Genetic management of non-indigenous carps for low input aquaculture systems in Asia

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The hatchery: the critical stage of genetic management. Decisions taken at this stage will affect the entire production cycle. (Rupali hatchery, Jessore, Bangladesh; DJ Penman)

The project we describe here, funded by the DFID Aquaculture and Fish Genetics Research Programme (AFGRP) (R7590), was developed to address the common theme of management of exotic (nonindigenous) carp species in Asian aquaculture.

It began in April 2000. In this article, we address some of the key issues the project is dealing with and also highlight some of the project activities in Bangladesh, India and Vietnam, the main target countries (see Boxes).

Of the fish species cultured in Asia, it is most often carps and tilapias which make contributions to the livelihoods of poor people, through farming, consumption and associated activities. Carps feed low down in the food chain, making them suitable for low input aquaculture and for many species the market prices are fairly low, making them affordable as a source of protein for poor people.

Although the project is not promoting the introduction of non-indigenous species for aquaculture, realistically it is accepted that several such species do make important contributions to aquaculture in Asia and to the livelihoods of the poorer sectors of society. While the genetic management and improvement of stocks of all species in aquaculture is important to sustain and improve production, particular problems are presented in the case of non-indigenous species. The founder stocks may have been of poor, or unknown, quality. For example, some of the stocks of Chinese carps originally introduced into Bangladesh were secondary transfers from countries other than China, whereas more recent introductions came straight from wild stocks in China. Small numbers of parent fish contributing to an introduction, or low survival/breeding rate among the introduced fish, may lead to poor performance through low genetic variation (bottlenecking) or a genetic makeup which is unrepresentative of the parent population (founder effect). For indigenous species, it is often possible, if necessary, to go back to local wild populations to replenish hatchery stocks, for example if a decline in performance is observed or suspected. For non-indigenous species, logistical and political factors may make this difficult, along with associated risks of introducing pathogens or other undesirable species. In tackling the particular problems of managing introduced species, we also hope to be able to promote the more general message of good genetic management of aquaculture broodstocks, which is often neglected.

Genetics is sometimes seen as a highly technical subject of little relevance to "real life". However, we believe that in the context of broodstock management, genetics is highly relevant to the livelihoods of stakeholders in aquaculture (hatcheries, nurseries, traders, ongrowers, consumers), and that appropriate research in aquaculture genetics can play a strong role in sustaining and improving livelihoods. The breeding of fish in hatcheries is not isolated from the rest of aquaculture. The seed produced in hatcheries work their way right through the network of nurseries, traders, on-growers and markets to consumers, and changes in the genetic quality of those seed will likewise have effects throughout this network. Some networks may be local, while others are far reaching both in geographical terms and in terms of the different socioeconomic groups who are linked through the network. For example, large private carp hatcheries in Jessore in SW Bangladesh are the source of much of the fish seed supply to small-scale ongrowers in NW Bangladesh, one of the poorest regions of the country.

In addition to seed leaving hatcheries, there should also be a flow of information from the rest of aquaculture back to the hatcheries, to feed into the process of good broodstock management by, for example, defining important traits or identifying superior stocks. Too often, this link is missing. In the absence of good genetic management of hatchery stocks or where management considerations are entirely "internal", for example where a numerical seed target is the main objective and broodstock replacement is from leftover fish, changes in genetic quality of seed are likely to be negative (through inbreeding or negative selection). Good broodstock management, ideally taking into account information from performance during on-growing on farms, will result in sustained or improved quality of broodstock and seed produced for aquaculture (e.g. as a result of good stock choice, prevention of inbreeding, planned selection or monosex fry production). Inbreeding has negative effects on many traits of interest to aquaculture (growth rate, survival rate, deformities, etc). Planned selection, however, generally focuses on only one or a few traits. While "growth rate" is the most common trait initially targeted in selective breeding, this has to be more carefully defined. Does it mean faster growth on unlimited resources or faster growth on fixed resources? The latter (i.e. increases in production efficiency) is likely to be more important to resource-poor fish farmers. We are trying to involve such farmers in defining appropriate traits for selective breeding, and there is evidence of the

benefits of such an approach from other agricultural crops (see Box 2).

While we can try to develop improved stocks for aquaculture and implement other changes at a local level, to have sustainable impact the project also needs to influence policy at state, national and international levels. This can mean supporting the implementation of improved broodstock management practices which will lead to sustainability of and improvements in seed quality at state or national level (as is already taking place for example with the Karnataka State Department of Fisheries in India). On a broader scale, links through international bodies such as INGA, the International Network for Genetics in Aquaculture, can help to spread knowledge and other project outputs more widely. INGA is coordinated by ICLARM, has member countries in Asia and Africa and also several associated Advanced Scientific Institute members. All of the institutes involved in the DFID project are members or associate members of INGA and participate in its activities.

