CROP PROTECTION PROGRAMME

Ecologically-based rodent management for diversified rice-based cropping systems in Bangladesh

R8184 (ZA0503)

FINAL TECHNICAL REPORT

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This project was somewhat unusual to be jointly funded by the CPP and the PETRRA programmes. Although both programmes share many objectives, considerable flexibility was demonstrated by both donors to facilitate this project's operation. The coordinated joint funding provided allowed this project to function at a higher level and involve more international collaboration which was essential to help build rodent research capacity in Bangladesh. We are grateful to Dr Frances Kimmins, CPP Manager and Noel Magor, PETRRA Programme Manager for their prescience to make this project work. It is hoped that the success of this project will help encourage funding alliances between donors in the future.

Executive Summary

Rodent pests have been identified as a serious constraint not only with regard to agricultural production of many crops, but also to the health of people and livestock through the spread of many communicable diseases. Rodents are a problem for both rich and poor, individuals and communities, with disproportionately larger impacts on the rural and urban poor who are the least likely to possess the tools and knowledge to control rodents effectively.

This research project was based on addressing the multiple impacts that rodents have on rural agricultural communities in Bangladesh and developing sustainable methods to manage rodents that could be implemented by these communities. Project activities were based in the districts of Comilla and Feni, southeast of Dhaka. This project had four main objectives:

- Understand the current impact of rodents upon rural agricultural communities
- Understand the impact of existing control strategies used by small-scale farmers upon rodent population dynamics, the environment and socio-economic capital
- Develop rodent control strategies through farmer participatory research
- Develop and disseminate policy recommendations to stakeholders involved in rodent pest control

Research, training and dissemination activities related to satisfying these objectives are presented in this report within ten different subsections. Each subsection presents work completed related to a particular theme such as collecting information on rodent damage or evaluating potential rodent management interventions. Each subsection presents the analysis of data solely collected within the project by the project staff and may involve activities that attempt to survey, demonstrate, evaluate and/or monitor. Anthropological and biological expertise were required to deliver the project outputs, involving technical staff from the UK, Australia and Bangladesh possessing a range of skills related to research, extension and training. The research was participatory in nature, fully involving entire communities in collecting baseline data, and using their knowledge and experience about their environment to evaluate the feasibility of various rodent management actions. Many of the research activities presented are novel in their approach and application and produce new information that has not been previously collected by other scientific endeavours in Bangladesh or elsewhere in the world. New knowledge about the impacts of rodents on people's lives has been generated, and ecologically-based rodent management actions have been demonstrated to work under the agro-ecological and socio-economic conditions found in rural agricultural communities in Bangladesh.

The research findings showed that rodents had significant impacts upon people's livelihoods in many ways including:

- Damage to field crops of rice, vegetables, and fruits
- Loss, damage and contamination of stored rice
- Damage to building foundations, structures, electrical cables
- Contamination of food and water supplies
- Damage to personal possessions such as clothes, fishing nets, furniture, kitchen utensils

The existing rodent management strategies applied by rural communities were not very effective in controlling their rodent problems. The analysis of project activities concluded that communities did not have sufficient knowledge about the impacts of rodents on their lives, and knew too little about how rodent management must work in order to reduce rodent populations and their damage.

Various rodent management interventions were evaluated in the villages, and it was shown that very significant reductions in the rodent population could be achieved through community-wide intensive trapping of rats with snap traps. The interventions significantly reduced rodent damage levels as observed through controlled monitoring trials as well as by observations of the community members themselves. A number of environmental management options were demonstrated that could lead to permanent reductions in the carrying capacity of the environment to sustain high rodent populations if adopted by a significant proportion of community households.

The results of the project and its implications for rodent management in Bangladesh were discussed with key stakeholders such as the Department for Agriculture Extension, and it is hoped the evidence will help reformulate existing national strategies and policies aimed at rodent pest management and rodent research in Bangladesh.

Background

Rodent pests are a well recognized problem in most countries in both rural and urban situations and affect people's lives by destroying many different crops, transmitting diseases to people and livestock, contaminating food and water, and damaging buildings and other possessions. Almost any agricultural crop grown can be attacked by rodents, and they are known carriers of more than 60 different life-threatening diseases that can be transmitted to people. The numbers of rodent pests are on the increase worldwide and are likely to continue increasing with urbanisation and agricultural intensification. Rodents are one of the major pest constraints to increased agricultural production in Bangladesh. Rice continues to be the most important crop in Bangladesh and yield gains have been shown to be the major driving force behind increasing crop diversification into higher value crops and increasing non-farm rural incomes.

Although effective rodent control methods exist, their poor application and adaptation to particular situations often results in treatment failures, leading to apathy and widespread acceptance of rodent pests in the environment. Generally, there is a poor perception about the impact of rodents on people's livelihoods which is partly due to their multiple impacts (agriculture and health), the difficulty to assess some of the problems (e.g. crop loss) and low public awareness (e.g. disease transmission) about the damage caused by rodents. People, therefore, do not always highlight rodent problems because of their low awareness, ingrained defeatism when trying to control rodents and acquiesce to rodent damage. Participatory appraisals and needs assessments, therefore, do not usually highlight rodent problems. For example, none of the 20+ stakeholder analysis reports commissioned by the PETRRA[1] programme in the year 2000 specifically highlighted rodent problems, despite rodents being a generally accepted problem in Bangladesh. Many of these stakeholder reports referred to problems with pests and diseases, but it is likely that the questions were proposed with reference to insect pests only, suggesting methodological and experiential bias on the part of surveyors. The failure to identify needs for better rodent management in Bangladesh through participatory frameworks is not unusual as people generally can not ask for unknown technology. Generally people highlight problems when they know there is a potential solution and have a good understanding of the severity of the problem. Without a good holistic understanding about rodent pest problems and the cost-benefits of rodent control, it can be difficult to convince people that rodent control is achievable and can lead to real benefits in their lives. In this context, it is important to note that scientific and extension experts in Bangladesh were highly supportive, giving the rodent proposal the highest priority ranking during it's evaluation for the PETRRA programme.

Current rodent control practices are often based on the use of poisons, termed rodenticides. Misuse of these poisons is unfortunately common in many countries including Bangladesh, which poses a threat to human health and environmental contamination by killing non-target species such as predatory birds. More importantly, misused rodenticides may not significantly reduce the rodent population, therefore having little impact on reducing the damage caused by rodents. When correctly used, rodenticides can be a highly effective tool. However, they are most appropriate in large-scale, intensive, high-value situations where safety and accuracy can be assured. Because rodenticides can be expensive and difficult to use safely, other rodent management methods involving trapping and environmental management are more appropriate for the rural agricultural situations found in Bangladesh. Because of the success of anticoagulant rodenticide baits in controlling rodents in developed countries, research on rodent pest management has traditionally focussed on the development of new poisons and baits. This has inadvertently stifled research on other aspects of rodent behaviour and ecology that could help develop more sustainable methods of control in the resource-poor situations found in developing countries. Rodent ecology research has, therefore, been neglected in most countries for several decades and is only now receiving the attention of scientists trying to understand the agricultural and health implications of growing rodent pest populations.

Using existing rodent management tools and techniques requires a good understanding of rodent biology and their local impacts upon people's livelihoods. Therefore, rodent pests disproportionately affect the poorest people who are less likely to possess appropriate knowledge and access to proven technology. By giving people appropriate knowledge and experience, they can develop cost-beneficial strategies where the input costs can be shown to lead to substantially increased food security, financial and health benefits.

[1] The Poverty Elimination through Rice Research Assistance Programme which ended in 2004 was funded by the DFID Bangladesh office and managed locally in Bangladesh by the International Rice Research Institute. The PETRRA jointly funded this rodent research project together with the Crop Protection Programme during the project's first two years.

This research project's objective to develop "Ecologically-based Rodent Management" is a relatively new research area that is being increasingly adopted by rodent research programmes around the world. Research activities for this project can be summarised as having proceeded in two phases: 1) an information gathering phase to improve understanding of the major ecological and anthropogenic issues and 2) an experimental phase to test new rodent management strategies. Phase one involved collecting baseline data related to rodent ecology and the anthropology of local communities. Specifically this involved gathering information on: 1) current knowledge, attitudes and practices of farmers; 2) identity of the major rodent pests; 3) the ecology of the major pests; 4) the damage to field crops; 5) the damage to stored food; 6) the damage to structures, possessions and 7) potential health risks. Phase two involved working with individuals and communities to design and test strategies that can reduce the rodent population. The second phase involved technology transfer, e.g. better-designed traps and trap barrier systems that communities may not be familiar with, and involved ways of reducing rodent access to food and harbourage as permanent ways of reducing the carrying capacity of the environment to support rodents. The most important aspect of this second phase of research was monitoring so that people could see for themselves whether their rodent management worked. This helped increase awareness of the rodent problem by demonstrating what people's lives were like in the absence of rodent pests, and this was particularly relevant because local people had little experience of what life was like in the absence of rodents in their houses and fields.

Project Purpose

The purpose of the project was to promote strategies that would minimise the impact of rodents in rice-based, land-water interface cropping systems which would be particularly beneficial for poor people in Bangladesh / South Asia. Because of the multiple impacts of rodents on people's livelihoods by affecting pre- and post-harvest agriculture, the health of people and livestock through transmitting diseases, and spreading environmental contamination, the project purpose specifically aimed for the development of rodent pest management strategies that can sustainably improve agricultural production, food security, human and environmental health, and the quality of rice and other crops grown by resource-poor communities.

The project's specific objectives were to:

- Understand the impact of rodents upon diversified rice-based systems of rural communities
- Understand the impact of existing control strategies used by small-scale farmers upon rodent population dynamics, the environment and socio-economic capital
- Develop rodent control strategies through farmer participatory research
- Develop and disseminate policy recommendations to stakeholders involved in rodent pest control

Successful ecologically-based rodent control can not generally target individuals, and communities must work together to have impact on rodent numbers and damage over a large area. The project was, therefore, designed from the outset to work with entire communities. The involvement of both men and women was important because of the division of labour between field (men) and village (women) activities which were known to have different rodent pest problems. Rodent problems in the house and field can, therefore, be seen as separate issues with separate responsibilities for action, despite rodents moving between and exploiting both environments.

There is little recent relevant information within Bangladesh regarding ecologically-based rodent management. Historical research on rodents in Bangladesh was usually based on station trials evaluating rodenticides or the simulation of rodent damage and could not be related to complex ecological phenomena as experienced by small-scale farmers. The project, therefore, had to be largely self-reliant in generating the appropriate data that could be used to develop rodent management strategies. Knowledge and research about rodent control and particularly ecologically-based rodent management has been developed and applied in a number of Asian and African countries. This general knowledge about rodent biology and potential strategies could be readily adapted to the Bangladesh situation when coupled with ecological and social information collected within Bangladesh.

Table 1. Information requirements for the project to succeed

Information Requirements	Information Sources
Data collection on rodent population dynamics, habitat usage and ecology	project field trials, previous research in Bangladesh and other countries
Impact of rodents on people's livelihoods	project field trials, qualitative and quantitative anthropological data
Community knowledge, attitudes and practice with regard to rodents	questionnaires, anthropological observations, group meetings and discussions, workshops and training events
Effects of different rodent management strategies	project field trials, previous research in Bangladesh and other countries
Sustainability of different rodent management strategies	qualitative and quantitative anthropological data, meetings and workshops with end users

Research Activities

Activities have been summarised within ten separate manuscripts. Some project activities are clearly inter-related and often satisfy multiple objectives (e.g. survey, demonstration, intervention, monitoring). However, for the sake of clarity, trials have been presented as they were conducted, and it is likely that results from different activities will be combined for the preparation of peer-reviewed journal papers.

In common to all activities, all trials took place in four villages in the district of Comilla. Some initial baseline surveys also took place in two villages of Feni district; however, the project activities ceased there before the intervention phase because it was difficult for the project team members to do all the required activities in more distant villages. In order to understand the impact of new rodent management and technology, the project was designed to compare villages where interventions occurred (treatment villages) with villages where no intervention occurred and the indigenous practice of the village was monitored only (control villages). Each treatment village, therefore, was paired with a control village to act as a comparison where similar agro-ecological conditions could be found. Survey and monitoring information was generally collected from all villages, while demonstration and intervention trials were only instigated in the treatment villages. The village names are: Jakunipara (treatment) – paired with Anandapur (control) and Sowara (treatment) – paired with Sahapur (control). The two villages in Feni district where some survey data were collected are Batania and Nasirgram. The treatment/control pairings were based on initial surveys to ensure similar parameters would be found in both villages related to agro-ecological conditions, village structure and population size. Village selection was also based on other criteria such as previous experience working with the NGO partner, general motivation and enthusiasm, and of course a majority of community members involved in small-scale agriculture.

Knowledge, attitudes and practices of rural farming communities: Quantitative surveys using rodent pest problem mapping and individual questionnaires

Introduction

Involving the affected community should be self-evident when developing any agricultural intervention. However, the knowledge, attitudes and existing practices agricultural communities have often been ignored in agricultural technology projects in the past. Rodent pest management has often failed in the past because it inadequately addressed the various time, labour and financial constraints affecting small-scale farmers and communities. Rural farmers often perceive rodenticides to be too expensive, dangerous and/or ineffective, which is largely why rodenticides are not widely used by small-scale farmers. For rodent management to be sustainable in a community, it must be informed by farmer knowledge, attitudes and practices (KAP) that are relevant to rodent pests. Interventions must address whether farmer awareness is too low about crucial issues for the interventions to succeed. Generally beliefs about rodents such as whether they are feared or revered can have major impacts on the success of management strategies. Improving or fine-tuning existing rodent management strategies may be more successful than introducing something entirely new; while understanding why farmers do or don't do certain activities that would result in better rodent management help design interventions that are most likely to be adopted by farmers.

Materials and Methods

Crop calendar and rodent pest problem mapping

At the beginning of the project, meetings were organised in three villages (Jakunipara, Sowara, Nasir Gram) to discuss the project and use the opportunity to find out what problems the communities had with rodents and what they were currently doing to control rodents. It was expected to make maps of the villages and fields, develop a crop calendar of important events and discuss current and potential rodent management actions with the village with a view to prioritising activities the villagers feel are effective or important.

Individual questionnaires

A questionnaire (Appendix 1) was designed through consultation with the project staff involved from each partner institution. The objectives of this questionnaire were to:

- Study farmers' background information about rodents
- Know about the farming practice of the community
- Assess knowledge about the damage caused by rodents for different aspects of farmers' livelihoods
- Know about the present rodent management efforts by the villagers
- Collect information about farmers' recommended methods for rat control
- Understand farmers' beliefs about rodent-borne diseases and existing hygiene practices.

The questionnaire contained 54 questions and was pre-tested with ten individual farmers from the target villages (results not presented) to ensure it was an acceptable format before use. The questionnaire was to be implemented in the four target villages, ensuring that different key categories of people were interviewed, including males-females, muslim-hindu, poor-rich, and old-young. It was expected to interview 30 people per village, randomly selecting participants (roughly based on the above categories). Participants had to volunteer to be interviewed and were not paid.

Results

Crop calendar and rodent pest problem mapping

Turnout was high in all three villages with well over 100 men and women participating in each village meeting (Figure 1). Maps were made in discussion with the village, highlighting areas they believed to be more susceptible to rodent damage (Figure 2). Activities were discussed during separate meetings with male and female villagers to establish the crop calendar in the different villages, the problems faced with rodent pests at different times, and the current and potential methods of rodent management that would be appropriate. A summary of these discussions is found in Tables 2 to 6.

Figure 1. Photograph showing initial project meeting with villagers to discuss rodent pest problems and management activities

Figure 2. Photograph showing village map making process with regard to rodent damage

Table 2. Issues related to rodent management discussed during meetings with communities

Actions (what)	Timing (when)	Where	Individual or community (Who)	Ecologically-based rodent management	Priority
1. Synchrony of cropping	Planting/harvest	Fields	Community	✪✪	V High
2. Irrigation channel <30 cm	All year	Fields	Community	✪✪	V High
3. Sanitation – keep grass growth low; clean around villages and rice stores	All year	Fields & Houses	Individual	✪✪	V High
4. Kill traps; Live traps; pitfall traps (gourds, etc) †	1 week after transplanting	Houses	Community	✪✪	High
5. Digging/flooding burrows †	1 week after transplanting	Fields	Community	✪✪	High
6. Beating †	1 week after transplanting	Fields & Houses	Community	✪✪	High
7. Clean cultivation and harvest; manage straw stacks	Tillering and harvest	Fields	Individual	✪✪	High
8. Promote predators	All year	Fields & Houses	Community	✪✪	High
9. Lanirat (Bromadiolone)	In upland habitats, edges of roads, etc., after land preparation (All crop stages)	Fields Houses (use kill traps instead)	Individual	✪	Medium
10. Zinc Phosphide	As above (All crop stages)	Fields Houses (use kill traps instead)	Individual	✪	Medium
11. Line TBS	Tillering and around harvest	Fields	Community	✪✪	Test
12. CTBS	Select crop	Fields	Community	✪✪	Test
13. Fumigate - Aluminium Phosphide Burning chilli	When rat numbers high	Houses	Individual		Low
14. Smoking – chilli or tobacco	Dry season	Fields & Houses	Individual		Low
15. Predator symbol – banana tree like man; palm frond like cobra	All year	Fields	Individual	✪	Low

† These activities must be done at the optimum time and place and by the community

Table 3. Cropping calendar as discussed with communities in three villages

Crop calendar Province/Crop	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Jakunipara - Comilla													
BORO Rice		Seedbed 40 day	Transplant				Harvest						
AUS Rice						Seed	Transplant			Harvest			
T. AMAN Rice								Seed	Transplant			Harvest Nov/Dec	
Vegetables													
Sowara - Comilla													
Rice as above													
Potato													
Brassicas										Sowing			Harvest
Fallow													
Nasir Gram – Feni													
BORO Rice		Seedbed 40 day	Transplant				Harvest						
Fallow		2-3 months fallow because of floods											
T. AMAN Rice										*Seedbed 45d	Transp		Harv. Dec
AUS Rice	none												
Vegetables							Vegetables – near houses						
	Potatoes - staggered												
Province/Crop	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**

* Seedbed is 45 days because of high water level in the fields – tillers need to be a minimum height before they can be transplanted.

Table 4. Farmer decision analysis for village of Jakunipara, Comilla

Actions (what)	Timing (when)	Where	Who (Individual or community)	Cost	Effective	Environ Friendly	Priority
1. Lanirat (Bromadiolone)	When rat numbers high	Fields + houses	Individual	300-500 taka/yr	Yes	No	High
2. Kill traps	As needed	Houses	Individual	Cheap	Yes	Yes	
3. Sanitation	All year	Houses + Fields	Individual	Nothing	Yes	Yes	
4. Live traps; pitfall traps (gourds, etc)	All year	Houses + Fields	Individual	Cheap	Yes	Yes	
5.Digging/flooding burrows	When rat numbers high	Fields	Individual	Nothing	Yes	Yes	
6. Cats as predators	All year	Houses	Individual	Nothing	Yes	Yes	
7. Zinc Phosphide	Dry season rat numbers high	Fields	Individual	Yes	No	??	
8. Burning chilli to fumigate	When rat numbers high	Houses	Individual	Cheap	Yes	No	

Notes:
Farmers thought all actions (except Zinc Phosphide) were important when rat numbers high
Main rat problems in the field in *T. Aman* crop after panicle initiation (Oct-Jan); also for the *Boro* crop (Apr-May)
All farmers act individually to control rats but prepared to work together
Rice crops staggered planting over 4-6 weeks; most farmers grow *Boro-T. Aman*-Vegetables
Rat losses: *T. Aman* rice 10-25% in 2001, usually around 10%; post-harvest 20% rice, 30-35% Wheat

Table 5. Farmer decision analysis for village of Sowara, Comilla

Actions (what)	Timing (when)	Where	Who (Individual or community)	Cost	Effective	Environ Friendly	Priority
1.Lanirat (Bromadiolone); some Zinc Phosphide	When crop damage seen	Crop only	Individual – most	50 taka/0.2 ha crop; 5 t/packet	Medium; rats soon build again; “kill rate not sufficient”	Not near houses; kills chicks	
2. Live traps; pitfall traps (gourds, etc)	When rat numbers high	Houses	Individual	Cheap – takes time	Yes	Yes	
3. Cage traps	As needed	Houses - storage	Individual	Cheap – 22 taka each	Yes	Yes	
4. Hunting	Anytime	Fields and village	Individual	Nothing “good feeling”	No – but feel good	Yes	
5. Digging burrows	When rat numbers high – rarely done	Fields	Individual	Nothing “good feeling to catch rats”	No – but feel good Burrows too deep and complex	Yes	

Notes:
75 households; 50 have irrigated holdings where *Boro* rice can be grown, but only 50% do so, others grow vegetables
Other insects (caterpillars) higher ranked pest in fields; rats highest post-harvest and major pest overall
Main rat problems in the field after panicle initiation, some to seed nurseries; 50% of households have serious problem – mainly those with crops on higher ground
Post-harvest damage greatest in mud-brick dwellings and where rice is stored on ground
All farmers act individually to control rats but prepared to work together
Farmers distinguished 4 rat and 1 mouse species – rats that live in trees and houses different; rats concentrate in and around houses in wet season, move out into the fields as waters recede

Table 6. Farmer decision analysis for village of Nasir Gram, Feni

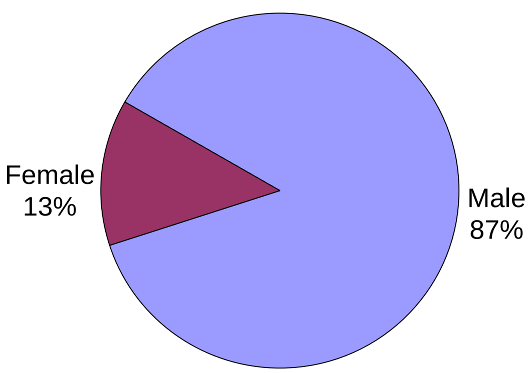
Actions (what)	Timing (when)	Where	Who (Individual or community)	Cost	Effective	Environ Friendly	Priority
1. Lanirat (Bromadiolone)	When rat numbers high	Fields + houses	Individual	300-500 taka/yr	Moderate -bait shyness	Not asked	Equal
2. Kill traps (bamboo)	As needed	Houses	Individual	Nothing	Yes		Equal
3. Digging/flooding burrows	In highlands when water rising	Fields	Individual	Nothing	Yes		
4. Cats as predators	All year	Houses	Individual	Nothing	Yes		

Notes:
Control actions are used most often when rat numbers high.
No communal actions.
Losses pre-harvest: *T. Aman* rice 10-30%, most 10-20%; *Boro* rice similar but less.
Losses post-harvest 10-15%.
Rats are a problem every year but the problem has been getting progressively worse over recent years. Farmers not clear why this is so, perhaps because breeding of rat populations has increased. They did note that intensity of cropping has increased over the past decade. (Staggering of planting not as pronounced as at Comilla because of the 2-3 month enforced fallow due to flooding).

Individual questionnaires
A total of 120 questionnaires were administered by an anthropologist over the period of October 2002 to October 2003. Although this work was expected to take approximately three months to complete, difficulties in recruiting and retaining anthropologists for this work resulted in this activity taking a full year to complete with results collected by four different staff members. Because of the long period of time over which the survey was conducted, it is likely that parallel project activities inadvertently affected the KAP survey results through raising awareness about rodents. This effect would generally hold true in both the control and treatment villages as similar activities (e.g. rodent habitat surveys, damage assessments) would have been taking place in all four villages. However, as interventions and demonstrations had not yet commenced, it can be argued that any impact of rodent project staff and activities to raise awareness would be relatively minimal.

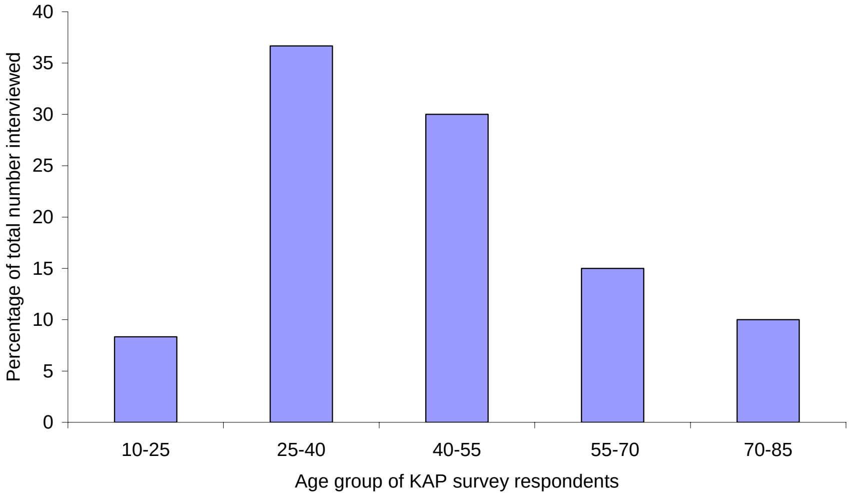
In Bangladesh, it was generally expected that households would be patriarchal. Figure 3 indicates that 86.7% of households interviewed were male-headed. *De facto* female-headed households (e.g. recent widows, husband working abroad) were generally seen as a temporary situation. There is no reason to suggest that these data are not representative of the wider situation found in this part of Bangladesh.

