. State level seminar on	Abstract only

problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	
Neospark Co. Studies on some ecological and pathological aspects in shrimp farms of *Penaeus monodon* (Fabricus) at Vakapadu, Visakhapatnam district. PhD synopsis.	Abstract only; no intervention
Neukirch M, Bottcher K, Bunnajirakul S. 1999. Isolation of a virus from koi with altered gills. *Bulletin of the Eurpoean Association of Fish Pathologists.* **19** (5): 221-224.	No statistical analysis
Nonthasakol T. 2000. The immunological study of black tiger prawn (*Penaeus monodon*) vaccinated with Norvax ® ShrimpVib. Veterinary Medical Aquatic Animal Research Centre, Faculty of Veterinary Science, Chulalongkorn University.	Imcomplete results – experiment terminated
Pal AK, Reddy AK, Pandey BD. 2002. Use of Raafres as non-antibiotic growth promoter in *Macrobrachium rosenbergii* juveniles. Report on contract research project, Central Institute of Fosheries Education, Mumbai, India.	No statistical analysis
Ponnuraj M, Murugesan AG, Sukumaran N. 1996. Role of Chromosome manipulation in aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Rajan AN, Ravindran AD. 1996. Growth of certain ornamental fish fed with single cell protein substituted feeds. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Rajee Q, Sukumaran N, Santhanakumar G. 1996. Culture of larvivorous fishes. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Rajesh M. 1996. Immunomodulatory effect of aluminium in *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Richard M, Rajan B. 1996. Immunostimulation by vitamin A in *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Robles R, Sorgeloss P, Van Duffel H, Nelis H. 1998. Progress in bioremediation using live foods. *Journal of Applied Ichthyology*. **14**: 207-212.	Outside target countries
Rombaut G, Dhert P, Vandenberghe J, Verschuere L, Sorgeloos P, Verstraete W. 1999. Selection of bacteria enhancing the growth rate of axenically hatched rotifers (*Brachionus plicatilis*). *Aquaculture.* **176**: 195-207.	Outside target countries
Rombaut G, Grommen R, Zizhong Z, Vanhoof V, Suantika G, Dhert P, Sorgeloos P, Verstraete W. 2003. Improved performance of an intensive rotifer culture system by using a nitrifying inoculum (ABIL). *Aquaculture*	Outside target countries

Research. **34**: 165-174.	
Selvaraj AM, Santhanakumar G. 1996. Fish processing and preservation. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Selvin J, Lipton AP. 2002. Development of a rapid 'mollusc foot adherence bioassay' for detecting potent antifouling bioactive compounds. *Current Science.* **83** (6): 735-736.	Outside target species
Shripatrao JV. 2002. Bioremediation of non-specific immune response in the tiger shrimp *Penaeus monodon* Fabricus with spirulina incorporated diet. MSc thesis submitted to Kerala Agricultural University, India.	Abstract only
Shome R, Shome BR, Soundararajan R. 1999. Studies on luminous *Vibrio harveyi* isolated from *Penaeus monodon* larvae reared in hatcheries in Andamans. *Indian Journal of Fisheries.* **46** (2): 141-147.	Outcome measures not related to aquatic animal health – bacterial characteristics
Shome R, Soundararajan R, Shome BR. 1999. Biofilm of luminous bacteria: A threat to hatchery production of larvae of *Penaeus monodon* in Andaman. *Fishing Chimes.* **18** (10): 19-20.	No intervention
Shome R, Shome BR, Krishnamurthy V, Soundarajan R, Saragi N. 1999. Fish disease investigations in Bay islands. *Fishing Chimes.* **19** (5): 35-39.	Review
Sorgeloos P, Dhert P, Candreva P. 2001. Use of brine shrimp, *Artemia* spp., in marine fish larviculture. *Aquaculture.* **200**: 147-159.	Outside target countries
Sorgeloos P, Coutteau P, Dhert P, Merchie G, Lavens P. 1998. Use of brine shrimp, *Artemia* spp., in larval crustacean nutrition: A review. *Reviews in Fisheries Science.* **6** (1-2): 55-68.	Outside target countries
Stead S. 2000. Management of Scotland's salmon resource – Advances in aquaculture. *Periodicum Biologorum.* **102:** 557-563. Supplement 1.	Outside target countries
Stead SM, Houlihan DF, McLay HA, Johnstone R. 1996. Effect of rration and seawater transfer on food consumption and growth of Atlantic salmon (*Salmo salar*) smolts. *Canadian Journal of Fisheries and Aquatic Science.* **53**: 1030-1037.	Outside target countries
Stead SM, Houlihan DF, McLay HA, Johnstone R. 1999. Food consumption and growth in maturing Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Science.* **56**: 2019-2028.	Outside target countries
Sudhan T. 1996. Immunostimulatory effect of vitamin E in *Oreochromis mossanbicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Sukumaran N. 1996. Application of biotechnology in aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Sukumaran N, Sankaran P. 1996. Effect of dietary lipid levels on growth, feed conversion and protein utilisation in fingerlings of carp, *Cirrhinus mrigala* (Hamilton). State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only

Santhanakumar G, Selvaraj AM. 1996. Integrated fish farming. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Santhanakumar G, Selvaraj AM. 1996. Freshwater fish seed resources. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Thampi Sam Raj YC, Vinod PN, Ramar G, Maharajan A, Dhandapani K. 2003. Commercial seabass seed production – RGCA shows the way. *INFOFISH International.* **2**: 8-13.	Review
Thampy DM, Sebastian MJ, Thankappan PC, Cherian CJ, Jayachadran KV. 1993. Post-mortem report for fishes. *Fishing Chimes.* P 35.	No intervention
Thankappan PC, Sebastian MJ, Thampy DM, Nirmalakumari KR, Mrithunjayan PS. 1993. A case of lordosis and kyphosis combination in the fish *Cirrhinus mrigala.* P 45.	No intervention
Vasudevan S. 2002. Aquafeed production for the shrimp grow-out industry. *Aqua Feed International.* **5** (2): 21-23.	Review
Velayudhaperumal S. 1996. Pollution and aquaculture. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Venkatesan P. 2000. Immunomodulation by leaf extracts of *Ocimum sanctum* Linn. And *Crossandra infundibuliformis* administered by immersion in *Oreochromis mossambicus* (Peters). Dissertation submitted to the American College, Madurai in partial fulfilment of the degree of Master of Philosophy in Zoology.	Abstract only
Venkateswara Rao A. 2003. Bioremediation for healthy ecology. *Employment News Weekly*. **27** (43): 1-3.	Review
Venkateswaran TV. 1996. The coastal aquaculture bill: a critical review. State level seminar on problems and prospects of aquaculture, 23-25th February, 1996. Society for Environmental Education and Development, Postgraduate Department of Zoology, Nagercoil, India.	Abstract only
Verschuere L, Rombaut G, Sorgeloos P, Verstraete W. 2000. Probiotic bacteria as biological control agents in aquaculture. *Microbiology and molecular biology reviews.* **64** (4): 655-671.	Outside target countries
Verschuere L, Heang H, Criel G, Sorgeloss P, Verstraete W. 2000. Selected bacterial strains protect *Artemia* spp. From the pathogenic effects of *Vibrio proteolyticus* CW8T2. *Applied and Environmental Microbiology.* **66** (3): 1139-1146.	Outside target countries
Verschuere L, Rombaut G, Huys G, Dhont J, Sorgeloos P, Verstraete W. 1999. Microbial control of the culture of *Artemia* juveniles through preemptive colonisation by selected bacterial strains. *Applied and Environmental Microbiology*. **65** (6): 2527-2533.	Outside target countries
Conference proceedings	
Reference	**Reason for exclusion**

Ali A, Karunasagar I, Karunasagar I. 1997. Effect of oxytetracycline in the immune response of *Labeo rohita* to *Aeromonas hydrophila* vaccine. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 187-191.	Obtained after time limit
Areechon N, Karoon B. 1993. Comparative studies on disease resistance and immunological response to *Aeromonas hydrophila* in a catfish hybrid and its parent species. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 21.	Abstract only
Areechon N, Karoon B. 1995. Comparative studies on resistance and immunological response of a hybrid catfish and the parent species to *Aeromonas hydrophila*. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 451-457.	Obtained after time limit
Areechon N, Suyawanish T. 2002. Effects of *Artemia* enriched with L-ascorbyl dipotassium-2-sulfate dehydrate on stress tolerance and disease resistance of *Penaeus monodon* postlarvae. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 105-111.	Obtained after time limit
Arthur JR. 1995. Efforts to prevent the international spread of diseases of aquatic organisms, with emphasis on the Southeast Asian region. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 9-25.	Review
Azad IS, Shankar KM, Mohan CV. 1997. Evaluation of an *Aeromonas hydrophila* biofilm for oral vaccination of carp. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 181-185.	Obtained after time limit
Babu MM, Marian MP. 2001. Developing bioencapsulated herbal products for maturation and quality larval production in *Penaeus monodon* (L.). Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001.	No statistical analysis
Baijal M, Saxena K. 1993. Effect of artificial diets on length-weight relationship and condition factor during early life of *Cyprinus carpio* (L.). The Third Indian Fisheries Forum Proceedings, 11-14th October, 1993, Pantnagar, India. p 27-32.	No statistical analysis
Bainy ACD. 1998. Biochemical and physiological changes in shrimp caused by contaminants. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Bhat SG, Singh ISB, Varghese V. 1998. Segregation of pathogenic strains from the family Vibrioniaceae associated with the larvae of *Macrobrachium rosenbergii* in hatchery. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Bhowmik ML, Pandey BK, Sarkar UK. Infleunce of domestic sewage on fish and incidence of microbial population. Thomas PC (Eds). Current and emerging trends in aquaculture. Daya publishing house, New Delhi, India. p 35-38.	No statistical analysis

Boonyaratpalin S, Boonyaratpalin M, Supamattaya K, Toride Y. 1993. Effects of peptidoglycan (PG) on growth, survival, immune response and tolerance to the stressor in black tiger prawn (*Penaeus monodon*). Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 5.	Abstract only
Chakrabarti R, Kumar S. 2001. Effect of feed protein manipulation on the survival, growth and enzyme activities of *Cirrhinus mrigala* larvae. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 129-132.	Obtained after time limit
Chanphong J, Chinabut S, Polchana J, Thompson K, Adams A. 2002. Production and characterisation of a monoclonal antibody against *Aeromonas hydrophila*. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP52.	Abstract only
Chinabut S. 1995. Epizootic ulcerative syndrome: the current state of knowledge. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 285-290.	Review
Danayadol Y, Direkbusarakom S, Supamattaya K. 1995. Viral nervous necrosis in brownspotted grouper, *Epinephelus malabaricus*, cultured in Thailand. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 227-233.	No statistical analysis
Danayadol Y, Direkbusarakom S, Boonyaratpalin S, Miyazaki T, Miyata M. 1997. Iridovirus infection in brown-spotted grouper (*Epinephelus malabaricus*) cultured in Thailand. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 67-72.	No statistical analysis
De Silva SS. 2000. A global perspective of aquaculture in the new millennium. International conference on aquaculture in the third millennium. Book of synopses. 20-25th February, 2000, Bangkok, Thailand. p 51-81.	Review
Direkbusarakom S, Danayadol Y. 2002. Effect of *Spirulina* sp. On antibody titer of seabass, *Lates calcarifer*. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP61.	Abstract only
Direkbusarakom S, Herunsalee A, Bonnyaratpalin S, Danayadol Y, Aekpanithanpong U. 1995. Effect of *Phyllanthus* spp. Against yellow-head baculovirus infection in black tiger shrimp, *Penaeus monodon.* Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 81-88.	No statistical analysis
Dube K. 1993. Effect of vitamin E on the fecundity and maturity of *Heteropneustes fossilis* (Bloch.). The Third Indian Fisheries Forum Proceedings, 11-14th October, 1993, Pantnagar, India. p 101-103.	No statistical analysis
Dung TT, Crumlish M. 2001. Infection by ectoparasites in cultured *Pangasius* catfish fingerlings in the Mekong Delta. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 166-169.	No statistical analysis
Dunham R, Majumdar K, Hallerman E, Hulata G, Gjedrem T, Mair G, Bartley D, Gupta M, Liu Z. 2000.	Review

Aquaculture genetics in the third millennium. Subasinghe RP, Bueno P, Phillips MJ, Hough C, McGalddery SE, Arthur JE (Eds). Aquaculture in the third millennium – Technical proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25th February, 2000. NACA, Bangkok and FAO, Rome. p 139-144.	
Ekpanithanpong U, Boonyaratpalin S, Direkbusarakom S. 1993. Efficacy of calcium hypochlorite as a disinfectant against yellow-head disease baculovirus in tiger prawn (*Penaeus monodon*). Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 76.	Abstract only
Evelyn TPT. 2002. Finfish immunology and its use in preventing infectious diseases in cultured finfish. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 303-324.	Review
Fegan DF. 1998. Practical aspects of disease control in commercial shrimp farms. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Fegan DF. 2001. Commercial larviculture of penaeid shrimp. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 202-203.	Review
Flegel TW. 2002. Emerging shrimp diseases and innovations to prevent their spread. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 137-149.	Review
Flegel TW, Fegan DF. 1995. Environmental control of infectious shrimp diseases in Thailand. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 65-79.	Review
Flegel TW, Boonyaratpalin S, Withyachumnarnkul B. 1997. Progress in research on yellow-head virus and white-spot virus in Thailand. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 285-295.	Review
George MR, John KR, Sundararaj V. 2002. Immunisation trials in penaeid shrimps using pathogenic *Vibrio alginolyticus*. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP16.	Abstract only
Graslund S, Bergqvist P, Bengtsson B. 2002. Potential formation of toxic by-products from the use of chlorine as a disinfectant in intensive shrimp farming in Southeast Asia. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP25.	Abstract only
Hao NV, Te BQ, Loan LTT, Yen LTP, Thanh LM. 1997. Pathogens in cultured shrimp in southern Vietnam. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 233-239.	No intervention

Hatano K, Arakawa T, Hioki N, Watanabe S, Miyazaki T. 1993. What acidifies the pond water of black tiger prawns in Thailand? Trials to control the water quality with calcium cilicate hydrate powder (Ceraclean). Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 22.	Abstract only
Horne MT, Poy M, Pranthanpipat P. 1995. Control of vibriosis in black tiger shrimp, *Penaeus monodon*, by vaccination. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 459-467.	No statistical analysis
Huong LTL. 2002. Methods of diagnosis and prevention of shrimp diseases caused by bacteria and virus in the central region of Vietnam. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP09.	Abstract only
Inglis V, Abdullah SZ, Angka SL, Chinabut S, Chowdbury MBR, Leano EM, MacRae IH, Sasongko A, Somsiri T, Yambot AV. 1997. Survey of resistance to antibacterial agents used in aquaculture in five southeast Asian countries. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 331-337.	No intervention
Itami T, Takahashi Y, Tsuchihira E, Igusa H, Kondo M. 1993. Enhancement of disease resistance of Kuruma prawn, *Penaeus japonicus*, after oral administration of peptidoglycan. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 6.	Abstract only
Jirayanichpaisal P, Traisresin C, Puanglarp N, Phumathon P, Chanratchakool P, Menasveta P. 2002. Growth promotion and enhancement of vibriosis resistance in penaeid shrimp after oral administration of lactic acid bacteria and marine bacteria. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP17.	Abstract only
Jiravanichpaisal P, Puanglarp N, Traisresin C, Pongtunya P, Chanratchakool P, Menasveta P. 2002. Growth promotion and enhancement of vibriosis resistance in penaeid shrimp after oral administration of lactic acid bacteria and marine bacteria. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 93-103.	Obtained after time limit
Kanchanakhan S, Chinabut S, Tonguthai K. 2002. Epizootic ulcerative syndrome of fishes: rhabdovirus infection and EUS induction experiments in snakehead fish. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 383-394.	No statistical analysis
Kanchanakhan S, Chinabut S, Tonguthai K, Richards RH. 2002. Epizootic ulcerative syndrome of fishes: Rhabdovirus infection and EUS induction experiments in snakehead fish. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP78.	Abstract only
Karunasagar I, Sugumar G, Karunasagar I. 1995. Virulence characters of *Aeromonas* spp. Isolated from EUS-affected fish. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section,	No intervention

Asian Fisheries Society, Manila. p 307-314.	
Karunasagar I, Otta SK, Devaraj TN, Shubha G, Karunasagar I. 1998. Immunostimulation of *Penaeus monodon* through the oral route. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Kasornchandra J. 2002. Major viral and bacterial diseases of cultured seabass and groupers in Southeast Asia. Diseases in aisan aquaculture IV. Lavilla-Pitogo CR, Cruz-Lacierda ER (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 205-212.	Review
Kaushik S. 2000. Applied nutrition for sustainable aquaculture development. Subasinghe RP, Bueno P, Phillips MJ, Hough C, McGaldderry SE, Arthur JE (Eds). Aquaculture in the third millennium – Technical proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25th February, 2000. NACA, Bangkok and FAO, Rome. p 155-158.	Review
Khongpradit R, Kasornchandra J, Bonnyaratpalin S. 1993. Susceptibility of the post-larval stages of lack tiger prawn (*Penaeus monodon*) to yellow-head baculovirus (YBV). Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 77.	Abstract only
Kim VV, Turnbull JF, Chinabut S. 2002. Investigation of red spot disease of grass carp (*Ctenopharyngodon idella*) in cultural systems in Vietnam. The Fourth Symposium on Diseases in Asian Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asina Fisheries Society, Philippines. PP79.	Abstract only
Kongkeo H. 2000. Asian aquaculture: Review of the trends, issues and prospects. International conference on aquaculture in the third millennium. Book of synopses. 20-25th February, 2000, Bangkok, Thailand. p 11-16.	Review
Langer RK, Somalingam J. 1993. Experimental culture of freshwater prawn in ponds at Powerkheda, Hoshangabad. The Third Indian Fisheries Fourm Proceedings, 11-14th October, 1993, Pantnagar, India. p 65-66.	No statistical analysis
Lavilla-Pitogo CR. 1995. Bacterial diseases of penaeid shrimps: an Asian view. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 107-121.	Review
Lim LC, Dhert P, Sorgeloos P. 2001. Recent developments in the application of live foods in the ornamental fish industy. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 313-314.	Review
Limsuwan C, Lamkom T, Chanratchakool P, Capelo F-X. 1993. Efficacy of oxolinic acid against *Vibrio alginolyticus* infection in black tiger shrimp. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 72.	Abstract only
Manjusha M, Varghese R, Singh ISB, Philip R. 2002. Histological demonstration of white spot virus and histopathology in experimentally infected moribund *Penaeus indicus* H. Milne Edwards in India. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP10.	Abstract only

Marte CL. 2001. Larviculture of marine species in Southeast Asia: Current research and industry status. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 333-335.	Review
Martin J-LM, Fuchs J, Populus J, Guelorget O. 1998. Shrimp production performance: the relationship with environmental conditions in ponds and the coastal environment. Development of a helping tool for site selection and for diagnosis of impact. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Mialhe E, Cedeno V, Bachere E, Rodriguez J, Bedier E, Goyard E, Boulo V, CAdoret J-P. 1998. Quantitative genetics and genetic transformation for the selection of pathogen-resistant strains. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Mitra G, Mukhopadhyay PK. 2001. Effect of feeding ascorbic acid enriched zooplankton on survival, growth and tissue biochemical composition of *Labeo rohita* larvae. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 381-385.	Obtained after time limit
Mohan CV, Shankar KM. 1995. Role of fungus in epizootic ulcerative syndrome of fresh- and brackishwater fishes of India: a histopathological assessment. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 299-305.	No intervention
Mohan CV, Shankar KM. 2002. Susceptibility of Indian major carps to epizootic ulcerative syndrome (EUS). The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP79.	Abstract only
Panchayuthapani D. 1997. A survey of shrimp diseases in India. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 225-232.	No intervention
Pawase AS, Shenoy S. Experimental farm trial on *Penaeus merguiensis* in Ratnagiri (Konkan, Maharashtra). Thomas PC (Eds). Current and emerging trends in aquaculture. Daya publishing house, New Delhi, India. p 74-79.	No statistical anlaysis
Phromkunthong W, Storch V, Supamattaya K, Boonyaratpalin M. 1995. Effects of ascorbic acid deficiency on the gill and liver histopathology of grouper, *Epinephelus malabaricus*. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 503-512.	No statistical analysis
Phuwapanish N, Witchawut M. 2001. Extensive rearing of seabass larvae using *Artemia.* Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 469-472.	No statistical analysis
Plumb JA. 1993. Chemotherapy vs vaccination: a reality for asian aquaculture? Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 34.	Abstract only
Plumb JA. 1995. Chemotherapy vs. vaccination: a reality for Asian aquaculture. Diseases in asian aquaculture II.	Review

Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 43-53.	
Poy M, Pranthanpipat P, Horne MT. 1993. Control of vibrio disease in *Penaeus monodon* by vaccination. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 19.	Abstract only
Prakash P. Effects of water qualities and biogenic capacities on fish growth in freshwater ponds of Barrackpore (West Bengal). Thomas PC (Eds). Current and emerging trends in aquaculture. Daya publishing house, New Delhi, India. p 65-68.	No intervention; no statistical anlaysis
Radheyshyam, Sharma BK, Chattopadhyay GN, Sarkar SK, Satpathy BB. 1993. Effects of phased increase in water level on the survival of *Cyprinus carpio* (L.) fry in nursery ponds. The Third Indian Fisheries Forum Proceedings, 11-14th October, 1993, Pantnagar, India.p 59-63.	No statistical analysis
Raina HS, Sunder S, Naulia U. 1993. Nutritional requirements for the juveniles of golden mahseer *Tor putitora* (Ham.). The Third Indian Fisheries Forum Proceedings, 11-14th Ocotber, 1993, Pantnagar, India. p 5-8.	No statistical analysis
Reddy AK, Sinha A, Sinha PSRK. 1993. Efficacy of formalin for the treatment of *Zoothamnium* infection in freshwater prawn hatchery. The Third Indian Fisheries Forum Proeedings, 11-14th October, 1993, Pantnagar, India. p 113-114.	No statistical analysis
Reddy AK, Sinha PSRK, Chandraprakash, Venkateshvaran K. 1993. Effect of stocking density on growth and survival of *MAcrobrachium rosenbergii* (de Man) post-larvae. The Third Indian Fisheries Forum Proceedings, 11-14th October, 1993, Pantnagar, India. p 37-39.	No statistical analysis
Roberts R. 1995. Aquatic animal health towards 2000. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 3-7.	Review
Roque A, Turnbull JF, Alday-Sanz, MV. 1993. Initial development of a *Vibrio* spp. Bath challenge method for the marine shrimp *Penaeus monodon.* Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 81.	Abstract only
Ruangpan L, Sangrungruang K. 1993. Bacterial flora of rearing water at different stocking densities of black tiger shrimp, *Penaeus monodon.* Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 73.	Abstract only
Ruangpan L, Tabkaew R, Sangrungruang K. 1995. Bacterial flora of ponds with different stocking densities of black tiger shrimp, *Penaeus monodon*. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 141-149.	No statistical analysis
Ruangpan L, Prapadsorn S, Sangrungruang K. 1997. Bacterial flora in sediments of black tiger shrimp ponds. Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 313-316.	Not related to aquatic animal health – bacterial flora
Ruangpan L, Direkbusarakom S, Danayadol Y, Pechmanee T, Predalumpaburt Y, Chanphong J.2002.	Abstract only

Development of *Clinacanthus nutans* for control of viral disease in black tiger prawn (*Penaeus monodon*). The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP21.	
Rukyani A, Ruchimat T, Sunarto A. 2002. Earthen pond trials of lipopolysaccharide (LPS) as an immunostimulant for shrimp. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP33.	Abstract only
Sahoo PK, Mukherjee SC. 2002. Immunosuppressive effects of aflatoxin B1 in Idian major carp (*Labeo rohita*). The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. PP56.	Abstract only
Shankar KM, Umesh NR, Mohan CV. 1993. Development of bacterial biofilm in ponds for possible application in oral vaccination of carps. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 99.	Abstract only
Singh AK, Das P. 1993. A technique for hormonal sex control in *Oreochromis mossambicus* (Peters). The Third Indian Fisheries Forum Proceedings, 11-14th October, 1993, Pantnagar, India. p 75-76.	No statistical analysis
Sirinarumitr T, Boonyawiwat V, Lertwatcharasarakul P, Srisook T, Wajjwalku W. 2002. A Thai foeld isolate of systemic ectodermal and mesodermal baculovirus (SEMBV) induces apoptosis in experimentally infected *Penaeus monodon*. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP09.	Abstract only
Somsiri T, Wannaprapa M, Soontornvit S. 1997. Accumulation of oxytetracycline in hybrid catfish (*Clarias gariepinus X C. macrocephalus*). Diseases in asian aquaculture III. Flegel TW, MacRae IH (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 327-329.	Obtained after time limit
Song Y, Huang C. 2002. Application of immunostimulants to prevent shrimp diseases. The Fourth Symposium on Diseases in Asuan Aquaculture, 22-26th November, 1999, Cebu City, Philippines. Fish Health Section, Asian Fishreies Society, Philippines. OP30.	Abstract only
Sorgeloos P, Coutteau P. 1998. Importance of diet on shrimp postlarval quality. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Subasinghe R, Bernoth E. 2000. Disease control and health management. Aquaculture in the third millennium – Technical proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25th February, 2000. Subasinghe RP, Bueno P, Phillips MJ, Hough C, McGalddery SE, Arthur JE (Eds). NACA, Bangkok and FAO, Rome. p 145-153.	Review
Suwanto A, Hala Y. 1998. Introduction and expression of ice nucleation gene in luminous *Vibrio* isolated from shrimp larvae. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Tanasomwang V, Ruangpan L. 1993. Bacterial flora of black tiger shrimp, *Penaeus monodon*. Second	Abstract only

symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 16.	
Tanasomwang V, Ruangpan L. 1995. Bacterial flora of larvae of he black tiger shrimp, *Penaeus monodon*. Diseases in asian aquaculture II. Shariff M, Arthur JP, Subasinghe RP (Eds). Fish Health Section, Asian Fisheries Society, Manila. p 151-162.	No statistical analysis
Tangtrongpiros J, Kueyputsa V, Nitibhon M. 1993. Vaccination of hybrid catfish (*Clarias macrocephalus* vs. *C. gariepinus*) against *Aeromonas* infections: preliminary results. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 92.	Abstract only
Tangtrongpiros J, Kueyputsa V, Nitibhon M. 1993. The use of immune products in shrimp disease prevention: preliminary observations. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 93.	Abstract only
Turnbull JF, Chanratchakool P. 1998. Field trials as a means of evaluating immunostimulation in shrimp health management. Workshop on shrimp immunity and disease control: An integrated approach, 8-10th November, 1998, Chiang Mai, Thailand.	Abstract only
Van Horenbeeck T, Merchie G, Wouters R, Nijs C, Tackaert W, Dinneweth C. 2001. Development of a nutritional flake for shrimp larviculture. Larvi 2001, Fish and shellfish larviculture symposium. Hendry CJ, Van Stappen G, Wille M, Sorgeloss P (Eds). European Aquaculture Society, Special Publication No. 30, Oostende, Belgium, 2001. p 618-621.	Obtained after time limit
Vasudevappa C, Swamy V, Mohire KV, Kumari NB. Cukture of giant freshwater prawn *Macrobrachium rosenbergii* – a case study. Thomas PC (Eds). Current and emerging trends in aquaculture. Daya publishing house, New Delhi, India. p 69-73.	No intervention; no statistical analysis
Yoshimizu M, Oh M-J, Ezura Y, Kimura T. 1993. Disinfectant effect of oxidant produced by ozonisation of sea water. Second symposium on diseases in Asian aquaculture. Aquatic animal health and the environment. Scientific sessions abstracts. 25-29th October, 1993, Phuket, Thailand. Fish Health Section, Asian Fisheries Society. p 48.	Abstract only
Theses	
Reference	**Reason for exclusion**
Hawthorn SC. 1995. Bacterial remediation product impacts on shrimp pond environments. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit

Karapanagiotidis I. 2000. A comparative study of the lipid nutritive value of wild tilapia and fish reared under different culture conditions in Thailand. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Kim VV. 1999. A study of Red Spot Disease (RSD) of grass carp (*Ctenopharyngodon idella*) in Vietnam. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Marsden W. 1994. Modern shrimp farming sustainability and environmental impact. An investigation in Chanthaburi province, Thailand. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Mar Tovar CL. 1998. An alternative system of transportation for common carp fry (*Cyprinus carpio* L.) in Eastern India. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Murray F. 1998. Potential for integrated aquaculture in farmer-managed micro-irrigation systems in Karnataka state, India. A situation analysis. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Prax J. 2000. Analysis of the fish seed production and distribution network in Mao Dien Commune Red River Delta, Northern Vietnam. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Tarazi MJN. 1998. Development of a small-scale solar-powered carp hatchery with water recirculation for water scarce regions in the tropics. A practical field investigation carried out in Eastern India. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	Unable to carry out data extraction before time limit
Vogliotti Skender G. 1995. Water quality characteristics and their relation to management strategies in an intensive black tiger shrimp *Penaeus monodon* farm and an intensive soft	Unable to carry out data extraction before time limit

shell crab *Scylla serrata* farm in Ranong Province, South West Thailand. Thesis submitted in accordance with the requirements of the University of Stirling for the degree of Master of Science.	
Documents from collaborating and associated institutes in India, Thailand and Vietnam	
Reference	**Reason for exclusion**
Abraham TJ, Palaniappan R. 2000. UV inactivation and photoreactivation of luminous *Vibrio harveyi* and *Vibrio splendidus. Journal of Aquaculture in the Tropics*. **15** (1): 59-64.	Obtained after time limit
Abraham TJ, Shanmugam SA, Uma A, Palaniappan R, Dhevandaran K. 2001. Biocontrol of shrimp bacterial pathogens using penaeid larva associated bacterium, *Alteromonas* sp. *Journal of Aquaculture in the Tropics*. **16** (1): 11-22.	Obtained after time limit
Acharya S. 2002. Humoral and cellular defense factors in Indian river prawn, *Macrobrachium malcolmsonii*: A preliminary study. *M.F.Sc. Thesis Abstract.* Central Institute of Fisheries Education, Mumbai.	Obtained after time limit
Achuthan C, Singh ISB, Philip R. 1999. Development of consortia of nitrifying bacteria for penaeid culture systems. *The Fourth Indian Fisheries Forum Proceedings held during 24-28th November, 1996, Kochin.* p. 345-347.	Obtained after time limit
Aekpanitanpong U, Krachaiwong V, Boonyaratpalin S. 1995. Residues of oxytetracyclin to black tiger prawn (*Penaeus nonodon*) and sediments from shrimp farms in Songkhla Province. NICA Technical paper: No. 6/1995. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Ahmed S. 1995. Assessment of chlorine as a piscicide in freshwater fish culture. For the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Obtained after time limit
Anabarasu K, Aruna BY, Chandran MR. 1998. Immunisation of catfish *Mystus gulio* against *Aeromonas hydrophila*. National Seminar on Aquaculture in the Changing Environmental	Obtained after time limit

Perspectives, 25-27th March, 1998. p. 58.	
Anbarasu K, Thangakrishnan K, Aruna BV, Challdran MR. 1998. Assessment of immune response in freshwater catfish *Mystus vittatus* (Bloch) to different bacterins of *Aeromonas hydrophila*. *Indian Journal of Experimental Biology*. **36**: 990-995.	Obtained after time limit
Anikumari NP, Mohamed KS. 2003. Optimum enrichment duration of two probiotic organisms in *Artemia* metanauplii. National Conference on Aquaculture Nutrition. NATP and CMFRI, Kochi, 12-14th March, 2003. Abstract **25**: 61.	Obtained after time limit
Anon. Antifungal activity and mode of action of saponins from *Madumca butyracea* Mach.	Not related to aquatic animal health
Arghese VV, Singh ISB, Bhat SG. Application of bacterins and yeast to protect the larvae of *Macrobrachium rosenbergii* from vibriosis.	Obtained after time limit
Ariyavongvadhana P. 2000. Effects Of Tributylitin Oxide On Embryonic And Larval Development Of Giant Freshwater Prawn *Macrobrachium rosenbergii* de Man. Master. Science (Inter-Program Environmental Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Azad IS, Shankar KM, Mohan CV, Kauta B. 1999. Protective response of common carp orally vaccinated with biofilm and free cells of *Aeromonas hydrophila* challenged by injection and immersion routes. *Journal of Aquaculture in the Tropics*. **15** (1): 65-70.	Obtained after time limit
Azad IS, Shekhar MS, Mishra SS, Santiago TC, Rao LH. 2001. Virulence and histopathology of *Aeromonas hydrophila* (SAH 93) in experimentally infected tilapia, *Oreochromis mossambicus* (L.). *Journal of Aquaculture in the Tropics*. **16** (3): 265-275.	Obtained after time limit
Azad IS, Rajendran KV, Rajan JJS, Vijayan KK, Santiago TE. 2002. Detection of WSV specificity to different tissues of tiger shrimp (*Penaeus monodon*) from the East coast of India, by polymerase chain reaction and histopathology. *Journal of Aquaculture in the Tropics*. **17** (3): 175-184.	Obtained after time limit

Barman et al. 2002. Identification of virulence specific RAPD markers of the fish pathogen *Aeromonas hydrophila*. *Aquaculture*	Obtained after time limit
Baruah ND, Prasad KP. 2001. Efficacy of levamisole as an immunostimulant in *Macrobrachium rosenbergii* (de Man). *Journal of Aquaculture in the Tropics*. **16** (2): 149-158.	Obtained after time limit
Bhat SG, Singh ISB. 1998. Vibrionaceae associated with the larvae and larval rearing system of *Macrobrachium rosenbergii*: Systematics and pathogenicity. *In:* Flegel TW (Eds). Advances in shrimp biotechnology. National Centre for Genetic Engineering and Biotechnology, Bangkok.	Obtained after time limit
Bhat SG, Singh ISB. 1999. Heterotrophic bacteria associated with healthy and moribund larvae of *Penaeus monodon* H. Milne Edwards. *The Fourth Indian Fisheries Forum Proceedings held during 24-28th November, 1996, Kochin.* p. 327-330.	Obtained after time limit
Bhuttajaroen A. The causes of poor growth and low survival rate in fresh water prawn (*Macrobrachium rosenbergii*) culture. *Aquatic Animal Diseases Newsletter*. **13** (1): 2-3. 2003. Bangkok, AAHRI.	Obtained after time limit
Booncher K. 1998. The Comparison of Some Soil and Water Properties between low and High Yield Ponds of Giant Tiger Shrimp (*Penaeus monodon*) : A Case Study at Tambon Na Saton Amphoe Hua-Sai Changwat Nakhon Si Thammarat. Master. Science (Environmental Management) Prince of Songkla University. Songkla (Thailand).	No intervention
Boonklomjitr S. 1996. Effects of Zinc and pH on *Puntius gonionotus* Bleeker. Master. (Environmental Biology). Mahidol University. Bangkok (Thailand).	Obtained after time limit
Boonyaratpalin M, Siripun N, Tookwinas S. 2003. Guideline and Regulation for Organic Marine Shrimp Farming in Thailand. *Thai Fisheries Gazette*. **56** (1): 11-17.	Review
Boonyaratpalin M, Pongmaneerat J, Borisut S, Boonchuay S. 1994. The effect of various	Obtained after time limit

supplemental methionine sources on growth and feed performances of shrimp (*Penaeus monodon*). NICA Technical paper: No. 14/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	
Chaibu P. 1995. The Relationship of Salinity and Povidone Iodine on the Death of Giant Tiger Prawn (*Penaeus monodon* Fabricius). Master. (Technology of Environmental Management). Mahidol University. Bangkok (Thailand).	Obtained after time limit
Chaiyanate N. 1994. Supplement of Astaxanthin Vitamin C, and Fish oil in Feed for Increased Resistance to Yellow-Head Disease in Juvenile Giant Tigers prawn. Master. Science (Biotechnology) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Chakrabarty A, Mukherjee M, Chakrabarty AN, Oastidar SG, Basak P, Saha B. 1996. Electron microscopic characteristics of actinomycetic agents having aetiological association with human leprosy and epizootic ulcerative syndrome of fish. *Indian Journal of Experimental Biology*. **34** (8): 810-812.	Obtained after time limit
Changingchit N, Klinpikul S, Thongrak S, Supamattaya K. 2003. A study of appropriate management for marine shrimp farm estates in Thailand. *Thai Fisheries Gazette*. **56** (1): 19-22.	No intervention
Chanpong J. Bacterial diseases in channel catfish (*Ictalurus punctatus*). *Aquatic Animal Diseases Newsletter*. **3** (1): 2-3. 1993. Bangkok, AAHRI.	Obtained after time limit
Chanpong J. A case report of diseased giant gouramy in Chainat province. *Aquatic Animal Diseases Newsletter*. **3** [2], 3-4. 1993. Bangkok, AAHRI.	Obtained after time limit
Chanpong J. Lernaea infection in fish. *Aquatic Animal Diseases Newsletter*. **4** (1): 6-8. 1994. Bangkok, AAHRI.	Obtained after time limit
Chanpong J. Columnaris disease. *Aquatic Animal Diseases Newsletter*. **4** (2): 6-8. 1994. Bangkok, AAHRI.	Obtained after time limit
Chanpong J. Sea lice. *Aquatic Animal Diseases Newsletter*. **5** (3): 7-9. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Some problems in shrimp farming during raining season. *Aquatic Animal Diseases Newsletter*. **3** (1): 5-6. 1993. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Pond preparation in intensive black tiger shrimp culture. *Aquatic Animal*	Obtained after time limit

Diseases Newsletter. **3** (2): 6-8. 1993. Bangkok , AAHRI.	
Chanratchakool P. A use of chlorine in black tiger shrimp farming. *Aquatic Animal Diseases Newsletter*. **4** (1): 5-6. 1994. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. A use of potassium permanganate in aquaculture. *Aquatic Animal Diseases Newsletter*. **4** (1): 8-9. 1994. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Shrimp farm management during cool weather period. *Aquatic Animal Diseases Newsletter*. **4** (2): 1-3. 1994. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Black tiger shrimp farm management in winter. *Aquatic Animal Diseases Newsletter*. **5** (1): 18-19. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Black tiger shrimp pond management. *Aquatic Animal Diseases Newsletter*. **5** (1): 6-9. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Pond preparation in intensive black tiger shrimp culture. *Aquatic Animal Diseases Newsletter*. **5** (1): 4-6. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Some measures to improve water quality and quantity in black tiger shrimp farm . *Aquatic Animal Diseases Newsletter*. **5** (1): 6-11. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Some problems in shrimp farming during raining season. *Aquatic Animal Diseases Newsletter*. **5** (1): 16-18. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. A use of chemicals and drugs in black tiger shrimp culture . *Aquatic Animal Diseases Newsletter*. **5** (1): 14-16. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. A use of chlorine in black tiger shrimp farming. *Aquatic Animal Diseases Newsletter*. **5** (1): 13-14. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. White spot disease of black tiger shrimp. *Aquatic Animal Diseases Newsletter*. **5** (1): 1-4. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Farm management tips for a black tiger shrimp culture in low salinity condition. *Aquatic Animal Diseases Newsletter*. **5** (3): 9-11. 1995. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Some measures of white spot disease prevention in black tiger shrimp. *Aquatic Animal Diseases Newsletter*. **6** (1): 8-11. 1996. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Does the viral shrimp diseases still remain their hassle? *Aquatic Animal Diseases Newsletter*. **6** (2): 6-9. 1996. Bangkok, AAHRI.	Obtained after time limit

Chanratchakool P. Strategies of black tiger shrimp culture in low salinity water. *Aquatic Animal Diseases Newsletter*. **8** (1): 7-9. 1998. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Black tiger shrimp farming in Thailand. *Aquatic Animal Diseases Newsletter*. **8** (2): 3-5. 1998. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Causes of diseased shrimp and some prevention. *Aquatic Animal Diseases Newsletter*. **11** (1): 5-6. 2001. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Problematic drug and chemical uses in aquaculture. *Aquatic Animal Diseases Newsletter*. **12** (2): 8-9. 2002. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P. Visiting the intensive white shrimp (*Penaeus vannamei*) farmings in Peru. *Aquatic Animal Diseases Newsletter*. **12** (1): 6-7. 2002. Bangkok, AAHRI.	Obtained after time limit
Chanratchakool P, Chinabut S. Liming in aquaculture. *Aquatic Animal Diseases Newsletter*. **5** (1): 11-12. 1995. Bangkok, AAHRI.	Obtained after time limit
Chantapa B. 1996. Optimal Protein-Energy Ratio in Artifical Diet for Juvenile, Black Tiger Prawn *Penaeus monodon*. Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Chanthawong A. 1993. Treatment of Wastewater from Intensive Culture of Black Tiger Prawn (*Penaeus Monodon*) by Using Agar Seaweed (Gracilaria – Verrucosa). Master. Science (Environmental Management). Graduate School. Prince of Songkla University Thailand.	Outcome measures not related to aquatic animal health
Chinabut S. A use of malachite green for aquatic disease treatment. *Aquatic Animal Diseases Newsletter*. **3** (1): 7-8. 1993. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Lymphocystis. *Aquatic Animal Diseases Newsletter*. **3** (2): 1-2. 1993. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Mycobacteriosis in exporting ornamental fish. *Aquatic Animal Diseases*	Obtained after time limit

Newsletter. **4** (1): 2-3. 1994. Bangkok, AAHRI.	
Chinabut S. Rust disease. *Aquatic Animal Diseases Newsletter*. **4** (2): 8-10. 1994. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Diseases of giant freshwater prawn. *Aquatic Animal Diseases Newsletter*. **5** (3): 3-7. 1995. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Sea lice. *Aquatic Animal Diseases Newsletter*. **6** (2): 4-5. 1996. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Threatening parasitic diseases from fish to man. *Aquatic Animal Diseases Newsletter*. **7** (1): 1-5. 1997. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. An outbreak of isopod in freshwater fish. *Aquatic Animal Diseases Newsletter*. **9** (1): 7-9. 1999. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. 2002. Antibiotic residue in shrimp. *Thai Fisheries Gazette*. **55** (3): 213-214.	Obtained after time limit
Chinabut S. Does the farm sanitary examination helpful or hessel? *Aquatic Animal Diseases Newsletter*. **12** (2): 2-3. 2002. Bangkok, AAHRI.	Obtained after time limit
Chinabut S. Attending Fish Vaccinology Conference in Norway. *Aquatic Animal Diseases Newsletter*. **13** (1): 13-15. 2003. Bangkok, AAHRI.	Obtained after time limit
Chitmon C. 1995. Effect of Chlorine on Intensive Black Tiger Shrimp Culture in Recycle System. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Chonprachr A. 2000. Utilization Of Golden Apple Snail (Pomacea canaliculata Lamarck) Dry Meat As A Substitue For Fish Meal In The Broilers Feed. Master. Science (Appropriate Technology for Resource Development). Mahidol University. Bangkok (Thailand).	Outside target species
Chooluck S. 1999. Cloning and Expression Of a cDNA Encoding Growth-Related Peptide Hormone Of *Penaeus monodon* in *Escherichia coli*. Master. Science (Molecular Genetics and Genetic Engineering) Mahidol University. Bangkok (Thailand).	Observational study

Danayadol Y, Direkbutsarakom S, Supamattaya K. 1993. A viral disease in paralytic syndrome of estuarine grouper (*Epinephelus malabaricus*). NICA Technical paper: No. 6/1993. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Danayadol Y, Direkbutsarakom S, Boonyaratpalin S. 1994. Epizootic haematopoietic necrosis, a new viral disease in seabass spawner, *Lates calcarifer*, cultured in Thailand. NICA Technical paper : No. 6/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Danayadol Y, Direkbutsarakom S, Boonyaratpalin S. 1994. Iridovirus – like infection in grouper, *Epinephelus malabaricus*, cultured in Thailand. NICA Technical paper: No. 13/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Darachai J. 1995. Effect of Astaxanthin from Haematococcus Pluvialis Nies144 on Growth of *Penaeus Monodon* Larvae. Master. Science (Biotechnology), Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Das BK, Mukherjee SC. Sub-lethal effect of quinalphos on selected blood parameters of *Labeo rohita* (Ham.) fingerlings. *Asian Fisheries Science.* **13**: 225-233.	Obtained after time limit
Das BK, Mukherjee SC. Effect of nuvan on haematology of rohu *Labeo rohita* (Ham.). *Indian Journal of Fisheries.* **48** (1): 85-92.	Obtained after time limit
Das BK, Mukherjee SC. 1997. Pathobiology of *Aeromonas* infection in rohu, *Labeo rohita* (Ham.) fingerlings. *Journal of Aquaculture.* **5**: 89-94.	Observational study
Das BK, Mukherjee SC. 1998. Behavioural and histopathological changes associated with urea toxicity in fingerlings of rohu, *Labeo rohita. Journal of Aquaculture.* **6**: 73-80.	Obtained after time limit
Das BK, Mukherjee SC. 1998. Symptomatology and histopathology of epizootic ulcerative	Observational study

syndrome in rohu, *Labeo rohita* (Ham.). *Indian Journal of Fisheries*. **45** (3): 315-319.	
Das BK, Mukherjee SC. 1998. Pathology of black spot disease in fry and fingerlings of rohu, *Labeo rohita* (Ham.). *Geobios*. **25**: 102-104.	Observational study
Das BK, Mukherjee SC. 1999. Effect of sublethal concentrations of nuvan on enzymatic profile of *Labeo rohita* (Ham.). *Journal of Aquaculture*. **7**: 43-50.	Obtained after time limit
Das BK, Mukherjee SC. 1999. Chronic toxic effects of quinalphos on some biochemical parameters in *Labeo rohita* (Ham.). *Toxicology Letters*. **144**: 11-18.	Obtained after time limit
Das BK, Mukherjee SC. 1999. A pathoanatomical study of myxoboliasis in fingerlings of rohu, *Labeo rohita* (Ham.). *Ad. Bios*. **18** (11); 79-84.	Observational study
Das BK, Mukherjee SC. 2000. A histopathological study of carp (*Labeo rohita*) exposed to hexachlorocyclohexane. *Veterinarski Arhi*. **70** (4): 169-180.	Obtained after time limit
Das BK, Mukherjee SC. 2003. Toxicity of cypermethrin in *Labeo rohita* fingerlings: biochemical, enzymatic and haematological consequences. *Comparative Biochemistry and Physiology. Part C: Toxicology & Pharmacology*. **134** (1): 109-121.	Obtained after time limit
Das BK, Mukherjee SC, Murjani G. 2000. Histopathological studies on the myxoboliasis of *Cirrhinus mrigala* (Hamilton-Buchannan). *Indian Journal of Fisheries*. **47** (1): 61-64.	Observational study
Das BK, Mukherjee SC, Murjani G. 2002. Acute toxicity of neem *Azadirachta indica* in Indian major carps. *Journal of Aquaculture in the Tropics*. **17** (1): 23-33.	Obtained after time limit
Das BK, Mukherjee SK, Sahu BB, Murjani G. 1999. Neem (*Azardirachta indica*) extract as an antibacterial agent against fish pathogenic bacteria. *Indian Journal of Experimental Biology*. **37** (11): 1097-1100.	Obtained after time limit

Das BK, Pattnaik P, Murjani G, Mukherjee SC. 2001. *Edwardsiella tarda* endotoxin as an immunopotentiator in singhi, *Heteropneustes fossilis* fingerlings. *Indian Journal of Experimental Biology*. **39** (12): 1311-1313.	Obtained after time limit
Dayal JS, Gopal C, Ali SA, Poornima M. 2003. Effect of vitamin C supplementation on growth and immune status in the juveniles of tiger shrimp, *Penaeus monodon* (Fabricus). National Conference on Aquaculture Nutrition. NATP and CMFRI Kochi, 12-14th March, 2003. Abstract **22**: 56-57.	Obtained after time limit
Dey RK, Mohanty AK, Chandra S. Effect of tumeric in combination with lime on the water quality parameters of fish ponds. *Journal of Aquaculture.* **5**: 83-87.	Obtained after time limit
Dinakaran Michael R, Quinn CG, Venkatalakshmi S. 1998. Modulation of humoral immune response by ascorbic acid in *Oreochromis mossambicus* (Peters). *Indian Journal of Experimental Biology*. **36** (10): 1038-1040.	Obtained after time limit
Direkbutsarakom S, Hirunsaree A, Rongkumnardwong S. 1996. The virucidal activity of nine species of herb against yellow head baculovirus on black tiger shrimp (*Penaeus monodon*). NICA Technical paper: No. 6/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	No statistical analysis
Direkbutsarakom S, Rongkumnardwong S, Hirunsaree A, Ruangpan L. 1996. Screening of Thai traditional herbs against shrimp pathogenic bacteria. NICA Technical paper: No. 7/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Direkbutsarakom S, Hirunsaree A, Boonyaratpalin S, Danayadol Y, Aekpanitanpong U. 1993. The virucidal activity of *Clinacanthus nutans* (Lindau) extracts against yellow head baculovirus on tiger prawn (*Penaeus monodon*). NICA Technical paper: No. 8/1993. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Donayadol Y, Krachaiwong V. 1996. Effects of some chemotherapeutic agents, hypersaline and freshwater on *Caligus* sp. Infection in seabass (*Lates calcarifer*). NICA Technical paper: No. 8/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla,	No statistical analysis

Thailand.	
Dung LT. 2000. Effects of *Aeromonas hydrophila* caused ulcerative diseases in some bio-chemical indexes of grass carp (*Ctenopharyngodon idellus*).	Outcome measures not related to aquatic animal health
Ekachote A. 1998. Effects of Trichlorfon on Black Tiger Shrimp (Penaeus monodon Fabricius) and Acetes sp. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Felix S. 2000. Occurrence of pathogemic bacteria in shrimp farming systems of Tamil Nadu. *Journal of Aquaculture in the Tropics*. **15** (4): 365-369.	Observational study
Garseevong S. 2000. Nursing Of Black Tiger Prawn Larvae (*Penaeus monodon* Fabricius) In Artificial Seawater. Master. Science (Aquaculture) Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Gupta DK, Gupta N, Gupta A. 2001. Infectivity and pathogenicity in *Clarias batrachus* parasitized by haemoflagellates. *Applied Fisheries and Aquaculture.* **1** (1): 75-77.	Obtained after time limit
Hameed ASS. 1993. Studies on the pathobiology of penaeid larvae and postlarvae. *CMFRI special publication.* **56**: 105-107.	Obtained after time limit
Hemmun P. 2000. Study On The Variations Of Water And Soil Qualities, Phytoplankton In Black Tiger Shrimp *(Penaeus monodon* Fabricius) Pond In Freshwater Area At Ratchaburi Province. Master. Science (Fisheries Science) Kasetsart University. Bangkok (Thailand).	Observational study
Hiranwat S. 2002. Safeguard and control measure for problems on contamination residue in tiger shrimp culture business. *Thai Fisheries Gazette*. **55** (3): 255-258.	Obtained after time limit
Holhaman VI, Pathuasnre J, Rammasamy P, Veukatesan RA. 1996. Maintenance of epithelioma papulosum cyprinid (EPC), a fish cell line for propogation of viruses of shrimps.	Obtained after time limit
Hunsonti P. 1998. Identification Of Genetic Marker By Rapd To Differentiate Normal And Viral Disease Tolerance Black Tiger Prawns (*Penaeus Monodon*) .Master. Science (Biochemistry) Chulalongkorn University. Bangkok (Thailand).	Observational study
Husnah. 2001. Efficacy and toxicity of chlorination to organisms in low salinity shrimp ponds. A thesis submitted in partial eticulate of the requirement for the degree of Master of	Obtained after time limit

Science. Asian Institute of Technology, Bangkok, Thailand.	
Innopakun P. 1998. Effect Of Omega-3 Fatty Acid Containing Lecithins On Production Of Larvae Black Tiger Prawn (*Penaeus monodon*). Master. Science (Biotechnology) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Intarasiripong W. 2000. Development of an information system for supporting freshwater fish resource management. Master. Science (Technology of Information System Management). Graduate School. Mahidol University. Bangkok (Thailand).	Not related to aquatic animal health
Intuseth J. Vaccines for aquatic animals. *Aquatic Animal Diseases Newsletter*. **7** (1): 5-7. 1997. Bangkok, AAHRI.	Obtained after time limit
Janakiram I, Jayasree I, Madhavi R. 2001. White gut disease of *Penaeus monodon* from culture ponds of Visa khapatnam (India): Microbiological and histopathological study. *Asian Fisheries Society Asian Fisheries Forum: Book of Abstracts*. **6**: 161.	Obtained after time limit
Jayasree L, Janakiram P, Madhavi R. 1999. Shell diseas in the freshwater prawn *Macrobrachium rosenbergii* (de Man): Aetiology, pathogenicity and antibiotic sensitivity. *Journal of Aquaculture in the Tropics*. **14** (4): 289-298.	Obtained after time limit
Jittivadhna K. 1999. Pcr-Based Detection Of Hepatopancreatic Parvovirus And White-Spot Syndrome Virus In Penaeus Monodon. Master. Science (Biochemistry) Mahidol University. Bangkok (Thailand).	Observational study
Juntubtim W. 2002. A way to increase snakehead production at Maela_Singburi. *Thai Fisheries Gazette*. **55** (5): 466-468.	Obtained after time limit
Juntubtim W, Sanguanngam C, Tawachsupa C. 2002. Producing of snakehead *(Channa striatus*, Bloch) fingerling from the broodstock rearing in cement tank. *Thai Fisheries Gazette*. **56** (6): 395-400.	Obtained after time limit
Juruphant P. 1995. Effect of *Alexandrium Minutum* and *Alexandrium Cohorticula* on Mortality of *Oreochromis niloticus* and *Penaeus monodon.* Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit

Kanchanaphum P. 1997. Use of PCR to Determine Ouurce of White Spot Viral Infections in The Black Tiger Prawn, *Penaeus monodon*. Master. (Biochemistry). Graduate School. Mahidol University. Bangkok (Thailand).	Obtained after time limit
Kanchanakhan S. Diseased koi carp at the House of Parliament. *Aquatic Animal Diseases Newsletter*. **6** (1): 3-4. 1996. Bangkok, AAHRI.	Obtained after time limit
Kanchanakhan S. Epizootic Ulcerative Syndrome (Part 2). *Aquatic Animal Diseases Newsletter*. **6** (2): 2-3. 1996. Bangkok, AAHRI.	Obtained after time limit
Kanchankhan S. Viral diseases in fish. *Aquatic Animal Diseases Newsletter*. **7** (1): 8-9. 1997. Bangkok, AAHRI.	Obtained after time limit
Kanchanakhan S. Diseases in giant gouramy (Part 3). *Aquatic Animal Diseases Newsletter*. **8** (1): 9-10. 1998. Bangkok, AAHRI.	Obtained after time limit
Kanchanakhan S. Koi Herpesvirus. *Aquatic Animal Diseases Newsletter*. **12** (2): 3-5. 2002. Bangkok, AAHRI.	Obtained after time limit
Kanchankhan S. A case report: Swim bladder disease in koi carp. *Aquatic Animal Diseases Newsletter*. **12** (2): 10. 2002. Bangkok, AAHRI.	Obtained after time limit
Kasornchandra J, Boonyaratpalin S. 1995. Development of monoclonal antibodies for specific detection of the yellow-head disease in *Penaeus monodon.* NICA Technical paper: No. 15/1995. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Outcome measures not related to aquatic animal health
Kasornchandra J, Khongpradit R. 1996. Isolation and preliminary characterization of a pathogenic irridovious-like agent in nursing grouper, *Epinephilus malabaricus*. NICA Technical paper: No. 5/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Kasornchandra J, Boonyaratpalin S, Khongpradit R, Aekpanitanpong U. 1995. A bacilliform virus, the causative agent of red disease with white patch in black tiger shrimp (*Penaeus monodon*). NICA Technical paper: No. 3/1995. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study

Keawchum S. 1994**.** Impacts of substrate and commercial bacteria on the growth performance of shrimp (*Penaeus monodon*) in intensive closed and open culture systems. A thesis submitted in partial eticulate of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	No statistical analysis
Khanobdee K. 1999. Morphological and biochemical studies of giant black tiger prawn, *Penaeus* monodon, infected with yellow-head virus. Ph.D. (Anatomy). Graduate School. Mahidol University. Bangkok (Thailand).	Observational study
Khomgpradit R, Kaesornchandra J. 1996. An iridovirus, the causative agent of the systemic infection in nursing seagass (*Lates calcarifer*, Bloch). NICA Technical paper: No. 13/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Khongpradit R, Kasornchandra J, Boonyaratpalin S. 1994. Susceptibility of the post-larval stages of black tiger shrimp (*Penaeus monodon*) to yellow – head baculovirus (YBV). NICA Technical paper: No. 4/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Klinputsorn R. 2000. A Sensitive Detection Of Yellow-Head Virus (YHV) Of *Penaeus monodon* In By Nested RT-PCR Amplification. Master. Science (Biochemistry) Mahidol University. Bangkok (Thailand).	Observational study
Kohanantakul K. Some tips for an ornamental fish fancier. *Aquatic Animal Diseases Newsletter*. **11** (2): 4-5. 2001. Bangkok, AAHRI.	Obtained after time limit
Krainara P. 2000. Change Of Organic Matter And Some Chemical Properties In Pond Bottom Soil Of *Penaeus Monodon* Fabricius Treated By Crushing Method. Master. Science (Aquaculture). Kasetsart University. Bangkok (Thailand).	Not related to aquatic animal health
Krishnani KK, Azad LS, Rajendran KV, Gupta BP, Joseph KO, Muralidhar M, Rajan JJS. 2001. A study of antibacterial activity of *Annona squamosa* seed oil. *In:* The Marine Biological Association of India. *Perspectives in Mariculture*. p. 207-212.	Obtained after time limit
Kueypudsa V. 1996. Study on vaccination against vibriosis in sea bas (*Lates calcarifer*) Thesis, Kasetsart University, Bangkok.	No statistical analysis

Kumar GS, Singh ISB, Philip R. 2000. Development of a cell culture system from liver, kidney and spleen of African catfish *Clarias gariepinus.* Congress on in vitro biology, March 2000. *INVITRO Animal.* **36** (3): 84A.	Obtained after time limit
Kumar GS, Singh ISB, Philip R. 2001. Development of a cell culture system from the ovarian tissue of African catfish (*Clarias gariepinus*). *Aquaculture.* **194**: 51-62. Congress on in vitro biology. March 2000. *INVITRO Animal.* **36** (3): 84A.	Obtained after time limit
Kumar GS, Singh ISB, Philip R. 2001. A cell culture system for the eyestalk of *Penaeus indicus. In:* Lindner-Olsson et al, (Eds). Animal Cell Technology. p. 261-265.	Obtained after time limit
Kumar GS, Singh ISB, Philip R, Raveendranath M, Shanmugam J. 1999. Development of a primary cell culture and cell line from the larval tissue of the freshwater fish *Poecilia reticulate. The Fourth Indian Fisheries Forum Proceedings held during 24-28th November, 1996, Kochin.* p. 349-352.	Obtained after time limit
Lamkom T. 1994. Efficacy of Oxolinic Acid Against Vibriosis Infection in Black Tiger Shrimp (*Penaeus monodon* Fabricius). Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Laoprasert T. Tetrahymena: a pathogenic protozoa in guppy (Poecilia eticulate). *Aquatic Animal Diseases Newsletter*. **10** (2): 5-7. 2000. Bangkok, AAHRI.	Obtained after time limit
Laoprasert T, Kanchanakhan S, Chinabut S. Amoebosis. *Aquatic Animal Diseases Newsletter*. **11** (1): 10-15. 2001. Bangkok, AAHRI.	Obtained after time limit
Laoprasert T. Pathogenic myxosporean in aquatic animals. *Aquatic Animal Diseases Newsletter*. **12** (2): 5-8. 2002. Bangkok, AAHRI.	Obtained after time limit
Laorasert T. Microsporidiosis in striped catfish (*Pangasius sutchi*). *Aquatic Animal Diseases*	Obtained after time limit

Newsletter. **13** (1): 5-9. 2003. Bangkok, AAHRI.	
Lertsuttichawal T. Monogenea. *Aquatic Animal Diseases Newsletter*. **9** (2): 9-10. 1999. Bangkok, AAHRI.	Obtained after time limit
Lertsuttichawal T. A role of Monogenea infection to its host taxonomy. *Aquatic Animal Diseases Newsletter*. **10** (2): 8-10. 2000. Bangkok, AAHRI.	Obtained after time limit
Lertsuttichawal T. Significance of monogenea in aquaculture. *Aquatic Animal Diseases Newsletter*. **11** (1): 7-9. 2001. Bangkok, AAHRI.	Obtained after time limit
Limjirakhajorn K. 1998. Effects Of Oxytetracycline And Salinity On Ammonia Excretion And Tissue Residue Of Black Tiger Shrimp (*Penaeus monodon*). Master. Science (Marine Science), Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Limsuwan C. Yellow head disease. *Aquatic Animal Diseases Newsletter*. **3** (1): 4-5. 1993. Bangkok, AAHRI.	Obtained after time limit
Limsuwan C. Black tiger shrimp farming in low salinity condition. *Aquatic Animal Diseases Newsletter*. **3** (2): 4-6. 1993. Bangkok, AAHRI.	Obtained after time limit
Limsuwan C. Prevention of black tiger shrimp from white spot disease. *Aquatic Animal Diseases Newsletter*. **5** (2): 1-4. 1995. Bangkok, AAHRI.	Obtained after time limit
Limsuwan C. Some clinical signs of white spot disease in black tiger shrimp. *Aquatic Animal Diseases Newsletter*. **7** (1): 10-12. 1997. Bangkok, AAHRI.	Obtained after time limit
Limsuwan C. Black tiger shrimp farming in 1999. *Aquatic Animal Diseases Newsletter*. **9** (1): 1-6. 1999. Bangkok, AAHRI.	Obtained after time limit
Limsuwan C. Foreseen lack tiger shrimp farming in 2000. *Aquatic Animal Diseases*	Obtained after time limit

Newsletter. **9** (2): 1-2. 1999. Bangkok, AAHRI.	
Lipton AP, Selvin J, Huxley AJ. 2003. Efficacy of *Ulva* incorporated therapeutic diet in managing bacterial diseases of *Penaeus monodon.* National Conference on Aquaculture Nutrition. NATP and CMFRI Kochi, 12-14th March, 2003. Abstract **23**: 58-59.	Obtained after time limit
Logambal SM, Dinakaran Michael R. 2001. Azardirachtin – An immunostimulant for *Oreochromis mossambicus* (Peters). *Journal of Aquaculture in the Tropics*. **16** (4): 339-347.	Obtained after time limit
Lopinyosiri K. 2000. Application Of Ozone For Controlling Water Quality In Black Tiger Shrimp Culture. Master. Science (Inter-Program Environmental Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Lumlertdecha S. The effect of fungal toxin to aquatic animal health. *Aquatic Animal Diseases Newsletter*. **5** (2): 5-6. 1995. Bangkok, AAHRI.	Obtained after time limit
Lusawatdigul C. 1999. Effect Of Alpha-Tocopherol Supplementation On Growth Of Juvenile Giant Tiger Prawn (*Penaeus monodon)* Fabricius. Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Mahitthi J. 1998. Effect Of Varying Salinity Levels On Osmoregulation Of Giant Tiger Prawn Penaeus (*Monodon fabricius*). Master. Science (Environmental science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Malem F. 1993. The Study of BOD Loading And Some Parameters of Water And Soil Quality From Intensive Marine Shrimp Farm With Varying Stocking Rates. Master. Science (Technology of Environmental Management). Graduate School. Mahidol University. Bangkok (Thailand).	Outcome measures not related to aquatic animal health
Manju KG, Dhevendaran K. 1996. Effect of bacteria and actinomycetes as single cell protein feed on growth of juveniles of *Macrobrachium idella* (Hilgendorf). *Indian Journal of*	Obtained after time limit

Experimental Biology. **35**: 53-55.	
Masswiwat N. 1999. Purification and Characterization of Chitinase and Chitobiase From the Tiger Prawn (*Penaeus monodon*) hemolymph. Master. Science (Biological Science) Prince of Songkla University. Songkhla (Thailand).	Not related to aquatic animal health
Mathivanan V, Visabhanayakam S, Rao A, Karpagaganapathy PR. 1998. Studies on vibriosis affected pond-raised shrimp, *Penaeus monodon.* National Seminar on Aquaculture in the Changing Environmental Perspectives, 25-27th March, 1998. p. 66.	Observational study
Mishra SS. 1998. Shrimp viruses: Their pathogenicity, diagnosis and control. National Seminar on Aquaculture in the Changing Environmental Perspectives, 25-27th March, 1998. p. 63.	Obtained after time limit
Mishra SS. 1998. Yellow head viral disease in shrimp experimental induction and pathological studies. National Seminar on Aquaculture in the Changing Environmental Perspectives, 25-27th March, 1998. p. 64.	Obtained after time limit
Mohanta KN, Subramanian S. 2003. Effect of enzyme-probiotic feed supplement on the growth performance of rohu (*Labeo rohita*) fry. National Conference on Aquaculture Nutrition. NATP and CMFRI, Kochi, 12-14th March, 2003. Abstract **24**: 60.	Obtained after time limit
Mohanty J, Sahoo PK, Mukherjee SC. 1998. Purification of rohu serum immunoglobulin: A preliminary study. *Journal of Aquaculture.* **6**: 67-72.	Obtained after time limit
Muhammad Arif C. 1995. Effects of water spinach (*Ipomoea aquatica*) on nutrient regime and fish growth. A thesis submitted in partial eticulate of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Obtained after time limit
Mukherjee M, Chakraharti A, Chakrabarty AN, Jaslidar SG. 1995. A pathogenicity model for the agents of epizootic ulcerative syndrome (EUS) in fish. *Indian Journal of Experimental*	Obtained after time limit

Biology. **33** (2): 134-135.	
Mukhi SK, Chandrika V, Madhavi B, Nayak BB. 2001. Incidence of B-haemolytic streptococcal infection associated with mass mortalities of cultured tilapia, *Oreochromis mossambicus* in brackish water ponds in India. *Journal of Aquaculture in the Tropics*. **16** (4): 373-383.	Obtained after time limit
Nikroth M. 1999. Isolation Of Bacteria Capable Of Removing Organic Wastes In Intensive Shrimp Farms. Master. Science (Environmental Biology) Mahidol University. Bangkok (Thailand).	Outcome measures not related to aquatic animal health
Nitiphaichit T. 1995. Occurrence of salmonella in shrimp and its rapid detection methods. A thesis submitted in partial fulfilment of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	No intervention
Nualchan T. Diseases detected in the exporting ornamental fish. *Aquatic Animal Diseases Newsletter*. 13 (1). 2003. Bangkok, AAHRI.	Obtained after time limit
Otta SK, Karunasagar I, Karunasagar I. 1999. Bacterial flora associated with shrimp culture ponds growing *Penaeus monodon* in India. *Journal of Aquaculture in the Tropics*. **14** (4): 309-318.	Observational study
Paibulkichakul C. 1996. Optimal Levels of Lecithin and Cholesterol in Diet for Black Tiger Prawn *Penaeus monodon* Larvae. Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Palagul B. 1993. Efficiency of Chlorine Dioxide to Reduce *Salmonella typhimurium* in Shrimp before Freezing Process. Master. Science (Food Science). Food Science and Technology (Food Science) Kasetsart University. Bangkok (Thailand).	Not related to aquatic animal health
Panchan N. 1998. Synthesis Of Partial Amino Acid Sequence Of Crustacean Hyperglycemic Hormone From (*Macrobrachium rosenbergii*) For Antibody Production Against Crustacean Hyperglycemic Hormone. Master. Science (Biotechnology).	Not related to aquatic animal health
Panritdam T. 1998. Use A Closed Recirculating Seawater System With A Denitrification Unit For The Culture Of Black Tiger Shrimp (*Penaeus monodon)*. Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit

Paripattananon T. Zinc and its effect on aquatic animal immunity. *Aquatic Animal Diseases Newsletter*. **7** (1): 2-5. 1997. Bangkok, AAHRI.	Obtained after time limit
Paripattananon T. Selenium and its effect on aquatic animal immunity. *Aquatic Animal Diseases Newsletter*. **8** (1): 5-7. 1998. Bangkok, AAHRI.	Obtained after time limit
Paripattananon T. The effect of astaxanthin on fish immunity. *Aquatic Animal Diseases Newsletter*. **8** (2): 8-10. 1998. Bangkok, AAHRI.	Obtained after time limit
Paripattananon T. A chromium requirement in aquatic animals for their growth and immunity. *Aquatic Animal Diseases Newsletter*. **9** (2): 6-8. 1999. Bangkok, AAHRI.	Obtained after time limit
Parnichsuk P. 1996. Possibility of using rotifer (*Brachionus rotundiformis*) and water flea (*Moina macrocopa*) for nursing of seabass (*Lates calcarifer*) instead of using the nauplii of brine shrimp (*Artemia* sp.). NICA Technical paper: No. 12/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Patanachan P. 1998. Heritability Estimation On Growth Rate Of Black Tiger Shrimp *Penaeus monodon* Fabricius, 1798 . Master. Science (Biotechnology) Chulalongkorn University. Bangkok (Thailand).	Outcome emasures not related to aquatic animal health
Patchimtug P. 1999. Effects of Vitamin C Levels on Disease Resistance in Green Catfish (*Mystus nemurus* Cuv.& Val.). Master. Science (Aquatic Science) Prince of Songkla University. Songkhla (Thailand).	Obtained after time limit
Pathak SC, Ghosh SK, Palanisamy K. 1996. The use of chemicals in aquaculture in India. Proceedings of the use of chemicals in aquaculture in Asia, 20-22nd May, 1996, Philippines. p. 87-112.	Review
Patil R, Jeyasekaran G, Shanmillgam SA. 2001. Occurrence and activity of marine actinomycetes against shrimp bacterial pathogens. *Appled Fisheries and Aquaculture*. ***1** (1):* 79-81.	Obtained after time limit

Payapmek P. 2000. Effect Of ~Ichlorella~I Sp. And (Oscillatoria sp. On (*Vibrio harveyi*) 1526 In Giant Tiger Prawn (*Penaeus monodon*) Fabricius Culture. Master. Science (Marine Science). Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Penprapai N. 1999. Study on species and histopathology of Mixosporidiosis in wild sea catfish (*Plotosus canius* Hamilton). Thesis, Kasetsart University, Bangkok.	Observational study
Petchinda T. Digenean fluke in freshwater fish. *Aquatic Animal Diseases Newsletter*. **9** (2): 3-6. 1999. Bangkok, AAHRI.	Obtained after time limit
Phatai T. 2000. Effects Of 0)-3hufa On Growth And Survival Rate Of Giant Tiger Shrimp (*Penaeus monodon*). Master. Science (Fisheries Science) Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Pinkate C, Wannasorn N' Chitmanat C. 2003. Effect of different culture systems on some water parameters and parasitic prevalence in tilapia (*Oreochromis niloticus*). *Thai Fisheries Gazette*. **56** (1): 35-39.	Outcome measures not related to aquatic animal health
Ploodpai P. 1994. Study on Viability of Yellow-Head Baculo virus in Sea Water and Histopathology and Haemocyte Changes of Black Tiger Shrimp *Penaeus monodon* (Fabricius) infected by Yellow-Head Baculovirus. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Observational study
Polchana J. Spring viraemia in koi carp. *Aquatic Animal Diseases Newsletter*. **13** (1): 4-5. 2003. Bangkok, AAHRI.	Obtained after time limit
Pongmaneerat J, Boonyaratpalin M. 1995. Use of plant proteins in diet for seabass (*Lates calcarifer*). NICA Technical paper: No.14/1995. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Poonpium P, Teeramaethee J, Sajea C. 2002. Inorganic-nitrogen Removal Efficiency of Nitrosomonas sp. Strain P-1 and *Nitrobacter* sp. Strain P-1 in the Culture of *Lates calcarifer*. *Thai Fisheries Gazette*. **56** (6): 431-435.	Obtained after time limit
Prakobboon T. 2002. Practices for non-chemical use in Thai culture shrimp production. *Thai Fisheries Gazette*. **55** (3): 215-217.	Obtained after time limit

Prapadsorn S. 1995. Bacterial Flora in the Sediment of Black Tiger Shrimp Pond with the Emphasis in *Vibrio* spp. And Their Resistance to Antimicrobial Agents. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Outcome measures not related to aquatic animal health
Rajendran KV, Thirunavukkarasu AR, Santiago TC. 2000. Mortality of captive seabass, *Lates calcarifer* (Bloch) due to monogenetic parasite, *Diplectanum lates* (Tripathi, 1957). *Journal of Aquaculture in the Tropics*. **15** (3): 199-206.	Obtained after time limit
Rattana-r-pa K. Effect of Creeper Shell (Cerithium sp. Bruguiere) in Intensive Black Tiger Shrimp (*Penaeus mondon* Fabricius) Culture in Closed System. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Ravichandran R, Jalaluddin RS. 2001. Stress management strategy with probiotics for preventing shrimp diseases. *Applied Fisheries and Aquaculture*. **1** (1): 73-74.	Obtained after time limit
Reddy B. 2001. Biofilm associated bacterial flora of a freshwater habitat. *M.F.Sc. Thesis Abstract.* Central Institute of Fisheries Education, Mumbai.	Obtained after time limit
Ruangpan L. 1995. Studies on Marine Vibrio Isolated from cultured Shrimp (*Penaeus monodon*) in Thailand. The Dissertation submitted to the United Graduate School of Agricultural, Kagoshima University for the Degree of Doctor of Philosophy. Kagoshima, Japan.	Outcome measures not related to aquatic animal health
Ruangpan L. 2002. Problem on antibiotic and shrimp. *Thai Fisheries Gazette*. **55** (3): 203-211.	Obtained after time limit
Ruangpanit N, Bunliptanon P. 1993. Some factors effect to the growth and survival rate of grouper larvae, *Epinephelus malabaricus*. NICA Technical paper: No. 20/1993. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	No statistical analysis
Ruangpanit N, Bunliptanon P. 1994. Suitable concentration of fish oil for enriching *Artemia* as a live feed for grouper larvae, *Epinephelus malabaricus*. NICA Technical paper: No. 19/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Rucksapram S. 1996. Studies on Diseases of Black Tiger Shrimp (*Penaeus monodon*) Water Quality and Planktons in Low Salinity Pond Culture. Master. Science (Fisheries Science).	No intervention

Kasetsart University. Bangkok (Thailand).	
Rukpratanporn S. 1999. Immunoenhancement In Black Tiger Shrimp (*Penaeus monodon*) By Bacillus Strain S11. Master. Science (Industrial Microbiology) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Ruwattanakul P. 1996**.** Effects of C-Vitamers on Development Growth and Survival of *Penaeus Monodon* Larvae. Master. Science (Marine Science), Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Saeoung S. 1996. Treatment of Wastewater from Intensive-culture of Black Tiger Prawn (*Penaeus monodon*) by Phytoplankton. Master. Science (Biotechnology). Graduate School.Prince of Songkla University Thailand.	Outcome measures not related to aquatic animal health
Sahoo M. 2001. Biochemical characterisation of serum immunoglobulins of mrigal, *Cirrhinus marigala. M.F.Sc. Thesis Abstract.* Central Institute of Fisheries Education, Mumbai.	Obtained after time limit
Sahoo PK, Mukherjee SC. 2000. Histological distribution and ultrastructure of exocrine pancreas in Indian major carp (*Labeo rohita* Ham.) and its alteration in aflatoxicosis. *Bangladesh Journal of Fisheries Research.* **4** (1): 1-6.	Observational study
Sahoo PK, Mukherjee SC. 2001. Dietary intake of levamisole improves non-specific immunity and disease resistance of healthy and aflatoxin-induced immunocompromised rohu, *Labeo rohita. Journal of Applied Aquaculture*. **11** (4): 15-25.	Obtained after time limit
Sahoo PK, Mukherjee SC. 2001. Effect of dietary B-1, 3 glucan on immune responses and disease resistance of healthy and aflatoxin B1 induced immunocompromised rohu (*Labeo rohita* Hamilton). *Fish and Shellfish Immunology*. **11**: 683-695.	Obtained after time limit
Sahoo PK, Mukherjee SC. 2003. Immunomodulation by dietary vitamin C in healthy and aflatoxin B1-induced immunocompromised rohu (*Labeo rohita*). *Comparative Immunology, Microbiology and Infectious Diseases*. **26**: 65-76.	Obtained after time limit

Sahoo PK, Mukherjee SC, Sahoo SK. 1998. *Aeromonas hydrophila* versus *Edwardsiella tarda*: A pathoanatomical study in *Clarias batrachus.Journal of Aquaculture*. **6**: 57-66.	Obtaiend after time limit
Sahoo PK, Mukherjee SC, Jain AK, Mukherjee AO. 1999. Histopathological, histochemical and ultrastructural alterations in liver of *Labeo rohita* (Hamilton) due to experimental aflatoxicosis. *Indian Journal of Veterinary Pathology*. **23**: 1-7.	Obtained after time limit
Sahoo PK, Mukherjee SC, Nayak SK, Dey S. 2000. Pathology of mixed infections of saprolegniasis-myxosporidiosis in Indian major carp (*Catla catla* Ham.). *Bangladesh Journal of Fisheries Research*. **4** (2): 171-177.	Observational study
Sahoo PK, Mukherjee SC, Mayak SK, Dey S. 2001. Acute and subchronic toxicity of aflatoxin B1 to rohu, *Labeo rohita* (Hamilton). *Indian Journal of Experimental Biology*. **39**: 453-458.	Obtained after time limit
Sahoo PK, Mukherjee SC, Mohanty S, Dey S, Nayak SK. 1998. Preliminary study on acute citrinin toxicity in rohu (*Labeo rohita*) fingerlings. *Indian Journal of Comparative Microbiology, Immunology and Infectious Disease*. **20** (1): 62-64.	Obtained after time limit
Sahoo PK, Sahu BB, Mohanty J, Murjani G, Mukherjee SC. 1998. Ulcer disease in catfish *Heteropneustes fossilis. Technological Advancements in Fisheries*. Publication number 1. School of Industrial Fisheries, Cochin Univeristy of Science and Technology. p. 147-152.	Obtained after time limit
Sahoo PK, Swain P, Sahoo SK, Mukherjee SC, Sahu AK. 2000. Pathology caused by the bacterium E*dwardsiella tarda* in *Anabas testudineus* (Bloch). *Asian Fisheries Science*. **13**: 357-362.	Obtained after time limit
Santiosh NK. 1995. Immunological studies in *Etroplus suratensis* (Bloch). *CMFRI special publication*. **61**: 53-59.	Obtained after time limit

Saranakomgul P. 1999. Quality changes in black tiger shrimp in relation to water salinity, cooking time and freezing method. A thesis submitted in partial eticulate of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Outcome measures not related to aquatic animal health
Seangwan S. Sleeping sickness disease in giant gouramy. *Aquatic Animal Diseases Newsletter*. **4** (2): 3-5. 1994. Bangkok, AAHRI.	Obtained after time limit
Seangwan S. Diseases of exported ornamental fish. *Aquatic Animal Diseases Newsletter*. **5** (2): 6-9. 1995. Bangkok, AAHRI.	Obtained after time limit
Seangwan S. Balantidium: a hectic protozoa in aquatic animals. *Aquatic Animal Diseases Newsletter*. **6** (1): 1-3. 1996. Bangkok, AAHRI.	Obtained after time limit
Seangwan S. Trichodina. *Aquatic Animal Diseases Newsletter*. **7** (1): 11-13. 1997. Bangkok, AAHRI.	Obtained after time limit
Seangwan S. Some problems in hybrid catfish culture in Roi-ed province. *Aquatic Animal Diseases Newsletter*. **7** (1): 6-9. 1997. Bangkok, AAHRI.	Obtained after time limit
Sen A, Singh ISB, Sen A, Kumar GS, Philip R. 1996. Isolation and partial characterisation of the aetiological agent of white spot disease in penaeids. *The Fourth Indian Fisheries Forum Proceedings held during 24-28th November, 1996, Kochin.* p. 331-333.	Obtained after time limit
Sen A, Singh ISB, Rengarajan R, Philip R, Kumar GS, Sen A. 1999. Evidence of a bacilliform virus causing outbreaks of white spot disease in *Penaeus monodon* H. Milne Edwards in India. *Asian Fisheries Science.* **12**: 41-47.	Obtained after time limit
Sethi SN. 2002. Studies on biochemical, pathological and immunological aspects of stress induced condition in freshwater prawn (*Macrobrachium malcolmsonii*). *M.F.Sc. Thesis Abstract.* Central Institute of Fisheries Education, Mumbai.	Obtained after time limit
Shekhar MS, Mishra SS. 1998. Detection of *Vibrio parahaemolyticus* from shrimp by polymerase chain reaction. National Seminar on Aquaculture in the Changing Environmental Perspectives, 25-27th March, 1998. p. 62.	Obtained after time limit

Silakes S. 1997. Production of Vaccine from *Vibrio harveyi* and its application in Black Tiger Prawn (*Penaeus monodon* Fabricius). Master. Science (Aquatic Science) Prince of Songkla University. Songkla (Thailand).	Obtained after time limit
Singh ISB, Philip R. 1995. A simple device for the separation of weak larvae of *Macrobrachium rosenbergii* (de Man). *Aquaculture Research.* **26**: 225-227.	Obtained after time limit
Singh ISB, Philip R. 1995. Development of primary cell cultures from kidney of freshwater fish *Heteropneustes fossilis. Indian Journal of Experimental Biology*. **33**: 595-599.	Obtained after time limit
Singh ISB, Philip R, Maqbool TK, Rameshi S, Harikrishnan P, Menoni NR. 1994. Bacteria associated with epizootic ulcerative syndrome in fishes of inland waters of Kerala. *Indian Journal of Microbiology*. **34** (3): 233-240.	Obtained after time limit
Siravuttinanon S. 1994. Using Aerated Lagoon System as a Treatment Process for Waste water from Shrimp Culture Ponds. Master. (Environnental Technology). Graduate School. Mahidol University. Bangkok (Thailand).	Outcome measures not related to aquatic animal health
Sitthipun M. 1998. Extraction of Beta-glucan from Yeast and Its Application Black Tiger Prawn (*Penaeus monodon*). Master. Science (Biotechnology). Graduate School.Prince of Songkla University. Songkla (Thailand).	Obtained after time limit
Somjetlertcharoen A. Banning chloramphenicol use in black tiger shrimp farming. *Aquatic Animal Diseases Newsletter*. **11** (2): 2-4. 2001. Bangkok, AAHRI.	Obtained after time limit
Somjetlertcharoen A. Problematic drug residues in black tiger shrimp. *Aquatic Animal Diseases Newsletter*. **12** (1): 3-5. 2002. Bangkok, AAHRI.	Obtained after time limit
Somsiri T. Diagnosis of fish infected with *Mycobacterium* . *Aquatic Animal Diseases Newsletter*. **4** (1): 3-4. 1994. Bangkok, AAHRI.	Obtained after time limit
Somsiri T. Exportation of aquatic animals. *Aquatic Animal Diseases Newsletter*. **5** (2): 9-10. 1995. Bangkok, AAHRI.	Obtained after time limit

Somsiri T. Andrographolide (*Andrographis paniculata*) and its potential pharmaceutical role in aquaculture. *Aquatic Animal Diseases Newsletter*. **12** (1): 9-11. 2002. Bangkok, AAHRI	Obtained after time limit
Somsiri T. Problems in the integrated fish farmings. *Aquatic Animal Diseases Newsletter*. **12** (1): 8-9. 2002. Bangkok, AAHRI.	Obtained after time limit
Songsangjinda P. 1994. Linear correlation of water quality and grow-out data of the tiger shrimp intensive culture in Ranot District, Songkhla Provice. NICA Technical paper: No. 10/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Songsangjinda P. 1994. Effect of different levels of ambient ammonia on oxygen consumption of tiger shrimp (*Penaeus monodon*). NICA Technical paper: No. 23/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	No statistical analysis
Songsangjinda P, Predalumpaburt Y. 1995. Effect of difference levels of oxytetracyclin of change of nitrogenous compounds, total organic carbon and chlorophyll a of intensive tiger shrimp cultured water. NICA Technical paper: No. 5/1995. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Outcome measures not related to aquatic animal health
Soowannayan C. 2000. Apoptosis In Yellow Head Virus Infected Shrimp. Master. Science (Biotechnology) Mahidol University. Bangkok (Thailand).	Obtained after time limit
Sriboonlue U. 1996. Effects of Cadmium, Chromium and their Combinations on *Puntius gonionotus* Bleeker Master. (Environmental Biology) Mahidol University. Bangkok (Thailand).	Obtained after time limit
Srisapoome P. 1999. Study on Acute Toxicity of Hydrogen Peroxide in *Penaeus monodon* (Fabricius) Larvae and Efficacy on Controlling Vibrio spp. And Some Phytoplanktons in Shrimp Pond. Master. Science (Aquaculture). Kasetsart University. Bangkok (Thailand).	Obtained after time limit
Sritunyalucksana K. 1995. Study of the Humoral Defence Factors in the Black Tiger Prawn, *Penaeus monodon*. Master. (Biotechnology). Graduate School. Mahidol University. Bangkok (Thailand).	Outcome measures not related to aquatic animal health
Sukphan C, Chinaksorn W. 2002. Comparison on nursing of giant freshwater prawn (*Macrobrachium rosenbergii* de Man) larvae with and without Oxytetracycline. *Thai*	Obtained after time limit

Fisheries Gazette. **56** (6): 537-543	
Sukrarurk W. 1999. Physiological Response Of Postlarva Black Tiger Prawn (*Penaeus Monodon*) To Combined Effect Salinity Water Soluble Fraction Of Dubai Crude Oil. Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obbtained after time limit
Supungul P. 1998. Genetic Variation And Population Structure Of The Black Tiger Prawn (*Penaeus Monodon)* In Thailand Determined By Microsatellite Markers. Master. Science (Biochemistry) Chulalongkorn University. Bangkok (Thailand).	Observational study
Suwanich R. 1995. Quantity and Ratio of Eicosapentaenoic Acid / Docosahexaenoic Acid on Growth and Survival of Black Tiger Prawn (*Penaeus monodon*) Postlarvae. Master. Science (Biotechnology), Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Suwannatos S. 2002. Quality prawn production for domestic consumption and exports. *Thai Fisheries Gazette*. **55** (3): 279-281.	Obtained after time limit
Suwannatos S, Juntubtim W. 2003. Snake head fish breeding and nursing for commercial purpose. *Thai Fisheries Gazette*. **56** (3): 241-259.	Obtained after time limit
Swain P, Nayak SK. Comparative sensitivity of different serological tests for seromonitoring and surveillance of *Edwardsiella tarda* infection of Indian major carps. *Fish and Shellfish Immunology (In press).*	Obtained after time limit
Swain SK, Rangacharyulu PV, Sarkar S, Das KM. 1996. Effect of a probiotic supplement on growth, nutrient utilisation and carcass composition in mrigal fry. *Journal of Aquaculture.* **4**: 29-35.	Obtained after time limit
Swain P, Nayak SK, Sahu A, Meher PK, Mishra BK. High antigenic cross-reaction among the bacterial species responsible for diseases of cultured freshwater fishes and strategies to overcome it for specific serodiagnosis. *Comp. Immunol. Micro. Inf. Dis. (In press).*	Obtained after time limit
Swain P, Nayak SK, Sahu A, Mohapatra BC, Meher P. 2002. Bath immunisation of spawn, fry and fingerlings of Indian major carps using a particulate bacterial antigen. *Fish and Shellfish Immunology*. **13** (2): 133-40.	Obtained after time limit

Swain P, Mukherjee SC, Sahoo PK, Das BK, Pattnaik P, Murjani G, Nayak SK. 2001. Dot-enzyme-linked immunosorbent assay (Dot-ELISA) for the diagnosis of *Edwardsiella tarda* infection in fish. *Asian Fisheries Science*. **14** (1): 89-93.	Observational study
Tachodamrongsin N. 1997**.** Use of Bacillus spp. To enhance black tiger prawn (*Penaeus monodon*) production. Master. Science (Biotechnology) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Taweesri J. Effective microorganism. *Aquatic Animal Diseases Newsletter*. **10** (2): 2-5. 2000. Bangkok, AAHRI.	Obtained after time limit
Tepahudee W. An essential of water colour in shrimp farm management. *Aquatic Animal Diseases Newsletter*. **6** (1): 7-8. 1996. Bangkok, AAHRI.	Obtained after time limit
Thankappan A. 2001. Analysis of *Aeromonas hydrophila* isolates using RAPD-PCR. *M.F.Sc. Thesis Abstract.* Central Institute of Fisheries Education, Mumbai.	Obtained after time limit
Thaweethamsewee P. Effects of 5-Methoxyindole Acetic Acid, Para Chlorophenyl Alanine and Cyproheptadine on Growth of Juvenile Giant Freshwater Prawns, Macrobrachium rosenbergii de Man. Master. Science (Anatomy) Mahidol University. Bangkok (Thailand).	Obtained after time limit
Thiraksapan T. 1993. The Study on Using Green Mussel (Perna sp.) to Improve Waste-water from Intensive Shrimp Pond. Master. Science (Technology of Environmental Management). Graduate School. Mahidol University. Bangkok (Thailand).	Outside target species
Thongphubate T. 2000**.** Management information system for Chumphon Marine Fishery Development Centre. Master. Science (Technology of Information System Management). Graduate School. Mahidol University. Bangkok (Thailand).	Not related to aquatic animal health
Tien VD, Lien DN, Luu LT. 2000. Changes of serum protein content and infection status of red spot disease in grass carp (*Ctenopharyngodon idellus*).	Outcome measures not related to aquatic animal health
Tonguthai K. Isopod: an aquatic blood lover. *Aquatic Animal Diseases Newsletter*. **3** (1): 1-2. 1993. Bangkok, AAHRI.	Obtained after time limit
Tonguthai K. *Clinacanthus nutaus*: a medical herb used in aquaculture. *Aquatic Animal Diseases Newsletter*. **5** (3): 1-3. 1995. Bangkok, AAHRI.	Obtained after time limit

Tonguthai K. Medical herbs and aquatic animals. *Aquatic Animal Diseases Newsletter*. **7** (1): 9-11. 1997. Bangkok, AAHRI.	Obtained after time limit
Tookwinas S. 2002. Auditting system for quality cultured shrimp by the Department of Fisheries. *Thai Fisheries Gazette*. **55** (3): 227-243.	Obtained after time limit
Tookwinas S. 2002. Guideline of freshwater prawn culture along code of conduct for responsible. *Thai Fisheries Gazette*. **55** (6): 551-554.	Obtained after time limit
Tuntipaswasin S. 2000. The assessment of limiting nutrients for intensive shrimp culture in plastic lined ponds. A thesis submitted in partial eticulate of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Outside target species
Tunvilai D, Chaiyakam K, Predalumpaburt Y, Sriwichai C. 1994. Water and soil quality monitoring of shrimp farms in Pattani Province. NICA Technical paper: No. 5/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Observational study
Van PT. 1998. The occurrence of epitheliocystis in Nile tilapia (*Oreochromis niloticus*) nurseries. A thesis submitted in partial eticulate of the requirement for the degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Observational study
Vattanakul V, Yashiro R, Ruangpanit N, Onlamai P. 1994. Experiment on nursing and rearing of mullet, *Liza subviridis*. NICA Technical paper: No. 16/1994. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Venkatalakshmi S, Dinakaran Michael R. 2001. Immunostimulation by leaf extract of *Ocimum sanctum* Linn. in *Oreochromis mossambicus* (Peters). *Journal of Aquaculture in the Tropics*. **16** (1): 1-10.	Obtained after time limit
Vivatchaiseth Y, Tipnet R. 2002. Guppies culture : a way to earn supplementary income. *Thai Fisheries Gazette*. **55** (4): 364-368.	Obtained after time limit
Vivatchaiseth Y. 2002. Organic culture of giant freshwater prawn in supunburi province. *Thai Fisheries Gazette*. **55** (6): 545-550.	Obtained after time limit
Vongsirisopak S. 1996. Effect of Water Hardness and Temperature on the Toxicity of Detergents to *Puntius gonionotus* Bleeker and *Oreochromis niloticus* (Linn). Master.	Obtained after time limit

(Environmental Biology). Graduate School. Mahidol University. Bangkok (Thailand).	
Warukamkul P. 1998. Effect of salinity and protein levels on energy budget of juvenile black tiger shrimp (*Penaeus monodon*). Master. Science (Marine Science) Chulalongkorn University. Bangkok (Thailand).	Obtained after time limit
Wirachawong P. 1995. Plankton Management in Tiger Prawn (*Penaeus monodon* Fabricius) Culture Ponds. Master. Science (Fisheries Science). Kasetsart University. Bangkok (Thailand).	Not related to aquatic animal health
Wongwisansri S. 1996. PCR-based Method and In Situ Hybridization Method for Detection of White Spot Virus in Penaeid Shrimp. Master. (Biochemistry). Graduate School. Mahidol University. Bangkok (Thailand).	No intervention
Wongprasert K. 2000. Histopathology and apoptosis in tissues of black tiger shrimp, *Penaeus* monodon, following white spot syndrome virus infection. Ph.D. (Anatomy). Graduate School. Mahidol University. Bangkok (Thailand).	Observational study
Wudthijinda W. 1998. Genetic Diversity Of Black Tiger Prawn (*Penaeus monodon*) Fabricius In Thailand. Master. Science (Biotechnology) Chulalongkorn University. Bangkok (Thailand).	Observational study
Yashiro R, Songtawontawe S. 1996. Cultivation of black tiger shrimp, *Penaeus monodon* broodstock by reducing stocking density and transferring pond. NICA Technical paper: No. 14/1996. National Institute of Coastal Aquaculture, Department of Fisheries. Songkla, Thailand.	Obtained after time limit
Yomjinda M. 1993. Effect of bottom muds on nutrient cycling and water quality in catfish-tilapia integrated culture. For the Degree of Master of Science. Asian Institute of Technology, Bangkok, Thailand.	Obtained after time limit

Appendix III

TEMPLATE FOR THE FLOW OF INFORMATION ANALYSIS

The template or guidelines below are not meant to be in the format of a questionnaire. These are intended to provide a guide to help **identify** the flow of information on aquatic animal health strategies from the Institutes to **all target groups** but particularly poor rural households involved with aquaculture. Not all of the areas will be relevant for all of the Institutes but they are meant to illustrate the potential pathways that may be significant in trying to ascertain the current remit and flow of information between the Institutes and the end-users (target groups). It is important to remember that the results from this are **not** to be a criticism of the current dissemination methods used by the Institutes in Asia but rather to document what is in place with the aim to **improve** the impact of information dissemination on livelihoods of poor people.

The analysis of the flow of information from the Institutes is called PART 1 and will be conducted by the local Institutes with limited assistance from the UK. The results from PART 1 will be synthesised with the results from some of the activities conducted during the situation appraisals called PART 2. The synthesis of these results will provide a greater understanding of the dissemination of information from aquatic animal health research and the impact of the strategies provided on livelihoods of poor people.

Part 1 Information flow from the Institutes

Below is a box with "Key Questions". These are the central themes to help focus the data collection and the analysis of the flow of information from the Institutes.

KEY QUESTIONS

Are poor people involved in aquaculture? If so, to what extent are they a target group for the research and activities undertaken by the institute?

What are the actual or potential channels through which information flows from the institute to poor people involved in aquaculture and vice versa?

In what ways do or could poor people involved in aquaculture benefit from the research and activities done, and knowledge produced by the institute?

Are there ways in which the activities of the institute could have a greater impact on this group?

The text in blue font is to highlight examples only.

1. The Institute

1.1 Please provide the mission statement of your Institute:

1.2 What is the overall role of the Institute (e.g. teaching, diagnostics, research, development, dissemination - local, national, regional)

1.3 Does that remit include dissemination/transfer of technical knowledge about practical aquatic animal health strategies for people working in aquaculture?

1.4 Please provide the number of staff and their activities within the Institute

1.5 What is the main areas of research within aquatic animal health within the Institute, (e.g. shrimp, frogs, bacterial diseases, immunology, virology)

1.6 What are the roles of the different staff and what percentage of their time is allocated to the various activities within the Institute? (not just research)

1.7 What resources are provided to the dissemination of aquatic animal health strategies? (these may include time and money)

1.8 Is there a diagnostic service linked with your Institute and if so please give details (e.g. what is the service, cost per sample, description of how the service works-who contacts who?)

1.9 Please give details of the diagnostic service used over the last 2 years (2000-2002), types of farmers, location from Institute, cost and service provided - was it only confirmation of the health problem or was their advice/treatments recommended?

2. Target Groups

2.1 Who are the Institutes direct target groups (please only give those that the Institute has DIRECT contact with, e.g. aquaculturists, companies, students, extension services).

2.2 Can you rank these target groups with respect to order of importance to the institute (in determining the focus of research and activities undertaken by the institute and time spent involved with these different groups)?

2.3 Which groups of people are involved in aquaculture at some level? Does this include the rural poor?

2.4 Please describe what access the Institute has with rural poor people involved in small-scale aquaculture?

2.5 Who are the points of contact within farming communities/among the farmers you work with?

2.6 Does the information for the Institutes reach poor farmers and rural communities and if so how?

2.7 Who benefits from the Aquatic disease control knowledge/strategies produced by the institute?

3. Research Activities within the Institute

3.1 Over the last 5 years (1998-2002) please list main areas of research (**with source of funding**) conducted within the Institute? (e.g. WSV detection in culture *P.monodon*, DFID).

3.2 What are the sources of funding available for research within the Institute? (please include national and international sources of funding)

3.3 How does the source of funding influence the focus of research selected by the institute?

3.4 Please list the target groups of people that should benefit from the research (e.g. extension services, policy makers, aquaculturists, research staff, fish farmers, traders etc.)

3.5 How many of the research activities in the last 5 years have produced practical strategies on aquatic animal health?

3.6 What happens to the results/knowledge produced from the Institutes' research activities?

3.7 How applicable is the research performed in the Institute to the livelihoods of rural poor people involved with aquaculture?

4. Education &Training

4.1 What are the degree-based courses available at the Institute (formal taught, research and distance learning) for undergraduate and postgraduate qualifications related to aquatic animal health?

4.2 Please describe the involvement of the Institute and staff within these courses.

4.3 What are the numbers of undergraduate students on each course (over the last 5 years or since the course was established)

4.4 Do the Institute staff teach aspects of aquatic animal health at other Institutes/Departments, locally, nationally and internationally and if so please provide details.

4.5 Does the Institute keep track of the progress of students once they have qualified from the courses taught?

4.6 In what areas of aquatic animal health are students from the Institute employed?

4.7 Please provide information on all types of training offered for people involved with aquaculture by the Institute.

4.8 How are people informed about the training course offered?

4.9 How is the content of the training course selected and by whom?

4.10 Please give details of the involvement of the Institute staff in Government level training courses using the bullet points below as a guide (if no Government training courses are offered please state this).

- What is the primary aim of that training?
- Who are the primary targets of the training (e.g. Large-scale commercial fish farmers, small scale, poor farmers, commercial companies, extension workers)?
- Who attends this training? Which groups of people have the opportunity to attend the courses/workshops
- Who funds their attendance for the training?
- What types of information/knowledge/technical strategies does the training focus on?

5. Extension

5.1 Please describe the linkages (both **from** and **to** the Institute) between the Institute and the Extension Services for Aquaculture using the bullet points listed below as a guide.

- Training of extension workers (if so what type of training)?
- Do extension workers study at the institute?
- Producing literature/material/manuals/booklets for extension workers. If so what type of material? Who is it aimed at? What kind of problems does it deal with? How is such material disseminated and to whom?
- Providing advice to extension workers (if so what type of advice, how is it passed on to farmers)?

5.2 Is there a separate group within the Institute who deals with the Extension Services and if so please give details.

5.3 Do extension officers report back to the institute on fish health problems encountered by farmers and areas in which technical advice and strategies are needed?

5.4 Do you think extension workers pass on accurate and practical advice?

5.5 Please provide information on the training of extension officers (over the last 5 years (1998-2002)) - who provided the training, what was the format of the training, who attended the courses, how long was the course/workshop/training?

5.6 How many of the students/staff trained (from 1998-2002) from the Institute currently work in the extension services?

5.7 Please describe if knowledge from research activities has been passed directly to extension services?

5.8 What kind of farmers are the extension services that you have contact with aimed at targeting?

6. Consultancy, Policy making and Development

6.1 Do any Institute members (staff) act as consultants and if so, then who is the consultancy for?

6.2 Do any members (staff) act as advisors and if so then who is this for?

6.3 What level of contact is there between the Institute staff members and Policy makers at Government, NGO, Development Programmes and DOF and at what level is there contact (Regional, National, Provincial, District, International)?

6.4 Please give details of any collaboration between the Institute and other departments responsible for rural development.

7. Commercial

7.1 Describe the relationship between the staff, the Institute and any commercial organisations.

7.2 Does the Institute receive any kind of sponsorship from commercial organisations and if so who are the organisations and what is the sponsorship used for?

7.3 Please give details of any training/workshops over the last 5 years that have been for commercial organisations or that the staff has been asked to contribute towards?

8. Dissemination & Uptake

8.1 What information on aquatic animal health does the Institute disseminate?

8.2 How do you select the specific messages and strategies for dissemination?

8.3 What is the format of this information and who is it targeted towards?

8.4 What are the routes of dissemination used by the institute to reach different target groups?

8.5 What are there existing channels through which technical advice/animal health strategies are disseminated to different groups? If so what are they?

8.6 What methods of dissemination are available?

8.7 Where is the information disseminated (e.g. organisations, workshops, training courses, public talks, loudspeaker announcements, TV or radio programmes, newspapers, advertisements, news letters, extension booklets, workshop handbooks, word of mouth, websites)?

8.8 Which channels and methods of dissemination do you see as the most effective in reaching different target groups?

8.9 What languages is the information disseminated and why?

8.10 How are members of the Institute involved with the dissemination of aquatic animal health information (e.g. TV or radio programmes, newspaper articles, advertisements)?

8.11 Is any of the information disseminated directly to people involved with rural small-scale aquaculture and if so how and when?

8.12 Do members of Institute staff monitor the uptake of information disseminated from the Institute to the target groups? If so how do they do this, what groups and information do they monitor?

8.13 Describe any linkages with the commercial sectors in the dissemination of information on aquatic animal health?

8.14 What demand is there for information by various levels of farmers involved with aquaculture?

8.15 How do you know about the demand for information from various target groups?

8.16 How does the target group affect the content/messages and form of the information disseminated?
8.17 Are strategies/information adapted to reach people involved in rural small-scale aquaculture? If so how?

8.18 How do you gain access to the target groups?

8.19 How is the commercial sector involved in the transfer and dissemination of information/advice to farmers?

9. Flow of Information from Farmers to the Institute

9.1 To what extent is the institute's research focused on the practical animal health problems faced by farmers?
9.2 Is the institute made aware of practical aquatic animal health problems faced by farmers, esp. those affecting poor people?

9.3 Does information flow from farmers back to the institute? If so from which groups of farmers does it come and how does it influence the activities of the institute?

Appendix IV

Thailand National Strategy for Aquatic Animal Health
(2004-2008)

: Support the fisheries products to meet quality and food safety standards for the consumers.

Objective

- To support good quality aquatic animal products for national consumptions and for export.
- A guideline for research and development work on aquatic animal health during this 5-year period.

National Strategy (2004-2008)

- There are numerous issues related to improvement of aquatic animal health and good quality of aquatic animal products.
- In reviewing and evaluating the previous works, nine possible problems were identified as constraints.

Law and regulations

- The existing Fisheries law has a very minor section on aquatic animal health.
- The Department of Fisheries has no adequate authority over farmers to enforce standard farm management, food safety assurance and import/export processes.
- Without the necessary law to support the Department, it is not possible for the responsible people to improve these issues.

Information and knowledge of responsible personnel

- There is not adequate information circulating at both the national and international levels.
- A lack of knowledge of epidemiology makes it very difficult to control the diseases. Inappropriate chemical and drug use leads to a severe problem in food safety.

Research and Researchers

- A lot of research on aquatic animal health has been conducted but the results have not been adequately transferred to the right targets.
- There is no close association between researchers and farmers to generate the outcome of the research results.
- Currently government support on this matter is insufficient.

Standard diagnostic techniques and laboratories .

- At present, there are several diagnostic techniques developed.
- Different techniques may give different results.
- Some of the private laboratories do not meet adequate standards for diagnostic work. Their services are therefore not satisfactory.

Field personnel

- The number of government field personnel is very limited and insufficient to give proper service to the farmers.
- These personnel are essential as they are act as facilitators between the researcher/laboratories and the farmers.

Cooperation of researchers from different institutions.

- A lack of cooperation among researchers from different institutions might create research repetition and competition which leads to a waste of research funding.

Public awareness

- There is very little understanding about the consequence of the aquatic animal health and chemical use in relation to food safety both for domestic consumption and for export.

Contingency plans

- Grave economic loss due to epizootics diseases in the past indicates the need to put forward emergency and contingency plans for aquatic animal health.

Financial support

- The budget available for research and implementation on aquatic animal health is inadequate.

Implementation of the strategy.

- The operation plan is established to solve these problems and to make a guide line for the work during the next five years.
- It is not possible to solve the problems all at once. Some of the problems may take long time to be solved.
- However, this plan will prioritize the urgent needs and develop achievable ways to address issues over the next 5 year period.

Plan I Law and regulations

- Action 1.1 There is an urgent need to revise the existing Fisheries Law and other related existing regulations in order that it can be applied to regulate aquatic animal health issues.
- Action 1.2 Food safety assurances must address both domestic consumption and exportation.
- Action 1.3 Clarified and increased role of responsible institutions for better cooperation and more effective service.

Plan II Information and Knowledge of responsible personnel

- Action 2.1 It is necessary to develop awareness and incentives for researchers to circulate and transfer their useful research results to farmers or interested group.
- Action 2.2 Increase national and international linkage for information exchanges and standard diagnostic techniques.

Plan II Information and Knowledge of responsible personnel

- Action 2.3 Develop an aquatic animal information network within the country.
- Action 2.4 Increase the support to existing personnel to develop their knowledge on aquatic animal health.

Plan III Research and Researchers

- Action 3.1 Encourage capable institutions or private agencies to do more research to solve problems on aquatic animal health including chemical use in aquaculture, which are of particular concern in relation to food safety.
- Action 3.2 Develop a cooperation among institutions at both national and international levels, on aquatic animal health research. Provide their researchers an opportunity to increase their ability in research.

Plan III Research and Researchers

- Action 3.3 Increase awareness of government and donor agencies of the need to provide financial support to researchers.
- Action 3.4 Develop a strategic research plan on aquatic animal health to guide researchers.

Plan IV Standard Diagnostic Technique

- Action 4.1 Establish a Fish Disease Committee (FDC) for Thailand.
- Action 4.2 Urgently develop standard diagnostic techniques (SDT).
- Action 4.3 Train diagnostic personnel in both government and private agencies on SD

Plan IV Standard Diagnostic Technique

- Action 4.4 Encourage private agencies to develop their laboratories to meet the standard.
- Action 4.5 Develop effective surveillance, quarantine and health certification to prevent disease transmission and upgrade food safety assurance.

Plan V Field personnel

- Action 5.1 It is the government's responsibility to increase field personnel in the responsible institutions to provide services to the farmers.
- Action 5.2 Develop a network of the field personnel in order to update and exchange information and techniques.
- Action 5.3 Provide regular training to the field personnel for effective services.

Plan VI Cooperation of the researchers and institutions

- Action 6.1 Increase close cooperation among the involved or interested institutions in order to reduce competition and duplication of research.
- Action 6.2 Develop a good strategy for better cooperation.

Plan VII Public awareness

- Action 7.1 Increase public awareness on aquatic animal health through the media, training and seminar.
- Action 7.2 Encourage educational institutes to include courses in aquatic animal health in their curriculums.

- Action 7.3 Encourage the Faculties of Fisheries at Kasetsart University or other universities to produce undergraduate or graduate students on aquatic animal health or aquatic animal veterinarians.

Plan VIII Contingency plan

- Action 8.1 It is the government's responsibility to set up a contingency plan on any emerging endemic of aquatic animal.

Plan IX Financial support

- Action 9.1 Increase financial support to research and services
- Action 9.2 Encourage researchers to seek for some financial support from oversea organizations to conduct aquatic animal health research.

Coordination and evaluation

- Designate a coordinating office to implement this plan and to coordinate governmental institutions and private agencies. Department of Fisheries should take the lead in implementing and coordinating this plan with support from FDC.

Coordination and evaluation

- During this 5-year period, the plan should be reviewed every 2 years to monitor progress and make adjustments if necessary.

Appendix V

Methodological Issues in Identifying the Impact of Research Projects: A Review of the Literature

R.L. Stirrat

Report produced for the Aquaculture and Fish Genetics Research Programme of the Department for International Development

Contents

Preface

The research and writing of this report was supported by the DFID-funded Aquaculture and Fish Genetics Research Programme. I am most grateful to James Muir not only for commissioning this work but also for commenting on an earlier draft. I must also thank John Sanchez, Dinah Rajak and Elizabeth Harrison for their comments- both supportive and critical.

The literature on impact assessment is seemingly never-ending and even at this stage I keep on finding new references and sources. But rather than keep on trying to gain some command of this ever-growing literature I have chosen to stop at this point and produce what must be seen as a provisional document.

Needless to say, I alone am responsible for any errors, misquotations, faults in interpretation, misrepresentation, missed references and faulty references.

Jock Stirrat
August 2003.

1. Introduction

Impact assessment is becoming increasingly popular. Not only are development interventions in general coming under scrutiny in terms of the impact they are having on eradicating poverty or achieving the other millennium goals.[1] Development research is also increasingly subject to such an examination. Indeed, the only justification for the expenditure of development funds on research is that it should achieve a developmental impact, however this might be conceptualised. As Balzer and Nagel somewhat disarmingly comment,

> Donors are becoming more and more interested in learning about utilisation and direct impact of agricultural research within an overall developmental process. Arguments which can plausibly demonstrate such effects will therefor greatly strengthen the position of CGIAR centres in the dialogue with the donor community (Balzer and Nagel 2003: 3).

But one does not need to be as cynical to recognise that there is an onus on the development industry to show that research expenditures do have a positive developmental impact, and that an effort has to be made to ensure that this developmental impact is maximised.

Not surprisingly, there is a substantial literature which claims to measure the impact of research. The most frequently quoted (and probably most ambitious) paper is by Alston *et al.* (1998). This is concerned with measuring the returns from agricultural research and development in both the developing and developed world, and whilst admitting that there are problems with the data, claims that the annual rate of return to research is over 70%. Even though agricultural research in the developing world shows a lower return, it is still extremely respectable. Other writers make similar claims for the developmental impact of research (e.g. Anandajayasekeram *et al.* 1997; Beynon *et al.* 1998).

This literature, and the individual studies on which it is based, are in the main concerned with output and not with development or poverty *per se*. Only recently have attempts been made to assess the impact of research on poverty, and some of these contributions

[1] Donecker and Green (1998) supply an overview of impact assessment in the multilateral development institutions.

will be discussed below. But more importantly, there has been little attempt to analyse in any detail the methods which might be suitable for assessing impact in different situations, and how these methods can be incorporated into the design of research projects in order to assist later impact assessment.

The objectives of this paper are two-fold:

- To identify the methods which might be used to identify the impact of research projects. A robust methodology is essential if the gains from research are to be identified and the lessons of successful research projects integrated into the development research arena. A range of methods is discussed and the situations in which one or other is appropriate is identified.

- To consider how the requirements for successful impact assessment can be incorporated into research design. As will be shown later, one of the problems facing impact assessment is that it tends to be done in a *post hoc* fashion, little attention being paid to the requirements of impact assessment at the research planning and implementation stages.

Section 2 of this paper is concerned with different conceptions of poverty. In a sense, to talk of 'impact' can open up an uncontrollable and unmanageable Pandora's box. Impacts of a research project can in theory be infinite, and clearly as far as the development community is concerned not all impacts are of interest. From a developmental point of view the prime concern is poverty and how research impacts on poverty. Yet there is little agreement on what poverty is and there are competing definitions of poverty. These in turn not only generate different forms of relevant research but also imply different strategies of impact assessment.

This is followed in section 3 by a discussion of the concept of 'research'. Here a number of epistemological issues will be examined as to what research might be and how these forms of research have different developmental implications. A simple typology of research is used which at least offers a starting point for examining impact.

Section 4 seeks to directly address the first major issue: what methodologies should be used to examine impact. A number of different approaches are examined and suggestions are made as to the conditions under which different approaches are legitimate or appropriate. This builds upon the previous sections which offer a broad grid for assessing what methods might be useful.

Then in section 5 the discussion moves on to examine how the requirements of successful impact assessment can be written into research project design and implementation. It is suggested that much more attention has to be paid to the 'assumptions' column of logframes in that the key to successful or unsuccessful impacts are often the result of unanalysed factors in the context in which research takes place.

But before turning to the body of the report, there are two issues which should be briefly addressed.

The first of these is the relationship between 'evaluation' and 'impact assessment'. For some writers there is little if any difference between the two and an evaluation of a research project (or indeed any sort of development intervention) covers impact. This is the approach adopted by, for instance, the World Bank (Baker 2000; World Bank 2002). However, there is often an implicit (and at times explicit) distinction made between the two. This sees evaluation as being concerned with whether or not any intervention achieved its planned outputs whilst impact analysis is seen as analysing the effects of those outputs. Put in logframe terms, evaluation concerns the lower two rows of the logframe whilst impact analysis is more concerned with the upper two levels of the logframe. Thus an evaluation of a research project could conclude that it was highly successful in that it generated the outputs planned for it and that these were highly rated by the research community,.Yet an impact analysis of the same project could conclude that it had an insignificant or even a negative impact in developmental terms. In this paper the emphasis is upon impact rather than evaluation, and this has certain methodological implications which will be examined below.

The second issue which has to be mentioned here is the coverage of this report. It is primarily concerned with reviewing the literature on agricultural and related research. There is an increasing literature on the impacts of other non-research orientated development interventions but no attempt is made to cover that literature in any detail. Nor is there any attempt to cover the literature on other areas of research (e.g. health; education). The literature covered derives primarily from a small set of institutions, the most important being the CGIAR group and the publications deriving from their Standing Panel on Impact Assessment. Literature from the World Bank, from DFID and various satellite institutions (e.g. ODI) and from other Development Banks is also discussed.[2]

2. Changing Concepts of Poverty

In theory, any intervention can have an infinite number of impacts. Thus whilst it might be interesting to know the whole range of impacts from any one research project it is in practice impossible to identify them all. Nor is it necessary. Rather, there has to be some sort of agreement as to what is the focus of impact studies. Given that in the broadest sense development interventions are concerned with alleviating or eradicating poverty then poverty must be the focus of impact assessment. And following from this, as concepts of what poverty is change, so too does the focus of interest in any impact analysis. This in turn relates to differences in methods for they at least in part are determined by how poverty is defined.

Clearly a full-scale analysis of the changing meaning of poverty is beyond the scope of this paper. But at the most general level the literature on the impact of research uses three broad approaches to poverty. The first implicitly defines it in terms of low productivity; the second defines it in terms of a statistical measure, usually an income of a dollar a day, and the third adopts a more complex approach which views poverty as more than just a matter of income.

The 'low productivity' approach to poverty sees poverty as a result of technological barriers. Improvements in the technology of production will lead to increases in output which in turn will lead to economic growth and development and thus a decline in poverty. Such an approach underlies much of the past work of the CGIAR group of research institutions and their interest in modern crop varieties. It also underlies most technical research concerned with crops and livestock which is concerned with maximising output. It is

[2] IFPRI (n.d.) traces the history of 'The Standing Panel on Impact Assessment (SPIA) on the Impact of Agricultural Research on Poverty' which is sponsored by the CGIAR group. The first phase of its work was completed in 1999 and culminated in Kerr and Kolavalli's important report (Kerr and Kolavalli 1999). The second phase was launched in 2002 and consists of seven case studies, 5 of which 'employ the sustainable livelihoods conceptual framework as a means of integrating social and economic assessment'. This has given rise to the paper by Adato and Meinzen-Dick (2002).

also the basis for claims that the rates of return to agricultural research are high (Alston *et al.* 1998; Kerr and Kolavalli 1999: 38).[3]

Yet the problem with such an approach to poverty is the assumed link between rising levels of productivity and reduced levels of poverty. There is no clear link between the two except at the most general and long-term level and there are many cases of poverty increasing following the adoption of technical innovations and rising productivity. Any measures of the impact of research interventions in terms of productivity tell us little about the impact of the research on poverty. But the attraction of such an approach is that it is relatively easy to design large-scale statistically impressive methods for measuring the impact of research.

The second approach is to define poverty not in terms of production but in terms of income. This is the approach adopted by the World Bank (and associated institutions) which defines extreme poverty as being an income of less than $1 per day per person. Such a definition of poverty has its advantages: it does set a global standard and allow comparison and it does form the basis for large-scale statistical exercises. Again, there is a certain attraction in such a definition of poverty because in theory at least it allows for statistical measurements relating research activities to reductions in poverty.

However, such a simple measure of poverty has been increasingly under attack over the last decade or so - primarily because it is too simplistic. To quote the UNDP, 'The concept of human poverty is much bigger than the measure' . Whilst organisations such as the UNDP have attempted to generate numerical indicators such as the Human Development Index, increasingly the most generally accepted approach to understanding poverty has become the Sustainable Livelihoods (SL) framework used by DFID and various other organisations . Such an approach shifts the focus away from externally determined and measurable indicators of poverty to definitions which are ideally generated by the poor themselves. These give weight to factors which are often ignored such as risk, gender differentials, social exclusion and sustainability.

It must be noted there are major theoretical problems with the concepts underlying an SL approach. It does tend towards a

---

[3] There is a host of examples of this sort of assessment. See for instance Ochmoke and Crawford 1996; Manyong *et al.* 2000; Prabhu 2000; and Bonte-Friedheim and Sheridan 1997.

formulaic approach to the complexities of the social, and some of the basic concepts involved are. to put it mildly, extremely questionable. This is particularly true of 'social capital'.[4] Yet even so, it does have many advantages. It recognises the complex nature of poverty in the developing world and that there are no simple linkages between technical research, technical change, increases in output, increases in income and a decline in poverty.

Clearly, if we are interested in assessing the impact of research on poverty, then the way in which poverty is defined will have a major impact on the methods we use. Each of the three broad ways in which poverty is defined has its advantages. A focus on production gives rise to relatively easy methods. Both a focus on production and on a 'dollar a day' poverty measures allow large scale statistical investigation. The SL approach allows for the complexity of poverty to be addressed. But the different approaches also give rise to major problems. The first two oversimplify poverty and may indeed disguise its reality. The SL approach is difficult to operationalise as the basis for generalisations and comparisions and is extremely difficult to use in the context of large-scale statistical analysis.

These issues will be returned to in more detail in section 4. But before addressing the issues of how to analyse impact we need to look at the nature of research itself.

3. Types of Research

Precisely what is research is a moot point. In a sense all development interventions involve research to a greater or lesser extent, and the research element has become increasingly important as process approaches to development interventions have become more popular. Furthermore, where the distinction between research and policy analysis lies is unclear. Ittcould be argued that the participatory turn in development thinking or the establishment of an SL approach to poverty are based on 'research' . But it could equally well be argued that they owe little to research and much more to shifts in the policy environment which are independent of the outcomes of 'research'. Indeed, most of the significant research into participation or sustainable livelihoods has come after they have been adopted as orthodoxy by the

---

[4] Although hailed as the 'missing link' in development (Grootaert 1997), it has been heavily criticised by authors such as Fine (2001) and Harriss (2002). See also Stirrat n.d.

development industry. And the way in which poverty is defined has a major influence on what is seen as being relevant or irrelevant research. Thus the shift from viewing poverty in technical terms to viewing it in terms of an SL framework has led to a shift in the research agenda.

There is also the problem of what is 'knowledge'. DFID policy statements talk about knowledge creation and management and 'knowledge systems'. Without entering into the major debates about the nature of knowledge and whether one can talk about 'knowledge systems', it has to be noted that from a philosophical point of view there are major problems in conceiving of knowledge in this way - as systematic and as somehow external to the contexts in which it is generated. Rather, research into the nature of knowledge indicates how it is fashioned by social and political contexts and can not be seen as existing in an absolute sense. This is most easily seen in the context of 'knowledge' about the social, for instance the conflicting knowledges concerning the nature of poverty. But it is also arguably true for more 'technical' research. Thus at the most general level, much research is concerned not with creating 'new knowledge' but with reinforcing existing ways of seeing and understanding the world.[5]

Whilst such issues must be born in mind, and in a more ambitious treatment of impact assessment would be essential, for the purposes of this report they are probably too recondite and a less radical approach should probably be taken.[6] As far as definitions of research, that offered by the OECD (the Frascatti definition) is probably as good as any. It suggests that,

> Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man (sic), culture and society, and the use of this stock of knowledge to devise new applications. (Surr *et al. 2002*:13)

Even so, this definition does not include policy research and as Surr *et al.* (2002) argue, it is probably better to use a very loose definition of what research might be.

---

[5] For one example of such an approach, see Phillips and Edwards (2000) who argue that all knowledge is socially constructed and that impact assessment of development projects is a matter of producing an 'acceptable story'. See also Fairhead and Leach (forthcoming).)

[6] Here a useful summary of the DFID position is given in the recent DFID research policy paper (Surr *et al.* 2002: 2-6)

Although there are other ways of classifying research, one common way is to group research activities into three broad categories: 'hard' technical research (e.g. new cultivars; new techniques of dealing with pests); 'soft' research (e.g. research on gender; on management of common property resources) and 'policy research' (e.g. research on policy management). Of course such a classification is not ideal. Later in this paper it will be suggested that it is perhaps a mistake to range different sorts of research along a continuum and that there is a major disjunction between forms of research based on a positivist tradition of knowledge and those which derive from a more humanist tradition., But for the moment the 'hard'/'soft' distinction is of some use in highlighting the major implications for impact analysis of different forms of research.[7]

'Hard' technical research has been at the core of the development research agenda for the last few decades. It is concerned with generating new technical forms of knowledge - new crop varieties; modified animal species; more efficient forms of irrigation and water conservation - which are usually, although not always, of a general rather than a specific nature. The object of this research has primarily been to increase productivity either through the more efficient use of existing resources or access to new resources. Ultimately it is based on a Promethean theory of development: that development is based on technical change and innovation. Most CGIAR-backed research has taken this form.

In contrast, other forms of research focus on what might be called 'softer' issues. Here, a rather different definition of development is at stake. Rather than see development being the result of technical innovations and implementation, social issues (in their broadest sense) are seen as central. This sort of research seeks to encourage poverty eradication through addressing the social, political and economic context which makes people poor. In extreme forms such an approach to development makes technology a secondary issue, driven by social forces. Thus research on gender relations, research on distribution of income or the role of credit all fall at the softer end of the continuum. Whilst there are research areas which are of general importance (e.g. the impact of primary level education on economic growth) research with a softer

[7] An alternative frame would be that made by DFID between 'enabling', 'inclusive' and 'focused' activities (see footnote 18). For an example of how this might be used in the research context, see Cox *et al.* 1998.

focus is often more specific to particular regions, countries or even parts of countries.

Finally there is 'policy research'. This overlaps with what I have called 'soft' research in that it is not concerned with 'technical fixes' but with the context in which technologies are used. Policy research deals with such matters as the role of subsidies, taxation, the place of the separation of the private from the public, the role of NGOs in development, the role of research in development and so on.

Now of course these distinctions between 'hard', 'soft' and 'policy' research are only heuristic and in many cases particular research projects involve elements from all three forms of research. But using this framework does allow us to recognise that there are different forms of research and that different methods may be appropriate for assessing their impact. The methods which have been and are developed for assessing the impact of -say - research into new cultivars are unlikely to be appropriate for an examination of the impact of research on participatory management of common resources. Methods developed in one epistemological space (e.g. epidemiology) are unlikely to be suitable in another (e.g. gender relations). [8]

4. Assessing impact

4.1 Preliminaries

Whether or not the impact of research can be satisfactorily assessed is a matter of some debate. Some writers argue that in the end it is not possible to come to any firm decision.[9] Thus Gardner (1999:19) argues that identifying the gains from policy research is 'highly conjectural', and Norton and Alwang (1998) come to similar conclusions. Casley and Kumar argue that in the end there can be no certainty and that all that can be expected is a 'reasonable indication of a strong association between a set of

[8] So for instance, gender is clearly a social construction and thus in a sense arbitrary whilst epidemiology, at least in theory, deals with the 'real' world 'out there'. Methods which can deal with an externally given reality are very different from those which have to cope with the complexities and ambiguities of the socially constructed.

[9] In development more generally, these comments fit in with those put forward by Pronk (2001) who argues that there is no meaningful relationship between aid and development and that at best aid can only act as a catalyst

variables in a temporal sequence, which is logically justifiable' (1988:151).[10]

Broadly speaking, the literature distinguishes two methods of assessing the impact of research projects. The first depends on the use of quantitative data and attempts to show through statistical analysis how certain research inputs lead to certain developmental outputs. Such methods are suitable for certain types of research projects mainly (although not all) at the 'hard' end of the continuum and where poverty is defined either in terms of productivity or in terms of a numerical measure (e.g. $1 per day). The second depends on qualitative data where causal chains rather than statistical correlations are seen as important. These methods are more suitable in contexts where poverty is defined in terms of the SL framework and where research is at the 'soft' end of the continuum, although once again there are exceptions. As poverty is increasingly defined in SL terms, more attention will be paid to qualitative than to quantitative techniques.

4.2 Quantitative techniques

Quantitative techniques of impact assessment depend upon numerical representations of 'before/after' or 'with/without' scenarios. The first involves the collection of baseline data on particular indicators before the research project commences (or more likely before the findings of the research project are disseminated) which can then be compared with data collected at a later stage. The second method involves comparing selected indicators in an area which has experienced the outputs of the research from another area which has not.[11]

In principle such a method is extremely attractive because it is logically so simple and can generate data which are transparent and which can give a clear measure of the impact of research. So for instance the impact of a new rice cultivar can be measured in terms of the cost of developing that cultivar in relationship to the increased value of output or the increased household income of those who

[10] There are also arguments as to what the unit of impact appraisal should be. Whilst in general the focus is upon individual research projects, some writers argue that appraisals should be at the level of the research programme (e.g. Maredia *et al.* 2000) whilst others work at an even more general level (e.g. the impact of new strains of rice on poverty in South Asia)

[11] There are many descriptions and textbooks which describe in detail these methods of assessing impact not just of research projects but of projects more generally. The World Bank is a regular producer of such manuals. A recent example of these is Baker 2000. Others include World Bank 2002; Prenushi *et al.* 2001.

use it. Or the impact of research into grain storage can be measured by comparing the incomes of those who have adopted the outputs from the research with those who have not.

Now of course, such methods are subject to the limitations that they depend on particular definitions of poverty: it is difficult to imagine this sort of analysis taking place in a context where poverty is defined in SL terms. But leaving that aside for one moment, even if one uses a narrower and more quantifiable definition of poverty, there are major problems with such methods. These include:

- *Expense*. Such methods are notoriously expensive in that they depend in the main on the collection of large bodies of data suitable for statistical analysis.
- *Confounding factors*. It is often extremely difficult to determine what were the impacts of a particular piece of research and what was the result of other factors. So for instance much of the argument over the impacts of the 'Green Revolution' in India depends on how far one sees them as simply the result of new cultivars and how much the result of other factors
- *Pre-designation of indicators*. Indicators have to be chosen which are measurable. Furthermore, for 'before/after' analyses they may well turn out to be the wrong indicators: the impact may well not be what it was expected to be and the wrong indicators may have been chosen.
- *Where does one stop*? What is clear from many impact studies is that there are not just direct and secondary impacts but often a whole chain of impacts which can result from the successful implementation of a research project. How far down this chain of causation one goes is in the end arbitrary.
- *Randomisation*. For such methods to have the robustness that are often claimed for them, data sources have to be randomised. This is often extremely difficult at a practical level. For instance, there are often good reasons why certain areas or groups of households have not adopted research outputs.
- *What can't be quantified*. There are impacts which can't in any simple sense be quantified. The tendency is to leave such impacts out of consideration.

Yet despite these major problems, there are situations in which large scale quantitative techniques are of value. An obvious example consists of the studies of the impact of improved rice and wheat cultivars in South and Southeast Asia. But it seems that they are of most use in relatively simple situations and in examining the direct and immediate impact of research. When the number of variables begins to increase; where the impacts of a piece of research have multiple impacts (e.g. on production levels; on employment; on gender relations; on land holding; on credit relationships) then it becomes increasingly difficult to assess impact using quantitative methods.

The basic problem with these methods is that ultimately they derive from the natural sciences where controlled experiments can take place. But as one moves away from highly controlled environments then it becomes more and more difficult to ensure the 'scientific' or 'objective' nature of the exercise.[12] As long as the assessment is concerned with relatively simple variables (e.g. income or levels of production of a few crops) then such methods remain plausible but once one introduces more and more variables the more unwieldy and expensive it gets. Yet such is the strength of the quantifiable model (to count it is to control it...) that it remains the dominant model of impact assessment.

4.3 Qualitative techniques

It is difficult to give a simple definition of 'qualitative techniques' and the oft used distinction that the latter use 'words' whilst quantitative techniques use 'numbers' does not hold up to much examination.[13] Quantitative research may involve more than just the collection of numerical data on output and income and involve much less tangible phenomena whilst qualitative research may be presented in a quantitative fashion. Rather what characterises a qualitative approach is a radically different epistemology from that which underlies quantitative methods. So whilst the latter is derived from a positivist tradition, the former is much more grounded in the humanities.[14] To quote Hulme,

> Its main features are an inductive approach, a focus on key informants, recording by notes or image and the data analyst is usually directly and heavily involved in data collection. This tradition does not try to 'prove' impact within statistically defined limits of probability. Rather, it seeks to

[12] Thus frequently these methods are referred to as 'quasi-experiments'. For a useful critique of the 'scientific method' in the context of impact assessment (in this case of micro-finance projects) see Hulme 1997. See\also Hulme 2000))
[13] 'Numbers give one a feeling of facts; qualitative stories give one a feeling of truth'. Quoted by Adato and Meinzen-Dick 2002: 32
[14] This distinction could be used to distinguish different types of research as well as impact studies. Thus the 'hard/soft' distinction is more properly a distinction between two traditions of research one rooted in a positivist and empiricist tradition; the other in a humanist tradition.

> provide an interpretation of processes involved in intervention and of the impacts that have a high level of plausibility (Hulme 1997:16)

The distinctions between qualitative and quantitative methods have been elaborated by Chung (1997 - quoted in Kerr and Kolavalli 1999: 155-6) and are summarised in Figure 1 below.

It is not a matter of qualitative research being less 'rigorous' than qualitative research but rather that it employs a different sort of rigour more concerned with interpretation than with 'proof'. Theoretically, it is much more open to alternatives to simple 'cause and effect' or correlational arguments and opens up the possibility of analysing the complex impact scenarios which are frequently the result of research initiatives.

Figure 1: A comparison of quantitative and qualitative approaches

	Structure	**Role of respondents**	**Role of models**	**Conclusions**
Quantitative	Highly structured research methods	Respondents as sources of pre-sorted data	Externally determined models	Generalised statistical conclusions
Qualitative	Highly flexible research methods	Respondents engaged with and have role in defining sorting of data	Respondents involved in creating models	Analytical and causative conclusions

(Based on Chung 1997 as summarised in Kerr and Kolavalli 1999)

Increasingly, qualitative and quantitative methods are seen as complementary to one another and there is evidence of a general concensus emerging as to the importance of using both methods (e.g. Kerr and Kothavalli 1999; Adato and Meinzen-Dick 2002; Kilpatrick 1998, to mention but a few). The argument is put forward that qualitative methods allow the assessor to identify research issues or hypotheses which can then be used to frame the more narrowly focussed quantitative research. Furthermore, it is also argued that a qualitative approach allows the assessor to understand what the quantitative research 'means'.

Yet it could be argued that qualitative analysis alone is often sufficient to allow conclusions to be reached and that the use of quantitative methods only produces a spurious scientificity. Often such data simply legitimise conclusions already reached through qualitative analysis. There is also the problem of how one marries two very different approaches, one ultimately deriving from the physical sciences and the other from a humanist tradition. From a philosophical point of view, simply bolting one onto the other is no answer.

Whatever the arguments concerning the potential complementarity of qualitative and quantitative methods, it is clear that qualitative methods are more suitable to approaches which are based on an SL approach to poverty. Furthermore, they are also more suited to an examination of research which focuses on the 'softer' end of the continuum and they open up means by which impact assessment can be more 'participatory'.

4.4 Participatory approaches to impact assessment

'Participatory' approaches to development have become the orthodoxy, and increasingly there are calls for a 'participatory' approach to impact assessment. It is argued that 'top down' approaches fail to uncover the realities of poverty and the processes that give rise to poverty, and that through 'participation' and the armoury of techniques associated with 'participation' a more effective approach to poverty can be developed. Thus the present group of IFPRI impact analyses are in part based upon a participatory approach (Adato and Meinzen-Dick 2002).

This obviously is not the place to go into an extended discussion of participatory methods in general. There is a vast and ever-increasing literature which covers participatory approaches in general and participatory techniques for monitoring and evaluation in particular, the latter often overlapping with impact assessment.[15]

[15] See for instance Abbott and Guijt 1998; Guijt 1998; Oakley, Pratt and Clayton 1998; Roche 2000. A comprehensive manual is provided on-line by IFAD 2002.

Proponents of a participatory approach to impact assessment are damning of the 'scientific' method. To quote Hulme once more,

> According to this line of argument the scientific method fails as it: ignores the complexity, diversity and contingency of winning a livelihood; it reduces causality to simple unidirectional chains, rather than complex webs; it measures the irrelevant or pretends to measure the immeasurable; and it empowers professionals, policymakers and elites. (Hulme 1997:17)

Hulme goes on to quote Chambers (1997: 123):

> ...conventional baseline surveys are virtually useless for impact assessments... The question now is how widely local people can be enabled to identify their own indicators, establish their own participatory baselines, monitor change, and evaluate causality.