In summary, we hope that through this project we will demonstrate that it is possible, in the medium to long term, to impact positively upon sustainable livelihoods through the appropriate application of genetics based methods focused on basic broodstock management and on traits important to the target stakeholders. We believe this impact will come directly through application of knowledge and improved fish stocks and indirectly through influence on policy. Links to related initiatives such as the INGA-coordinated ABD carp genetics project and the AFGRP funded seed quality in Asia project (R7052) will also be important in achieving impact and developing appropriate further research.

Acknowledgement

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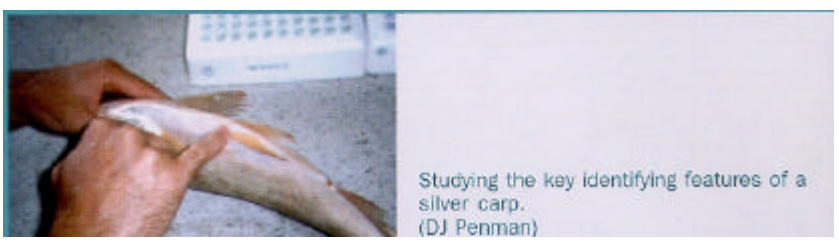
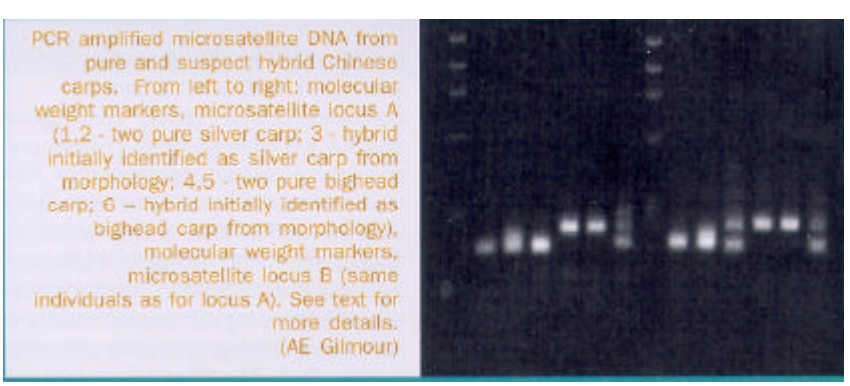
Box 1: **Using DNA markers to assess hybridization between silver carp and bighead carp in hatcheries in Bangladesh.**



Studying the key identifying features of a silver carp.
(DJ Penman)

Dr John Taggart, from the IOA. has developed DNA microsatellite loci for studies on Chinese carps. Although these loci were cloned from silver carp, several can also be amplified by PCR in the bighead carp and three of these show clear differences between the species. They can thus be used as species markers.

There have been many anecdotal reports of hybridization between these two species in hatcheries in Bangladesh, and a preliminary survey carried out by Dr Younus Mia, from BFRI, substantiated this. A major reason for producing this hybrid is a lack of mature bighead carp males at the time of year when the females are mature, leading hatcheries to use silver carp males instead. The F_1 hybrids appear to perform poorly in aquaculture (this is being assessed), but another potential problem is genetic introgression between the two species in the hatchery broodstock if the F, hybrids are crossed to either pure species and the resulting offspring again used as broodstock.



PCR amplified microsatellite DNA from pure and suspect hybrid Chinese carps. From left to right: molecular weight markers, microsatellite locus A (1,2 - two pure silver carp; 3 - hybrid initially identified as silver carp from morphology; 4,5 - two pure bighead carp; 6 – hybrid initially identified as bighead carp from morphology), molecular weight markers, microsatellite locus B (same individuals as for locus A). See text for more details.
(AE Gilmour)

The figure shows pure silver carp and pure bighead carp from the stocks held at NFEP, Parbatipur (DOF), and hybridisation detected among samples collected by Dr Mia from broodstock in different hatcheries. Most of the broodstock assessed in the preliminary study in the Mymensingh area proved to be pure silver or bighead carp but some hybrids were detected. Sample 6, although identified as a bighead carp by the hatchery owner, showed the hybrid genotype for both of the microsatellite loci illustrated, while sample 3, identified as a silver carp by the hatchery owner, showed the hybrid genotype at locus B and the silver carp genotype at locus A, probably indicating that this fish comes from backcross between a hybrid and a pure silver carp, or a further hybrid generation. A larger hatchery survey is underway.