Figure 3. Percentage of male- and female-headed households of KAP interviewees from the villages of Jakunipara, Sowara, Sahapur and Anandapur in Comilla District, Bangladesh.



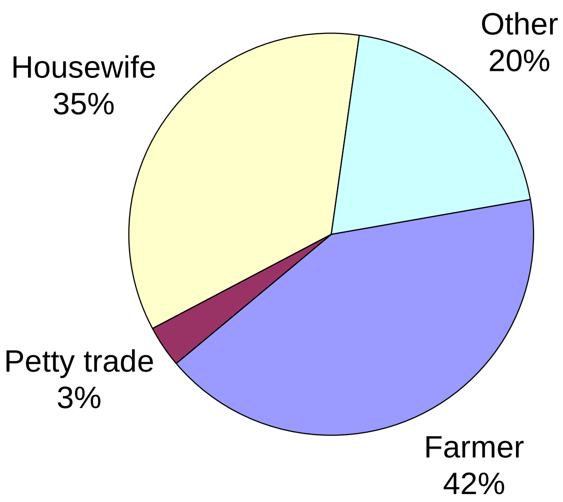
Respondents were divided into five age group categories. Most respondents were between 25 to 40 years old (Figure 4). Although it appears that the relative abundance of respondents is biased towards the primary producers of society, it has been confirmed through discussions with the villages to be a relatively fair snapshot of the village population age structure in the communities surveyed, although under-representing children (children below the age of 10 (not shown) would slightly reduce the median age).

Figure 4. Age group of individuals interviewed during a KAP survey in the villages of Jakunipara, Sowara, Sahapur and Anandapur in Comilla District, Bangladesh.



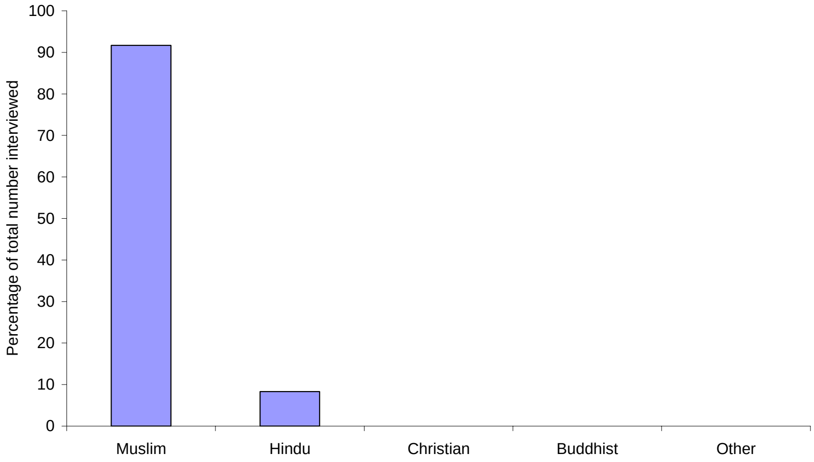
The occupation of those surveyed was dominated by farming (Figure 5). The farming category is largely comprised of male respondents, either landowners or farm labourers. The category of housewife includes a number of female farmers, but this is not usually seen as their main activity, but one of many. The category of 'Other' includes activities such as rickshaw pullers, students and pensioners.

Figure 5. Occupation of individuals interviewed during a KAP survey in the villages of Jakunipara, Sowara, Sahapur and Anandapur in Comilla District, Bangladesh.



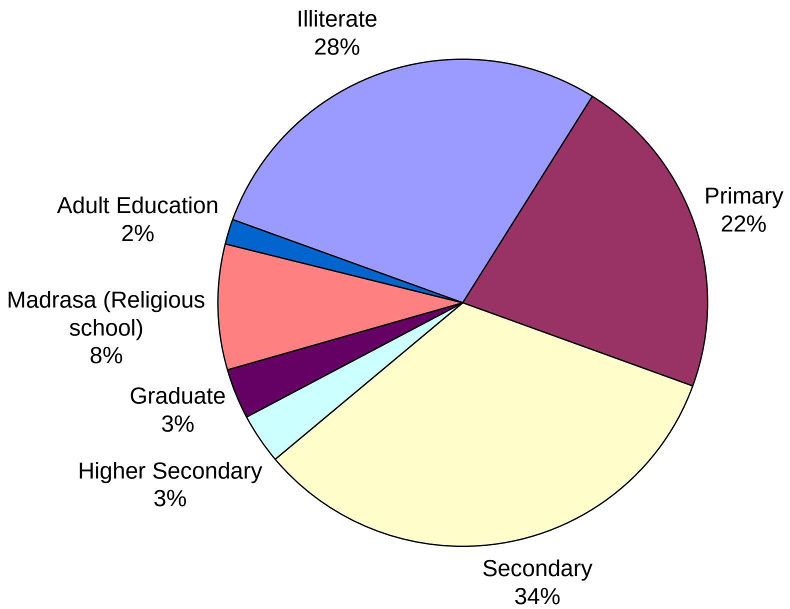
The Hindu minority can be found in most parts of Bangladesh, and the surveyed area is generally comparable to national statistics. With the exception of the village of Sowara where no Hindus were found, the other three villages showed similar percentages, giving an overall percentage of 8% Hindu out of the total interviewed (Figure 6).

Figure 6. Religious identity of the respondent interviewed during a KAP survey in the villages of Jakunipara, Sowara, Sahapur and Anandapur in Comilla District, Bangladesh.



Education levels indicated that 73% of the population could be considered functionally literate (Figure 7). Feedback from the communities surveyed suggested this over-represented illiteracy in their villages, but this may of course be a hard truth to accept. Larger national surveys would suggest the data are representative of literacy rates in rural Bangladesh.

Figure 7. Education level of respondents interviewed during a KAP survey in the villages of Jakunipara, Sowara, Sahapur and Anandapur in Comilla District, Bangladesh.



Migration is an increasingly important phenomenon in Bangladesh. However, little evidence was found of inward migration to the villages surveyed with 96% of respondents claiming to be from the village. Most others were from the locality with approximately 1% coming from further away in Bangladesh. Family size was variable, with the majority of respondents (53%) reporting their households had 6-10 family members. 35% reported family sizes of 2-6, and 12% reported 10-14 family members living in a single household. Household income indicated that 33% of households were below the official poverty line (Table 7).

Table 7. KAP respondents indication of household income (in Bangladeshi Taka)

Annual income	% of total response
below Tk. 10000	33.3
Tk. 10000 -Tk. 14000	1.7
Tk. 15000 -Tk. 19000	5.0
Tk. 20000 -Tk. 29000	8.3
Tk. 30000 and above	51.7

Household building construction is variable, but most people live in clay brick houses (wall and floor) with tin roofs (71%). 11% responded that their walls were made of tin, with the remainder having walls and roofs made from a combined variety of materials including bamboo, tin and straw.

Land ownership is the most important resource and indicator of wealth (Table 8). Of those surveyed, 70% of people have their own land for cultivation; most other respondents were still involved in cultivation for other family members or as labourers. Low amounts of cultivable land (1-49 decimals) are usually indicative of homestead gardens for vegetable growing only. Farmers with larger areas of land usually grow two rice crops per year with approximately 5% producing three crops. Three important relationships with the land are found in all four villages 1) *Bandhak* is a kind of mortgage or loan on land when a landowner needs a large amount of money which involves mortgaging the land to another until the money can be repaid, 2) *Lagit* is a time-bound contractual land rental agreement, and 3) *Vaagaa* is a sharecropping arrangement where the sharecropper usually pays 50% of the profits back to the landowner.

Table 8. Amount of cultivable land attributed to households by respondents interviewed in KAP survey

Amount of cultivable land (decimals)	% of total response
1-49	20
50-99	13.3
100-149	20
150-199	1.6
200 and above	15
Landless	30

KAP respondents said the methods used for rodent control were generally poisons and traps (Table 9). Traps are usually traditionally made from gourds or metal containers with narrow necks with a food bait placed inside. The traps contain no restraining device, and it is necessary to notice that a rodent is inside in order for it to be captured as it can easily escape.

Table 9. Rodent control methods cited by respondents interviewed in KAP survey

Rat control method	% of total response
Poison/Rodenticide	75.8
Trap	68.3
Stick	1.6
Make them run away	1.6

Table 10. KAP respondents' indication of whether their control methods are effective

Control efficacy	% of total response
Effective	74.6*
Not effective	25.4
Non-response	0

*Of the 75% of respondents thinking their method of rat control was effective, most indicated that it was only effective for the first few days.

Table 11. KAP respondents' perception about the safety of poisons

Poison safety	% of total response
Safe	13.8
Not safe	82.8
Maybe	3.4
Non-response	0

Table 12. KAP respondents' perception about rodents causing health problems for family members

Rodent effect on human health	% of total response
Health problems	55.9
No health problems	23.7
Maybe	5.1
Do not know	15.3
Non-response	0

As indicated in Table 12, the majority of respondents accepted that rodents cause health problems. The anthropologist discussed the issue further with interviewees and determined that villagers understood rodents could spread dirt around and contaminate food and water. Most villagers did not know about specific diseases carried by rodents and how they could be transmitted. The issues of rodent disease and hygiene are reported separately in the next section on qualitative anthropological studies. A series of mainly yes/no questions were asked, with responses showing strong agreement among village opinions (Table 13).

Table 13. KAP responses to a series of binary questions

Question posed	Response
Do you think your methods of rat control are effective?	74% responded yes
Why do you think this?	70% cited seeing fewer rats around
Do you use rodenticides?	76% responded yes
Do you think they are safe?	14% responded yes
For whom are rodenticides harmful?	59% responded they are harmful for humans
How do you assess rat damage in your field or house?	98% responded by visual observation, 55% by unearthed plants and 42% by rat burrows
Rat control must be carried out.	98% responded yes
Rat damage can severely decrease rice yields.	94% responded yes
Rats can be controlled.	55% responded yes
Rats can only be controlled if farmers work together with other farmers.	66% responded yes
Rats should be controlled at all stages of the growing season.	55% responded they didn't know

Discussion

These anthropological surveys have provided baseline knowledge about specific issues that are relevant to designing rodent management strategies and ultimately encouraging changes to human activities and practices related to reducing the impacts of rodent's on their livelihoods. The surveys do support the premise that rodents are a significant pest problem for rural agricultural communities and that people have generally had low success in managing the problem effectively. There is a general awareness about the management tools that can be used to control rodents such as traps and poisons, but knowledge about how to use them effectively appears to be entirely lacking among almost all villagers. There are major problems of human perception of their rodent problem and how to control it. Existing management could be termed "crisis management" where rodent control is only adopted when the problem is at its peak, and villagers do not appreciate that their efforts to control rodents at this stage are largely ineffective as they use no systematic or clear observational method of determining the damage caused by rodents before or after treatment. Women particularly see rodents as a problem, and this is likely to be related to their presence around homesteads where more obvious indicators of rodent damage can be found as opposed to field damage where men are mainly responsible for management activities. Although there is a perception that rodent pests are a community problem, their current control is almost always based on individual action. Communities do engage in relatively laborious rodent management actions such as digging burrows, and hunting, recognising that the benefits are limited, and this suggests that villagers will make time for rodent management activities. Villagers also occasionally buy rodent poisons, which is encouraging as it suggests that labour and financial outlays can be redirected to more efficient means of rodent control without significant changes in community perceptions of what is required to control rodents. These issues are discussed in more detail in the following section about qualitative indicators of people's knowledge, attitudes and practice about rodents.

As the project has been extended to carry out further activities related to the dissemination of rodent knowledge, it is planned to repeat the KAP survey near the end of the project timeframe. The results of this final survey will help assess how the project has changed people's knowledge, attitudes and practices regarding rodents since the project commenced. In this regard, we would expect there to be little change in people's KAP in the two control villages where no rodent management interventions occurred, and significant positive changes in the two treatment villages where rodent management interventions took place. These results will be captured in the final report delivered at the end of the extension.

Knowledge, attitudes and practices of rural farming communities: Qualitative surveys using farmer group discussions and observation

Introduction

It is well established that humans do not always do what they say they do. The differences between what is said and done highlight important issues relevant to rodents indicating that people may know certain behaviours or activities are risky, but make their choices based on other factors. For example, quantitative surveys have indicated that people do recognise that rodents are unhygienic, contaminating food and water. And because of this people will claim that prepared food is kept covered at all times to prevent rodents/cockroaches gaining access. In casual observations around villages, however, it can be seen that household practices do not always live up to the declared expectations. It is, therefore, difficult to obtain important human practice information through quantitative surveys alone. Observational and group discussion work can reinforce and clarify behavioural data, highlighting where practice and assertion diverge. Qualitative anthropological research can also help identify key informants, role models, and individuals that could be used to help disseminate knowledge and information to the wider community.

Materials and Methods

Farmer group discussions

Ten topics were selected for discussion with each topic discussed in separate sessions. Each discussion session continued up to 45 to 55 minutes and would be limited to a maximum group size of 20 people (males and females, separately, and focussing on homogenous peer groups, e.g. village elders, young men, housewives, etc.) who were invited to the meeting. Drinks and snacks were provided and efforts by the anthropologist were made to get each participant to feel comfortable to express their opinions and ideas about the discussion topic. Topics were as follows:

- Knowledge, attitude and practices about rodents and their impacts
- Pest management
- Constraints in agricultural production
- Ethno-ecology-animals
- Hygiene risks in food preparation
- Population dynamics
- Cropping cycle and seasons
- Rodent diseases and transmission
- Environmental impact on pests
- Historical climate and seasonal changes

Observation of hygiene standards and food preparation

The objectives of this study were to obtain an in-depth understanding of the hygiene and food preparation activities of the villagers, the nature and type of activities villagers are involved in, and explore and identify risks related to disease transmission by rodents. Anthropological data were collected from primary sources through observation of individual villager activities. This involved establishing a good relationship with the villagers in a wider context and selecting individuals that were willing to be observed in their daily routines. Observations were recorded in a diary, making notes of particular issues related to rituals, practices related to household hygiene, and food preparation. All observations were carried out in the village of Jakunipara.

Results

Farmer group discussions

Approximately 450 villagers were involved in these discussions. Each discussion group was generally comprised of 15 male or female participants, and the three categories of target groups were defined as village elders, housewives and young men. The results from each discussion topic are not easily summarised as they are based on recording individual comments from farmers during the meetings. However, many similar statements are made by villagers at separate meetings with few discernable differences in views expressed by females and young or old males. The main comments repeatedly mentioned by farmers can be found at the end of this report in Appendix 2.

Observation of hygiene standards and food preparation

Preliminary observations and previous quantitative work suggested three categorical groups were present in the village that merited separation: 1) the Hindu community, 2) poor Muslims and 3) rich

Muslims. As will be described below, the Hindu community and poor Muslims share many common attitudes and practices, and observations about each group will be discretely summarised. In total, 75 households were observed for this study.

Hindu community
There are 37 Hindu households in Jakunipara (500 households in total) with a population of approximately 200 Hindus. Literacy and economic status are poor, and occupations are diversified. Few Hindus own land, many are labourers and sharecroppers, and a few are shopkeepers or involved in informal trade (smuggling). Household construction is poor, and there are two sanitary 9-ring slab latrines for the area. Observations indicate that many people defecate in open places close to fallow and bushy areas. The latrines have a link to a holding tank and ultimately to the irrigation canal so that waste material can be released; however, the latrines were in poor repair affecting their proper functioning. Women generally feel self-conscious about using the latrines and feel somewhat ashamed when using them. Usage is subsequently often confined to the hours of darkness. Very few people appear to use soap for hand washing after defecation. Most Hindus use tube well water for drinking, but this is not exclusive, and using pond water for drinking has been observed. As throughout Bangladesh, ponds are usually highly contaminated environments, where dead animals, human waste, kitchen waste and waste water is thrown. Hindus do clean fish, meat and vegetables before cooking them, but with pond water. Rice is almost exclusively cooked in pond water as it is believed that tube well water turns the rice dark (tube well water is often high in mineralised iron). Kitchens in Hindu households are relatively clean as this is related to religious rituals. Although most Hindu kitchens in the village have mud floors, they are regularly cleaned with mud water. Kitchen utensils are usually kept clean and stacked when not in use, but stored in the open. Prepared food is often left uncovered for several hours or even overnight (evening meal leftovers eaten the following morning). Child rearing practices among Hindus are poor with respect to hygiene. Children wander around with little supervision or attention. It is not the general practice to take children to the latrine, and they usually defecate in the household courtyard. Although adult faeces is seen to be highly polluting and disgusting, children's faeces is not. As a result, after defecation the woman who cleanses the bottom of a child does not wash her hands with care.

Poor Muslims
Literacy levels are poor and similar to the Hindu community. Few are involved in agriculture and have little or no cultivable land. Many are rickshaw pullers, labourers, furniture makers or market traders. Household construction is similar to that found in the Hindu community. Houses and courtyards are rarely swept and contain rubbish, livestock waste and standing water. Tube wells are often far away and shared with neighbours. Bathing, clothes washing and washing kitchen utensils are all done in ponds. Livestock can often be kept within the courtyard near human living areas. Households do not have separate latrines, resulting in many people defecating in fallow or field areas. Children defecate in courtyards, sharing similar attitudes and poor practices observed among Hindu women. In contrast to Hindus, kitchens and utensils are not cleaned regularly, dirty utensils are sometimes used again. Food can be left standing in the open for long periods of time. Soap is not regularly used for hand washing or bathing. Diarrhoea, jaundice, skin infections, fever and coughing are common ailments among poor Muslims. People believe that hygiene/contamination does play a role in such diseases; however, some believe such diseases take place because of their own fault (supernatural punishment) or curses of others, or that the diseases are symptoms of malnutrition. Rodents and particularly the shrew, *Suncus murinus*, are blamed for spreading filth in the environment and contaminating food.

Rich Muslims
The literacy rate is high. Land ownership is common with relatively larger areas under cultivation. Many households have members working overseas, and cash inflows are visible through material possessions and quality of household building construction. Well-off households are much more hygienic and people try to keep themselves neat and clean. However they are still somewhat casual and careless about the hygiene of children as indicated above. It was observed that children are not taken to latrines and allowed to defecate in the courtyard. Adults regularly use latrines and wash their hands with soap afterwards. Latrine ownership is high and people keep their latrines clean and functioning. Tube well water is used for drinking and hand washing. However pond water is still often used for washing clothes and utensils. There is a better appreciation to maintain high standards of hygiene, food and drinking water are properly covered and stored, and diarrhoeal diseases are subsequently less common.

Figure 8. Photograph of a farmer discussion group facilitated by the project anthropologist, Noor Mohammed

Figure 9. Photograph of spear or killing pole used to hunt rats in Bangladesh

Figure 10. Photograph of rodent burrows in house foundation

Figure 11. Photograph of rodent burrow inside a village house

Figure 12. Photograph of rodent damage to ripening tomatoes

Figure 13. Photograph of rodent damage to rice

Figure 14. Photograph of rodent contamination to stored rice

Discussion

Farmers experienced various types of damage by rats in everyday life. Rat damage is generally widespread, affecting the whole sector of farmers' livelihoods. Most rat damage was related to crops and stored food, particularly rice. Farmers said that rats damage and cut everything, and create a dirty environment. However, the women are not concerned with the outdoor damage caused by rats as they are involved with the household and indoor activities. There is a division of labour with the women's sector in the household; although sometimes the boundary of labour division is overlapping with women working in the field as well. Female farmers informed that men are concerned with the field damage caused by rats because their main interactions with rodents are in the field. Women farmers are less concerned about field damage and more concerned about the household damage. Farmers of the four villages said that they could not store rice easily due to rat damage and that rat damage occurred to all stores no matter what the store construction. Some farmers said that rats cut clothes, hair and spread dirt in the environment; however most farmers were unable to express the rodent loss in monetary terms. Specific damage, such as to a new shirt that cost three hundred taka, was mentioned, but total costs of rodent damage were unknown by farmers. One farmer said that rats cut his fishing net which cost six hundred taka. Some people said that they reserve a portion of field crops for rats, and refer to it as the rat's portion. Farmers also noted rodent damage to chickens, eggs and cattle food and damage to vegetables and fruits like guava, jackfruit, mango, bean, potato, chilli, pumpkin and gourds. It was noted that when the rice is in the ripening stage then the damage and destruction of rats increases. There is a saying in the villages that a male rat collects seven wives during the rice ripening stage, using the female rat labour to store more rice in their burrows. Rat damage was also noted to bags, plastic utensils, wooden furniture and houses. Most of the houses in the study villages are made of clay, and the farmers always said that the rats damage their houses and can cause buildings to fall down by their burrowing.

The local farmers have the knowledge that the rats may belong to several different species, and they alluded to similarities with humans which have different colours, classes and races. The farmers generally have the clear idea that mice are not baby rats, and they mentioned mice are another species. To give an example farmers said, as adult men can be undersized, so can adult rats. Although this is slightly different from the general concept of species being unable to breed with each other, this perhaps says more about Bangladeshi perceptions of humanity than about rats.
Farmers mentioned the rat varieties are:
1. The field rat. Its colour is generally grey/black, and the size is both big and small.
2. The house mouse, locally named batti indur, which is small and speedy.
3. The big house rat, which likes to make holes and destroys houses.
4. The tree rat, generally eats and damages fruits, which is bigger and a different colour from the other species.

The villagers' common opinion is that rats like to live in dark and dirty places, live in burrows but also in trees, haystacks and bushes where they make nests. They are more active at night. Some people thought that rat damage and annoyance is higher in the village area rather than the urban area because most of the rat population lives in the village area.

About fifty percent of people in the study area believe that rats can spread diseases among the human population. Only some educated and elderly people were able to mention that plague is a rat borne disease. About sixty percent of people surveyed believed that food with rat droppings or partially rat-eaten food is contaminated and can cause stomach problems if eaten. Villagers said that they try to keep safe their food from rats by using covers but said that it is not always possible to keep all kinds of food from rat contamination as rats can easily remove the cover. The case of rats directly biting people appears to be rare, but some farmers from Jakunipara mentioned bites on fingers or toes. Generally people are aware that good hygiene is important but fail to recognise the importance of particular actions to reduce disease transmission, e.g. hand washing, covering food and water.

The people of the study areas generally use traps and poison for rat control, with nearly all households saying they used poisons. Some other methods of rat control mentioned were:

- Digging up rat burrows
- Pouring water in burrows, sometimes with hot water. In this method people sealed one of the entries and then wait for the rodent to come out to kill it.
- Put smoke in rat burrows

- Put banana tree in the field crop. Farmers believe this is effective because the rats think it is a human and a distance from this field.
- Dried gourds, metal or clay containers with single small holes that are used as live traps
- Live and kill traps bought from local markets.
- Rat poison mixed with food and placed near rat burrows
- Sticks and poles for beating and killing rats

The study found that women are more involved in rat control and are responsible for trap set up, bait making, mixing poison with food and placing it in the rat-affected areas. Male participation in household rat control is lower; men usually buy rat poison from the market, bring it in home and hand over it to the women. Many villagers know that they need to work cooperatively in the issues of rat control but admit this is difficult to do. Not all villagers knew that rat poisons must be used carefully to avoid harm to children and livestock. However, some few cases of child poisoning were reported.

Assessment of rodent population dynamics, habitat utilisation, species composition and breeding rates

Introduction

The United States National Wildlife Research Centre worked for many years in Bangladesh on rodent ecology and management in collaboration with Bangladesh scientists. Some of this research was field-based ecological and taxonomic studies. Unfortunately, research came largely to a halt when the US funding stopped in the early 1980's. Since this work, cropping systems have changed dramatically, and it was likely the rodent population dynamics would be very different where the number of crops grown, cropping intensity and diversification have subsequently increased. Assessments of habitat utilisation by rodents had not been previously done anywhere in Bangladesh, and this was particularly important to understand temporal and spatial movements of rodents to more accurately identify the timing and location of rodent control actions.