These are noble sentiments indeed, but how far they can be realised in practice is another matter. What is clear is that much of what passes as participatory research in no way measures up to the ideals outlined by Chambers. Simply labelling research which involves talking to people as 'participatory' in no way moves the locus of enquiry into the agenda of the poor. At present, the term is used to cover such a wide range of situations - from a few random discussions with the rural poor through focus groups and village meetings to situations in which the rural poor are truly empowered - that the term 'participatory' is almost devoid of any general meaning.

At the same time, there is an increasing literature which raises major questions as to the nature and efficacy of participatory methods (e.g. Mosse 1994; 2001, Cooke and Kothari eds. 2001). The few detailed studies of participation in action (as distinct from studies which claim to use a participatory approach) show that the methods are easily hijacked by local elites and that the voices of the poor are frequently ventriloquised by those elites or by researchers (Whitehead and Lockwood 1999). More generally, the skills and analytical abilities which are necessary for successful local level research are at least as sophisticated as those required in the 'scientific' approach. Finally, there is an increasing number of theoretical discussions which indicate that from an analytical point of view participatory methods frequently involve the imposition of a particular way of thinking on the participants, in effect denying the 'bottom up' pretensions of much participatory research.[16]

Clearly, any study of the impact of research on poverty has to address the experience of the poor and clearly this has to involve in some form or other their involvement both as sources of information and as analysts of the situation. Furthermore, such an approach does not necessarily have to involve only qualitative data: it can also be used as the basis for obtaining quantitative data. Any effective assessment of impact has to involve the participation (at some level) of those who are supposed to be its beneficiaries. However the populist turn, the glorification of the local, and the claim that there are 'multiple realities' are dangerous tendencies in that they are ultimately anti-analytical. Whilst a participatory approach may generate a valuable body of information as to how the impact of research was experienced (or not), if it is restricted to the local level it will tell us very little about the chains of influence, power and knowledge-flows which link research to people's lives. Impact assessment is not just about whether or not the poor became less poor but how the knowledge generated by research has an effect on the poor.

4.5 **Causal linkages**

At the risk of over-generalising, quantitative methods of assessing impact tend to be associated with a 'top-down', technologically driven approach to development. Categories of data are derived from the outside and imposed upon local situations. On the other hand, participatory and qualitative methods of impact assessment are associated with 'bottom up', supposedly user-driven research agendas. Yet what is perhaps crucial is the excluded middle: how do the outputs of research get to the supposed beneficiaries of that research? What are the chains of communication and dissemination and in what situations are they effective or non-effective? In assessing the impact of research these processes are crucial not only in understanding what impact has occurred but also how research can be made more effective in achieving developmental goals.

This approach to IA has been taken up by a number of writers. For instance, Spilsbury (2000) argues that IA should focus on 'impact

[16] For an example of this see Adato and Meinzen-Dick 2002: 31). See also Cooke and Kothari eds. 2001)

pathways' - the routes through which research findings travel to their ultimate users - and the effects they have on poverty at the local level. Balzer and Nagel (2000) use the same term although they fail to define it in any detail. Davidson (2000) argues for a similar approach which he labels 'causative strategies': the 'cause and effect' links between research and its impacts, whilst Grahn (2002) uses the phrase 'tracking impact and uptake'.

Despite different terms, what all these writers are advocating is that impact analysis should focus on a process rather than on the end result. As Grahn puts it, impact and uptake can not be precisely measured but what can be observed is an ongoing process which involves continuing social relations and continuing impacts on poverty.

Such an approach does not rule out the use of quantitative techniques, nor does it rule out local level participatory impact assessment. But what it adds is an examination of the ways in which new knowledge or new techniques have a continuing effect. This may be direct, for instance how a new technology is disseminated through an extension system, how particular users adopt and others reject it, how it has a positive impact on poverty or not. Or it may be less direct, for instance how findings from research are disseminated at a national level; how they change policy and the impact that change has on poverty.

In effect what this approach involves is an 'ethnographic' approach which seeks to place research within a social and political context not just at the local level but also within national (and potentially international) contexts. This involves a more correct use of the term 'holistic' than is commonly used. One of the problems with 'participatory' approaches is that they tend to reify the local 'community' setting it apart from and in opposition to the larger social and political formations in which they lie. This approach seeks to show not just the impact which research has had but also how it achieved that impact or failed to achieve the expected impact. The result is (or should be) a greater understanding of the role of 'confounding factors' which may well cease to be confounding and rather be seen as crucial to whether or not any particular piece of research has an impact.

4.6 **Poverty, research and impact assessment**

At this point it may be worthwhile trying to bring together some of the points made in the previous sections. Broadly speaking, it has been argued that there are differences in how poverty is defined and differences in the nature of research. These in turn have implications for the methods which can be used for impact assessment, and these are summarised in figure 2

Figure 2: Impact assessment strategies

Concept of poverty	Production/Income	SL Framework
'Technical' Research	1	2
'Soft' Research	3	4
Policy Research	5	6

1. This cell denotes the use of large-scale quantitative methods to assess the impact of 'hard' technical research. Such methods can be appropriate where the produces a general output which can be taken up (or rejected) widely. It is possible to measure the impact primarily in terms of changes in output but also in terms of a quantified income figure. Examples of this are obviously those which involve the development of new cultivars and modern crop varieties. Examples of such assessments abound, particularly in the context of the Green Revolution. Yet even here there is evidence of difficulties in employing such a methodology as evinced by the debates on the actual impact of the Green Revolution.

2. This cell denotes attempts to measure the impact of 'hard' technical research where poverty is conceptualised in terms of the SL framework. Here large-scale quantifiable methods are probably unsuitable and qualitative methods more appropriate. Even though the research is technical, teasing out the detailed non-quantifiable impacts requires much more qualitative approaches, almost certainly involving the use of a 'causal linkages' approach

3. This cell denotes the assessment of the impact of 'soft' research in a context where poverty is defined in quantitative terms. Here probably both qualitative and quantitative methods are appropriate. Although the research is 'soft', the focus on a

statistical measure of poverty encourages the use of quantifiable methods.

4. This cell denotes the assessment of the impact of 'soft' research in terms of the SL model. Qualitative methods are appropriate. The research is 'soft' and the SL poverty frame encourages such methods.

5. This cell denotes the assessment of policy research in a context where poverty is measured in quantitative terms. Here, a quantitative approach to impact assessment can be attempted, but the general consensus is that it is very difficult to come to any firm conclusion using these methods.

6. This final cell concerns the assessment of policy research in the context of an SL approach to poverty. Quantitative methods will be of limited use in such assessments.

Overall, qualitative methods would seem to be generally more suitable for situations where poverty is defined in SL terms. The exceptions are research projects which are highly technically orientated or policy research which works at a macro level (e.g. research into taxation policy). But increasingly the SL framework is defining not only the nature of poverty but also what sorts of research should be supported to eradicate poverty. The result is that therewill be a decreasing interest in large scale quantitative research into the impact of research and more interest in developing tools for qualitative analysis using both participatory methods and methods which focus on causal chains.

So far, relatively little work has been done on assessing the impact of any sort of development intervention in terms of an SL framework. Outside research, one pioneer effort is Ashley and Karim (2000) whilst another is Wakelin and Basheer's preliminary work on the impact of new technologies (2000). One of Ashley and Karim's conclusions, however, is that whilst the SL framework is useful at the local level, they find it difficult to operationalise at higher levels. In the field of research impact assessment the only work so far is the ongoing studies by IFPRI reported on by Adato and Meinzen-Dick (2002). They too report difficulties (some of which have been alluded to above) and point to some of the conceptual problems in the SL approach to development in general. These include issues concerning the nature of social capital and an absence of power as a significant dimension in the framework.

One of the major implications of this conclusion is that the ways in which impacts are measured and compared will have to change. Traditional quantifiable measurements focusing on a few key indicators have the advantage that comparisions can be made between different types of research and between research and other forms of development intervention. The shift towards an SL approach to poverty coupled with (and implying) the use of generally non-quantifiable and qualitative approaches to impact assessment makes comparision much more difficult and less 'objective'. Indeed it involves the rejection of the traditional scientific paradigm and a willingness to accept interpretative and evaluative impact assessments. The widespread adoption of an SL framework coupled with a stress on participation also implies that the distinction between 'research' and 'development' interventions will become increasingly blurred, what is presently seen as research becoming increasingly defined by developmental objectives (Surr *et al.* 2002)

5. Writing assessment needs into research project design

It is one thing to consider how one might go about assessing the impact of existing or past research projects: it is another to consider how one might write 'impact' more clearly into the design of research projects. The present 'A to H' scale used to assess the performance of projects is only a beginning for what it attempts to measure is dissemination and uptake, surely poor indicators of impact.[17] But at the same time, simply to favour supporting projects which produce an easily measurable impact is dangerous. As Spilsbury points out, this would bias research programmes towards short term, incremental research with cumulative impacts rather than the systemic impact which he sees as being of more lasting importance (Spilsbury 2000).

One approach to this issue is outlined by Cox, Farrington and Gilling (1998). This paper is primarily concerned with determining what sort of research should be supported in order to decrease poverty.[18]

[17] See the rather caustic remarks of Flint and Underwood 2002:12.
[18] See Hazell and Haddad (2001) for a parallel discussion of what sorts of research might help the poor.

Using an 'enabling/inclusive/focused' set of categories[19], they argue that in terms of the *numbers* of poor people who stand to benefit, research into 'enabling' issues and strategic focused research is likely to have the greatest impact.[20] But even so, they argue that,

> NR research is a blunt instrument for achieving social objectives: whilst it can promote broad patterns of growth from which the poor can and often do benefit, it is difficult to target in such a way that the poor disproportionately benefit. Its impact is highly dependent on a range of demand and supply based variables which often do not favour the poor (Cox *et al.* 1998: 43)

In other words, no matter how 'good' the research is, its impact will depend on factors extraneous to the research project itself, and they go on to develop a 'toolkit' to assess the potential poverty focus of NR research.[21]

The general conclusions reached by Cox *et al.* - that the impact of research is determined in large part by the wider context in which the results of research are implemented or disseminated - is supported by a number of other observers.[22] One particularly striking example of this is in Freebairn's discussion of the impact of the Green Revolution on inequality (Freebairn 1995: 23). He shows not only that different conclusions appear to be reached by different writers using different methods, but also that whilst a technology may be 'scale neutral' its impact depends on the particular context into which it is introduced. And he goes on to quote Pearse who claims that,

---

[19] *Enabling* actions are those which underpin policies for poverty reduction and lead to social, environmental or economic benefits for poor people; *inclusive* actions include sector programmes which aim to benefit population groups (including poor people) and address issues of equity, barriers to participation or access of poor people, and *focused* actions focus on the rights, interests and needs of poor people (Cox *et al.* 1998: 17).
[20] They are particularly dismissive of other forms of focused research: 'their (generally) applied nature often makes them highly photogenic... they therefor tend to feature strongly in public relations material - and some would argue that they receive publicity out of all proportion to their overall impact on poverty' (Cox *et al.* 1998: 28)
[21] Although fairly elementary, this could form a basis for writing impact assessment needs into project design.
[22] See for instance Bussolo and O'Connor (n.d.), Conway 1997 and Lipton and Longhurst 1989

> It is not possible to disassociate the social and the economic effects of the technology from the social system in which it is functioning. The structure of the social system determines both that the technological package will be implemented and how the benefits will be distributed. It is not possible to isolate one from another (Pearse 1980: 276)

And this implies that if we are going to support effective research projects and if we are going to be able to assess their impact in any persuasive fashion, much more attention has to be paid to these contextualising factors.

Cox *et al.* were primarily interested in attempting to define in advance the sorts of project which would help the poor and not with how one might measure impact *per se*. Perhaps the only writers to face up to this issue directly in any detail are Balzer and Nagel (2000), although they are concerned with 'impact monitoring' (an internal management tool) rather than 'impact assessment' (Balzer and Nagel 2000: 4). However, one of the crucial points they make is that much more effort has to be made into 'unpacking' and more closely specifying the nature of the statements made in the 'assumptions' column of the logframe.

> Statements like 'favourable political environment', 'availability of funds', 'interested decision-makers', 'target group willing to co-operate' are too unspecific for monitoring purposes. (Balzer and Nagel 2000:11).

And indeed, they are also too vague for effective impact assessment. For if the aim of the assessment is to understand successes and failures, then it is not just a matter of understanding the success or failure of the research in its own terms. Research does not take place within a vacuum. The success and failure of a project in terms of the social, political and institutional context in which it is being carried out has also got to be assessed. This would in part deal with the problem of the 'confounding factors' which bedevil issues surrounding attribution.

Directly linked to this is the need for a greater specification at the planning stage of how the research will actually impact on the poor. At present, the specific and detailed links in project planning are at the activities and outputs levels and the relationship between them. These are relatively easy to define and as they are directly under the control of project staff it would be surprising if goals at these levels were not achieved. But what is much vaguer, much less specific, and much less detailed, are the purpose and objectives levels of the logframe and the links between them. In order to assess impact there has to be much greater specification at these levels and the generation of causative models which, in conjunction with much more clearly delineated sets of assumptions, provide the basis for post project impact assessment.

Clearly there are problems of proportionality and expense in the matter of building impact assessment into research design. As Balzer and Nagel point out, the use of sophisticated data collection and processing is not feasible in normal cases (Balzer and Nagel 2000: 10). Furthermore, with the increasing use of the SL framework for the analysis and understanding of poverty, the large scale use of control groups, baseline studies and quantifiable indicators is probably unwarranted and unsuitable.

Yet as research becomes more SL-orientated, an argument could be mounted that before research, especially technical research, takes place, much greater note has to be taken into the context in which this research is taking place and the supposed impacts that it is going to have. This would do two things: first it would act as a viability check on the relevance of the research project's outputs for poverty alleviation objectives, and secondly, it would provide the sorts of data which would become the basis for serious assessments of impact.

6. Conclusions

1. It is clear that it is impossible to produce precise and 'proven' assessments of the impact of research except in a few very specific situations. Even then, the cost and complexities of doing such assessments are probably prohibitive.

2. If poverty is defined in terms of an SL approach then research will tend to have a 'softer' focus. This requires a more nuanced and interpretive approach where judgement rather than proof is central.

3. The best approach to assessing the impact of research is through tracing the dissemination of research outputs and identifying where they have had (or have not) had an impact on the poor. This will involve an 'ethnographic' approach based on interviews, case studies, perhaps oral histories and possibly

some quantitative work. What will be crucial here is 'plausibility': does the story which emerges make logical sense and ring true to the various stakeholders involved?

4. Straightforward 'participatory' impact assessments will be of limited use by themselves as such methods fail to address central issues of power, hierarchy and social exclusion.

5. In planning future research projects there is a need to develop fuller models of how the proposed research will impact on poverty and much greater specification of the assumptions that link outputs with poverty

6. In planning future research projects there is an argument that any 'technical' research project will have to be preceded by what amounts to an SL research project in order to identify whether or not the preconditions for the successful dissemination of the research exist, and whether or not the outputs of the research project will address real rather than imagined research needs.

References

J. Abbot and I. Guijt 1998. 'Changing views on change: participatory approaches to monitoring the environment'. SARL Discussion Paper No 2. London, IIED.

M. Adato and R. Meinzen-Dick 2002. Assessing the Impact of Agricultural Research Using the Sustainable Livelihoods Framework. Washington, IFPRI (FCND Discussion Papers 128; EPTD Discussion Paper 89).
http://www.ifpri.org/divs/eptd/dp/papers/eptdp89.pdf

J. Alston, M.C. Marra, P. Pardey and T.J.Wyatt 1998. Research Returns Redux: A Meta-analysis of the Returns to Agricultural R&D. Washington, IFPRI. (EPTD Discussion Papers 38)

C. Ashley and H. Karim 2000. Developing Methodologies for Livelihood Impact Assessment: Experience of the African Wildlife Foundation in East Africa. London, ODI (Working Paper 129).
http://www.odi.org.uk/publications/wp129.pdf

P.W.Anandajayasekeram, A. Masters and J.F. Oehmke 1997. Impact Assessment of African Agricultural Technology Development and Transfer. Synthesis of Findings and Lessons Learnt. Policy Synthesis 28.

J.L. Baker 2000. Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners. Washington, The World Bank. http://www.worldbank.org/poverty/library/impact.pdf

G. Balzer and U. Nagel 2003. Logframe Based Impact Monitoring within the CGIAR System.
CGIARhttp://www.cgiar.org/tac/spia0500/balzer.pdf

J. Beynon, S. Akroyd, A. Duncan and S. Jones 1998. Financing the Future: Options for Agricultural Research and Extension in Sub-Saharan Africa. Oxford, Oxford Policy Management.
http://www.opml.co.uk/papers.htm

C. Bonte-Friedheim and K. Sheridan (eds.) 1997. The Globalisation of Science: The Place of Agricultural Research. The Hague, ISNAR. www.isnar.cgiar.org/publications/books/Globalization.htm

M. Bussolo and D. O'Connor. n.d. 'Technology and Poverty: Mapping the Connections' In, Technology and Poverty Reduction in Asia and the Pacific. ADB Web site. www.isnar.cgiar.org/publications/ books/Globalization.htm

D. Casley and K. Kumar 1988. The Collection, Analysis and Use of Monitoring and Evaluation Data. Baltimore, Johns Hopkins University Press.

R. Chambers 1997. Whose Reality Counts? Putting the Last First. London, IT Publications.

G. Conway 1997. The Doubly Green Revolution. London, Penguin.

K.R. Chung 1997. Identifying Good Practice for the Integration of Qualitative and Quantitative Methods for Survey-Based Poverty Research. Draft, Watson Institute for International Studies, Brown University.

B. Cooke and U. Kothari (eds.) 2001. Participation: The New Tyranny? London, Zed Books.

A. Cox, J. Farrington and J. Gilling 1998. Reaching the Poor? Developing a Poverty Screen for Agricultural Research Proposals. London, ODI (Working Papers 112). http://www.odi.org.uk/publications/working_papers/wp112.pdf

E.J. Davidson 2000. 'Ascertaining causality in theory-based evaluation'. New Directions for Evaluation 87: 17-26.

J. Donecker and M. Green 1998. Impact Assessment in Multilateral Development Institutions. London, DFID.

J. Fairhead and M. Leach (forthcoming) Science/Policy and Society: African and Caribbean Engagements with Transnational Environmental Knowledge and Power.

Ben Fine 2001. Social Capital versus Social Theory: Political Economy and Social Science at the Turn of the Millennium. London, Routledge.

M. Flint and M. Underwood 2002. Synthesis Study of the Impact of Renewable Natural Resources Research Programmes. London, DFID

B.L. Gardner 1999. Returns to Policy-Related Social Science Research in Agriculture. Washington, IFPRI. (Impact Discussion Papers 9). www.ifpri.org/impact/iadp09.pdf

R. Grahn 2000. A Study into Methods for Tracking the Research Uptake and Developmental Impact of NRSP Funded Research Projects. Final Report.

I. Guijt 1998. 'Participatory monitoring and impact assessment of sustainable agricultural initiatives: an introduction to the key elements'. SARL Discussion Paper No. 1. London, IIED.

Christiaan Grootaert 1998. Social Capital: The Missing Link? Social Capital Initiative Working Paper No 3. Washington, The World Bank. http://wbln0018.worldbank.org/Networks/ESSD/icdb.nsf/D4856F112E805DF4852566C9007C27A6/3B71DED97819DB848525676D00685ED5/$FILE/SCI-WPS-03.pdf

P. Hazell and L. Haddad 2001. Agricultural Research and Poverty Reduction. Washington, IFPRI. (Food, Agriculture and the Environment Discussion Paper No 34). http://www.ifpri.org/2020/dp/2020dp34.pdf

J. Harriss 2002. Depoliticising Development: The World Bank and Social Capital. London, Anthem Press.

D. Hulme 1997. Impact Assessment Methodologies for Microfinance: A Review. Paper prepared for a meeting of the CGIAP working group on Impact Assessment Methodologies. http://www.cgap.org/assets/images/impact2.PDF

D. Hulme 2000. 'Impact methodologies for micro-finance: theory, experience and better practice'. World Development 28: 79-98.

IFAD 2002. Managing for Impact in Rural Development: A Guide for Project M&E. Rome, IFAD. http://www.ifad.org/evaluation/guide/

IFPRI n.d. Standing Panel on Impact Assessment (SPIA) on the Impact of Agricultural Research on Poverty. Washington, IFPRI.

J. Kerr and S. Kolavalli 1999. Impact of Agricultural Research on Poverty Alleviation: Conceptual Framework with Illustrations from the Literature. Washington, IFPRI (EPTD Discussion Paper 56). http://www.ifpri.org/divs/eptd/dp/epdtp56.htm

H.E. Kilpatrick 1998. Some Useful Methods for Measuring the Benefits of Social Science Research. Washington, IFPRI. (Impact Discussion Papers 5). http://www.ifpri.org/impact/iadp05.pdf

M. Lipton and R. Longhurst 1989. New Seeds and Poor People. London, Unwin Hyman

V.M. Manyong, J.G. Kling, K.O. Makinde, S.O. Ajala and A. Menkir 2000. Impact of IITA-Improved Germplasm on Maize Production in West and Central Africa. Ibadan, IITA. www.iita.org/info/impact/maize.pdf

M. Maredia, D. Byerlee and J. Anderson 2000. Ex Post Evaluations of Economic Impacts of Agricultural Research Programmes. CGIAR

D. Mosse 1994. 'Authority, gender and knowledge. Theoretical reflections on the practice of participatory rural appraisal'. Development and Change 25: 497-526.

D. Mosse 2001. '"People's knowledge", participation and patronage: operations and representations in rural development'. In, B. Cooke and U. Kothari (eds.) 2001. Participation: The New Tyranny? London, Zed Books.

G.W. Norton and J. Alwang 1998. Policy for Plenty: Measuring the Benefits of Policy-Orientated Social Science Research. Washington, IFPRI. (Impact Discussion Papers 6).

P. Oakley, B. Pratt and A. Clayton 1998. Outcomes and Impact: Evaluating Change in Social Development. (INTRAC NGO Management and Policy Series No 6). Oxford, INTRAC.

J.F. Ochmoke and E.W. Crawford 1996. Payoffs to Investments in Agricultural Technology in Sub-Saharan Africa. USAID Bureau for Africa, Office of Sustainable Development. Policy Synthesis no 20.

A.C. Pearse 1980. Seeds of Plenty, Seeds of Want. Social and Economic Implications of the Green Revolution. New York, Oxford University Press.

S. Phillips and R. Edwards 2000. 'Development, impact assessment and the praise culture'. Critique of Anthropology 20: 47-66.

P. Prabhu 2000. Milestones in Impact Assessment in the CGIAR, 1970-1999.

G.G. Prennushi, G. Rubio and K. Subarao 2001. Monitoring and Evaluation. Washington, World Bank. Draft.

J.P. Pronk 2001. 'Aid as catalyst'. Development and Change. 32: 611-629.

C. Roche 2000. 'Impact assessment: seeing the wood from the trees'. Development in Practice 10: 543-555.

M. Spilsbury 2000. CIFOR- Using a 'Systems' Approach to Research Evaluation.

R.L. Stirrat n.d. 'Dumbing down development: the case of social capital'.

M. Surr, A. Barnett, A. Duncan, M. Speight, D. Bradley, A Rew and J. Toye 2002. Research for Poverty Reduction: DFID Research Policy Paper. Draft. London, DFID.

Oliver Wakelin and Shadrach Basheer 2000 Impact Assessment of Appropriate and Innovative Technologies in Enterprise Development. London, DFID.

A. Whitehead and M. Lockwood 1999. ‘Gender in the World Bank’s poverty assessments: six cases from sub-Saharan Africa’. Development and Change 30: 525-555.

World Bank 2002. A User's Guide to Poverty and Social Impact Analysis (Draft). Washington, World Bank.

Appendix VI

Situation Appraisal Questions & Survey Sample Frame
September 2002, AAHRI, Thailand.

AFGRP PROJECT R8119 – IMPACT OF AQUATIC ANIMAL HEALTH STRATEGIES ON LIVELIHOODS OF POOR PEOPLE IN ASIA

Plan of Activities, Methods and Interview Questions for Pichit Case Study (22/09/02-05/10/02)

AGENDA

Tue, 4 Sept-22September:

1. **Planning Situation Appraisal at AAHRI**:

- Making research plan: – selection of case study site and reasons for choosing this area, agenda and schedule, aims, primary research questions, key areas to focus on, outline of interview questions, methods for doing this, logistical details
- Looking at secondary data: - statistical household data on the case study area and other relevant literature
- Preliminary trips to field site?

2. Discussion/informal interviews with staff about role of institute in transfer of aquatic animal health knowledge and it's impact on livelihoods of farmers
3. Discussion of the Flow of Information activity

Sun, 22 Sept	Leave Bangkok, Arrive Pichit (case study site)
Mon, 23 Sept	- Pilot Test Questionnaire (4 farmers in Amphoe Muang area) - Meet with Bun Yung, Chief extension Officer (Discuss our plans, practical arrangements) - Decide Schedule for visiting villages
Tues, 24 Sept- Fri 4th Oct	Village Visits (conduct interviews, focus groups etc., carry out questionnaire)
Sat, 5th Oct	Leave Pichit, return Bangkok
5th Oct – 14th October	- Discussion of Fieldwork findings - Discussion of key issues for report, of content and form of report - Anything else.

AIM

- To combine methodologies derived from social research and scientific research in order to produce a localised case study.
- This case study will investigate the impact of aquatic animal health strategies on the livelihoods of poor people in Pichit Province which will contribute to our over all understanding of the role of aquaculture and aquatic animal health strategies in livelihoods in Asia.
- The case study will address the following research question:
    1. POVERTY and AQUACULTURE - What is the relationship between aquaculture and poverty in Pichit?
    2. LIVELIHOODS and AQUACULTURE - What is the role of aquaculture in the livelihood strategies of the various groups of people involved in fish farming in the province (with a focus on poor farmers)
    3. LIVELIHOODS and AAH - How does aquatic animal health knowledge contribute to sustaining livelihoods derived from aquaculture among the target groups

4. KNOWLEDGE FLOW - How does aquaculture knowledge and information flow, evolve and develop within the institutional and socio-economic context of the area of study
5. ACCESS - To what extent to farmers have access to sources of information on aquaculture?
6. PATHWAYS - What are these sources and what are the pathways through which they reach farmers?
7. DISSEMINATION - How effective/useful is the information and how effectively are the pathways/media through which it is dissemination?
8. UPTAKE – How do farmers use the AAH knowledge and information?

PRINCIPLE TARGET GROUP OF STUDY: poor farmers involved in aquaculture

LOCATION: Pichit Province, Amphoe Pho Thale (selected because (i) high level of aquaculture practiced in the amphoe (ii) severely restricted access to the rest of the amphoes in the province due to floods)

METHODOLOGICAL APPROACH

- Combining qualitative social research methods (in-depth interviews with range of stakeholders – see below) with scientific methods (questionnaire conducted with randomly selected farmers).
- This dual methodology will produce both qualitative fieldwork findings and quantitative data (analysed using a database) which will be synthesized to produce one report of the findings from the Case Study.
- It is important that we interview as diverse as possible as a range of farmers and people involved in aquaculture as possible (see list below) in order to try and understand the social structure of the area and the different ways in which aquaculture contributes to people's livelihoods and impacts on poverty.
- In this way we can build up a picture of the processes, networks and structures which define the practice of aquaculture in the region. We can construct a case study of the paths through which aquatic animal health knowledge flows and how it impacts on people's livelihoods in Pichit.

METHODS
1) <u>In-depth Interviews</u>

- Using the approach of derived from social anthropology we will be conducting in-depth interviews with a range of participants from the stakeholder groups listed below.
- The approach is flexible involving semi-structured interviews (see lists of interview questions below).
- These will be conducted in Thai by Noon and Dinah and recorded. They will then be transcribed and discussed in the field to look for emerging patterns and key themes and issues which will be further explored in the interpretation and analysis stage.
- ACCESS TO PARTICIPANTS:

<u>How do we select/find the Participants?</u>

- we will roughly aim to visit one of the ten villages per day in Amphoe Pho Thale randomly selected for the questionnaire survey (see below).

- while Tuk conducts the questionnaire interviews with the farmers randomly selected in the village for the questionnaire, Noon and Dinah[1] will conduct interviews with informants in that village (see list below).
- We will aim to interview a range of farmers and people involved in aquaculture to get as full a picture as possible:
    1. Both registered and unregistered farmers(those not on the extension officer's list)
    2. Both households involved in aquaculture and those not practicing fish farming (to get an understanding of the motivations for practicing aquaculture and the role it plays in the livelihood strategy of a household)
    3. Farmers who practice a range of different farming systems (mono-culture, polyculture, integrated…see below)
- We will rely on a variety of 'gatekeepers' (key informants) to help us find a range of participants, consulting them about the different types of households involved in aquaculture in each village and how we can get access to as diverse as possible a range of informants:
    1. Village headmen
    2. Other Farmers
    3. Extension Officer (aquaculture and agriculture)

Stakeholder/Target Groups for Interview

- Total number of interviews 50 - 60
1. Aquaculture Extension Officers (1-2 interview)
2. Registered and Un-registered Fish Farming Households (hatchery, nursery, grow-out; mono-culture, polyculture, integrated) (20-30 interviews):
    a. Large scale commercial fish-farmers (?)
    b. Employees of commercial fish-farms (?)
    c. Small-scale fish-farmers (?)
    d. Non-commercial fish-farming households/ subsistence fish-farmers (?)
3. Company Salesman/Representatives (1-2 interviews)
4. Agricultural Supplier (agricultural shops) (1 interviews)
5. Seed Traders/Middlemen (2 interviews)
6. Fish Traders/Middlemen (2 interviews)
7. Markets (1-? Visits)
8. Village Headmen (5-10 interviews)
9. Agricultural Extension Officer (1 interview)
10. Non-Aquaculture Farming Household (5-10 interviews)
11. Fisheries Biologist (1 interview – concerning role of Freshwater Fisheries Station)
12. Bank Representatives (1 interview)

[1] M Crumlish will be involved in both the in-depth interviews and questionnaire while she is in Pichit and in the initial stages of interpretation and analysis back at AAHRI after the case study.

2) <u>Questionnaire</u>

- A questionnaire designed by Mags, Dinah and Noon will be conducted with 65-72 households practicing aquaculture in Amphoe Pho Thale, Pichit Province.
- The Questionnaire will be conducted by: Tuk.
- Target Group: Farming households involved in aquaculture
- How do we select participants:

1. Amphoe Pho Thale was selected from the 12 amphoes in Pichit Province because of:
   - restricted access to the rest of the province due to floods
   - the high level of aquaculture activity in the amphoe.
2. 9 of the 11 districts in amphoe Pho Thale have aqualcture activity in them. We randomly selected 50% of the 9 districts (rounding down).
3. We randomly selected 50% of the villages in each of the 4 districts to make a total of 10 villages
4. From the extension service list of fish farmers we randomly selected 50% of the households involved in aquaculture in each village making a total of 72 households.

Analysis of findings: data from the questionnaire will be inputted by Noon into a database (Epi Info) prepared by Mags. Results from the data analysis will be used in the synthesis report of fieldwork findings to provide quantitative findings which will compliment the qualitative findings from the in-depth interviews.

FOR FISH FARMER QUESTIONNAIRE and LIST OF SELECTED FARMERS BY VILLAGE AND DISTRICT - SEE BELOW

<u>INTERVIEW QUESTIONS FOR FARMERS</u>

- NAME?
- ADDRESS?
- OWNER/HUSBAND/WIFE/HELPER/MANAGER?
- TYPE OF FARM?
- SPECIES?
- NUMBER OF PONDS?
- SIZED OF PONDS?
- STOCKING DENSITY?
- STOCKING DATE?
- HARVEST DATE?
- SOURCE OF FEED?
- SOURCE OF SEED?
- SOURCE OF WATER?
- WATER EXCHANGE?
- DO YOU PREPARE YOUR FARM BEFORE STOCKING? – IF YES, WHAT DO YOU DO?
- WEIGHT AT HARVEST?
- APPROXIMATE PRICE AT HARVEST?
- HOW MANY YEARS FISH FARMING?
- WHAT DID YOU DO BEFORE?
- WHY DID YOU DECIDE TO START FISH FARMNG?
- WHO WORKS AND HELPS WITH THE FISH ON THE FARM?
- DO YOU RENT OR OWN THE FARM?
- OTHER SOURCES OF INCOME IN THE HOUSEHOLD?
- MAIN SOURCE OF INCOME?
- WHICH ACTIVITY DO YOU CONSIDER TO BE YOUR PRIMARY LIVELIHOOD ACTIVITY?
- WHY DO YOU DO AQUACULTURE?
- WHAT DO YOU DO WITH THE FISH?

- SELL:
- EAT:
- BOTH:

WHO DO YO SELL YOUR FISH TO?
- MARKET:
- DOOR-TO-DOOR:
- TRADER:

IF YOU DON'T SELL YOUR FISH WHY NOT?
DO YOU HAVE ANY PROBLEMS SELLING YOUR FISH?
HAVE YOU RECEIVED ANY INFORMATION ABOUT FISHFARMING?
IF YES – WHO FROM? WHAT ABOUT? DID YOU USE IT? HOW EFFECTIVE WAS IT?
TYPE OF INFORMATION
SOURCE OF INFORMATION
HAVE YOU RECEIVED INFORMATION ON:

FEED
SEED
MANAGEMENT
WATER QUALITY
POND PREPARATION
STOCKING DENSITIES
MARKET AND PRICE
DISEASE AND TREATMENTS

HAVE YOU EVER ATTENDED A TRAINING COURSE?
IF SO WHAT WAS IT ON?
IF NOT HAVE YOU EVER HEARD ABOUT THEM?
DO YOUR FISH GET SICK?
IF YES – DO YOU KNOW WHEN THEY GET SICK?
HAVE YOU HAD DISEASE?
HOW DO YOU RECOGNISE IT?
DO YOU KNOW WHAT IT IS?
IS IT A PROBLEM FOR YOU? IF SO IN WHAT WAY?
WHAT DO YOU DO IF YOU HAVE A PROBLEM?
HOW DO YOU KNOW WHAT TO DO?
DOES IT WORK?
DO YOU SHARE KNOWLEDGE WITH OTHER FARMERS?
IF SO WHAT KNOWLEDGE DO YOU SHARE?
IF SO WHEN/IN WHAT SITUATION?
ARE YOU IN A FARMERS GROUP?
IF SO
IS IT:

FORMAL ASSOCIATION
INFORMAL GROUP
SOCIAL GROUP

HOW MANY FARMERS ARE IN IT?
HOW OFTEN DO YOU MEET/HAVE YOU MET?
WHAT DO YOU DO/DISCUSS?
IS IT USEFUL?

Specific Disease Problems

- HAVE YOU RECEIVED INFORMATION ON ANY SPECIFIC HEALTH MANAGEMENT OR DISEASE ISSUE?
- IF SO:
  - WHAT WAS IT?
  - WHAT WAS THE SOURCE?
  - DID YOU FOLLOW THE ADVICE? HOW?
  - WAS IT USEFUL?
  - WHAT WAS THE FORMAT OF THE INFORMATION

(EG. POSTER, NEWSLETTER, MANUAL, PAMPHLET, TV PROGRAMME, RADIO PROGRAMME, ADVICE FROM EXTENSION OFFICER, ADVICE FROM OTHER FARMER, ADVICE FROM TRADER, ADVICE FROM SALESMAN)?

Loans

- DO YOU HAVE ANY LOANS?/DID YOU GET ANY LOANS TO START FISH-FARMING?
- IF SO – FROM WHO (BANK, INDIVIDUAL PERSON)
- ARE THEIR GOVERNMENT/BANK LOANS AVAILABLE FOR FISH-FARMING?

- WHAT ARE THE MAJOR PROBLEMS YOU FACE WITH FISH-FARMING?
- DO YOU THINK FISH FARMING IS RISKY?
- IF SO – WHY?
- DOES YOUR INCOME FROM YOUR FISH VARY A LOT FROM YEAR TO YEAR?
- IF SO? WHY IS THIS?

INTERVIEW QUESTION FOR EXTENSION OFFICER

Information on Fish-Farming in Pichit

- How does the Extension Service define small, medium and large scale with reference to fish farming?
- What are the indicators/criteria used by the Extension Service for the grouping of fish farmers on the farmers list into Group 1,2,3,4?
- Do you have access to any fairly recent statistics concerning fish-farmers and fish farming in the province?
- Do you have any statistics on or an approximate idea of the following:
    - Number of fish farmers in Pichit Province?
    - What proportion of them small-scale, large-scale commercial, non-commercial fish-farming household?
    - What type of fish do they farm? Shrimp, catfish etc.?
    - Age and sex of pond-owners?
    - Approximate number of new fish-farmers? Socio-economic status of those who are now starting fish farming?
    - Income from fish-farming production versus other farming activities (in the province and within families)?
    - Percentage of fish-farming and non-fish-farming households owning livestock or other assets such as TV, bicycle, house, land.
    - Common structure of households (extended families or smaller family units? Number of adult men in household?)
    - Approximate income from fish farming as percent of total farming income for households involved in small-scale subsistence aquaculture.

Interview Questions

<u>Role of Extension</u>

- What is your involvement with farmers groups?
- What is the role of the extension service especially for the fish-farmer/what do you
- see your role to be?
- Is there an annual report produced?

- What is the plan for this year?
- What are the challenges and opportunities presented when attempting to achieve your plan?
- What new strategies for aquatic animal health and disease control are there?
- What are the most serious problems aquaculturalists faced last year?
- Who was affected by these? Who was most affected?
- What are the most serious problems aquaculturalists are facing this year?
- Who is affected by these? Who is most affected by these?

General Information

- What is the socio-economic status of those involved in fish farming in comparison to non-fish-farming families?
- In your view what are the principle constraints faced by aquaculturalists?
- In your experience how much money/how much of their income are large-scale commercial, small-scale and non-commercial fish-farming family willing to put into Aquatic animal health treatments.
- How important do they see these?
- What do you think are the primary fears, vulnerabilities and insecurities of farmers (small-scale, large-scale, subsistence)?
- What are the primary risks involved?
- What do think is the key motivation of people starting fish-farming?

Farm visits

- How often do you visit farms?
- Which farms do you visit (large and small-scale? What about non-commercial fish-farming households?)
- Do more remote subsistence farmers have access to extension services?
- Do you do routine visits or do you visit when a farmer calls you?
- What kind of advice and information do you give farmers?
- Do farmers listen to the advice/information you give them? Do they act on it?

Farmers Training Courses

- How many training courses does he conduct/ year?
- What were the subject of the training courses?
- How long do the meetings last?
- Who attends the meeting? (what type of farmer? Men or women?)
- Who has the opportunity to attend the meetings/courses?
- Are they free?
- How are the meetings advertised?
- How many people attend them?
- What important information do the participants receive at the meetings
- What are the problems that the farmers raise at the meetings?

- Are the training courses essential for the farmer?
- Do you feel the content and training at the meetings is appropriate?
- Do the farmers require other information that you cannot give them?
- Where do you get your information from?
- How do you become informed of problems that fish-farmers are facing

Television

- How important do you think TV programmes are for informing farmers about AAH information and issues?
- Which type of farmers have access to this source of information?

Radio

- How important do you think Radio programmes are for informing farmers about AAH information and issues?
- Which type of farmers have access to this source of information?

Newsletters, Posters and Magazines

- How important do you think newsletters, posters and magazines are for informing farmers about AAH information and issues?
- Where are they found?
- Which type of farmers have access to this source of information?
- What is the approximate level of literacy among farmers (large-scale and small-scale)?

Interaction with Institutions

- What is your interaction with Research Institutes?: (bringing problems to their notice? Taking strategies from them to the farmers?)
- Have you attended training courses at institutes? If so what for? Did you gain useful knowledge? Who was it run by? How often? Where was it? Was it free?
- Which institutions do you work with?
- Do you always agree with the information they give you?
- Is the information they give you useful for the farmers?
- Are there aquatic animal health issues and problems that you think require research?
- Have you been involved in projects with any other agency (FAO, CARE, DANIDA, CIDA, DFID)? If so what?

Commercial Fish-farming and Employment:

- What is your involvement with commercial fish-farmers?
- What type of aquatic animal health problems do they have?
- Can you help them?
- How? What information and advice do you give them?
- Where do you get it from?

- Approximate number of people employed by the fish-farming industry in Pichit (including, fish-farms, hatcheries, fingerling producers, traders, middlemen, market sellers, export business, fish-feed company, preparations and sorting of harvested fish). Therefore (if possible) number of households dependent on labour from).
- Average daily wage of people employed in fish-farming industry?
- Approximate proportion of household income earned from employment in fish-farming industry as opposed to other livelihood strategies?
- What alternative work is available in other agricultural industry in Pichit? Is it difficult to get it?
- What happens then when production is very low for a year, or there is a disease outbreak?

Women

- How involved are women in fish-farming in Pichit?
- Do you work with women fish-farmers in your job?
- Do they attend farmers meetings?
- Do they have access to sources of information on aquatic animal health?

Fish Consumption

- What alternative sources of fish exist other than farmed fish?
- Amount of fish harvested by household (in small-scale fish-farming household) for own consumption versus that harvested for sale?
- How does this change according to fish disease patterns?

Markets

- Where do small scale fish farmers sell their fish?
- How does disease effect local markets?
- How does disease effect the export industry?

Loans and Finance

- What bank or government loans/ micro-credit schemes are available for small-scale fish-farmers?

Examples

- Can you think of an example when fish-farming production clearly benefited from the introduction of a specific aquatic animal health strategy?

This Year

- Is this year an especially low year for production?
- If so, Why?
- What does this mean for small-scale farmers and their livelihoods?
- What does this mean for large-scale commercial farmers? Will they be unable to employ as many people? Do you think this will affect a large number of families?
- Have many farmers come to you with these problems?
- What do you think is affecting the fish?

- What do you and the farmers who come to you, think the condition is?
- Is it disease?
- Do you have any ideas about what to do?
- Have the farmers received any useful advice about the problem?
- If so, from who?
- Has it made any difference?
- What advice do you give them?

Conclusions

- How important do you think aquatic animal health research and information is to reducing poverty?
- How can this be done better?
- What are the major challenges to this?
- How could the flow of information to farmers and the dissemination of AAH strategies be improved?
- Would this have an impact on poverty?

QUESTIONS FOR AGRICULTURAL SUPPLIER/SALEMEN

1. General information on their role?
2. What Agricultural material do you sell to the farmer?
3. What type of farmers come to your shop/do you sell products to?
4. When do you sell your products? When do farmers come to your shop? (times/yr)
5. Does the farmer ask you for advice? Information?
6. In your experience what type of information does the farmer need eg. disease, health strategies, market etc.?
7. What advice/information do you give?
8. Where do you get the information from?
9. How do the farmers pay you?
10. Do they have problems making their payments?

INTERVIEW QUESTIONS FOR VILLAGE HEADMAN

- What are the main livelihoods of your village?
- Traditionally what have been the primary activities of people in the village (agricultural or otherwise)?
- What is the importance of aquaculture in your village?
- How long have people in the village been involved in aquaculture?
- How has it affected the village?
- What do you think the main motivations are for people to get involved in aquaculture?
- What is the relative wealth/socio-economic status of households involved in aquaculture in comparison to those who households which are not? Details?
- What types of households practice aquaculture in your village (wealthy, poor etc.)?
- What types of aquaculture is practiced in your village (polyculture, mono-culture, integrated)?
- What other types of farming are practiced in your village?
- Are there any problems with aquaculture in your village? If so what?

- Are the main problems encountered by households practising aquaculture in your village?
- Do farmers have disease problems with their fish? If so how does this affect their livelihoods?
- How does this affect the village?
- Are there loan schemes or loans projects available for farmers in the village? Details?
- Who manages the loans?
- Do fish farmers have problems paying loans back? If so why and what happens to them?
- Are there sources of information for fish farmers in the village? If so what and do they use them?
- Are there any formal or informal farmers groups in the village for fish farming?
- Do farmers come to you for advice? If so what do you tell them? Do they listen?
- Are there any government projects to help fish farmers in your village or to promote aquaculture (e.g. training courses, communal village ponds etc.)
- What contact do you have with fisheries or agriculture extension officers?
- Do you think the extension office is important for farmers? If so how?
- Are there households involved in aquaculture in your village who would not be on the extension service list? If so why?
- Is it possible to visit them?
- Are there any traders, agricultural suppliers or salesmen in the village? Is it possible to visit them?

EXPLAIN WHAT WE ARE INVESTIGATING AND ASK HIM IF HE CAN SUGGEST PEOPLE WE MIGHT TALK TO?

Women and Gender ***(how important are women in aquaculture? Stakeholder group?)***

1. How are women involved in aquaculture?
2. What role does this play in the households' livelihood strategy?
3. In the household who makes the decisions concerning fish-farming practices/activities/strategies and levels of input (time/money/labour) invested in aquaculture as opposed to other livelihood activities?
4. What other livelihood activities are they involved in?
5. Which do they see as the most significant for sustaining the household?
6. Do they have access to information on aquatic animal health and disease?
7. If so how?:
    - i. Do they attend farmers' seminars?
    - ii. Are they informed about them?
    - iii. Do they feel welcome at them?
    - iv. Do they read newsletters? Posters?
    - v. Do they watch TV programmes or listen to radio programmes on farming practices?

vi. Do they communicate with/receive help from extension officers?

vii. Which of these have they found useful

8. What sort or informal knowledge networks exist among women involved in aquaculture (e.g. farmer to farmer)?

Survey sample Frame

- Province Pichit was selected by Thai partners - part of previous project with varied aquaculture activities
- A list of the districts was supplied and the ones with aquaculture activities selected
- 50% of the districts were selected randomly
- From these districts a list of the villages was provided and again 50% of these were randomly selected
- From the selected villages, a list of the households practising aquaculture was provided and again 50% of these were randomly selected

These were the households of interest for the questionnaire and the household list was supplied by the Provincial Extension Services.

Appendix VII
Situation Appraisal in Thailand

SECTION ONE: INTRODUCTION AND CONTEXT

1. Introduction

This report is concerned with the impact of aquatic animal health (AAH) strategies on the livelihoods of poor people in Thailand. It arises from a growing sense among researchers, planners and policy-makers of the urgent need to look more rigorously at the impact of strategic knowledge programmes in the field of natural resources and poverty reduction, and the challenges inherent in such impact studies. The report presents the findings from fieldwork conducted amongst aquaculturalists in Pichit Province, Thailand in 2002.

A literature review conducted during 2002/3 provided the background to the case studies. This review found that previous research tended to neglect the social impact of natural resource research and the institutional context within which knowledge is generated, communicated and received. These studies had often been based on simplistic, economic models of technology transfer that focused on overall production goals, equating these with poverty reduction, to the neglect of localised experiences of fish farming. The case studies therefore aimed to provide a detailed, situated understanding of the social impact of shrimp farming and AAH strategies, set within the broader national, regional and global trends in technology transfer and aquaculture described in the literature review.

The report is organised in three sections. The first describes the context in which the study was conducted. It elaborates the institutional background of research, extension and government supported projects in which small-scale aquaculture in Thailand has developed over the last two decades. This section also outlines the methodological approach taken in the study which investigated the impact of previous projects concerned with the production and transfer of technical knowledge about aquatic animal health. The analysis and methodological framework derive, to a large extent, from the initial literature review in which the broader context of aquaculture development and technology transfer in South East Asia is elaborated in greater detail (Rajak 2002). The second section presents the fieldwork findings. Running through it is a series of case studies taken from the fieldwork which illuminate central themes in the analysis. The third section presents conclusions from the study. This section also points to future directions for AAH research and intervention projects and their role in poverty reduction strategies.

This report should be read in conjunction with the findings from the institutional analyses examining the flow of information from the scientific research institutes involved in the project to end-users. Together these outputs aim to provide a detailed yet broad understanding of the processes of generation, dissemination, extension and uptake of

AAH strategies and the impact they have on the livelihoods of fish farmers in Pichit Province. A comparative case study was also carried in the Mekong Delta in Vietnam as part of this project. The findings from the case studies combined with the critical literature review and the institutional analyses aim to provide a broad view of the social impact of aquatic animal health strategies on the livelihoods of poor people in Asia. This report also provides recommendations for future planning and policy in the field of aquaculture development, and guidelines for optimising the promotion and uptake of information and strategies produced by aquaculture development research projects.

1.1 The Case Study in Thailand

This report presents findings from the case study carried out in Thailand as part of the DFID supported research project R8119, 'The Impact of Aquatic Animal health Strategies on the Livelihoods of Poor People in Asia'. The project was funded through the Aquaculture and Fish Genetics Research Programme at the Institute of Aquaculture, Stirling and is being jointly undertaken by The Institute of Aquaculture, Stirling; the University of Sussex; the University of Liverpool; the Research Institute for Aquaculture No.2, Ho Chi Minh City; the College of Aquaculture and Fisheries, CanTho University; the College of Fisheries, Mangalore; and the Aquatic Animal Health Research Institute, Bangkok.

The case study presented in this report was conducted in Thailand in September and October 2002. The field research focused on small-scale aquaculture in Pichit Province, Thailand. The aim of this research was to identify the ways in which strategies relating to fish farm management, and specifically to aquatic animal health management and disease control, impact on the livelihoods of small-scale farmers in Pichit. The research involved a review of the changing livelihood context of people involved in aquaculture and the effects of aquatic animal disease on household economy in selected locations. The study explores the relationship between farming practice, technology transfer and poverty reduction and evaluates the institutional capacity to improve the benefits derived by poor people from aquaculture through research and technology transfer. It examines the provision of technical support services in their attempts to reduce the high level of risk inherent in aquaculture in this area. The report aims to provide an insight into the relationship between knowledge, practice and the uptake of AAH strategies within the context of small-scale fish farming.

The case studies were conducted by a multi-disciplinary team of researchers from anthropology and the biological sciences, combining both qualitative and quantitative methods. An ethnographic approach was adopted, involving informal interviews with a variety of stakeholders and participant observation in farmer's group meetings, extension meetings and women's group meetings. This was combined with a quantitative socio-economic survey of farmers in the two sites selected for the field research.

The literature review revealed that studies investigating the impact of projects concerned with the production and transfer of technical knowledge often neglect the crucial stage of

uptake. Research tends to focus on what kind of strategies are being produced; on what channels exist for the dissemination of information; on whether, and in what form, information is leaving the research institute; and on whether or not there is an active extension service and regular contact with farmers or 'end-users'. But at this point the track seems to stop. The question of *uptake* is a much more slippery question and one which, for the most part, defies measurement. It demands that we shift the focus of research to ask, not only, whether farmers receive advice or attend training courses, but also, whether these inform their practice, how and why they chose to apply specific management strategies, and to what extent they benefit them.

The case studies conducted in Thailand and Vietnam for this project aimed to address the question of uptake. The research aimed to do this by looking broadly at questions of risk and motivation, so as to understand the importance of technical knowledge in the management of fish farms and the overall livelihood strategy of people involved in aquaculture. This involved thinking about questions which relate to the role and significance of aquaculture in rural livelihoods in Pichit, questions such as:

- To what extent do farmers see themselves as 'fish-farmers'?
- How are decisions made within a household about the level or type of technical and financial investment in aquaculture?
- What do farmers consider the primary risks involved in practicing aquaculture and what strategies are available for coping with these risks?
- What motivates a household to take up aquaculture and how does motivation inform decision-making about AAH and management strategies?
- Which farmers are market-orientated and which not and how does this inform the types of AAH strategies they use and interested in?

1.2 Study Objectives and Methodology

R.L.Stirrat's recent study of 'Methodological Issues in Identifying Impact' (Stirrat 2002) has highlighted the need to re-think impact in terms of a sustainable livelihoods approach to poverty reduction, rather than conventional economic goals of increased production. This demands a more 'nuanced and interpretive approach where judgement rather than proof is central' (Stirrat 2002: 3). This case study has attempted to adopt such an approach to understanding the impact of aquatic animal health strategies on the livelihoods of poor people in Pichit Province, Thailand.

As is highlighted by Stirrat in his study, impact assessment presents both researchers and development practitioners with a number of challenges. Furthermore, as Rayner, points out, the task of impact assessment and evaluation becomes even more difficult when the aim is to track impact across a whole sector of research and intervention rather than one distinct project:

> Most evaluation is of single projects. There is very little systematic or comparative evaluation across multiple sites and different techniques…the general problem facing outcome evaluation [is] that it is impossible to establish

> causal links between the process and its outcomes and to establish what the counterfactual situation would have been (Rayner 2003: 165).

At the outset of the project, participants agreed that it would be almost impossible to measure the direct impact of a specific AAH strategy on the livelihoods of poor people involved in aquaculture in the selected area. As this impact study was conducted as a separate project, retrospectively charting the impact of a set of technical aquaculture strategies and projects, rather than having been integrated into the original project or programme design the question of how we look at impact becomes even more complex. Therefore the approach taken in this case study was to focus more generally on the available channels of communication for technical information and AAH strategies to small-scale fish farmers in Pichit. The case study aimed to look at what types (in terms of form, content and messages) of information about AAH are available to farmers and which farmers have access to these and which do not. An iterative approach was taken by which impact could be traced through a series of interviews involving key actors involved in fish farming in the area. In this way the study aimed to reveal the role of aquaculture in rural livelihoods in Pichit; the key problems faced by aquaculturalists in the area; the strategies and techniques employed by farmers to deal with the problems; the source of farmers' knowledge and information about managing their farms and dealing with the problems they identified; and finally, the effectiveness of these strategies in improving or sustaining the livelihood of the household.

The study had four principle objectives:

1. To develop an understanding of the role of aquaculture in the livelihoods of farmers in Pichit Province.

2. To assess the provision of technical support services and aquatic animal health strategies to farmers.

3. To investigate the uptake of AAH strategies and the impact of such strategies on poverty.

4. To examine the relationship between aquaculture and AAH knowledge, and practice.

These objectives were met through a range of research methods, both qualitative and quantitative. The project deals with both the 'scientific' and the 'social' and therefore provided an appropriate arena for multi-disciplinary collaboration. This was reflected in the methodology adopted for the research. This involved a qualitative ethnographic approach derived from anthropology. In-depth, informal interviews were conducted with a range of stakeholders involved in aquaculture (including farmers, traders, middlemen, extension officers, village heads, local government officers and agricultural bank officials). Observation of village loan meetings and informal farmers' group gatherings provided an insight into the way in which knowledge about farm management was shared and the way in which various stakeholders related to each other.

Through the ethnographic approach the researchers engaged more closely with the complex set of socio-economic processes that define the practice of aquaculture and household economy. This enabled the researchers to examine commonly neglected issues such as:

- Motivation for farming
- Conceptions of profit and loss
- The relationship between knowledge and practice
- Decision-making within the household
- The way in which risk is calculated against investment.

These issues are crucial to examining the reception and uptake of technical aquaculture strategies and the role-played by aquaculture and AAH in rural livelihoods.

A questionnaire was also conducted with farmers randomly selected from the provincial extension service list of farmers. Flooding seriously constrained access to villages and farms. The lack of a recent farmers' list (last up-dated in 1999) also presented some difficulties. Despite these constraints the questionnaire survey provided a representative sample revealing broad trends in farming practice such as choice of culture species and model, access to extensionists and training courses, and the popularity of different media as sources of technical information on farm management.

1.3 The Fieldwork Context: Why the Focus on Pichit?

Fresh water fish aquaculture was selected as the focus of the situation appraisal, rather than shrimp farming as in the Vietnam case study. The literature review revealed that shrimp farming has been the subject of a large number of recent studies concerned with the socio-economic and technical dimensions of aquaculture in Thailand, and remains the focus of a multitude of on-going projects. In contrast, fresh-water aquaculture has been somewhat eclipsed by the growing shrimp industry and consequently neglected by international NGOs, research institutes and donors. Unlike shrimp farming, freshwater fish farming in Thailand does not generate significant export revenues. As a result it does not command the same level of government interest or benefit from the institutional support and large-scale commercial investment that the shrimp industry has attracted.

The province selected for the case study was Pichit province, which is situated in the lower Northern Region of Thailand. This province provided the researchers with a range of monoculture and poly-culture systems. Farmers in Pichit culture a variety of species (including Clarias, Pangasius, Puntius, Gourami, Tilapia and Common Carp). The socio-economic status of households that practice some form of aquaculture varied significantly, from those categorised by the extension service as 'poor, small-scale' aquaculturalists to those described as 'commercially-orientated, large-scale' farmers (see Table 1.1). Levels of investment and profits generated through aquaculture varied accordingly.

Severe flooding in the Province during the course of the fieldwork restricted access to certain parts of the Province. Due to this, and the decision to concentrate the case study on Amphoes in which there is a relatively high level of aquacultural activity, the fieldwork focused primarily on Amphoe Pho Thale and Amphoe Wa Chi Ra Ba Ra Mi[1].

Table 1.1: Number of fish farms in Pichit Province as recorded on the Provincial Fisheries Extension Office Farmers List 1999.

Category of Farm	Approximate Number of Farms
Large scale commercial *	30
Medium- to small-scale	3,000
Small-scale	7,000
Estimate of unlisted small - scale farms	10,000

*The categories used in the table are those assigned by the extension service

Pichit Province was also selected because it had been the site of previous DFID-funded technical research. This research on, 'Control of Bacterial Disease in Small-Scale Freshwater Aquaculture' (Thompson and Crumlish 1999, Project R7054) aimed to produce strategies for the management of aquatic animal health in small-scale fish farming. Thus, Pichit presented an ideal case study in which to track the impact of aquatic animal health strategies on the livelihoods of people involved in small-scale aquaculture and the role of such strategies in poverty reduction. The large-scale survey of fish farmers, conducted as part of the previous technical research, highlighted a number of questions. The ethnographic, qualitative approach taken in this case study aimed to explore these questions in greater depth: such as a household's motivation for practising aquaculture and how households make the decision to invest in AAH.

[1] For a complete list of the Amphoes in Pichit Province and a breakdown of the population of Pichit by Amphoe, gender and number of households see Annex 3.

2. Background

2.1 Aquatic Animal Health Research and Technology Transfer

Over the past two decades aquaculture has come to be seen as a panacea of development, with the potential to deliver economic growth, food security, livelihood sustainability and also a solution to decreasing wild fish stocks. This vision has given rise to a great number of research projects and intervention strategies dedicated to the promotion and development of aquaculture. Projects, spurred on by the bold claims made on behalf of aquaculture, have at times failed to disaggregate those various claims. In so doing they fail to clearly identify the supposed targets of research or the apparent beneficiaries of intervention strategies. For the most part, these projects have been primarily concerned with the production and delivery of tangible, physical outputs and technical strategies. The socio-economic dimensions of aquaculture have, to a large extent, been overlooked. Crucially, we are only now beginning to ask key questions such as: Who is benefiting from aquaculture technologies? What impact has technical research and intervention strategies had on the livelihoods of farmers? Is the goal of technical research to maximise productivity or to reduce poverty?

One reason for the relative paucity of socio-economic studies of fish farming in South East Asian over the past decade has, arguably, been the dominance of shrimp farming on national, regional and international agendas[2]. As a result, shrimp farming has monopolised resources devoted to the development of Asian aquaculture and the host of research projects and extension programmes that supports the industry. Due to the large revenues earned for the Thai economy from shrimp exports, the shrimp industry has been prioritised as the focus of institutional and technical support. Growing fears concerning the impact of intensive shrimp farming, following the collapse of the shrimp industry in Taiwan in 1988, due, to a large extent, to disease (Bort, Ovares and Stonich 1997: 165), have pushed shrimp farming to the centre of both scientific research, and studies of the social and economic impact of shrimp farming in Thailand. It has been the subject of international and regional conferences on the future of shrimp farming and research on aquatic animal disease.

The development of shrimp farming as a commercial industry has been supported by the Thai government, research centres, and international donors and agencies, who have hailed it as a major source of revenue both for the national economy and for individual households. Concern for the ecological implications of intensive commercial shrimp farming has grown and produced a number of interesting studies focused on the environmental question. As the shrimp industry has experienced significant growth in production levels, it has generated enormous revenue for a number of groups within the Asian agricultural sector. The transformation of shrimp farming into a global industry

[2] Official encouragement to expand shrimp aquaculture in fact began much earlier than this, dating from 1972 'when the Thai government began to offer financial assistance and the Department of Fisheries adopted a policy of promoting coastal aquaculture by encouraging farmers to upgrade their farming methods' (Burch *et al* 2000: 517).

controlled, to a large extent, by multi-national corporations, has been behind the striking increase in research in the field of shrimp aquaculture. The areas of research that dominate the industry, as well as government and international interest in shrimp farming, are disease, feed, pollution and, to a lesser extent, a range of issues raised by 'green' groups. The role of technical research and institutional support for the shrimp industry and its social impact are discussed more fully in the literature review (Rajak 2002).

Thus shrimp farming benefits from a high level of national and international, as well as public and private sector, interest in finding solutions to AAH problems which threaten the shrimp industry. This has resulted in a sophisticated framework of 'scientific services'(Burch *et al* 2000: 517), including research, technical support and extension, and diagnostic services, available to large numbers of farmers involved in the shrimp industry and provided by the Thai government, multi-national corporations (such as The CP Group), and supported by regional and international research and management initiatives. By contrast, in-land small-scale aquaculturalists have been sidelined in the provision of adequate extension services, adaptive research programmes and the transfer of viable management strategies and technologies that focus on meeting the needs of poorer households, in favour of shrimp farming which demands much greater input of capital and time, as well as, 'Green Revolution' kinds of technologies and the commercialisation of land and labour. In comparison to the constant and vigorous monitoring of shrimp production, there is also a lack information and up-to-date statistics from the Department of Fisheries (DoF) on households producing fish for local markets or household consumption. The provincial fisheries extension offices lack both funds and staff to carry out surveys regularly or extensively.

The case study revealed the failure of the national and provincial extension service both to reach the poorest households involved in aquaculture, and to provide small-scale aquaculturalists with technical support appropriate to the kind of extensive, low-input systems practiced by low-income households. The extension service suffers from a severe lack of resources, combined with weak institutional linkages and channels for the dissemination of AAH management strategies, as well as the prevailing dominance of conventional 'trickle down' approaches to technology transfer and extension which focus on wealthier 'master' farmers. The findings from the case study exemplify the way in which factors and conditions vary, not only from province to province, but between households. The conventional extension approach by which a 'package' of technical strategies is delivered to farmers fails to reflect such difference and therefore can provide little support to some households. On-farm demonstrations and interactive training courses in which farmers can raise individual concerns, though costly, are therefore seen to be the most successful medium for providing technical support to farmers. One researcher at a government research institute said it simply does not work to hand over a neat package of technical information and strategies which have been tried and tested in the laboratories and expect farmers to follow and repeat these. However more progressive approaches to extension would demand much greater funding which is not available.

Research concerned with the development of aquaculture takes place at government research institutes and stations. An increasing amount of research is being conducted in private facilities as part of the research and development plans of multinational corporations involved in the production of agro-chemicals and feed. However, the focus of research has been, and continues to be, dominated by biotechnical concerns and interests, while socio-economic considerations are seen as obstacles to be overcome or managed in the process of technology transfer. The primary target of technical research in the field of aquatic animal health, has, in the past been commercial aquaculture and not small-scale rural farmers:

> 'In the past, research was focused on export commodities, the development of large-scale operations and technologies for improving fish harvesting capacity. Training and education has largely been devoted to these areas' (World Bank 1991: 28).

This is reflected in the activities of government research institutes which, directed by government interest in export revenues, tend to focus greater resources on research, diagnostic services and health certification processes that support the production of export-orientated aquaculture, such as shrimp farming. The difficulty in focusing research on developing basic AAH management strategies appropriate to the kind of small-scale, low-input aquaculture practiced by poorer households was summed up by an employee of the Provincial Fisheries Station who explained how the kind of research conducted at the station is not appropriate or relevant to most of the farmers in the surrounding area. He qualified this saying that it was impossible for the station to get funding from the DOF to carry out research concerned with basic aquacultural management strategies that might be of direct use to farmers locally, such as examining the most effective type of fish feed in terms of cost-efficiency for households who are reluctant or unable to afford the high cost of processed fish feed pellets. Instead their research tends to focus on the development of more expensive, aquaculture technologies of interest to larger scale, commercial fish farmers.

Government-supported research institutes, such as the Aquatic Animal Health Research Institute (AAHRI) in Bangkok, which is 'responsible for experiment[al] research to prevent aquatic animal disease…providing [a] treatment service and technical information' (Department of Fisheries 2003), occupy a central position in the system of research, dissemination and extension that supports the development of small- and large-scale aquaculture in Thailand. Institutes, such as the AAHRI in Bangkok, have extensive and highly effective research and dissemination channels and training activities, which have had a significant positive impact on AAH management and disease control in fish farming[3]. For example, AAHRI alone holds 4-5 training seminars annually in each province for shrimp farmers. These workshops, often attended by hundreds of farmers, are commonly arranged by farmers' groups in collaboration with the research institute

[3] With support from DFID, AAHRI also trained approximately 40 fisheries biologists who work at different provincial fisheries stations. This project was undertaken 5 years ago with the aim of capacity building within local provincial fisheries stations and providing staff with the skills to carry out diagnostic tests and develop local strategies appropriate for dealing with local aquatic health management issues and disease outbreaks as they arise. However such projects have a limited life-span without continued financial support and recognition from national government departments of the importance of such activities and the need for greater institutional support.

with the aim, not only to disseminate technical AAH strategies, but also to bring together actors from different levels of the industry, so strengthening ties between hatcheries, farmers and processing companies. The farmers' training seminars are seen also to be arenas in which farmers can communicate problems and issues affecting them back to the research centres, so ensuring the flow of information both 'up and down stream'[4]. However, many recent studies of the research-dissemination-extension relationship have been critical of the way in which extension materials produced by researchers 'in the lab' or at national centres for training and extension can tend to be overly scientific or inappropriate in meeting the needs of farmers. Research questions and the focus of extension materials are often generated in the lab or office, rather than on the farm (Rajak 2002). Primary problems in production identified by scientists or civil servants, can turn out often not to be major concerns of farmers and vice versa.

Mass media channels of communication such as television have been similarly mobilised in the service of the shrimp industry as farmers receive technical advice from television programmes sponsored by feed and chemical companies.[5] The programmes are designed to follow the production cycle covering issues such as, preparing and stocking the pond, and problems that arose during the previous production cycle. During the cycle programmes focus on key issues such as, feed management, disease control and prevention, and harvest. The programmes have an interactive format which allows farmers to phone or write in with questions and problems to be answered by the technician or researcher presenting the programmes. Both private corporations and government departments enlist the service of researchers at research institutes such as AAHRI to provide the content of technical advice posters, newsletters and, TV and radio programmes. TV programmes are broadcast on a national TV station at times appropriate to farmers, usually either early morning or early evening. In this way direct channels of dissemination exist between the research centres and the sources of mass media providing information to the farmers.