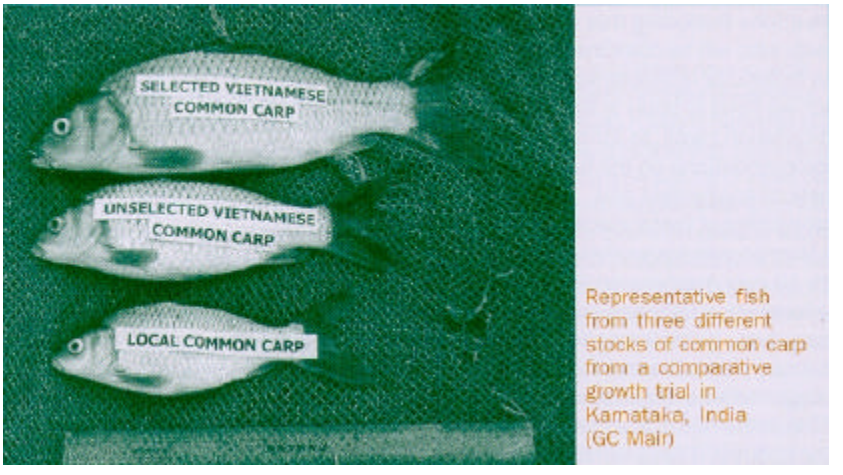
Box 2: Stock evaluation and selective breeding of common carp in Karnataka. India

Research staff and farmers inspect fish from a growth trial in a pond in Manjenahalli microwatershed, Karnataka, India (DJ Penman)

The local stock of common carp in Karnataka grows relatively slowly and matures at 6-8 months old (sometimes at less than 100g). There is also evidence of early maturation in common carp in other parts of Asia. Various approaches have been assessed in Karnataka for improving the performance of common carp: these include hormonal sterilisation, triploidy and monosex production. The most promising and practical approach is to evaluate different stocks of common carp, set up a base population from the most promising stock(s) and develop a breeding programme to improve traits of importance to farmers.

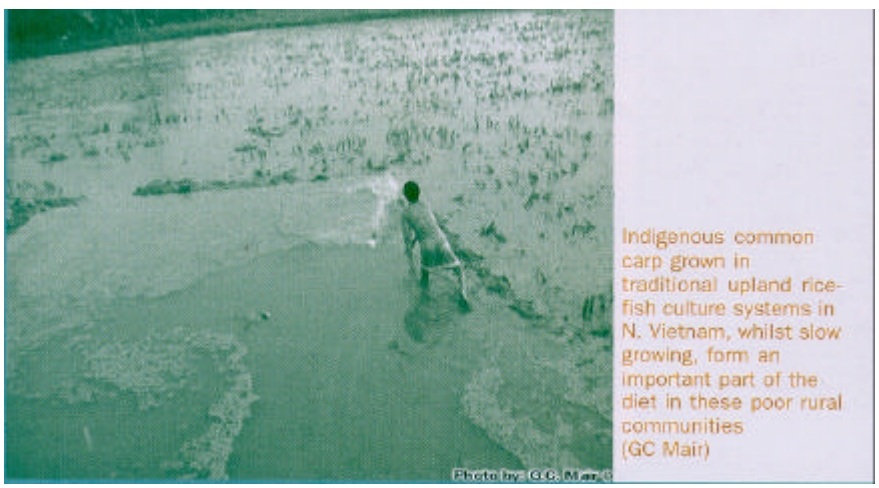
We are currently evaluating several stocks of common carp in different culture environments. These have been obtained through the International Network on Genetics in Aquaculture (INGA), following its recommendations on germplasm transfers, quarantine, etc. Some of these evaluations are taking place in farmers' ponds in areas which are already involved in the UASB micro watershed management research programme, which aims to improve the livelihoods of farming households in these watersheds through a variety of measures, including improved water and soil conservation and diversification of farming practices. Some of the farmers in this watershed programme have previously been involved in participatory research on the evaluation of different strains of millet (the value of this kind of approach was demonstrated when the farmers made it clear that they valued millet straw as well as the seed yield - some varieties gave high seed yield but brittle straw).