Materials and methods

Trapping rodents was initiated to collect data on rodent taxonomy, monitor prevalence and breeding over time in different habitats in different rural agricultural villages. Trapping took place in six villages (Jakunipara, Anandapur, Sowara, Sahapur in Comilla District and Batania and Nasirgram in Feni District). Data will not be presented here for the two villages in Feni District as these sites were dropped from further project activities due to logistics. The habitats that were surveyed in each village were: 1) rainfed rice fields; 2) irrigated rice fields; 3) houses; 4) vegetable plots; 5) ponds; 6) roadsides. A total of 20 traps was used for each habitat per village. Live capture traps were used in all outdoor habitats, while kill traps were used for the household habitat. Traps were placed out for three nights in each village once per month over a period of 16 months starting in August 2002. Traps were placed approximately 10 m apart from each other in the same positions during each repeat census. Live capture traps were usually set and baited with coconut oil and kill traps with fresh coconut each evening, and captured animals were collected the following morning. In the laboratory, animals were measured and dissected to obtain taxonomic and reproductive biology information.

Results

Trap success was generally much higher in the village habitat than in the outdoor habitats (Figures 15 to 22). This may reflect a true difference in rodent population dynamics; however, this interpretation of the data must be treated with caution as the enclosed household area makes it easier to capture rodents than in open areas by influencing trap density. Comparisons of trap success between the household habitat and other habitats is also confounded by the use of kill traps inside and live traps outside. Interpretation of these data will be assisted by information on rodent breeding and community structure presented in the section on intensive trapping found later in this report.

As Figures 15 to 22 indicate, comparison of results from each village do show some correlation among particular population changes such as peaks in household capture rates in the villages around September/October. This is approximately 1-2 months before harvest, and rodent numbers are likely to be high from breeding over the previous months of favourable environmental conditions. Generally, capture rates are too low in the outdoor habitats to conclude strong trends.

Figure 15. Trap success of all animals caught in the village of Sowara in six different habitats

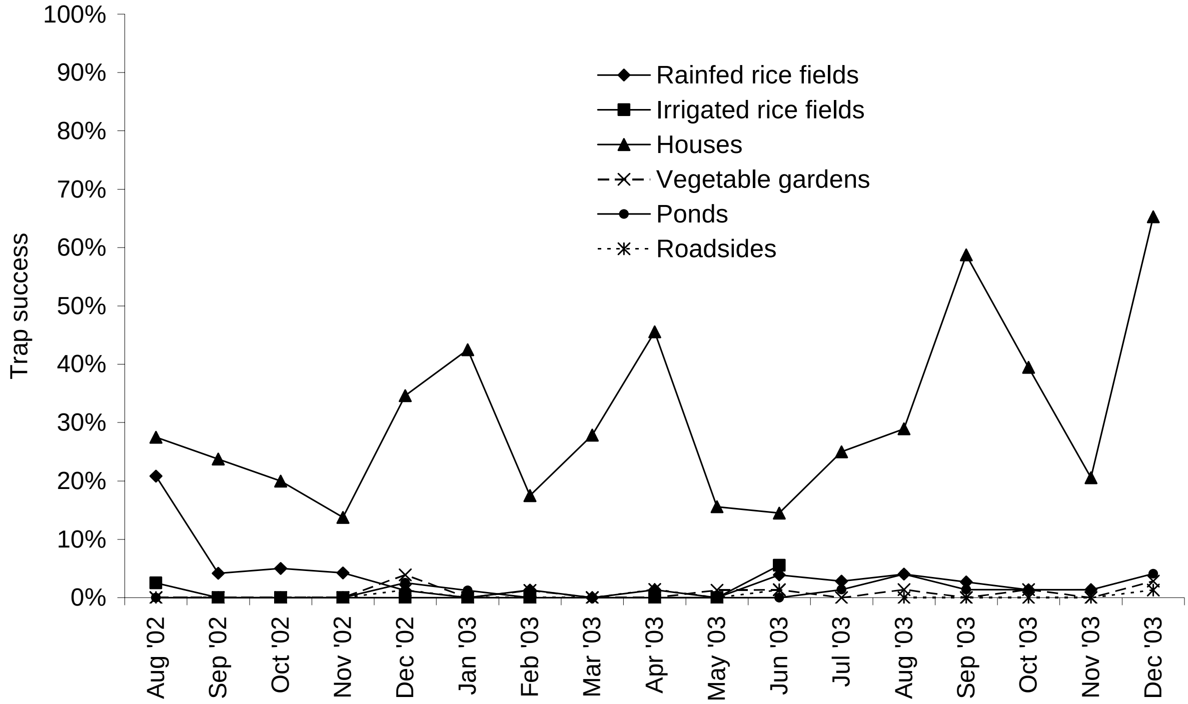


Figure 16. Trap success of all animals caught in the village of Sowara without the household habitat

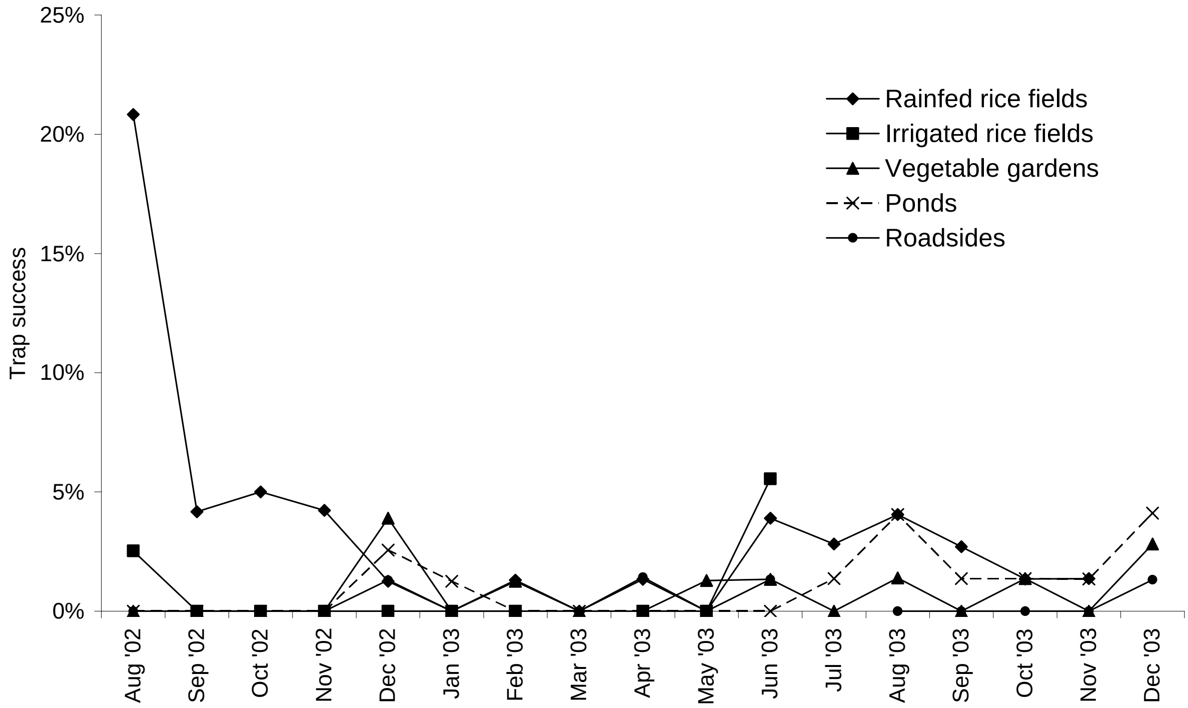


Figure 17. Trap success of all animals caught in the village of Jakunipara in six different habitats

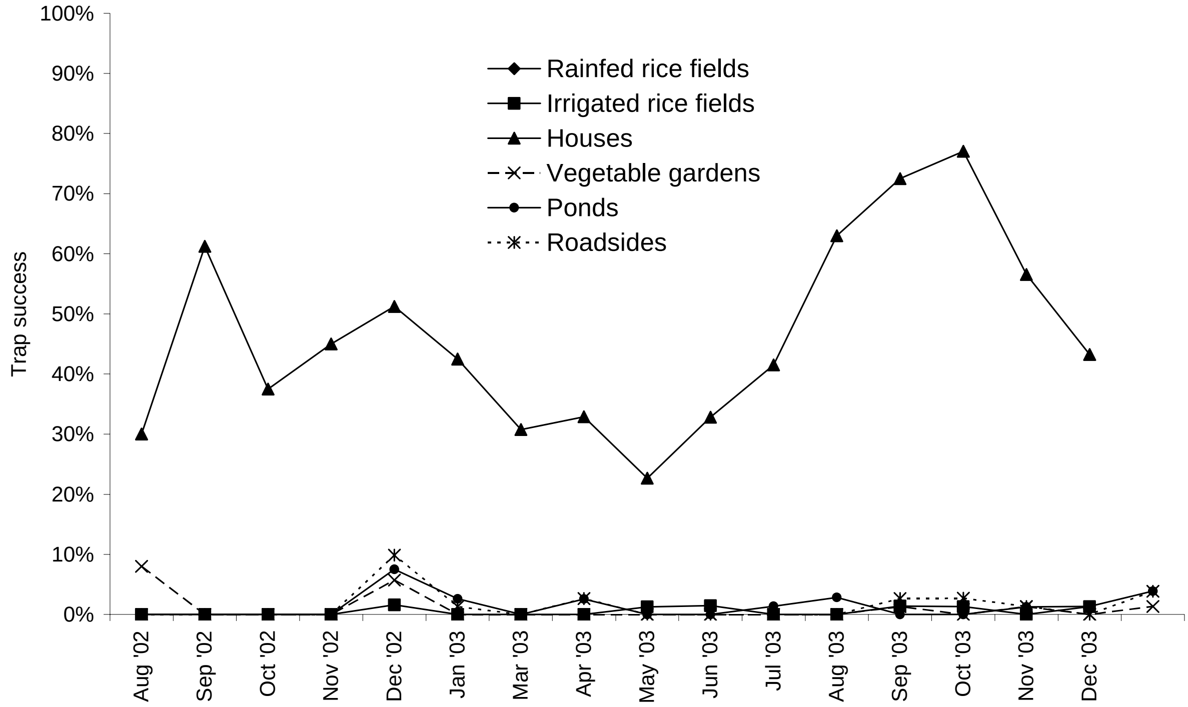


Figure 18. Trap success of all animals caught in the village of Jakunipara without the household habitat

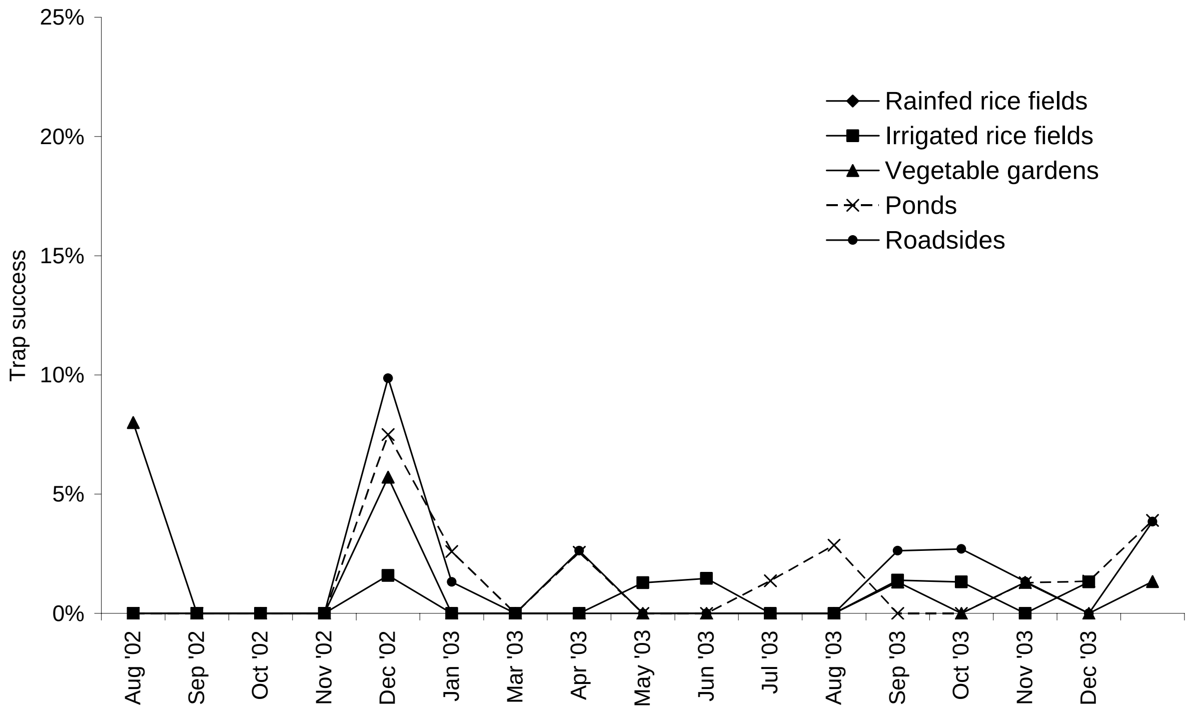


Figure 19. Trap success of all animals caught in the village of Sahapur in six different habitats

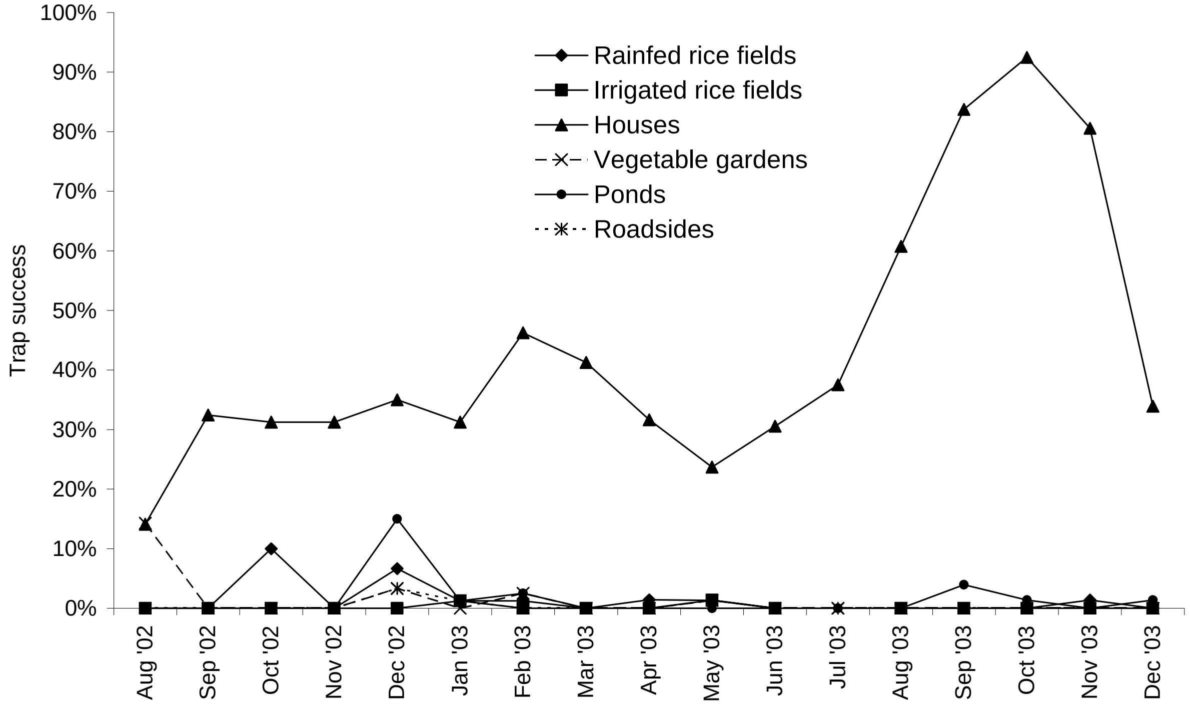


Figure 20. Trap success of all animals caught in the village of Sahapur without the household habitat

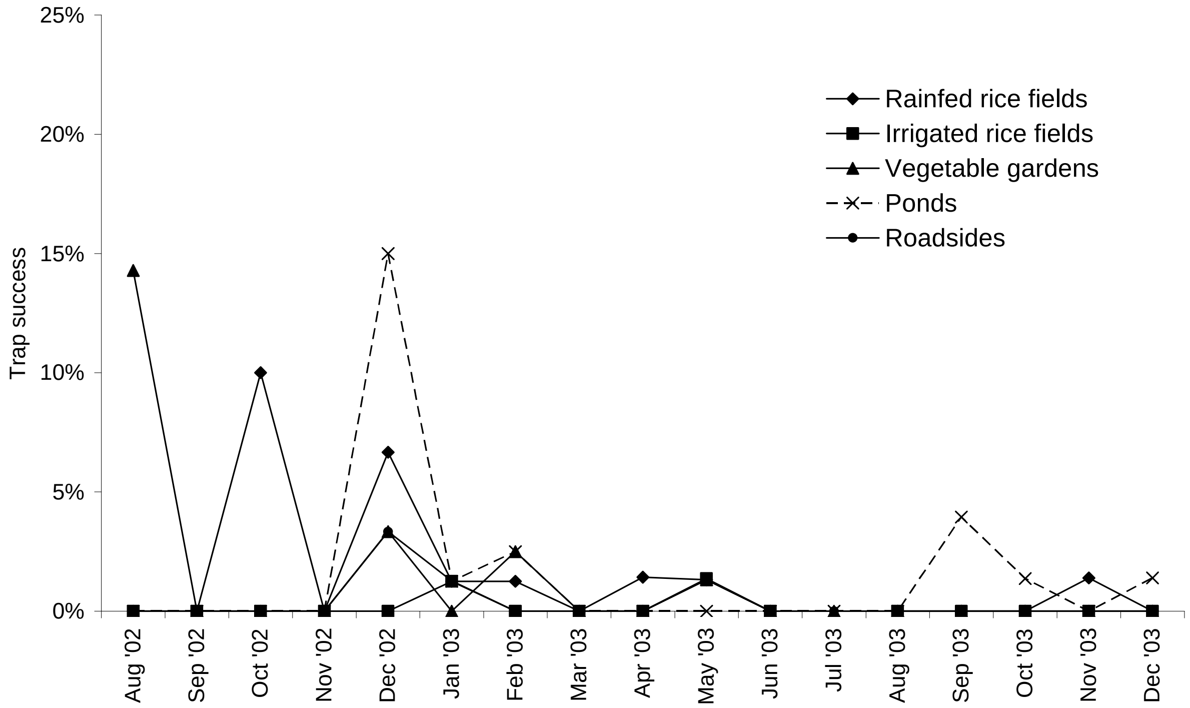


Figure 21. Trap success of all animals caught in the village of Anandapur in six different habitats

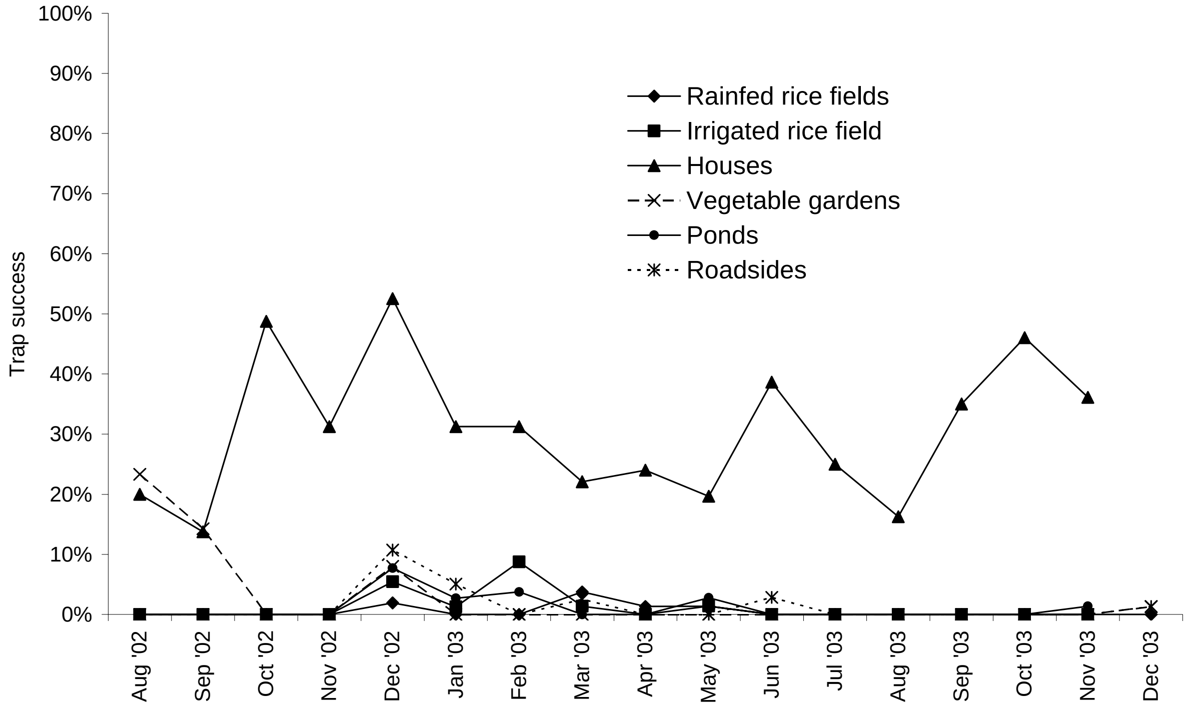
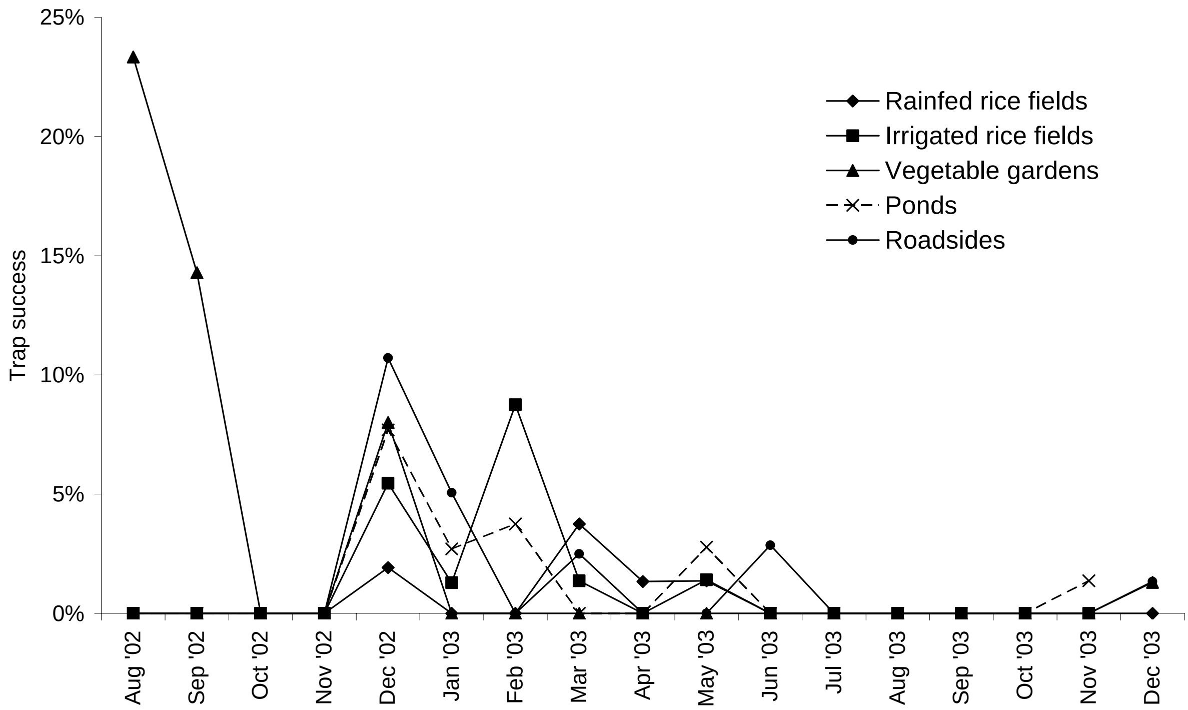


Figure 22. Trap success of all animals caught in the village of Anandapur without the household habitat