As well as regular television programming devoted to the technical aspects of shrimp farming, radio is also used as a channel of communication[6]. Kasetsart University, which houses AAHRI along with a number of other government research institutes, has its own radio station, 'Radio for Agriculture' devoted to agriculture extension programmes and broadcast in a number of provinces. Kasetsart's 'Radio for Agriculture' is accompanied by three or four similar stations broadcasting from other universities in Thailand. Added to these are the local provincial radio stations, which place agricultural extension programmes high on their agenda. Companies such as the CP Group involved in all levels of the shrimp industry produce their own newsletters monthly. For shrimp farmers, monthly magazines, heavily sponsored by private companies and sold commonly for about 50/65Baht (the cost of about half a kilogram of shrimp) are available. These provide current information on the shrimp cycle, new strategies,

---

[4] Greater detail on the flow of information from the research institute is provided in the institutional analyses conducted as part of this project.
[5] There is concern in the research community about the neutrality of technical strategies and advice on best practice for shrimp farming being filtered through a framework of corporate sponsorship.
[6] For a discussion of radio and television as a tool of extension for small-scale freshwater aquaculturalists see Section 6.3.

technical innovation, information on the state of the market and promotion of various products. As inland freshwater fish farming is not subject to the same level of strong corporate interest, no such magazines exist for fish farmers and it is likely that if they did the price would be prohibitively high for small-scale fish farmers for whom fish farming is often not the sole or primary livelihood activity. The decision to take small-scale freshwater fish farming as the focus for the case study was motivated by the recognition that households involved in small-scale freshwater aquaculture have, to a large extent, been sidelined, by the prioritisation of export-orientated commercial aquaculture, and especially the shrimp industry, by national and international research and development agendas, and private sector investment.

During the last five to ten years, the importance of disseminating information and strategies generated by research has gradually received greater recognition and integration into research frameworks and projects. However, technical research programmes and projects have, for the most part, failed to address the other end of the research-dissemination process: **reception**, **uptake** and **impact**. Only very recently have projects begun to respond to the need to integrate 'impact assessment' into the original design of projects and the framework of programmes. For, while it is somewhat easier to track the ways in which information leaves the research institute and in what direction, the question of how it is received and used by farmers, and what impact it has on the overall livelihoods of households is far more slippery and intangible. The situation appraisals therefore aimed to focus on these complex issues of 'reception', 'uptake' and 'impact' and to investigate the ways in which farmers interact with the institutional framework of research, dissemination and extension through which AAH strategies are communicated.

2.2 The Institutional Context: Government Planning and Projects

The potential of aquaculture to contribute to poverty reduction and improve the sustainability of rural and peri-urban livelihoods has been a focus of national and international development planning and policy-making for over two decades. Concern about food security and access to reliable sources of nutrition for poor rural households, and the potentially high market price of fish have underpinned the host of projects and loan schemes devoted to the promotion of small-scale aquaculture which has evolved over the past fifteen to twenty years. The national interest in aquaculture reflects the trend in development thinking over the past two decades, which has elevated aquaculture as a catch-all solution to problems of low income, vulnerability, lack of nutrition, food-security and declining wild fish stocks worldwide. The movement hailed as the 'blue revolution' generated massive funding and support for aquaculture development research and intervention projects across Asia, Africa and Latin America.

In Thailand, the DOF's promotion of aquaculture demonstrates a broad, country-wide approach to policy and planning. Projects concerned with the development and promotion of aquaculture have taken a variety of directions over the years, including: village loans, extension support in the construction of ponds free of charge and fish seed donation, community village ponds and the introduction of fish ponds in schools. However, for the most part, these projects have been implemented sporadically and through a top-down, countrywide approach, emanating from the DOF and implemented through provincial extension offices. As is frequently the way, such blanket, countrywide approaches to policy and planning fail to respond to the varying contexts and needs of different provinces. The role and practice of aquaculture in Pichit Province, for example, differs vastly from aquaculture in Thailand's North and North Eastern Provinces. Thus, as is discussed in Section 4.2, national initiatives to promote aquaculture as an alternative livelihood activity and source of nutrition for household consumption in conditions of scarcity are, to some extent, inappropriate for the socio-economic and natural resource context of the central provinces such as Pichit, where aquaculture has a quite different role in rural livelihoods. As projects have tended to be implemented as part of top-down countrywide strategies, they commonly overlook localized needs specific to each province and the differing levels of institutional and technical support available in different provinces. Equally, there has been little grass-roots planning or management of such projects which, as a result, often fail to meet the needs and interests of households.

These projects have included a variety of approaches to the promotion of fish farming implemented through the local provincial extension service. Some examples are given below:

<u>Community Village Ponds</u>

Over a decade ago, the DOF conducted a countrywide survey revealing that most villages had some form of communal pond. These ponds were used primarily as a source of water but provided secondary benefits such as wild fish which spawned naturally in the ponds. Working from this existing structure, the DOF initiated a project aimed at developing and building communal ponds in villages. Fish seed was donated to each village, in an effort to promote communal fish farming activities around the pond, and in so doing, provide a source of fish where poor households have limited access to nutritional food such as fish due to the high market cost and scarcity of natural sources of fish[7]. The communal pond, it was hoped, would also act as a model for farmers in the village by encouraging households to build their own ponds when they had seen the benefits provided by the village pond. In provinces where there had been a tradition of such activities due to limited access to sources of water and fish, this intervention met with some success. However, the failure of such countrywide planning for aquaculture was demonstrated by the lack of participation in the scheme in areas such as Pichit, in which the population was more mobile and diffused across a large area, and natural sources of water and fish are widely available for much of the year.

<u>Pond construction</u>

[7] These communal ponds worked on a ticket system whereby people in the village could buy tickets to use the pond and take out fish in proportion to the inputs and 'rent' (in the form of the tickets) that they paid to use the pond. Participants were then responsible for the communal management of the pond.

Both the DOF and the Department of Land and Development (DOLD) continue to support the development of freshwater aquaculture through government-assisted pond construction, implemented through provincial extension offices. The case study revealed that a high number of pond-owners in Pichit Province had built their ponds in response to sporadic government projects over the past two decades. These schemes provide incentives such as loans, donations of fish seed and labour for pond construction, to encourage households to diversify their livelihood strategies by adopting aquaculture as a potentially high-profit additional activity to rice farming[8].

School Pond Project

Following the model of fruit and vegetable cultivation in schools, initiated by the Department of Education, the DOF instituted a project designed to introduce fish ponds in schools. The aim of these ponds was to provide a site for vocational training in pond management which could be of benefit, especially to low-income rural households. The success of this project, which was initiated approximately fifteen years ago, has, and still does, rely on the availability and allocation of resources and trained staff within local schools, and consequently has met with varied success.

Loans

Over the past twenty years the DOF has implemented a sporadic programme of low-interest loans for households adopting aquaculture as an additional livelihood activity. However, the case study revealed that the loans have tended to be distributed without the necessary level of institutional or technical support, such as training courses and technical manuals. Many households, attracted by the low-interest loans, found that after the initial extension support in building the ponds, they were left without the technical know-how or sources of information to manage the ponds. As a result they experienced losses due to disease, and lack of knowledge about basic pond management strategies, such as stocking densities and feeding, and were therefore reluctant to continue investing time and money for the small yields they received from their ponds. The role and impact of loans and credit initiatives on the uptake of AAH technologies and management strategies for aquaculture is explored further in the next section.

National aquaculture policy and projects, such as those discussed above, are produced by the Department of Fisheries and implemented through provincial Fisheries Stations and extension offices. According to this sector-based arrangement, institutional support for aquaculture is subsumed within fisheries, and isolated from the broader field of rural development. Extension programmes and projects are shaped according to current concerns, goals and agendas within the Fisheries sector, whereas a poverty-reduction approach that aims to meet the diverse livelihood needs of poorer households requires a

[8] Rice farming remains the primary livelihood activity for the majority of rural, land-owning households in Pichit Province. Besides aquaculture, other additional activities include pig and chicken husbandry and vegetable cultivation. In recent years, lime and orange farming have become popular in some parts of Pichit, offering a high-profit alternative to growing rice for households with enough capital to convert their land to citrus groves.

system in which aquaculture is integrated into agricultural extension programmes and broader rural development strategies. Empirical research has demonstrated the need to locate aquaculture planning and extension within a broader institutional framework for rural development, rather than as an isolated branch of fisheries, if it is to respond to the diverse livelihood strategies of small-scale practitioners, for whom aquaculture is commonly only one amongst a number of income-generating activities. As Harrison argues:

> Fish farming has technical peculiarities. A particular set of problems derive from (for example) the breeding characteristics of tilapia, and the specific requirements for soil and water. But the same can be said for other activities. But the difference is that, while lessons have been slowly learned concerning the fit of these diverse activities to rural livelihoods, aquaculture has for the most part remained a separate "sector", tenuously – and uncomfortably – attached to Fisheries Departments... Although dealing with fish in the technical sense, they have all too frequently had a catch management, biological sampling or conservationist focus (Harrison 1994: 9).

However, despite Harrison's call almost a decade ago that aquaculture planning be 'incorporated within overall rural development strategies' (ibid: 1), aquaculture planning and extension in Thailand, as in many countries, continues to be an isolated branch controlled by the Department of Fisheries: 'the Fisheries Extension Division is responsible for the extension planning; deciding of ways and means to promote aquaculture, fishing, processing and fish market; producing of printed materials and audio-visual equipment; fisherman welfare; and other duties to be assigned' (Department of Fisheries 2003). A separate unit is responsible for training of extension personnel and the production of extension materials: 'Training Division is responsible for planning and organizing of trainings for the Department's personnel, farmers, fishing crews and any other persons who are interested in aquaculture, fishery resources conservation…It produces materials for training courses and also monitors/evaluates/reports outcomes of training' (Department of Fisheries 2003). Planning and extension is thus defined according to rigid sectoral divisions. Collaboration over policy initiatives, and extension programmes between the DOF and the Department of Agriculture, and other related departments such as the Department of Land and Development, the Department of Irrigation and the Department of Livestock tends to be on a short-term basis at both a national and provincial level[9].

[9] Reform aimed at cutting through the problems of the local level sectoral divisions and reducing bureaucracy begun in 2002. However there are concerns that this reform will ultimately result in a reduction of extension officers and services to farmers so reducing the technical support provided to farmers further. The aim of the reform will be to merge the various extension officers into one person who will provide technical support on aquaculture, agriculture, irrigation in an integrated way, so cross-cutting the sectoral divides between the various extension offices. They aim to provide a 'one-stop' service in the villages where farmers can receive advice on all areas of their activities rather than treating each activity as a distinct unit, so reflecting the real practice of households with integrated multiple livelihood activities.

SECTION TWO: VIEW FROM THE FARMS

3. Starting Out: Investing in Aquaculture

3.1 Aquaculture in Pichit Province

The term aquaculture covers a wide spectrum of practices of varying intensity, from a muddy little pond into which a few fish are thrown for household consumption[10]; to a large commercial enterprise producing hundreds of tonnes of fish per year, for domestic, and potentially export, markets. Large-scale commercial operations rely on a far greater input of technical expertise, particularly in the area of health management and disease control. The development and communication of effective AAH strategies and technologies is crucial to the success of large-scale operations of this kind. Intensive commercial operations provide a source of employment for local wage-labourers, both on the farm and in post-harvest processing activities, the success or failure of such operations therefore has a direct and indirect impact on the livelihoods of workers within the industry. However, according to the Fisheries Extension Office in Pichit Province, large-scale intensive operations makes up less than 2% of aquaculture practiced in the province. Furthermore, the study found that in all but three cases, ponds were managed solely by members of the household without any additional paid labour, with the exception of harvest time, when neighbours often assisted with each others' harvests. The exceptions were large-scale commercial operations which provided limited and sporadic opportunities for paid employment to between five and ten labourers. The majority of aquaculturalists in the province are small-scale and extensive or semi-intensive producers. For most farmers, their fish farms are an additional or secondary activity. This study, therefore, is concerned primarily with the role and impact of AAH strategies on the livelihoods of poorer, small-scale farmers in Pichit.

While the degree of commercialisation is evidently crucial to the level of technical input and the role of AAH strategies in farm management, this study does not adhere to the conventional and simplistic binary classifications of subsistence and commercial farming. As Harrison notes in the context of aquaculture in sub-Saharan Africa, 'purely subsistence farmers do not exist' (Harrison 1994: 10). This is equally the case for fish farming in Pichit. For, as Harrison goes on to state,

> 'The balance between the elements of production which are consumed within the household and those which are sold or exchanged, is constantly changing' (ibid)

Understanding the dynamic and differing motivations of farmers who practice aquaculture is therefore key to understanding both the role of AAH strategies and their impact on the livelihoods of farmers. The question of motivation will be explored in **Section 3.3**.

[10] The limits of what does and does not constitute aquaculture continues to be the subject of debate, with some researchers arguing that such muddy little ponds should be seen as storage units rather than sites of aquaculture production.

Pichit's low-lying plains fed by substantial natural water sources, provides a good natural breeding ground for wild fish. Due to the availability of easily accessible stocks of wild fish in the Province, there is little market demand in Pichit for farmed fish at present. The ready availability of wild fish also reduces the reliance on fish farming as a safety net providing a source of nutritional food for household consumption, food security and additional cash income. However, as fish stocks diminish, aquaculture is likely to play an increasingly important role in the future. Pichit also benefits from a good infrastructure and a range of natural resources and agricultural activities beyond the staple crop of jasmine rice, including pomelo and lime farming and a growing orange industry.

The most recent farmers list (produced by the Pichit Provincial Fisheries Extension Office in 1999) indicates that within Pichit there are 30 farmers categorised by the extension service as 'large-scale commercial' fish farmers. A further 3000 were identified as being involved in 'medium- to small-scale' aquaculture. For these households fish farming was generally not the only activity, but farmers intended to sell the bulk of their harvest to local markets and invested in low-cost inputs such as lime, often bought fish feed pellets on credit or with extra capital, and on occasion used, what many farmers described generically as 'drugs'. Many of these farmers said that they had initially been attracted by the potentially high profits they saw other farmers earning from aquaculture, but had since run up debts (either in bank loans or credit from agents) buying the costly drugs and pellets. In some cases this had forced farmers to abandon their ponds as the cost of processed feed (at approximately 350B for 20kg of catfish pellets) and drugs had increased whilst the market price for many species of farmed fish had dropped, leaving farmers with mounting debt.[11]

According to the extension service statistics approximately 7000 farmers on the list and a further 10,000 unlisted farmers in Pichit keep low- or no- input fish ponds for household consumption, commonly stocked with fish caught from the wild and left to spawn and feed naturally. The majority of the farmers interviewed fitted into this category, many of whom said they had started to practice this form of extensive aquaculture in response to a government project in their village which offered loans or assistance for digging fish ponds and donated the initial fish seed. While integrated rice-fish production is rare in Pichit, for many farmers their fish pond(s) is one component of an overall system of production: chickens and pigs provide feed/fertiliser for the pond while *trash fish*, fish too poor to sell or consume within the household, provide food for chickens and pigs. It is therefore crucial that research and extension activities targeted towards rural households involved in small-scale fish farming, approach aquaculture as part of an overall system of production and not as an isolated activity, as in the case of large-scale aquaculture operations.

[11] All informants concurred on the dramatic drop in the price of catfish over the past 5 years (most put the fall in price from 40Baht per kg 5 years ago to 20-27 Baht per kg now). This was seen to be due to increasing numbers of farmers culturing catfish within Pichit and other provinces, and the introduction of hybrid catfish species with a greater disease resistance. As a result many farmers had abandoned aquaculture altogether or switched from 'grow-out' catfish farming to nursery farms for catfish fingerlings which they sold to traders from other provinces, particularly those in the Northern regions.

Rice farming remains the primary livelihood activity for the majority of rural, land-owning households in Pichit Province (see **Table 3.1**). Besides aquaculture, other additional on-farm activities include pig, chicken and duck husbandry, and vegetable cultivation. An increasing number of farmers are seeking additional employment outside their farm, as wage-labourers to boost their household income. In many households men took on extra labouring jobs when available, while wives and children acted as the primary care takers of the farm. In recent years, lime and orange farming have become popular in some parts of Pichit, offering a high-profit alternative to growing rice to households with enough capital to convert their land to citrus groves.

Table 3.1: Livelihood activities within households identified by farmers in farmer survey.

Livelihoods Activity	Number of Farmers
Rice farming	33
Fish farming	27
Pig farming	0
Duck farming	4
Rearing cows	1
Rearing chickens	2
Fruit and vegetable farming	1
Labouring	5
Government employment	0
Other	2

Table 3.2: Primary source of income in household identified by farmers in farmer survey

Primary Source of Income	Number of Farmers
Rice farming	30
Fish farming	1
Vegetable and fruit farming	1
Labouring	2

Despite ubiquitous claims amongst development practitioners and aquaculture experts that fish farming provides a high-profit, low-labour alternative to rice farming (a highly labour-intensive activity commonly seen to yield small returns in income), the study indicated that, while a large number of households (see **Table 3.1**) practice some form of aquaculture, for all but one of these farmers, fish farming is an additional livelihood activity, while rice farming remains the primary source of income for the households (see **Table 3.2**). A number of factors have contributed to this phenomenon, most notably the high risks involved in fish farming and a dramatic decline in the market value of farmed fish in Pichit. These factors are explored in more depth below (see Sections 3.3, 4.4 and 4.5). Due to the introduction of a resilient strain of hybrid catfish species with a fast growth rate (*Clarias macrocephalus* × *Clarias gariepinus*) in the past decade, the most popular species cultured by both large-scale and medium- to small- scale farmers in

Pichit is catfish. However, mono-culture catfish farming tended to attract wealthier farmers with enough extra capital to invest in what is both a highly risky and potentially high-profit enterprise, as the high investment costs and difficulty in finding a reliable market in which to sell the fish is prohibitive for the majority of resource-poor households. Indeed, the study indicated that, beyond the pockets of commercially orientated catfish and fingerling farmers to be found in a couple of districts in Pichit, such as Wat Kwang District in Amphoe Pho Thale, many farmers see semi-intensive monoculture fish farming as requiring prohibitively high in-puts of time and money in a context of high risk[12] and falling prices for farmed fish in a market which favours wild fish over farmed fish.

3.2 The Promotion of Aquaculture

Government promotion of freshwater fish aquaculture in Thailand over the last decade has been informed by a sustainable livelihoods approach to poverty reduction. Through a series of government sponsored projects farmers have been encouraged to diversify their livelihood strategies, reducing vulnerability by increasing income-generating activities and household food security. Within this model aquaculture can provide a source of fish for household consumption or cash flow through market sale. To this end the government has been involved in assisting farmers to dig fishponds, donating fish seed, providing loans for aquaculture and establishing communal village ponds. However the need to reduce vulnerability demands a low-risk and low-input activity. Such national, blanket policies and projects often fail to take account of localised factors and trends, such as risks posed by annual flooding or lack of market demand for farmed fish in an area such as Pichit where wild fish is readily available and favoured by consumers.

A disparity exists between the *promotion* of aquaculture as part of the government's poverty-reduction strategy through a sustainable livelihoods agenda, and institutional *support* for aquaculture through research and extension activities which continue to be underscored by traditional models of technology transfer (the goal of such models being to encourage productivity and support economic growth.), rather than a direct concern with poverty reduction and sustainable livelihoods. Government-sponsored aquaculture has been successful in that it has encouraged many farmers to keep low-input ponds primarily for household consumption or to ‘dip into and sell if a trader passes by’ (Mrs Nam Kang Sang Ton, Ban Ta Ta Sua Village, Amphoe Pho Thale). On an institutional level there is, at best, a tenuous link between government support for household aquaculture of this kind and the outputs of research institutes targeted towards more commercially orientated intensive aquaculture.

Thus, whilst many of the farmers participating in the study had adopted aquaculture in response to government projects which offer loans, fish seed and assistance with pond

[12] Annual flooding, thieves (euphemistically termed ‘black-hair disease’), suspicion of being cheated by traders and disease were the most commonly cited risks to fish farming. During the case study severe flooding had resulted in many fish farmers losing their crop. Conversely the floods had brought an influx of wild fish into many areas of the province.

construction, most farmers did not consider fish farming to be a reliable source of income and view their ponds as additional or secondary livelihoods activities. For this reason, most said they were unwilling to expend time or money on pond management and aquaculture technologies and had little interest in AAH strategies. Strategies demanding higher technical inputs hold little appeal for farmers who are unwilling to invest in an enterprise which had either proved to be or was perceived to be subject to a high level of risk including flooding, thieves and disease:

> *If there's some water I culture fish…if they get sick I don't pay attention. If they die I throw them out… Those that survive I eat or sell a little bit* (Mr Som Ruam, Clong Ta Ngaw Village, Amphoe Pho Thale).

The high cost of processed fish feed and chemicals set against the falling market price for farmed fish are further disincentives for many households to invest time or money in commercially orientated aquaculture. For these households the most important AAH strategies are those dealing with basic pond management (such as, cleaning, draining and drying the pond if possible, appropriate feeding practices, preventing predators from entering the pond and leakage from the ponds).

The experience of Miss Tippawan Arun No was shared by many of the farmers interviewed and highlights the way in which government-sponsored aquaculture programmes have focused on *promoting* aquaculture, rather than continued institutional *support* for aquaculturalists. Miss Tippawan Arun No built her pond 6 years ago when an extension officer came to her village in Amphur Wa Chi Ra Ba Ra Mi offering loans for farmers to build ponds as part of the government's 'Recovery Fund Project'. Initially attracted by the cash offered in the loan, and describing the pond as 'better than nothing', she was given assistance by the extension officer on how to build the pond and received a small amount of donated fish seed. Since this initial meeting she has had no contact with the extension officer who has not re-visited the village, and has received no technical support or advice about fish farm management. She has never bought fingerlings to stock the pond but leaves the fish to spawn and feed naturally, using the pond only for household consumption. Like many other farmers Miss Tippawan Arun No recognises the signs of disease among her fish from the similar signs she has seen on wild fish in the cold season. However, like her, most farmers said they were reluctant to expend time or money on seeking out information on disease prevention or treatment. In order to understand the reasons for this reluctance it is necessary first to consider the varying motivations of farmers for adopting aquaculture.

3.3 Questions of motivation

Exploring motivations for adopting aquaculture is integral to understanding the role of aquaculture technologies and management strategies in the broader livelihood contexts of rural households. Attempts to promote improved management must be informed by a greater understanding of the reasons why farmers dig ponds in the first place. Extension officers and researchers are often puzzled by the apparent reluctance of some aquaculturalists to improve farming practices, adopt health management strategies and invest in low-cost techniques to maximise productivity. An investigation into the motivations behind the adoption and practice of aquaculture is therefore crucial in order to shed light on the reasons why farmers may have little (or no) interest in AAH strategies.

As Harrison notes in her study of aquaculture in Sub-Saharan Africa, a variety of factors come together to induce people to dig ponds. These include the hope of an additional household income and the opportunity to earn some extra cash; a source of fish for household consumption and the possibility of increased food security and nutritional intake; or the expectation of development assistance and credit from government, NGOs or development agencies (Harrison 1994: 27). Motivation varies significantly according to difference between, and indeed, within, households.

Case Study: Mrs Wee Ra Muan Chum, Wat Kwang District, Amphoe Pho Thale

Mrs Wee Ra Muan Chum of Wat Kwang District in Amphoe Pho Thale (one of the areas of the highest concentration of fish farming in the province) who has been practicing fish farming for only a year described her reasons for embarking on fish farming: a year ago an agricultural extension officer visited the head of the village in which she lives and then called a meeting to ask whether any farmers were interested in integrating aquaculture into their farming activities. At the time she had 2 Rai of unused land that was unsuitable for growing rice. She said that the officer was offering help to construct the pond free of charge, some donated fish seed and a loan of 5000 Baht to begin fish farming, so she ***'gave it a try'****. Mrs Wee Ra Muan Chum chose to stock her pond with Gourami fish on the advice of neighbouring farmers, a species less commonly farmed in Pichit for which she was told there would be a greater market demand. However she said that she added both the free seed donated to her by the extension officer (Puntius fish seed) and other fish that she caught during the year. Mrs Wee Ra Muan Chum stated that other than the initial help in constructing the pond she has received no technical advice relating to management of the pond, pond preparation, feeding, disease prevention or harvesting. She added that, other than chatting informally and occasionally to neighbouring farmers she had not actively sought information about pond management or aquatic animal health, and that she was not concerned about the potential for disease affecting her fish. She said that she did not consider herself to be* ***'a fish farmer'****, her primary income deriving from her rice fields and pomelo orchard, and that she viewed the fish farming more as* ***'a hobby'*** *with the possibility of earning a little extra cash and having a ready stock of fish to eat.*

Many of the farmers interviewed in this area stated that they had built their ponds in response to government-sponsored projects such the 'Recovery Fund Project' or encouragement from extension officers who had visited the villages, as in the case of Mrs Wee Ra Muan Chum. Such projects commonly offer low-interest loans to encourage farmers to diversify their farming activities by trying new activities such as chicken rearing or fish farming. Many of the farmers interviewed said that they were motivated predominantly by the offer of low-interest loans, but did not view fish farming as a reliable, more profitable alternative to rice farming and were therefore reluctant to direct either money or time to fish farming beyond the initial construction of the pond. Thus Miss Tippawan Arun No of Amphoe Wa Chi Ra Ba Ra Mi, who built her polyculture pond 6 years ago when an extension officer came to her village offering loans for farmers to build fish ponds as part of the government's 'Recovery Fund Project', described her reasons for starting fish farming as ***'better than nothing'***.

This pattern is further supported by the case of a project set up by the Pichit Provincial Fisheries Extension Office following severe flooding in 1998 which had resulted in large numbers of farmers losing their rice harvests throughout the province. The project aimed to encourage households to diversify their livelihoods by building ponds on spare land in which to culture fish. Extension officers visited villages that had been hard hit by the floods, assisted farmers with digging ponds, offered loans to cover start-up costs and donated fish seed for the first crop. According to the Chief of the Provincial Fisheries Station the initial response to the project was positive and many households began culturing fish as a result of the initiative. However, like most projects, the initiative had a short life-span: the extension office received no further funds from the DOF and was therefore unable to offer continued technical support to households beyond initial assistance in digging ponds.

Furthermore, the Chief of the Extension Service believed that initially high response rates to the project were due, to a large extent, to the offer of low-interest loans to households. For this reason, a large number of households throughout Pichit province continue to keep low-input fish ponds for household consumption and the possibility of earning a little extra income by selling fish in the local market, but have little interest in investing time or capital in AAH strategies or aquaculture technologies. According to the Head of the Provincial Fisheries Station and local government hatchery, while it is common for land-owning households in Pichit to keep a fish pond, what he referred to as ***'serious'*** fish farming (semi-intensive and intensive operations in which farmers have invested heavily as a ***'business'*** or primary livelihood activity) are restricted to a few pockets of intensive activity in the Province:

> Most people in Pichit who have a pond keep herbivorous fish just to eat and then sell a few…They don't expect money from the pond….If they want to sell some fish they will take it to the local small market in the village. In Amphoe Pho Thale there is some ***serious*** fish farming… Normally farmers copy activities that they see other farmers doing and making a good profit from. When they see others do fish, they follow.

The picture that emerges is one in which aquaculture is indeed a component of the livelihood strategies of many rural households in Pichit Province. However, this is a low-input extensive form of aquaculture in which, to a large extent, fish are left to spawn and feed naturally in the pond. As the report will go on to highlight, for many households, intensification of their aquaculture activities involves both too great a level of risk and prohibitively high cost of inputs. These factors, combined with the limited and sporadic institutional support available to farmers who practice aquaculture means that for most households fish farming remains an additional household activity. For these reasons

AAH strategies and technologies have a limited impact on the livelihoods of poor households in province.

Nevertheless, pockets of more intensive aquaculture activity exist within the Province. Semi-intensive and intensive aquaculture operations demand a much greater input of capital, labour and time. This type of highly commercialised aquaculture is therefore only open to those farmers with the capital, or access to credit, necessary to cover investment costs. However within these clusters, the hope of high-profits inspired by the success of neighbouring farmers, and the availability of both formal and informal sources of credit, have persuaded a diverse range of households to switch from rice farming to semi-intensive fish farming. In these areas farmers have met with varying degrees of success and failure. It is necessary, therefore to go on to explore the way in which, for these farmers, AAH strategies and pond management techniques clearly play a vital role in preventing losses and sustaining and improving production levels.

4. Managing the Farm

4.1 Disease and Health Management

The findings from the farmer's survey conducted as part of this study indicate that, despite a number of aquaculturalist claiming to encounter no problems in the management of their farms (see **Table 4.1**), the most common concerns among fish farmers in Pichit province are flooding, low sale-price of fish and disease (see **Table 4.1**). Other constraints sited by farmers in the survey include losses due to theft, the cost of fish pellets, slow growth rates of fish, and the lack of outlets at which to sell their fish (both in terms of traders and local markets). These findings were, to some extent, supported by the findings from the qualitative interviews. However, the lack of markets and traders, and the high cost of pond inputs emerged as much greater concerns for large number of farmers from the interview process.

Table 4.1: Major problems encountered by farmers practicing aquaculture identified by farmers in the farmer survey.

Problem	Number of Farmers
Floods	9
Disease	5
Thieves stealing fish from pond	3
Lack of market to sell fish	1
Low sale price of fish	8
High price of fish pellets	3
Slow growth of fish	1
Lack of trader to buy fish	1
No problems	10
Total number of respondents	34

Losses through animal predation, flooding and theft are significant. While some are unavoidable, good advice on pond location and construction can reduce the losses. This is particularly the case for losses due to aquatic predators. Some farmers stated that for a number of years when they began the small-scale polyculture of fish, more than half of their crop seemed to disappear. They explained that with no previous experience or technical support they did not know that many of the fish in the pond were being consumed by other carnivorous species placed in the pond. In these cases the farmers lacked sources of advice both on appropriate species for polyculture and good pond construction to limit the number of outside predators entering the pond.

The majority of farmers who participated in the study said that they recognized the signs of disease in their ponds because they had seen the same signs on wild fish in rivers and lakes, prior to practicing aquaculture. Indeed, as outbreaks of some diseases tend to be seasonal, signs of disease outbreak are commonly detected in wild fish first and can, to some extent, be predicted. This is especially the case with EUS in the rainy season. During these time, disease spread rapidly and natural sources of fish suitable for consumption, abundant at other times of the year, become scarce and cannot be eaten. At these times there is a much greater reliance on farmed fish and household ponds however the disease quickly spreads to fish ponds if strategies are not adopted to prevent the spread of disease through contaminated water or fish entering the pond.

For this reason, advice on basic AAH management is vital. According to the provincial extension office, such strategies commonly include: preventing the wild fish from entering the pond and stopping the flow of water from outside sources into the pond; attempting to maintain water quality while avoiding water exchange in order to prevent contamination; removing and burning infected fish to prevent further spread of the disease; and planning the cycle in such away as to harvest the fish before the rainy season, is vital for farmers. Both extensionists and researchers referred to posters produced by government research institutes which detail both the signs of disease and basic health management strategies for preventing and controlling disease outbreaks. However, the findings detailed in **Tables 4.2** and **4.3**, as well as the evidence from interviews conducted with farmers (see case study below), indicate that such strategies are not being adequately communicated to farmers. According to the findings displayed in **Table 4.2**, the most common response to disease is to change the water in the pond. While maintaining water quality is essential for AAH, water exchange with outside sources is commonly believed by researchers to be a major factor contributing to contamination of fishponds and the spread of disease.

Table 4.2: Strategies used by farmers in response to fish disease

Strategies	Number of Farmers
Change the water	9
Put lime into the pond	4
Remove the fish from the pond	4
Put salt into the pond	3
Stop feeding the fish	0
Put alum into the pond	1
Put Potassium Permanganate ($KMnO_4$) into the pond	1
Put formalin into the pond	1
Unspecified 'treatment' of the pond	5

Table 4.3: Source of information about disease control and treatment strategies identified by farmers in Table 4.2.

Source of Information	Number of Farmers
Fisheries extension officer	1
Local government officer	1
Other farmers	10
Personal experience	2
Chemical and feed salesman	0
Magazine	0
Training course	0
Television	0
Radio	0

Case Study: Mr and Mrs Sun Prom Chi, District Ba Noi, Amphur Pho Thale

Mr and Mrs Sun Prom Chi switched from rice farming to catfish farming as their primary livelihood activity 7 years ago when they saw the profits made by a neighbouring catfish farmer. They built two ponds of half a Rai each for culturing catfish. However, they said that after the first good harvest when they made a good profit, their harvest failed during the next two years as their fish died from disease. Mr Sun Prom Chi said that he had never received any technical advice either from extension officers, salesmen or training courses and that he felt his farm had failed because of his lack of knowledge. In order to treat the disease he had followed a neighbouring farmer who sold him 'white' and 'yellow' powders, but he felt these had been a waste of money.

Due to the lack of success the family switched from culturing Clarias to Pangasius. But, again, they said they had no information about appropriate stocking densities, so that they over-stocked their ponds and the fish did not grow sufficiently, so that they could not sell them for a high enough price to cover their initial outlay. Since then Mr and Mrs Sun Prom Chi have cultured Puntius in their ponds, but they said that they leave the fish to spawn and feed naturally in the pond and sell them to market sellers at Ban Munak market when they need some extra cash. They no longer invest in their ponds or rely on them for their household income, for which they have now turned to orange and lime farming.

*They are no longer concerned with pond preparation or whether the fish are affected by disease or eaten by predators such as snakehead, but simply '**let the fish die'** and sell or eat those that survive. Mr and Mrs Sun Prom Chi said that they had never had any contact with the extension service throughout the time they were fish farming and that they had received little advice from other farmers because the low market demand for farmed fish in the province created a high level of competition between farmers in the village. They attributed the failure of their fish farm primarily to disease, and their lack of knowledge about disease control and prevention, and basic fish health management strategies, such as pond preparation and stocking density.*

The study revealed that semi-intensive and intensive monoculture fish farmers tend to focus on disease treatment, rather than prevention, expending large amounts of money on costly disease treatments or drugs (most commonly referred to by farmers as the ‘yellow’ or ‘white’ powders), with little reliable advice on appropriate usage and dosage and dubious levels of success. It is evident that in the case of farmers such as Mr and Mrs Sun Prom Chi, there is an urgent need for effective extension services and basic pond management strategies which include disease prevention strategies. In this respect information is not reaching many farmers, especially those in more remote places or those outside the pockets of intensive aquacultural activity where there are sufficient numbers of fish farmers to induce visits from feed and chemical company technicians, as well as extensionists. The need for reliable information about disease control and treatment is urgent as many of the farmers spoke of spending significant sums of money on unspecified powders for disease treatment. Few farmers claimed to know what the powders were or exact dosages, and most said that they generally estimated how much to use and then stopped when they believed the disease had gone.

Many farmers, such as Mr Sam Nieng a nursery farmer in Tung Noi District, Amphoe Pho Thale, stated that, following the practice of other farmers or advice from agricultural salesmen, like many of the fish farmers in his village, he spent large sums of money on ‘white’ or ‘yellow’ powders, bought from agricultural suppliers to treat disease at approximately 100 Baht per 100 grams. Mr Anan Sawadee and Mr Bunlao Wa Chi Ra are among a cluster of nursery farmers in Wat Kwang District of Amphur Pho Thale who culture catfish fingerlings. Both farmers said that when they observed signs of disease on their fish, they used a combination of six powders which they had mixed together themselves after buying them from the agricultural shop following advice from other farmers. They said that they did not know the names of the drugs, referring to them as ‘white’ and ‘yellow powder’, and that, despite being very expensive they believed them to be effective. They both stated that they had received no ‘official’ information about the appropriate use and dosage of the drugs and chemicals either from extension officers or the agricultural shop.

This points to the weakness of institutional support available to farmers in Pichit and to the lack of effective channels for communicating appropriate and cost-effective farm management strategies to small-scale rural fish farmers. Both government officers and extensionists refer to the Provincial Fisheries Extension Office as the first point of contact for farmers seeking advice on AAH, particularly in the case of a widespread outbreak of disease. According to formal institutional structures, this is followed by the Provincial Fisheries Station which has a diagnostic unit, hatchery and carries out some locally-based research. However as **Table 4.3,** and the findings from the case studies indicate, the reality is quite different. The majority of farmers interviewed said that they had never had any contact with extension officers, nor had they been invited to or informed about training courses organised by the extension service. Similarly, few farmers mentioned having seen posters detailing the signs of disease and response strategies and none referred to posters as a source of information on AAH very. Indeed, an extension officer stated that disease is not a significant problem for freshwater fish farming in the area. This, he explained, accounted for the fact that few farmers approached the extension office seeking information concerning AAH.

Relatively rapid technical change with regards to the use of agro-chemicals and the increasing availability of a wide range of drugs for disease prevention and treatment has important implications for notions of 'local knowledge'. While most farmers claimed that their knowledge is based on their own personal experience, their experience of using various chemicals and drugs is often limited. Technical knowledge often appeared to derive from a mixture of hearsay and the advice of agricultural salesmen and the agents of agrochemical and feed companies. As government extension services for freshwater aquaculture in the area are relatively weak and over-stretched (see **Chapter 5**), these agents often usurped the role of extension agents for their clients who became dependent on their partial advice as the only source of aquatic animal health information readily available. The transfer of information thus becomes contingent on a private commercial relationship between salesman and farmer, to which poorer farmers who cannot afford this service are excluded (this is discussed in greater detail in Sections 5.6 and 5.7). This has consequences for the use of chemicals and drugs. As the visits from agents are often sporadic and inconsistent, many farmers determined the application and amount of chemicals required according to a system of trial-an-error. Others simply said that they copied their neighbours. The result is likely to be inappropriate application and overuse that is not only economically inefficient, but also, potentially damaging to both the fish and the environment.

In the areas of more intensive commercially orientated aquaculture reliable and cost-effective AAH strategies are undoubtedly essential. Here, a number of highly successful, long-term fish farmers benefited from close and familiar ties to extension personnel, provincial fishery station officials, feed company technicians or privately hired technicians and engineers. They had the capital to make use of diagnostic services offered by research institutes and had often been singled out as ‘master farmers’ to be recipients of on-farm technical demonstrations by the extension service. Many of these more successful farmers operated simultaneously as feed or chemical agents. In this way they strengthened their ties with other stakeholders in the market, and increased the dependency of less successful neighbouring farmers who relied on them for advice, in-puts (such as pellet and chemicals) and credit. Meanwhile, for the most part, their clients claimed to have had little or no contact with government extension services. Thus, while AAH strategies have a direct positive impact on the wealthiest farmers, households with limited resources are not only denied such advantages but are caught within precarious patron-client relationships, increasing their dependency and vulnerability.

4.2 Feeding the fish

The price of processed fish feed was shown to be one of the major concerns for fish farmers in Pichit. Many of the farmers in the area said that they relied on loans from the agricultural bank to pay for fish feed pellets. As the price of pellets has risen steadily, whilst the sale-price of farmed fish in the province fell, farmers said that they were finding it increasingly difficult to repay these loans (see **Section 4.4** for a further discussion of the role of loans and credit). The fish feed pellets are produced and distributed by large multinational companies, such as the CP Group, one of the most popular brands of fish feed pellets in Thailand and throughout the region. The CP Group, who are also heavily involved in the shrimp and chicken industry, is one of a number of multinationals, who are 'engaged in the full cycle of production (from the inputs of feed and farm technology to the marketing of products)', in this respect they have enormous power over the industry and can influence the 'organisational relations of production at every level' (Burch *et al* 2000: 519). Farmers stated that, in recent years, the cost of a 20 kg bag of catfish pellets had increased from approximately 350 Baht in the past five years. Meanwhile, the price paid by traders for fully-grown catfish was said to have fallen from around 40 Baht per Kg to 20-25 Baht per kilogram in the same amount of time.

Case Study: Mr Suan Janchua, District Ta Bua, Amphur Pho Thale

Mr Suan Janchua was among the first to begin fish farming in his village ten years ago. He began fish farming in response to a salesman from a fish feed company who came to the village to promote catfish (Clarias) farming, appealing to farmers with the potentially high profits that could be made from farming Clarias at the time. Mr Suan Janchua, following the example of the Village Headman, invested heavily in turning over much of his rice fields to construct fish ponds for mono-culture Clarias farming. He said that at the time he visited the Agricultural College in Nakhon Sawan, along with the Village Headman, in order to learn more about the management of his fish farm, how to best prepare his ponds, strategies for disease prevention and control, and how best to feed his fish. According to Mr Suan Janchua, his fish rarely experienced infections and therefore disease did not significantly affect his profits. Until 4 years ago he said that he was making a good return on his fish farm and earning more money than he had done from rice farming. However, in the past 4 years, he said that the price of Clarias had dropped from 40 Baht per Kilogram to 20 Baht per kilogram, but that the price of Catfish pellets had more than doubled. He had therefore been forced to get significant loans to cover the cost of the pellets in order to sustain his fish farm until eventually he abandoned his fish farm last year left with a debt of 100,000 Baht which he attributes almost exclusively to cover the costs of pellets. He has now turned the catfish ponds, while concentrating on his remaining rice fields for the bulk of his household income.

Mr Som Ruam of Ta Bua District, Pho Thale, said that he had faced similar difficulties. When he started fish farming 8 years ago fish feed cost him 120Baht for 20 kg of catfish pellets. Since than he said that the price had increased by more than 200%, and was now 350 Baht per 20 kg, while the sale price for catfish had dropped from 40Baht per kilogram to 27 Baht per Kilogram. Similarly, Mr Sam Nieng a nursery farmer in Tung Noi District, Amphoe Pho Thale stated that his biggest problem is the cost of pellets to feed the fingerlings, added to which is the cost of the 'white powder' that he buys from the agricultural supplier to treat disease which he says costs100Baht per 100 grams (see **section 4.1** on Disease and Health Management, for a discussion of the use of chemicals and drugs for disease treatment). According to a large number of farmers, due to the lack of technical support from the extension service, they relied heavily on feed company sales representatives and promotional workshops sponsored by the companies for technical information on appropriate feeding techniques (the role of agricultural salesmen and feed company representatives as agents in the transfer of technical knowledge to farmers is discussed further in **sections 5.5** and **5.6)**. This highlights the need for extension support to focus on delivering cost-effective strategies for producing home-made feed to farmers in order to provide an alternative to the crippling cost of processed feed pellets from feed companies.

4.3 Markets and Trading: A Market for Fish?

The lack of market demand for farmed fish – natural fish being both readily available and favoured by consumers –is a significant barrier to farmers investing in aquaculture as a commercial enterprise. According to Mr Wattana, a former catfish farmer from Amphoe Ban Munak, the falling market value of farmed fish was one of the most critical problems faced by fish farmers in teh area and had forced many farmers, including himself, to abandon their fish farms in favour of more reliably profitable activities or a return to rice farming. Mr Wattana added that, 'people prefer wild fish, so it's very hard for us to sell our fish and the price keeps going down'. Farmers, extensionists and market sellers echoed the opinion that fish from natural sources is favoured by consumers over farmed fish. The Chief of the Provincial Fisheries Station qualified this saying that, 'In Pichit, for most of the year, there is plenty of natural fish to catch, so the market for farmed fish within the province is very restricted. Unless they can find traders from outside the province, it is very difficult for fish farmers to get a sufficiently high price for their harvest to cover their input costs'. Farmers appeared unwilling to spend either capital or time on AAH and improving pond management when the market value for farmed fish had fallen consistently over the past five years.

According to an employee of Pichit Provincial Fisheries Station the slump in the market value of *Clarias* (catfish) was due, to a large extent, to the introduction of a hybrid catfish species which he described as, 'easier to culture', and consequently had resulted in a marked increase in productivity. This was supported by the account of Mr Anun, the owner of the largest commercial fish farm in Pichit Province. The farm was begun in 1982 by Mr Anun's father, initially, he says, as a 'hobby'. Mr Anun has since taken over management of the farm, from his father and has expanded the operation to include a large hatchery and nursery which supplies catfish fingerlings to many local farmers; a fish restaurant; and a processing plant, producing, among other products, a type of fish sausage which they distribute to supermarkets in Pichit and neighbouring provinces including Nakhon Sawan. The owner explained that with the drop in the price of catfish in the past 5-10 years it would be difficult to make a profit from farming fish as a primary activity. One reason for this, he explained, has been the development and introduction of a hybrid catfish species (*Clarias macrocephalus* × *Clarias gariepinus*). Which, over the past decade has given rise to both an increase in the number of farmers choosing to culture catfish due to the appeal of high yields produced by this species, and consequently, an increase in levels of production.

The hybrid catfish species, currently one of the most commonly cultured fresh water fish species in Thailand, is popular due to its short culture cycle, high growth rate and comparatively high tolerance to low water quality and low water volumes (Somsiri *et al* 2001). Thus, while research has shown that the hybrid species continues to be vulnerable to disease problems and high mortality rates (ibid), the short culture cycle and high growth rate ensures a higher yield. For this reason, many farmers stated that disease control and treatment are no longer major concerns for them. The increase in the amount of catfish produced as a result of this intervention, however, has become a major concern to farmers, as the increased yield has forced the price of farmed catfish down dramatically. More and more farmers have begun to culture this genetic hybrid in the last 10 years. Production rates have risen further as losses due to poor water quality have been reduced and hybrid species have a significantly higher growth rate.

However, while optimistic predictions made over a decade ago claimed that the newly introduced hybrid catfish, was not only producing a much greater yield, but could command a higher market price (Wattanutcharya *et al* 1982), in the past 10 years the opposite has shown to be true. The increase in yield produced by this species has ultimately resulted in a slump in market price. According to Mr Anun, the market value of farmed catfish has dropped by 50% over the last five years. The production of farmed fish, and most notably species of catfish, has, over the past 5 years, become sufficiently high to drive prices down. As a result, some of farmers have switched from grow-out catfish farming to nursery farming, supplying fingerlings to catfish farmers both within Pichit and, in a few cases, to traders from other provinces such as Chiang Rai. As yet the number of farmers culturing catfish fingerlings is relatively small and they tend to be clustered in few specific areas within the province have, such as the Wat Kwang District of Amphur Pho Thale. One such farmer who had switched from grow-out catfish farming to fingerling farming, Mr Sunee, summarised the fears of many of the farmers interviewed in this area that as an increasing number of farmers were starting to try nursery farming, the sale price of the fingerlings would also soon drop.

This highlights the way in which research and intervention strategies which focus on maximising output can, in some cases, have a negative impact on the livelihoods of farmers. This is particularly true with regard to the development and introduction of ‘green revolution’ type technologies such as hybrid catfish species, the objective of which is to maximise productivity. As Stirrat has highlighted, ‘the low-productivity approach to poverty sees poverty as a result of technological barriers’ (Stirrat 2002: 5). This approach is underpinned by the assumption that improved technology or technical knowledge leads to increased production, which ultimately leads to a reduction in poverty. The commitment to maximising productivity, which underpins technical research and intervention strategies in the field of aquaculture, can, in many cases, have the opposite effect. As in the case of catfish farming in Pichit, while technical innovations have increased production rates, increased production have driven down prices. As a result, farmers are finding it harder, rather than easier, to sustain a living from fish farming.

The study revealed that, along with the falling value of farmed fish in Pichit, farmers face further difficulties in finding an outlet in which to sell their harvest. There is only one large central market in the Pichit, in Amphoe Muang (there is also a much smaller weekly market in Amphoe Ban Munak). Farmers said that there was not sufficient demand at this market for farmed catfish, and most of the sellers at the market said that their fish came from natural sources. The majority of catfish traders are mobile, passing through the province at specific times. As levels of production have increased, along with the numbers of farmers producing catfish, while traders remain few and far between, farmers must compete to sell their harvest. This has the effect of driving sale-prices down further. In contrast to these itinerant traders, a small number of fixed traders operated solely within the province, working as middlemen between the farmers and the local market. These middlemen often act as patrons to a selected group of farmers, doubling as agricultural salesmen. In this way they control various levels of the production. By providing agro-chemicals and feed, and, in some cases, fingerlings, on credit, they have ultimate purchasing power over the end product. Farmers expressed frustration at having little power over setting the sale price of their harvest and often said that they felt 'cheated' by traders to whom they were forced to sell their harvest for a low price.

Table 4.4: Modes of selling fish identified by farmers in farmer survey

Mode of Selling	Number of Farmers
Local market	10
Door-to-door	17
Trader	12

The vast majority of farmers remain small- or medium scale producers, with only a handful of medium- and large-scale commercial operations in the province having access to traders and markets outside the province[13]. The widespread lack of access to traders is suggested by Table 4.4 which indicates that, over two thirds of fish farmers in Pichit sell their harvest either door-to-door or in the local market. Many of the farmers who participated in the study stated that the lack of traders was one of the biggest problems they encountered in fish farming. This was highlighted by Mr Sutep, a catfish fingerling

[13] With only a handful of large-scale operations, similar to that of Mr Anun's, aquaculture in Pichit provides only a limited number of labouring opportunities both on the farms and in processing plants. As this research project focused primarily on the impact of aquatic animal health strategies on the livelihoods of poor *farmers* in the selected areas, further research would be required to examine the employment opportunities provided by the processed feed and chemical industry which supports the practical of aquaculture.

farmer in the Tung Noi District of Amphoe Pho Thale who said that he knows of only one trader in the neighbouring district and that many farmers compete to sell him their fingerlings. For farmers, such as Mr Sutep, who live in areas of the Province where they were isolated from other fish farmers, access to traders is further restricted as, according to Mr Sutep, 'they don't bother coming to this village, because no one besides myself cultures fish'. A large number of small- to medium-scale farmers therefore sell their harvest door-to-door in local areas, for which they said they made a higher price than selling them to a trader (30-35B per kg rather than 20-25B), but had to offset this against the cost of transport. This mode of selling is available only to those households who have both access to a car or small truck in which to transport the fish, and the necessary extra time/labour. Thus, as Mr Sutep stated, ***'it is not culturing fish that is risky, but selling them'***. This highlights an important question for the direction of aquaculture research in the future: should poverty-targeted research focus on trade rather than production?

The lack of market demand and restricted access to traders and markets outside the province is one of the most significant factors influencing the reception of AAH and other farm management strategies by farmers. Due to the unpredictable and restricted market demand for farmed fish, combined with the falling value of farmed fish and the difficulty faced by farmers of finding profitable modes of selling their harvest, farmers said it was difficult to make predictions and calculate cost of inputs against likely profits. Many farmers are therefore reluctant to invest significant capital, time or labour on disease prevention and control strategies and aquaculture technologies, for fear that the income generated from the sale of harvested fish will no cover the input costs and preferring instead to divide their time and resources between their fish ponds and other livelihood activities.

4.4 Loans, Credit and Capital

The provision of loans and credit facilities is a vital component in the promotion of aquaculture. It is of particular importance when considering the role and impact of aquatic animal health strategies on the livelihoods of aquaculturalists. While development practitioners and researchers have often lauded the great benefit of aquaculture as an alternative or additional livelihood activity that makes use of existing on-farm resources, the study revealed that, most households involved in semi-intensive or intensive fish farming, Pichit Province, rely heavily on bank loans and informal credit from agricultural salesmen in order to cover the costs of stocking the pond, feeding the fish and treating disease. The capacity of households both to access and benefit from AAH strategies and management techniques is, in many cases, contingent on the availability of credit. However this study suggests that, while credit does indeed play a fundamental role in enabling both small and large-scale farmers to invest in aquaculture technologies and to expand production, the relationship between credit, production and poverty is more complex.

Credit schemes which focus on a particular category of producers, such as women, are commonly viewed as essential mechanisms, providing the necessary resources to enable more marginalized or resource-poor households to invest in aquaculture technologies, allowing them to diversify their livelihood strategies, so increasing food security and reducing vulnerability to environmental and social shocks. To this end, government initiatives promoting aquaculture as a way of diversifying livelihoods have tended to focus on the provision of loans. Indeed, as has been discussed above, many farmers have been attracted to fish farming primarily by the offer of low-interest loans. In this way, the provision of loans to encourage the adoption of aquaculture is liable to be exploited by those have no need for loans or those who have no interest in aquaculture. The worst-case scenario highlighted by the research was the way in which the offer of credit induced farmers with neither the necessary resources nor access to essential technical information, to adopt aquaculture, saddling them with a burden of debts which they could not repay. The initial 'start-up' loans quickly turned into a cycle of increasing debt required to cover the cost of inputs with no possibility for repayment.

The market value for farmed fish (particularly catfish, the most commonly cultured species in Pichit) has dropped dramatically over the past five years. This has been accompanied by a rise in the cost of inputs such as fish feed pellets, chemicals and drugs for the control and treatment of disease. These factors, combined with fluctuations in productivity due to floods, theft, predation and disease means that, for many farmers, income often does no cover input costs. Indeed, the prohibitively high cost of processed fish pellets proved to be one of the major constraints for many farmers who invested in semi-intensive or intensive aquaculture as a primary livelihood activity, contributing significantly to the increasing dependence of many farmers on credit and loans. Many households, particularly those without alternative sources of income, are finding it increasingly difficult to repay formal bank loans, informal loans from neighbouring farmers and credit owed to agricultural salesmen. In this way, the research indicated that a number of farmers, including those who are considered 'successful' farmers in terms of good management practice, low mortality of fish due to disease or other health risks, and consequently high pond productivity, may, in reality be making little or no cash profit because of the costly outlay on inputs. This is exemplified in the two case studies below which highlight both the way in which the risks and costs involved in fish farming result in many farmers becoming dangerously dependent on both formal loans from the agricultural bank and high-interest informal credit from agricultural salesmen and neighbouring farmers.

Case Study: Mr Preecha, District Ban Noi, Amphur Pho Thale

Mr Preecha began culturing catfish 8 years ago, following the example set by other farmers in his village who had switched from rice farming to catfish farming and appeared to be making large profits. He received assistance from the extension service in the construction of his 5 ponds and advice from the extensionist on how to manage the ponds, including: appropriate feeding techniques, use of lime in the pond, draining and drying the pond between cycles, avoiding contamination of the water with wild fish, how to recognise the signs of disease and control the infection. After 8 years he explained *that he was eventually forced to abandon his monoculture catfish farm as he was unable to meet the cost of the catfish pellets (approximately 350B for 20kg of catfish pellets). After calculating the cost of the pellets, lime and additional labour required for harvesting the pond against the falling price of catfish, losses due to theives, floods and disease he was left both with loans to the agricultural bank and unpaid credit to pellet salesmen. Like many of the farmers interviewed, Mr Preecha has since converted his ponds to virtually no-input polyculture ponds which he stocks with fish caught from the wild, leaves in his pond to spawn ad feed naturally and 'dips into' mainly for household consumption or occasionally to sell to passing traders. He now relies on his rice fields and small grocery business for income and to pay back the debts accrued from catfish farming. When asked if his fish still suffer from disease, he said '**probably yes but I don't notice because I don't pay attention to the fish anymore, I just keep them there'**.*

Case Study: Miss Pornchai, Ba Noi District Ampur, Pho Thale

Nine years ago, motivated by the high profits she had seen neighbouring farmers earn from aquaculture, Miss Paearn Buadi converted five Rai of her thirty-five Rai of Rice fields into 6 ponds for fish farming. In two of the ponds she cultures Clarias. In the other four ponds she cultures Puntius, Pangasius, Tilapia and Giant Gourami. Despite continuing to farm rice on thirty Rai of land, as well as growing vegetables and running a small food stall, she said that she considered fish farming to be her primary livelihood activity, although she did not feel she had been very successful at it. Miss Pornchai was concerned by the high level of risk involved in aquaculture and said that her main problems were the floods (in which she had lost two of her six ponds' harvest this year) and the falling price for farmed fish. She said that she receives an average of 300Baht for every 20kg of fish that she sells (approximately 15-18 Baht per Kg, varying a little according to the species), but that the 20kg bags of CP Group fish pellets that she buys from the sales representative cost her 340 Baht for carnivorous fish and 210 Baht for herbivorous fish. The 20kg bag lasts her three days. Input costs were therefore exceeding income generated from the sale of fish. Miss Pornchai stated that over the years she has continued to borrow money from the agricultural bank and her local agricultural salesman to pay for both fish pellets and the 'yellow' and 'white' powders she bought on the advice of an agricultural salesman to treat disease infections in the pond, as she was not earning enough money cover the costs of inputs. She estimated that she now had debts of approximately 310,000 to both the agricultural bank and her local agricultural salesman that she had no way to repay.

Miss Pornchai's experience was not uncommon. Similar accounts of lack of capital, high input costs, particularly that of the fine pellets required for feeding fingerlings (approximately 360 Baht per 20 Kg bag), and reliance on credit were given by a cluster of catfish fingerling farmers in the Tung Noi District of Amphur Pho Thale. For farmers such as Miss Pornchai reliable extension advice about the use of chemicals in disease treatment, and alternative feeding strategies which reduce dependence on expensive processed fish pellets, are clearly essential and a crucial point at which greater efforts to increase the impact of AAH strategies should be targeted. In the absence of such support many informants stated that they sought advice from pellet and chemical salesmen or received information diffused through the local network of other farmers. The situation of Mrs Pornchai, and many farmers like her, not only highlights the need for accessible and reliable technical support. It demonstrates the demand for technical support on pond management and AAH to be partnered with advice on credit, loans, and financial planning in farm management.

The study showed that for those farmers seen to be eligible for bank loans, the Agricultural and Cooperative Bank played a significant role, not only in providing low-interest short and long-term loans, but also, in providing technical and farm management support to farmers. For these farmers the bank also acts a channel for technical assistance which comes as part of the loans package. Mr Paibool, an official at the Agricultural and Cooperative Bank in Pichit described how the bank sought to cultivate relationships with its clients that go beyond the financial ties. Thus, farmers who have borrowed money for a specific enterprise, such as aquaculture or chicken farming receive visits from bank officers with expertise in farm management who monitor their progress and offer technical as well as financial assistance. Initiatives such as the Bank's *Friend Helps Friend* project organizes fieldtrips for clients to visit other farmers involved in similar activities in order to exchange information and observe alternative techniques and management strategies. Such trips are funded by the Bank and are free to farmers. Similarly 'model' or 'excellent' farmers will be used by the Bank as demonstrations for other farmers. A collaborative project involving both the bank and the extension service began in April 2001 aimed at encouraging farmers to diversify their livelihood activities into new areas. Farmers can receive loans with a three year grace period before repayment begins, during which time the agricultural or fisheries extension service is responsible for monitoring the progress of the farmer's new activity, offering technical assistance and organizing field trips and training course for all the farmers involved in the project pursuing a particular activity such as aquaculture or chicken farming.

However, not all farmers have access to this kind of financial and technical support. According to Mr Paibool, farmers who applied to the bank for loans for aquacultural activities tended to be wealthier farmers, who, as he put it, ***'could afford to be in debt'***, i.e. farmers who, not only had the collateral required to be eligible for a loan, but also the financial freedom that allowed them to invest in aquaculture technologies and innovative strategies. According to Mr Paibool, farmers who were felt by the Bank to be ineligible for a personal loan were required to apply for loans in a group with other farmers, each guaranteeing the others' loans. When one defaulted on repayments, as often happened, all were held responsible for the loan.

However, for the poorest households, lacking the collateral required, even group loans are not an option. While obtaining information on informal loans is far trickier, the study indicated that for many farmers, particularly the poorer ones, a number of there are a number of obstacles preventing them from accessing low-interest loans from the bank or a government project. According to a fisheries extension officer in Pichit, many households are distrustful of formal banks such as the Agricultural and Cooperative Bank, viewing them as an extension of local government, and preferring to borrow money from neighbouring farmers who they know, despite the frequently high rates of interest. A further barrier to accessing formal loans from the bank or government loans programmes was highlighted by Mr Somsong, a catfish farmer from Amphoe Sam Ngam. As the only fish farmer in his village, Mr Somsong said that the head of his village, charged with responsibility of administering loans from sporadic government village loans projects such as the One Million Baht project, had refused to grant him any loans from such projects, as he believed fish farming to be too risky. Local officials, such as village headmen often play a pivotal role in the administration and delivery of government loans projects to farmers or as guarantors for farmers seeking loans from the bank, and can, therefore, present significant barriers for some farmers in their attempts to access low-interest formal loans.

Consequently, farmers who are unable to obtain loans either from the bank or government credit schemes, are forced to depend on high-interest informal loans from money-lenders and neighbouring farmers and credit from agricultural salesmen, as their only source of generating the capital necessary to finance their fish farms. The research highlighted the way in which patron-client relationships emerged through informal systems of credit between agricultural salesmen or wealthy large-scale producers (who often doubled as sales representatives for feed and drug companies) and poorer farmers within a local area. As Harrison points out, 'credit can easily become a tool to be manipulated by those who have least need of it' (Harrison 1994: 26). As poorer households become increasingly dependent on credit from wealthier producers, their livelihoods become increasingly precarious and unstable (this will be explored in greater depth in **Section 5.6**).

4.5 Heads of Tails? Profit and Risk

In Pichit Province a number of factors come together to make aquaculture a high risk activity. Rather than offering a reliable, low cost alternative source of income to poor households, investment in aquaculture is considered by many farmers to be somewhat of a 'gamble' involving high levels of risk, making it a suitable business venture only for farmers with sufficient capital, experience and additional sources of income to mitigate the unpredictable and fluctuating outcomes from fish farming. Many of the farmers who participated in the study view their ponds as a small additional livelihood activity producing a ready source of fish for household consumption and potentially yielding some extra income by selling the fish door-to-door or at the local market This kind of small-scale aquaculture enterprise plays a significant role in many farmers lives, however most do not rely on it as their main livelihood activity perceiving it as too risky and unpredictable. Farmers such as these viewed aquaculture as an additional activity which allowed them to exploit on-farm resources rather than demanding investments of time and capital for an uncertain income, and, as a result, tended to show little interest in the benefits of improved pond management or AAH strategies.

Nevertheless, the perception of aquaculture as a high-profit enterprise has, over the last two decades, attracted significant numbers of farmers in Pichit to fish farming. In recent years, many of these farmers have become reluctant to invest time, labour and capital on inputs necessary for semi-intensive or intensive operations believing the risk involved to be too great within a context of limited market demand and diminishing returns due to the falling market value of farmed fish. While disease continues to be a factor contributing to the perception of risk, greater risk was seen to derive from annual flooding. Informants spoke also of fear of thieves stealing their fish from the ponds. Fear of being cheated by unscrupulous traders was also widespread. Such fears centred around the belief that traders either offered a lower price than the farmer believed their fish to be worth or deliberately miscounted or miscalculated the weight of the fish so as to offer a lower price for the crop. For these reasons the inputs required for commercial aquaculture, including the high cost of processed pellets, chemicals and drugs for disease treatment, combined with time spent feeding, cleaning, draining and guarding the pond were seen to increase vulnerability and dependency on loans and credit to cover the necessary financial demands rather than reducing it by providing a relatively predictable additional income for the household.

Even the most successful long-term fish farmers claimed that aquaculture was a risky business, and by doing so made claims to their personal expertise and innovative entrepreneurship in managing the risk and making significant profits from their farms. This is highlighted in the opinion expressed by one of the most successful farmers in Amphoe Pho Thale who has been practicing aquaculture for 20 years: Mr Sukkasem, who claimed that fish farming was ***'90% risk-taking'***. However farmers such as Mr Sukkasem have managed to reduce risk by controlling other elements of the production system, so insuring themselves against severe loss even in the event of a bad harvest – after years of fish farming they have moved into highly lucrative aspects of the system. Thus Mr Sukkasem acts also as the local pellet agent and drugs and chemical salesman, motivating other neighbouring farmers to invest in aquaculture by following his example and offering them advice, pellets, drugs and chemicals on credit. Similarly the head of one village acted as a mediator, linking up local fish farmers with highly sought after traders from Chiang Rai for a commission of their sale, so insuring an income for his household even in the even of a bad harvest or disease outbreak on his own farm. In this way risk is indirectly transferred to weaker farmers, while wealthier, more established farmers such as Mr Sukkasem are safeguarded against the risk and uncertainty involved by being assured of alternative incomes through which to sustain their fish farm in bad years.

Case Study: Mr Som Porn, Wat Kwang District, Amphur Pho Thale

Mr Som Porn of Wat Kwang District, Amphur Pho Thale has been fish farming for 20 years. He said that fish farming is ***'too risky'*** *but that he has invested everything in his farm and that it is his main source of income. He stated that the high risk demanded constant adaptability, switching from different species and then from farming market-size catfish to fingerlings in order to respond to the fluctuations in the market and the drops. Thus he said that he had some good years where he made enough profit to carry his household through the years when his harvest was unable to cover his investment costs. His fish were sporadically affected by disease however he said that the risk involved in aquaculture comes not from the threat of disease so much as from the unpredictability of the market and annual floods.*

The majority of farmers (23) interviewed for the questionnaire survey stated that they believed that fish farming was risky, while less than half as many (11) believed there to be no risk involved. The factors sited as contributing to the level of risk are listed in Table 4.5. The findings detailed in the table indicate that farmers perceive flooding to be by the far the greatest risk to their ponds. The risk posed by flooding was clear: during the course of the fieldwork, many aquaculturalists throughout the province lost their crops to severe flooding, leaving them with no means by which to repay the cost of feed and seed bought on credit for the present crop cycle which had been lost to the floods. At the same time, the floods provided an abundance of wild fish in any parts of the province, so further decreasing the demand for farmed fish, for those who were trying to sell what remained of their harvest. While more than half the farmers who participated in the study believed fish farming to be a risky venture, most farmers focused exclusively on the risks posed by flooding[14]. Nevertheless, the low sale price of fish and disease were cited as risk factors by a few farmers.

Table 4.5: Risks involved in small-scale aquaculture identified by farmers in the farmer survey.

Risks	Number of Farmers
Disease	3
Low sale price of fish	4
Fluctuations in sale price of fish	1
Fish stolen from pond	2
Low survival rate of post larvae	1
Floods	16
Problems in farm management	1
Total number of responses	23

An interesting comparison can be drawn between the *risk factors* identified by farmers in Table 4.5 and the *problems* identified by them in Table 4.1. By comparing the two tables it is possible to infer that, while low sale price is not seen as a risk factor for many farmers, it was one of the most commonly stated problems encountered by aquaculturalists. The value of farmed fish has dropped consistently over the past five to ten years. It is therefore not so much a matter of risk or unpredictability as a constant and endemic problem faced by farmers in the Province. In contrast, flooding and outbreaks of disease are contingent on climatic and environmental conditions, which are, to a large extent unpredictable, making it difficult for farmers to calculate the level of risk they present and the impact they might cause. This points to the significant difference between risk (which is seen to be calculable and can, therefore, be managed to a certain extent) and uncertainty (which is characterised by a more complete lack of knowledge). As Mehta, Leach and Scoones explain,

[14] While flooding is an annual occurrence in the province, the magnitude and severity of the floods is, to a large extent, unpredictable. Thus the findings presented in this report should be read with consideration of the influence which the flooding had on the results. For a discussion of the impact of the floods on the research findings see Annex 1.

> Uncertainty describes a situation where we don't know what we don't know. This is...distinct from risk, where probabilities of outcomes can be calculated (Mehta, Leach and Scoones 2001: 2).