We aim to develop a mass selection programme, which will improve common carp performance but also be practicable in its operation. Whatever the design of the breeding programme, sustainable implementation and benefits to common carp farmers and consumers will require integration with fish seed production and dissemination networks. Perhaps unusually, in Karnataka seed production is dominated by the state system. The project already has very good links with the Karnataka Department of Fisheries (DOF), and other organisations such as the Karnataka Fish Farmers Development Agencies (FFDA). For example, together with the DOF we have implemented changes in broodstock management of catla at the main state seed farm at Bhadra Reservoir Project (BRP), to minimise inbreeding in broodstock and to test crossbred catla and wild catla on a commercial scale (largely developed through a earlier project, R6059). In common carp we are now developing a nucleus breeding centre and distribution network to allow continuation of selective breeding after the project has ended and to distribute improved broodstock to state and private hatcheries.



Representative fish from three different stocks of common carp from a comparative growth trial in Karnataka, India (GC Mair)

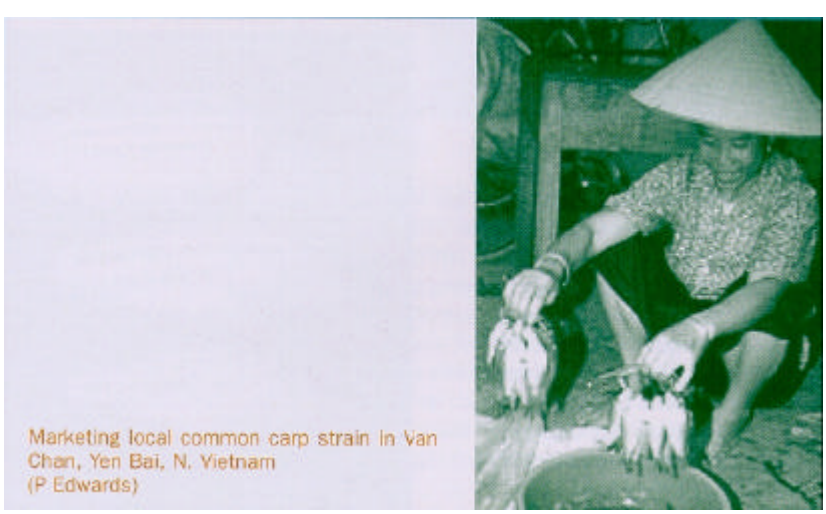
Box 3: National Broodstock Centres in Vietnam



Indigenous common carp grown in traditional upland rice-fish culture systems in N. Vietnam, whilst slow growing, form an important part of the diet in these poor rural communities (GC Mair)

In Vietnam we are evaluating all of the exotic carp species which are of importance in low-input polyculture systems. There are two or three stocks of each species (including rohu, mrigal, silver carp, grass carp and common carp) present in Vietnam following a series of introductions over the past two decades. The culture performance of these stocks is being evaluated in a range of low-input culture systems including upland and lowland rice-fish systems, sewage-fish ponds and the ubiquitous integrated farming systems known as Vuong (vegetable garden)-Ao (pond)-Chung (animal rearing pen), or more commonly VAC. The results from these evaluations (including that of some crossbreds) will be combined with data from molecular characterisation, which we hope to apply in the Chinese and common carps, to formulate recommendations on the future genetic management and improvement of these stocks.

The Vietnamese government, as part of its 10 year master plan for development of fisheries and aquaculture, is implernenting an ambitious plan to create three strategic national broodstock centres (NBCs) in the north, south and centre of the country. These will form the basis of a centralised seed supply network to ensure the supply of quality seed for inland aquaculture throughout the country, through existing Provincial hatcheries and via private sector hatcheries and traders. There is obvious synergy between the project and the plans for NBCs and it is hoped that the outputs from this research (knowledge, policy recommendations and improved fish) will feed directly into the seed supply network via the NBCs. It is likely however that there will be some poor farmers who may remain outside this centralised seed supply system, for example farmers operating traditional upland rice-fish culture systems in the remote mountainous areas of northern Vietnam. These farmers have traditionally utilised indigenous common carp in these systems. These carp, which are often managed as reproductively isolated populations, are known to have relatively poor growth performance, possibly as a result of inbreeding and/or negative selection. However, it is also evident that these fish have become adapted to the rice-fish environment and have developed characteristics suited to their use in such systems, most importantly their property of residence (they stay within the rice-field whereas nonadapted strains or species often escape). The project is evaluating whether there is potential for improving the culture performance of these indigenous fish (e.g. by crossbreeding them) whilst retaining these important properties, rather than attempting to replace these fish with faster growing strains (such as are already available in Vietnam), which may lack critical properties of adaptation.



Marketing local common carp strain in Van Chan, Yen Bai, N. Vietnam (P Edwards)