Although there are some notable exceptions, differences among rodent species prevalence in different habitats and the different villages were subtle. Although the data suggest that rodent movements among habitats and their exploitation of various habitats is widespread, there are some general population trends that are apparent from the analysis. The village habitat supports large populations of mice (*Mus* spp.) and shrews (*Suncus murinus*) and relatively lower numbers of *Rattus* spp. and *Bandicota benegalensis*. The main rodent species in field crops are *B. benegalensis* and *Rattus rattus*. Species such as *B. benegalensis* are more likely to move into village habitats after each rice harvest. Relatively smaller numbers of *Mus* spp. and *B. indica* can be found in habitats around field crops, e.g. ponds, river banks, roadsides. Although technically not a rodent, shrews are ubiquitous in high numbers in all habitats, particularly villages. Although shrews may be providing benefits such as insect predation in field crops, they are considered a pest in households through eating and contaminating household food and potentially spreading disease. Although mice can be found in the field, their presence in houses is considerable. For example, data from the village of Jakunipara indicate that household mice populations increase after August (Figure 23). While the same principle holds true in Sowara, overall population levels of mice are about half that found in Jakunipara (Figure 24). The opposite appears to be true for populations of *Rattus rattus* in these two villages, where Sowara has approximately double the number found in Jakunipara (Figures 25 and 26). These data could support theories of rodent competition whereby the presence of larger rodents exclude smaller species from access to food and harbourage. However, further research would be essential to confirm the scope of interspecific competition in the habitats found around rural villages in Bangladesh. Additional evidence of interspecific competition is presented later in this report within the section on rodent management through intensive trapping. Data on capture rates of *Bandicota benegalensis* indicate migrations of rodents into villages from the fields after harvests (Figures 27 and 28)

Figure 23. Capture rate of *Mus musculus* from traps placed in houses in the village of Jakunipara

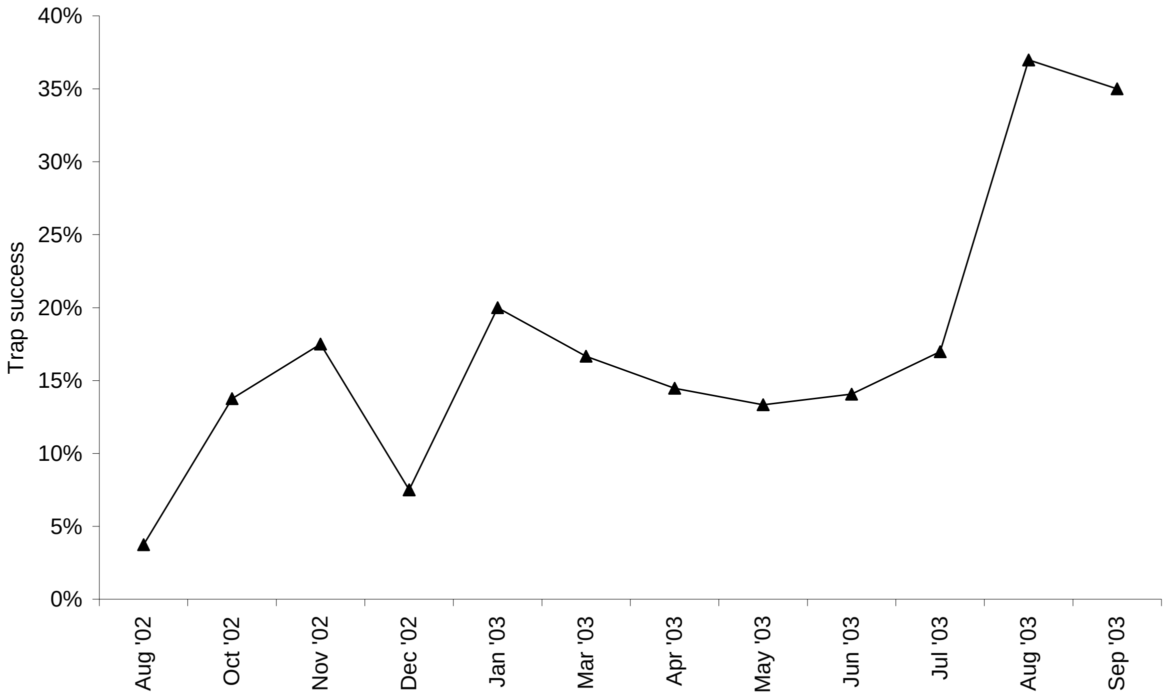


Figure 24. Capture rate of *Mus musculus* from traps placed in houses in the village of Sowara

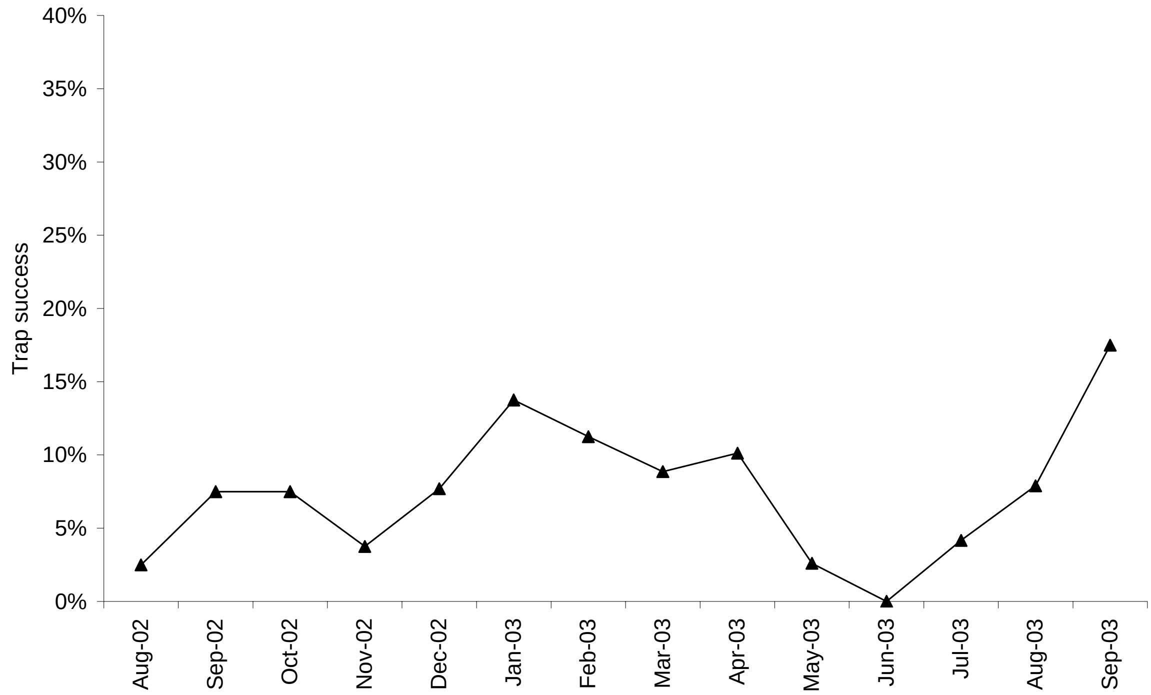


Figure 25. Capture rate of *Rattus rattus* from traps placed in six habitats in the village of Sowara

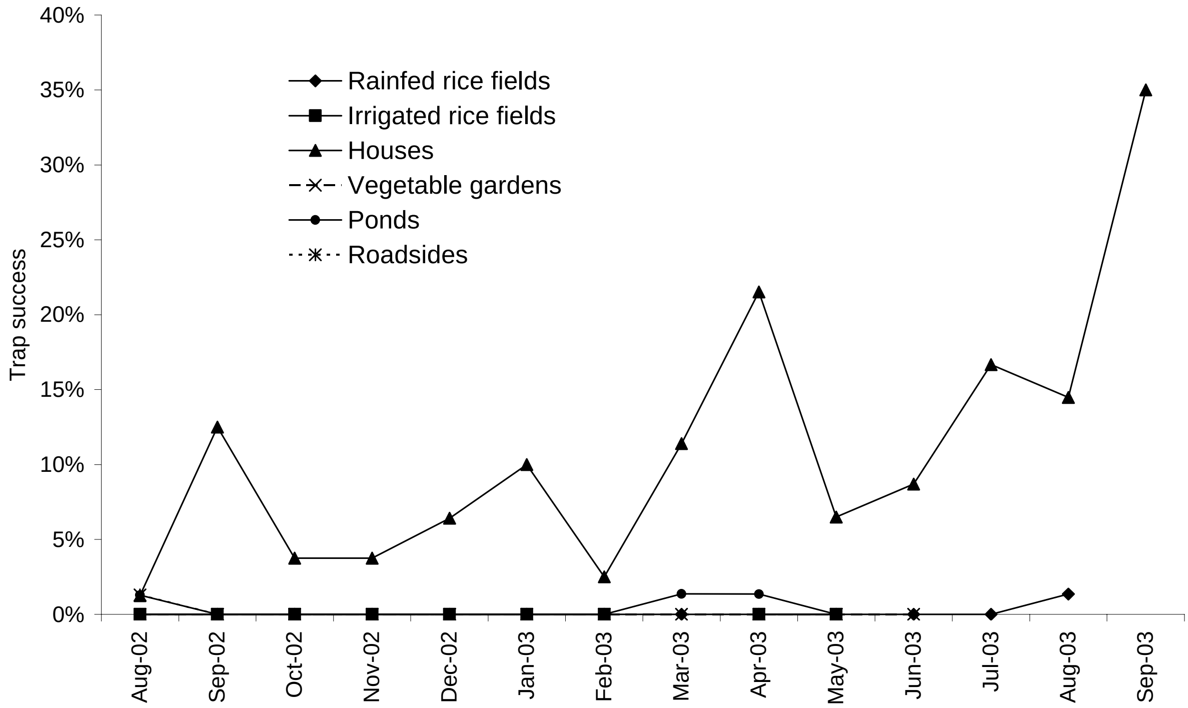


Figure 26. Capture rate of *Rattus rattus* from traps placed in six habitats in the village of Jakunipara

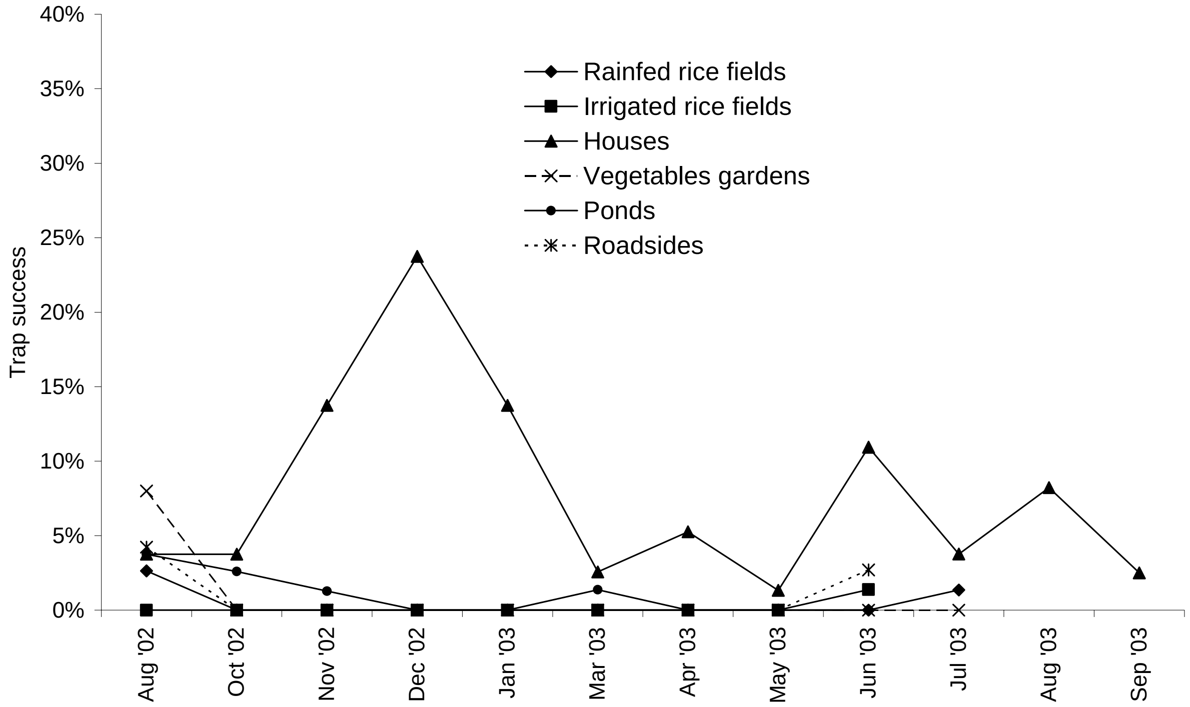


Figure 27. Capture rate of *Bandicota benegalensis* from traps placed in six habitats in the village of Jakunipara

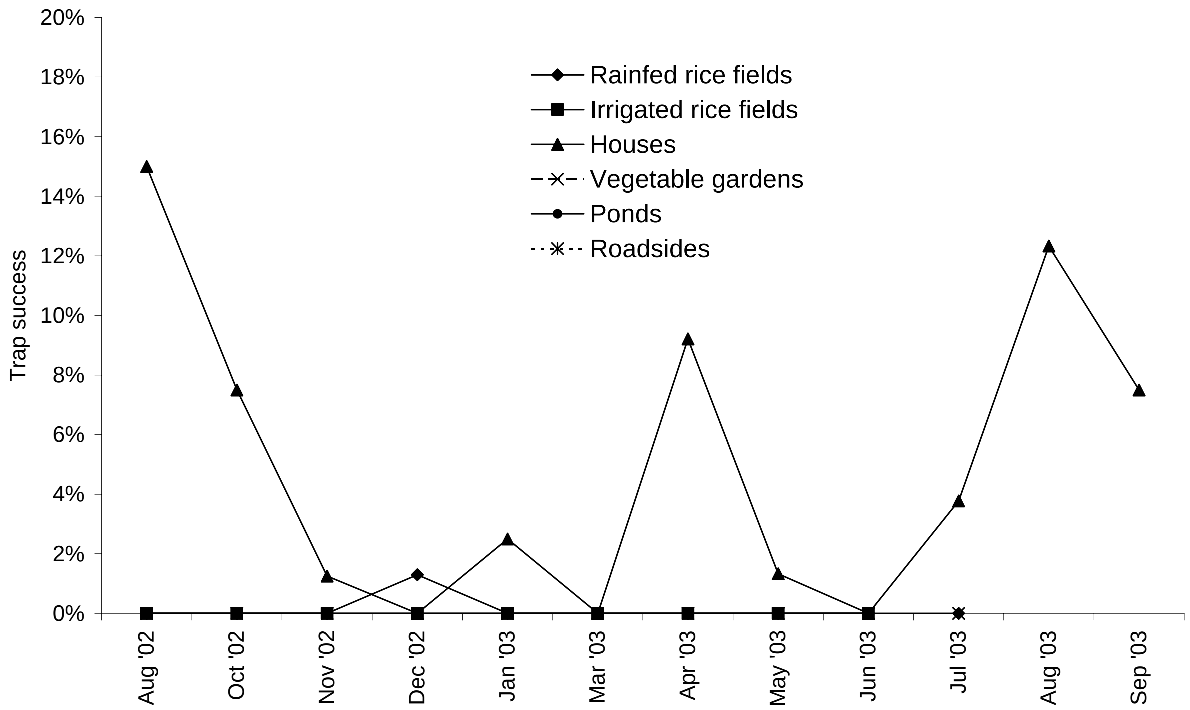
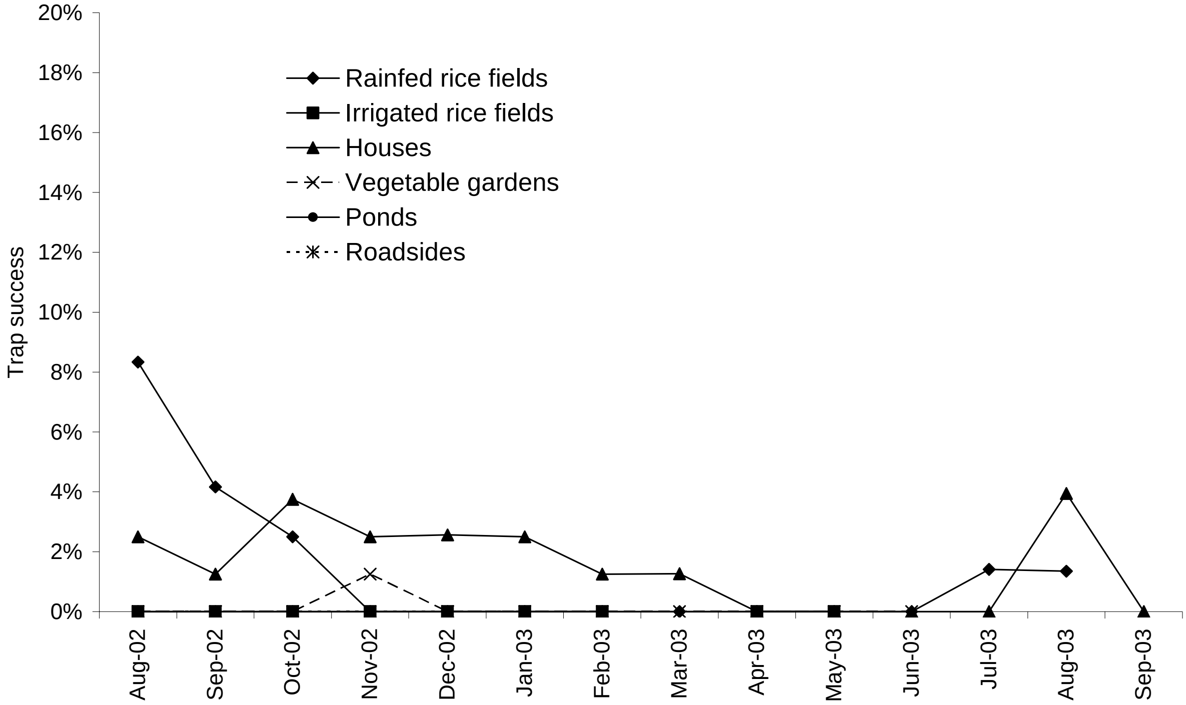


Figure 28. Capture rate of *Bandicota benegalensis* from traps placed in six habitats in the village of Sowara



Assessments of rodent species community structure indicated similar trends in the four villages in Comilla (Figures 29 to 32). The data indicated very high populations of *Suncus murinus* could be found in all habitats. The high trap success with *S. murinus* is certainly partly explained by its well-known lower levels of neophobia than rodents and its relatively higher activity levels. The low capture rate of rodents in the outdoor habitats make these data difficult to interpret, and repeating the trial over more than one season with better and/or more traps would help bring confidence to these data. Data derived from the household trapping are likely to be an accurate reflection of the community structure in this habitat because overall trap success was generally greater than 40%. Further data regarding community structure are presented later in this report in the section on intensive trapping.

Figure 29. Rodent community structure in different habitats found in the village of Jakunipara based on habitat trapping surveys conducted over the period of August 2002 to December 2003

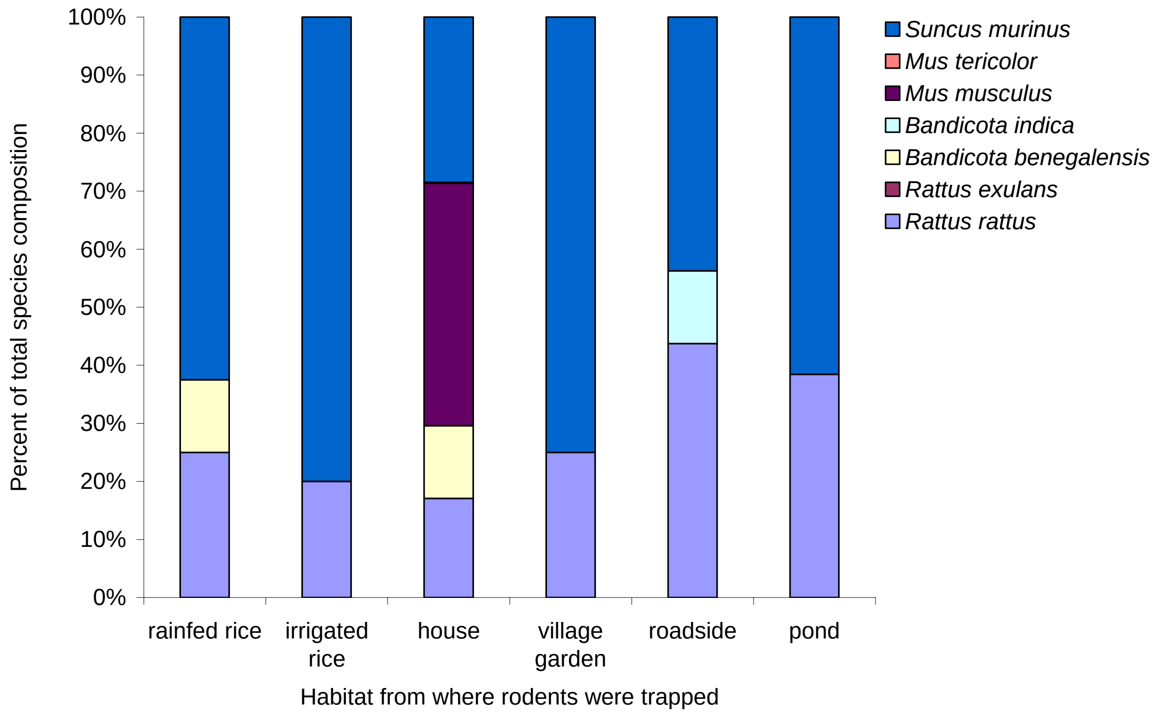


Figure 30. Rodent community structure in different habitats found in the village of Sowara based on habitat trapping surveys conducted over the period of August 2002 to December 2003

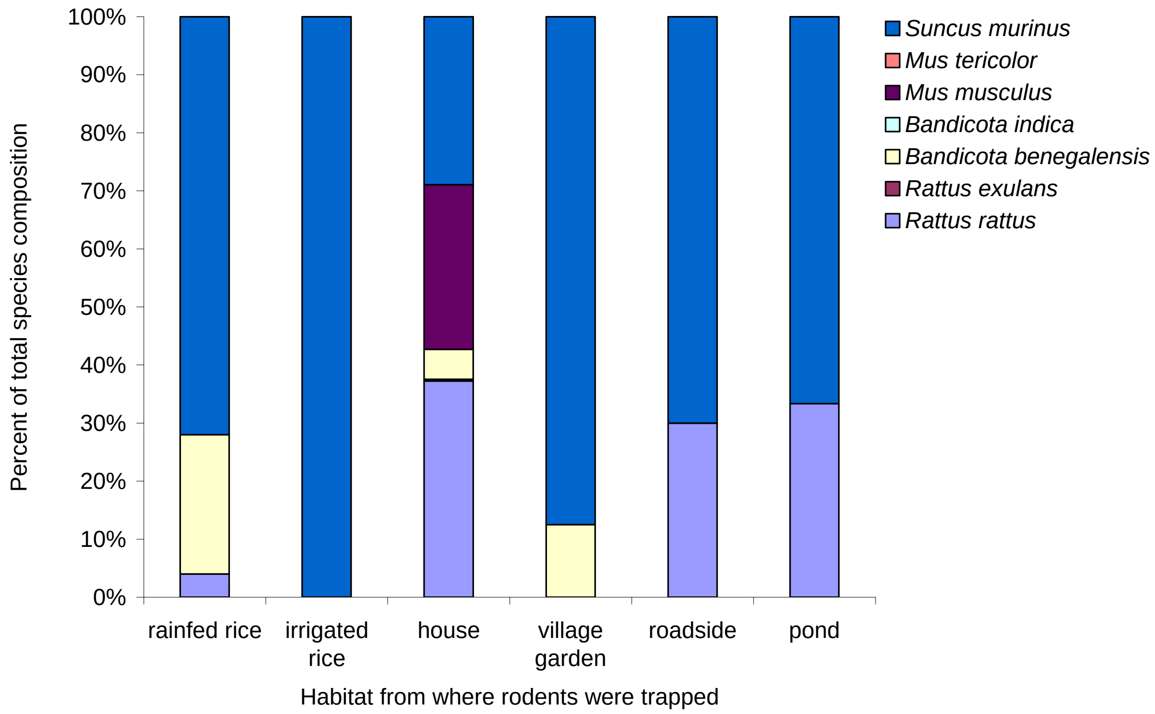


Figure 31. Rodent community structure in different habitats found in the village of Anandapur based on habitat trapping surveys conducted over the period of August 2002 to December 2003