In the face of such uncertainty, people adopt more flexible approaches to daily life, 'allowing them to patch together new livelihood strategies continuously, depending' for example, 'on the timing, intensity and duration of flooding in conjunction with other variables such as market conditions' (Chase Smith *et al* 2001: 42). A researcher at one of the government institutes devoted to fisheries and aquaculture research highlighted the need for research, strategies and planning to work from an assumption of instability and uncertainty rather than stability. This has been confirmed by recent studies which look critically at the way in which development, particularly in areas of natural resource management, often assume a context of stability and predictability. While aquacultural and agricultural strategies derived from research and promoted by extension are often premised on predictability, management practices have been responding continually to ecological, economic and political instabilities, and to social and institutional change (Fairhead and Leach 2002b: 75; Chase Smith *et al* 2001: 36). As Fairhead and Leach note, 'at times, scientific methods and models that hold true under certain conditions (e.g. laboratories) may be caught out in real life situations by unanticipated variables' (Fairhead and Leach 2002a: 10).

The adoption of new technologies and the implementation of AAH strategies is not cost free. They require inputs of time, cash and labour that are often not available to the poorest households. While the techniques are essentially stable, the context within which they make such demands on a household's labour, time, cash is not. Thus, within the context of a market slump in the price of farmed catfish, sudden floods, or the absence of traders in the area to whom farmers can sell their harvest, for example, farmers are reluctant to invest any surplus cash in fish health management strategies with the intention of increasing productivity, rather than save the money or invest it in another direction. The varying marketability of fish and fish products present a decisive factor for the levels of financial (and other) expenditure on management strategies and inputs into production that a farmer will be willing to invest (European Commission 1994: 23). In this way a farmer may be reluctant to expend time or money on disease control in the pond if the market value for the species s/he has stocked has dropped and the income generated at harvest will not justify the investment on health management.

Furthermore, farming technologies and the market, do not operate as two distinct spheres, but are mutually dependent and influenced by each other. While new techniques have the capacity to mitigate against risk and to increase predictability, as in the case of AAH strategies, they can, at the same time, adversely affect the market value of a product. Fegan's comparison with the poultry industry is informative on this point:

> In the early years, very little technology was involved and production levels increased through *ad hoc* development. However, the increased production led to an increase in the incidence of disease and losses. As this occurred, continued research into genetics, nutrition and disease led to the development of specifically selected strains, better feeds and improved disease control strategies...these led to

> increased production, decreased price and increased costs, the industry has developed to where it now produces a large volume-low margin product which is highly predictable (Fegan 1996: 27).

The findings from the fieldwork carried out in Pichit Province, Thailand (2002) as part of this research project revealed a similar pattern in the introduction of the hybrid catfish (see **section 4.3**). While this has resulted in a rise in yields of catfish and greater consistency of outputs, the increased production has been reflected in the decreasing market price for catfish as the market has been saturated with catfish, leaving farmers with a narrowing profit margin and a desire to seek more profitable species to farm or alternative livelihood activities.

Information, Knowledge and Extension

5.1 Introduction

Extension and uptake of basic pond management strategies remain two significant challenges for the future. The findings from this study demonstrate that the focus on technical research has lead to a neglect of the processes by which the products of such research (AAH Strategies, for example) impact on the lives of farmers. Thus we need to shift the focus away from the production of technical strategies and onto the institutional support provided to farmers through the extension services. This means, not only examining the extension-farmer nexus, but also looking at the links between research institutes and provincial extension services.

Practical constraints, such as lack of resources and limited access, are as great a barrier to effective extension provision as the problematic relationship between extensionists and farmers. The majority of farmers interviewed stated that they had had little or no contact with extension officers, nor had they been invited to any training courses. Due to this they expressed a feeling of distrust in the extension services. Extension officers echoed this saying that farmers trusted each other more that the advice of the officers. Information travelled through informal networks of neighbouring farmers and relatives. While TV fisheries extension programmes were popular amongst many of the farmers interviewed, farmers often commented that they could not apply the techniques presented in the programmes due to the costly investment of time and capital they demanded.

Poorer farmers tend to be neglected by extension services in favour of those categorised as ‘change agents’, ‘innovators’ or ‘master farmers’. Such an approach assumes a trickle down effect of technology transfer that imagines that the benefits of AAH knowledge and technical support provided to successful ‘entrepreuneurial’ farmers will eventually reach the poorest ‘conservative’ farmers through a process of diffusion. This model advocates the effectiveness of targeting 'model' farmers who demonstrate the motivation and potential to intensify production, demanding a higher level of technical inputs in pursuit of greater commercialisation of their operation. This model relies on the increasing 'privatisation' of the various elements of aquaculture production: hatcheries, seed supply, and most significantly, transfer of technical information and strategies, which commonly accompany the sale of feed pellets and agro-chemicals by company agents eager to culture loyalty amongst actual and potential customers through the provision of private company technicians and training courses. Such an approach to extension is therefore underpinned by the imperative towards greater intensification and commercialisation of the elements of aquaculture production. These processes are seen to be crucial to the national development of aquaculture. Yet this philosophy seems to contradict the claims that aquaculture represents a low-input, basic technology to help improve the livelihoods of the poorest farmers and to undermine the commitment to promoting and supporting the adoption of small-scale aquaculture by the poorest farmers as part of national poverty reduction strategies.

The 'trickle-down' approach to extension which targets 'master farmers' neglects the politics of competitiveness between farmers in a restricted market, as well as the intricate power relations of dependency and patronage that exist between farmers. The case study in Pichit revealed the way in which such an approach primarily serves the wealthier, successful farmers who become the chief audience of the extension support and AAH strategies. Consequently, poorer farmers are either denied the benefits of such advice or receive advice filtered through a patron-client relationship of credit and dependency. This is what has been termed in this report the *'unofficial privatisation'* of extension. The extension service requires not only greater resources to extend its reach, but needs to be restructured to direct its attention much more rigorously towards reaching poor people.

Key Challenges/Issues for Extension

- Lack of funds and resources (only 6 fisheries extension officers for the province).
- Problematic farmer-extensionist relationship.
- Most farmers had no contact with extension officer, never invited to training workshops.
- Lack of faith in the extension service.
- Persistence of traditional top-down extension models which target 'master farmers'. *Trickle Down* assumed but competitiveness among farmers in a restricted market is neglected.
- Wealthy successful farmers are primary beneficiaries of extension activities. This has lead to the neglect of the poorest farmers.
- Lack of participatory approaches which respond directly to the concerns of small-scale farmers and involve them more fully in the extension process.
- Extension focuses almost exclusively on technical strategies, to the neglect of the socio-economic dimensions of farm management, such as financial planning, efficient use of labour and capital and credit schemes.
- The divide between Fisheries extension, responsible for aquaculture management, and agricultural extension services does not reflect the integrated farming systems or diverse livelihood activities of small-scale farmers.
- Mass media: TV programmes popular but demand capital for the techniques and are therefore unsuitable for small-scale extensive aquaculture.
- Lack of consistency and appropriateness of advice received by farmers.

5.2 Access and Scope of the Extension Service

The extension services in Pichit do not directly target poor farmers, nor, in most cases, are poorer farmers able to access technical support from the extension office. Lack of resources, and the resulting shortage of personnel, are one of the primary constraints to effective extension provision in Pichit province. With only six full-time extension officers covering the entire province, the capacity of the extension services to reach a large number of farmers is severely restricted. As a result access to formal extension support is mainly limited to those farmers with the time, resources and transport to seek out extension advice for themselves, or the few who have personal ties with extension officers. In most cases these tended to be successful medium-large scale farmers. Those with the least access to extension support, are the farmers who are in most need of technical support: the poorest farmers.

Many said that their only interaction with the extension services had been when an officer had come to the village to encourage farmers to adopt aquaculture as an alternative livelihood activity. Since the initial meeting, they had received no further technical support and extension officers had not returned to the village. In contrast a number of farmers said that they received advice on animal husbandry, rice farming, irrigation techniques and vegetable cultivation from the agricultural extension officer who visited the village on a regular basis. The most remote areas in the province appeared to have no contact whatsoever with the extension services. Farmers explained that the remote location of their farms made it very difficult for them to travel to training courses or visit the extension office in the Provincial capital. Furthermore, due to the remote location both traders and sales representatives from feed and chemicals companies rarely visited the farmers. Farmers in these areas, therefore, depended entirely on advice from neighbouring farmers or relatives as their only source of technical information on farm management. In such areas, effective outreach programmes are urgently required.

Extension officers tended to concentrate their activities on areas where there was an enclave of commercially orientated aquaculturalists, neglecting villages where only a few farmers practiced aquaculture. In areas such as these, farmers who did culture fish were particularly isolated, both from the extension service which tended to target the areas in which clusters of fish farmers existed, and from other farmers with whom to share knowledge about pond management and AAH. Thus one farmer said of his village that the agricultural extension officer visits every month to give advice on rice, vegetable and fruit farming, and on animal husbandry, but that no fisheries extension officer has ever visited because he is one of only three farmers in the village who practice aquaculture. Similarly, none of them have ever been invited to or informed about any training courses on pond management. They are isolated not only from official technical support provided by the extension service, but also, from unofficial networks of information exchange between other farmers practicing aquaculture. Furthermore, neither traders nor sales representatives come to the village since there are too few potential clients. Farmers in these villages said that they had never seen any posters or leaflets relating to AAH or other technical aspects of fish farming. The lack of traders meant that farmers who wanted to sell their harvest had to find a way to transport their fish to the local market and try to sell it there. The cost of such a venture, both in terms of time, labour and cost of transport, combined with the lack of technical support either from the extension services or informal channels, had deterred many farmers from adopting aquaculture as an alternative livelihoods strategy. This picture was reinforced by the chief of the provincial extensions service who stated that due to lack of resources and personnel the more remote districts and those with less aquaculture receive the least support from the extension service and are often neglected.

5.3 Extensionists and Farmers

Due to the lack of contact most farmers have with extension officers most farmers expresses a general feeling of mistrust in the extension service and its officers. Extension officers echoed this saying that farmers trusted each other more that the advice of officers. Information travelled through informal networks of neighbouring farmers and relatives. This was exemplified by the comments of Miss Jaruwan a fingerling producer from the Wa Tub Tim District of Amphoe Pho Thale, who explained that if she encounters a problem with her ponds she asks other neighbouring farmers who, she believed, are likely to have faced the same problem, rather than seeking advice from the extension service. Mrs Jaruwan explained that, since an extension officer had only visited her village on one occasion many years ago, she would not trust the advice they gave her, but would prefer to speak with other farmers who she had known for many years and who were involved in the same activities as her. This was supported by the account of Mrs Kasem, a fingerling producer from the Wat Plow District of Amphoe Pho Thale. Mrs Kasem explained how she had received information on pond management and AAH from her uncle when she began fish farming five years ago. When faced with problems on her farm, such as the signs of infection in her fingerlings, she asks advice of her uncle, rather than contact the extension services. She added that her uncle received advice from a particular salesman from whom he had been buying pellets and drugs for many years, but that she would not trust extension officers because she had never met one and because ***'they are not farmers'***. Furthermore a number of farmers said that they believed that the agriculture extension officer could provide more help to them. A commonly held view among farmers involved in small-scale aquaculture was that the fisheries extension officers know only about fish farming. While this in-depth knowledge could be appropriate for medium-large scale producers with semi-intensive or intensive culture systems, it had little relevance to the low-input, extensive ponds of poorer small-scale producers, for whom the pond was only one, sometimes minor component, of an integrated farming system.

Provincial extension officers expressed concern about the problematic relationship between themselves and farmers, suggesting that in many cases they believed that farmers had little faith in them and the advice they gave. However, a number of extensionists expressed the opinion that poorer farmers tended to disregard their advice more than successful farmers. This, they believed is because poorer farmers do not have sufficient knowledge or education to understand the advice they give and put the strategies into practice. This reinforced the prevalent view within the extension service that poverty was the result of ignorance and conservatism. A clear disparity emerged between the accounts of a large proportion of poorer farmers and extension officers. While farmers stated that they had little, if any, contact with extension officers and therefore little faith in the extension service as a source of reliable technical support, extensionists attributed this feeling of mistrust to the ignorance and conservatism of poorer farmers, whose lack of education and entrepreneurial spirit made them reluctant to adopt the strategies suggested by trained extensionists.

Extensionists, therefore, tended to create a dichotomy between farmers they described as 'poor', 'conservative' and with low education levels and those they identified as 'change agents', 'innovators' or 'entrepreneurs'. The chief of extension stated that the successful farmers have an 'entrepreneurial spirit' but the others do not want to learn. The choice not to apply a certain technique or strategy such as applying lime to the pond or allowing the pond to dry between cycles, was viewed as conservative, irrational or due to lack of understanding, education or imagination rather than a calculated decision to mitigate against risk and uncertainty. This prevalent view has, and continues to, underpin much of orthodox extension theory and practice, which concentrates activity on 'master' farmers, who are singled out for demonstrations of new techniques, on-farm trials[15] and training. The underlying assumption is that such farmers will provide models of success and best practice for poorer, small-scale or less-successful producers, encouraging them to follow the lead of these 'change agents'. In this way, knowledge, and the benefits it brings, will 'trickle down' to poorer farmers. Thus, extension policy and practice appears to be driven by traditional economist models of technology transfer (the goal of such models being to encourage productivity and support economic growth.), rather than a direct concern with poverty reduction and sustainable livelihoods.

5.4 Mass Media

In recent years the importance of mass media such as radio and television as tools for the communication of farming strategies and information has been recognised. A number of recent studies have highlighted how these channels have successfully been mobilised to reach a broad sector of farmers. However, just as there is a tendency to view technology as neutral, so the media is often represented uncritically as an a-political, a-social channel

[15] The success of on-farm trials and demonstrations as an alternative to conventional methods of extension has been recorded in three Southeastern provinces of Vietnam. In the provinces of Binh Phouc, Tay Ninh and Long An a three year intervention strategy introducing on-farm trials to test and try appropriate farm management techniques has been implemented by the fisheries extension service. According to the results of the study, the average yield of fish culture of 56 project farms has increased by 20, 30 and 130 percent respectively in the three provinces (Nyuyen Van Tu and Trinh Truon Gg Giang 2003). However, as with many such studies these dramatic results must be read with caution. From the steep increase in production rates on-farm trials appear to present an effective alternative approach to extension activities that could yield positive results in Phichit. Nevertheless the selection of trial farms is an area of concern as such interventions are often targeted at those farmers identified by the extension service as 'innovators'. Appropriate and effective techniques that evolve from such trials and demonstrations are not automatically transferred to other farmers, especially, poorer farmers. Thus such interventions must directly target poorer farmers and be followed up by a continuing extension presence. Such studies rely on production levels as a measure of impact. The success, or failure, of such methods in reducing poverty is commonly overlooked in the evaluation of such initiatives.

of communication. The fact that people have access to television or radio should not be translated into evidence that these channels are effective tools of transfer. This is highlighted by the findings from the research in Pichit Province.

The study revealed that aquaculture extension programmes broadcast regularly on television are very popular among farmers. Both fisheries and agricultural extension officers believed television to be the most effective channel for the communication for technical information. According to extensionists, aquaculture programmes were shown at suitable times for farmers and were widely popular among local farmers, the vast majority of whom had access to television[16]. However, many farmers said that they watched the programmes but could not apply the techniques advocated on the programmes because they were too costly both in terms of time and money and appropriate only for medium-large scale, semi-intensive or intensive operations. In this way, poorer farmers were once again excluded from important channels of communication. It was evident that there was either a lack of cost-effective, simple strategies for disease control and aquatic animal health management or that those that existed were not being effectively communicated to farmers.

However, it is not simply a question of whether information is *reaching* farmers through the channels of mass media. We must ask, who are the intended *targets* of such programmes? Just as the study revealed that the extension service was neither equipped, nor structured in such a way to *target* its activities towards the poorest farmers, so various forms of mass media, such as television, magazines and leaflets, have been mobilised in the service of increasing production rather than poverty reduction. Television programmes, extension videos and pamphlets tend to target medium- to large-scale farmers, rather poor small-scale aquaculturalists. They advocate techniques which are inappropriate to poor farmers as they demand too great an high input of capital, time and labour. They focus exclusively on fish farm management, rather than integrating this into a broader farming systems approach which responds to the diverse livelihood strategies of poorer households. A further criticism voiced by farmers was that they focused too heavily on scientific information which was either irrelevant or unclear to farmers. Thus, as Turongruang and Demaine point out,

> 'In the absence of a conventional extension service, one alternative is the use of mass media in the form of leaflets, pamphlets and videos. Unfortunately many such materials are designed by research scientists and contain too much and too scientific information…. The programme has sought to address this problem through a participatory approach to the development of such extension materials….Thus the design stage, includes farmers who have taken part in project on-farm trials' (Turongruang and Demaine 2003: 251).

This study in the Northeast of Thailand underlines fundamental issues concerning the need to adopt a more participatory approach in the production of extension materials and

[16] Radio however was found to be less popular. Despite a considerable amount of programming devoted to agricultural and fisheries extension programmes (for example the weekly programme in which successful farmers are interviewed about their techniques), extensionists claimed that radio was comparatively unpopular amongst farmers. Similar views were expressed by many of the farmers interviewed.

the use of mass media channels of communication. It highlights the need to move away from the 'lab' as the source of materials in which strategies are framed through the lens of academic science. Demonstrating the existence of extension materials or television programmes is not enough. Such sources of information must be considered as part of a process of dissemination, reception and uptake. Thus, during the course of the fieldwork in Pichit, extension officers made frequent reference to the variety of instructional videos, leaflets and booklets on issues of farm management and aquaculture practice that they had received from the department of fisheries and kept in the office. However, the videos seemed to be shown exclusively at training courses and workshops and therefore very few of the farmers interviewed had seen or heard about such materials. The vast majority of manuals and leaflets that farmers owned were produced by feed and chemical companies and had been given to farmers by agricultural salesmen. Few owned or had seen official technical booklets or posters from the extension service. Again, many farmers said that they found the information in such booklets overly scientific and unclear, and that they did not have the time or capital to invest in the techniques which they suggested.

The study in Pichit highlighted the need to focus more clearly and rigorously on the supposed target or audience of extension materials and mass media channels. If extension materials, television and radio programmes, magazines and such like, are to provide technical support to poor households involved in aquaculture, they must, firstly, be targeted at poor households, and must be relevant to the type of integrated, small-scale aquaculture practiced by such households as a secondary or additional activity. Secondly, farmers must be involved in the production of such materials, both in terms of content, format and communication.

5.5 Training Courses

The majority of farmers who participated in the study had never heard or been invited to training courses organised by the provincial fisheries extension service[17]. For the most part, farmers were of the opinion that training courses or workshops were attached to specific credit schemes or development projects, and were therefore available only to the small number of farmers selected for a particular project. The head of the provincial extension office expressed similar frustration over the fact that funding for training courses tended to be attached to specific projects with directives sent from the national department of fisheries, stipulating specific criteria for attendees and providing few generalised courses for others. Often the courses were not full up but according to project regulations they were unable to open up the courses to any other farmers who might have been interested in attending.

[17] These findings echoed the results from the survey carried out in Pichit as part of part of earlier technical research investigating 'Control of Bacterial Disease in Small-Scale Aquaculture' (Thompson and Crumlish 1999). This earlier survey had revealed that only 2 out of the 19 households interviewed said that they had received any form of training regarding fish health and disease either from the extension service or commercial feed company.

Farmers who had attended courses said that they had found them useful and had, for the most part attempted to apply techniques learned at the workshop, such as using lime in the pond, on their farms. However, a couple of key issues emerged from the accounts of those who had attended training seminars. First: farmers said that some of the more capital- and labour-intensive techniques, taught on the course, were not appropriate for their small-scale, extensive system of production. Secondly, farmers said that they felt bombarded with too great a quantity of information during the day workshop, and therefore could not take all of it in. This suggests the need to identify and highlight key messages, as well as to replace the top-down, 'classroom' teaching method, with more participatory approaches to training which revolve around on-farm demonstrations.

Both the survey and the interviews indicated that in approximately half the farms, women were the primary caretakers of the ponds and managers of fish production. Indeed, extension officers in the province said that they had found that in the majority of farms they visited much of the daily management of the ponds was undertaken by women. However, extensionists stated that a minority of those who attended training courses were women. This was reinforced by the accounts of a number of women who stated that while they took care of the fish farm on a daily basis, they had never attended a training course but learnt how to manage the ponds from their husband or other male relatives. The research highlight the need for a gendered approach to the planning and design of training courses and for strategy to make training courses more accessible to women. As Harrison notes, 'information transfer from husbands to wives is unlikely to be as effective as direct training of pond managers' (Harrison 1994: 48). Women should, therefore, be a primary target for training courses. In order to promote women's participation in training courses, extensionists should consider the constraints of all people who are likely to benefit from attending when planning the timing and location of workshops. Women may often experience a number of constraints to attending courses such as being restricted from travelling long distances or being away from the home for extended periods of time. Courses which both prioritise female attendance, and which attempt to mitigate the constraints on female attendance, are therefore required.

Almost all farmers who participated in the study said that, given the opportunity, they would attend training courses. Many specified that they would welcome workshops on disease treatment and prevention and on low cost feeding alternatives to expensive processed fish pellets. A large number of farmers interviewed in the study said that, while they had never attended a training course organized by the extension service, they had been invited to workshops held locally by sales representatives from feed and drugs manufacturing companies such as the CP Group. These promotional training presentations were common in areas in which a large number of households practiced fish farming. One of the primary motivations for attending the workshops appeared to be the free product samples distributed by the sales representatives. The workshops primarily acted as a forum for companies to advertise their products, demonstrate how they worked, and to distribute free samples of products and gifts, such as hats and T-shirts emblazoned with the company logo. The workshops were generally not perceived by farmers to be a good source of technical information on farm management and aquatic animal health. They did nevertheless, some extent as unregulated channels for the flow of information concerning farm management. For the most part, the workshops were accessible only to those farmers who had previous contact with a particular sales representative or were regular buyers of a specific product from the company sponsoring the workshop. They thus served to reinforce the relationship between farmers and the companies. In this way unregulated information flowed according to private commercial channels. Poorer farmers and those in more remote areas, which are infrequently visited by sales representatives, did not have access to these channels. The extension service appeared to take an ambiguous position towards these commercial workshops. Some of the extension officers expressed concern at the way the information provided by the representatives and company technicians was unregulated and motivated chiefly by the desire to advertise the products. However some officers seemed to act *unofficially* as advocates for certain companies and products so endorsing the relationship.

As has been discussed above, the rising cost of processed feed pellets, set against the falling value of farmed fish, was one of the major constraints for small-scale producers in Pichit. Many farmers, echoed Mr Prayab, who said that his only source of information on appropriate feeding techniques came from the sales representatives of feed companies who visited his village in order to advertise his products and private training workshops sponsored by feed companies. For farmers such as Mr Prayab, technical support becomes part of a commercial relationship between farmer and salesman. According to this system, advice is offered only to clients. In order to receive such advice, the farmer must buy products from the representative. In the absence of effective government extension services, farmers such as Mr Prayab become increasingly dependent on these commercial relationships as their only source of advice on farm management and AAH. In this way, the flow of technical information to farmers is becoming evermore *privatised* as the private sector takes the place of an effective government extension service.

The dangers of this *privatised* extension network are clear. Both extension officers and researchers at government research institutes expressed concern over the lack of regulation of the information given to farmers from private companies through their sales representatives. Both the quality and objectivity of such advice are compromised. In the absence of other sources of information about alternative feeding or disease control techniques, farmers are forced to continue purchasing high-cost processed feed and chemicals from sales representatives. Furthermore, the *privatisation* of technical support, serves to reinforce and increase the disparity between wealthy and poor households, between successful farmers and those who are failing. The flow of information is dependent on commercial relationships between farmer as client, and salesman or company agent. Capital is thus translated into information, which, in turn, by improving management techniques and increasing productivity, eventually is translated back into capital. Once again, poorer farmers, who do not have the capital to attract sales representatives and engage in such relationships, are either excluded from this source of information, or, as will be discussed in section 5.7, become dependent on informal, high-interest loans and credit from salesmen or other farmers.

5.6 ‘*Privatising*’ Extension

Case Study: Aquaculture in Wat Kwang District

A significant number of catfish farmers are clustered in the Wat Kwang District of Amphoe Pho Thale. Within this area a complex framework of social and economic relations exist between those farmers identified by local extensionists as ‘master’ farmers or leading entrepreneurs in local catfish farming and the rest of the farmers who are said to have ‘followed their lead’. Mr Sukkasem was identified by many of the farmers in one village in Wat Kwang as the pioneer who introduced commercial aquaculture to the district 20 years ago and continues to be one of the most successful farmers in the district. Having practiced aquaculture for twenty years, he owns 20 monoculture catfish ponds from which he claims to harvest on average 3 tonnes of fish per pond twice yearly. He hires 7 workers to help him manage the ponds. In common with the majority of fish farmers in Pichit, Mr Sukkasem sited the rising cost of fish pellets and the falling wholesale price of fish as his chief concerns. Despite his evident success Mr Sukkasem described fish farming as 90% risky.

Mr Sukkasem stated that he was constantly trying to update his knowledge. He receives information regularly from the technical research unit of a leading pellet company and actively seeks information and new techniques by visiting farms in neighbouring provinces and agricultural trade shows. According to Mr Sukkasem many people started fish farming after him, including the village headman, Mr Kansuk, who was similarly described as a ‘leading’ aquaculturalist in the area. Both farmers agreed that the farmers in the area ***‘share knowledge openly’*** *informally amongst themselves. They meet informally and frequently to give advice and exchange information on the conditions of their farms so that all the farmers in the area may benefit from each other’s experience and contacts with traders and seed suppliers. According to the village headman, Mr Kansuk, there was no need for extension officers to visit the village as they learnt from each other and had many years experience of fish farming:* ***‘The fisheries officer came to the village a long time ago, but never since then. It is not necessary for the officer to visit because they do not know better than we do…we do not need any other information from outside’.***

Both Mr Sukkasem and Mr Kansuk act as agents for feed and drug companies, supplying most of the fish farmers in their village and the neighbouring village with catfish pellets and chemicals to treat disease. Many of the farmers in the area said they met very frequently with other local farmers when they went to Mr Sukkasem’s house to buy fish feed, and that they received both advice on disease treatment and credit to buy ‘powders’ to treat the disease from the village headman and Mr Sukkasem when they had a problem. Mr Kansuk plays a vital role as a mediator, connecting local farmers with traders who come from Chiang Rai Province to Wat Kwang to buy catfish fingerlings, for which he receives a commission of the sale profits from the farmers.

A striking contrast emerged between the success stories presented by Mr Sukkasem and Mr Kansuk, and many of the other farmers in the area. Mr Bunma explained how six years ago he converted his 9 Rai of rice fields into 9 ponds for culturing catfish fingerlings, following the lead of Mr Sukkasem, who gave him advice on feeding and disease control, and sold him pellets on credit. When he experienced a disease outbreak in his ponds, Mr Sukkasem advised him on treatments and sold him 'white powder' on credit with which to treat the disease. However, according to Mr Bunma, he continued to lose his crops to disease for three successive years, despite continuing to buy both pellets and drugs on credit. His experience was echoed by a number of other farmers in the village who had since been forced to abandon their ponds and continued to owe money for the pellets and drugs that they had bought on credit. Such is the position of Mrs Banglom who stated that, after 3 successive years of losing much of her harvest to disease and predators, and buying feed pellets and 'powder' to treat the disease, compounded by the low value of farmed catfish, she can no longer afford either to stock her pond with fingerlings, or buy pellets with which to feed her fish. Consequently she has virtually abandoned her ponds, yet continues to owe approximately 20,000Baht for pellets and drugs bought on credit from Mr Sukkasem.

The case study from Wat Kwang exemplifies the way in which the diffusion of technical knowledge and financial support among fish farmers is mediated through systems of patronage and dependency, reinforcing social and economic power relations between farmers. Contrary to the widespread belief that technical innovations and farm management information and the benefits they bring, will 'trickle down' from 'master' farmers to poorer farmers, these frameworks serve to constrain poorer farmers and limit their access to appropriate technical support and credit.

The case study above demonstrates the way in which extension has been, in effect, *privatised*. The expansion of the private sector into all sphere's of rural aquaculture through systems of vertical integration, whereby companies gradually come to directly and indirectly control every level of production, from the delivery of agrochemicals and feed, to the provision of technical support, is often seen as an indication of the increasing level of commercialisation, productivity and economic growth within a particular industry (Burch *et al* 2000). Information thus flows according to the demands and needs of the market. Or, to put it another way, market forces shape the transfer of technical knowledge. However, while the increasing private sector interest in rural aquaculture, can serve to increase productivity and boost economic growth, the processes by which extension and knowledge networks are effectively *privatised* simultaneously serves to benefit successful farmers, while restricting the access of poor farmers both to reliable sources of technical support and to a share in the commercial market for farmed fish.

In this way this system reinforces the disparity between rich and poor. Resource-rich farmers with access to capital are able to monopolise an aspect of fish production within their local area, such as Mr Sukkasem providing chemical and feed agent to farmers in the village, or Mr Kansuk acting as middleman between traders and farmers. Through their position as sales agent or middle men, these farmers become not only 'master farmers' within their local area but, are elevated to a position of control over the local aquaculture economy and are seen by other local farmers as repositories of knowledge and sources of advice concerning fish farm management. In adopting these roles they themselves gain greater access to a variety of sources of information and strengthen their own ties with other stakeholders within the industry such as traders and company technicians, while simultaneously controlling the access to information of other farmers seeking advice on farm management or disease control (see for example, the comment made by Mr Kansuk, the village headman in the case study above, that the farmers in his village 'do not need any other information from outside' the village). Access to advice thus becomes contingent on the purchase of products suggested by these leading farmers in their capacity as sales representatives. Income earned from their role as sales agent or middleman, combined with interest earned from the provision of credit, provides leading farmers such as Mr Sukkasem with both a safety net to mitigate the risk of fluctuating productivity due to disease, flooding etc, and sufficient capital to invest in aquaculture technologies and innovations in order to increase production on their farms. The risk is then passed on to the smaller, more resource poor producers who are denied access to neutral and basic information or advice on AAH except through their relationship of dependency on wealthy farmers. The result is a patron-client relationship between wealthy farmers with access to information and poorer farmers who, as clients, receive unregulated advice from leading farmers along with credit for purchasing products such as feed pellets and drugs for disease treatment. As the case study above shows, these patterns of patronage serve to increase the dependency and vulnerability of poorer households, as debts accumulate forcing them to abandon their fish farms and seek alternative livelihood strategies.

5.7 Sharing Knowledge: Farmers Groups

The most recent figures collected by the Provincial Agricultural Extension Office (1997) demonstrate the existence of a large number of formal groups for farmers, and an even larger number of women's agricultural groups (see table 5.1). Despite there being no figures collected since 1997, Agricultural extension officers in Pichit attest to the continuing strength of such groups. The primary purpose of such groups is to facilitate and support the delivery of low-interest government loans schemes and provide a forum for discussion, extension support and knowledge sharing amongst farmers. However, no formal groups appear to have been organised to support aquaculturalists in the province. This is supported by the majority of farmers interviewed who said that they were not part of any formal farmers groups, whether for fish farming, rice farming or other types of agriculture.

Table 5.1: Number of formally established agricultural groups and their members in Pichit Province by Amphoe (Community Development Office 1997)

Amphoe	Agricultural Group		Agricultural Women's Group		Youth Agric. Group		Savings Group	
	No. of Groups (G)	No. of Members (M)	G	M	G	M	G	M
Muang	11	1,555	29	800	9	173	22	1,542
Taphan Hin	5	956	19	457	2	22	30	2,477
Thapkhlo	5	955	12	348	3	50	17	1,487
Bang Mun Nak	8	974	10	298	2	39	30	1,482
Wa Chi Ra Ba Ra Mi	4	278	27	580	7	105	8	727
Wang Sai Phun	6	683	11	420	7	87	8	1,442
Sam Ngam	4	721	10	213	4	59	13	725
Pho Thale	4	1,311	17	642	9	118	14	879
Pho Prathap	4	600	5	98			15	824
Sak Lek	3	548	11	418			6	410
Dong Charoen	3	581	8	254	3	45	7	671
Bueng Na Rang			7	183			4	457
Total	57	9,162	166	4,711	46	698	174	13,105

There is a clear disparity between the formal establishment of farmer's groups as demonstrated by extension office documents and statements, and the accounts of farmers who participated in the study, the majority of whom said they were not involved in any formal organisations for the support of either agriculture or aquaculture. This points to the general failure of the extension services to mobilise farmers in the area into formal networks. Such networks could serve to strengthen ties between aquaculturalists, providing arenas in which farmers could discuss issues such as AAH, pond management, disease outbreaks, the lack of traders and markets, the falling value of farmed fish and the increasing price of pond inputs.

The study revealed that while informal networks existed in areas where a number of fish farmers are clustered together, those in more remote areas or where there is little aquacultural activity are isolated from both formal sources of support and informal networks. Furthermore, as has been discussed in **Section 5.6**, the reliance on informal channels of technical support, has given rise to the emergence of patron-client relationships between wealthier dominant farmers and poorer farmers. This underlines the need for the extension service to move away from the ***exclusive*** focus on *master farmers* as pivotal points in the process of technology transfer from which, it is assumed, knowledge will gradually diffuse to other farmers, and to adopt a more ***inclusive*** approach which focuses on the organisation and mobilisation of formal farmer's groups as the principle site of interaction between extension officers and farmers. In this way the extension service could reach a broader and more diverse range of farmers, providing effective channels of communication, discussion and dissemination of AAH strategies through which poorer farmers could access extension support, and interact with other aquaculturalists. By providing farmers with inclusive and reliable sources of technical support, such organisations would undermine the power of informal networks built along patron-client relationships, which serve simultaneously to increase the dependency of weaker farmers and the power of dominant producers.

SECTION THREE: CONCLUSION AND RECOMMENDATIONS

6. Summary of Key Findings and Recommendations

KEY THEMES	PROBLEMS/COMMENTS	RECOMMENDATIONS
1. Development Context	- Aquaculture is an aspect of farming, not fisheries. - In many cases farmers practice small-scale aquaculture as an additional, and often minor, activity, rather than as a primary livelihood activity. - Projects have arisen from a vision of aquaculture as a panacea for development, economic growth, food security and livelihood sustainability, rather than from the needs of apparent beneficiaries.	- Aquaculture planning and research should be considered within broad rural development frameworks, not as a sub-set of Fisheries Departments. - Projects should not attempt to adapt hi-tech strategies for small-scale producers. They should pay greater attention to the overall livelihood strategies of households of which fish farming may only be one component. - Disaggregate the various claims made on behalf of aquaculture. projects must identify target groups more rigorously and respond directly to their needs. - *Support* rather than *promote* aquaculture.
2. Technology Transfer	- AAH strategies will be useful and appropriate for only a limited number of farmers. - The desire to maximise production should not be assumed. Farmers may have little interest in technical strategies if motivation is not primarily about optimal productivity. - For some farmers attempts to maximise productivity are too risky due to poor pond location, lack of aquaculture knowledge, capital investment, time or labour. - Some farmers have the desire, as well as financial and human resources to increase productivity, but lack appropriate, consistent and reliable sources of information.	- Examine in advance of project planning: i) Motivations for adopting fish farming ii) Bio technical and environmental factors iii) Alternative economic opportunities iv)Existing land and natural resource availability v) Markets and value of fish vi) Processes of decision-making, labour distribution and resource-control within the household v) Institutional capacity for continued support of the intervention. - Rethink traditional models of technology transfer which focus on tangible technical inputs to maximize productivity.

	- Increased productivity does not equate to decreased poverty	
3. Sustainability	- Projects which focus exclusively or primarily on the delivery of tangible inputs often have limited sustainability due to lack of capacity within institutions involved (e.g. Provincial Extension Office).	- Consider: (i)Institutional legacy - how and why projects failed in the past (ii)How different organisations/institutions will work together (iii)Institutional and individual priorities driving the project.
4. Research	- The primary beneficiaries of technical research in the field of AAH are successful, medium-large scale aquaculturalists, not small-scale rural farmers. - Many technical strategies produced from research have a limited impact on the lives of poor farmers who lack the financial, human and physical capital to invest in them.	- Poverty-focused research should concentrate on the basic principles of farm and pond management and on reaching many farmers who remain without access to this kind of basic training, rather than technical outputs - Poverty-focused research should be driven by the priorities of poor households, not adapted to their needs afterwards. This involves incorporating participatory methods in all stages of the research esp. project-planning.
5. Extension	- Limited reach due to lack of personnel and under-funding. Often, those who are not reached are the most remote, marginalized or needy. - Top-down model of extension which focuses on 'master-farmers' benefits more successful and wealthier farmers at the expense of poorer ones. - Extension officers are not trusted by farmers, due to infrequency of visits. Farmers are more likely to trust advice from other farmers. - Inappropriate advice. - Extension staff have little	- Extension services require more funding, for personnel, transport, extension materials, collection of survey information and training courses. - Extension service rigorously target the poor and most remote households who have least access to information - Participatory approaches incorporated into extension planning. - Develop peer training workshops and facilitate farmer-to-farmer learning and knowledge sharing. - Focus on quality, consistency and accessibility of messages/advice rather than quantity of information. - Focus on appropriateness of strategies to meet the particular needs of household and farm.

	participation in aquaculture development planning which is done predominantly at a national level. - Extension officers focus exclusively on technical and fish-farming related issues.	- Aquaculture extension should be integrated within agriculture. - Train extensionists in: i) Aquaculture as a component of farming systems ii) Participatory extension methods iii) Socio-economic issues iv) Advice on markets and loans v) Gendered aspects of farm management.
6. Input Costs	- The cost of processed feed and chemicals required to maximize production in the pond is prohibitively high for poor households and forces farmers to become dependent on formal and informal credit.	- Research and extension should focus on basic pond management strategies which require little capital or labour (such as home-made feed and water quality).
7. Markets and Price	- Increases in fish production and the availability of wild fish has forced down the price of farmed fish dramatically. - Many farmers are therefore making little profit or, in some cases, generating insufficient income to cover the rising cost of outlays on fish feed, chemicals and drugs for disease treatment. - Only a handful of farmers have been able to access more profitable markets outside the province.	- As commercially orientated aquaculture involves a high level of risk, high input costs and limited potential for significant income generation, projects and research that aim to maximize productivity may not be appropriate for poor households. -Technical research should be informed by greater understanding of socio-economic context esp. markets and valuation of fish.
8. Credit	- Credit/loans is a vital component in the promotion of aquaculture. - Many small-medium scale producers are heavily dependent on credit which they are unable to repay. - Successful farmers are the primary beneficiaries of formal credit schemes while the poorest farmers are often unable to access low-interest government loans and become	- Credit/loans schemes should be supported with continued technical and farm management advice. - In some cases, rather than improving livelihoods, aquaculture increases the vulnerability of poor households, as they become dependent on formal and informal sources of credit. A more contextualised approach to the promotion of aquaculture is required.

	dependent on high-interest private credit suppliers in order to cover inputs into pond. - The provision of credit can often be manipulated by those least in need of it.	- More research on the relationship between rural aquaculture and formal and informal systems of credit is required.
9. Disease	- Many farmers sited loss of fish due to disease as a problem. - For poorer farmers AAD was not a primary concern. - Most farmers recognized signs of disease but many had limited knowledge of low-cost disease prevention strategies. - There is an urgent need for training in basic pond management techniques which reduce the incidence of disease (e.g. water quality maintenance and disposal of infected fish). - Many farmers become heavily indebted buying drugs (e.g. antibiotics) for disease treatment with little knowledge what they are or correct dosage.	- Extension advice should focus on basic pond management strategies for AAH, rather than capital and labour-intensive strategies for disease prevention and treatment. - Extension officers should provide advice to farmers about the use of drugs and chemicals for disease prevention, and suggest alternative low-cost strategies for disease control.
10. Flooding and Theft	- Farmers consider flooding and theft as primary risks to aquaculture production. Many are unwilling to invest time and cash in AAH treatments due to these risks.	- While flooding and theft cannot be avoided, their impact on production can be mitigated, through advice to farmers about pond location and defence systems.
11. Impact Assessment	- Impact is conventionally considered in relation to levels of production, rather than poverty reduction or social change. - The project confirmed the difficulty of finding relevant and measurable indicators of the impact of technical research on poverty reduction.	- Re-think impact in terms of sustainable livelihoods approach to poverty reduction, rather than conventional economic goals of increased production. - Impact assessment should be integrated into the early stages of project design.

7. Re-thinking Technology Transfer and Extension

This study demonstrated the prevailing dominance of conventional models of technology transfer upon which development research, intervention strategies and extension planning have been based. In so doing, the study has highlighted the way in which the technical dimensions of aquaculture continue to be prioritised to the neglect of socio-economic and institutional realities in which the practice of aquaculture is embedded. The traditional paradigm of technology transfer focuses on the production, dissemination and delivery of tangible technologies or packages of technical strategies to farmers, with the goal of maximising productivity. According to this model poverty is seen to be the result of technological barriers. This conception of technology transfer relies on an assumption that information, and the benefits it brings, will trickle down from 'master farmers' or innovators to the poor. Technology or technical strategies are therefore seen to be universally beneficial.

The findings from this study contradict this orthodox conception of technology transfer, demonstrating that new technology can be as much a burden to the poor as a benefit. The findings indicate that in most cases the poorest households have the least access to information and technical support, and that, the primary beneficiaries of AAH strategies and aquaculture technologies are the most successful, resource-rich farmers. In most cases, farming technologies, even of a basic, low-tech kind, require not only financial capital, but labour, time and usually, certain physical resources. In order to meet these demands on capital, poorer farmers are forced to turn to formal, and often, informal sources of credit. In doing so many accumulate debts that they are unable to repay due to the high risk and poor returns from their ponds and become enmeshed in relationships of dependency and patronage with wealthier farmers. Thus, credit and technical knowledge can be manipulated by more successful farmers. In this way we can see that technology is not neutral: it is embedded within relationships of power and dependency. In such cases, the projects which focus on the delivery of technical inputs can serve to increase the dependence and vulnerability of poor households, rather than reducing it.

The study showed the failure of the national and provincial extension service both to reach the poorest households involved in aquaculture, and to provide small-scale aquaculturalists with technical support appropriate to the kind of extensive, low-input systems practiced by low-income households. The extension service suffers from a severe lack of resources, combined with weak institutional linkages and channels for the dissemination of AAH management strategies, as well as the prevailing dominance of conventional 'trickle down' approaches to technology transfer and extension which focus on wealthier 'master' farmers. The findings from the study exemplify the way in which factors and conditions vary, not only from province to province, but between households. The conventional extension approach by which a 'package' of technical strategies is delivered to farmers fails to reflect such difference and therefore can provide little support to some households. Needs and priorities vary according to specific the geographical area and context. They vary from household to household within the same area. Management strategies must, therefore, be adaptive and flexible. As Harrison states:

> Small scale fish farming is a relatively simple technology. When complications arise, they are usually the result of particularities of the environment or farm into which the technology is being introduced. It therefore makes more sense for technical research to be adaptive to and closely involving farmers themselves than for it to attempt to deliver technical "packages" (Harrison 1994: 50)

On-farm demonstrations and interactive training courses in which farmers can raise individual concerns, though costly, are therefore seen to be the most successful medium for providing technical support to farmers.

The extension service does not have adequate mechanisms for delivering appropriate and low-cost AAH strategies and broader farm management strategies to the poorest households. The result is that these households are becoming marginalized to an even greater extent, as they are left to cope with little or no institutional support and are neglected by an under-funded extension service of which wealthier, large-scale farmers are the chief beneficiaries. This highlights the need for effective, wide-reaching extension services for rural in-land farmers involved in fish farming. Greater donor and government input is required to support initiatives focused on improvement of the research-extension and training framework, such as a recent collaborative project between the Thai government and the Australian Aid Agency which aims to renovate the extension service to respond to the needs of poorest households, provide training for farmers on their own farms, and to use this as a nucleus for the surrounding area. Aqauculture projects which are technology-driven or are focused on the the delivery of technical inputs such as aquatic animal health strategies often have very limited chances for sustainability. This is in part due to the lack of funding for Fisheries Departments, which consequently lack the capacity to provide regular and appropriate advice to farmers throughout the province, particularly farmers in more remotes areas. Without the necessary funding, the Departments are limited by lack of personnel, transport, resources for providing training courses, up-to-date information concerning the state of aquaculture in the province, and the flexibility to adapt and modernise the extension techniques and strategies.

8. The Implications for Future Research and Intervention

This study confirmed the challenges inherent in assessing the socio-economic impact of technical research. It demonstrated the difficulty of finding relevant and measurable indicators of the impact of technical research on poverty reduction. As Harrison points out, a common response to the challenges of impact assessment has been to focus on the quantity of data collected, or to set up 'evermore sophisticated databases' with which to process the data (Harrison 1994). The focus on tangible data misses the point. For, the impact of strategic research programmes on poverty is rarely explicit or directly attributable to a particular innovation or piece of research. A line cannot simply be drawn from the work of research institutions, the strategies they produce and the livelihoods of households. While quantifiable indicators can demonstrate the way in which a specific piece of bio-technical research, such as the development of a new and resilient type of grain, has achieved an increase in production, the relationship between research and poverty reduction is both more complex and less easily evaluated. This was underlined by the Provincial Agricultural Extension Officer who stated that the link between agricultural and aquacultural technical research and poverty reduction was tenuous.

The primary target of technical research in the field of aquatic animal health, has, in the past been commercial aquaculture and not small-scale rural farmers. Extensive low- or no-input aquaculture practiced by the poorest households is often overlooked by researchers and excluded from studies, in favour of larger ventures which demand higher investments of time and capital. Indeed some researchers debate whether such extensive practices even constitute aquaculture. Most technical strategies produced from research have a limited impact on the lives of the poorest farmers. Such farmers lack the financial, human and physical capital to invest in the technologies or the time to seek out information. Furthermore, they are reluctant to invest capital in an enterprise which involves both a high level of risk and too few rewards due to the decreasing value of fish in local markets. Conversely, rich farmers who have both access to sources of technical information, outside markets and capital to invest in strategies, can fully exploit the outputs of research, boosting their production and squeezing smaller producers out of the market. This was reinforced by the words of an officer at Pichit Provincial Fisheries Station, who stated that poor farmers do not need more research or sophisticated techniques for fish farming. Instead researchers, planners and extensionists should focus on the basic principles of farm and pond management and on reaching the large number of farmers who remain without access to this kind of basic training. This points to the weakness of up-stream communication channels from provincial government officers and extensionists who interact with aquaculturalists on a daily basis, and policy-makers and planners at a national level.

The study indicates that insufficient attention is paid to the intended target of both research and intervention strategies. This is not simply a question of paying greater attention to the socio-economic context of technical research. The direction and focus of the research itself should be determined by the needs of the target audience. While strategic research has a crucial role to play in poverty reduction, this study underlines the way in which development research programmes have tended towards technical research projects with a livelihoods agenda bolted on. The focus of research has been, and continues to be, dominated by biotechnical concerns and interests, while socio-economic considerations, such as low education or literacy levels, are seen as obstacles to be overcome or managed in the process of technology transfer. Projects promoting rural aquaculture continue to concentrate on the delivery/transfer of physical inputs or technical strategies, while the institutional context is, to a large extent, neglected or relegated to a separate project. The strategies produced by such research are adapted to the chosen target (e.g. 'poor farmers') which in turn justifies the research. The findings from the case study in Pichit reveal that the outputs of technical research projects concerned with AAH, while significant for middle- and high-income farmers, either have marginal relevance for farmers with limited financial and physical resources or do not reach them, and consequently have little direct impact on poverty. As Harrison asks:

> Is fish farming supported as a means for diversification/income generation in the

> rural sector, as a means to increase overall fish availability (possibly for supplying urban populations, as a means of improving food security, or as a tool for economic growth? (Harrison 1994: 42).

This points to the need for a shift towards target-led research, as opposed to research projects designed 'in the lab' and then adapted for the chosen context and target. Research which is driven by the poverty-reduction agenda and objectives focused on livelihood improvement, must ensure that the research is constantly informed by the needs of the poorest and most vulnerable people, and special efforts are made to ensure that the products of research reaches the target group. However, as this research has revealed, in some cases, aquaculture may not be the most appropriate activity/means of diversification for the poorest households. In some cases aquaculture may increase vulnerability rather than reducing it. Indeed, the study supports the findings from the case study in highlighting that those households who are currently benefiting from aquaculture are not the poorest/most vulnerable. As is the case for many other farming technologies, those who are most able to exploit technical strategies and innovations, and become productive fish farmers, are not the poorest. Thus projects that aim to *promote*, rather that *support*, rural aquaculture, either through research or extension, may in some cases have little direct influence on poverty reduction. In such cases, we must ask: who is the research for? what are the expected outcomes? And, who stands to benefit from them? The conclusion of this study is not that research and extension should necessarily be focused on enabling the poorest households to benefit from aquaculture technologies, but to argue that greater attention must be paid to ensure that project objectives and outputs are *appropriate* to their stated targets. Research and extension should be driven and informed by the needs, priorities and capabilities of the target group (whether it be the poorest of the poor, small-scale farmers or large-scale producers) and not vice versa.

Over the past decade a number of development researchers and practitioners have called for the integration of aquaculture research and planning into a broader perspective on farming systems.[18] Nevertheless, projects devoted to the promotion and development of rural aquaculture continue to approach aquaculture as a discrete activity isolated from other development strategies and livelihood activities. It is vital that aquaculture be considered as part of broader rural development frameworks rather than as a marginalized sub-set of fisheries. This project attempted to cut across disciplinary and sector-based boundaries by bringing together a diverse range of skills and methodologies from a wide spectrum of disciplines in order to taker a broader perspective on the role of aquaculture in rural livelihoods and its impact on poverty reduction.

However, the project highlighted the way in which the priorities and agendas of various stakeholders involved in the project may differ, with potentially negative consequences for the project. This is especially important for multi-disciplinary, collaborative projects involving a large number of institutions, where the rationale and broad goals of a project can be perceived differently by different institutions and individuals involved in the project. The institutional framework of development research projects and the need for

---

[18] See for example, Harrison 1994; Lightfoot and Pullin 1991; Edwards 2000.

multi-disciplinary collaboration across a number of organisations can, at times, result in the over-arching goals of the donor being imposed on institutions whose remits do not correspond either with those of other participating institutions, or with the objectives of project. Differing interests, priorities and methodologies are often not evident or made explicit in project documentation, but emerge during the course of the project. As Harrison states, the priorities of stakeholders, of donors, hosts and participants, are not 'monolithic or fixed in opposition. They also belong simultaneously to institutions and to the individuals attached to these institutions.' Priorities and interests emerge through the course of a project, through engagement in the project and with other participants, they are constantly shifting and negotiated. Just as projects are not fixed in stone, but are mobile and dynamic, there is a need to address the changing, and at times competing, agendas which drive them. A reflexive approach is required which engages with the multiple interests and priorities of individuals and institutions involved in the project be seen as mobile and dynamic rather than fixed in stone, so responding to the changing and, at times, competing, agendas and interests which drive them.

Areas for Future Study

As a province with substantial natural water sources and, consequently, easily accessible stocks of wild fish, there is little market demand in Pichit for farmed fish at present. The ready availability of wild fish also reduces the reliance on fish farming as a safety net providing a source of nutritional food for household consumption, food security and additional cash income. Although, as fish stocks diminish, aquaculture is likely to play an increasingly important role in the future. Pichit also benefits from a good infrastructure and a range of natural resources and agricultural activities beyond the staple crop of jasmine rice (including pomelo and lime farming and a growing orange industry). Future research in Thailand on the role of aquaculture in poverty reduction and rural livelihoods should therefore focus on the Northern and North Eastern regions of Thailand: regions in which access to water is restricted and wild fish not readily available, and therefore, unaffordable to poorer households. In this context household ponds play a potentially crucial role in providing a good source of nutrition within the household and cash flow due to the high market demand for fish.

In areas such as these, the impact of aquaculture as a means of increasing food security is of much greater importance for households which, although less productive in fish farming have little or no other access to fish. The research revealed that this was not the case for most of the households in Pichit Province. The abundance of natural water sources, and consequently the availability of wild fish, meant that the link between the promotion of aquaculture and aquaculture technologies, and increased food security was, at most, tenuous. Nevertheless further research is required in order to explore the way in which the dramatic increases in farmed fish in Pichit over the past decade, which has led to an equally dramatic drop in price, provides a local source of cheap fish for households who otherwise could not afford wild fish, which tends to fetch a higher price in local markets.

This study showed that rural poverty cannot be understood simply in terms of a ‘gap’ in technology or technical knowledge. It highlights the need to move away from the ‘low-productivity’ approach to poverty reduction which views poverty as the result of technological barriers. In so doing, it underlines the need to re-think current research frameworks which privilege technical research over the socio-economic and institutional dimensions of poverty. Similarly, the way in which current research is structured according to sector or discipline reinforces the marginalized position of aquaculture, isolating it from broader rural development frameworks. In this way, research often fails to respond to the dynamic and diverse contexts of rural livelihoods. Future research should shift the focus away from the generation of technical strategies to maximise productivity, and towards the capacity of institutions to support aquaculture as a component of rural livelihoods.

Annexes

Annex 1. Research Methods and Materials

This study was conducted over a 6 week period in September and October 2002. Of the 6 weeks approximately 3 weeks were spent at the Aquatic Animal Health Research Institute housed at Kasetsart University Campus in Bangkok. During this time the research strategy was designed and time was spent collecting data and interviewing employees about the institutes interaction with farmers and their various research, dissemination, training and diagnostic activities.

An initial visit of a few days was made to Pichit Province to establish the parameters of the field of study, and to arrange the logistics of carrying out the fieldwork. During this visit, the questionnaire was pilot tested and pilot interviews were conducted with medium- and small-scale fish farmers. Key informant interviews were also carried out with the head of the Pichit Provincial Extension Office in order to gather background data and information on the state of aquaculture in the province.

A further two weeks were spent interviewing various stakeholders involved in aquaculture in the Province and observing the pond management practices. A questionnaire-based survey of farmers involved in fish farming was also conducted during this time in order to generate quantitative data on pond management practices, production cycles, investment costs and income earned from fish farming and access to sources of information on AAH and disease and credit facilities (See Annex 2.). The questionnaire was conducted with farmers randomly selected from the provincial extension service list of farmers.

The fieldwork was carried out by a multi-disciplinary team of natural and social scientists from three of the institutions collaborating in the project: The Aquatic Animal Health Research Institute in Bangkok, The Institute of Aquaculture at The University of Stirling, and the Department of Anthropology at the University of Sussex). The data collected from questionnaire was compiled and analysed at the Aquatic Animal Health Research Institute, Bangkok.

The case study employed a range of research methods, both qualitative and quantitative. The project deals with both the ‘scientific’ and the ‘social’ and therefore provided an appropriate arena for multi-disciplinary collaboration. This was reflected in the methodology adopted for the research. This involved a qualitative ethnographic approach derived from anthropology.   A stakeholder analysis was carried out in order to identify the primary and secondary stakeholders involved in aquaculture production in the Province. In-depth, semi-structured interviews were conducted with people from the list of stakeholders, including:

- Medium- and small-scale farmers who practice aquaculture
- Large-scale commercial fish farmers
- Farmers who do not practice fish farming
- Provincial fisheries extension officers

- Provincial Agricultural extension officers
- Local government officers
- Representatives from the Agricultural Cooperative Bank
- Staff at the Pichit Provincial Fisheries Station
- Fish seed suppliers
- Traders of harvested fish
- Agricultural products salesmen
- Villages heads

Observation of village loan meetings and informal farmers' group gatherings provided an insight into the way in which knowledge about farm management was shared and the way in which various stakeholders related to each other.

Through the ethnographic approach the researchers engaged more closely with the complex set of socio-economic processes that define the practice of aquaculture and household economy. This enabled the researchers to examine commonly neglected issues such as:

- Motivation for farming
- Conceptions of profit and loss
- The relationship between knowledge and practice
- Decision-making within the household
- The way in which risk is calculated against investment.

These issues are crucial to examining the reception and uptake of technical aquaculture strategies and the role played by aquaculture and AAH in rural livelihoods.

Through a series of interviews with village headmen and farmers we were able to reach farmers who were not on the extension service's most recent official farmers list (1999) This also approach also revealed informal farmers' groups and clusters of farmers in one area with similar culture models. The flexible iterative approach allowed us to follow pathways revealing informal networks through which information travels and knowledge is shared, and to explore the social and economic relationships between various actors involved in aquaculture production in the area.

Research Constraints

During the course of the field research, severe flooding strictly limited access to villages and farms. As a result it was necessary to make changes to the original fieldwork design and to restrict the study primarily to two Amphoes in Province in which there is a high level of aquacultural activity and to which it was possible to gain access.

It is important to note that the floods presented not only a constraint to way in which the fieldwork was conducted, but also impacted on the findings revealed by the research. Many farmers had lost the crops from both their ponds and rice fields as a result of the floods. Where farmers were willing to be interviewed, the primary concern for many was the threat posed by flooding to their livelihood, in comparison to which, other difficulties, such as the threat of disease outbreaks in the pond, of slumping market price and thefts from the pond, appeared comparatively less significant. Furthermore, the flooding, while destroying many farmer's fish and rice crops, simultaneously produced a temporary abundance of freshwater, and consequently wild fish, in the area. As a result the availability of wild fish in the Province appeared far greater than at other times during the year when there may be a greater reliance on farmed fish. While flooding is an annual occurrence in the province, the magnitude and severity of the floods is, to a large extent, unpredictable. Thus the findings presented in this report should be read with consideration of the influence which the flooding had on the results. This highlights that, while projects are constrained by the realities of time and budget, for a fuller picture of the state of aquaculture in a specific area, ideally, it would be necessary to spend a much longer time in the field, following the full cycle, from stocking to harvest.

The lack of a recent farmers' list (last up-dated in 1999) also presented some difficulties. Despite these constraints the data collected in the questionnaire survey provided a representative sample revealing broad trends in farming practice such as choice of culture species and model, access to extensionists and training courses, and the popularity of different media as sources of technical information on farm management.

Annex 2. Farmer's Questionnaire

Thailand Case Study: Farmers Questionnaire

Pichit Province

Below is the questionnaire. Instructions for interviewer are in brackets. Instructions for data entry are in **bold font.**

Name:____

District:______________________ Village:_______________________

Number:______________________ Date of Interview:______________

Is this the (please tick all that apply)

Owner	Husband	Wife	Worker/Helper	Manager

A. Farm

A1. Type of Farm (please tick all that apply):

Pond	**1**	
Cage	**2**	
Nursery	**3**	
Grow-out	**4**	
Hatchery	**5**	
Integrated	**6**	
Monoculture	**7**	
Polyculture	**8**	

Please insert the number into the database

A2.	1	2	3	4	5
Number ponds/cages					
Species					

Stocking density					
Size of Pond/cage					
Stocking date					
Harvest date					

A3. Type of fish feed:____

A4. Source of fish feed:____

A5. Source of fish seed:____

A6. Source of water:____

A7. Do you exchange water on the farm? YES/NO/DON'T KNOW/NO REPLY/SOMETIMES (please delete as appropriate)

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

A8. If YES, what are the exchange rates?_________________________________

A9. Do you prepare the farm before stocking? YES/NO/DON'T KNOW/NO REPLY/SOMETIMES (Please delete as appropriate)

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

A10. If YES, what do you do?____

____

A11. What is the weight of fish at harvest? Total Weight______________________

A12. What is the individual weight of fish at harvest?________________________

A13. What is the price per kg at harvest?______________________________ Baht

A14. How many years have you been practicing fish farming?______________ Years

A15. What did you do before this?_____________________________________

A16. Why did you start fish farming?___________________________________

A17. Why do you do aquaculture?_____________________________________

A18. Who works/helps on the fish farm?_________________________________

A19. When do they work/help?_______________________________________

A20. Do you rent the farm? YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

A21. Do you own the farm? YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

A22. Please describe the other sources of income in your household

____

____

A23. What is the main source of income in your household?_______________________

____

A24. What is your primary (main?) livelihood activity?__________________________

____

A25. What do you do with the fish you produce? (please tick one box only)

Sell fish	**1**	
Eat Fish	**2**	
Both	**3**	

A26. Who do you sell fish too? (please tick all that apply)

Market	**1**	
Door-to-door	**2**	
Trader	**3**	

A27. If you do not sell your fish please explain why not?_________________________

____

A28. Please describe problems in selling fish____________________________________

____

<u>B Advice and Information</u>

B1. Have you received information about fish farming?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

B2. If YES, from who?____

B3. What was the subject?____

B4. Did you use the information? YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

B5. If YES, how effective was it?____

B6. Have you received information on the following? (Please tick all that apply)

Fish Feed	**1**	
Fish Seed	**2**	
Farm Management	**3**	
Water Quality	**4**	
Pond Preparation	**5**	
Stocking Density	**6**	
Market source and price for fish	**7**	
Diseases	**8**	
Treatments	**9**	

B7. Have you ever attended a training course on fish farming?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

B8. If YES, please describe (who ran it, when and what was it on?)

____

B9. If NO, do you know about any training courses?   YES/NO

<u>C. Disease</u>

C1. Do your fish ever get sick?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

C2. If YES, when?____

C3. How do you know your fish are sick?___________________________________

C4. What do you do when your fish get sick?________________________________

____

C5. Is this a problem for you?

YES/NO/NO REPLY/DON'T KNOW/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

C6. Is YES, why is it a problem?____

C7. What do you do if you have a problem?_____________________________________

____

C8. How do you know what to do?____

C9. Does it work?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

C10. Do you share your knowledge with other farmers? YES/NO

C11. If YES, when (what situation)?____

C12. Are you in a farmers group or club? YES/NO

C13. If YES, is it (please tick one box only):

Formal Association	**1**	
Informal Association	**2**	

C14. How many farmers belong to the group?___________________________________

C15. How often do you meet?____

C16. What do you do/discuss?____

C17. Do you think that this is useful?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

C18. Have you received any information on fish diseases? YES/NO

C19. If YES (insert details in table below):

C20. What was it?	
C21. Who was it from?	
C22. What was the format?	
C23. Did you follow the	YES/NO/DON'T KNOW/SOMETIMES

advice?	**(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)**
C24. Was it useful for you?	YES/NO/DON'T KNOW/NO REPLY/ SOMETIMES **(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)**

D. Loans

D1. Do you have any loans for your fish farm? YES/NO

D2. If YES, who are these from?____

D3. If YES, what are these for?____

D4. Are there government loans available to you for your fish farm?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

D5. Please describe the major problems you have in your fish farm

____

____

D6. Do you think that fish farming is RISKY? YES/NO

D7. If YES, please explain why____

D8. Does the income from your fish farm vary between production cycles (or years)?

YES/NO/DON'T KNOW/NO REPLY/SOMETIMES

(yes = 1, no = 2, don't know = 3, no reply = 4, sometimes = 5)

D9. If YES, please explain why____

Thank you very much for your help and time. This information is for use in a research project and will not be used for any other purpose. If you have any problems or questions please contact ____________________________________.

Annex 3.

Population and number of households in Pichit Province by Amphoe, as of December 2000

No.	Amphoe	Population			No. of Households
		Total	**Male**	**Female**	
1	Muang Pichit	118,856	58,014	60,842	30,628
2	Taphan Hin	80,032	39,106	40,926	18,578
3	Thapkhlo	53,442	26,412	27,030	11,923
4	Bang Mun Nak	53,381	26,119	27,262	13,554
5	Wa Chi Ra Ba Ra Mi	31,020	15,406	15,614	7,532
6	Wang Sai Phun	28,352	13,986	14,366	6,126
7	Sam Ngam	45,439	22,429	23,010	10,835
8	Pho Thale	63,806	31,231	32,575	15,559
9	Pho Prathap	44,805	21,933	22,872	10,039
10	Sak Lek	24,832	12,348	12,484	6,194
11	Dong Charoen	20,969	10,304	10,665	5,127
12	Bueng Na Rang	28,877	14,259	14,618	6,474
	Total	593,811	291,547	302,264	142,569

Annex 4. References

Bort, J., Ovares, L. and Stonich, S. 1997. 'Globalisation of shrimp mariculture: the impact on social justice and environmental quality in Central America', Society and Natural Resources, Vol. 10, No. 2, 161-179.

Burch, D., Goss, J. and Rickson, RE. 2000. 'Agri-Food Restructuring and Third World Transnationals: Thailand, the Cp Group and the Global Shrimp Industry', World Development Vol. 28 No. 3, 513-530.

Chase Smith, R. *et al*. 2001. 'Tropical Rhythms and Collective Action: Community-Based Fisheries Management in the Face of Amazonian Unpredictability' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 36-47.

Department of Fisheries, 2003. Organization of Department of Fisheries. http://www.fisheries.go.th/english/organization.html

Edwards, P. 2000. 'Aquaculture, Poverty Impacts and Livelihoods', ODI Natural Resource Perspectives No. 56, ODI, http://www.odi.org.uk/nrp/56.html.

European Commission, Directorate General for Development 1994. 'Fisheries and Aquaculture – Operational Guidelines for the Incorporation of Gender in Project/ Programme Preparation and Design'.

Fairhead, J. and Leach, M. 2002a. 'Introduction: Changing Perspectives on Forests: Science/Policy Processes in Wider Society' in Amanor, K., Fairhead, J. and Leach, M. Science and the Policy Process: Perspectives from the Forest, IDS Bulletin Vol 33, No. 1, Jan 2002, 1-12.

Fegan, D. 1996. 'Sustainable Shrimp Farming in Asia: Vision or Pipedream?', Aquaculture Asia, Vol. I, No. 2, 22-39.

Harrison, E. 1994. 'Fish Farming in Africa - What's the Catch?', Overseas Development Agency, University of Sussex and Institute of Aquaculture, University of Stirling.

Nguyen Van Tu and Trinh Truong Giang, 2003. Improving the Efficiency of Fisheries Extension Activity in Southeastern Province of South Vietnam. College of Aquaculture and Forestry, Ho Chi Minh City, Vietnam.

Lightfoot, C. and Pullin, RSV. 1991. 'Why Asian FSRE Needs Qualitative Methods for Integrating Agriculture with Aquaculture', Journal of Asian Farming Systems Association Vol. 1, No. 2, 201-215.

Mehta, L., Leach, M. and Scoones, I. 2001. 'Editorial' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 1-10.

Pichit Provincial Administration Office, 2000. Population and Number of Households in Pichit Province by Amphur.

Pichit Provincial Community Development Office, 1997. Table of Agricultural Groups and Members in Pichit Province by Amphur.

Pichit Provinicial Fisheries Extension Office, 1999. List of Farmers practicing aquaculture.

Rajak, D., 2002. 'Asian Aquaculture. Livelihoods and Knowledge: A Critical Literature Review', Unpublished.

Rayner, S., 2003. 'Democracy in the Age of Assessment: reflections on the Roles of Expertise and Democracy in Public-Sector Decision-making', *Science and Public Policy*, Vol. 30, No. 3, 163-170.

Somsiri, T., Crumlish, M., Dumrongphol, Y., Panbanpaw, A. & Thompson, K.D., 2001. Study of Bacterial Loading in Macrophage Cells of Hybrid Catfish (to Poceedings of the 4th Symposium on Diseases in Asian Aquaculture).