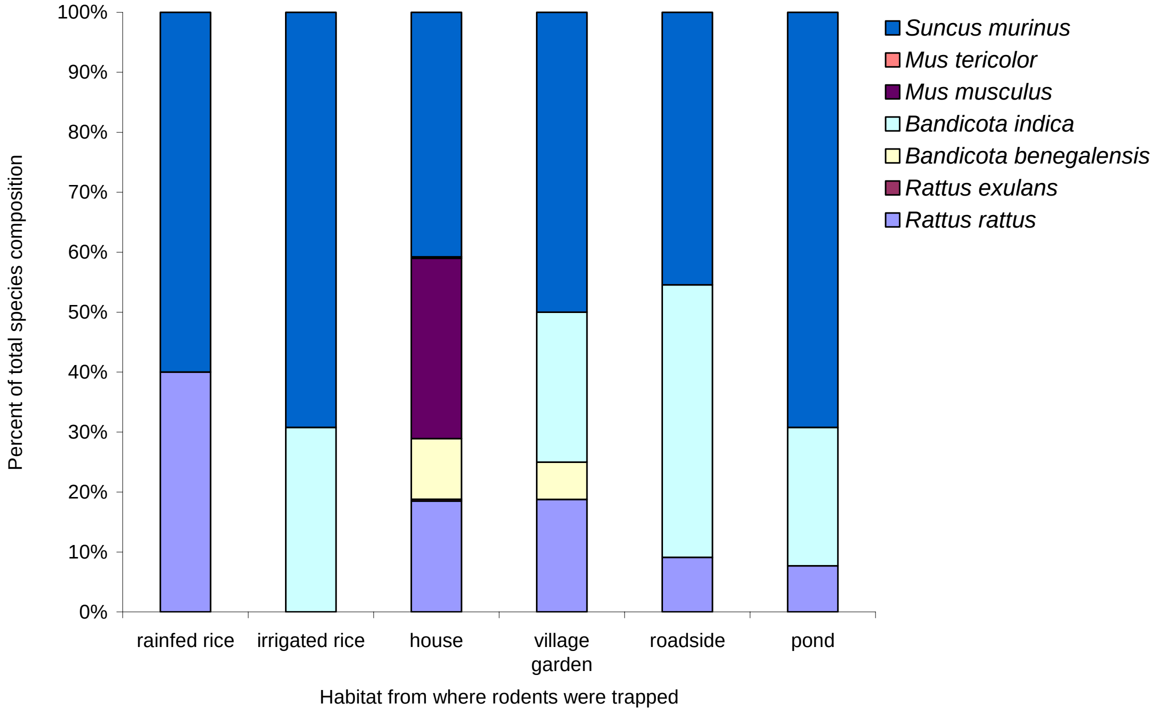
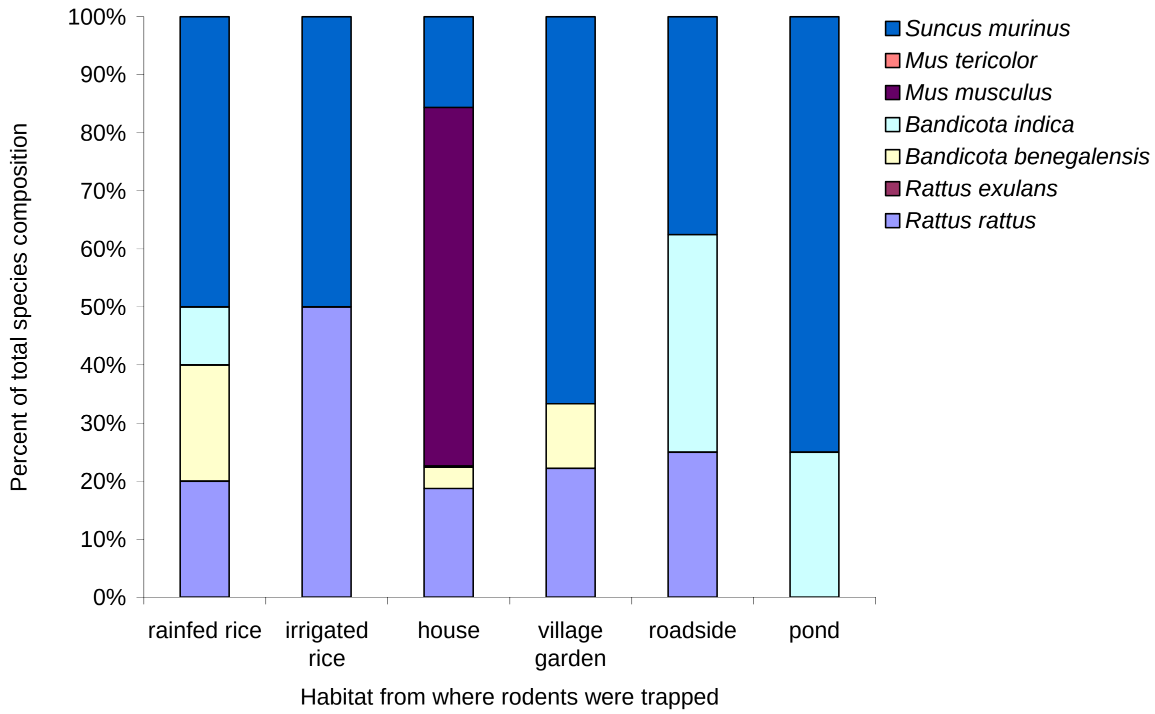


Figure 32. Rodent community structure in different habitats found in the village of Sahapur based on habitat trapping surveys conducted over the period of August 2002 to December 2003



Rodent populations in different habitats may be affected by migration between habitats, but it is largely driven by periods of rodent breeding which may be seasonal for certain species or in certain environments. Dissection of captured animals allowed the maturity and breeding condition of males and females to be assessed. Some examples of these data are illustrated in the below figures where the uterine condition of females is presented (Figures 33 to 35). To briefly explain the four uterus conditions, a thin non-vascularised uterus would be present in a juvenile rodent, a thin vascularised uterus would be present in an adult female getting ready to breed for the first time, a thick vascularised uterus would occur in an adult that has had previous litters, and a uterus with embryos suggests current breeding. No clear breeding patterns are obvious from these data. However, as the data samples are proportionately biased by household trapping where capture rates were higher, the data do suggest that breeding may occur year-round, at least on the part of rodents captured in villages. As indicated with previous analyses of these data, the low trap success in key field habitats for species such as *Bandicota benegalensis* are likely to have influenced the interpretation of breeding rates. Further data regarding rodent breeding are presented later in this report in the section on intensive trapping where high capture rates are likely to demonstrate more reliable data.

Figure 33. Breeding condition of female *Bandicota benegalensis* captured from all habitats in all villages based on habitat trapping surveys conducted over the period of August 2002 to December 2003

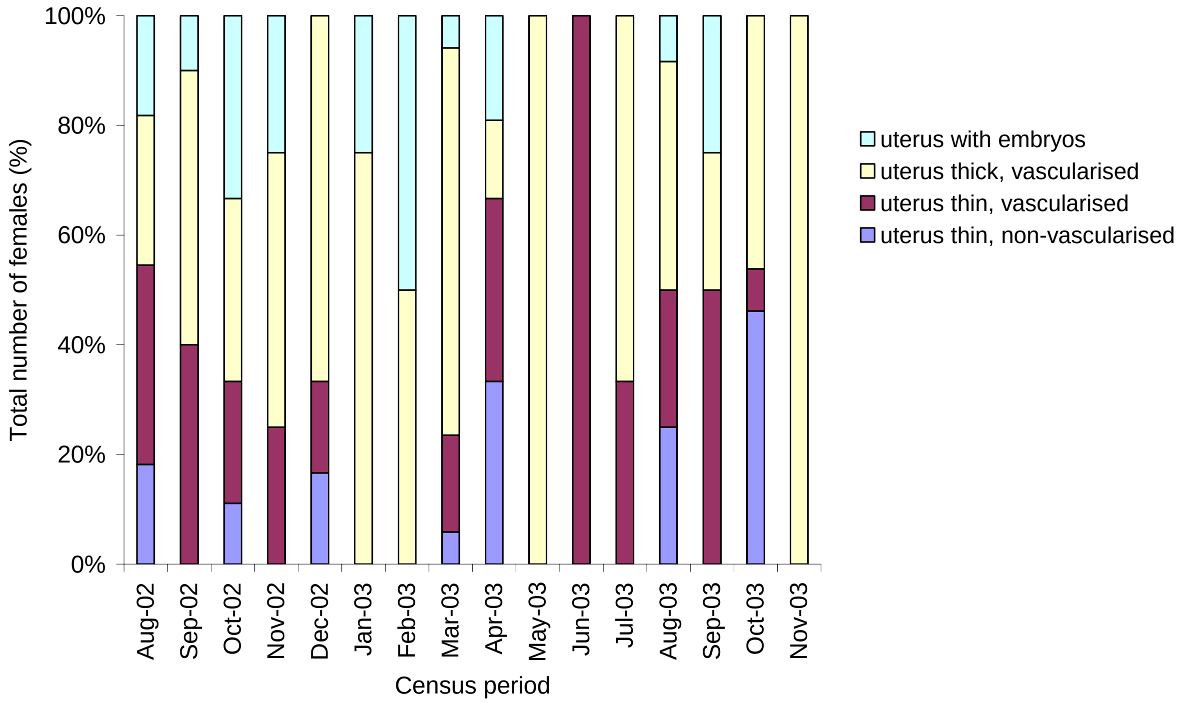


Figure 34. Breeding condition of female *Mus musculus* captured from all habitats in all villages based on habitat trapping surveys conducted over the period of August 2002 to December 2003

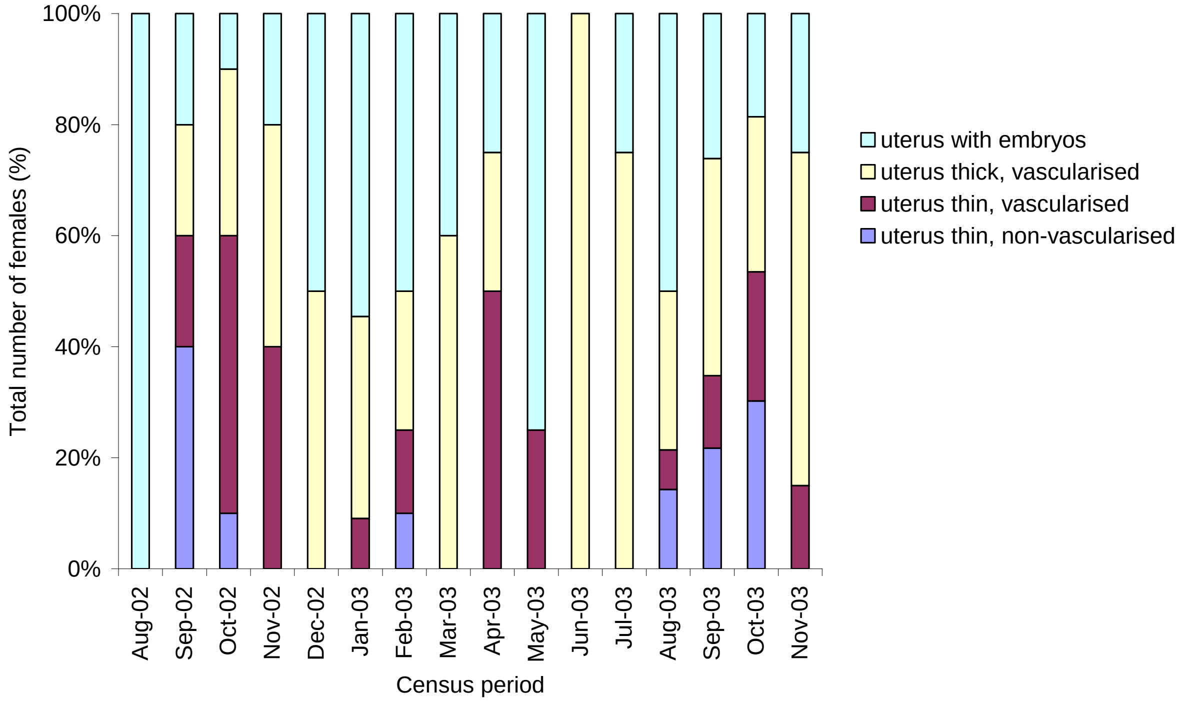


Figure 35. Breeding condition of female *Rattus rattus* captured from all habitats in all villages based on habitat trapping surveys conducted over the period of August 2002 to December 2003

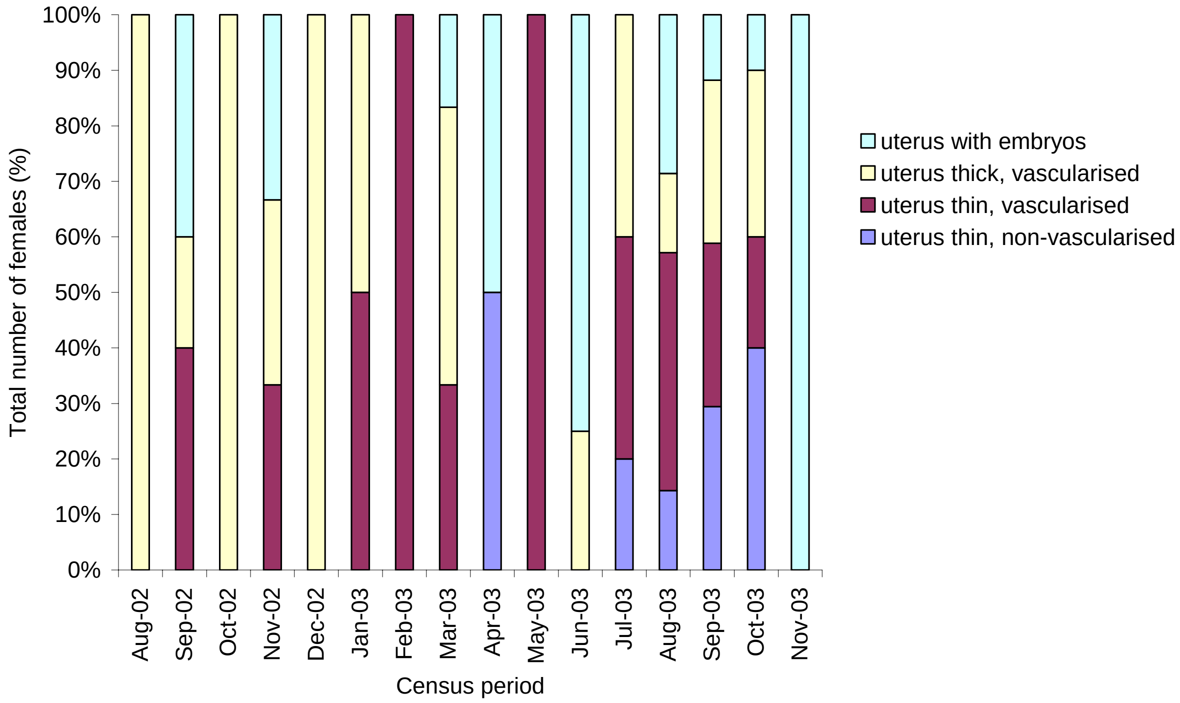


Figure 36. Photograph of the common rice field rat in Bangladesh, *Bandicota benegalensis*

Figure 37. Photograph of *Bandicota indica*, the largest rodent found in Bangladesh

Figure 38. Photograph of *Rattus rattus*

Figure 39. Photograph of the shrew, *Suncus murinus*

Figure 40. Photograph of trap setting for habitat monitoring trials

Figure 41. Photograph of rodent project staff weighing a rodent as part of the taxonomic and breeding measurements taken from captured rodents

Discussion

Results of this trial indicate that rodents are a problem year-round in rural agricultural communities. The proximity of diverse habitats, asynchronous cropping of rice, diversified crops, and the abundance of food, water and harbourage have resulted in encouraging rodent breeding throughout the year for most species. Rodents can easily migrate between the different habitats available to them to find their food and harbourage requirements over an annual cycle and have easy access to houses where they are encouraged by the abundance of shelter and food provided within. Unfortunately the quality of the data set makes it difficult to provide conclusive indicators of rodent populations and breeding rates in different habitats. As all species were caught in all habitats, it can not be certain whether clear differences exist among habitats because of their relative proximity or that there is little rodent behavioural separation or specialisation/exploitation of different habitats. The trial had limited time to run within the project timeframe as the activities had to end in order to free up staff resources and for the data to be used to inform other project activities. In an ideal world the collection of such data would have been carried out over a period of years, allowing interannual variation to be documented and strengthening the data analyses. On its own, these data could not be published in a peer-reviewed journal. However, it is likely that similar data collected from village-wide intensive trapping trials (presented later in this report) could be combined with these data to make more robust conclusions about the rodent populations found in rural agricultural communities.

Post harvest assessment of rodent loss, damage and contamination to rice stored at the household level in rural agricultural communities

Introduction

What happens to food after it is harvested has always been a minority concern by agricultural scientists who have traditionally focussed on increasing crop yields. Although increasing concerns over international food safety have kindled a renaissance within the field of post-harvest microbiology, post-harvest science is usually viewed in developed countries as something for engineers as opposed to ecologists. However, what happens to stored food in a developing country raises a number of researchable problems for ecologists interested in the dynamics of crop damage and loss and how to best mitigate against losses in quantity and quality of stored food and protect a farmer's investment when it is at its highest value. Despite rodents being a well-known problem during the storage of grain, there have been very few attempts to assess the levels of damage that farmers routinely experience. This is certainly because it is technically challenging to design scientifically objective methods to ascertain grain loss caused by rodents under farm store conditions. The scientist either needs to build separate grain stores or somehow work with existing farmers' stores. The first option is expensive and may not provide comparable results to what occurs in farmer stores, whereas the second option may result in untrustworthy data because farm stores are dynamic systems where it is virtually impossible to monitor all inputs and outputs. Our project has devised a method that attempts to address the shortcomings of both options and merge them into one, allowing the scientist to maintain good control over data collection while still using the environment of the farmer store.

Materials and methods

Commonly available baskets made of woven bamboo were purchased from the local market (Figure 42). It was determined that these baskets could hold approximately 8kg of paddy, bringing the level of paddy to within 2-3 cm of the top edge. Farmer consent to place these baskets of grain within their own stores was granted. Farmers promised not to disturb the basket when they removed or added grain to their store so that scientific staff were able to regularly visit the basket to measure loss, damage and contamination caused by rodents. Starting with the *T. Aman* harvest in December 2002 a series of trials were implemented as per Table 14.

Figure 42. Photograph of project staff and farmers collecting data from trials evaluating impact of rodents on stored rice

Table 14. Methodology of trials evaluating impact of rodents on stored rice

Season	Start - End Date	Replicates	Data sampling frequency	Remarks
T. Aman	Dec 2002 to April 2003	10 households per village X 6 villages = 60 replicates	Fortnightly in Comilla, monthly in Feni	Measured from basket and farmer store: Rice moisture content, rodent droppings from 175g sub-sample, rodent hairs from 175 g sub-sample, damaged grains out of 2 X 100 randomly sub-sampled grains Measured from basket only: rice weight loss
T. Aman	Jan 2004 to April 2004	30 households per village X 4 villages = 120 replicates	10 visited fortnightly, 20 visited monthly	Measured from basket and farmer store: rice moisture content, rodent droppings separated for Bandicota, Rattus and Mus from 175 g sub-sample, rodent and insect damaged grains out of 2 X 100 randomly sub-sampled grains Measured from basket only: rice weight loss Farmer storing boiled or unboiled rice noted. Intervention trapping commenced in April 2004 in two villages.
Boro	June 2004 to September 2004	13 households per village with three households storing two baskets (1 boiled, 1 unboiled) X 4 villages = 52 unboiled + 12 boiled replicates	fortnightly	Measured from basket and farmer store: rice moisture content, rodent droppings separated for Bandicota, Rattus and Mus from 175 g sub-sample, rodent and insect damaged grains out of 2 X 100 randomly sub-sampled grains Measured from basket only: rice weight loss Farmer storing boiled or unboiled rice noted. Intervention trapping commenced in April 2004 in two villages.
T. Aman	Dec 2004 to April 2005	6 households per village X 4 villages = 24 replicates	fortnightly	Data outstanding, will measure as above Intervention trapping stopped in December 2004 in one village. Six proofed stores included in dataset.

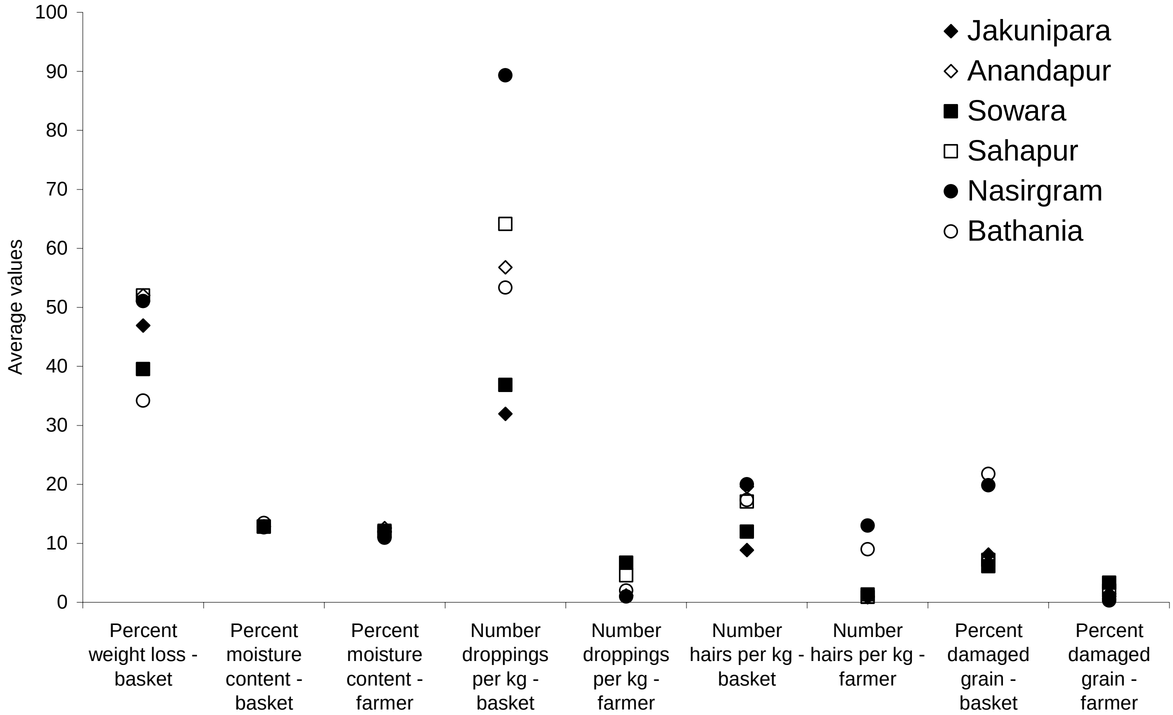
As the above table suggests, the methodology evolved in minor ways to improve data collection efficiency and improve its value and relevancy to answering particular hypotheses. Once it was established that the trial results showed clear levels of rodent loss, damage and contamination, the protocol was used to establish whether it could be determined which rodent species were causing the damage (by the droppings), whether parboiling rice affected levels of rodent damage, loss and contamination, and whether the loss and damage could be explained by insects or changes in moisture content. These trials also showed the methodology to be a useful monitoring method to assess changes in rodent impacts after intervention strategies were introduced. In this regard the trial continued to monitor rodent damage, loss and contamination to stored rice after intensive trapping trials and store modification trials commenced.

Results

Presenting all the data and analyses from these trials would be extensive and demonstrate a degree of redundancy that is really only required for peer-reviewed publication. Therefore, a selection of key findings will be used to demonstrate the worth of the data.

Results of the first trial conducted over the period of December 2002 to April 2003, indicated there were minor differences in levels of rodent damage, loss and contamination among the six villages (Figure 43)

Figure 43. Comparison of parameters among villages and between paddy stored in baskets and the farmer's own store. Values are derived after a 17-week period of storage from 10 household replicates per village.



As expected, weight loss, damage and contamination levels increased over the trial duration, with similar trends among villages and between data collected from the basket and the farmer’s own store as is demonstrated by Figure 44. Statistically significant correlations are repeatedly found in the temporal relationships among the parameters with Pearson coefficients ranging from 0.6 to 0.9, and significant linear regressions can be found for most comparisons as demonstrated by Figure 45.

Figure 44. Mean monthly rates of contamination, damage and loss caused by rodents to baskets of rice (8kg) placed in farmer stores (n=30) in the village of Anandapur

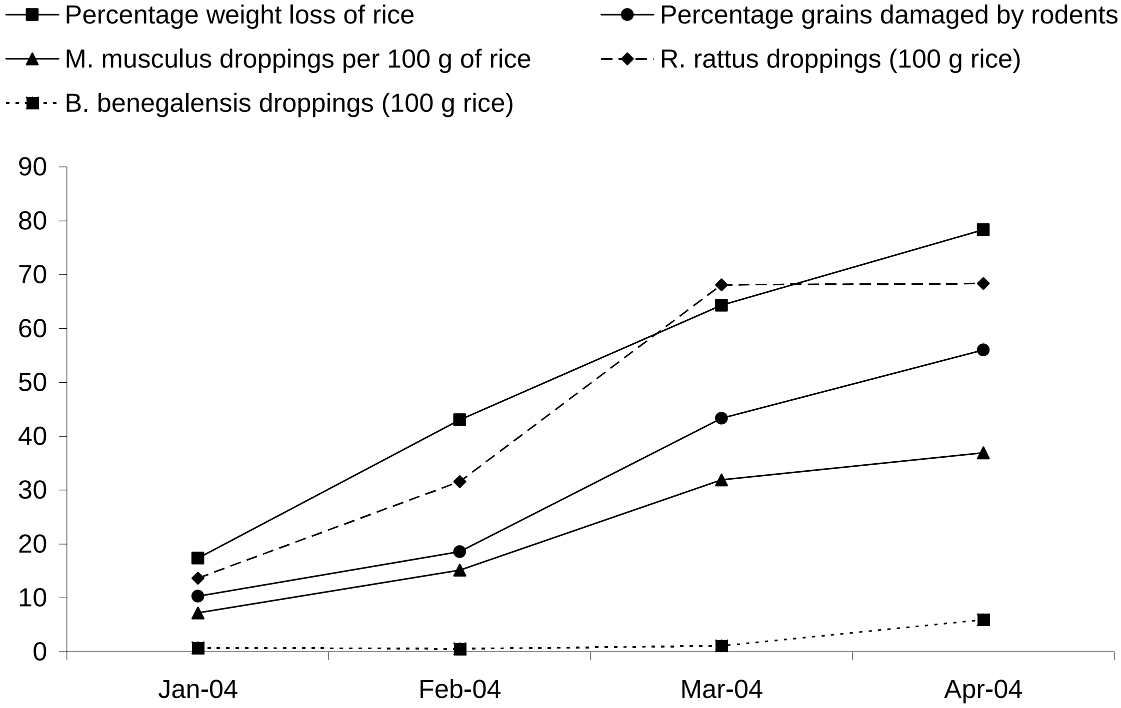
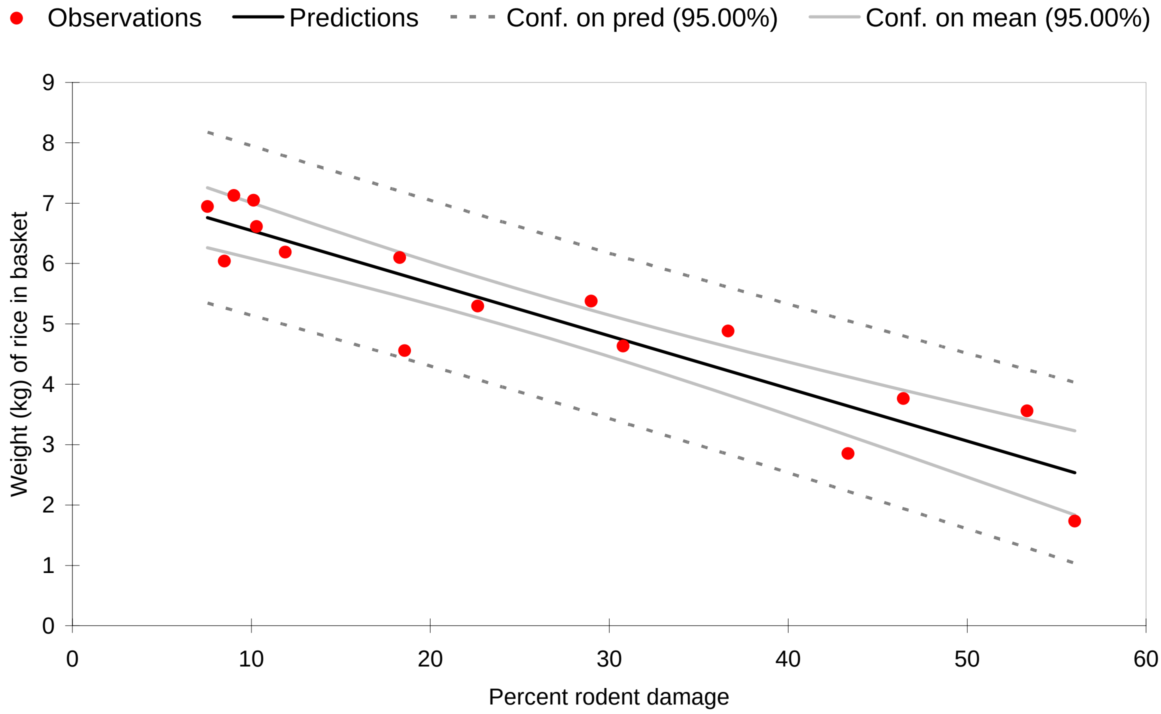
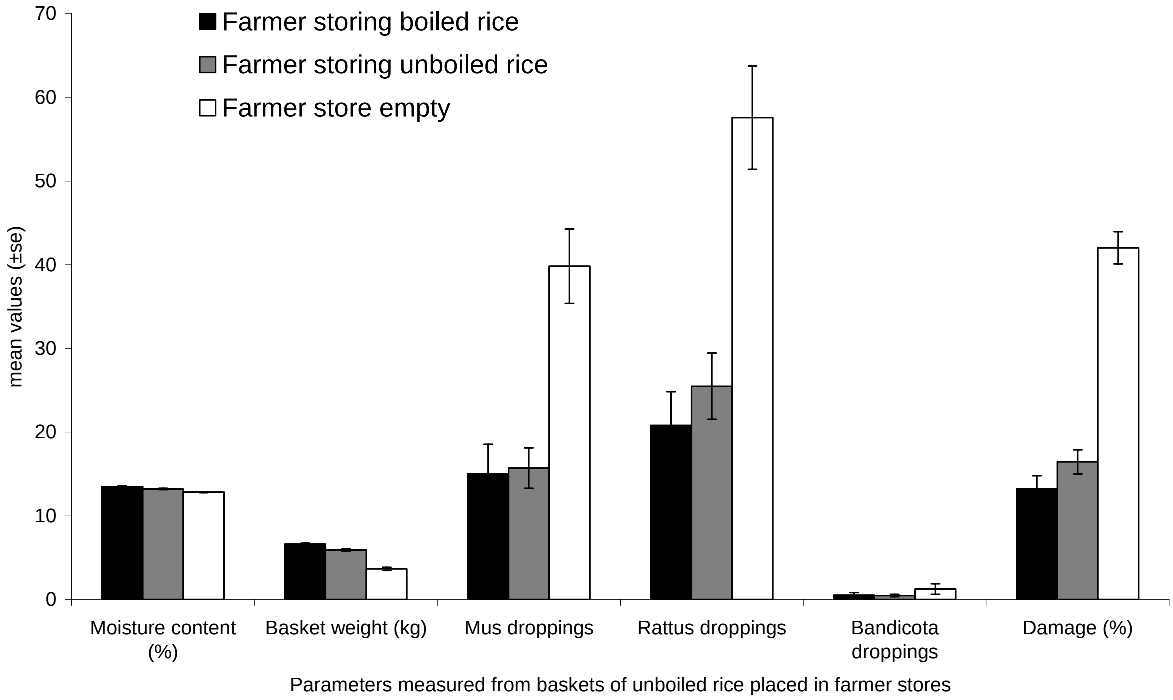


Figure 45. Linear regression of data collected from the mean values of four villages over four months (January to April 2004) comparing temporal changes in rodent damage and weight loss.



The importance of the status of the farmer store, i.e. whether the farmer store was storing parboiled paddy, unboiled paddy or whether the farmer had run out of stored rice was found to significantly affect the levels of loss, damage and contamination experienced to the baskets of paddy (Figure 46). Boiled paddy was marginally less favoured by rodents than unboiled paddy. Once the farmer's own store became empty, losses from the basket dramatically increased. Analysis of variance indicated significant separation between the three potential states with regard to moisture content and weight loss of paddy only (ANOVA, weight loss F = 95.4, df =2, P < 0.0001); damage and contamination parameters were only significantly separated when the farmer store was empty and the farmer store was full (i.e. boiled and unboiled paddy were not significantly different from each other for these parameters).

Figure 46. Effect of farmer store status on rodent damage, loss and contamination to baskets of unboiled paddy placed inside farm stores during the period January to April 2004. 162 samples were taken when store was boiled paddy, 218 samples taken when store was unboiled paddy and 197 samples taken when store was empty



Although weight loss could only be directly measured to the paddy in the basket and not from the farmer store (due to uncontrolled grain movements by the household) rates of damage and contamination occurring in the basket and the farmer store were correlated. As rodent activity is confined to the top surface of the grain bulk, damage and contamination was more diffuse in the farmer store as it would be continually mixed with the larger quantities of grain lying below the surface. Correcting for the different surface/volume ratios between the basket and farm stores significantly improved the correlations of damage and contamination occurring between the baskets and farm stores. This indicated that the rate of loss experienced to paddy in the basket should be comparable to the rate of loss experienced to the farmer store, based on the surface area exposed to rodent activity. This allowed the measurements of grain loss from the basket to be extrapolated to the loss likely to have occurred to the farmer store over the same period. The first step in this process is to calculate the rate of loss to the baskets between sampling intervals (Figure 47). Linear and non-linear regressions indicated that the rate of loss in each of the four villages was relatively constant over each trial (Figure 48). The slight rate increase observed in Figure 48 over the final sampling interval can be attributed to the phenomena described in Figure 46 where farmer stores start to run out of grain, causing increased feeding pressure on the grain in the basket.

Figure 47. Loss rate of rice removed from baskets by rodents between sampling periods in the village of Anandapur. Each data point represents the amount of rice removed by rodents over a two week period.

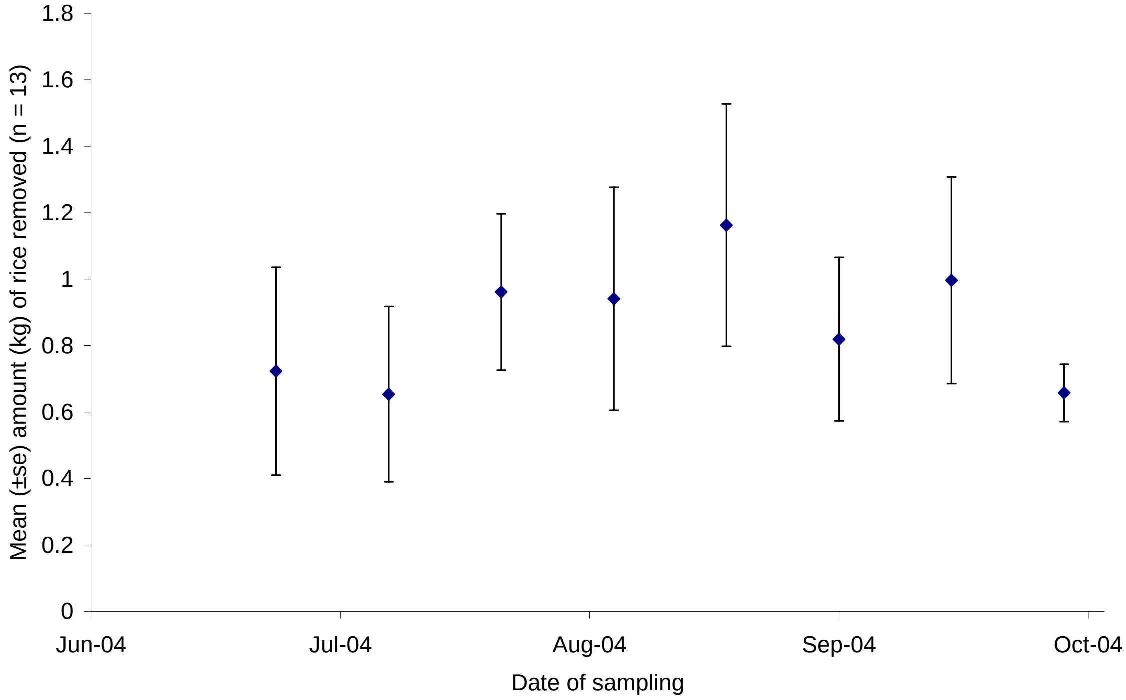
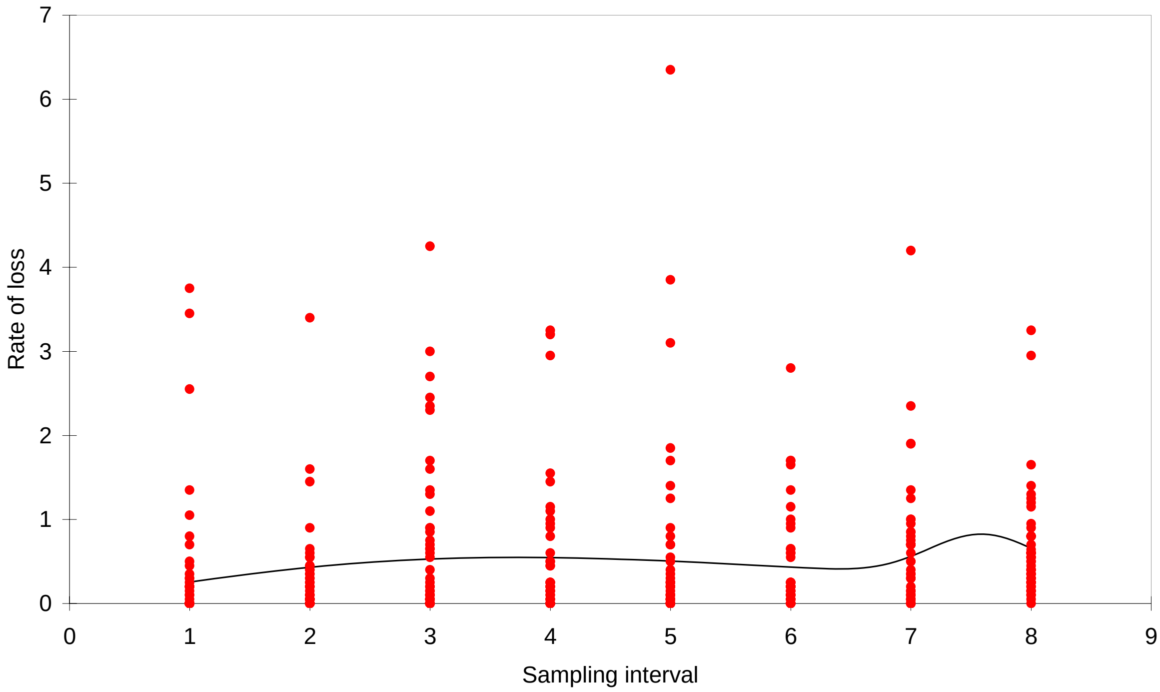


Figure 48. Non-linear regression best fit model to data generated from rate loss data calculated from 64 baskets of paddy stored in household grain stores over four months (June to September 2004)



From this analysis and removal of the last sampling interval, variability of rate loss can be shown to be statistically insignificant, allowing a constant daily rate loss to be calculated for the trial duration. For example, the rate loss experienced by farmers in the village of Anandapur storing rice over the period of June to September 2004 was found to be 61.4 g (±6.7) of rice per day removed from the basket. As this is related to the surface area of rice in the basket exposed to rodents, a 61 g loss is equivalent to 0.042 g/cm^2/day. This unit loss can then be used to estimate the amount of rice lost in the farmer's own store by combining the rate loss constant with the known surface area of each farmer store (Figure 49). This, of course, must assume that rodent feeding pressure from the surface area of the store is uniform and that the rate loss data obtained from the basket is equivalent to the rate loss experienced in the farmer store. These assumptions would be very difficult to verify; nevertheless, we believe them to be reasonable assumptions based on existing knowledge of rodent behaviour and correlations of damage/contamination levels between baskets and farm stores. As the experimental baskets of paddy are placed on top of the paddy in the farmer store (Figure 50), rodents would first need to enter the farmer grain store and then climb into the basket in order to remove grain from the basket. This would imply that the rate loss data from the basket would generally underestimate the rate loss in the farmer store. Hence calculations of farmer store losses will be inexorably conservative estimates.

Figure 49. Estimated amount of rice eaten by rodents from farmer's own grain stores in the village of Anandapur derived from data collected during the storage period of June to September 2004 (n = 13)

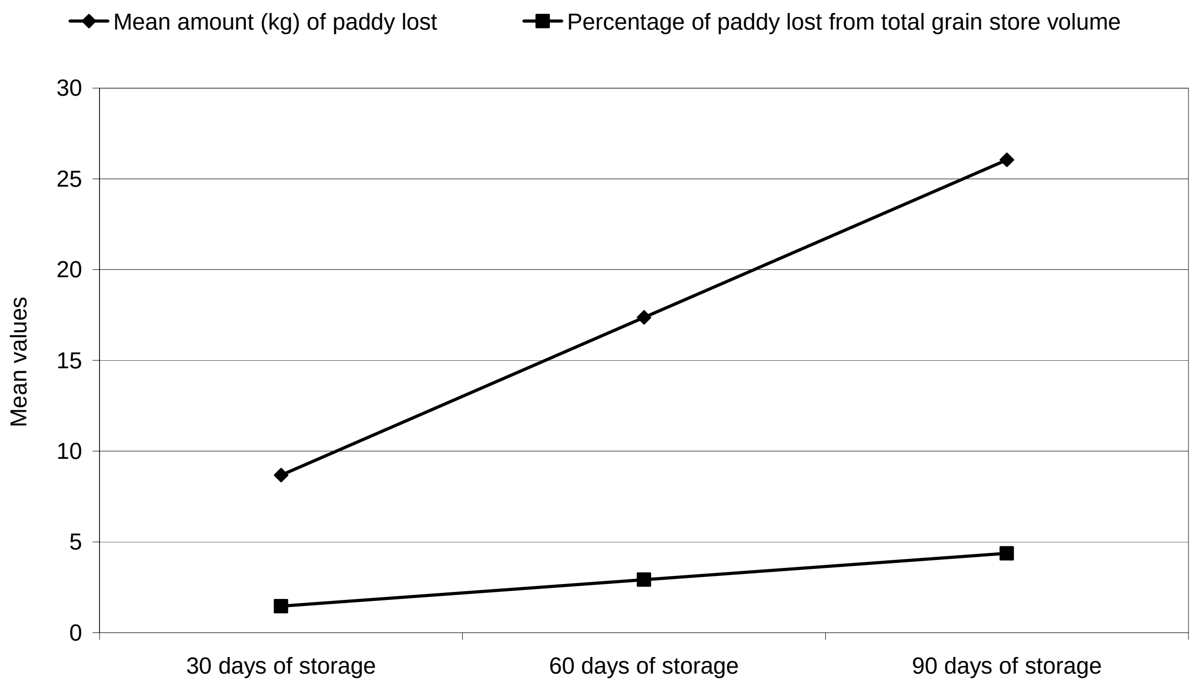


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Figure 50. Photograph showing experimental basket of paddy within a farmer grain store

These experiments proved to be an effective monitoring tool for rodent activity, generating a responsive indicator of rodent population and impact on people's livelihoods. Intervention trials to reduce rodent populations by intensive trapping are described later in this report. The effects of intervention should not only be measured by changes in the rodent population but through their impacts, and the methodology described above for monitoring the effects of rodents on stored paddy provided strong evidence on the effects of the rodent management intervention. As has been previously described, villages were categorised at the outset as treatment (intervention) or control (no intervention), and this allowed the effects of intervention to be measurable through comparison (Figures 51 and 52). Levels of loss in the two treatment villages were similar to the control villages in storage periods before the rodent management intervention commenced. Discriminant analysis and ANOVA of the parameters presented in Figure 51 separated the two treatment villages into a single group with each control village distinct from each other and the treatment villages (Table 15). One can conclude from this analysis that the rodent management intervention has reduced inherent variability among households within the same village in comparison to much larger variability present in non-intervention villages. The benefits of the rodent management, therefore, accrue to all members of a community, but households with the worst rodent problems benefit the most.

Table 15. Fisher (LSD) analysis of the differences between groups with a confidence range of 95.00 %

Categories	Difference	Standardized difference	Critical value	Pr. > Diff	Significant
Jakunipara ~ Anandapur	2.555	14.037	1.965	0.0001	Yes
Jakunipara ~ Sahapur	1.834	10.096	1.965	0.0001	Yes
Jakunipara ~ Sowara	0.236	1.290	1.965	0.198	No
Sowara ~ Anandapur	2.319	12.688	1.965	0.0001	Yes
Sowara ~ Sahapur	1.598	8.761	1.965	0.0001	Yes
Sahapur ~ Anandapur	0.721	3.976	1.965	0.0001	Yes

Figure 51. Comparison in the levels of loss, contamination and damage measured from baskets of stored rice placed in farm stores from June to September 2004 in two villages that have been intensively trapping rodents against two villages that have not been trapping rodents

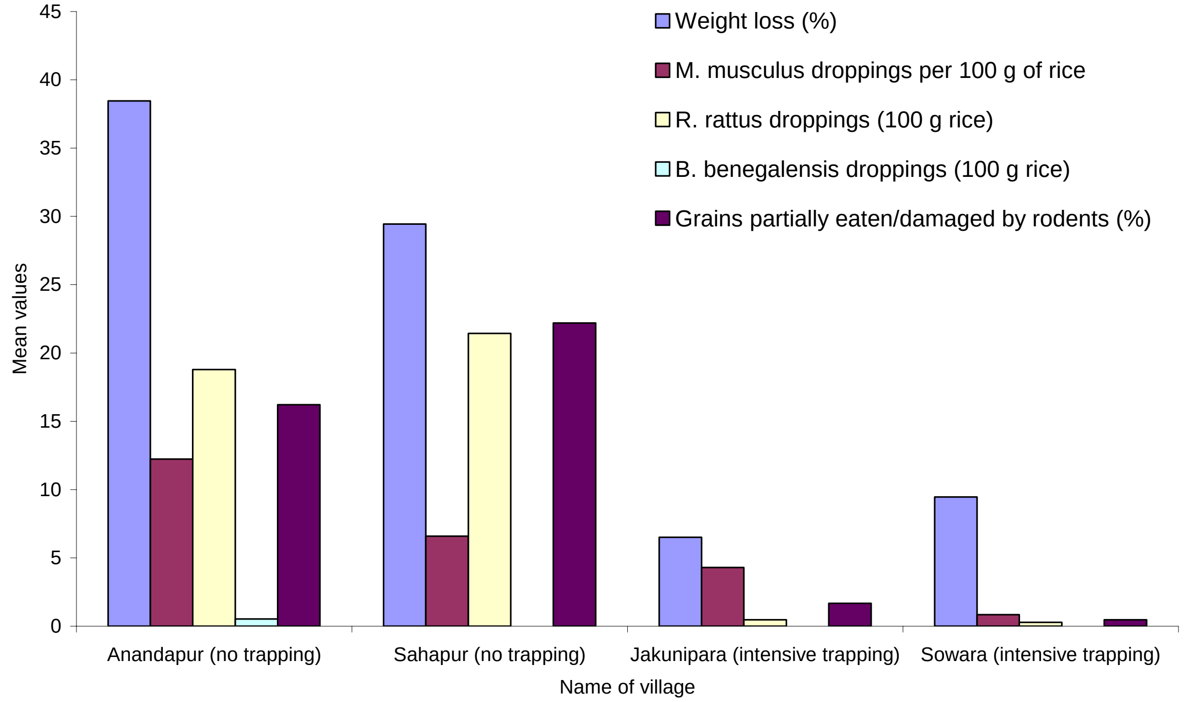
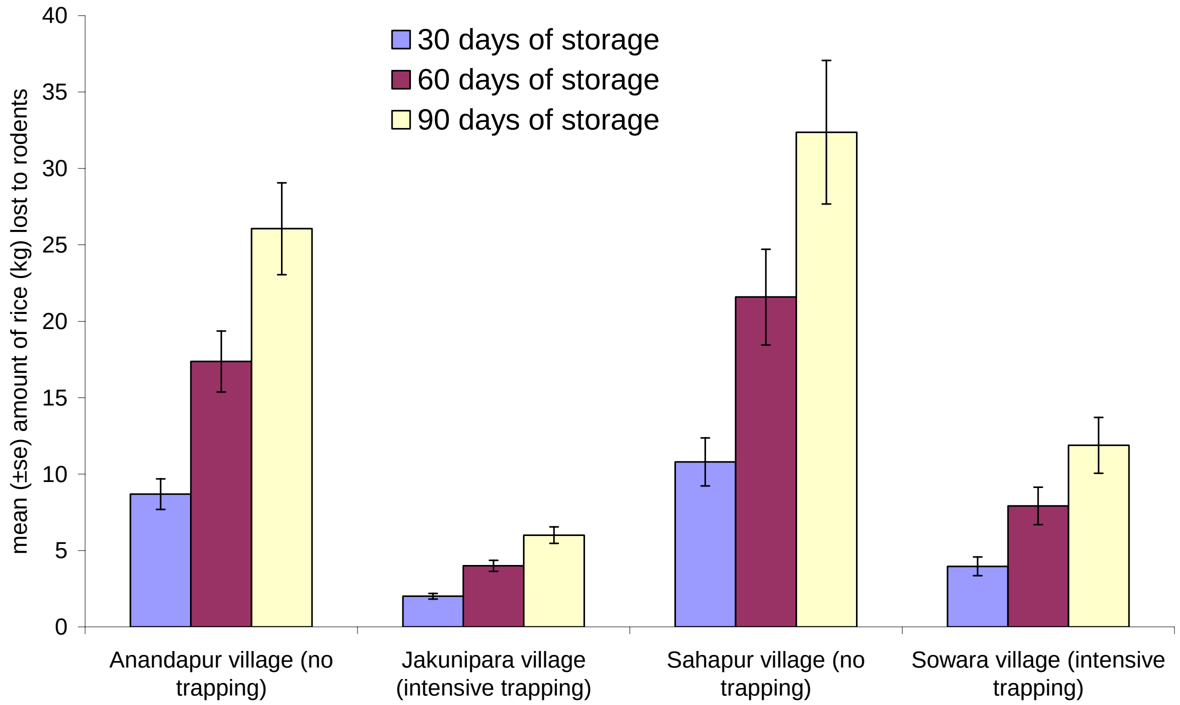


Figure 52. Effect of intensive trapping on the estimated amount of rice eaten by rodents from farmer's own grain stores (n = 13 per village) from June to September 2004 in two villages that have been intensively trapping rodents against two villages that have not been trapping rodents



Discussion

These trials have presented a novel way of assessing rodent impacts on rural agricultural communities. Very little previous quantitative research can be found regarding rodent losses in storage, and it is well accepted that exact post-harvest rodent losses are difficult to assess. Previous research to assess the impact of rodents on stored food has not used a direct form of sampling methodology within a local context. Most previous estimates have been based on a combination of the daily food requirements of a rodent coupled with the potential number of rodents in the food store or through artificial station trials whereby mock stores are built (usually out of their ecological context and storing much smaller quantities of grain). We believe our methodology is significantly more accurate than previous estimates and that it is applicable to many situations where commodities are stored at the small-scale farm level. Our data showed that the intensive trapping was able to reduce the percentage of grain lost by more than 50%. Combining data from households in the two treatment villages indicated that they would, on average, lose 0.8% of their rice to rodents after three months of storage. For households in the two control villages where no intensive trapping occurred, the average loss expected was 3.3% by the end of three months of storage. Families in the treatment villages, therefore, save about 30 kg of rice during the course a normal storage period of four months, or more than 60 kg per year from the combined *Boro* and *T. Aman* crops. These savings would lead to at least an additional two months of rice consumed as their main staple for an adult member of each household. Based on the current prices of rice in Bangladesh (12 Taka per kg of rice), these savings from one year alone (700 Taka for 60 kg of rice) would allow a family to buy more than an adequate supply of rat traps. The cost of an imported trap of the type used in the research trials would be approximately 100 Taka. However, we believe the cost of the traps would be significantly less if they were produced locally. Research on intensive trapping presented later in this report suggests that each household would only need one or two traps if most households in a community trapped together. We can, therefore, conclude that the post-harvest savings alone (ignoring other rodent impacts) can justify and pay for community-wide intensive trapping.