Stirrat, RL. 2002. 'Impact Assessment', DRAFT.

Thompson, K.D. & Crumlish, M., 1999. Final Technical Report. Control of Bacterial Disease in Small-Scale Freshwater Aquaculture. Institute of Aquaculture, University of Stirling.

Turongruang, D. and Demaine, H., 2003. Participatory Development of Aquaculture Extension Materials and their Effectiveness in Transfer of Technology: the Case of the AIT Aqua Outreach Programme, Northeast Thailand. Asian Insitiue of Technology, Thailand.

Wattanutchariya, S. *et al* 1982. Economics of *Clarias* farming in Chachoengsao Province in 1980. National Inland Fishries Institute, Bangkok.

World Bank 1991. 'Fisheries and Aquaculture Research Capabilities and Needs in Asia – Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region', World Bank Technical Paper Number 47, Fisheries Series, Washington DC: World Bank.

Appendix VIII

'Taking a Gamble': Knowledge, Risk and Shrimp Farming in The Mekong Delta, Vietnam

Dinah Rajak

Department of Anthropology
University of Sussex

Department of Anthropology

University of Sussex

Aquaculture and Fish Genetics Research programme (AFGRP)

Institute of Aquaculture

University of Stirling

Department for International Development (DFID), UK

'Taking a Gamble': Knowledge, Risk and Shrimp Farming in the Mekong Delta, Vietnam

TABLE OF CONTENTS

"Taking a Gamble": Knowledge and Risk in Shrimp Farming in the Mekong Delta, Vietnam

PREFACE

This report presents findings from two case studies carried out in Vietnam as part of the DFID supported research project R8119, 'The Impact of Aquatic Animal health Strategies on the Livelihoods of Poor People in Asia'. The project was funded through the Aquaculture and Fish Genetics Research Programme at the Institute of Aquaculture, Stirling and is being jointly undertaken by The Institute of Aquaculture, Stirling; the University of Sussex; the University of Liverpool; the Research Institute for Aquaculture No.2, Ho Chi Minh City; the College of Aquaculture and Fisheries, CanTho University; the College of Fisheries, Mangalore; and the Aquatic Animal Health Research Institute, Bangkok.

The case studies presented in this report were conducted in Vietnam in March and April 2003. The field research focused on small-scale shrimp aquaculture in Southern Vietnam. Following the lead of other South East Asian nations, the dramatic, government-sponsored development of the shrimp industry in Vietnam in the last decade has effected significant social and economic change, particularly in the southern regions of the country. Shrimp aquaculture, therefore, provides a lens through which to examine the social impact of technical research, innovation and transfer of aquatic animal health strategies on the livelihoods of small-scale farmers in Vietnam. Two areas that have experienced the rapid development of shrimp farming - the district of Can Duoc in Long An Province and the district of My Xuyen in Soc Trang Province in the Mekong Delta – were selected as the sites for the case studies.

The aim of this research was to identify the ways in which strategies relating to shrimp farm management, and specifically to shrimp health management and disease control, impact on the livelihoods of small-scale farmers in Southern Vietnam. The research involved a review of the changing livelihood context of people involved in shrimp aquaculture and the effects of shrimp disease on household economy in selected locations. The study examines the relationship between farming practice, technology transfer and poverty reduction and evaluates the institutional capacity to improve the benefits derived by poor people from shrimp culture through research and technology transfer. It examines the provision of technical support services in their attempts to mitigate against the high levels of risk inherent in shrimp farming. The case studies provide an insight into the relationship between knowledge, practice and the uptake of AAH strategies within the context of potentially high profits, but substantial levels of risk, which characterises small-scale shrimp enterprise. This report should be read in conjunction with the findings from the institutional analyses examining the flow of information from the scientific research institutes involved in the project to end-users. Together these outputs aim to provide a detailed yet broad understanding of the processes of generation, dissemination, extension and uptake of AAH strategies and the impact they have on the livelihoods of shrimp farmers in Vietnam.

The literature review had revealed that previous studies had, for the most part, focused on the quantifiable, economic impacts of the shrimp industry, neglecting aspects of the social changes brought about by the rapid development of shrimp farming. These studies had often been based on simplistic, economic models of technology transfer that focused on overall production goals, equating these with poverty reduction, to the neglect of localised experiences of shrimp farming. The case studies therefore aimed to provide an in-depth, situated understanding of the social impact of shrimp farming and AAH strategies, set within the broader national, regional and global trends in technology transfer and shrimp aquaculture.

The case studies were conducted by an interdisciplinary team of researchers from the fields of anthropology and the biological sciences, combining both qualitative and quantitative methods. An ethnographic approach was adopted involving informal interviews with a variety of stakeholders and participant observation in farmer's group meetings and extension meetings and women's group meetings. This was combined with a quantitative socio-economic survey of shrimp farmers in the two sites selected for the field research.

This report should be read in conjunction with the reports of the case study carried out in Thailand. This report also provides recommendations for future planning and policy in the field of aquaculture development, and guidelines for optimising the promotion and uptake of information and strategies produced by aquaculture development research projects.

A number of people have been instrumental in the production of this report. I would particularly like to thank: at RIA2 in Ho Chi Minh City, Nguyen Van Hao and Do Quang Tien Vuong; at the Tien Giang Provincial Fisheries Department, Pham Thi Bich Hong; at CanTho University, Tham Cong Binh and Nguyen Quoc Thinh; and Margaret Crumlish at the Institute of Aquaculture for her invaluable help with the statistical data analysis.

In order to protect the anonymity of those who participated in the study, the names of all informants have been changed in this report, with their permission.

ACRONYMS

AAD	Aquatic Animal Disease
AAH	Aquatic Animal Health
AAHRI	Aquatic Animal Health Research Institute (Bangkok, Thailand)
CAF	College of Auaculture and Fisheries, University of CanTho
DARD	Provincial Department of Agriculture and Rural Development, Vietnam
DFID	Department for International Development, UK Government
DoF	Provincial Department of Fisheries, Vietnam
Ha	Hectare
HCMC	Ho Chi Minh City
MARD	National Ministry of Agriculture and Rural Development, Vietnam
MoF	National Ministry of Fisheries, Vietnam
MT	Metric Tonnes
RIA1	Research Institute for Aquaculture 1 (Hanoi)
RIA2	Research Institute for Aquaculture 2 (Ho Chi Minh City)
VND	Dong (Vietnamese unit of currency)

LIST OF MAPS, PLATES, FIGURES & GRAPHS

MAPS

PLATES

FIGURES

GRAPHS

GLOSSARY

Ap	Hamlet
Benh	Disease
Cau Lac Bo (CLB)	Club
Commune	Administrative area approximate to a village. The commune is then sub-divided into hamlets.
Dong	Vietnamese Unit of Currency (VND)
Hoi Nong Dan	Farmers Association
Huyen	District
Khuyen Ngu	Fisheries Extension
Kien Thuc	Knowledge
Thong Tin	Information or Message
Xa	Commune or Village

SUMMARY OF PRINCIPLE FINDINGS AND CONCLUSIONS

1. Introduction

This study is concerned with the impact of aquatic animal health (AAH) strategies on the livelihoods of poor people in the Mekong Delta, Vietnam. It arises from a growing sense among researchers, planners and policy-makers of the urgent need to look more rigorously at the impact of strategic knowledge programmes in the field of natural resources and poverty reduction and the challenges inherent in such impact studies. The report presents the findings from two case studies conducted amongst shrimp aquaculturalists in Long An and Soc Trang Provinces, in 2003.

A literature review conducted during 2002/3 provided the background to the case studies. This review found that previous research tended to neglect the social impact of natural resource research and the institutional context within which knowledge is generated, communicated and received. These studies had often been based on simplistic, economic models of technology transfer that focused on overall production goals, equating these with poverty reduction, to the neglect of localised experiences of fish farming. Stirrat's study of 'Methodological Issues in Identifying Impact' has highlighted the need to re-think impact in terms of the sustainable livelihoods approach to poverty reduction demanding a more 'nuanced and interpretive approach where judgement rather than proof is central'. This case study has attempted to adopt such an approach.

The study has four principle objectives:

1. To develop an understanding of the role of aquaculture in the livelihoods of farmers in Long An and Soc Trang Provinces.
2. To assess the provision of technical support services and aquatic animal health strategies to farmers.
3. To investigate the uptake of AAH strategies and the impact of such strategies on poverty.
4. To examine the relationship between aquaculture and AAH knowledge, and practice.

2. Methodology

These objectives were met through a range of research methods, both qualitative and quantitative. The project deals with both the 'scientific' and the 'social' and therefore provided an appropriate arena for multi-disciplinary collaboration. This was reflected in the methodology adopted for the research. This involved a qualitative ethnographic approach derived from anthropology. In-depth, informal interviews were conducted with a range of stakeholders involved in aquaculture (including farmers, traders, middlemen, extension officers and chairmen on the commune and hamlet people's committees). Observation of commune extension meetings and informal farmers' group gatherings provided an insight into the way in which knowledge about farm management was shared and the way in which various stakeholders related to each other.

Through the ethnographic approach the researchers engaged more closely with the complex set of socio-economic processes that define the practice of aquaculture and household economy. This enabled the researchers to examine commonly neglected issues such as:

- Motivation for farming
- Conceptions of profit and loss
- The relationship between knowledge and practice
- Decision-making within the household
    - The way in which risk is calculated against investment.

These issues are crucial to examining the reception and uptake of technical aquaculture strategies and the role played by aquaculture and AAH in rural livelihoods.

A questionnaire was also conducted with farmers randomly selected from the provincial extension service list of farmers. The questionnaire survey provided a representative sample revealing broad trends in farming practice such as choice of culture species and model, access to extensionists and training courses, and the popularity of different media as sources of technical information on farm management.

3. Context of the Study

The field study in Vietnam comprised two separate, but comparative case studies . The first case study was conducted in the commune of Tan Chanh, Can Duoc District in Long An Province. The second was conducted in two communes (Hoa Tu I and Thanh Quoi) in the My Xuyen District of Soc Trang Province in the Mekong Delta.

4. Findings

This study demonstrated the dominance of conventional models of technology transfer upon which development research, intervention strategies and extension planning have been based. In so doing, the study has highlighted the way in which the technical dimensions of aquaculture continue to be prioritised to the neglect of socio-economic and institutional realities in which the practice of aquaculture is embedded. The traditional paradigm of technology transfer focuses on the production, dissemination and delivery of tangible technologies or packages of technical strategies to farmers, with the goal of maximising productivity. According to this model poverty is seen to be the result of technological barriers. This conception of technology transfer relies on an assumption that information, and the benefits it brings, will trickle down from 'master farmers' or innovators to the poor. Technology or technical strategies are therefore seen to be universally beneficial.

The findings from this study contradict this orthodox conception of technology transfer. They demonstrate that new technology can be as much a burden to the poor as a benefit. The findings indicate that in most cases the poorest households have the least access to information and technical support, and that, the primary beneficiaries of AAH strategies and aquaculture technologies are resource-rich farmers. In most cases, farming technologies, even of a basic, low-tech kind, require not only financial capital, but labour, time and usually, certain physical resources. In order to meet these demands on capital, poorer farmers are forced to turn to formal, and often, informal sources of credit. In doing so many accumulate debts that they are unable to repay due to the high risk of failure and consequently poor returns from their shrimp farms and become trapped in cycles of debt or enmeshed in relationships of dependency and patronage with wealthier farmers. Thus, credit and technical knowledge can be manipulated by more successful farmers. In such cases, projects which focus on the delivery of technical inputs can serve to increase the dependence and vulnerability of poor households, rather than reducing it.

The findings from the study demonstrate that the conventional extension approach by which a 'package' of technical strategies is delivered to farmers fails to reflect such difference and therefore can provide little support to some households. On-farm demonstrations and interactive training courses in which farmers can raise individual concerns, though costly, are therefore seen to be the most successful medium for providing technical support to farmers.

5. Conclusions

This study confirmed the challenges inherent in assessing the socio-economic impact of technical research. It demonstrated the difficulty of finding relevant and measurable indicators of the impact of technical research on poverty reduction.

The study indicates that insufficient attention is paid to the intended target of both research and intervention strategies. The direction and focus of the research itself should be determined by the needs of the target audience.

While strategic research has a crucial role to play in poverty reduction, this study underlines the way in which development research programmes have tended towards technical research projects with a livelihoods agenda bolted on. The focus of research has been, and continues to be, dominated by biotechnical concerns and interests, while socio-economic considerations, such as low education or literacy levels, are seen as obstacles to be overcome or managed in the process of technology transfer.

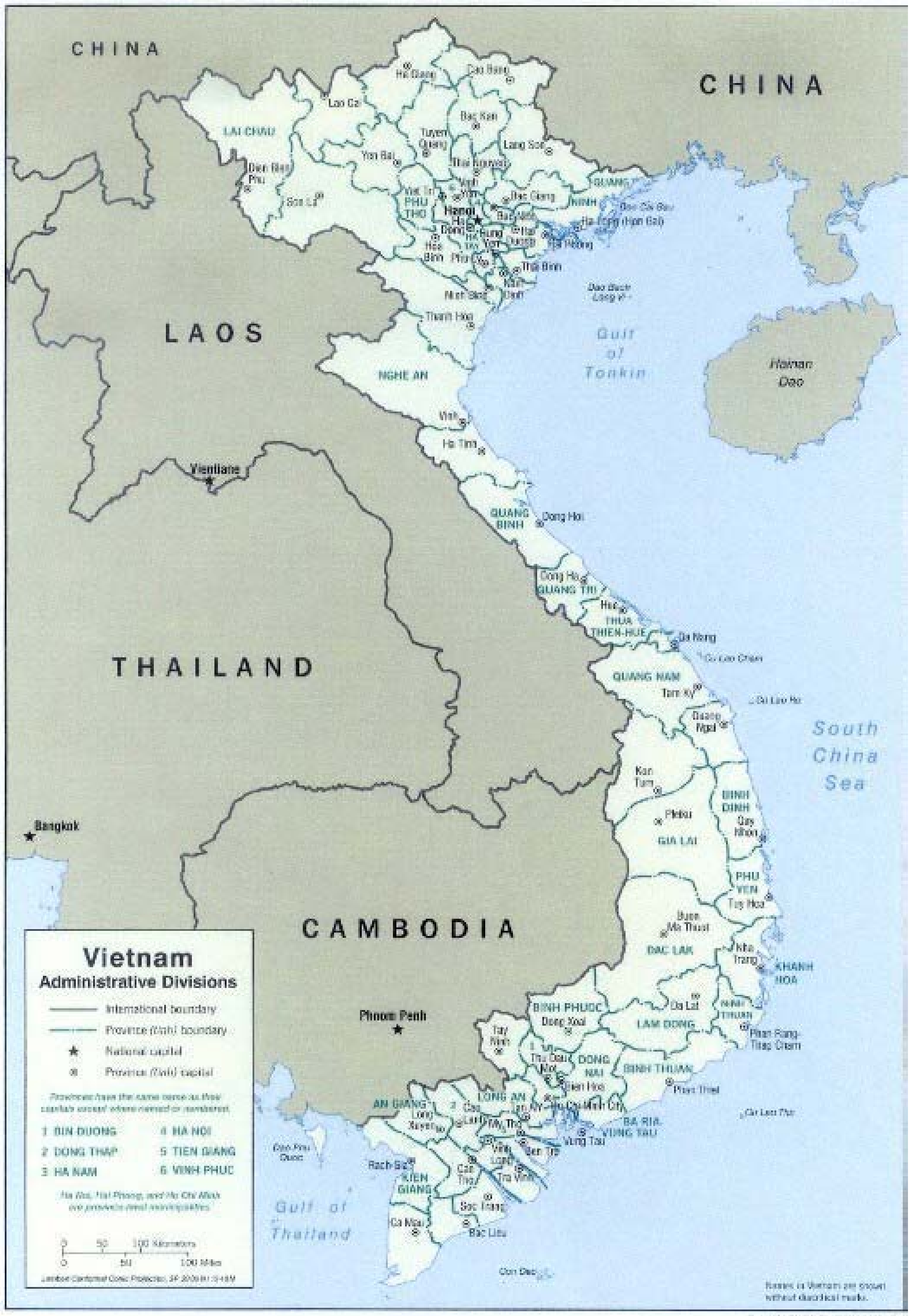
This study reveals that, in some cases, aquaculture, and particularly shrimp culture may not be the most appropriate activity/means of diversification for the poorest households. The study indicated that, in many cases, shrimp farming may increase vulnerability rather than reducing it. Those households who are currently benefiting the most from AAH strategies for shrimp farming are not the poorest/most vulnerable. As is the case for many other farming technologies, those who are most able to exploit technical strategies and innovations, and become productive fish farmers, are not the poorest. Thus projects that aim to *promote*, rather that *support*, shrimp farming, either through research or extension, may in some cases have little direct influence on poverty reduction.

6. Recommendations

This points to the need for a shift towards target-led research, as opposed to research projects designed 'in the lab' and then adapted for the chosen context and target. Research which is driven by the poverty-reduction agenda and objectives focused on livelihood improvement, must ensure that the research is constantly informed by the needs of the poorest and most vulnerable people, and special efforts are made to ensure that the products of research reaches the target group.
Research and extension should be driven and informed by the needs, priorities and capabilities of the target group (whether it be the poorest of the poor, small-scale farmers or large-scale producers) and not vice versa.

The shrimp industry boom of the past decade has been supported and, arguably, driven by an increasingly sophisticated, extensive and well-funded network of scientific research and development programmes committed to increasing productivity. The appeal of large export revenues from the global shrimp market and the consequent dominance of biotechnical concerns in research and development agendas has led to a neglect of the very real threats the intensification of shrimp production presents for both the sustainability of the shrimp industry in Vietnam on a macro level, as well as that of individual farms at the household level. This report argues that due to the capital required and the high levels of risk inherent in shrimp farming, combined with the concerns around its medium and long-term sustainability, shrimp aquaculture, in many cases, increases the vulnerability of poorer households. Greater attention must be paid to the intended targets of programmes which support and facilitate the adoption of shrimp aquaculture and, at the same time, claim a commitment to poverty-reduction.

This report highlights the urgent need to re-focus attention on the institutional and governance issues around shrimp farming in Vietnam and on the way in which the livelihoods and farm management strategies of shrimp farmers are bound up with national targets for shrimp production set by the government. At this crucial point, the need for much greater regulation of shrimp farming activities and the imperative towards intensification emerges as key. Research agendas should focus on strategies focusing on sustainability of the industry and alternative livelihood activities for the growing number of households whose shrimp farms are failing.


CHINA
CHINA
LAOS
THAILAND
CAMBODIA
Gulf of Tonkin
South China Sea
Gulf of Thailand
Hainan Dao
Hanoi
Vientiane
Bangkok
Phnom Penh
LAI CHAU
NGHE AN
QUANG BINH
QUANG TRI
THUA THIEN-HUE
QUANG NAM
BINH DINH
GIA LAI
PHU YEN
DAC LAK
KHANH HOA
BINH PHUOC
LAM DONG
DONG NAI
BINH THUAN
LONG AN
AN GIANG
BA RIA-VUNG TAU
KIEN GIANG
Lao Cai
Vinh
Ha Tinh
Dong Hoi
Da Nang
Kon Tum
Pleiku
Tuy Hoa
Buon Ma Thuot
Nha Trang
Da Lat
Ho Chi Minh City
Vung Tau
Can Tho
Ca Mau
Bac Lieu
Soc Trang
Vietnam
Administrative Divisions
International boundary
Province (tinh) boundary
National capital
Province (tinh) capital
1 BIN DUONG
2 DONG THAP
3 HA NAM
4 HA NOI
5 TIEN GIANG
6 VINH PHUC

SECTION ONE

INTRODUCTION AND CONTEXT

1. Introduction

This report is concerned with the impact of aquatic animal health (AAH) strategies on the livelihoods of poor people inVietnam. It arises from a growing sense among researchers, planners and policy-makers of the urgent need to look more rigorously at the impact of strategic knowledge programmes in the field of natural resources and poverty reduction, and the challenges inherent in such impact studies. The report presents the findings from fieldwork conducted amongst shrimp farmers in the Long An and Soc Trang Provinces, Vietnam in 2003.

A literature review conducted during 2002/3 provided the background to the case studies. This review found that previous research tended to neglect the social impact of natural resource research and the institutional context within which knowledge is generated, communicated and received. These studies had often been based on simplistic, economic models of technology transfer that focused on overall production goals, equating these with poverty reduction, to the neglect of localised experiences of shrimp farming. The case studies therefore aimed to provide a detailed, situated understanding of the social impact of shrimp farming and AAH strategies, set within the broader national, regional and global trends in technology transfer and aquaculture described in the literature review.

The report is organised in three sections. The first describes the context in which the study was conducted. It elaborates the institutional background of research, extension and government supported projects in which small-scale shrimp farming in Vietnam has developed over the last two decades. This section also outlines the methodological approach taken in the study which investigated the impact of previous projects concerned with the production and transfer of technical knowledge about aquatic animal health. The analysis and methodological framework derive, to a large extent, from the initial literature review in which the broader context of aquaculture development and technology transfer in South East Asia is elaborated in greater detail (Rajak 2002). The second section presents the fieldwork findings. Running through it is a series of case studies taken from the fieldwork which illuminate central themes in the analysis. The third section presents conclusions from the study. This section also points to future directions for AAH research and intervention projects and their role in poverty reduction strategies.

This report should be read in conjunction with the findings from the institutional analyses examining the flow of information from the scientific research institutes involved in the project to end-users. Together these outputs aim to provide a detailed yet broad understanding of the processes of generation, dissemination, extension and uptake of AAH strategies and the impact they have on the livelihoods of fish farmers in Phichit Province. A comparative case study was also carried in Phichit Province in Thailand as part of this project. The findings from the case studies combined with the critical literature review and the institutional analyses aim to provide a broad view of the social impact of aquatic animal health strategies on the livelihoods of poor people in Asia. This report also provides recommendations for future planning and policy in the field of aquaculture development, and guidelines for optimising the promotion and uptake of information and strategies produced by aquaculture development research projects.

1.1 The Case Study in Vietnam

The two case studies presented in this report were conducted in Vietnam in March and April 2003. The field research focused on small-scale shrimp aquaculture in Southern Vietnam. Following the lead of other South East Asian nations, the dramatic, government-sponsored development of the shrimp industry in Vietnam in the last decade has effected significant social and economic change, particularly in the southern regions of the country. Shrimp aquaculture, therefore, provides a lens through which to examine the social impact of technical research, innovation and transfer of aquatic animal health strategies on the livelihoods of small-scale farmers in Vietnam. Two areas that have experienced the rapid development of shrimp farming - the district of Can Duoc in Long An Province and the district of My Xuyen in Soc Trang Province in the Mekong Delta – were selected as the sites for the case studies.

The aim of this research was to identify the ways in which strategies relating to shrimp farm management, and specifically to shrimp health management and disease control, impact on the livelihoods of small-scale farmers in Southern Vietnam. The research involved a review of the changing livelihood context of people involved in shrimp aquaculture and the effects of shrimp disease on household economy in selected locations. The study examines the relationship between farming practice, technology transfer and poverty reduction and evaluates the institutional capacity to improve the benefits derived by poor people from shrimp culture through research and technology transfer. It examines the provision of technical support services in their attempts to mitigate against the high levels of risk inherent in shrimp farming. The case studies provide an insight into the relationship between knowledge, practice and the uptake of AAH strategies within the context of potentially high profits, but substantial levels of risk, which characterises small-scale shrimp enterprise. This report should be read in conjunction with the findings from the institutional analyses examining the flow of information from the scientific research institutes involved in the project to end-users. Together these outputs aim to provide a detailed yet broad understanding of the processes of generation, dissemination, extension and uptake of AAH strategies and the impact they have on the livelihoods of shrimp farmers in Vietnam.

The literature review revealed that studies investigating the impact of projects concerned with the production and transfer of technical knowledge often neglect the crucial stage of ***uptake***. Research tends to focus on what kind of strategies are being produced; on what channels exist for the dissemination of information; on whether, and in what form, information is leaving the research institute; and on whether or not there is an active extension service and regular contact with farmers or 'end-users'. But at this point the track seems to stop. The question of *uptake* is a much more slippery question and one which, for the most part, defies measurement. It demands that we shift the focus of research to ask, not only, whether farmers receive advice or attend training courses, but also, whether these inform their practice, how and why they chose to apply specific management strategies, and to what extent they benefit them.

The case studies conducted in Thailand and Vietnam for this project aimed to address the question of uptake. The research aimed to do this by looking broadly at questions of risk and motivation, so as to understand the importance of technical knowledge in the management of fish farms and the overall livelihood strategy of people involved in aquaculture. This involved thinking about questions which relate to the role and significance of shrimp farming in rural livelihoods in Long An and Soc Trang, questions such as:

- To what extent do farmers see themselves as ‘shrimp-farmers’?
- How are decisions made within a household about the level or type of technical and financial investment in aquaculture?
- What do farmers consider the primary risks involved in practicing aquaculture and what strategies are available for coping with these risks?
- What motivates a household to take up shrimp farming and how does motivation inform decision-making about AAH and management strategies?

The literature review also demonstrated that previous studies had, for the most part, focused on the quantifiable, economic impacts of the shrimp industry, neglecting aspects of the social changes brought about by the rapid development of shrimp farming. These studies had often been based on simplistic, economic models of technology transfer that focused on overall production goals, equating these with poverty reduction, to the neglect of localised experiences of shrimp farming. The case studies therefore aimed to provide an in-depth, situated understanding of the social impact of shrimp farming and AAH strategies, set within the broader national, regional and global trends in technology transfer and shrimp aquaculture.

The case studies were conducted by a multi-disciplinary team of researchers from anthropology and the biological sciences, combining both qualitative and quantitative methods. An ethnographic approach was adopted, involving informal interviews with a variety of stakeholders and observation in farmer’s group meetings and extension meetings. This was combined with a quantitative socio-economic survey of farmers in the two sites selected for the field research.

1.2 Study Objectives and Methodology

R.L.Stirrat’s recent study of ‘Methodological Issues in Identifying Impact’ (Stirrat 2002) has highlighted the need to re-think impact in terms of a sustainable livelihoods approach to poverty reduction, rather than conventional economic goals of increased production. This demands a more ‘nuanced and interpretive approach where judgement rather than proof is central’ (Stirrat 2002: 3). This case study has attempted to adopt such an approach to understanding the impact of aquatic animal health strategies on the livelihoods of poor people in the Mekong Delta, Vietnam.

As is highlighted by Stirrat in his study, impact assessment presents both researchers and development practitioners with a number of challenges. Furthermore, as Rayner, points out, the task of impact assessment and evaluation becomes even more difficult when the aim is to track impact across a whole sector of research and intervention rather than one distinct project:

> Most evaluation is of single projects. There is very little systematic or comparative evaluation across multiple sites and different techniques…the general problem facing outcome evaluation [is] that it is impossible to establish causal links between the process and its outcomes and to establish what the counterfactual situation would have been. (Rayner 2003: 165).

At the outset of the project, participants agreed that it would be almost impossible to measure the direct impact of a specific AAH strategy on the livelihoods of poor people involved in aquaculture in the selected area. As this impact study was conducted as a separate project, retrospectively charting the impact of a set of technical aquaculture strategies and projects, rather than having been integrated into the original project or programme design the question of how we look at impact becomes even more complex. Therefore the approach taken in this case study was to focus more generally on the available channels of communication for technical information and AAH strategies to small-scale shrimp farmers in Long An and Soc Trang Provinces. The case study aimed to look at what types (in terms of form, content and messages) of information about AAH are available to farmers and which farmers have access to these and which do not. An iterative approach was taken by which impact could be traced through a series of interviews involving key actors involved in fish farming in the area. In this way the study aimed to reveal the role of aquaculture in rural livelihoods in the Mekong Delta; the key problems faced by aquaculturalists in the area; the strategies and techniques employed by farmers to deal with the problems; the source of farmers' knowledge and information about managing their farms and dealing with the problems they identified; and finally, the effectiveness of these strategies in improving or sustaining the livelihood of the household.

The study had four principle objectives:

1. To develop an understanding of the role of shrimp farming in the livelihoods of farmers in Long An and Soc Trang Provinces.

2. To assess the provision of technical support services and aquatic animal health strategies to farmers.

3. To investigate the uptake of AAH strategies and the impact of such strategies on poverty.

4. To examine the relationship between aquaculture and AAH knowledge, and practice.

These objectives were met through a range of research methods, both qualitative and quantitative. The project deals with both the 'scientific' and the 'social' and therefore provided an appropriate arena for multi-disciplinary collaboration. This was reflected in the methodology adopted for the research. This involved a qualitative ethnographic approach derived from anthropology. In-depth, informal interviews were conducted with a range of stakeholders involved in aquaculture (including farmers, traders, middlemen, extension officers and chairmen of the commune people's commitee). Observation of commune extension meetings and informal farmers' group gatherings provided an insight into the way in which knowledge about farm management was shared and the way in which various stakeholders related to each other.

Through the ethnographic approach the researchers engaged more closely with the complex set of socio-economic processes that define the practice of aquaculture and household economy. This enabled the researchers to examine commonly neglected issues such as:

- Motivation for farming
- Conceptions of profit and loss
- The relationship between knowledge and practice
- Decision-making within the household
- The way in which risk is calculated against investment.

These issues are crucial to examining the reception and uptake of technical aquaculture strategies and the role played by aquaculture and AAH in rural livelihoods.

A questionnaire was also conducted with farmers randomly selected from the provincial extension service list of farmers. The questionnaire survey provided a representative sample revealing broad trends in farming practice such as choice of culture species and model, access to extensionists and training courses, and the popularity of different media as sources of technical information on farm management.

1.3 The Fieldwork Context: Why the Focus on Can Duoc and My Xuyen?

The field study in Vietnam comprised two separate, but comparative case studies . The first case study was conducted in the commune of Tan Chanh, Can Duoc District in Long An Province. The second was conducted in two communes (Hoa Tu I and Thanh Quoi) in the My Xuyen District of Soc Trang Province in the Mekong Delta. These two case studies presented a spectrum of both, shrimp culture models (from intensive to improved extensive and integrated rice-shrimp farming models), and socio-economic status of households involved in shrimp farming. These ranged from large-scale shrimp farmers with significant influence over the processes of shrimp production in their area (controlling access to traders and providing pond inputs and credit to poorer farmers), to small-scale, resource-poor households who struggled to find the capital to invest in their farms, were often found to be heavily indebted to traders and salesmen and, commonly, had limited access to information and technical support on farm management.

The two districts studies provided an interesting comparison for a number of reasons. Proximity to Ho Chi Minh City provided households in Can Duoc with greater opportunities for off-farm employment as well as greater access to technical support services (provided both by government institutions such as research centres, and the private sector in the form of salesmen and representatives from agro-product companies). These factors, combined with the district's extensive experience of shrimp culture (Can Duoc was involved in some of the government's earliest shrimp culture demonstrations in the Southern Regions) and the growing number of intensive, large-scale shrimp culture operations, had resulted in a substantial capital injection into the area which was visible in the high number of newly built houses, roads and bridges. Thus one local farmer, Mr Pham Van Ke, described his newly built house as, *'A house built of shrimp'*.

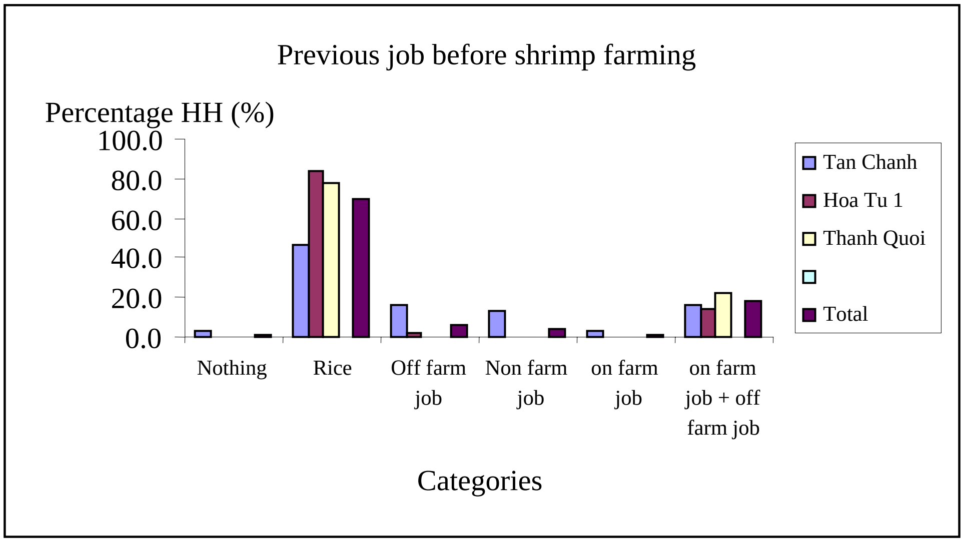
In comparison, households in My Xuyen do not benefit from the same degree of physical capital and have limited opportunities for alternative income generation beyond their farms. This is demonstrated in the livelihood activities of households in the two districts prior to the advent of shrimp farming. In My Xuyen, rice farming was the primary livelihood activity of 80-90% of households before they converted their fields for shrimp culture. In Can Duoc, the number was significantly lower – with less than 50% of households farming rice prior to becoming shrimp farmers (see graph 1). The majority of households in Can Duoc continue to derive income from one or more member of the household employed off the farm in labouring, construction, factory or office work in Ho Chi Minh City. While a number also run small businesses in addition to their shrimp farms such as boat transport services or building contractors. Thus, Mrs Dang Thi Na, a local seed supplier based in Tan Chanh stated that:

> *'Farmers here have been getting richer and richer because of shrimp, but also because of all the little building and transport businesses – everyone has cranes or boats'*

These additional livelihood activities provided those households with the capital to invest in their shrimp farms and an important safety net allowing them to sustain failure of a crop of shrimp due to disease.

The two districts also provided a significant contrast in terms of shrimp culture model. As farmers become more experienced at shrimp farming there is a tendency to intensify, thus a little over 60% of shrimp farmers in the commune have now upgraded their farms from improved extensive to semi-intensive models of farming (see Graph 2). Can Duoc therefore provided an interesting comparison to the other study sites in the District on My Xuyen in Soc Trang Province, the communes of Thanh Quoi and Hoa Tu I, in which only 3-4% and 5% of farmers respectively practice semi-intensive shrimp farming, while the vast majority in both communes practice integrated rice-shrimp farming (see Graph 2).

Graph 1: Livelihood Activity of Farmers Prior to Shrimp Farming



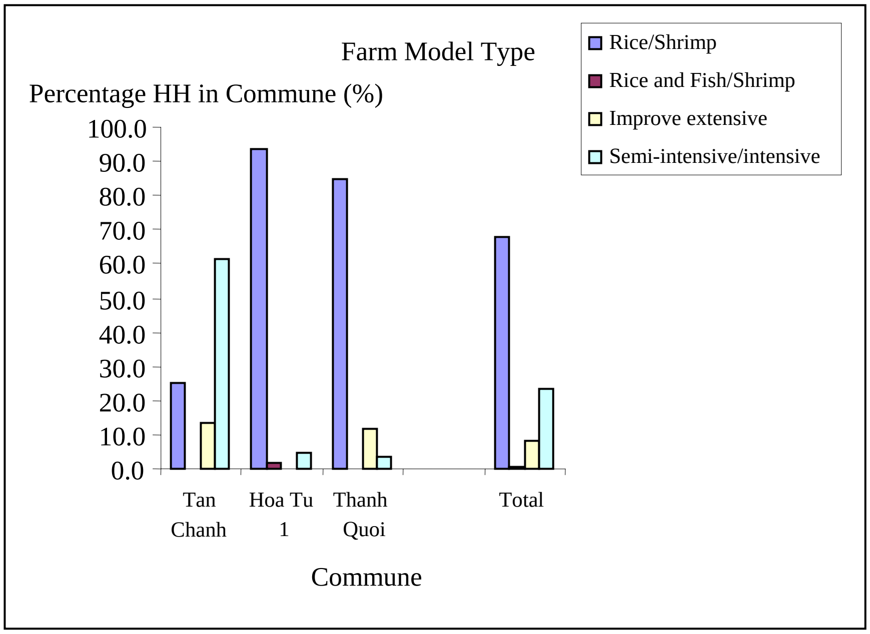
1.4 Shrimp Farming in Tan Chanh

The commune of Tan Chanh was selected for a number of reasons. Due to the high proportion of shrimp farmers in this district it provided an appropriate site in which to study the impact of aquatic animal health strategies on the livelihoods of shrimp farmers in the Southern regions of Vietnam. Many of the farmers have been culturing shrimp farming for 10-11 years since the first government demonstration of shrimp culture in the area. One leading farmer in the commune who had been involved in the first government sponsored shrimp culture trials explained that,

> *'In the beginning only the wealthy farmers and business men started shrimp farming, but now, any farmer who has land and labour has converted their land for shrimp'*

As has been noted above, previous research suggests that as farmers become more experienced at shrimp farming there is a tendency to intensify, thus a little over 60% of shrimp farmers in the commune have now upgraded their farms from improved extensive to semi-intensive models of farming (see Graph 2). This allowed us the opportunity to investigate the effects of intensification and long-term shrimp farming on the area. As is commonly seen to be the pattern, long-term shrimp culture and intensification has led to severe disease outbreak problems in the district. This research aimed to address the crucial question of how increasing disease outbreaks impact on the livelihoods of farmers in the area and to assess the role of aquatic animal health research and strategies in helping farmers to cope with the threat posed by shrimp epidemics to their livelihoods.

The District of Can Duoc was also selected because it had been the site of previous DFID-funded scientific research projects on shrimp disease using epidemiology to track the patterns of disease outbreak and farm management practices, the aim of which was to come up with technical intervention strategies for AAH management and the control of disease outbreaks. This, therefore allowed us to chart the impact of technical research and strategies for AAH on the livelihoods of farmers in the area



Graph 2: Type of Shrimp Culture Model

1.5 Shrimp Farming in Hoa Tu I

Almost 100% of farmers in this commune practice shrimp farming. Shrimp farming began in the area almost a decade and a half ago (1988-9) when a few farmers who ahd observed shrimp farming in other parts of the province and attracted by the high profits offered by shrimp production, converted their rice fields to shrimp ponds. In 1991 government demonstrations of shrimp farming were held in the commune. In the years following these official deminstrations, most farmers in the commune switched from rice farming to rice-shrimp farming. Though a small number of farmers are new to shrimp farming have taken it up in the past couple of years. Around 95% of shrimp farmers in Hoa Tu I have integrated rice-shrimp culture models, with around 1% of farmers also stocking fish in there fields during the wet season, and only 5% of farms semi-intensive. Since the early years of extensive shrimp-rice farming in Hoa Tu I, most farmers have increased the level of investment in their farms, using industrial shrimp feed, higher stocking densities, chemicals and antibiotics in an attempt to deal with growing disease outbreaks.

Many farmers reported a dramatic rise in the incidence of shrimp disease over the past two years. Hoa Tu I was also the site of previous technical research on shrimp disease carried out by the Research Institute for Aquaculture 2 in HCMC. Hoa Tu I is also being used as a test site for extension club trials in Soc Trang Province. These clubs aim to provide an arena knowledge and information sharing and a target for extension activities. However, their dual purpose is to provide a forum for co-management of the surrounding area, communal resources and environment by local farmers and government officers. This initiative has been driven by growing concerns about epidemics in farmed shrimp of white spot and yellow head disease which have begun to affect the area significantly in the last couple of years (see section 6.5)

1.6 Shrimp Farming in Thanh Quoi

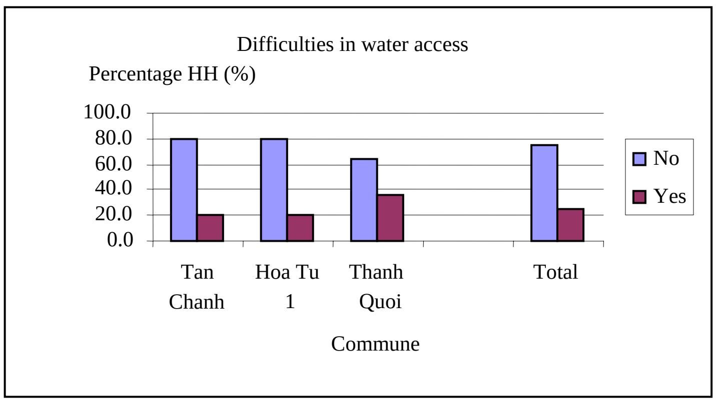
Unlike, its neighbouring commune Hoa Tu I, Thanh Quoi offered a study site in which the area under shrimp cultivation can be roughly divided into two sections, the first area in which shrimp cultivation began 8 years ago and in which the effects of long-term shrimp farming are now being felt and a second area in which farmers only started to practice shrimp farming 1-2 years ago and in which most farmers reported successful first crops and no disease outbreaks. In common with Hoa Tu I, the vast majority of shrimp farmers in Thanh Quoi practice integrated rice-shrimp farming (85%), while roughly 10-15% of farms are ‘improved extensive’ and only around 3-4% are semi-intensive (see Graph 2).

One farmer in the hamlet of Huynh Tham in Thanh Quoi, described how, in 1994, as part of the government promotion of shrimp farming in the Mekong Delta, scientists from Can Tho University’s College of Aquaculture and Fisheries held a meeting in the hamlet inviting farmers to participate in trials of *Penaeus monodon* culture. he was among the original 30 farmers who agreed to particpate. The university supplied them with seedstock and credit with which to buy feed (to be repaid after harvets) and assisted them in preparing their fields for shrimp culture. A technician from the university stayed in his house for 4 months (one crop cycle) to monitor the trials and support the new shrimp farmers with technical advice and information. This project continued for a further 3 years, each year supplying the farmers with both credit and a technician resident in the hamlet for the duration of each crop. Since these early years of shrimp farming in the hamlet, increasing numbers of households have followed the lead of the first farmers who participated in the project.

Thanh Quoi provided an interesting contrast to Hoa Tu I. Initial observations of the commune revealed a weaker infrastructure than that of Hoa Tu I: poorer roads, with some hamlets in the commune accessible only by boat along narrow waterways, and poorer quality housing with only a few newly built concrete houses and communal buildings in much need of repair. These physical realities, and particularly the lack of new houses in the area, point to the much more recent adoption of shrimp farming in Thanh Quoi than in the neighbouring commune of Hoa Tu I. Much of Thanh Quoi is therefore only now experiencing the high profits yielded by shrimp farming after the initial investment costs required to convert rice fields to shrimp cultivation have been covered. Until recently, large parts of Thanh Quoi have been unsuitable for shrimp farming as they have been protected from salinization as fresh water areas for rice cultivation by a dyke.

The location of Thanh Quoi is such that, while roughly half the commune has been assigned for shrimp culture, the other half has been protected from saline intrusion by a dyke in order to preserve the soil fertility for rice and vegetable cultivation. The result appears to be enhanced socio-economic disparity, as some households in the village are reaping enormous profits since switching their land to shrimp cultivation, while other farmers who are not in the shrimp farming areas are suffering from the falling price of rice (which has been declining in quality and yield over the past few years, arguably, due to the declining fertility of the soil from saline intrusion). A number of farmers on the other side of the dyke have broken sections of it away, thus allowing salt water to enter the area and so making it suitable for shrimp farming. However neighbouring rice and vegetable farmers believe that this influx of salt water is severely damaging the quality of their soil and is thus responsible for declining productivity on their farms. Thanh Quoi is thus subject to tensions over land use which highlight the need for both effective organisation of the land into zones, greater regulation of shrimp farming activity and extension clubs which could potentially facilitate the co-management of communal resources and land use.

A further challenge faced by farmers in Thanh Quoi is limited access to water sources (see Graph 4). While only 20% of farmers in Hoa Tu I and Tan Chanh reported limited access to water as a constraint on their farms, in Thanh Quoi the number is closer to 40%. Access to water is a vital factor in shrimp health management. The limited availability of water sources makes it difficult for farmers to exchange water in the event of a disease outbreak and to prevent sediment build up in the ponds. While infrastructure developments involving the construction of irrigation channels have been planned for Thanh Quoi, these have not, as yet, been put into action.



Graph 3: Difficulties in Access to Water

Thanh Quoi also provided an interesting comparison to Hoa Thi I as, unlike Hoa Tu I, it does not have trial extension clubs and the remoteness of some parts of the commune makes it difficult for farmers to come together or for extension officers and agri-product salesmen to reach some of the more remote farms. Thanh Quoi has also been the subject of previous technical interventions aimed at improving AAH and farm management practices of shrimp farmers in the area. These projects, which were run by the College of

Aquaculture and Fisheries at the CanTho University, aimed to increase the availability of good quality shrimp seedstock in the area by providing training courses for farmers who were interested in starting seedstock nurseries and supplying local farmers with seedstock.

2. Background

2.1 Global Trade, Local Politics: Shrimp Farming in Vietnam

Vietnam's largely rural population of 80 million is concentrated along the coast and is heavily dependent on agriculture (67% of the workforce was involved in the agriculture sector in 1997[1]). However the recent *doi moi* liberalisation policy has opened Vietnam to global markets and increased the countries participation in world trade. Following the trend of other South East Asian countries, the Vietnamese government has invested heavily in and promoted aquaculture to increase export earnings, create employement and alleviate poverty in rural areas (see Figure 1). In particular, shrimp farming has played a central role in Vietnam's economic development and the country is currently one of the leading exporters of farmed shrimp. In 2000 Vietnam was the world's fifth largest producer of farmed shrimp[2]. Favourable agro-climatic conditions (especially in the South), the opening of the economy to international trade following the economic liberalisation process of *doi moi*, the expansion of the global shrimp market, and the collapse of the shrimp indusrty in other Asian countries due to disease, has resulted in Vietnam's dramatic entry into the world shrimp market.

Figure 1

Government Decision No. 21, 1998:

'To quickly develop the aquatic product economy into a spearhead branch in the economy of the country, create many more jobs in order to help raise the standard of living of the people, bring about a face-lift of the rural coastal areas and contribute to living problems of the ecological environment to develop shrimp farming: to gradually move from extensive shrimp farming to improved extensive, semi-intensive farming to encourage the forms of inter-farming while forming areas of concentrated intensive shrimp farming' (Government of Vietnam 1998)

Shrimp farming is a major component of the Vietnamese economy and one of the most important activities in Vietnam in terms of area, production, employment and foreign earnings. In 1998, aquaculture products represented the fourth largest foreign exchange earner for Vietnam (Martinelli 2000). In particular brackish water shrimp (tiger shrimp) production has expanded dramatically in the past decade and now accounts for the majority of Vietnam's aquaculture exports. Export earnings derived from shrimp farming are estimated at around US$500 million per year and are increasing annually. Shrimp farming continues to expand rapidly accross the country. Production increased from under 200 tonnes in 1976 to over 100,000 tonnes in 2000 and 158, 755 tonnes in 2001,

[1] CIA 2001. *World Factbook*. Central Intelligence Agency. Washington DC, 2001.
[2] World Bank, NACA, WWF and FAO, 2002. *Shrimp Farming and the Environment. A World Bank, NACA, WWF and FAO Consortium Program to 'Analyse and Share Experience on the Better Management of Shrimp Aquaculture in Coastal Areas' Synthesis Report.*

with 80% of this production in the South and two- thirds of annual production processed for export. Between 2000 and 2001 the amount of land under shrimp production increased by 97% to 446,208 ha, with an average yield of 0.36 ton/ha[3]. Expansion of the industry is being promoted as part of a government strategy to increase the seafood export target to US$ 3 billion. The Ministry of Agriculture and Rural Development plans to increase the total area of shrimp cultivation to 500,000 ha and increase production to 300,000 tonnes by 2005 (Environmental Justice Foundation 2002)[4]. The government has estimated that Vietnam's current marine aquaculture capacity is only reaching half of its potential for development. Thus Prime Minister Plan Van Khai recently called on the fisheries industry to launch a new drive to boost quality, with a view to reaping US$2 billion in turnover in 2002 and raised the seafood export target to US$3 billion for 2005[5]. Official support for the expansion of shrimp culture has taken the form of preferential taxation and supply of credit and large low-interest government loans for shrimp farmers, as well as heavy investment in related infrastructure and extension services. For example farmers in Soc Trang were offered capital boosts of VND 18-20 million (approximately $1200-1333) per Ha and unsecured loans of up to VND 50 million (US$ 3333) to encourage conversion of their land to aqucaulture (Environmental Justice Foundation 2002).

Vietnam's main international export markets are the USA, Japan and EU, with some export to Africa, although Vietnam is currently seeking new export markets. In the first 5 months of 2002 Vietnam's seafood exports to the EU fell by 51% in value (Environmental Justice Foundation 2002). This slump is widely believed to be due to the detection of chloramphenicol residues in Vietnamese shrimp. In 2002 European media reported a ban placed by the EU on seafood exports from a number of Asian countries, including Vietnam, as a result of residues of chloramphenicol being detected in seafood products. Choramphenicol is a wide-spectrum antibiotic used to treat bacterial meningitis and typhoid, but which some scientists have linked to childhood leukemia. Farmers often buy antibiotics from feed suppliers to treat infections in the pond, often with limited knowledge about the effects or appropriate use of the antibiotics. On 25th February 2002, Prime Minister Plan Van Khai issued an instruction demanding that the Ministries of Agriculture and Rural Development and Fisheries ban the use in food of any chemical banned by the EU and USA. To date this ban includes ten antibiotics and chemicals for use in the breeding, raising and processing of seafood. Billboards can now be seen in most shrimp farming communes announcing the list of banned chemicals.

However, the EU ban on seafood imports from Vietnam in 2002 and the resultant slump in the value of shrimp exports demonstrates the extent to which the livelihoods of shrimp farmers in the Mekong Delta are vulnerable to the whim and will of global trade

---

[3] Asia Pulse Ltd 2001. *Vietnam Shrimp Farms a Key Part of Fisheries Five Year Plan*. Asia Pulse Limited, 20 February 2001

[4] Le Quang Minh, 2001. 'Environmental Governance: A Mekong Delta Case Study with downstream Perspectives' in N. Bademoch and M. Dupar (eds) *Mekong Regional Environmental Governance: Perspectives on Opportunities and Challenges*. Workin Papers of the REPSI Mekong Regional Environmental Governance and Research Dialogue Group. Chiang Mai, Thailand.

[5] Asia Pulse Ltd, 2002. *Vietnam FisheriesSector Steps up Effort to Improve Qualit*yy. Asia Pulse Limited, 16 July 2002.

structures and market trends. Research on household level farm management and AAH strategies often neglects this broader picture. The impact of farming techniques and technology transfer are often viewed through a narrow lens which fails to look beyond the localised structures of 'the farm' and 'the village'. Such a view neglects the dangerous dependency of shrimp farmers in the Mekong Delta on the trends, fluctuations and whims of the global seafood market. The intensification of shrimp aquaculture in the Mekong Delta, as promoted by government policy, is supported by scientific research, development and transfer of increasingly sophisticated farming technologies to boost production. Such technology transfer programmes have a tendency to neglect both the long term social and environmental impact of such technologies, and the extent to which the expansion and intensification of shrimp farming to meet export targets, serves to increase the dependency of rural households in the Delta on uncertain and unpredictable global trade patterns and market trends. This increases the vulnerability of households whose livelihoods depend completely on shrimp culture.

This study demonstrates how, while shrimp aquaculture has had a significant impact on poverty reduction and the improvement of livelihoods for some households, due to the high levels of risk inherent in shrimp farming, it seems, at the same time to have led to increased socio-economic disparity, increasing conflict over resource and land use and decreasing shrimp and agicultural yields due to over-salinization of the land. Despite optimistic visions of aqauculture as a panacea of development and poverty alleviation, shrimp farming is capital, rather than labour intensive. Shrimp farming provides a small number of well-paid jobs for technical experts and a small and sporadic number of low-wage jobs for unskilled local workers particularly around harvest time or in pond construction. Nevertheless, shrimp processing plants have provided jobs for thousands of workers in the lower regions of Vietnam, particularly the provinces of Soc Trang and Ca Mau. However recent studies have highlighted the poor conditions and low pay of workers in processing factories, arguing that the shrimp industry has displaced people from their land, resulting in a growing number of landless poor who are forced to sell their labour cheaply to an unsustainable industry (Environmental Justice Campaign 2002).

Furthermore, although Vietnam's shrimp industry is currently dominated by small producers, as Martinelli points out 'it presents an attractive target for transnational agribusiness companies, such as Thailand's CP Group, seeking to expand sales of inputs such as feed and fertiliser'. Martinelli goes on to highlight the experience of the shrimp industry in Thailand where, 'after several decades of intensive shrimp production dominated by this vertically-integrated conglomerate (CP Group) which controls all stages of the input, production, processing and marketing chain, the shrimp industry is characterised, not only by massive and widespread environmental degradation, but significant social dislocation' (Martinelli 2000) as small-scale farmers have been displaced from their land by industry giants who have set up large-scale intensive enterprises across Southern Thailand.

A number of studies have indicated that many of the negative environmental and associated social impacts of shrimp farming are directly related to inadequacies in current farming practices and the process of intensification of shrimp aquaculture. Responses to this situation have therefore concentrated on technical solutions such as promotion of improved production techniques (particularly with respect to improved AAH management) and accompanying initiatives devoted to greater education, technical support and technology transfer. However this study indicates that there is an urgent need to refocus attention on land-use planning and regulation of farming practices to prevent intensification of shrimp aquaculture. For Vietnam, it is therefore, crucial that lessons are learnt from the experiences of other countries, particularly those of the Phillipines, Thailand and Taiwan, where the shrimp industry has suffered periodic collapses due to over-intensification causing degradation of land, pollution and outbreaks of aquatic animal disease. This involves both broad and localised strategies which promote the sustainability of the industry, reducing the negative social and environmental impacts of shrimp culture.

This study demonstrates that, while the environmental and social impacts of the intensification of shrimp farming are felt across the board, poorer farmers, are much more vulnerable to the effects of environmental change, due in a large part to their restricted access to institutional support, resource endowments and alternative livelihood strategies. This study therefore highlights the need to consider the way in which the 'impact' of AAD and the corresponding AAH strategies for coping with disease differ according to a wide spectrum of characteristics, phenomena and processes which heighten or reduce levels of vulnerability over time, not least because the technological and institutional factors which shape vulnerability and resilience are themselves in, what Adger and Kelly refer to as a 'state of constant flux' (Adger and Kelly, 2001).

This study, therefore, takes vulnerability as a more appropriate framework of analysis than the conventional focus on poverty. The state of social and economic vulnerability does not equate directly to the level of poverty or any other single characteristic of an individual or group as there are many diverse factors that contribute to a household's level of vulnerability and their capacity to respond to risk. Indicators of vulnerability include poverty, marginalisation, access to resources and market structures, resource dependency and diversity, inequality and access to institutional structures for enhancing resilience (Adger and Kelly 2001).

2.2 The Institutional Context: Aquaculture Research and Technology Transfer

Over the past two decades aquaculture has come to be seen as a panacea of development, with the potential to deliver economic growth, food security, livelihood sustainability and also a solution to decreasing wild fish stocks. This vision has given rise to a great number of research projects and intervention strategies dedicated to the promotion and development of aquaculture. The potential of aquaculture to contribute to poverty reduction and improve the sustainability of rural livelihoods has been a focus of national and international development planning and policy-making for over two decades. Concern about food security and access to reliable sources of nutrition for poor rural households, and the potentially high market price of fish have underpinned the host of projects and loan schemes devoted to the promotion of small-scale aquaculture which has evolved over the past fifteen to twenty years. The national interest in aquaculture reflects the trend in development thinking over the past two decades, which has elevated aquaculture as a catch-all solution to problems of low income, vulnerability, lack of nutrition, food-security and declining wild fish stocks worldwide. The movement hailed as the 'blue revolution' generated massive funding and support for aquaculture development research and intervention projects across Asia, Africa and Latin America.

The development of shrimp farming as a commercial industry in Vietnam has been supported by the Vietnamese government (see figure 1), research centres, and international donors and agencies, who have hailed it as a major source of revenue both for the national economy and for individual households. Concern for the ecological implications of intensive commercial shrimp farming has grown and produced a number of interesting studies focused on the environmental question. As the shrimp industry has experienced significant growth in production levels, it has generated enormous revenue for a number of groups within the Asian agricultural sector. The transformation of shrimp farming into a global industry controlled, to a large extent, by multi-national corporations, has been behind the striking increase in research in the field of shrimp aquaculture. The areas of research that dominate the industry, as well as government and international interest in shrimp farming, are disease, feed, pollution and, to a lesser extent, a range of issues raised by 'green' groups. The role of technical research and institutional support for the shrimp industry and its social impact are discussed more fully in the literature review (Rajak 2002).

Mass media channels of communication such as television have been also mobilised in the service of the shrimp industry as farmers receive technical advice from television programmes sponsored by feed and chemical companies.[6] The programmes are designed to follow the production cycle covering issues such as, preparing and stocking the pond, and problems that arose during the previous production cycle. During the cycle programmes focus on key issues such as, feed management, disease control and prevention, and harvest. The programme's have an interactive format which allows farmers to phone or write in with questions and problems to be answered by the technician or researcher presenting the programmes. Both private corporations and government departments enlist the service of researchers at research institutes to provide the content of technical advice posters, newsletters and, TV and radio programmes. TV programmes are broadcast on a national TV station at times appropriate to farmers, usually either early morning or early evening[7]. In this way direct channels of dissemination exist between the research centres and the sources of mass media providing information to the farmers.

Thus shrimp farming benefits from a high level of national and international, as well as public and private sector, interest in finding solutions to AAH problems which threaten the shrimp industry. This has resulted in a sophisticated framework of 'scientific

[6] There is concern in the research community about the neutrality of technical strategies and advice on best practice for shrimp farming being filtered through a framework of corporate sponsorship.
[7] For a discussion of radio and television as a tool of extension for small-scale freshwater aquaculturalists see Section 5.3.

services'(Burch *et al* 2000: 517), including research, technical support and extension, and diagnostic services, available to large numbers of farmers involved in the shrimp industry and provided by national governments, multi-national corporations (such as The CP Group), and supported by regional and international research and management initiatives. By contrast, in-land small-scale aquaculturalists have been sidelined in the provision of adequate extension services, adaptive research programmes and the transfer of viable management strategies and technologies that focus on meeting the needs of poorer households, in favour of shrimp farming which demands much greater input of capital and time, as well as, 'Green Revolution' kinds of technologies and the commercialization of land and labour.

Growing fears concerning the impact of intensive shrimp farming, following the collapse of the the shrimp industry in Taiwan in 1988, due, to a large extent, to disease (Bort, Ovares and Stonich 1997: 165), have inspired a number of studies on the environmental issues surrounding shrimp farming (see, for example World Bank *et al* 2002; Bort, Ovares and Stonich 1997; Boonyaratpalin 1996; Barraclough and Finger-Stich 1996). Nevertheless, the social dimensions of shrimp farming continue to be largely neglected, or tend to be dealt with in a superficial or simplistic manner. As the focus of a high level of international criticism concerning environmental impacts and the commercialisation of land and labour, literature and research on shrimp farming in South East Asia tends, often, to fall into one of two polarised camps – the critics and the defenders. The result is that, often times, studies which examine the socio-economic and environmental dimensions of shrimp farming become vehicles for the expression of particular environmental politics or economic interests. Complex social realities are reduced to simplistic and superficial pictures used to serve a particular side of this polemical debate. On the one side there is a tendency to cast all shrimp farmers, as large-scale entrepreneurs, who pollute the surrounding environment and alienate small-scale farmers from their land. The reality is very different. The shrimp industry is made up of a wide spectrum of actors from multinational companies (the most famous being Thailand's CP Group) to small-scale rural farmers who, motivated by the potentially high profits offered by shrimp farming, have switched from rice farming to shrimp farming, a high risk enterprise upon which livelihoods are precariously balanced between high earnings and financial ruin.

Projects, spurred on by the bold claims made on behalf of aquaculture, have at times failed to disaggregate those various claims. In so doing they fail to clearly identify the supposed targets of research or the apparent beneficiaries of intervention strategies. For the most part, these projects have been primarily concerned with the production and delivery of tangible, physical outputs and technical strategies. The socio-economic dimensions of aquaculture have, to a large extent, been overlooked. Research in the field of aquaculture and development has been, and continues to be, dominated by bio-technical concerns and interests, while socio-economic considerations are ssen as obstacles to be overcome or managed in the process of technology transfer. Crucially, we are only now beginning to ask key questions such as: Who is benefiting from aquaculture technologies? What impact has technical research and intervention strategies had on the livelihoods of farmers? Is the goal of technical research to maximise productivity or to reduce poverty?

One reason for the relative paucity of socio-economic studies of shrimp farming in South East Asia over the past decade has, arguably, been the dominance of technical and macro-economic paradigms of development. Due to the large export revenues earned for the Vietnam economy from shrimp exports, the shrimp industry has been prioritized as the focus of institutional and technical support. As a result, shrimp farming has monopolised resources devoted to the development of Asian aquaculture and given rise to a host of national, regional and international research projects and extension programmes that support the industry. This support has focused on increasing production levels to meet government targets, through technological innovation and transfer. The poverty reduction and sustainable livelihoods agenda has, for the most part, been subsumed within this focus on increasing production and industry growth at the macro level.

During the last five to ten years, the importance of disseminating information and strategies generated by research has gradually received greater recognition and integration into research frameworks and projects. However, technical research programmes and projects have, for the most part, failed to address the other end of the research-dissemination process: **reception**, **uptake** and **impact**. Only very recently have projects begun to respond to the need to integrate 'impact assessment' into the original design of projects and the framework of programmes. For, while it is somewhat easier to track the ways in which information leaves the research institute and in what direction, the question of how it is received and used by farmers, and what impact it has on the overall livelihoods of households is far more slippery and intangible. The situation appraisals therefore aimed to focus on these complex issues of 'reception', 'uptake' and 'impact' and to investigate the ways in which farmers interact with the institutional framework of research, dissemination and extension through which AAH strategies are communicated.

In Vietnam, research concerned with the development of aquaculture takes place at government research institutes and stations. An increasing amount of research, development and technology transfer initiatives is being conducted in private faciltities as part of the research and development plans of multinational corporations involved in the production of agro-chemicals and feed. Companies such as the CP Group involved in all levels of the shrimp industry produce their own newsletters monthly. For shrimp farmers, monthly magazines, heavily sponsored by private companies, and sold commonly for roughly the whole-sale price of about half a kilogram of shrimp, are available to those farmers who can afford them. These provide current information on the shrimp cycle, new strategies, technical innovation, information on the state of the market and promotion of various products. However, the focus of such privatised research and dissemination programmes has been, and continues to be, dominated by bio-technical concerns and interests and, tends to focus on semi-intensive or intensive culture models rather than the improved extensive systems farmed by poorer farmers. The primary target of technical research in the field of aquatic animal health, has, in the past been commercial aquaculture and not small-scale rural farmers:

> 'In the past, research was focused on export commodities, the development of

> large-scale operations and technologies for improving fish harvesting capacity. Training and education has largely been devoted to these areas' (World Bank 1991: 28).

This is reflected in the activities of government research institutes which, directed by government interest in export revenues, tend to focus greater resources on research, diagnostic services and health certification processes that support the production of export-orientated aquaculture, such as shrimp farming.

Government-supported research institutes, such as the Research Institute for Aquaculture 1(RIA1) in Hanoi and the Research Institute for Aquaculture 2 (RIA2) in HCMC, occupy a central position in the system of research, dissemination and extension that supports the development of small- and large-scale aquaculture in Vietnam. Institutes, such as the RIA2 in HCMC, have extensive and highly effective research and dissemination channels and training activities, which have had a significant positive impact on AAH management and disease control in shrimp and fish farming. Information on the role of research institutes in developing and disseminating AAH strategies to shrimp farmers is detailed in a separate analysis of the flow of information from and to the institutes which should be read in conjunction with this report. The aim of such support activities, is not only to disseminate technical AAH strategies, but also to bring together actors from different levels of the industry, so strengthening ties between hatcheries, farmers and processing companies. The farmers' training seminars are seen also to be arenas in which farmers can communicate problems and issues affecting them back to the research centres, so ensuring the flow of information both 'up and down stream'[8]. However, many recent studies of the research-dissemination-extension relationship have been critical of the way in which extension materials produced by researchers 'in the lab' or at national centres for training and extension can tend to be overly scientific or inappropriate in meeting the needs of farmers. Research questions and the focus of extension materials are often generated in the lab or office, rather than on the farm (Rajak 2002). Primary problems in production identified by scientists or civil servants, can turn out often not to be major concerns of farmers and vice versa.

2.3 Shrimp Farming in Southern Vietnam

According to the Provincial Fisheries Extension Officer, 48,000 Hectares of land are currently being used for aquacultural production in Soc Trang Province in which the second case study was located. 38,000 out of the total 48,000 Hectares are under Penaeus Monodon culture, with the remaining 10,00 divided between, fin fish (5,200 Ha); Macro Brachium, freshwater shrimp, (100 Ha); crab (225 Ha); Artemia, live feed for shrimp culture (137 Ha); and natural extensive aquaculture (4,200 Ha). The vast majority of farmers in the two study areas (Hoa Tu I and Thanh Quoi) in Soc Trang Province practice an integrate model of rice-shrimp farming. Unlike the semi-intensive or intensive shrimp farming that has become popular in Can Duoc in the last decade, the more extensive rice-shrimp model is believed to offer the best possibility for sustainable shrimp production, minimizing its environmental impact. It does not, however, offer the same dramatic rise

[8] Greater detail on the flow of information from the research institute is provided in the institutional analyses conducted as part of this project.

in productivity demanded by government targets for the shrimp industry. The total area of land under rice-shrimp cultivation in the Mekong Delta was around 40,000ha in 2000 with an estimated annual production of 10,000 MT of shrimp and 100,000 MT of rice. Shrimp farming in these areas in generally practiced according to an extensive culture model, where shrimp are stocked at low densities and inputs into the pond are relatively low. In the rice-shrimp culture model, rice fields have been reconstructed with a trench and dyke around the perimeter of the field. At the start of the shrimp season, when water in the local canal system has become saline, the trenches are filled and the entire field is flooded with saline water suitable for shrimp production[9]. At the beginning of the wet season, the combination of rainfall and fresh water from the river are used to flush the fields of residual salinity, before the rice crop is planted. Most farmers stock with *Penaeus Monodon* (see Figure 2), a species that is not locally abundant. Most of the farmers in the study added supplementary feed (most commonly manufactured feed) and chemical inputs into the pond to boost production levels.

Figure 2 Vietnamese Shrimp Species[10]

Four species dominate Vietnamese shrimp production:
Machrobranchium Rosenbergii – A freshwater species
Metapenaeus Ensis – The Greasyback Shrimp, a brackish water species, exploited from the wild rather than being farmed
Penaeus Merguiensis – Initially popular, this species, the Banana Prawn, is easy to breed but difficult to grow out after reaching 20g. Due to tts intolerance of extreme salinity fluctuations that occur in Vietnam it has largely been abandoned
Penaeus Monodon – The Black Tiger Shrimp has better growth rates (almost directly proportional to duration of culture) and copes better with salinity changes. this is now the species of choice for most shrimp farms. However, the high salinity (15-30ppt) required by this species means that in the Mekong Delta this species can only be cultivated in the dry season.