Assessment of rodent damage to rice fields: quantitative and qualitative surveys to determine the phenology of damage, yield loss, and rodent field activity

Introduction

Most previous work on rodent management in Bangladesh has focussed on developing methods for measuring levels of rodent damage to standing crops or methods for estimating yield loss due to rodent damage. Typically, these methods are regarded as a fundamental component of any rodent management project, often providing the only means of measuring the potential impact of rodent management strategies. However, such methods typically are labour intensive. Moreover, they are potentially specific to particular spatial or temporal patterns of damage and hence non-transferable between different cropping systems or rodent pests.

We decided early in our project to take a broader approach to measuring rodent impacts in the Comilla study area, with assessments of stored grain, house structures, household possessions etc. as well as field production. Nevertheless, some measure was required of rodent impacts on rice production under the pre-existing rodent management activities, and some means of assessing whether our final experiment in ecologically-based rodent management was effective at reducing field damage.

Our approach uses a combination of qualitative and quantitative observations on damage and yield loss, encouragement of non-chemical methods of rodent control in the rice cropping areas, and farmer estimates of yields before and after the implementation of rodent management in the field and village environments. In some areas our planned work was compromised by the failure of the MSc student programme to deliver reliable data.

Materials and methods

Our information on rodent damage to rice crops at Comilla comes from the following sources:
1) Farmer group meetings
2) Key informant interviews
3) Direct field observations of damage and rodent activity, including the contents of excavated burrow systems
4) Counts of rodent burrows in selected fields
5) Crop cuts to estimate yields in the same fields
6) Farmer estimates of yields in the same fields.

Methods 4 to 6 were conducted in a total of 21 fields at Jakunipara. These were selected in April 2003 to sample three categories of fields: 1) fields that experience low rodent damage in most years (LOW); 2) fields that experience high rodent damage in most years (HIGH); 3) fields that experience high rodent damage in some years but low damage in others (SOMETIMES). In each field six crop cuts were taken, each of a 2 X 2 m area; two of these were randomly positioned near the edge of the field, two in the central area, and two in areas of high damage. The grain from each crop cut was weighed and a measurement taken of the moisture content. For each field a number of counts were taken of rodent burrow entrances: 1) burrow entrances in the field bunds; 2) burrow entrances in the floor of the field; 3) burrow entrances in all adjacent fields (floors + bunds).

This activity was carried out at Jakunipara in the *T. Aman* season of 2003 and then repeated in *Boro* 2004 and *T. Aman* 2004. For the *T. Aman* season of 2004 one other component was added to the study such that farmers responsible for each field were asked whether their yields from that field were lower, higher or the same as the 2003 *T. Aman*; further, if the yield was different, they were asked what they attributed the difference to. These farmer interviews were also conducted in 21 fields selected by the same criteria in each of the remaining three villages.

Results and Discussion

General observations on rodent ecology and damage

An initial impression of rodent damage to field crops was obtained from the farmer group meetings and field visits with key informants. These sources indicated that rodent damage was usually more severe during the *T. Aman* cropping season than during the *Boro* season. Farmers typically estimated

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their yield loss during the *T. Aman* season at 10-15%. However, they also indicated that damage is of variable intensity between different fields and also between different years.

The early field visits were conducted during the early months of the *Boro* cropping season of 2002. At this time, we observed abundant evidence of rodent activity in the form of burrow systems of *Bandicota benegalensis* around the margins of fields and networks of rodent trackways. However, virtually no damage was observed to growing rice anywhere in the region. On a subsequent visit, during the ripening phase of the *Boro* crop, we saw localized patches of damage in proximity to burrow complexes. However, the overall level of damage was still relatively trivial, confirming the farmers' statements. Similar observations made during the course of the following *T. Aman* season identified diffuse but low level damage during the vegetative stage of rice growth, followed by locally severe damage during the ripening stage, once again associated with burrow complexes of *B. benegalensis*.

From our own observations and previous reports on the biology of *B. benegalensis* we concluded that this species causes little if any damage to rice plants prior to the ripening stage. At this stage, *B. benegalensis* cuts tillers and carries the panicles into its extensive burrow systems to provision storage chambers. Single burrows can contain several kilograms of grain (Figure 53). At times when *B. benegalensis* is not consuming rice, it appears to be feeding predominantly on rice field invertebrates including molluscs and crustaceans, probably supplemented with vegetative matter from weeds and grasses growing on the bunds.

The marked contrast in the level of damage between the *Boro* and *T. Aman* seasons requires explanation. From our observations at Comilla, we suggest that the difference reflects the condition of the fields in each season. In *Boro*, the fields are moist at planting and then become increasingly saturated as rainfall continues through the monsoonal season. Most fields are inundated by the time the crop reaches ripening stage. In contrast, *T. Aman* fields are usually saturated at the time of planting and, unless provided with regular irrigation water, are dry by the onset of ripening.

When the fields are flooded, burrow systems of *B. benegalensis* are confined to the larger and higher field bunds and adjacent upland areas. For the *Boro* season, the fields are flooded at the time when the crop is ripening and this clearly limits the ability of *B. benegalensis* to extend their burrow systems beneath the floor of the fields. However, since *B. benegalensis* is a competent swimmer (and is reported to cause heavy damage to deep water rice) this factor alone does not account for the lack of damage during this season. One possible explanation is that the lack of rice damage reflects the continued availability of aquatic invertebrate food resources through this period (This could be tested by dietary analysis of *B. benegalensis* collected at this time). It is not related to breeding activity which takes place during the maturation and ripening stages of both *Boro* and *T. Aman* cropping seasons as indicated by data elsewhere in this report.

During the final weeks of the *T. Aman* season *B. benegalensis* extends its burrow systems into the floors of the fields, either by tunnelling out from the bunds or by moving into the field to dig a new burrow. These field floor burrow systems are often surrounded by areas in which virtually all tillers are removed from the rice plants. The strong emphasis on ripening grain at this time might be due to a decline in the aquatic invertebrate food resources as the field dries.

Figure 53. Photograph of rice hoard within a rodent burrow

Burrow counts vs. yield estimates

The data collected from 21 fields at Jakunipara at the 2003 *T. Aman* harvest showed a clear distinction between the low and high damaged fields (Table 16). Low damage fields have higher yields, low burrow counts both in the immediate field and in surrounding fields. These fields are typically far (175-250 m) from upland habitat and have uniformly low bunds (Bund Index = 1.5). High damage fields have lower yields and higher burrow counts; these fields are positioned within 120 m of upland habitat and have higher and broader bunds (BI = 3.5). The contrast in burrow counts was especially marked in the case of the field floor and much less striking in the case of the bunds; this supports the general observation that most damage is done in dry fields where *B. benegalensis* is able to extend its burrow systems into the floor habitat. Not surprisingly, fields in the 'sometimes damaged' category spanned almost the full range of values of both of the primary categories.

Table 16. Comparison of rice yield, rodent activity and field location in the village of Jakunipara over two rice growing seasons

Crop season / damage level		crop cut yield (kg / 4 m^2)				total burrow count				nearest upland (m)			
		mean	sdev	min	max	mean	sdev	min	max	mean	sdev	min	max
T. Aman 2003	High	1.25	0.08	0.97	1.52	365.5	151.2	160.0	625.0	58.33	48.34	0.00	120.0
	Sometimes	1.53	0.16	1.25	1.86	162.4	68.68	72.00	248.0	18.33	25.98	0.00	80.00
	Low	1.40	0.06	1.35	1.47	82.33	31.01	34.00	118.0	204.1	24.58	175.0	250.0
T. Aman 2004	High	1.64	0.22	1.40	1.90	89.00	47.34	19.00	152.0	58.33	48.34	0.00	120.0
	Sometimes	1.66	0.32	1.10	2.00	87.67	26.08	62.00	137.0	18.33	25.98	0.00	80.00
	Low	1.46	0.21	1.10	1.80	119.6	25.96	78.00	152.0	204.1	24.58	175.0	250.0

The relationship between rodent burrow counts and crop cut yield was quite strong when the floor burrow count was used either singly or in combination with the bund counts (Figures 54 to 57). However, bund burrow counts alone were a poor predictor of yield, again supporting the notion that it is the condition of the field itself rather than the bunds that is critical in predicting the level of damage. The best correlation was observed when counts from adjacent fields were also included (Figure 58). The 2004 *T. Aman* data did not present any strong correlation between crop cut yields and rodent burrow counts. However, as shall be discussed below, almost all fields produced higher crop cut yields and lower burrow counts than in the previous year. An interesting feature of the 2004 burrow counts was the fact that burrow counts in the bunds were higher in all categories of fields than in the previous year.

Figure 54. Comparison of rodent burrow activity in field bunds with rice yield from 21 fields in the village of Jakunipara for the 2003 *T. Aman* crop.

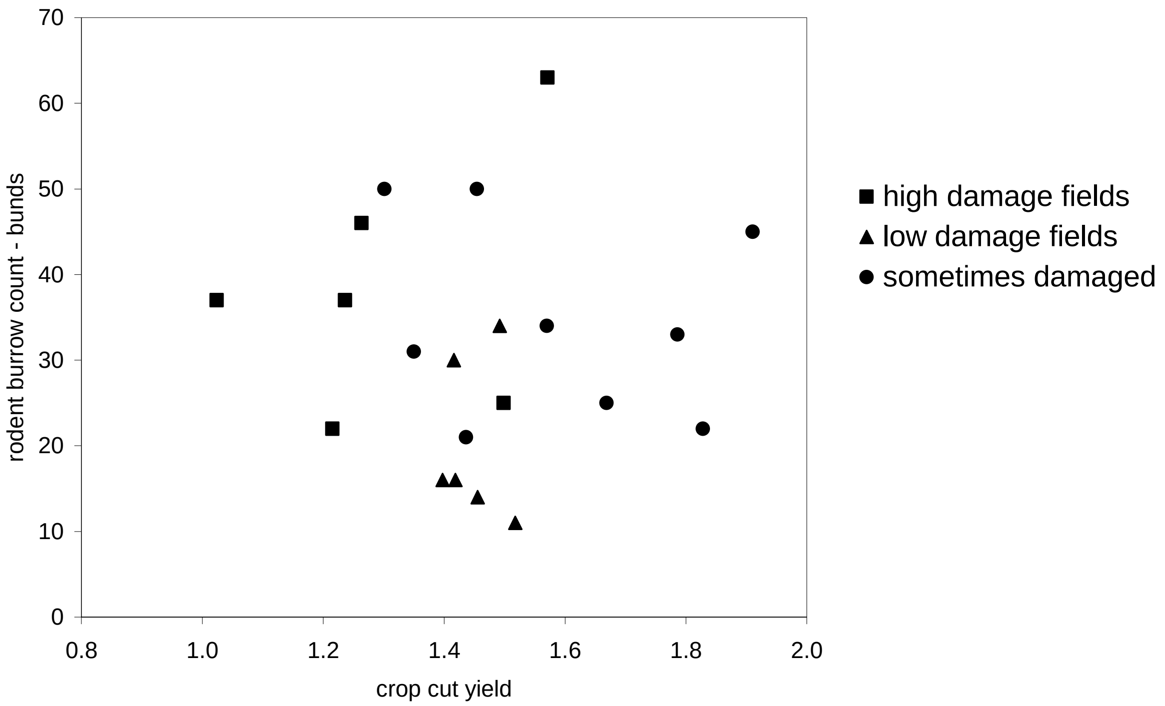


Figure 55. Comparison of rodent burrow activity in field floor with rice yield from 21 fields in the village of Jakunipara for the 2003 *T. Aman* crop.

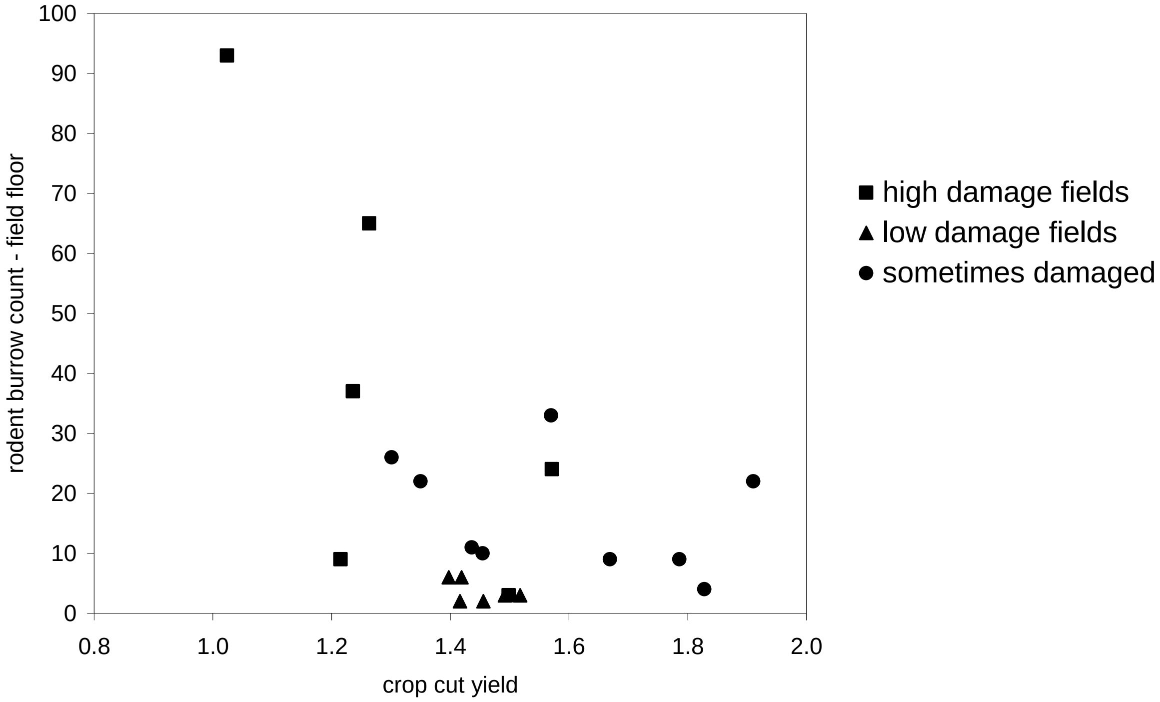


Figure 56. Comparison of rodent burrow activity in field bunds and field floor with rice yield from 21 fields in the village of Jakunipara for the 2003 *T. Aman* crop.

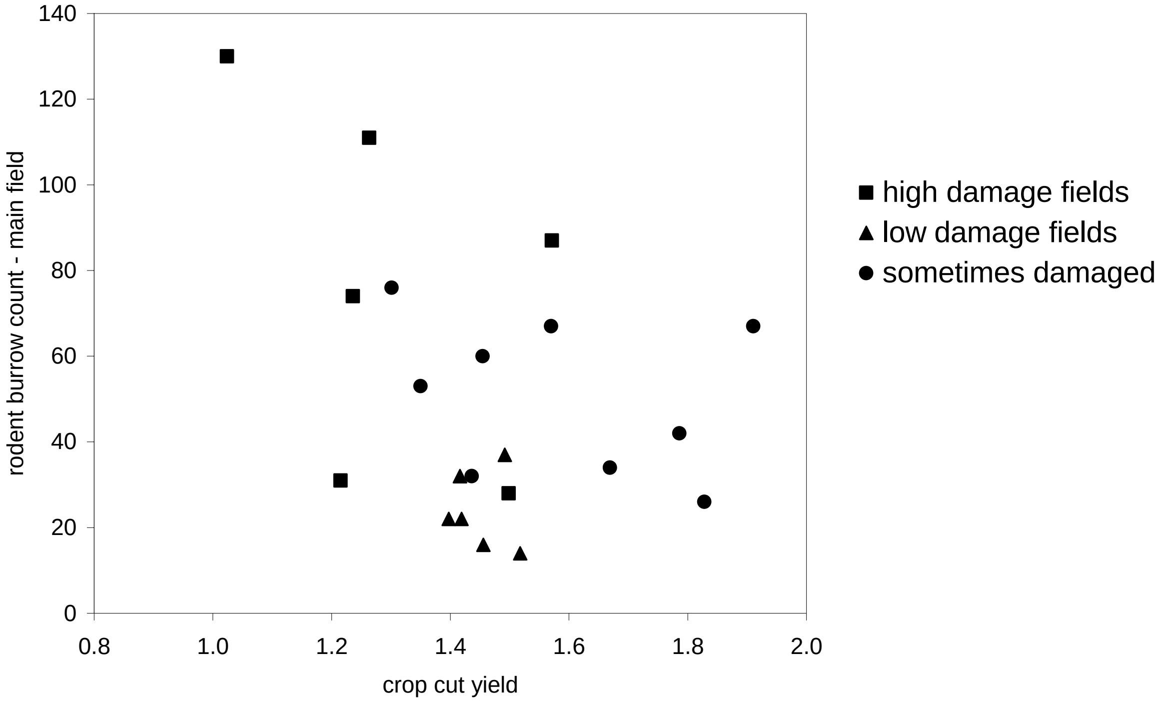


Figure 57. Comparison of rodent burrow activity in field and surrounding fields with rice yield from 21 fields in the village of Jakunipara for the 2003 *T. Aman* crop.

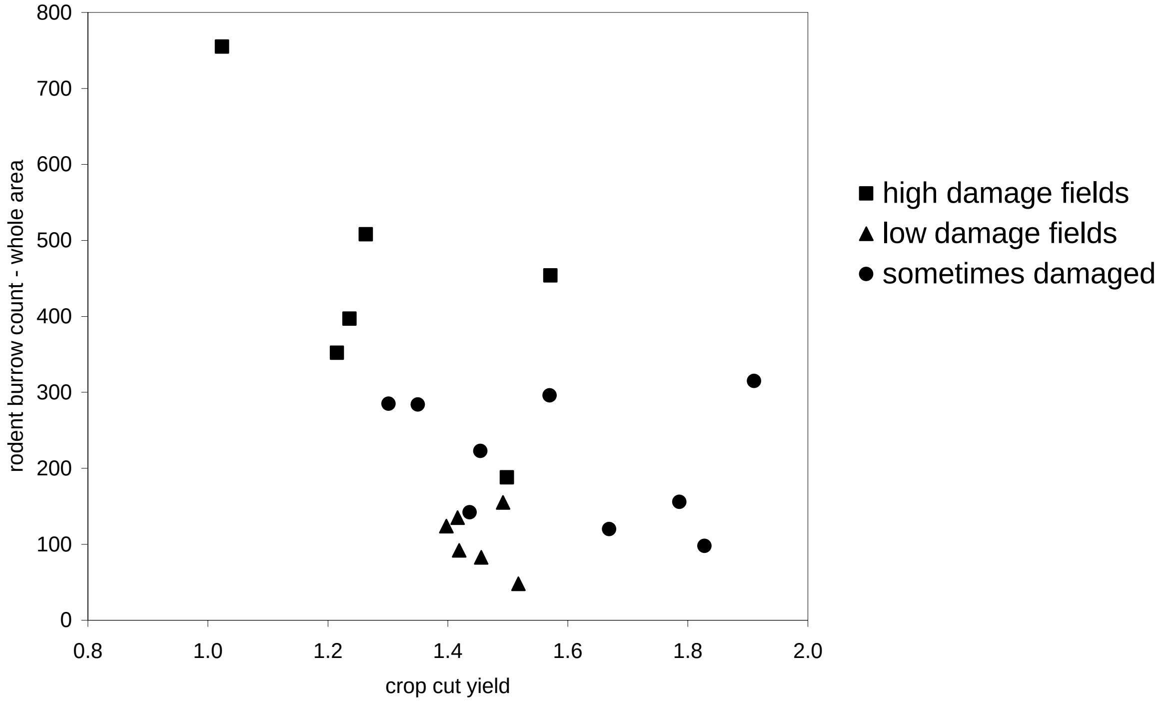
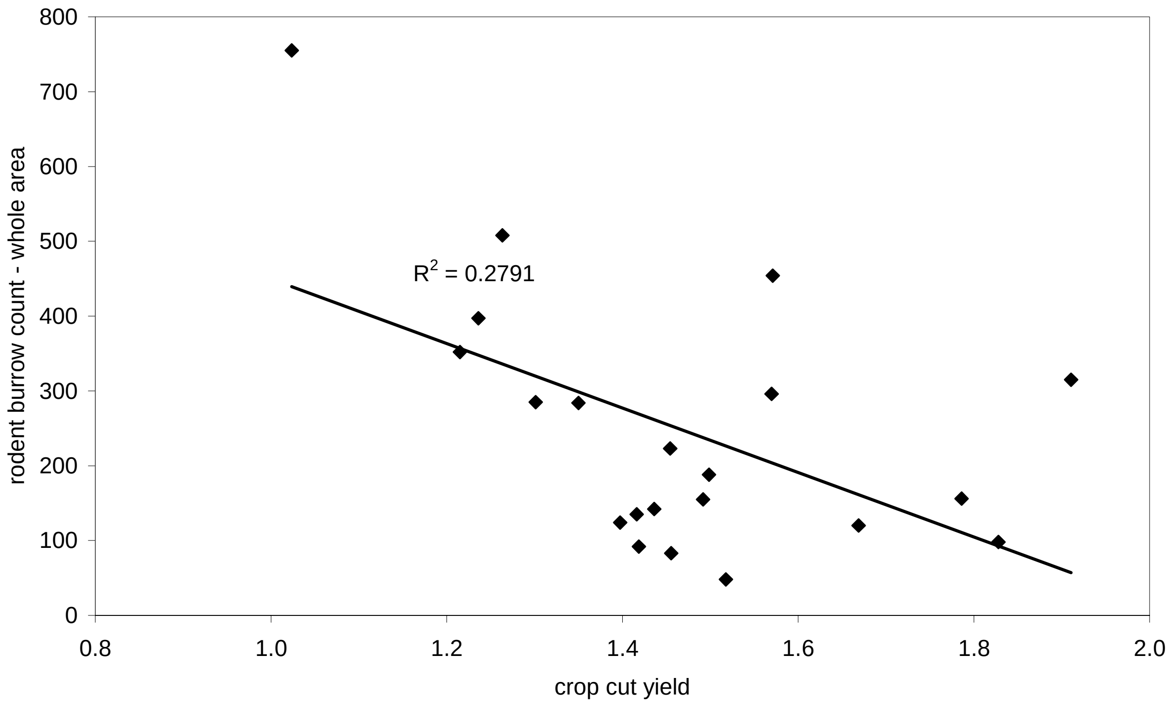


Figure 58. Linear regression between rice yield and rodent burrow activity, using burrow counts from field floor, bunds and all the adjacent fields surrounding the field assessed for the 2003 *T. Aman* crop in the village of Jakunipara



Comparison of T. Aman cropping seasons 2003 vs. 2004

The same fields at Jakunipara were revisited at the end of the *T. Aman* cropping season with two main objectives. The first was to obtain further data on the relationship between yield loss and burrow counts. The second was to facilitate a comparison of crop yields and rodent burrow counts before and after the period of intensive trapping in the village habitat. In particular, we wished to examine whether the demonstrably effective control of rodents in the village habitat might have had spill-over benefits in the surrounding cropping systems. As shown in Table 16, crop cut yields were higher in 2004 in all three categories of fields but only significantly higher in the high damage category. These fields and the 'sometimes damaged' category also showed a significant reduction in the number of rodent burrows where these counts included the field floors (main field and adjacent fields). Essentially, almost all fields were brought down to 'low damage' status in 2004, compared with the extreme variation observed in the previous year.