The freshwater rice crop provides ‘a buffer between the brackish water shrimp crops’ (Brennan *et al* 2002). Empirical research suggests that alternating between rice and shrimp negative environmental impacts that results from intensive shrimp farming and which ultimately can lead to the collapse of production due to over-pollution of the land. As brennan *et al* state, the rice-shrimp system, in common with other extensive systems, offers a more environmentally sustainable approach to shrimp farming. In so doing it provides a more sustainable livelihood to households. For, while the integration of dry

[9] Saline intrustion is a naturally occuring phenomenon which impacts on the land’s productivity even in the absence of shrimp culture. In general the saline intrusion means there is only sufficeint time to grow one rice crop per year, though in the districts closest to the coast, early saline intrusion (an early dry season) can also mean that the wet season crop is affected towards the end of the growing cycle, because canal water is too saline for irrigation. nevertheless, as Brennan *et al* point out, ‘the practice of shrimp culture exacerbates the limited cropping cycle because farmers delay in order to wait for rains to flush the salts from the soil after the shrimp phase. This increases the risk that the canal water will be salty before the rice crop has been harvested’ (Brennan *et al* 2002).
[10] Wade, H. *et al*, 2002. *Preliminary Overview of Shrimp Aquaculture in Vietnam*. International Marine Life Alliance (IMA), Hanoi, Vietnam.

season shrimp farming into rice fields has raised incomes dramatically over several consecutive seasons for many households in the area, this has also resulted in the intensification of culture systems in order to boost earnings further. crops allows the land to 'recover' and that the influx of saline water drying the dry season does not appear to lead to a long-term build up of salts in the soil which would reduce rice yields (ibid). Thus, rice-shrimp culture is seen to mitigate many of the

Setting up a shrimp farm or hatchery is a very capital intensive enterprise. Most small to medium scale farmers in the Mekong Delta who have done so, therefore depend heavily on credit from both formal and informal sources. However obtaining information on informal systems of credit is problematic (see Section 4.4). Equally, assessing wealth is not straightforward, as indicators such as the state of housing or accumulation of material goods might point at a certain stage of the development cycle or a household rather than its actual wealth. Due to the high levels of risk involved in shrimp farming household incomes fluctuate dramatically from cycle to cycle. Indictors such as state of housing and material goods, used in conventional wealth-ranking assessments can therefore often mask heavy dependence on credit and loans and are more indicative of a short term increase in household income due to a successful crop in the previous cycle than an improved and sustainable livelihood. Furthermore, Small-scale farmers do not have the same capacity to absorb losses due to prawn diseases as larger companies. In the Mekong Delta a large number of farmers have been forced to abandon their shrimp farms due to persistent losses due to disease and poor health in the pond, making huge financial losses and frequently leaving them saddled with large debts which they are unable to repay. Others find themselves trapped in a viscous circle of having to reinvest their income in an attempt to at least recover the initial investment. In order to do so, however, they are reliant on more loans or credit to cover the cost of shrimp hatchlings, feed and chemicals. Increasing prices for inputs from the international market and high interest rates, particularly from informal sources of credit, further aggravates the situation. In times such as this, when diseases are widespread, shrimp farming becomes a lottery. The hatcheries are also affected by these collapses as demand for post-larvae decreases.

Within the shrimp industry the periodic failure of productivity due to disease are, arguably, the consequence of lack of management and regulation combined with a lack of technical expertise on shrimp farm management. However, small-scale shrimp farms might not only have a greater part in aggravating the situation due to their unregulated nature, but are also the most vulnerable to the effects of disease. Few have the capacity to absorb losses, and many households in the Mekong Delta have been hard hit by losses. Thus in contrast to some of the research and recent campaigns (see for example, Environmental Justice Campaign 2002), small scale shrimp farmers in the Mekong Delta are as much victims as agents of environmental degradation.

Although most farmers claim that their knowledge is based on their experience, the latter is often limited. Technical knowledge often stems from a combination of hearsay and the advice of agents of agrochemical companies. This has consequences for the use of agrochemicals. Many people determine the amount needed through a system of trial-and-error. Others simply copy their neighbours. The result is likely to be overuse which is not only economically inefficient and potentially harmful to the crop, but may result in longer term damage to the environment which will ultimately reduce productivity on the farm and beyond.

This report argues that the biggest challenge remains the threat of intensification of shrimp farming through the Southern regions of Vietnam. There are a number of contradictory voices over the question of intensification. Researchers at government research institutes spoke strongly of the need to limit intensification and avoid the possible environmental degradation and collapse of the shrimp industry experience in Thailand and The Philippines. However, while government policy continues to explicitly encourage and support the expansion and intensification of shrimp aquaculture to meet increasing production targets (see Figure 1), the Vietnamese government has simultaneously called for shrimp aquaculture development to be carefully planned and has encouraged diversification of livelihoods and integrated farming systems which preserve the ecological balance in order to reduce the risk of an industry collapse. However intensive and semi-intensive shrimp culture is not compatible with a diverse or integrated farming system. The majority of shrimp farms in the Southern regions of Vietnam are small-scale household enterprises for whom shrimp farming is their major, and in some cases, only livelihood activity. The capital required to invest in shrimp culture, means that households have little option but to devote most, or all, of their resources to their shrimp ponds. Furthermore this study found that in many cases, rice fields have been converted to shrimp ponds in such a way that prevents farmers from integrating rice farming with shrimp culture or returning to rice cultivation if their shrimp farm should fail. This leaves farmers with a dangerous and potentially unsustainable dependency on shrimp culture.

SECTION TWO

VIEW FROM THE FARMS

3. Managing the Farm

3.1 Stocking the Pond

Two major problems have confronted farmers throughout the Province of Soc Trang: the limited availability of good quality seedstock and disease. The growing number of shrimp farmers in the hamlet put even greater pressure on the dearth of good quality seedstock in the area. However, in response to this problem, the provincial DoF organised training workshops in the My Xuyen area for farmers who wanted to set up nurseries for seedstock with which to supply farmers in their local area. This project was again run over 3 years, during which 7 courses were held for farmers and over 400 farmers trained in nursing seedstock. Mr Nguyen Van Tuan, a farmer in the hamlet of Huynh Tham in Thanh Quoi, was one of the participants and, in 2001, following the exam at the end of the course, received the necessary certification from the DoF to establish himself as a nursery farmer and seed supplier (though, he added, that many seed suppliers do not have the necessary certification, pointing to the need for tighter regulation). He now supplies almost all the farmers in his hamlet with seedstock. Many of the households have insufficient capital, so buy seedstock from him on credit at the beginning of the cycle. However, Mr Nyuen Van Tuan echoed the concerns of numerous farmers, seed suppliers and extension officers involved in the study, as he explained that in recent years, increasing numbers of farmers were unable to repay the credit he gave them as their crop had been wiped out by disease. Mr Nguyen Van Tuan, said that he and the other farmers involved in the project to promotes shrimp culture, enjoyed successful harvests for the first three years of shrimp farming. The following year, the first year without the technician present in the hamlet to monitor and advise during the culture period, the first serious outbreak of disease was observed. Mr Nguyen Van Tuan indicated that one the problems was the gap between strategies and techniques designed by scientists in the lab and the realities and conditions faced on the farm:

> *'I've attended so many courses through the years, I've been in the lab where they showed us how disease is transmitted, but lab conditions are very different to conditions on the farm and so we need someone to come and demonstrate here, at our farms.'*

In their study of rice-shrimp farming systems in the Mekong Delta, Brennan *et al* indicated a number of key constraints that need to be addressed in order to improve the environmental and economic sustainability of shrimp farms. These concentrated on the inadequacies of current farming techniques such as the traditional practice of recruiting native shrimp species through water exchange which is believed to be unsustainable due to the attendant built up of sedimentation on the farm. The more recently-adopted system of stocking with hatchery-reared postlarvae, combined with low water exchange, reduces the incidence of disease and the build-up of sedimentation, but is constrained by the limited availability of healthy postlarvae. Thus Brennan *et al* view the current lack of investment in technology for improved health screening and domesticated seedstock production techniques as critical constraints to the sustainability of the rice-shrimp system (Brennan *et al* 2002). Siting a recent study by Walker *et al*, Brennan *et al* state that 'recent viral screening of *P. monodon* postlarvae from hatcheries in the Mekong Delta indicated that the prevalence of infection with yellow head complex viruses was in excess of 50% (Brennan *et al* 2002).

This supports the findings of the case studies in My Xuyen and Can Duoc, which indicated that low quality of postlarvae is one of the primary concerns of shrimp farmers in the area, many of whom perceive this to be primarily responsible for decreasing production levels. Farmers further indicated that the problem was compounded by shortages of *P. monodon* seedstock (postlarvae) throughout the Mekong Delta shrimp farming areas. This means that most of the *P. Monodon* postlarvae sold to farmers in the Mekong Delta region have been transported for several hours by road from hatcheries in Khanh Hoa Province in Central Vietnam. This is believed to place the seedstock under increased physical stress weakening them before they even reach the ponds of farmers in the Mekong Delta. A Fisheries Resource Protection Office has been established for the purpose of testing seed stock and ensuring that it reaches government standard. However the majority of farmers in Soc Trang stated that poor quality seedstock was one of their major concerns, requesting that the government should be much more rigorous in their testing procedures. This highlights the need for improved institutional capacity for monitoring and screening seedstock, as well as the promotion of hatchery technologies in the Mekong Delta so that farmers do not have to rely on seedstock transported for several hours from hatcheries in the central provinces.

In Soc Trang Province, the Department of Agriculture regulates the stocking schedule and prohibits seed suppliers from selling seedstock or farmers from buying seedstock outside the specified stocking period. Due to seasonal change, early stocking has been seen to increase the risk of disease outbreaks, which then spread rapidly when farmers release infected water into the canals at the same time as other farmers are preparing their ponds for stocking. However, according to a number of farmers and members of the People's Committee in the province, despite the threat of a fine if caught, these regulations are very difficult to enforce and are therefore transgressed by both farmers and seed suppliers in the Province. Mr Thanh An, a farmer in Hoa Tu I and member of the People's Committee, estimated that, despite the frequency of disease outbreaks on farms stocked early in the season and consequently high rates of failure, around 30% of farmers stock their fields before the stocking date stipulated by the DoA.

These technical problems have serious financial repercussions for farmers. Due to the high price of seedstock, most small-scale farmers buy postlarvae on credit or with formal banks loans. For example, the cost of stocking a shrimp pond in My Xuyen in 1997 was 3.6 million VD, which is three times the net cash income earned from the rice crop (Brennan *et al* 1999). Our study indicated that these prices have risen steadily since 1997 to prohibitively high prices, making shrimp farming both an extremely capital-intensive and highly risky venture for poorer farmers. If credit or bank loans are unavailable they are forced to seek loans from high-interest informal sources (known as 'hot loans'). Farmers rely on a good harvest to repay loans or credit from the seed supplier. When losses occur poorer farmers are unable to repay the loan and often have no choice but to borrow more money in order to re-stock the pond and hope for a better harvest, so entering into a spiral of debt.

The case study in My Xuyen revealed the emergence of patron-client relationships between individual 'suppliers' upon who supplied pockets of shrimp farmers with seedstock transported from hatcheries in Central Vietnam, manufactured feed and chemical inputs for the pond. These suppliers commonly acted as also as traders buying back the harvested crop from farmers to sell on the processing factories. In this way their clients were completely dependent on them at every stage of production. One such supplier said that he supplied 'his familiar customers' with seed, feed and chemicals on credit saw it as a form of 'informal investment in their farms':

> *'Most years 60-70% of my farmers are successful, but this year many more have failed because of disease, I give advice to them on how to prevent disease but sometimes there's nothing anyone can do. But when they fail and can't pay back the credit I've given them I have no choice but to give them more seedstock to try again or I won't get my money back'*.

Networks such as this, can provide farmers with vital financial and technical support. At the same time they can also create potentially dangerous relationships of dependency, which can be manipulated at times to the disadvantage of farmers who find themselves obliged to sell their harvest to their 'supplier'. Nevertheless, such suppliers have close contact with a large number of farmers, are involved in every level of production and thus have invaluable knowledge of the challenges faced by farmers. Their pivotal role therefore provides the extension service with an opportunity to extend its reach and increase its understanding of farming practices and problems. Ways of mobilising into the service of extension, providing them with training and materials, and regulating the advice they provide to farmers should be explored.

3.2 Disease and Health Management

One of the characteristics of shrimp farming is the high risk of shrimp mortality from disease. Throughout Asia, the shrimp industry has suffered periodic collapses. At a macro level, the industry is often seen to be defined by 'boom and bust' cycles. At a household level, farmers are at risk of potentially devastating losses that can result in financial ruin due to the high capital investment (seedstock, feed and chemical inputs) required by shrimp farming and the risk of poor survival rates of their crop. This study indicated that in certain parts of the Mekong Delta such losses are already being felt by farmers, some more severely than others. This is supported by other studies which have demonstrated decreasing production levels in other areas of the Delta (see for example, Tran and Hiep 2000 and Brennan *et al* 1999). This is particularly the case for areas where shrimp culture has become the dominant activity for a number of years and where farming practices have become increasingly intensive (this is discussed further below with respect to the comparative levels of infection in the two study areas, Can Duoc District in Long An Province and My Xuyen in Soc Trang Province).

While semi-intensive or intensive culture models promise high returns quickly, all the evidence points to decreasing production levels and, potentially, total collapse in the long-term. Thus the rice-shrimp farming system, favoured by farmers in the study sites in My Xuyen District, offers relatively better financial security and livelihood sustainability for households As farmers become more experienced in shrimp culture there is a tendency to intensify. As a result of decreasing productivity in some areas, the potential for greater earnings and encouraged by government strategy for increasing export targets shrimp farmers have increasingly intensified their modes of culture. During the course of this study a great number of farmers asked the researchers for information of techniques to further intensify their operations in the hope of boosting production. This is supported by recent research that found that:

> *'With limited annual yields of 100-200kg/ha, improved extensive aquaculture began to give way in the late 1990s to more intensive production. Yields increased to 3000-4000kg/ha, with occasional Black Tiger Shrimp yields of 5000kg/ha being recorded. Most farms in Central Vietnam have now adopted intensified systems while those in Northern and Southern Vietnam continue to practice a variety of semi-intensive systems. A recent study found that 90% of shrimp farmers in Northern Vietnam, and over 50% of farmers in Southern Vietnam intended to further intensify their production' (Environmental Justice Foundation 2000)*

The movement towards increasing intensification is served and facilitated by increasingly an increasingly sophisticated world of scientific research, development and technology transfer geared towards increasing productivity and funded by nationally and internationally by both the private and public sector. Contradictory messages are evident between explicit discouragement of intensification of shrimp production and warnings of the danger of environmental collapse and the pressure to meet optimistic government targets for increasing shrimp production dramatically in the next few years. These contradictions are manifest not only at the level of national government policy, but at the local level. Thus, while the Chairman of the People's Committee in on of the communes in Can Duoc District stated that:

> *'Only a few farmers do intensive shrimp farming, the commune discourages it, we encourage one crop of rice and one crop of shrimp in order to preserve the eco-balance,'*

According to the case study, 60% of farmers in the area describe their farms as intensive or semi-intensive. This is clearly visible from the proliferation of aerators in ponds in the Can Duoc area (see Plate 4). Aerators are generally used on semi-intensive and intensive farms to help regulate the oxygen, particularly during the early morning and evening when the oxygen levels are reduced or reducing.

Intensive culture systems are neither environmentally nor economically sustainable and the socio-economic impacts of such intensification are already being felt by farmers in the Mekong Delta in the terms of increasing outbreaks of disease. Attempts to combat white spot epidemics and reduce the spread of infection through regulation of farming practices have been instituted in communes throughout the Southern Regions of Vietnam. Such attempts take the form of posters which can be seen in most hamlets giving basic advice on disease prevention and control, as well as legal mandates from the District People's Committee such as the *Instruction Concerning Epidemics and Environemntal*

Management for Penaeus Monodon Culture in 2003 from the Can Duoc District People's Committee issued on 17th January 2003 (see Annex 3). Instructions such as these prohibit the disposal of infected shrimp carcasses and the release of water from infected ponds and sediment into communal water sources – activities believed to be the key causes of the rapid spread of white spot and yellow head epidemics throughout neighbouring farms. The instructions also specify a set period for pond preparation and stocking (for example the Can Duoc Instruction for 2003 stipulates that this period should not exceed the 15th January 2003). In the event of failure of the crop, removal of sludge, pond preparation and re-stocking for a second cycle while other farmers are still mid-cycle with their first crop is also prohibited. Furthermore, in the event of an outbreak of disease in their ponds, farmers are instructed to inform the local government office and appropriate organizations (ie the extension office) in order to receive appropriate advice of disease treatment and containment of the infection to prevent it spreading (See Annex 3).

While these instructions explicitly state that transgression is punishable by law, the study revealed that local government institutions have neither the capacity nor the resources to monitor farm management practices and enforce these bans accross so large an area and so many farms. Thus farmers in both Can Duoc and My Xuyen reported that farmers continue to dispose of diseased shrimp and release their ponds into communal canals and waterways; that most farmers will try a second cycle of shrimp if their first crop fails; and that stocking schedules continue to be unharmonised with a number of farmers chosing to stock early in the hope of buying postlarvae for a reduced price and selling their harvested shrimp for a higher price. This points to the need to shift resources from technical research and the production of more technical AAH strategies to improving the institutional capacity of both local government to regulate shrimp farming practices, and farmers groups in order to promote co-management and cooperation between farmers.

Case Study: The Hamlet of Thanh Hoa in Thanh Quoi Commune, My Xuyen District, Soc Trang

The remote hamlet of Thanh Hoa in Thanh Quoi Commune is accessible only by boat. According to Mr Tran Van Dien, the head of the hamlet, of the 190 ha of land in the hamlet are under shrimp cultivation, 100Ha have already 'failed' *this year. In other terms, of the 162 households in the hamlet who practice shrimp farming, 90 have lost their crop to disease this year. The farmers of this hamlet began shrimp farming in 1992, when many began to integrate shrimp farming into their rice fields. Shrimp farming has now replaced rice farming as the primary livelihood activity in the hamlet. The advent of shrimp farming resulted in a dramatic rise in living standards in the first 5 years. According to the head of the hamlet* 'since shrimp farming began many households have built new houses and bought TVs, but most households also have more loans from the bank as well and there is much more debt'.

Until 1995, roughly 50% of households rotated one crop of shrimp with one of rice, while the other 50% attempted 2 crops of shrimp and one of rice. However since 1995, shrimp farming has gradually intensified and the majority of households now cultivate two crops of shrimp and one of rice per year. According to Mr Tran Van Dien, before 1998-1999 there were no disease outbreaks in the shrimp farms of the hamlet, some farmers reported low survival rates of postlarvae but this was uncommon and attributed to poor quality seedstock. In 1999-2000 outbreaks of white-spot disease affected about 10% of farms in the hamlet and in the past two years severe epidemics of white-spot have broken out, usually only one and a half months after the stocking period. Mr Tran Van Dien explained that before 1995, most farmers practiced improved-extensive shrimp farming, the stocking density was low, they did not use lime or chemical in the pond and they fed their shrimp home-processed feed. Input costs were low but the profits were good. In recent years, investment costs have increased more and more, as farmers have intensified their operations stocking high densities, buying manufactured feed, chemicals and vitamins, and yet profits have decreased, as the incidence of disease increases.

Mr Tran Van Dien stated that these disease outbreaks have had a 'severe impact on the livelihoods of farmers in this hamlet, some cannot afford to re-invest and stock their ponds again, the seed supplier offers them postlarvae on credit but then they are in even more debt, some don't know what to do'. *The situation is further aggravated by the way in which the agricultural and cooperative bank categorises farmers for loan eligibility. On the basis of collateral and repayment performance, farmers are categorised as '*good*' or '*bad*' in terms of repayment. Those categorised as good are able to receive further cash loans. A voucher system exists for those categorised as 'bad' who can only receive loans in credit vouchers. This denies them the flexibility that they need to cope with the unpredictability and risk involved in shrimp farming and in some cases they are forced to pay more for products and seedstock by suppliers who prefer cash to credit vouchers.*

Response to disease varies according to available resources. Wealthier farmers with additional capital take samples of diseased fish to the district extension station for testing and advice. Others must wait until the extension officer visits to conduct a training course (usually twice a year) and ask for help then, when it may well be too late. However, according to the head of the hamlet, most farmers now recognise the signs of white spot disease:

> 'They know that it cannot be treated, so they harvest what remains of their shrimp, sell it for a lower price, release the infected water and, if they can, they re-stock the pond and try again. There's lots of sources of information here for farmers. We can't hear the commune radio broadcast because we're too far from the commune, but the programmes on TV about shrimp culture are very popular. We also have training courses organised buy the salesmen from feed companies, like Vinh Thinh

> Company, who bring booklets on disease prevention and feeding instructions and show us products like vitamins, chemicals and types of feed to improve to help the shrimp grow. Most of the farmers here studied until secondary school so they can read, but some find the booklets too technical. Most farmers just talk to each other to get advice on shrimp farming. So there's lots of information and the farmers have a lot of experience at shrimp farming now, but they still don't know what to do about white spot disease, noone does'.

*A few farmers in the village displayed copies of the type of booklet Mr Tran Van Dien referred to, one saying that she had followed all the instructions and spent a lot of money on buying the expensive feed, the vitamins and the chemicals but '*it doesn't work, my shrimp still get disease and now I've run out of money*'. Mr Tran Van Dien predicted that for years to come people in the hamlet will continue to farm shrimp, '*but if current disease outbreaks persist maybe next year 60% of farmers will fail, and the year after than 80% will fail and it will carry on getting worse'.

Relatively rapid technical change with regards to the use of agro-chemicals and the increasing availability of a wide range of drugs for disease prevention and treatment has important implications for notions of 'local knowledge'. While most farmers claimed that their knowledge is based on their own personal experience, their experience of using various chemicals and drugs is often limited. Technical knowledge often appeared to derive from a mixture of hearsay and the advice of agricultural salesmen and the agents of agrochemical and feed companies. Agents often usurped the role of extension agents for their clients who became dependent on their partial advice as the only source of aquatic animal health information readily available. The transfer of information thus becomes contingent on a private commercial relationship between salesman and farmer, to which poorer farmers who cannot afford this service are excluded (this is discussed in greater detail in Sections 4.5). This has consequences for the use of chemicals and drugs. As the visits from agents are often sporadic and inconsistent, many farmers determined the application and amount of chemicals required according to a system of trial-an-error. Others simply said that they copied their neighbours. The result is likely to be inappropriate application and overuse that is not only economically inefficient, but also, potentially damaging to both the shrimp and the environment. Furthermore, the use and misuse of drugs and chemicals within the shrimp industry has serious implications for both the national economy and livelihood sustainability.

Vietnam's main international export markets are the USA, Japan and EU, with some export to Africa, although Vietnam is currently seeking new export markets. However, in the first 5 months of 2002 Vietnam's seafood exports to the EU fell by 51% in value (Environmental Justice Foundation 2002). This slump is widely believed to be due to the detection of chloramphenicol residues in Vietnamese shrimp. In 2002 European media reported a ban placed by the EU on seafood exports from a number of Asian countries, including Vietnam, as a result of residues of chloramphenicol being detected in seafood products. Choramphenicol is a wide-spectrum antibiotic used to treat bacterial meningitis and typhoid, but which some scientists have linked to childhood leukemia. Farmers often buy antibiotics from feed suppliers to treat infections in the pond, often with limited knowledge about the effects or appropriate use of the antibiotics. On 25th February 2002, Prime Minister Plan Van Khai issued an instruction demanding that the Ministries of Agriculture and Rural Development and Fisheries ban the use in food of any chemical banned by the EU and USA. To date this ban includes ten antibiotics and chemicals for use in the breeding, raising and processing of seafood. Billboards can now be seen in most shrimp farming communes announcing the list of banned chemicals. However, the EU ban on seafood imports from Vietnam in 2002 and the resultant slump in the value of shrimp exports demonstrates the extent to which the livelihoods of shrimp farmers in the Mekong Delta are vulnerable to the whim and will of global trade structures and market trends. Research on household level farm management and AAH strategies often neglects this broader picture.

3.3 Loans, Credit and Capital

The provision of loans and credit facilities is a vital component in the promotion of shrimp aquaculture. It is of particular importance when considering the role and impact of aquatic animal health strategies on the livelihoods of aquaculturalists. Shrimp farming is a capital-intensive activity and even low-cost, low-tech AAH strategies demand a certain degree of financial flexibility. This was evident from the number of farmers who said that while they knew that in order to reduce the risk of an infection spreading from their pond to that of neighbouring farmers they should treat the water before releasing it into communal water sources, they felt they could not afford to this after losing their own crop to disease and chose instead to use any additional capital or credit to re-stock their pond and try again. The role of loans and credit in understanding the way in which farmers make decision concerning aquatic animal health management is crucial. The study revealed that, most households involved in shrimp farming rely heavily on bank loans and informal credit from seed suppliers and aquacultural product salesmen in order to cover the costs of stocking the pond, feeding the fish and treating disease. The capacity of households both to access and benefit from AAH strategies and management techniques is, in most cases, contingent on the availability of credit. However this study suggests that, while credit does indeed play a fundamental role in enabling both small and large-scale farmers to invest in aquaculture technologies and to expand production, the relationship between credit, production and poverty is more complex.

Credit schemes which focus on a particular category of producers, such as women, are commonly viewed as essential mechanisms, providing the necessary resources to enable more marginalised or resource-poor households to invest in aquaculture technologies, allowing them to diversify their livelihood strategies, so increasing food security and reducing vulnerability to environmental and social shocks. To this end, government initiatives promoting aquaculture with the dual aim of reducing poverty and increasing shrimp productivity to meet export targets, have tended to focus on the provision of loans. However, not all farmers have access to this kind of financial support

For the poorest households, which lack the collateral required to apply for formal loans from agricultural cooperative bank, finding the capital to invest and re-invest in their farms with each cycle is a significant challenge, especially after a crop has failed. The study indicated that for many farmers, particularly the poorer ones, there are a number of obstacles preventing them from accessing low-interest loans from the bank or a government project. Farmers reported difficulties in accessing official loans from the bank because of the lengthy and bureaucratic procedures which the application entails. Other problems sited were failure of the bank to pay the loan in time for the farmers to buy the seed with which to stock the pond at the beginning of the cycle. In many cases loans are only paid out in the form of a voucher with which to buy postlarvae, a three-way relationship existing between the bank, the seed supplier and the farmer. The farmer is therefore reliant on finding a seed supplier who accepts payment in the form of vouchers and thus loses his or her negotiating power and freedom to select the best seed. One head of a hamlet in My Xuyen said that while the voucher system is aimed at meeting the specific costs of pond preparation, stocking and feeding, it denies farmers the flexibility they need to cope with the unpredictable realities of shrimp farming. Thus, resource poor farmers in need of cash are forced to sell their vouchers illegally for less than they are worth.

Farmers who are unable to obtain loans either from the bank or government credit schemes, are forced to depend on high-interest informal loans from money-lenders and neighbouring farmers and credit from agricultural salesmen, as their only source of generating the capital necessary to finance their shrimp farms. The research highlighted the way in which patron-client relationships emerged through informal systems of credit between agricultural salesmen or wealthy large-scale producers (who oftened doubled as sales representatives for feed and drug companies) and poorer farmers within a local area. As Harrison points out, 'credit can easily become a tool to be manipulated by those who have least need of it' (Harrison 1994: 26). As poorer households become increasingly dependent on credit from wealthier producers, their livelihoods become increasingly precarious and unstable (this will be explored in greater depth in **Section 4.5**).

While finding our information about informal sources of credit and loans is difficult, anecdotal evidence from farmers suggests that a high proportion of farmers rely on what are referred to as 'hot loans' to meet the costs of pond inputs at the beginning of the cycle. This is supported by a Government Report on Agriculture and Rural Development from 1998 which states that:

> 'Vietnam has many successes in building rural credit systems and in doing so has significantly improved the credit supply situation for farmers. However, loans only meet about 50% of the demand for farmers' needs. Many families do not approach official credit organisations for loans but rather borrow from non-official sources at high interest rates' (Government of Vietnam 1999: 38).

This is further supported by a case study carried out in Soc Trang Province on rural livelihoods in which the researcher found that:

> 'While loans given by the VBA (public loans) have enough low-interest rates, the giving loans is based on trust and assets collateral. Thus the borrowers try very much to get money to repay loan on time as soon as possible. Their strategies in

> finding immediate money for repayment of the public loans are to take loans from other sources such as neighbours, relatives or private moneylenders at high interests…or directly mortgage their land.' (Lam Thi Mai Lan 2001: 60).

High levels of risk associated with shrimp culture, combined with the speed with which an AAD outbreak on one farm spreads to the surrounding farms, have led to increased socio-economic disparity between communities in the Southern regions of Vietnam, with many small-scale farmers entering poverty spirals as they are unable to repay loans borrowed at the beginning of the crop cycle. Small-scale shrimp farmers often become heavily obligated to feed and supply companies, which advance materials on credit. When repayments cannon be met, many farmers are forced to sell or abandon their farms.

3.4 'Taking a Gamble'? Profit and Risk

A number of factors come together to make shrimp farming a high risk activity. As the incidence of disease across the Southern regions of Vietnam becomes evermore commonplace, so the levels of risk involved in shrimp farming increase. Rather than offering a reliable, low cost alternative source of income to poor households, investment in shrimp farming is considered by many farmers to be somewhat of a 'gamble' involving high levels of risk, making it a suitable business venture only for farmers with sufficient capital, experience and additional sources of income to mitigate the unpredictable and fluctuating outcomes from shrimp farming. Thus Mr Huynh Thi Len, a shrimp farmer of 10 years from Hoa Tu I, stated explicitly that:

> *'Shrimp farming is a gamble, sometimes you win and sometimes you lose and you're not sure when you'll win or lose'*

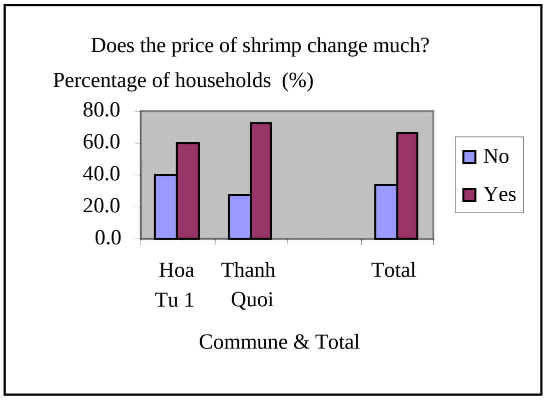
Nevertheless, the appeal of potentially high profits to be earned from shrimp farming and the provision of government sponsored loans to facilitate conversion to shrimp culture have encouraged increasing numbers of households to switch from low-profit rice farming to shrimp over the last two decades. The inputs required for shrimp farming, including the high cost of processed pellets, chemicals and drugs for disease treatment, combined with time spent feeding, cleaning, draining and guarding the pond in many cases increase vulnerability and dependency on loans and credit to cover the necessary financial demands rather than reducing it by providing a relatively predictable additional income for the household.

As has been discussed above, wealthier farmers tend to have safety nets which provide a form of insurance against losses due to disease and retain sufficient capital to reinvest in another crop. These in some cases take the form of alternative incomes from employment, small businesses, provision of credit or leasing land to neighbouring farms thus passing the risk on to them. In a couple of cases, the study revealed that the wealthiest farmers had even taken out official insurance policies with companies such as Groupama for their shrimp farms so that if their crop fails due to white spot disease, so long as they have followed the guidelines on stocking density and feeding, they will receive a pay out to cover the losses. One such policy stated that, *'Groupama will compensate the farmer for damage in the case of disease due to environmental* *conditions'* and went on to list other such events covered by the policy including: natural disaster such as flooding, disease outbreak and damage to the communal environment.

The adoption of new technologies and the implementation of AAH strategies are not cost free. They require inputs of time, cash and labour that are often not available to the poorest households. Equally, Farming technologies and the market, do not operate as two distinct spheres, but are mutually dependent and influenced by each other. While new techniques have the capacity to mitigate risk and to increase predictability, as in the case of AAH strategies, they can however, at the same time, adversely affect the market value of a product. While the techniques are essentially stable, the context within which they make such demands on a household's labour, time, cash is not. A context which is shaped by fluctuations in the international shrimp export market, battles over export tariffs as in the case of the 'catfish war' between Vietnam and the US in 2003, or a ban on seafood imports from Vietnam and other South East Asian countries over the use of antibiotics on shrimp farms. The impact of this level of unpredictability and fluctuation at the international level, combined with the risk of failure due to disease is felt keenly by farmers whose livelihoods are precariously balanced between profit and debt. This is evident from the accounts of the majority of farmers who stated that the price of their harvested shrimp fluctuates significantly (see Graph 4). One farmer, Mr Dang Thanh Mang, from Can Duoc attributed the fluctuations in price to traders cooperating with one another to set a price for shrimp in the area. However when Mr Dang Thanh Mang asked the trader why the prices changes so frequently, the trader told him that it is set daily by the processing plant. This was supported by the accounts of other farmers and traders in the Can Duoc area, according to whom the price of shrimp is set daily by the Processing Plant in Ho Chi Minh City and about which the local traders are then informed. Many farmers spoke about traders with suspicion and felt powerless to negotiate what they believed to be a fair price for the sale of their shrimp.

Within this context, farmers can be reluctant to invest any surplus cash in fish health management strategies with the intention of increasing productivity, rather than save the money or invest it in another direction. The varying marketability of shrimp and shrimp products present a decisive factor for the levels of financial (and other) expenditure on management strategies and inputs into production that a farmer will be willing to invest (European Commission 1994: 23). In this way a farmer may be reluctant to expend time or money on disease control in the pond if the market value for the species s/he has stocked has dropped and the income generated at harvest will not justify the investment on health management.

In the face of such uncertainty, people adopt more flexible approaches to daily life, 'allowing them to patch together new livelihood strategies continuously, depending' for example, 'on the timing, intensity and duration of flooding in conjunction with other variables such as market conditions' (Chase Smith *et al* 2001: 42). This underlines the need for research, strategies and planning to work from an assumption of instability and uncertainty rather than stability. This has been confirmed by recent studies which look critically at the way in which development, particularly in areas of natural resource management, often assume a context of stability and predictability. While aquacultural and agricultural strategies derived from research and promoted by extension are often premised on predictability, management practices have been responding continually to ecological, economic and political instabilities, and to social and institutional change (Fairhead and Leach 2002b: 75; Chase Smith *et al* 2001: 36). As Fairhead and Leach note, 'at times, scientific methods and models that hold true under certain conditions (e.g. laboratories) may be caught out in real life situations by unanticipated variables' (Fairhead and Leach 2002a: 10).



Graph 4: Fluctuations in Shrimp Sale Price

4. Information, Knowledge and Extension

4.1 Introduction: Approaches to Extension

The shrimp industry benefits from a high level of both government and private sector interest both nationally and internationally. This has resulted in the emergence of a sophisticated government-sponsored extension system. Shrimp aquaculture is also the target of considerable research, development and the provision of technical support services undertaken by the private sector. Thus, the existing aquaculture extension infrastructure, with fishery extension officers active in every commune, commonly in close cooperation with universities, government research institutes, and local People's Committees, provides a sophisticated and effective structure for communication and information exchange for shrimp farmers**.** 25 Fisheries extension officers are active in Soc Trang Province alone, divided between the 6 district stations. This is contrasted sharply with the lack of extension services available for animal husbandry and rice farming. The case studies found that farmers who are not involved in shrimp farming, have rarely, if ever been visited by an agricultural extension officer or received technical advice on animal husbandry, the use of agro-chemicals or rice farming. Equally, none had either heard about or attended training courses. This suggests a diversion of government resources to shrimp farming at the expense of other forms of farming which do not net the government such high earnings in foreign exchange.

However, despite the efficiency of the aquaculture extension services, cooperation over stocking schedules, water exchange and disease management procedures in the event of an outbreak, remains a crucial challenge. Furthermore, the findings from this study demonstrate that the focus on technical research has lead to a neglect of the processes by which the products of such research (AAH Strategies, for example) impact on the lives of farmers. This highlights the need to shift the focus away from the production of technical strategies and to focus the institutional support provided to farmers through the extension services. This means, not only examining the extension-farmer nexus, but also looking at the links between research institutes and provincial extension services.

Figure 3 Hierarchy of Government Extension Service

1. Central Government
Ministry of Fisheries (MoF)
Ministry of Agriculture and Rural Development (MARD)

2. Provincial Level
Provincial Department of Fisheries (DoF) and Provincial Department of Agriculture and Rural Development (DARD). Fisheries Extension Centre and the Senior Fisheries Extension Officers exist within the DoF. Similarly the Agricultural Extension Centre and Senior Agricultural Extension Officers exist within DARD. The extension centre covers every city and district within the province.

3. District Level – Extension Officers
Extension officers employed by DoF and DARD. The District Extension Service oversees the district and communes within the district. Approximately 6-10 officers are in involved in aquaculture, livestock farming, agromics, forestry etc.

4. Commune Level – 'Extension Assistant'
Assistants are not a full-time employee of the Extension Service. They receive an allowance from DoF or DARD, to facilitate with their semin-informal role of promoting best practice and giving technical support and information on fish husbandary to farmers in the commune. They receive information from the Provincial and district extension offices and they are encouraged to attend training courses which are both short and long term.

4.2 Access and Scope of the Extension Service

The case study revealed that extension officers tend to concentrate their activities on areas where there is an enclave of shrimp aquaculturalists, neglecting communes where only a few farmers practice aquaculture. In areas such as these, farmers who do culture shrimp are particularly isolated, both from the extension service which tends to target the areas in which clusters of shrimp farmers exist, and from other farmers with whom to share knowledge about pond management and AAH.

A further obstacle to reaching the poorest farmers is the prevailing dominance of conventional 'trickle down' approaches to technology transfer and extension which focus on wealthier 'master' farmers. Poorer farmers tend to be neglected by extension services in favour of those categorised as 'change agents', 'innovators' or 'master farmers'. Such an approach assumes a trickle down effect of technology transfer that imagines that the benefits of AAH knowledge and technical support provided to successful 'entrepreuneurial' farmers will eventually reach the poorest 'conservative' farmers through a process of diffusion. This was highlighted in the account of one of the extension officers based in Can Duoc:

> *'There are a lot of successful farmers in this area, the successful ones tend to be the educated ones who come to the meetings and develop their knowledge and techniques. The less educated farmers are more conservative, they're too scared to try new techniques and so their farms don't do so well.'*

This model advocates the effectiveness of targeting 'model' farmers who demonstrate the motivation and potential to intensify production, demanding a higher level of technical inputs in pursuit of greater commercialisation of their operation. This model relies on the increasing 'privatisation' of the various elements of aquaculture production: hatcheries, seed supply, and most significantly, transfer of technical information and strategies, which commonly accompany the sale of feed pellets and agro-chemicals by company agents eager to culture loyalty amongst actual and potential customers through the provision of private company technicians and training courses. Such an approach to extension is therefore underpinned by the imperative towards greater intensification and commercialisation of the elements of aquaculture production. These processes are seen to be crucial to the national development of aquaculture. Yet this philosophy seems to contradict the claims that aquaculture represents a low-input, basic technology to help improve the livelihoods of the poorest farmers and to undermine the commitment to promoting and supporting the adoption of small-scale aquaculture by the poorest farmers as part of national poverty reduction strategies.

The 'trickle-down' approach to extension which targets 'master farmers' neglects the politics of competitiveness between farmers in a restricted market, as well as the intricate power relations of dependency and patronage that exist between farmers. This was highlighted in the account of Mrs Nguyen Thi Van, a widow in Tan Chanh who stated that he had been culturing shrimp for 9 years, but had only made a profit in the second year, every other cycle he said had been hit by disease or the shrimp had simply ‘failed to grow’:

> *‘I rarely go to the meetings organised by the extension service. Only some farmers get invited to the meetings in the commune to learn a new technique or discuss problems – the ones that are selected as representatives by the head of the hamlet – they are always the richer ones who’s farms never fail and they are supposed to come back and tell the other farmers what they learnt and discussed. But there are hundreds of farmers here and they only talk to some of them.’*

The case study in Vietnam revealed the way in which such an approach primarily serves the wealthier, successful farmers who become the chief audience of the extension support and AAH strategies. Consequently, poorer farmers are either denied the benefits of such advice or receive advice filtered through a patron-client relationship of credit and dependency. This is what has been termed in this report the *‘unofficial priviatisation’* of extension. The extension service requires not only greater resources to extend its reach, but needs to be restructured to direct its attention much more rigorously towards reaching poor people.

This underlines the need for the extension service to move away from the ***exclusionary*** focus on *master farmers* as pivotal points in the process of technology transfer from which, it is assumed, knowledge will gradually diffuse to other farmers, and to adopt a more ***inclusionary*** approach which focuses on the organisation and mobilisation of formal farmer's groups as the principle site of interaction between extension officers and farmers. In this way the extension service could reach a broader and more diverse range of farmers, providing effective channels of communication, discussion and dissemination of AAH strategies through which poorer farmers could access extension support, and interact with other aquaculturalists. By providing farmers with inclusive and reliable sources of technical support, such organisations would undermine the power of informal networks built along patron-client relationships, which serve simultaneously to increase the dependency of weaker farmers and the power of dominant producers.

4.3 Mass Media

In recent years the importance of mass media such as radio and television as tools for the communication of farming strategies and information has been recognised. A number of recent studies have highlighted how these channels have successfully been mobilised to reach a broad sector of farmers. However, just as there is a tendency to view technology as neutral, so the media is often represented uncritically as an a-politcal, a-social channel of communication. The fact that people have access to television or radio should not be translated into evidence that these channels are effective tools of transfer. This is highlighted by the findings from the research in Soc Trang and Long An.

The study revealed that interactive shrimp aquaculture programmes in which farmers can phone or write in with questions are broadcast regularly on television and are very popular among farmers. Extension officers believed television to be the most effective channel for the communication for technical information. According to extensionists, aquaculture programmes were shown at suitable times for farmers and were widely popular among local farmers, the vast majority of whom had access to television either in their homes, those of their neighbours, or in coffee shops in the hamlet. However, it is not simply a question of whether information is *reaching* farmers through the channels of mass media. We must ask, who are the intended *targets* of such programmes? Many farmers said that they watched the programmes but could not apply the techniques advocated on the programmes because they were too costly and appropriate only for semi-intensive or intensive operations. Thus one farmer in Thanh Quoi said that although he regualrly watched programmes on shrimp aquaculture and was desperate to find disease control and treatment strategies, he could not afford the water treatment strategies suggested on the programmes which were suitable only for semi-intensive or intensive shrimp farms, rather than the improved extensive models common amongst poorer farmers:

> *There's nothing for farmers like me, we cannot afford the techniques they advise on the TV and I cannot borrow any more money, but we have disease in our ponds too, last year my first crop all died from white-spot disease. The same is true for many farmers around here, and yet no one can tell us how to cure this disease, so what are we supposed to do?*

In this way, poorer farmers were once again excluded from important channels of communication. It was evident that there was either a lack of cost-effective, simple strategies for disease control and aquatic animal health management or that those that existed were not being effectively communicated to farmers. While TV fisheries extension programmes are popular amongst many of the farmers interviewed, farmers often commented that they could not apply the techniques presented in the programmes due to the costly investment of time and capital they demanded. Thus Mr Tran Hong Phuoc, a farmer in Hoa Tu I said:

> *I listen to the radio and watch the TV programmes on shrimp farming everyday, but I don't dare apply them because I don't have any extra money to try them out and if they don't work I'll either have wasted money or, at worst, I'll lose my whole crop. I can't afford to take that risk.*

Just as the study revealed that the extension service was neither equipped, nor structured in such a way to *target* its activities towards the poorest farmers, so various forms of mass media, such as television, magazines and leaflets, have been mobilised in the service of increasing production rather than poverty reduction. Television programmes, extension videos and pamphlets tend to target medium- to large-scale farmers, rather poor small-scale aquaculturalists. They advocate techniques which are inappropriate to poor farmers as they demand too great an input of capital, time and labour. They focus exclusively on shrimp farm management, rather than intrgrating this into a broader farming systems approach which responds to the diverse livelihood strategies of poorer households. A further criticism voiced by farmers was that they focused too heavily on scientific information which was either irrelevant or unclear to farmers. Thus, as Turongruang and Demaine point out,

> 'In the absence of a conventional extension service, one alternative is the use of mass media in the form of leaflets, pamphlets and videos. Unfortunately many such materials are designed by research scientists and contain too much and too scientific information…. The programme has sought to address this problem through a participatory approach to the development of such extension materials….Thus the design stage, includes farmers who have taken part in project on-farm trials' (Turongruang and Demaine 2003: 251).

This study in the Northeast of Thailand underlines fundamental issues concerning the need to adopt a more participatory approach in the production of extension materials and the use of mass media channels of communication. It highlights the need to move away from the 'lab' as the source of materials in which strategies are framed through the lens of academic science. Demonstrating that the existence of extension materials or television programmes is not enough. Such sources of information must be considered as part of a process of dissemination, reception and uptake. . In common with the case study conducted conducted amongst aquaculturalists in Phichit Province, Thailand[11], this study found that the vast majority of manuals and leaflets that farmers owned were produced by feed and chemical companies and had been given to farmers by agricultural salesmen. Few farmers owned or had seen official technical booklets or posters from the extension service. Again, many farmers said that they found the information in such booklets overly scientific and unclear, and that they did not have the time or capital to invest in the techniques which they suggested.

The study in Vietnam highlighted the need to focus more clearly and rigorously on the supposed target or audience of extension materials and mass media channels. If extension materials, television and radio programmes, magazines and such like, are to provide technical support to poor households involved in aquaculture, they must, firstly, be targetted at poor households. Secondly, farmers must be involved in the production of such materials, both in terms of content, format and communication. Due to private sector interest in the shrimp industry, feed and chemical multinationals such as the CP Group represent a major source of funding for such mass media channels of communication as TV programmes, magazines and leaflets, both in terms of sponsorship and advertising revenues, as well as the personal relationship between company salesmen and farmers. If mass media are to be mobilized in the service of providing support to poor, small-scale producers, alternative sources of funding will need to be found.

---

[11] The findings from the case study in Thailand are documented in *Poverty, Ponds and Profit: Re-thinking the Relationship between Knowledge and Practice among Fish Farmers in Phichit Province, Thailand,* (2004)

4.4 Training Courses

In all three of the study sites regular training courses are organised by the People's Committee of the commune in collaboration with the district extension service throughout the shrimp cycle. Training courses cover all the areas of the shrimp production cycle, such as:

- Pond preparations
- Selection of good quality postlarvae
- Stocking, culture and harvest schedules
- Feeding regimes
- Disease prevention, control and treatment
- Water treatment and exchange

Such courses are open to all farmers in the hamlets which fall within the areas designated for shrimp farming and are invited by the head of their hamlet. However, government attempts at land use zoning in Soc Trang Province have designated some hamlets in Thanh Quoi as shrimp farming areas, while others lie in areas allocated for agriculture, protected from saline intrusion by a dyke. In recent years, attracted by the high earning promised by conversion to shrimp farming, some farmers within these hamlets have broken down parts of the dyke in order to allow an influx of salt water necessary for shrimp farming. This is, not only the cause of potentially serious conflict between neighbouring farmers, but, also, means that farmers within these hamlets who have recently begun to culture shrimp with little experience, are excluded from training courses and other forms of extension support and so have little, if any access to technical support on aquatic animal health management and disease prevention (this is discussed further in Section 5).

Hoa Tu I has also initiated an exchange programme in which farmers are taken to visit shrimp farms in other communes and districts of Soc Trang to observe a variety of culture techniques and farm management practices. However, due to limited resources those farmers, identified by the People's Committee as 'leading' or 'key' farmers are selected for such visits with the hope that the knowledge they gain from such visits will be passed on to or copied by other farmers in the commune.

In common with the study conducted amongst aquaculturalists in Phichit Province, Thailand, the case studies in Vietnam indicated that in approxiamately half the farms, women were the primary caretakers of the ponds and managers of fish production. Indeed, extension officers in the province said that they had found that in the majority of farms they visited much of the daily management of the ponds was undertaken by women. However, extensionists stated that a minority of those who attended training courses were women. This was reinforced by the accounts of a number of women who stated that while they took care of the fish farm on a daily basis, they had never attended a training course but learnt how to manage the ponds from their husband or other male relatives. The research highlights the need for a gendered approach to the planning and desgn of training courses and for strategie to make training courses more accessible to women. As Harrison notes, 'information transfer from husbands to wives is unlikely to be as effective as direct training of pond managers' (Harrison 1994: 48). Women should, therefore, be a primary target for training courses. In order to promote women's participation in training courses, extensionists should consider the constraints of all people who are likely to benefit from attending when planning the timing and location of workshops. Women may often experience a number of constraints to attending courses such as being restricted from travelling long distances or being away from the home for extended periods of time. Courses which both prioritise female attendance, and which attempt to mitigate the constraints on female attendance, are therefore required.

A large number of farmers interviewed in the study said that, they had been invited to workshops held locally by sales representatives from feed and drugs manufacturing companies such as the CP Group. In this way it became clear that feed and chemical companies provided a similar role within the shrimp industry in Vietnam as they had been found to do, to a lesser extent, within freshwater fish production systems in Central Thailand. However the ubiquity of sales representatives, promotional brochures and training courses in shrimp farming areas in Vietnam testifies to the far-reching influence of these multinationals and to the level of control they wield over every stage of shrimp production from hatchery to processing plant. These promotional training presentations were common in areas in which a large number of households practiced shrimp farming. One of the primary motivations for attending the workshops appeared to be the free product samples distributed by the sales representatives. The workshops primarily acted as a forum for companies to advertise their products, demonstrate how they worked, and to distribute free samples of products and gifts, such as hats and T-shirts emblazoned with the company logo. The workshops were generally perceived by farmers to be a good source of technical information on farm management and aquatic animal health. In this way they do provide important, if unregulated channels for the flow of information concerning farm management. For the most part, the workshops were accessible only to those farmers who had previous contact with a particular sales representative or were regular buyers of a specific product from the company sponsoring the workshop. They thus served to reinforce the relationship between farmers and the companies. In this way unregulated information flowed according to private commercial channels. Poorer farmers and those in more remote areas, which are infrequently visited by sales representatives did not have access to these channels.

Many farmers stated that their primary source of information on appropriate feeding techniques and product selection came from either salesmen or training courses organized by local company sales representatives. For these farmers, technical support becomes part of a commercial relationship between farmer and salesman. According to this system, advice is offered only to clients. In order to receive such advice, the farmer must buy products from the representative. In the absence of effective government extension services, farmers such as these become increasingly dependent on these commercial relationships as their only source of advice on farm management and AAH. In this way, the flow of technical information to farmers is becoming evermore *privatised* as the private sector takes the place of an effective government extension service.

The dangers of this *privatised* extension network are clear. Both extension officers and researchers at government research institutes expressed concern over the lack of regulation of the information given to farmers from private companies through their sales representatives. Both the quality and objectivity of such advice are compromised. In the absence of other sources of information about alternative feeding or disease control techniques, farmers are forced to continue purchasing high-cost processed feed and chemicals from sales representatives. Furthermore, the *privatisation* of technical support, serves to reinforce and increase the disparity between wealthy and poor households, between successful farmers and those who are failing. The flow of information is dependent on commercial relationships between farmer as client, and salesman or company agent. Capital is thus translated into information, which, in turn, by improving management techniques and increasing productivity, eventually is translated back into capital. Once again, poorer farmers, who do not have the capital to attract sales representatives and engage in such relationships are either excluded from this source of information, or, as will be discussed in the next section, become dependent on informal, high-interest loans and credit from salesmen or other farmers.

4.5 ‘*Privatising*’ Extension

The case studies from Can Duoc and My Xuyen exemplify the way in which the diffusion of technical knowledge and financial support among shrimp farmers is mediated through systems of patronage and dependency, reinforcing social and economic power relations between farmers. Contrary to the widespread belief that technical innovations and farm management information and the benefits they bring, will ‘trickle down’ from ‘master’ farmers to poorer farmers, these frameworks serve to constrain poorer farmers and limit their access to appropriate technical support and credit. This is in no way a new phenomenon and should not, as has been done in the past, be attributed exclusively to the commercialization of the rural economy by the overweening forces of the international shrimp industry. Similar processes were found to be at work within the systems of freshwater fish production in rural central Thailand as detailed in the case study report from Phichit Province. Nevertheless the revenues produced by the shrimp industry have resulted in unprecedented commercial interest in rural aquacultural production, and in this way have put a far greater premium on the communication, content and trajectories of technical information.

Areas where a high number of the households have shrimp ponds appeared saturated in visits from sales agents from a variety of feed companies. In one hamlet a number of farmers said they had already been visited by agents from Uni-President, Na Sa, and CP selling feed, chemicals and offering technical advice. In some cases sales representatives offer to take samples of shrimp from farmers back to the company laboratories for testing and diagnostic services which would otherwise be extremely expensive and time-consuming for famers. This is in stark contrast to the more remote hamlets of Thanh Quoi accesible only by boat or narrow paths, and the new shrimp farms emerging in the fresh water area of Thanh Quoi, where farmers said they had to travel far in search of inputs for the pond and were visited neither by sales agents, company technicians or extension officers.

In Can Duoc a number of highly successful, long-term fish farmers benefited from close and familiar ties to extension personnel, provincial fishery station officials, feed company technicians or privately hired technicians and engineers. They had the capital to make use of diagnostic services offered by research institutes and had often been singled out as 'master farmers' to be recipients of on-farm technical demonstrations by the extension service. One such farmer explained that if he observes the signs of disease in his shrimp he simply takes a sample of the seed to the Provincial capital to be tested in a private lab run by one of the feed and chemical companies. He also does this with a sample taken from a prospective seed supplier prior to committing to purchasing the seedstock in order to be confident in the quality of the postlarvae. Both the transport and the service, however, are costly in terms of time and money.

Case Study: The Hamlet of Ba Nghia in Tan Chanh Commune, Can Duoc District, Province of Long An

Seed supply within the hamlet of Ba Nghia is controlled for the most part by one supplier, Mr Tran Van Ro who also owns sub 2500 square metres of semi-intensive shrimp ponds. Mr Tran Van Ro operates in partnership with a large scale shrimp trader who owns a local shrimp processing and packaging plant as well as significant amounts of land in the hamlet which he rents to farmers. Farmers who rent land from the trader are supplied with postlarvae, often on credit, by Mr Tran Van Ro who also acts as a middleman between them and the trader when it becomes time to harvest and sell their shrimp. Mr Tran Van Ro said that his clients often come to him for advice on feeding, stocking density, disease treatment and general farm management and he advises them on appropriate products, chemical and dosage. His own knowledge of shrimp farming derives from experience within the industry and from brochures he receives from feed companies and his partner. In this way Mr Tran Van Ro and his partner control every aspect of shrimp production within the network of farmers under their patronage. What is significant in this set of relationships is that the high levels of risk inherent in shrimp production are passed on from the dominant actors (Mr Tran Van Ro and the trader) to the farmer. If the crop fails due to disease the farmer must still find sufficient capital to pay rent to the trader, and pay their debts for seed bought on credit from Mr Tran Van Ro.

The case above demonstrates the way in which extension has been, in effect, *privatised*. The expansion of the private sector into all spheres of rural aquaculture through systems of vertical integration, whereby companies gradually come to directly and indirectly control every level of production, from the delivery of agrochemicals and feed, to the provision of technical support, is often seen as an indication of the increasing level of commericalisation, productivity and economic growth within a particular industry (Burch *et al* 2000). Information thus flows according to the demands and needs of the market.

Or, to put it another way, market forces shape the transfer of technical knowledge. However, while the increasing private sector control of the shrimp industry, can serve to increase productivity and boost economic growth, the processes by which extension and knowledge networks are effectively *privatised* simultaneously serves to benefit successful farmers, while restricting the access of poor farmers both to reliable sources of technical support and to a share in the market. In this way the disparity between rich and poor is reinforced. Resource-rich farmers such as, Mr Tran Van Ro, with access to capital are able to monopolise an aspect of shrimp production within their local area. Through their position as sales agent or middle men, these farmers become not only 'master farmers' within their local area but, are elevated to a position of control over the local aquaculture economy and are seen by other local farmers as repositories of knowledge and sources of advice concerning shrimp farm management. In adopting these roles they themselves gain greater access to a variety of sources of information and strengthen their own ties with other stakeholders within the industry such as traders and company technicians, while simultaneously controlling the access to information of other farmers seeking advice on farm management or disease control.

Access to advice thus becomes contingent on the purchase of products suggested by these leading farmers in their capacity as sales representatives. Income earned from their role as sales agent or middleman, combined with interest earned from the provision of credit, provides leading farmers such as Mr Tran Van Ro with both a safety net to mitigate the risk of fluctuating productivity due to disease, flooding etc, and sufficient capital to invest in aquaculture technologies and innovations in order to increase production on their farms. The risk is then passed on to the smaller, more resource poor producers who are denied access to neutral and basic information or advice on AAH except through their relationship of dependency on wealthy farmers. The result is a patron-client relationship between wealthy farmers with access to information and poorer farmers who, as clients, receive unregulated advice from leading farmers along with credit for purchasing products such as feed pellets and drugs for disease treatment. As the case study above shows, these patterns of patronage serve to increase the dependency and vulnerability of poorer households, as debts accumulate forcing them to abandon their fish farms and seek alternative livelihood strategies.

Plate 1

Plate 7

Plate 3

Plate 4

5. Cooperation and Conflict

5.1 Introduction: Cooperation and Conflict

Despite the efficiency of the aquaculture extension services, cooperation over land use, stocking schedules, water exchange and disease management procedures in the event of an outbreak, remains a crucial challenge. As has been discussed above in section 3.2, attempts to combat severe shrimp disease epidemics and reduce the spread of infection through regulation of farming practices have been instituted in communes throughout the Southern Regions of Vietnam. Such attempts take the form of posters which can be seen in most hamlets giving basic advice on disease prevention and control, as well as legal mandates from the District People's Committee. Interventions such as these focus on preventing farmers from disposing of infected shrimp carcasses and releasing water from infected ponds and sediment into communal water sources – activities believed to be the key causes of the rapid spread of white spot and yellow head epidemics throughout neighbouring farms.

While these instructions explicitly state that transgression is punishable by law, the study revealed that local government institutions have neither the capacity nor the resources to monitor farm management practices and enforce these bans accross so large an area and so many farms. Thus farmers in both Can Duoc and My Xuyen reported that farmers continue to dispose of diseased shrimp and release their ponds into communal canals and waterways; that most farmers will try a second cycle of shrimp if their first crop fails; and that stocking schedules continue to be unharmonised with a number of farmers opting to stock early in the hope of buying postlarvae for a reduced price and selling their harvested shrimp for a higher price. While technical research and the development of innovative strategies to combat AAD are crucial, this study highlights the need to focus on improving the institutional capacity of both local government to regulate shrimp farming practices whether through more stringent regulatory frameworks and monitoring or the promotion of cooperation and *co-management* amongst farmers.

The concept of *co-management* has recently emerged as a possible approach to the management of farming practices and land use in Soc Trang Province, which currently have the potential to give rise to conflict between neighbouring farmers. This is crucial not only to prevent the devastating socio-economic and ecological effects of AAD epidemics, but also to protect the livelihoods of non-shrimp farmers which are being threatened by the dramatic expansion of shrimp culture throughout the province and the resultant salinzation of surrounding farm land making it inhospitable for rice farming and vegateble cultivation.

Indeed, *co-management*, has become a buzz word in natural resource management. As such, it presents a possible approach to bring farmers and local government together in order to promote cooperation and harmonize farming practices in an attempt to avoid the potentially damaging ecological effects of shrimp farming and reduce the risk of an industry collapse due to epidemics of shrimp disease. Attempts to implement some form of co-management scheme can be seen in the recent innovation from the Vietnamese government which involves bringing farmers in various communes in Soc Trang Province together in shrimp farming ‘extension clubs’. These seem to offer opportunities not only for organisation and regulation of techniques employed by farmers on there shrimp farms, but equally as sites for knowledge sharing. Nevertheless such clubs do not provide a catch-all solution to the lack of regulation of shrimp farming practices and conflict over land use in Soc Trang Province.

While laws exist prohibiting intensification of shrimp farming in the area, these are virtually impossible to enforce – clear signs of intensification such as oxygen aerators in large ponds are evident. Equally, while attempts at zoning have been made in the province in order to protect rice and vegetable farm land from saline intrusion, farmers, attracted by the potentially high profits offered by shrimp farming have broken parts of the dyke wall which prevents salt water from entering those areas designated as non-shrimp farming land. Surveys in one district of Tra Vinh Province in 1995 found that rice yields had declined by 50-90% over the past three decades primarily due to salt intrusion. The expansion of shrimp farming in the area is likely to have exacerbated this situation. This is supported by the accounts of farmers in Thanh Quoi Commune who’s farm lie within the areas designated non-shrimp farming zones in Soc Trang, exemplified in the case study below. However, considering the size of the area and the number of farmers, such infringements are virtually impossible to enforce, yet have potentially devastating impacts on both the

5.2 Land Use and Zoning

The location of Thanh Quoi is such that, while roughly half the commune has been assigned for shrimp culture, the other half has been protected from saline intrusion by a dyke in order to preserve the soil fertility for rice and vegetable cultivation. The result appears to be enhanced socio-economic disparity, as some households in the village are reaping enormous profits since switching their land to shrimp cultivation, while other farmers who are not in the shrimp farming areas are suffering from the falling price of rice (which has been declining in quality and yield over the past few years, arguably, due to the declining fertility of the soil from saline intrusion). A number of farmers on the other side of the dyke have broken sections of it away, thus allowing salt water to enter the area and so making it suitable for shrimp farming. However neighbouring rice and vegetable farmers believe that this influx of salt water is severely damaging the quality of their soil and is thus responsible for declining productivity on their farms. Thanh Quoi is thus subject to tensions over land use which highlight the need for both effective organisation of the land into zones, greater regulation of shrimp farming activity and extension clubs which could potentially facilitate the co-management of communal resources and land use.

Case Study: Shrimp Farming in the 'Freshwater' Area

'There are some farmers who protest about shrimp culture coming into the areas. Others haven't gone to the government but have asked the shrimp farmers to line their fields with nylon so that the salt water can't get into the soil and damage it. Orginially this area was brackish, so there's still salt in the soil anyway and most of the farmers who have started shrimp around here pump the salt water in, rather than breaking the dyke, so there's not as much saline intrusion. It's not like in Hoa Khanh where the farmers completely borke down the dyke to allow the salt water to enter, the government came a gave a warning to the farmers who had done this, but they can't punish them because there's so many farmers doing this. The government is now going to designate it a shrimp culture area anyway, so if there's still farmers there who want to do two crops of rice and don't want to change to shrimp farming, then there's nothing they can do'

(Mr Huynh Tin Nhien, shrimp farmer in the designated 'freshwater' area of Thanh Quoi)

'Shrimp farming will develop well in this area because more and more farmers want to do it, so they're destroying the dyke to let in salty water. But I think the development of shrimp culture could be dangerous because shrimp farming is developing very very fast, but technical knowledge about it is not advancing fast enough to keep pace with it. In the past this was a brackish area, then there was a government programme to make the area better for rice farming, so they built a damn to keep out the salt water and make it a fresh water area. It's taken a number of years for the land to become good for rice farming and now they're breaking down the dyke to let the salt water in again for shrimp farming. But if shrimp farming starts to fail and farmers can't afford to do it anymore, they won't be able to go back to rice farming because the soil will be salty and the water brackish, so what will they do then?'

(Mr Bui Thi Bich Ngo, shrimp farmer in the designated 'freshwater' area of Thanh Quoi)

The account of Mrs Huynh Thi Len started shrimp culture only a year ago further highlights the tensions surrounding land use and problems arising over the expansion of shrimp culture into areas previously designated as 'freshwater areas'. Mrs Huynh Thi Len began integrated shrimp-rice farming (one crop of each) a year ago. She had received no support from the extension service because the area was designated a fresh water area for rice farming, protected by the dyke. However, she said, that she had 'no choice but to start shrimp farming because farmers around here have started to break the dyke'. This allows salt water to come in so that she can no longer grow two crops of rice a year and 'we cannot live on just one. She added that:

> *'I am lucky, my mother lives in a shrimp culture area and has been shrimp farming for 10 years so I received all the technical advice from her. Extension officers and salesmen often come to her hamlet, but they don't come here, so some farmers here are starting shrimp farming with no knowledge at all'.*

The official denial that shrimp farming is expanding into these areas means that farmers are, not only excluded from technical support provided by the extension services, but are also denied the financial support (primarily in the form of low-interest loans) offered by government to farmers in shrimp culture areas in order to promote the industry. Farmers here are eligible only for rice farming loans, which are significantly lower than those for shrimp farming, and do not begin to cover the costs required for shrimp culture (around 3.5 million VD per ha compared to the 18-28 million VD per ha offered to shrimp farmers).

Yet increasing numbers of households in so-called 'fresh-water' areas are finding their livelihoods compromised by the destruction of the dyke and intrusion of salt water into the area of their rice fields. The only option is to convert their fields to integrated rice-shrimp farming, but without the help of either low-interest government loans or technical support. Many farmers reported having to seek high-interest informal loans, known as 'hot loans' from money-lenders to raise the capital demanded by shrimp farming, or were forced to by all their seedstock and pond inputs on credit from suppliers, for roughly 10% more than the price if bought with cash. Furthermore, the absence of extension officers in the area means that shrimp farming practices and techniques, and their impact on the environmental and social life of the communities here, is, to a large extent, unmonitored and unregulated. While the majority of households in this area have only recently embarked on shrimp cultivation and few reported significant losses to disease, experience from other areas suggests that disease outbreaks can be expected in years to come if the expansion of shrimp culture is unregulated. This could have a potentially devastating impact on the livelihoods of farmers in this area who rely almost exclusively on income from shrimp production and decreasing rice production (which is likely to decrease further as shrimp farming expands).

5.3 Clubs and Co-management

During the period of this study the first experimental extension clubs had just been established in Hoa Tu I as part of a government supported trial exploring the potential of clubs as potential loci for sharing information and the regulation and harmonization of farming practices through co-management. Four such clubs had been established in one hamlet, and a further one in another hamlet. The Chairman of the commune's People's Committee stressed that these were still in the trial phase, if they proved successful, attempts would be made to replicate them in other hamlets, and hopefully other districts. However they require both manpower and commitments of time by farmers. Farmers who join must pay a small subscription fee, with the aim of building up a fund which can be lent to any member in need.

The potential of the clubs to promoting cooperation among farmers and in doing so, prevent disease outbreaks is underlined in Mr Tran Van Hong's account of the new clubs. A shrimp farmer of 10 years from one of the hamlets of Hoa Tu I, he explained that, like most of the farmers in the hamlet, when he first started experiencing epidemics of white spot in his shrimp ponds a few years ago, he tried to treat the shrimp with chemical, lime, vitamins and antibiotics. However he quickly realised that he was wasting his money, so he simply released the water into the canals and re-stocked his pond with a new batch of seedstock,

> *'none of us treated the water before releasing it, because it costs money to buy the chemical treatments and time and we had just lost all our shrimp and all the money we'd invested in the pond, so we couldn't see the point'.*

Mr Tran Van Hong, said that, farmers were beginning to understand that if this continued, each time there was a disease outbreak on one farm, they'd all be affected. He believed that the new extension clubs, which have been established to facilitate coordination of water exchange, stocking times and awareness of the effects of releasing untreated water, sediment and shrimp carcasses into communal water sources, 'could foster a communal spirit, so that people will care more what happens to other farmers, even if they have already lost their shrimp to disease'.

However, in these initial stages, with very limited financial resources at their disposal, there was great pressure on the clubs to demonstrate their direct benefit to farmers and so maintain interest. Thus one farmer who had been nominated as the head of one of the clubs stated that:

> *'Some of us recognize the benefits of having the clubs, maybe not immediately, but in time they'll make a difference, but some farmers think they can work on their own. In this hamlet 50% of farmers have joined one of the four clubs, but we need everyone to be involved because if there are still individuals outside, who do not participate and do not follow the rules decided in the clubs about when to stock the ponds, when to exchange water and so on, then we all suffer.'*

A number of farmers suggested that the farmers who were reluctant to join the clubs were recent newcomers to the area, revealing a sense of suspicion towards those perceived as 'outsiders' in the commune. These so-called 'outsiders' often seemed to be perceived as individualistic and uninterested in collective farm and environmental management strategies, and were thus became scapegoats for the spread of shrimp diseases through the anti-social practices attributed to them such as stocking their ponds at different times from the rest of the hamlet and releasing untreated water and shrimp carcasses into communal water ways.

Furthermore, in many cases women are the primary caretakers of the pond, yet membership of the clubs was open only to men. While separate women's clubs exist, these are not focused on shrimp farming. Women are thus excluded from discussions on management, cooperation and technical management strategies. This can, in turn, reduce their power as decision-makers within the household concerning the management and distribution of resources and labour

While ‘extension clubs’ offer a forum for co-management, the label ‘co-management’ often involves a number of assumptions which ignore the power dynamics of such arrangements. As is sometimes the case with ‘participatory’ and ‘community-driven’ initiatives, ‘co-management’ presumes a collective will, purpose and goals on the part of local government and farmers. However, the establishment of extension clubs has been driven from above by national and local government policy-makers, who have invited farmers to participate in the initiative, rather than being driven by grass-roots movements among farmers. This is not to say that the extension clubs cannot have a positive impact, nor that participating in them is not voluntary. Interviews conducted with farmers indicated that farmers joined willingly as they saw direct benefits to be derived from membership of the clubs, primarily as sites of knowledge-sharing and sources of technical advice. This case study was conducted during the early days of the extension clubs, more research is therefore required to assess both their impact on farming practices and the community, as well as to examine the power dynamics and relationship which are being forged through these structures. This highlights the need to shift the direction of research from a predominant focus on the technical aspects of shrimp farming and a preoccupation with technology transfer, to address the urgent issues of regulation, land use and zoning.

SECTION THREE

CONCLUSIONS AND RECOMMENDATIONS

6. Summary of Key Findings and Recommendations

6.1 Key Findings from the Case Study in Can Duoc

KEY THEMES	PROBLEMS/COMMENTS	RECOMMENDATIONS
1. Development Context	- Most farmers' livelihoods have improved dramatically since starting shrimp farming (many new houses have been built) - Local infrastructure has improved (roads, bridges, communal buildings) -The majority of wealthier shrimp farmers have additional livelihood activities, most commonly: small businesses such as feed or seed supplier, construction or transportation; salaried employment in HCMC	
2. Credit & Loans	-However, almost all farmers rely heavily on formal or informal loans and credit from agric-product and seedstock suppliers in order to sustain their shrimp farms. -Where households do not have alternative livelihood activities this dependency makes them vulnerable to both losses from AAD and fluctuations in the market	- Greater regulation of government credit support for shrimp farmers - Loans should be accompanied by technical support on farm management and disease control/prevention for farmers - Greater availability of low-interest government loans for poorer households who are reliant on high-interest 'hot loans' - Households should be encouraged to diversify their livelihood activities, rather than investing all in shrimp farming.
3. Aquatic Animal Health	- Epidemics of serious shrimp disease (white spot and yellow head) have become an increasing problem in recent years. -Wealthier farmers and especially those with additional livelihood activities have greater resources to devote to field/pond preperation, disease control and water treatment;	- Development and transfer of low-cost, appropriate, Disease control and prevention strategies to farmers - Introduction of extension clubs as vehicles for collective strategies to prevent the spread of disease and co-management of communal resources - Increased regulation of shrimp culture activity (ie. coordination of

	and are managing to cover losses with high profits from succesful crops -Poorer households which rely soley on income earned from shrimp farming do not have the resources to weather losses and often find themselves in debt spirals or face financial ruin	stocking schedules, disposal of infected water and shrimp carcasses, and sediment from the pond) -National and local government should promote rice-shrimp and improved extensive culture models as the most sustainable and make efforts to prevent the further intensification of shrimp farming.
4. Extension	- Extension services well-organised and efficient - But lack resources to meet the demand of expanding shrimp aquaculture -Wealthier and succesful farmers have greater access to extension support and other sources of advice than poorer farmers -Extension strategies for AAH often require significant resources for field/pond preperation; feed; disease control and water treatment and are therefore more suitable for wealthier farmers. -Extension support and training courses generally target 'master farmers'. - Strategies and advice do not reach poorer farmers as diffusion or trickle down model of extension from master farmers to others does not work. -Some farmers find training courses and TV extension programmes 'too theoretical'	- Extension services require more funding, for personnel, transport, extension materials, collection of survey information and training courses. -Develop low-cost, disease and AAH management strategies appropriate from resource-poor households - Extension service rigorously target the poor and most remote households who have least access to information - Participatory approaches incorporated into extension planning. - More practical training model for farmers eg. on-farm demonstrations
5. Knowledge-Sharing	- Farmer's exchange information and advice informally - Marginalised households and those in remote locations are further disadvantaged as they have least access to these	- Establish inclusive extension clubs for shrimp farmers in the commune to facilitate farmer-farmer learning, loans, financial support for farmers when crop has failed etc, and co-management of communal resources

	informal knwoeldge networks - Female-headed households are sometimes marginalised from informal shrimp-farmer communities - Shrimp farmers desire greater organisation to facilitate farmer-farmer learning, loans, financial support for farmers when crop has failed etc	

6.2 Key Findings from the Case Study in My Xuyen

KEY THEMES	PROBLEMS/COMMENTS	RECOMMENDATIONS
1. Development Context	- Many farmers' livelihoods have improved since starting shrimp farming (some new houses have been built) -The majority of longer-term shrimp farmers report crop fails for past two years due to disease outbreaks and cannot repay loans. -New shrimp farmers report successful first and second crops - In Hoa Tu I infrastructure is improving (roads, bridges, communal buildings). Thanh Quoi where shrimp farming is more recent, requires infrastructure improvements	- Local government to vigorously pursue its plan for infrastructure development in Thanh Quoi
2. Credit & Loans	-However, almost all farmers rely heavily on formal or informal loans and credit from agric-product and seedstock suppliers in order to sustain their shrimp farms. -Where households do not have alternative livelihood activities this dependency makes them vulnerable to both losses from AAD and fluctuations in the market	- Greater regulation of government credit support for shrimp farmers - Loans should be accompanied by technical support on farm management and disease control/prevention for farmers - Greater availability of low-interest government loans for poorer households who are reliant on high-interest 'hot loans' - Households should be encouraged to diversify their livelihood activities, rather than investing all in shrimp farming.
3. Aquatic Animal Health	- Epidemics of serious shrimp disease (white spot and yellow head) have become an increasing problem in recent years. -Wealthier farmers and especially those with alternative livelihood activities are managing to cover losses with high profits from	- Development and transfer of low-cost, appropriate, Disease control and prevention strategies to farmers - Introduction of extension clubs as vehicles for collective strategies to prevent the spread of disease and co-management of communal resources - Increased regulation of shrimp

	succesful crops -Poorer households which rely soley on income earned from shrimp farming do not have the resources to weather losses and often find themselves in debt spirals or face financial ruin	culture activity (ie. coordination of stocking schedules, disposal of infected water and shrimp carcasses, and sediment from the pond) -National and local government should promote rice-shrimp and improved extensive culture models as the most sustainable and make efforts to prevent the further intensification of shrimp farming.
4. Extension	- Soc Trang extension services are very well organised and efficient with 50 officers employed in the provincial extension division -Frequent and numerous training courses available to most farmers -But still lack resources to meet the demand of expanding shrimp aquaculture -Remote areas (eg. hamlets in Thanh Quoi accessible only by boat) have less access to extension support especially in the event of disease outbreaks and are less frequently visted by feed company technicians and agri-product suppliers -New shrimp farmers in areas designated non-shrimp culture areas have no access to shrimp culture loans or training courses - Many farmers are visted regularly by feed company technicians and attend training courses hosted by feed companies. -Farmers exchange knoelwedge informally. New shrimp farmers benefit from pre-existing relationships with older shrimp farmers eg. learning from relatives	- Extension services require more funding, for personnel, transport, extension materials, collection of survey information and training courses. - Potential for 'mobile extension clinic'? - Urgent need for zoning plan so as to support those shrimp farmers who need technical and financial support and, at the same time, protect, non-shrimp farming land from the environmental impact of shrimp farmers - Private sector can be exploited as cost-effective source of info. BUT potential danger of unregulated technical advice and unequal access to 'privatised' extension

	- Farmers without such ties are at a disadvantage -TV is an important source of information. Many farmers watch extension programmes, but say that strategies target semi-intensive farming	- Extension progarmmes should encourage improved extensive and rice-shrimp culture models rather than (semi-)intensive and should support them with strategies appropriate to these systems.
5. Farmers' Groups	- Trial extension clubs for shrimp farmers in Hoa Tu I have been a success - There is a need and desire among shrimp farmers for greater organisation (clubs) in Thanh Quoi	- Replicate extension clubs in other communes - Extension clubs should be explored as vehicles of co-management to facilitae cooperation over disease control strategies such as water release, harmonising stocking schedules, regulating intensification and the effect of saline-intrusion on rice farmers

6.3 General Findings from the Vietnam Study

KEY THEMES	PROBLEMS/COMMENTS	RECOMMENDATIONS
1. Development Context	- Aquaculture is an aspect of farming, not fisheries. - Projects have arisen from a vision of shrimp aquaculture as a panacea for development, economic growth, food security and livelihood sustainability, rather than from the needs of apparent beneficiaries. -The development of the shrimp industry to meet government targets for export revenues receives strong institutional and financial support from the government and private sector including technical research, development and extension. - The social and environmental impact of increasing expansion and intensification of shrimp farming is already being felt in lower regions of Vietnam. Concerns are being voiced over the sustainability of this intensification	- Aquaculture planning and research should be considered within broad rural development frameworks, not as a sub-set of Fisheries Departments. - Disaggregate the various claims made on behalf of shrimp aquaculture. projects must identify target groups more rigorously and respond directly to their needs. - Advocacy with the government of Vietnam to prevent the over-intensification of shrimp farming and avoid the industry collapses and negatives social and environmental impacts experienced by other Asian countries -Integrated rice-shrimp and imrpoved extensive culture models of shrimp farming offer the best hope for a sustainable shrimp industry
2. Technology Transfer	-Shrimp farming is both capital intensive and highly risky. Despite the promise of large profits it may increase the vulnerability of poor households, rather than offering a sustainable and improved livelihood strategy - Increased productivity does not equate to decreased poverty - Technical intervention strategies are often developed in a vacuum, neglecting global market dynamics, access to resources and socio-economic disparity between households. - Technical farm management strategies benefit wealtheir	- Examine in advance of project planning: i) Motivations for adopting shrimp farming ii) Biotechnical and environmental factors iii) Alternative economic opportunities iv)Existing land and natural resource availability v) Global and local markets and value of shrimp vi) Processes of decision-making, labour distribution and resource-control within the household v) Institutional capacity for continued support of the intervention.

	farmers, often to the disadvantage of poor farmers.	- Need for more cost-effective disease prevention strategies for poor farmers
3. Research	- The primary beneficiaries of technical research in the field of AAH are successful, medium-large scale aquaculturalists, not small-scale rural farmers. - Many technical strategies produced from research have a limited impact on the lives of poor farmers who lack the financial, human and physical capital to invest in them.	- Poverty-focused research should consider the resource-base of poor households and concentrate on the basic principles of farm and pond management, as well as on reaching many farmers who remain without access to this kind of basic training, rather than technical outputs - Poverty-focused research should be driven by the priorities of poor households, not adapted to their needs afterwards. This involves incorporating participatory methods in all stages of the research esp. project-planning.
4. Extension	-Extension services for shrimp farmers in Vietnam are very well organised and efficient. Industry is well supported by the government because of high foreign exchange earning from shrimp industry -The 'trickle down' approach to extension does not work. This model benefits wealthier, successful farmers at the expense of poorer farmers - Limited reach due to lack of personnel and underfunding. Often, those who are not reached are the most remote, marginalised or needy. - Inappropriate advice. - Extension staff have little participation in aquaculture development planning which is done predominantly at a national level.	- Extension services require more funding, for personnel, transport, extension materials, collection of survey information and training courses. -New models for extension and training are required that target the poorest farmers rather than 'master' farmers - Extension service rigorously target the poor and most remote households who have least access to information - Participatory approaches incorporated into extension planning. - Develop peer training workshops and facilitate farmer-to-farmer learning and knowledge sharing. - Focus on quality, consistency and accessibility of messages, not quantity of information. - Focus on appropriateness of strategies to meet the particular needs of household and farm. - Train extensionists in: i) Aquaculture as a component of

	- Extension officers focus exclusively on technical and shrimp-farming related issues.	farming systems ii) Participatory extension methods iii) Socio-economic issues iv) Advice on markets and loans v) Gendered aspects of farm management.
5. Input Costs	- Capital for investment in pond and financial management remains one of the biggest problems for farmers - The cost of processed feed and chemicals required to maximize production in the pond is prohibitively high for poor households and forces farmers to become dependent on formal and informal credit.	- The technical is not enough: Integrate credit facilties, and advice on markets and financial management into technical support services
6. Markets and Price	- Shrimp farmers are vulnerable to trends and fluctuations in the global shrimp market. - Poorer farmers can face financial ruin as a result of market fluctuations or interventions such as the EU ban on seafood imports.	-Technical research and the promotion of shrimp culture should be informed by greater understanding of socio-economic context esp. global market dynamics and valuation of fish.
7. Credit	- Credit/loans are a vital component in the promotion of shrimp aquaculture. - Many small-medium scale producers are heavily dependent on credit which they are unable to repay. - Successful farmers are the primary beneficiaries of formal credit schemes while the poorest farmers are often unable to access low-interest government loans and become dependent on high-interest private credit suppliers in order to cover inputs into pond. - The provision of credit can often be manipulated by those least in need of it.	- Credit/loans schemes should be supported with continued technical and farm management advice. - In some cases, rather than improving livelihoods, shrimp farming increases the vulnerability of poor households, as they become dependent on formal and informal sources of credit. A more contextualised approach to the promotion of aquaculture is required. - More research on the relationship between shrimp farming and formal and informal systems of credit is required.
8. Aquatic Animal Health	-Epidemics of serious shrimp disease (yellow head and white	- Greater investment in technology for improved health screening and

and Disease	spot) are a major problem for farmers in the lower regions of Vietnam. Disease outbreaks appear to increase with long term shrimp farming and intensification. - Poorer farmers have been forced to abandon their farms or face financial ruin and spiralling debt as a result of losses due to disease - Farmers consider poor seed quality one of the primary causes of disease - Many farmers become heavily indebted buying drugs (eg. Antibiotics) for disease treatment with little knowledge what they are or correct dosage. - Urgent need for training in basic pond management techniques which reduce the incidence and spread of disease (eg. water quality maintenance, disposal of infected fish).	domesticated seedstock production techniques - Extension officers should provide advice to farmers about the use of drugs and chemicals for disease prevention, and suggest alternative low-cost strategies for disease control. - Greater regulation and coordiniation of shrimp farming acitivities is required among farmers to prevent the spread of disease
9. Regulation	- Continuing expansion and intensification of shrimp aquaculture driven by government - Expansion of shrimp farming into rice and vegetable farming areas creates conflict and adversely effects productivity of rice and vegetables	- Advocacy: strategies for influencing government policy to prevent the over-intensification of shrimp farming in Vietnam (learning from the experience of other Asian countries) - Need for greater regulation of shrimp farming actitivities; effective zoning of the land; co-management of natural resources; and support for no-shrimp farmers.
10. Impact Assessment	- Impact is conventionally considered in relation to levels of production, rather than poverty reduction or social change. - The project confirmed the difficulty of finding relevant and measurable indicators of the impact of technical research on poverty reduction.	- Re-think impact in terms of sustainable livelihoods approach to poverty reduction, rather than conventional economic goals of increased production. - Impact assessment should be integrated into the early stages of project design.

7. Re-thinking Technology Transfer and Extension

This study demonstrated the prevailing dominance of conventional models of technology transfer upon which development research, intervention strategies and extension planning have been based. In so doing, the study has highlighted the way in which the technical dimensions of aquaculture continue to be prioritised to the neglect of socio-economic and institutional realities in which the practice of aquaculture is embedded. The traditional paradigm of technology transfer focuses on the production, dissemination and delivery of tangible technologies or packages of technical strategies to farmers, with the goal of maximising productivity. According to this model poverty is seen to be the result of technological barriers. This conception of technology transfer relies on an assumption that information, and the benefits it brings, will trickle down from ‘master farmers’ or innovators to the poor. Technology or technical strategies are therefore seen to be universally beneficial.

The findings from this study contradict this orthodox conception of technology transfer. They demonstrate that new technology can be as much a burden to the poor as a benefit. The findings indicate that in most cases the poorest households have the least access to information and technical support, and that, the primary beneficiaries of AAH strategies and aquaculture technologies are resource-rich farmers. In most cases, farming technologies, even of a basic, low-tech kind, require not only financial capital, but labour, time and usually, certain physical resources. In order to meet these demands on capital, poorer farmers are forced to turn to formal, and often, informal sources of credit. In doing so many accumulate debts that they are unable to repay due to the high risk of failure and consequently poor returns from their shrimp farms and become trapped in cycles of debt or enmeshed in relationships of dependency and patronage with wealthier farmers. Thus, credit and technical knowledge can be manipulated by more successful farmers. In this way we can see that technology is not neutral: it is embedded within relationships of power and dependency. In such cases, projects which focus on the delivery of technical inputs can serve to increase the dependence and vulnerability of poor households, rather than reducing it.

The findings from the study demonstrate that factors and conditions vary, not only from province to province, but between households. The conventional extension approach by which a ‘package’ of technical strategies is delivered to farmers fails to reflect such difference and therefore can provide little support to some households. Needs and priorities vary according to specific geographical area and socio-economic context. Management strategies must, therefore, be adaptive and flexible. As Harrison states, ‘it makes more sense for technical research to be adaptive to and closely involving farmers themselves than for it to attempt to deliver technical “packages”’ (Harrison 1994: 50). On-farm demonstrations and interactive training courses in which farmers can raise individual concerns, though costly, are therefore seen to be the most successful medium for providing technical support to farmers.

8. The Implications for Future Research and Intervention

This study confirmed the challenges inherent in assessing the socio-economic impact of technical research. It demonstrated the difficulty of finding relevant and measurable indicators of the impact of technical research on poverty reduction. As Harrison points out, a common response to the challenges of impact assessment has been to focus on the quantity of data collected, or to set up 'evermore sophisticated databases' with which to process the data (Harrison 1994). The focus on tangible data misses the point. For, the impact of strategic research programmes on poverty is rarely explicit or directly attributable to a particular innovation or piece of research. A line cannot simply be drawn from the work of research institutions, the strategies they produce and the livelihoods of households. While quantifiable indicators can demonstrate the way in which a specific piece of bio-technical research, such as the development of a new and resilient type of grain, has achieved an increase in production, the relationship between research and poverty reduction is both more complex and less easily evaluated.

The study indicates that insufficient attention is paid to the intended target of both research and intervention strategies. This is not simply a question of paying greater attention to the socio-economic context of technical research. The direction and focus of the research itself should be determined by the needs of the target audience. While strategic research has a crucial role to play in poverty reduction, this study underlines the way in which development research programmes have tended towards technical research projects with a livelihoods agenda bolted on. The focus of research has been, and continues to be, dominated by biotechnical concerns and interests, while socio-economic considerations, such as low education or literacy levels, are seen as obstacles to be overcome or managed in the process of technology transfer. Projects promoting rural aquaculture continue to concentrate on the delivery/transfer of physical inputs or technical strategies, while the institutional context is, to a large extent, neglected or relegated to a separate project. The strategies produced by such research are adapted to the chosen target (for example,. ‘poor farmers’) which in turn justifies the research.

This points to the need for a shift towards target-led research, as opposed to research projects designed ‘in the lab’ and then adapted for the chosen context and target. Research which is driven by the poverty-reduction agenda and objectives focused on livelihood improvement, must ensure that the research is constantly informed by the needs of the poorest and most vulnerable people, and special efforts are made to ensure that the products of research reaches the target group. However, as this research has revealed, in some cases, aquaculture, and particularly shrimp culture may not be the most appropriate activity/means of diversification for the poorest households. The study indicated that, in many cases, shrimp farming may increase vulnerability rather than reducing it. Indeed, the case study suggests that those households who are currently benefiting the most from AAH strategies for shrimp farming are not the poorest/most vulnerable. As is the case for many other farming technologies, those who are most able to exploit technical strategies and innovations, and become productive fish farmers, are not the poorest. Thus projects that aim to *promote*, rather that *support*, shrimp farming, either through research or extension, may in some cases have little direct influence on poverty reduction. In such cases, we must ask: who is the research for? what are the expected outcomes? And, who stands to benefit from them? The conclusion of this study is not that research and extension should necessarily be focused on enabling the poorest households to benefit from aquaculture technologies, but to argue that greater attention must be paid to ensure that project objectives and outputs are *appropriate* to their stated targets. Research and extension should be driven and informed by the needs, priorities and capabilities of the target group (whether it be the poorest of the poor, small-scale farmers or large-scale producers) and not vice versa.

Over the past decade a number of development researchers and practitioners have called for the integration of aquaculture research and planning into broader perspectives on poverty reduction and rural development.[12] Nevertheless, technical projects devoted to the promotion and development of the shrimp industry continue to approach shrimp aquaculture as a discrete activity isolated from other development strategies and the realities of global trade and international markets.

The shrimp industry boom of the past decade has been supported and, arguably, driven by an increasingly sophisticated, extensive and well-funded network of scientific research and development programmes committed to increasing productivity. The appeal of large export revenues from the global shrimp market and the consequent dominance of biotechnical concerns in research and development agendas has led to a neglect of the very real threats the intensification of shrimp production presents for both the sustainability of the shrimp industry in Vietnam on a macro level, as well as that of individual farms at the household level. This report argues that due to the capital required and the high levels of risk inherent in shrimp farming, combined with the concerns around its medium and long-term sustainability, shrimp aquaculture, in many cases, increases the vulnerability of poorer households. Greater attention, therefore, must be paid to the intended targets of programmes which support and facilitate the adoption of shrimp aquaculture and, at the same time, claim a commitment to poverty-reduction.

This report highlights the urgent need to re-focus attention on the institutional and governance issues around shrimp farming in Vietnam and on the way in which the livelihoods and farm management strategies of shrimp farmers are bound up with national targets for shrimp production set by the government. At this crucial point, the need for much greater regulation of shrimp farming activities and the imperative towards intensification emerges as key. Research agendas should focus on strategies focusing on sustainability of the industry and alternative livelihood activities for the growing number of households whose shrimp farms are failing. We are left asking, as Fegan asked almost a decade ago, 'sustainable shrimp farming in Asia: vision or pipe-dream?' (Fegan 1996).

This project attempted to cut across disciplinary and sector-based boundaries by bringing together a diverse range of skills and methodologies from a wide spectrum of disciplines in order to taker a broader perspective on the role of shrimp farming in rural livelihoods and its impact on poverty reduction. However, the project highlighted the way in which

[12] See for example, Harrison 1994; Lightfoot and Pullin 1991; Edwards 2000.

the priorities and agendas of various stakeholders involved in the project may differ, with potentially negative consequences for the project. This is especially important for multi-disciplinary, collaborative projects involving a large number of institutions, where the rationale and broad goals of a project can be perceived differently by different institutions and individuals involved in the project. The institutional framework of development research projects and the need for multi-disciplinary collaboration across a number of organisations can, at times, result in the over-arching goals of the donor being imposed on institutions whose remits do not correspond either with those of other participating institutions, or with the objectives of project. Differing interests, priorities and methodologies are often not evident or made explicit in project documentation, but emerge during the course of the project. As Harrison states, the priorities of stakeholders, of donors, hosts and participants, are not 'monolithic or fixed in opposition. They also belong simultaneously to institutions and to the individuals attached to these institutions.' Priorities and interests emerge through the course of a project, through engagement in the project and with other participants, they are constantly shifting and negotiated. Just as projects are not fixed in stone, but are mobile and dynamic, there is a need to address the changing, and at times competing, agendas which drive them. A reflexive approach is required which engages with the multiple interests and priorities of individuals and institutions involved in the project be seen as mobile and dynamic rather than fixed in stone, so responding to the changing and, at times, competing, agendas and interests which drive them.

ANNEXES

Annex 1. Research Methods and Materials

This study was conducted over a 7 week period in March and April 2003. The fieldwork was carried out by a multi-disciplinary team of natural and social scientists from four of the institutions collaborating in the project: The Research Institute for Aquacuclture 2 (RIA2) in Ho Chi Minh City, The College of Aquacuclture and Fisheries (CAF) at CanTho University, The Institute of Aquaculture at The University of Stirling, and the Department of Anthropology at the University of Sussex). The data collected from questionnaire was compiled and analysed at RIA2 and CAF.

During the 7 week period, approximately 2 weeks were spent at the project base at RIA2 in Ho Chi Minh City. During this time a few days were also spent at CAF in CanTho. During this time the research strategy was designed and time was spent collecting data and interviewing employees about both institutes' interaction with farmers and their various research, dissemination, training and diagnostic activities.

Initial visits were made to the study sites (Tan Chanh Commune in the Can Duoc District and the communes of Hoa Tu I and Thanh Quoi in the My Xuyen District) at the beginning of each case study in order to obtain permission from the local people's committee to undertake the research, as well as to establish the parameters of the field of study, and arrange the logistics of carrying out the fieldwork. During these visits, the questionnaire was pilot tested and pilot interviews were conducted with medium- and small-scale shrimp farmers. Key informant interviews were also carried out with the head of the commune people's committee in order to gather background data and information on the state of aquaculture in the province.

The field research was divided into three stages. Two weeks were spent conducting the case study in one commune (Tan Chanh) in Can Duoc District, Long An Province. A further two weeks were spent undertaking the case study in two communes (Hoa Tu I and Thanh Quoi) in the My Xuyen District of Soc Trang Province, with a week spent in each commune.

During these case studies interviews were conducted with various stakeholders involved in aquaculture in the Province and observing the pond management practices. A questionnaire-based survey of farmers involved in shrimp farming was also conducted during this time in order to generate quantitative data on pond management practices, production cycles, investment costs and income earned from shrimp farming and access to sources of information on AAH and disease and credit facilities (See Annex 2.). The questionnaire was conducted with farmers randomly selected from the provincial extension service list of farmers.

The case study employed a range of research methods, both qualitative and quantitative. The project deals with both the 'scientific' and the 'social' and therefore provided an appropriate arena for multi-disciplinary collaboration. This was reflected in the methodology adopted for the research. This involved a qualitative ethnographic approach derived from anthropology. A stakeholder analysis was carried out in order to identify the primary and secondary stakeholders involved in aquaculture production in the Province. In-depth, semi-structured interviews were conducted with people from the list of stakeholders, including:

- Extensive, semi-intensive and intensive shrimp farmers who practice shrimp farming
- Farmers who do not practice shrimp farming
- Provincial fisheries extension officers
- Shrimp seed suppliers
- Shrimp traders
- Agricultural products salemen
- Chairmen of commune and hamlet people's committee
- Heads of shrimp farming extension clubs

Observation of commune extention meetings and informal farmers' group gatherings provided an insight into the way in which knowledge about farm management was shared and the way in which various stakeholders related to each other.

Through the ethnographic approach the researchers engaged more closely with the complex set of socio-economic processes that define the practice of aquaculture and household economy. This enabled the researchers to examine commonly neglected issues such as:

- Motivation for farming
- Conceptions of profit and loss
- The relationship between knowledge and practice
- Decision-making within the household
- The way in which risk is calculated against investment.

These issues are crucial to examining the reception and uptake of technical aquaculture strategies and the role played by aquaculture and AAH in rural livelihoods.

Through a series of interviews with chairmen of the commune and hamlet people's committee and farmers we were able to reach a variety of farmers in each commune. This also approach also revealed informal farmers' groups and clusters of farmers in one area with similar culture models. The flexible iterative approach allowed us to follow pathways revealing informal networks through which information travels and knwoeldge is shared, and to explore the social and economic relationships between various actors involved in aquaculture production in the area.

Annex 2. Farmer's Questionnaire

Vietnam Situation Appraisals: Shrimp Farmers Questionnaire

March-April 2003

Tan Chanh Commune, Can Duoc District, Long An Province,
Hoa Tu I and Thanh Quoi Communes, My Xuyen District, Soc Trang Province

1. Farmer

1.1 Code:

1.2 Date of Interview:

1.3 Name:

1.4 District:

1.5 Commune:

1.6 Hamlet:

1.7 Age:

1.8 Educational: A Illiterate B Primary School C Secondary School
D High School E Other ________________(please specify)

1.9 Is this the (please circle all that apply):

A Owner B Husband C Wife D Worker/Helper E Manager

2. Farm

2.1 Type of Farm (please tick all that apply):

Rotating Rice/Shrimp	
Rotating Rice and Fish/Shrimp	
Extensive shrimp only	
Semi-intensive/Intensive shrimp only	

2.2 Information of the most benefit pond in 2002:

2.2.1 Pond area: ______ ha

2.2.2 Number of crops/No. of years: _______

2.2.3 Stocking density: _____ con/m^2

2.2.4 Month of stocking:

2.2.5 Culture period: A 1 month B 2 month C 3 month D 4 month

2.2.6 What is the total weight to shrimp at harvest?____________________

2.2.7 How many shrimp per kilogram?_______________________

2.2.8 What is the average price per kilogram?___________________

2.3 Type of shrimp feed:____

2.4 How do you buy the feed? A Cash B Credit C Both

2.4.1 In case of cash, in what culture period:
A The first 2 month B After that C Both

2.4.1 In case of credit, in what culture period:
A The first 2 month B After that C Both

2.5 Source of shrimp seed: A Stock with Pls B Stock with acclimated shrimp

2.6 Do you have problems with access to water? A YES B NO

2.7 Source of water exchange: A Direct from canal B Reservoir

2.8 Do you clean the pond every crop? A YES B NO

2.9 How much money do you invest in pond cleaning?______________________

2.10 Whom do you get the price information from?

A Trader B Neighbour farmers C Processing Plant

D Other (please specify)___________

2.11 Does the price change a lot? YES NO

2.12 If YES, why: A Quality of crop B Change in market value

2.13 Tenure and investment:

A Own land and self investment B Own land and co-investment

C Rent land and self-investment D Rent land and co-investment

3. Labour

3.1 Household size:____people

3.2 Labour force of household (16-60 years old):_____people

3.3 Labour force of household involved in shrimp culture:____people

3.4 Hired labour days per crop:_____

3.5 Purpose of hired labour: A Pond preparation B Harvesting

C Take care of pond D A&B E A,B&C

4. Livelihoods and Income

4.1 What did you do before you started shrimp farming?________________________

4.2 Has your income increased a lot since you started shrimp farming?

A No B A little bit C A lot D Decrease

4.3 Is shrimp farming the main source of income for the household? A YES B NO

4.4 Share of family income due to shrimp farming:_______%

4.5 Share of household labour time spent on shrimp farming_____%

4.6 What other livelihood activities does your household do? (tick all that apply):

Activity	Commercial	Household consumption
Poultry Farming		
Pigs		
Fish farming		
Rice		
Fruit		
Vegetable		
Remittence money from relatives working abroad or in city		
Trader		
Domestic worker		
Labourer		
Small business (please specify)		
Other (please specify)		

4.7 Do you have problems selling your shrimp? YES NO

4.8 If YES, what?

A Access to trader B Quality of shrimp C Market fluctuations

D Transporting shrimp E Trader cheats you F Other(please specify)

4.9 Does your income from shrimp farming change a lot from year to year? YES NO

Year	Approximate Income
1st year of shrimp farming	
2nd year of shrimp farming	
2000	
2001	
2002	

5. Disease and Health Management

5.1 Do your shrimp ever get sick? YES NO

5.2 If YES, when? A 1st month of culture (MOC) B 2nd MOC C 3rd MOC

5.3 How do you know your shrimp are sick? (please tick all that apply)

A Recognise/observe signs B Advice from other farmer

C Advice from technician or extensionist D Shrimp die

5.4 What do you do when your shrimp get sick? (please tick all that apply)

A Nothing B Change water C Apply chemical

D Harvest

5.5 Who advised you to do this?

A Extensionist B Other farmer C Personal experience

D Other (please specify)____

5.6 Is it effective? A YES B NO C SOMETIMES

5.7 Is it a problem for you when your shrimp get sick?

A YES B NO C SOMETIMES

5.8 Do you test the quality of the shrimp seed before you buy it? A YES B NO

5.9 If YES, how?

A Observation B Lab test C Stress test

6. Information and Knowledge

6.1 Have you received information about shrimp farming? A YES B NO

6.2 If YES, from who?

A extensionist B Other farmer C Seed supplier

D Feed supplier E drug seller F trader

G Media______ Other (please specify)_________________

6.3 Please tick which subjects you have received information on and grade how useful you found the advice (1=negative effect, 2=no use, 3=little bit useful, 4=very useful)

Subject	Source of information	How useful
Shrimp seed		

Shrimp feeding		
Farm management		
Water quality		
Pond preparation		
Chemicals for preparation		
Chemicals for disease treatment		
Stocking density		
Disease prevention		
Disease treatment		
Market price and selling		

6.4 Have you ever attended a training course? A YES B NO

6.5 How many times? ___________

6.6 Who organised them? A Extension service B Farmers association

C Research Institute D Feed/chemical company E Other_________________

6.7 If NO, why have you not attended?_______________________________________

6.8 How were you informed about the training course:

A Invitation B Other farmers C Extension officer D Poster

E Other_______________________

6.9 Did you find the training useful?

A Not useful B A little bit useful C Very useful

6.10 Do you share your knowledge with other farmers? A YES B NO

6.11 If YES, what situation?

A Formal farmers group B Informal/social meeting C Other_______________

6.12 How often do you meet?____

6.13 What do you discuss/do?____

6.14 Do you think this is useful? YES NO

6.15 Please tick the following sources of information on shrimp farming that you use and rank them (1=not useful, 2=a little useful, 3=very useful)

Source of information	**How useful**
TV programme	
Radio Programme	
Loudspeaker broadcast	
Newspaper	
Magazine	
Extension Booklet/manual	

6.16 Have you received any information on shrimp disease?

6.17 If YES (insert details in table)

Who was it from?	
Subject?	
Did you follow the advice?	YES NO
Was it effective?	YES NO

7. Loans and Credit

7.1 Do you have a loan from the bank? A YES B NO

7.2 If YES, What for? A Pond preparation B Buy seed C Other_______

7.3 What is the interest rate?_________

7.4 Do you have trouble repaying the loan? A YES B NO C SOMETIMES

7.5 Do you have a high-interest loan? A YES B NO

7.6 If YES, What for? A Pond preparation B Buy seed C Other_______

7.7 What is the interest rate?_______________

7.8 Credit from seed supplier paid after harvest? A YES B NO

7.9 Credit from feed supplier paid after harvest? A YES B NO

7.10 Credit for chemicals paid after harvest? A YES B NO

7.11 Most important credit/loan source?_____________________________

8. Conclusion

8.1 What are the main problems you have in shrimp farming? (tick all that apply)

A Lack of capital to invest B Access to bank loans

C Lack of knowledge D Access to information and training

E Disease F Market price G Access to water

H Seed quality I Other (please specify)______________

8.2 Do you think that shrimp farming is risky? A YES B NO

8.3 If YES, why? (please tick all that apply)

A Disease B Market fluctuation C Flooding

D Environment (please give details)_______________________

E Other____

8.4 What is your opinion on the future of shrimp farming in this area?

A Stay as it is B Slow down C Intensify

Thank you very much for your help and time. This information is for use in a research project and will not be used for any other purpose. If you have any problems or questions please contact RIA2, Ho Chi Minh City.

Annex 3.

PEOPLE'S COMMITTEE OF CANDUOC DISTRICT

SOCIALIST REPUBLIC OF VIETNAM
Independence- Freedom- Happiness

No: 01/CT.UB Canduoc town, 17/ 01/ 2003

INSTRUCTION

(Concerning epidemics and environmental management for *Penaeus monodon* culture in 2003)

Penaeus monodon culture plays a very important role in the district. Successes or failures of shrimp crops will directly affect the socioeconomic development of the district and people's livelihoods in lower region communes.

In recent years, especially in 2002, despite weather and climate fluctuations, *Penaeus monodon* culture in the district continues to be successful. Farmers' technical and scientific knowledge and experience of shrimp culture is increasing daily; this is a fundamental factor for the success of shrimp crops. However, *Penaeus monodon* culture in the district is adversely affected by certain factors, specifically, shrimp farmers preparing their ponds at the different times. In order to dispose of pond sediment and soil from newly dug ponds shrimp farmers have been throwing mud and soil freely into the rivers and canals, blocking flow of the rivers and canals, polluting the water and creating stagnation. When shrimp are affected by disease, measures to control disease epidemics have been inadequate. This is due to shrimp farmers disposing of infected shrimp carcasses and releasing the water from their diseased shrimp ponds untreated into the surrounding water systems. If these activities are not stopped, they are going to affect the sustainability of the whole shrimp culture community. Faced with the above situation, the District People's Committee instructs:

1. The People's Committee of communes with shrimp aquaculture must inspect pond preparation for the 2003 crop of shrimp farmers; They must ensure that:
   i) Farmers dispose of mud/sediment and prepare their ponds at the same time so as not to affect the surrounding environment.
   ii) The period of pond preparation does exceed 15/01/2003
   iii) Mud and organic sediments are not released into the public rivers and canals.
   iv) Strictly ban shrimp culture farmers from removing sludge from their ponds and re-stocking the pond with a second crop in the event of the first crop failing during the time when the main crop (the first crop) is still in the culture stage.

Pond preparation and sludge removal violations which affect the areas of the commune under shrimp cultivation will be punished following Section C, Point I, Clause 9 of the

Decree 48/CP 12/08/1996 of the *Government Regulations for Penalty of Administrative Violations in the Fisheries Resources Protection*.

Preparation, sludge removal and disposal violations which block the flow of the rivers and canals will be punished following Clause 28 of the *Irrigation Works Protection and Exploration* State Law declared by the Parliament Standing Committee of the Socialist Republic of Vietnam 04/04/2001.

2. Shrimp farmers must be held responsible , together with the People's Committee at the appropriate level and its functional organizations for controlling the outbreak of disease epidemics efficiently and preventing the spread of infection, through the above activities.

    i)When the shrimp culture ponds get disease, farmers must inform the local government office and functional organizations for treatment measures. Violations, will be punished according to Section A, Point I, Clause 9.

    ii)Strictly ban throwing shrimp carcasses into the rivers, canals and neighbouring culture ponds. Violations will be punished according to Section B, Point I, Clause 9 of the decree 48/CP 12/8/1996 of the *Government Regulations for Penalty of Administrative Violation in the Fisheries Resources Protection*.

    iii)Strictly ban the release of untreated water from culture ponds or fields when infected with 'serious' diseases (white spot disease, yellow head disease) into the shrimp cultivation area. Violations will be punished according to Section C, Point I, Clause 9 of the Decree 48/CP 12/8/1996 of the *Government Regulations for Penalty of Administrative Violation in the Fisheries Resources Protection*.

The People's Committees of shrimp culture communes, the head of relevant sections of the District People's Committee and shrimp culture households have a responsibility and duty to carry out this instruction strictly.

On behalf of The People's Committee of the District

Signed and sealed by The Chairman

Annex 4. References

Adger, W.N., and Kelly, P.M., 2001. 'Social Vulnerability and Resilience' in W.N.Adger *et al* (eds) *Living with Environmental Change: Social Vulnerability, Adaptation and Resilience in Vietnam*. London and New York: Routledge, pp19-35.

Asia Pulse Ltd 2001. *Vietnam Shrimp Farms a Key Part of Fisheries Five Year Plan*. Asia Pulse Limited, 20 February 2001

Asia Pulse Ltd, 2002. *Vietnam Fisheries Sector Steps up Effort to Improve Qualit*y. Asia Pulse Limited, 16 July 2002.

Barraclough, S. and Finger-Stich, A. 1996. Some Ecological and Social Implications of Commercial Shrimp Farming in Asia, UNRISD, March 1996.

Boonyaratpalin, S. 1996. 'Viral Diseases of Farmed Shrimp – Present Status and Future Research', Towards Sustainable Shrimp Culture in Thailand and the Region, Proceedings of a Workshop held at Hat Yai, Songkhla, Thailand, 28 Oct-1 Nov 1996, ACIAR, 80-82 http://www.aciar.gov.au.publications/proceedings/90/ACIAR-proceedings-90.pdf.

Bort, J., Ovares, L. and Stonich, S. 1997. 'Globalisation of shrimp mariculture: the impact on social justice and environmental quality in Central America', Society and Natural Resources, Vol. 10, No. 2, 161-179.

Brennan, D. *et al*, 1999. *Economic and Social Characteristics and Farm Management Practices of Farms in the Brackish Water Region of Soc Trang and Bac Lieu Provinces, Mekong Delta, Vietnam: Results of a 1997 Survey*. http://www.reap.com.au/riceshrimpsurvey97.pdf

Brennan, D. *et al*, 2002. 'An Evaluation of Rice-Shrimp Farming Systems in the Mekong Delta', Report prepared for the World Bank, NACA, WWF and FAO, 2002. Shrimp Farming and the Environment. A World Bank, NACA, WWF and FAO Consortium Program.

Burch, D., Goss, J. and Rickson, RE. 2000. 'Agri-Food Restructuring and Third World Transnationals: Thailand, the Cp Group and the Global Shrimp Industry', World Development Vol. 28 No. 3, 513-530.

Chase Smith, R. *et al*. 2001. 'Tropical Rhythms and Collective Action: Community-Based Fisheries Management in the Face of Amazonian Unpredictability' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 36-47.

CIA 2001. *World Factbook*. Central Intelligence Agency. Washington DC, 2001.

Department of Fisheries, 2003. Organization of Department of Fisheries. http://www.fisheries.go.th/english/organization.html

Edwards, P. 2000. 'Aquaculture, Poverty Impacts and Livelihoods', ODI Natural Resource Perspectives No. 56, ODI, http://www.odi.org.uk/nrp/56.html.

European Commission, Directorate General for Development 1994. 'Fisheries and Aquaculture – Operational Guidelines for the Incorporation of Gender in Project/ Programme Preparation and Design'.

Fairhead, J. and Leach, M. 2002a. 'Introduction: Changing Perspectives on Forests: Science/Policy Processes in Wider Society' in Amanor, K., Fairhead, J. and Leach, M. Science and the Policy Process: Perspectives from the Forest, IDS Bulletin Vol 33, No. 1, Jan 2002, 1-12.

Fegan, D. 1996. 'Sustainable Shrimp Farming in Asia: Vision or Pipedream?', Aquaculture Asia, Vol. I, No. 2, 22-39.

Government of Vietnam 1998. Decision on the Ratification of the Programme of Developing the Export of Aquatic Products up to 2005, No. 251/1998/QD-Ttg. 25 December 1998.

Government of Vietnam 1999. 'Government Direction on Agriculture and Rural Development, A Government Report for Consultative Group Meeting held in Paris December 7-8 1998' in *Vietnam's Socio-Economic Development*, No. 17, p.28-43.

Harrison, E. 1994. 'Fish Farming in Africa - What's the Catch?', Overseas Development Agency, University of Sussex and Institute of Aquaculture, University of Stirling.

Nguyen Van Tu and Trinh Truong Giang, 2003. Improving the Efficiency of Fisheries Extension Activity in Southeastern Province of South Vietnam. College of Aquaculture and Forestry, Ho Chi Minh City, Vietnam.

Lam Thi Mai Lan 2001. 'Landless Households in the Mekong River Delta (A Case Study in Soc Trang Province' in *Vietnam's Socio-Economic Development* No. 27, p. 56-66.

Le Quang Minh, 2001. 'Environmental Governance: A Mekong Delta Case Study with downstream Perspectives' in N. Bademoch and M. Dupar (eds) *Mekong Regional Environmental Governance: Perspectives on Opportunities and Challenges*. Workin Papers of the REPSI Mekong Regional Environmental Governance and Research Dialogue Group. Chiang Mai, Thailand.

Lightfoot, C. and Pullin, RSV. 1991. 'Why Asian FSRE Needs Qualitative Methods for Integrating Agriculture with Aquaculture', Journal of Asian Farming Systems Association Vol. 1, No. 2, 201-215.

Martinelli, A., 2000. *Finding the Balance between Riches and Ruin. An Assessment of the Shrimp Industry in the Mekong River Delta of Vietnam and Prospects for Sustainable Poverty Alleviation*, Oxfam Hong Kong and Vietnam, October 2000.

Mehta, L., Leach, M. and Scoones, I. 2001. 'Editorial' in Mehta, L., Leach, M. and Scoones, I. (eds) Environmental Governance in an Uncertain World, IDS Bulletin Vol. 32, No. 4, 1-10.

Rajak, D., 2002. 'Asian Aquaculture. Livelihoods and Knowledge: A Critical Literature Review', Unpublished.

Rayner, S., 2003. 'Democracy in the Age of Assessment: reflections on the Roles of Expertise and Democracy in Public-Sector Decision-making', *Science and Public Policy*, Vol. 30, No. 3, 163-170.

Somsiri, T., Crumlish, M., Dumrongphol, Y., Panbanpaw, A. & Thompson, K.D., 2001. Study of Bacterial Loading in Macrophage Cells of Hybrid Catfish (to Poceedings of the 4th Symposium on Diseases in Asian Aquaculture).

Stirrat, RL. 2002. 'Impact Assessment', DRAFT.

Tran, T.B., and Hiep, T.T.N., 2000. *Rice-shrimp Farming Systems in the Study Area: Changes over Three Years, 1997-99*, ACIAR Rice-Shrimp Final Workshop, December 12-15, Can Tho University, Vietnam.

Turongruang, D. and Demaine, H., 2003. Participatory Development of Aquaculture Extension Materials and their Effectiveness in Transfer of Technology: the Case of the AIT Aqua Outreach Programme, Northeast Thailand. Asian Insititue of Technology, Thailand.

Wattanutchariya, S. *et al* 1982. Economics of *Clarias* farming in Chachoengsao Province in 1980. National Inland Fishries Institute, Bangkok.

World Bank 1991. 'Fisheries and Aquaculture Research Capabilities and Needs in Asia – Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region', World Bank Technical Paper Number 47, Fisheries Series, Washington DC: World Bank.

World Bank, NACA, WWF and FAO, 2002. *Shrimp Farming and the Environment. A* World Bank, NACA, WWF and FAO Consortium Program to 'Analyse and Share Experience on the Better Management of Shrimp Aquaculture in Coastal Areas' Synthesis Report.

Appendix IX

Scientific outputs from Epidemiology study

PEER REVIEWED

Corsin, F., Turnbull, J.F., Hao, N.V., Mohan, C.V.,Phi, T.T, Phuoc, L.H., Tinh, N.T.N. & Morgan, K.L. (2001) Risk factors associated with White Spot Syndrome Virus infection in a Vietnamese rice-shrimp farming system. Disease of Aquatic Organisms. 47, 1-12.

Corsin, F., Turnbull, J.F., Hao, N.V., Mohan, C.V., Phi, T.T., Phuoc, L.H., Tinh, N.T.N. & Morgan, K.L. (2002) Problems and solutions with the design and execution of an epidemiological study of white spot disease in black tiger shrimp (*Penaeus monodon*) in Vietnam. Preventative Veterinary Medicine. 53, 117-132.

Thakur, P.C., Corsin, F., Turnbull, J.F., Shankar, K.M., Hao, N.V., Padiyar, P.A., Madhusudhan, M., Morgan, K.L. & Mohan, C.V. (2002) Estimation of prevalence of white spot syndrome virus (WSSV) by polymerase chain reaction in *Penaeus monodon* postlarvae at time of stocking in shrimp farms of Karnataka, India: a population-based study. Diseases of Aquatic Organisms. 49, 235-243.

Mohan, C.V., Corsin, F., Thakur, P.C., Padiyar, P.A., Madhusudan, M., Turnbull, J.F., Hao, N.V. & Morgan, K.L. (2002) Usefulness of dead shrimp specimens to study the epidemiology of white spot syndrome virus (WSSV) and chronic bacterial infection. Diseases of Aquatic Organisms. 50, 1-8.

Corsin, F., Thakur, P.C., Padiyar, P.A., Madhusudhan, M., Turnbull, J.F., Mohan, C.V., Hao, N.V. & Morgan, K.L. (2003) Relationship between WSSV and indicators of quality in *Penaeus monodon* post-larvae in Karnataka, India. Diseases of Aquatic Organisms. 54, 97-104.

Turnbull, J.F., Corsin, F., Mohan, C.V., Padiyar, P.A., Thakur, P.C., Madhusudan, M., Hao, N.V., & Morgan, K.L.(In Press). Predicting outbreaks of white spot disease in a semi-intensive *Penaeus monodon* culture system in Karnataka, India. DAA5 Aquaculture Special Edition.

CONFERENCE PRESENTATIONS

Turnbull, J.F., Corsin, F., Hao, N.V., Mohan, C.V. & Morgan, K.L. (1999) An epidemiological study of White Spot Disease in a rice-shrimp culture system in the Mekong delta. DFID/FAO/NACA Workshop on aquatic animal health care in rural aquaculture. Dhaka, Bangladesh. 27-30 September 1999.

Corsin F., J.F. Turnbull, N.V. Hao, C.V. Mohan, T.T. Phi, L.H. Phuoc, N.T.N. Tinh, K.L. Morgan (2001) White Spot Syndrome in Vietnamese rice-shrimp farms. Poster Society of Veterinary Epidemiology and Preventive Medicine

(SVEPM) annual conference. 28-30 March 2001, Noordwijkerhout (The Netherlands).

Corsin F., J.F. Turnbull, N.V. Hao, C.V. Mohan, T.T. Phi, L.H. Phuoc, N.T.N. Tinh, K.L. Morgan (2001) Risk factors associated with White Spot Syndrome Virus infection in a Vietnamese rice-shrimp farming system. Association of Veterinary Teachers and Research Workers (AVTRW) annual conference. 9-12 April 2001, Scarborough (UK).

Corsin F., P.C. Thakur, P.A. Padiyar, M. Madhusudhan, J.F. Turnbull, C.V. Mohan, N.V. Hao, K.L. Morgan (2001) Relationship between WSSV and indicators of quality in Penaeus monodon post-larvae in Karnataka, India. AVTRW annual conference. 9-12 April 2001, Scarborough (UK).

Corsin, F., P.C. Thakur, P.A. Padiyar, M. Madhusudhan, J.F. Turnbull, C.V. Mohan, N.V. Hao, K.L. Morgan (2002) Feeding farmed shrimp with shrimp waste – the lesson for aquaculture from BSE. AVTRW annual conference. 25–27 March 2002, Scarborough (UK).

Corsin F., J.F. Turnbull, C.V. Mohan, N.V. Hao, K.L. Morgan (2002) Observational epidemiology and practical intervention strategies for disease control: lessons from a study of White Spot Disease. Invited presentation European Aquaculture Society, annual conference. 16-19 October 2002, Trieste (Italy).

Corsin F., Turnbull, J.F., Mohan, C.V., Hao, N.V. & Morgan, K.L. (2002) Farm level risk factors for white spot disease outbreaks. Invited presentation 5th Symposium on Diseases in Asian Aquaculture. 24-28 November 2002, Brisbane (Australia).

Turnbull J.F., Corsin, F. Mohan, C.V., Padiyar, P.A., Thakur, P.C., Madhusudan, M., Hao, N.V. &Morgan, K.L. (2002) Predicting outbreaks of white spot disease in a semi-intensive *Penaeus monodon* culture system in Karnataka, India. 5th Symposium on Diseases in Asian Aquaculture. 24-28 November 2002, Brisbane (Australia).

Mohan C.V., Corsin, F., Turnbull, J.F., Hao, N.V. & Morgan, K.L. (2002) Farm level biosecurity. Invited presentation 5th Symposium on Diseases in Asian Aquaculture. 24-28 November 2002, Brisbane (Australia).

Corsin F., Thakur, P.C., Padiyar, P.A., Madhusudhan, M., Turnbull, J.F., Mohan, C.V., Hao, N.V. & Morgan, K.L. (2002) Feeding farmed shrimp with shrimp waste – the lessons for aquaculture from BSE. 5th Symposium on Diseases in Asian Aquaculture. 24-28 November 2002, Brisbane (Australia).

Turnbull J.F., Corsin, F., Mohan C.V., Thakur P.C., Padiyar M., Madhusuddhan, N.V., Hao N.V. & Morgan K.l. (2003) An epidemiological study of white spot disease in shrimp farms of Karnataka India. SVEPM. April 2003, Warwick (UK).

Appendix X

A SURVEY OF RESEARCH AND TRAINING IN AQUATIC ANIMAL HEALTH AND PRODUCTION

SECTION A: PUBLICATIONS

1. Have you been an author or co-author on any papers published in refereed journals since January 2000? **YES** ☐ **NO** ☐
(please place a tick like this ✓ in one box only)

IF NO: **GO TO QUESTION 2**
IF YES: Please circle the number of papers published each year in the table below.
For example 1

Year	Manuscripts
2000	1 2 3 4 5 6 7 8 9 10
2001	1 2 3 4 5 6 7 8 9 10
2002	1 2 3 4 5 6 7 8 9 10

2. Have you been an author or co-author on any other written articles published since January 2000? **(please tick one box only)** **YES** ☐ **NO** ☐

IF NO: **GO TO QUESTION 3**
IF YES: Please circle the **number of each type** published each year in the table below, (> = more than).

Year	Conference proceedings	Aquaculture trade journals	Information leaflets/pamphlet s/sheets	Newsletters	Other
2000	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5
2001	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5
2002	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5	0 1 2 3 4 5 >5

SECTION B: PRESENTATIONS AT MEETINGS

3. Have you attended **any** aquatic health and production or scientific meetings since 2000? **YES** ☐
(please tick one box only) **NO** ☐

IF NO: **GO TO SECTION C**

IF YES: Please circle the **number of meetings** attended each year in the table below, (> = more than).

Year	Meetings
2000	**0 1 2 3 4 5 6 7 8 9 >9**
2001	**0 1 2 3 4 5 6 7 8 9 >9**
2002	**0 1 2 3 4 5 6 7 8 9 >9**

4. Have you been **invited** to speak at any **International** scientific meetings since January 2000? **(please tick one box only)** **YES** ☐ **NO** ☐

IF NO: **GO TO QUESTION 5**

IF YES: Please **CIRCLE** the number of invitations **received** and the number **accepted** each year in the table below (> = more than).

	2000	**2001**	**2002**
Number of invitations **received**	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of invitations **accepted**	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6

5. Have you been **invited** to speak at any other aquatic animal health and production or scientific meetings since January 2000? **YES** ☐ **NO** ☐
(please tick one box only)

IF NO: **GO TO QUESTION 6**

IF YES: Please **CIRCLE** the number of invitations to give talks **received** and the number **accepted** each year in the table below (> = more than).

Total number of invitations for national scientific meetings:	**2000**	**2001**	**2002**
Received	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Accepted	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of invitations for aquaculturist or farmers meetings:			
Received	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Accepted	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of invitations for commercial or trade company meetings:			
Received	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Accepted	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of invitations for other meetings:			
Received	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Accepted	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6

6. Have you given a talk (not invited) at any International scientific meeting since January 2000? **(please tick one box only)**

YES ☐
NO ☐

IF NO: **GO TO QUESTION 7**

IF YES: Please **CIRCLE** the number of talks given each year in the table below (> = more than).

	2000	**2001**	**2002**
Number of talks given	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6

7. Have you given a talk at any other aquatic animal health and production or scientific meetings since January 2000? **(please tick one box only)**

YES ☐
NO ☐

IF NO: **GO TO SECTION C**

IF YES: Please **CIRCLE** the number of talks given each years at each type of meeting in the table below (> = more than).

	2000	**2001**	**2002**
Number of talks at International Meeting (s)	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of talks at National Scientific Meeting(s)	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of talks at meetings to aquaculturists or farmers	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of talks to Commercial or Trade Companies **e.g. feed, seed, technical equipment, pharmaceuticals**	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6
Number of talks to other organisations	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6	0 1 2 3 4 5 6 >6

SECTION C :TRAINING

8. Have you attended any training courses in aquatic animal health and production or related sciences since January 2000? **(please tick one box only)** **YES** ☐ **NO** ☐

IF NO: **GO TO SECTION D**

IF YES: Please **LIST** the **subjects** and the **length** of the courses attended (in days) in the table below. **Please do not complete column 4 at this point.**

COLUMN 1 **YEAR**	COLUMN 2 **COURSE SUBJECT**	COLUMN 3 **LENGTH (DAYS)**	COLUMN 4 **SCORE**
2000	1.		1 2 3 4 5
	2.		1 2 3 4 5
	3.		1 2 3 4 5
	4.		1 2 3 4 5
	5.		1 2 3 4 5
	6.		1 2 3 4 5
	7.		1 2 3 4 5
	8.		1 2 3 4 5
2001	1.		1 2 3 4 5
	2.		1 2 3 4 5
	3.		1 2 3 4 5
	4.		1 2 3 4 5
	5.		1 2 3 4 5
	6.		1 2 3 4 5
	7.		1 2 3 4 5
	8.		1 2 3 4 5
2002	1.		1 2 3 4 5
	2.		1 2 3 4 5
	3.		1 2 3 4 5
	4.		1 2 3 4 5
	5.		1 2 3 4 5
	6.		1 2 3 4 5
	7.		1 2 3 4 5
	8.		1 2 3 4 5

9. How useful or important have these courses been for your career or professional development?

PLEASE SCORE THEM FROM 1 TO 5 IN COLUMN 4 IN THE TABLE ABOVE USING THE FOLLOWING SYSTEM: 1 = not at all useful or important
5 = extremely useful and important

SECTION D: INVOLVEMENT IN RESEARCH PROJECTS

10. Have you been involved in any international research projects since 2000? **YES** ☐
(please tick one box only) **NO** ☐

IF NO: **GO TO QUESTION 12**
IF YES:. Please **CIRCLE** the number of projects in the table below (>= more than).

Total number of **international** research projects you were involved in between Jan 2002 and Dec 2002.	0 1 2 3 4 5 6 7 8 9 >9
Number of **international** projects you were involved in on Jan 1st 2000?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **international projects started** between Jan 1st and Dec 31st **2000** that you were involved in?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **international projects started** between Jan 1st and Dec 31st **2001** that you were involved in?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **international projects started** between Jan 1st and Dec 31st **2002** that you were involved in?	0 1 2 3 4 5 6 7 8 9 >9
Number of **international** projects you were involved in on Dec 31st 2002?	0 1 2 3 4 5 6 7 8 9 >9

11. What was your main role in these projects?

(please tick all that apply)

- Data collection ☐
- Principal scientists ☐
- Research assistant ☐
- Experimental design ☐
- Project management ☐
- Project co-ordination ☐
- Research student ☐
- Other ☐

12. Have you been involved in any national, regional or local research projects since 2000? **(please tick one box only)**

YES ☐
NO ☐

IF NO: **GO TO SECTION E**

IF YES: Please **CIRCLE** the number of projects in the table below (> = more than).

Total number of **national/regional /local** research projects you were involved in between Jan 2002 and Dec 2002.	0 1 2 3 4 5 6 7 8 9 >9
Number of **national/regional /local** projects you were involved in on Jan 1st 2000?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **national/regional /local** projects started between Jan 1st and Dec 31st 2000 that you were involved in ?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **national/regional /local** projects started between Jan 1st and Dec 31st 2001 that you were involved in?	0 1 2 3 4 5 6 7 8 9 >9
Number of NEW **national/regional /local** projects started between Jan 1st and Dec 31st 2002 that you were involved in?	0 1 2 3 4 5 6 7 8 9 >9
Number of **national/regional /local** projects you were involved in on Dec 31st 2002?	0 1 2 3 4 5 6 7 8 9 >9

13. What was your main role in these projects?

(please tick all that apply)

- Data collection ☐
- Principal scientists ☐
- Research assistant ☐
- Experimental design ☐
- Project management ☐
- Project co-ordination ☐
- Research student ☐
- Other ☐

SECTION E: TEACHING

14 Have you given/taught all or part of any theoretical or practical teaching courses since 2000? **(please tick one box only)** **YES** ☐ **NO** ☐

IF NO: **GO TO SECTION F**

IF YES: Please **LIST** the course subject, **CIRCLE** the level and **WRITE** the length in hours in the table below.

YEAR	COURSE SUBJECT	LEVEL U-undergraduate G-graduate N-non-university O-other	COURSE LENGTH (HOURS)
2000	1.	U G N O	
	2.	U G N O	
	3.	U G N O	
	4.	U G N O	
	5.	U G N O	
	6.	U G N O	
	7.	U G N O	
	8.	U G N O	
2001	1.	U G N O	
	2.	U G N O	
	3.	U G N O	
	4.	U G N O	
	5.	U G N O	
	6.	U G N O	
	7.	U G N O	
	8.	U G N O	
2002	1.	U G N O	
	2.	U G N O	
	3.	U G N O	
	4.	U G N O	
	5.	U G N O	
	6.	U G N O	
	7.	U G N O	
	8.	U G N O	

SECTION F: ABOUT YOU

15. Do you have a University Degree or qualification? **YES** ☐ **NO** ☐

IF NO: **GO TO QUESTION 16**

IF YES: What subject was your first degree in? …………………………………

Do you have a masters degree? **YES** ☐
(please tick one box only) **NO** ☐

In what general subject area is your Masters? ………………………..
(for example Nutrition, Pathology, Engineering)

Do you have a doctorate degree? **YES** ☐
(please tick one box only) **NO** ☐

In what general subject area is your doctorate? ………………………..
(for example Nutrition, Pathology, Engineering)

16. Which of the following best describes your occupation?
(please tick all that apply)

- Teacher ☐
- Researcher ☐
- Administrator ☐
- Extension worker ☐

Other **(please specify)** …………………………………..

17. Approximately how many hours do you spend each week on each of the following?

ACTIVITY	**AVERAGE WEEKLY TIME (IN HOURS)**
TEACHING	
RESEARCH	
ADMINISTRATION	
EXTENSION WORK	
OTHER…………………………………..	
OTHER…………………………………..	

18. What is your job title? ………………………………………………..

19. How many people (including staff and students) do you supervise?

- None ☐
- less than 5 ☐
- 6-10 ☐
- 11-15 ☐
- 16-20 ☐
- more than 20 ☐

20. In which scientific areas do these people work?
(please tick all that apply)

- Microbiology ☐
- Nutrition ☐
- Epidemiology ☐
- Immunology ☐
- Statistics ☐
- Environment ☐
- Parasitology ☐
- Diagnostics ☐
- Molecular Biology ☐
- Genetics ☐
- Other ☐

21. Have you attempted to improve your knowledge or skills through self-learning?
(please tick one box only)

- **YES** ☐
- **NO** ☐

IF NO: GO TO QUESTION 23

IF YES: What tools have you used to achieve this?
(please tick all that apply)

- Textbooks ☐
- Internet ☐
- Personal Tuition ☐

Other **(please specify)**…………………………………

Other **(please specify)**…………………………………

22. In what subject area(s) have you tried to improve your knowledge and skills?

(please tick all that apply)

English	
Sociology	
Politics	
Other languages	
Epidemiology	
Statistics	
Data analysis	
Animal disease diagnosis	
Aquatic Animal Health (general)	
Other (non-science based)	
Other (science based)	

23. What age are you?

(please tick one box only)

<25	**26-35**	**36-45**	**46-55**	**56-65**	**>65**

24. What sex are you? **MALE** ☐

(please tick one box only) **FEMALE** ☐

25 What is your name? (**please print in capital letters/upper case**).

………………………………………………………………………………………………..…

PLEASE RETURN THE QUESTIONNAIRE IN THE ENCLOSED ENVELOPE AND THANKYOU FOR TAKING THE TIME TO DO THIS.

APPENDIX XI

Abbreviations

AA	Aquatic Animal
AAH	Aquatic Animal Health
AAHRI	Aquatic Animal Health Research Institute
ACIAR	Australian Centre for International Agriculture Research
ADB	Asian Development Bank
ADCP	Aquaculture Development and Coordination Programme
AIT	Asian Institute of Technology
APO	Asian Productivity Organization (Tokyo)
ASPAC	Asian and Pacific Council
BIOSIS	
BMP	Best Management Practice
Bt	Thai Bhat
CAF	College of Aquaculture and Fisheries, Can Tho
CARE	Christian Action Research and Education
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
COF	College of Fisheries
DANIDA	Danish International Development Agency
DARD	Provincial Department of Agriculture and Rural Development, Vietnam
DFID	Department for International Development (UK)
DoF	Department of Fisheries
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FTR	Final Technical Report
HCMC	Ho Chi Minh City
ICLARM	International Centre for Living Aquatic Resource Management
IDRC	International Development Research Centre
IDS	Institute of Development Studies
IIRR	International Institute of Rural Reconstruction
IOA	Institute of Aquaculture
MoF	Ministry of Fisheries
NACA	Network of Aquaculture Centres for Asia-Pacific
NORAD	Norwegian Agency for International Development
NR	Natural Resources
MARD	National Ministry of Agriculture and Rural Development, Vietnam

MoF	National Ministry of Fisheries, Vietnam
ODI	Overseas Development Institute
PRUS	Poverty Research Unit at Sussex
RIA1	Research Institute for Aquaculture Number 1, Hanoi
RIA2	Research Institute for Aquaculture Number 2, Ho Chi Minh City
SD	Stocking density
SL	Sustainable Livelihoods
STREAM	Support to Regional Aquatic Resource Management
TNC	Trans National Company
UK	United Kingdome
UNRISD	United Nations Research Institute for Social Development
VND	Vietnamese Dong
WebCT	Web Course Tools
WSSV	White Spot Syndrome Virus
WWF	World Wildlife Fund