While it is tempting to get excited about this result, for two reasons we believe that it would be premature to claim this result as a benefit of the village rodent control activities. The first comes from the survey of farmers' estimates of yield (Table 17). In Jakunipara this survey was conducted among the 21 farmers responsible for the crop cut and burrow count fields. Their estimates of whether the 2004 *T. Aman* cropping season had produced more or less rice than the 2003 season were remarkably congruent with our crop cut results, with only one major discrepancy among the 21 participants. However, comparable farmer estimates from fields selected to cover the same range of damage categories in each of the two control villages (Anandapur and Sahapur) also indicated an overall increase in yields in 2004 compared with 2003. Accordingly, we might conclude that the outcome at Jakunipara is due (at least in part) to regional factors rather than any specific treatment applied within the village habitat at Jakunipara (and Sowara). The second reason for caution is that the participating farmers at Jakunipara typically attributed the improved yields in 2004 to climatic factors that provided optimal growing conditions for the *T. Aman* crop. Indeed, only two farmers in this group at Jakunipara mentioned fewer rats as a contributing cause to their improved yield; furthermore, none of the seven farmers who experienced reduced yields in 2004 identified rodents as a contributing factor. The majority of farmers in the other villages also attributed the good yields of 2004 to climatic factors and few gave specific mention to rodents.

Table 17. Summary of farmer comparisons of their rice yields between the 2003 and 2004 *T. Aman* crops

	More in 2004	Same	Less in 2004
Jakunipara			
high	5	0	1
sometimes	6	0	3
low	3	0	3
Sowara			
high	5	1	0
sometimes	7	0	2
low	5	1	0
Sahapur			
high	5	1	0
sometimes	6	0	3
low	3	1	2
Anandapur			
high	5	0	1
sometimes	7	1	1
low	3	1	2

Our interpretation of the results from the 2004 *T. Aman* is that the favourable pattern of rainfall maintained high water levels in those fields that usually dry late in the season, thereby protecting these fields against the usual pattern of damage by *B. benegalensis*. This interpretation of events is supported by the fact that a higher number of burrows were present in the field bunds than in the previous year, despite the overall lower counts.

Assessment of the village environment and how it can be changed to reduce rodent pest problems

Introduction

An important premise of the overarching design of the project methodology, which was to compare villages where interventions would occur with villages where no interventions would occur, is that the general environment and living conditions were similar among the treatment-control pairings of villages. Observations and site surveys carried out at the beginning when villages were selected suggested that villages were comparable in many ways. Once data started to come in from various activities related to measuring rodent populations and their damage, variability and trends among villages emerged. It, therefore, became necessary to make more quantitative assessments of the environment that could perhaps explain the observed differences, e.g. to variable rates of rodent damage, or different proportions of rodent species present. This was achieved by measuring a number of parameters, both objective and subjective, that could be quantitatively analysed.

Although many rodent management interventions focus on killing rodents (traps or poisons), modifications to the environment can be more sustainable by permanently reducing the carrying capacity of the environment to sustain large numbers of rodents. This is largely achieved by reducing rodent access to food, water and harbourage. Although it is possible to reduce rodent access to human drinking water to prevent disease transmission, it is not possible to reduce rodent access to plentiful water sources in Bangladesh as a means of controlling the rodent population. However, there was potential to reduce rodent access to food and harbourage sites in rural agricultural villages, through proofing, better waste management, improved hygiene, and general tidiness. As rice is stored inside human living areas and is generally not well protected against rodents, it was clear that reducing rodent access to people's homes and the food store itself would have major benefits to people's livelihoods by reducing disease risks and preventing food loss. Other aspects of the environment from which rodents were likely to benefit were also targeted.

Materials and methods

Environmental parameters

A number of features were found that could be variable regarding the physical environment, such as the materials used to construct houses, or the relative density of houses (Table 18). Although it was likely that some of these features would affect the movements of rodents and their success in finding food and harbourage, it was unknown which features could be considered more important. The parameters indicated in Table 18 were taken from 30 households in each of the four villages: Jakunipara, Sowara, Anandapur and Sahapur, to determine potential similarities / dissimilarities among the villages, particularly with regard to treatment – control pairings. Although some of these features could be simply measured, others such as hygiene required subjective assessment, and it was therefore necessary to create indices that could be applied for assessment (Table 19). Potential variation was reduced by having the same person make all the subjective assessments.

Table 18. Description of quantitative environmental factors measured for 30 households in each of four villages

Parameter measured	Methodology
number of rice stores in house	Numeric
height of rice store (cm)	Numeric
diameter or width of rice store (cm)	Numeric
length of rice store (cm)	Numeric
Roof material	Codified for different materials and combinations
Percentage cover of roof	Subjective observation
Wall material	Codified for different materials and combinations
Distance between wall and rice store	Numeric
Floor material	Codified for different materials and combinations
Rice store material	Codified for different materials and combinations
Rice store platform material	Codified for different materials and combinations
Additional use of store	Codified for different activities, e.g. sleeping, cooking
Inside hygiene index	Subjective categorisation into six categories
Nearest house	Measured for the three nearest houses
Nearest cattle	Measured for the three nearest cattle
Nearest haystack	Measured for the three nearest haystacks
Number of standing water bodies within 50m	Numeric
Number of coconut trees within 20m	Numeric
Number of cropping areas within 50m	Numeric
Outside hygiene index within 5m	Subjective categorisation into six categories

Table 19. Categories of hygiene used to assess village households, both internally and externally

Category	Inside hygiene index	Outside hygiene index (within 5 m of the building)
1	Very, very untidy and badly maintained. Full of materials that provide cover for rodents. About as badly maintained as is possible.	Very poor conditions ideal for rodents. Plentiful cover, harbourage, and possibly food and water and little or no disturbance. About as bad as it gets!
2	Very untidy and much additional stored material but could be worse.	Poor conditions but providing slightly less ideal conditions than category 1 for rodent infestation. Could be worse but not much!
3	Worse than average, but not by a great deal.	Poor conditions but only slightly worse than average conditions
4	Just better than average. Reasonably tidy and well maintained.	Slightly better than average! Some cover and opportunities for rodents but not much.
5	Significantly better than average and quite tidy, but there remain some aspects that could be improved.	Fairly good environmental conditions here, tidy and clean, but could still be slightly better!
6	Very, very tidy and clean store. No improvements to be made here.	Excellent hygiene providing no opportunities for rodent populations to live! Very tidy and clean and open.

Demonstration of environmental management

A number of factors were identified in villages that were observed to promote rodent access to food and provide harbourage in rural agricultural villages. Improving hygiene can be one of the simplest and most effective tools to reduce rodent activity by removing waste sources that can act both as food supplies and harbourage areas for rodents. Animal fodder in the shape of large haystacks are found throughout Bangladeshi villages, and these have been shown to provide excellent harbourage for rodents (Figures 59 and 60). The stabling of livestock near houses also promotes plenty of food and dirt that can be exploited by rodents. There is often much clutter inside houses, particularly in roof voids, that give rodents plenty of places to seek refuge and even to take up permanent residence. Because of the number of issues that could be addressed, it was proposed to demonstrate “ideal situations” whereby households would volunteer for “makeovers” that could be used to show how the environment can be improved. Six household “makeovers” were carried out, two in the village of Sowara and four in the village of Jakunipara. The activities which took place at each demonstration site involved the following: 1) Clean and tidy houses, inside and out; 2) Proof / repair houses, particularly under doors and eaves; 3) Proof rice stores, from below and above; 4) Proof haystacks; 5) Proof coconut trees.

Figure 59. Photograph of haystack commonly used for animal fodder and widely found throughout Bangladesh villages

Figure 60. Photograph of the base of a dismantled haystack showing well-established rodent burrows at the bottom of the haystack.

Results

Environmental parameters

The four villages were found to be very similar to each other as shown through a correlation matrix of all the environmental parameters collected (Table 20). Pearson correlations are 0.98 and above among all the villages, indicating that the village environment is highly similar for those parameters measured.

Table 20. Comparison of the numeric and codified values obtained for environmental parameters measured in four different villages.

Pearson correlation coefficient matrix

	Anandapur	Jakunipara	Sahapur	Sowara
Anandapur	1.000	**0.989**	**0.995**	**0.998**
Jakunipara	**0.989**	1.000	**0.985**	**0.990**
Sahapur	**0.995**	**0.985**	1.000	**0.997**
Sowara	**0.998**	**0.990**	**0.997**	1.000

In bold, significant values (except diagonal) at the level of significance alpha=0.050 (two-tailed test)

Although marginal, there were a few environmental parameters when assessed on their own which were significantly variable across the villages when analysed by Kruskal-Wallis tests. Those parameters that significantly varied across the villages were: the rice store volume, the floor material, number of nearest cattle, proximity of water, number of coconut trees nearby and external hygiene. However, these factors were borderline significant (P = 0.02 – 0.04), and it is perhaps wise not to read too much into these results as the mean values are relatively similar. Correlations among environmental parameters were generally very weak or non-existent (Table 21). As the coefficients are quite low in Table 21, it would perhaps be wrong to try to suggest strong relationships exist. However, significant correlations do make environmental sense in most cases. For example, increasing house distance is positively correlated with the number of cropping areas nearby, i.e. the further houses are apart from each other, the more crops are nearby.

Table 21. Comparison of the relationships between environmental parameters collected in four different villages.

Pearson correlation coefficient matrix

	# rice stores	volume of rice store	% cover of roof	distance between wall and rice store	house distance	cattle distance	heap distance	standing water within 50m	coconut trees within 20m	crops within 50m	additional use of store	inside hygiene	outside hygiene within 5m
# rice stores	1.000	-0.058	0.006	-0.045	0.109	**0.185**	0.133	0.154	-0.131	-0.015	0.031	-0.155	0.138
Volume of rice store	-0.058	1.000	-0.128	-0.057	0.024	0.053	**-0.224**	**-0.231**	0.071	-0.090	-0.038	-0.006	0.008
% cover of roof	0.006	-0.128	1.000	0.072	0.043	0.090	-0.050	-0.002	-0.052	0.048	-0.065	0.175	0.160
Distance between wall and rice store	-0.045	-0.057	0.072	1.000	-0.133	0.066	-0.017	-0.009	-0.047	0.020	**0.328**	-0.012	-0.167
house distance	0.109	0.024	0.043	-0.133	1.000	0.155	-0.129	0.089	-0.061	**0.373**	-0.172	-0.063	0.031
cattle distance	**0.185**	0.053	0.090	0.066	0.155	1.000	**0.283**	0.075	-0.063	**0.224**	-0.105	-0.165	**0.241**
heap distance	0.133	**-0.224**	-0.050	-0.017	-0.129	**0.283**	1.000	-0.008	**-0.185**	-0.040	**-0.251**	-0.035	**0.191**
Standing water within 50m	0.154	**-0.231**	-0.002	-0.009	0.089	0.075	-0.008	1.000	-0.051	0.044	-0.106	**-0.197**	0.056
coconut trees within 20m	-0.131	0.071	-0.052	-0.047	-0.061	-0.063	**-0.185**	-0.051	1.000	-0.046	0.153	**0.183**	0.011
crops within 50m	-0.015	-0.090	0.048	0.020	**0.373**	**0.224**	-0.040	0.044	-0.046	1.000	0.097	0.088	0.008
Additional use of store	0.031	-0.038	-0.065	**0.328**	-0.172	-0.105	**-0.251**	-0.106	0.153	0.097	1.000	-0.004	-0.063
Inside hygiene	-0.155	-0.006	0.175	-0.012	-0.063	-0.165	-0.035	**-0.197**	**0.183**	0.088	-0.004	1.000	**0.219**
Outside hygiene within 5m	0.138	0.008	0.160	-0.167	0.031	**0.241**	**0.191**	0.056	0.011	0.008	-0.063	**0.219**	1.000

In bold, significant values (except diagonal) at the level of significance alpha=0.050 (two-tailed test)

Although the data suggest the four villages are comparatively very similar environments, the parameters could also be used to interpret the results of other trials. Comparative analysis between this environmental data set and the data from the trial on rodent damage, loss and contamination for stored rice presented some significant and biologically relevant correlations. One interesting correlation was between the distance between the house wall and the rice store with the level of contamination with *Mus musculus* droppings (Linear regression, $F = 7.04$, $P = 0.009$). Rice stores that were relatively further away from the house wall were less likely to contain *Mus* droppings. No similar correlations existed for *Rattus* or *Bandicota* droppings found in the store. As their small size would prevent mice jumping larger distances, this indicates there is scope to reposition rice stores further away from walls to reduce access by mice. Whether this is a realistic option for most farmers is, of course, debatable. Another interesting correlation was that *Bandicota* contamination in rice stores was positively related to the number of water bodies nearby. This could be interpreted as suggesting *Bandicota* are indeed living in the fields, ponds and external environments, while foraging in villages but not actually strongly resident in villages. This would lead to the conclusion that houses near the edge of the village and / or near bodies of water are more likely to have problems with *Bandicota* in their houses.

Demonstration of environmental management

There were few difficulties in recruiting households to volunteer to act as demonstration sites. The households that were chosen were spread around the villages so that neighbours would be able to observe what was happening. Working with the project team, areas of general clutter and poor hygiene were identified in and around each homestead, and the household worked on its own initiative to the instructions given. This usually involved clearing up piles of rubbish, removing or tidying materials stored in the roof, improving drainage where standing water accumulates, and reinforcing accepted practices such as sweeping and cleaning particularly with regard to faecal and food waste generated by livestock and children in the homestead courtyard. Repairs to household structures that would make it more difficult for rodents to gain entry were also undertaken. Together with the project team modifications were carried out to the household rice store and to their haystacks (Figures 61 and 62). Expenses related to the purchase of bamboo and tin for the modifications were borne by the project. Coconut trees and/or other fruit trees attacked by rodents were proofed with pieces of tin (Figures 63 and 64). Feedback from the households was very positive to these activities, and there were no complaints or difficulties in making the changes. Discrete data showing the impact of the demonstration trials is currently being collected, with the results expected to be reported in the final report of the current extension to this project. These activities involve: 1) monitoring the proofed stores for rodent loss, damage and contamination in comparison to unproofed stores using the same methodologies reported earlier in this report; 2) disassembling a set of proofed and unproofed haystacks to count the number of rodents living, where the haystacks had been previously constructed at the same time; 3) monitoring the uptake of the technology throughout the villages. With regard to monitoring uptake, we have seen that a number of households have already made their own haystack platforms. Those made by other farmers differ from those demonstrated by having no tin baffles on the legs, but are otherwise similar. As tin must be purchased and formed into the baffles, the cost could impact on their uptake, particularly by the poorest farmers. We expect the baffles are important to prevent rodent access, but further trials are not planned to evaluate their effect compared to platforms with no baffles.

Figure 61. Photographs showing two different types of modified rice store. The modifications shown are placing the farmer's rice store on a platform made of bamboo where each leg is proofed with a tin baffle. A cover is made from tin to place on top of the rice store, sufficiently overhanging to prevent rodents from entering the rice store.

Figure 62. Photographs of proofed haystacks. The baffles on the legs make it difficult for rodents to climb up into the haystack from the ground. Smaller animals such as poultry and goats often seek shelter underneath which is seen as an additional benefit by villagers.

Figure 63. Photograph of rat-damaged coconuts to an unproofed tree

Figure 64. Photograph showing a coconut tree that has been proofed against rodents with a band of tin. The tin is simply wrapped around and nailed to the tree and prevents rodents climbing up the tree.

Discussion

The environmental conditions are comparable in each village with regard to housing density, number of livestock, haystacks, etc. Variability of household structures is apparent, but the analysis shows that the same levels of variability are present in all the villages. It is, therefore, justified to compare between villages before and after interventions as well between villages where interventions occurred with villages where no interventions occurred. Some variable features of the environment (e.g. rice store location relative to internal walls) appeared to have some correlation with the measurement of rodent damage and impact. It was disappointing that relatively few correlations between the environment and rodent damage could be observed within the data set. However, the absence of correlations could be explained by a combination of relatively homogenous environmental parameters and/or insufficient replication of complex habitats. There is certainly merit in pursuing further research to establish correlations between rodent damage and the environment, particularly when coupled with environmental changes proposed as rodent management interventions.

The demonstration to villagers of potential interventions they can make to reduce the impact of rodents on their lives can largely be considered a success if the changes are increasingly adopted by other villagers. Although it is still too early to say whether the changes to stores and haystacks will spread through the community, the preliminary feedback is positive, and some farmers are taking the initiative to make changes on their own, both through proofing and improving hygiene. It is planned to monitor the uptake of these changes during the project extension. It is also necessary to demonstrate that these modifications are indeed beneficial. This has not been directly quantified and presented in this report, and further research is required to evaluate the benefits of changing haystacks and rice store structures. The impacts of the changes with regard to rodent utilisation will be measured and presented in the final report related to the extension phase of the project.

Assessment of community trap barrier systems and linear trap barrier systems in Bangladesh

Introduction

Trap barrier systems consist of some kind of fence or barricade with traps set on gaps at intervals along the barrier. Animals intersect the fence during their movements and pass through the gaps to enter the traps. Multiple capture traps are often used in these systems. Linear trap barrier systems (LTBS) are usually placed perpendicular to an inferred or observed direction of movement (e.g. nightly movements in and out of a cropping area; seasonal movements between habitats). Community trap barrier systems (CTBS) are constructed to fully enclose a 'lure crop' that serves to draw animals towards the CTBS and into the traps. The latter was formerly called 'Trap barrier system with trap crop' but was later relabelled CTBS to emphasize the fact that the system is beneficial for communities of farmers rather than individual farmers and requires community participation to be most effective. Anthropological and sociological studies have emphasized the importance of various social factors in the successful implementation of CTBS.

The CTBS method has been studied most intensively in lowland irrigated rice cropping systems in Southeast Asia (including Indonesia, Vietnam, Cambodia, Philippines, Malaysia) and it is currently under investigation in rainfed rice cropping systems in Myanmar. In Southeast Asia the principal rodent pest is the Ricefield Rat (*Rattus argentiventer*), a terrestrial but non-fossorial species that readily enters flooded fields and breeds in direct response to the growth stage of the rice crop (commencing at maximum tillering stage). Few details are yet available on the implementation of CTBS in areas where other rodent species (e.g. *Rattus rattus*, *Bandicota* spp.) are the principal agricultural pests.

We tested the utility of LTBS in each of the two treatment villages, selecting sites that might intersect regular or seasonal movement of rodents between areas of harbourage and field crops. The LTBS were also likely to provide useful ancillary information on the timing of breeding of the main field pests. We decided against large scale testing of the CTBS method in the Bangladesh study for two reasons. First, the early interactions with farmers suggested that rodent problems were most severe in the village habitat rather than in the rice fields. And second, previous ecological studies (and local farmer knowledge) on one of the major field pests (*Bandicota benegalensis*) makes it an unlikely candidate for control by this method. Specifically, it is known to breed in response to the ripening of grain and to be highly fossorial and thus capable of digging beneath any practical barrier. In addition, the rice cropping system at Comilla typically involves a mosaic of different planting times and maturation varieties, both of which are likely to compromise the effectiveness of CTBS implementation in any context.

Despite these reservations, we erected one CTBS in each of the two treatment villages to 1) examine the temporal pattern of captures of the main field pests (*R. rattus* and *B. benegalensis*), and 2) investigate the pattern of damage to the CTBS structure and trap crop by these species.

Materials and methods

In each village we constructed one CTBS and three LTBS in each of the two main rice growing seasons in 2004 (*Boro* and *T. Aman*). The LTBS were placed along the margins of rice cropping areas where these abutted against village habitat (2 per village) or upland vegetable fields (1 per village). The CTBS were constructed around existing rectangular field plots and positioned centrally in large areas of rice fields but close to areas of high rodent activity (e.g. upland habitat). They varied in size and shape but averaged around c. 75 X 75 m. We selected fields that were to be planted with fast maturing rice to optimize the 'lure' effect. The same or adjacent fields were used for the two cropping seasons.

The CTBS and LTBS barriers were constructed from bamboo stakes, medium density opaque plastic sheeting and a continuous strand of thin wire to suspend the top of the plastic. The plastic was nailed to the bamboo stakes and stapled around the wire. The plastic was buried in a trench dug to a depth of c. 40 cm and stood to heights of 50-75 cm above ground. Because of the 'micro-terraced' nature of the field systems it was not possible to construct a 'moat' around the CTBS fence. Single cone multiple capture traps were held in place by bamboo stakes. CTBS units had 8 traps (2 per side). TBS had from 9-14 traps, depending on the length of fence. Traps were set to open in both directions, alternate traps facing towards the rice field and the village or upland habitat.

In each village, one local resident was employed to maintain the TBS units and to record the captures. The TBS monitors were Md. Anwar Hossain (*Boro*) and Mr Atikulha (*T. Aman*) in Jakunipara and Mrs Roksana (both seasons) in Sowara. The village staff were trained in the handling and disposal of captured animals, rodent species identification and assessment of reproductive status, and data recording. Their activities were monitored on a regular basis by members of the project team. The trap number was recorded for each capture to provide a measure of directionality of movement.

Any decision to conduct crop damage assessment in relations to the CTBS and LTBS trials was withheld until such time as the capture rate could be determined.

Results

CTBS

Very few animals were captured in either season (Tables 22 to 25). In both villages there was a slightly higher number of captures in the *Boro* crop (9 and 10 mammals) vs. the *T. Aman* crop (1 and 3 mammals). A relatively small number of frogs and snakes were captured in both; these were released, as were any squirrels and mongoose. In both seasons captures mainly occurred during the first half of the growing season, although samples are small in all cases.

The small number of captures was not due to a lack of rodent activity in the vicinity of the CTBS. In both villages, burrow systems of *B. benegalensis* were present in the adjacent upland habitat and numerous fresh track-ways were observed alongside the CTBS fences during field visits by the project staff. The low number of captures is therefore due to a failure on the part of the animals to enter the traps. Whether this is due to extreme trap shyness on the part of *B. benegalensis* or to a lack of effectiveness of the 'lure' crop is not known. However, our data on the phenology of damage caused by *B. benegalensis* suggests that this species is not especially attracted to the rice plants during the vegetative or early reproductive phase, but only when the grain is ripening.

The *T. Aman* rice crop typically experiences higher rodent damage at Comilla. In this context, the slightly higher capture rate during the *Boro* season seems anomalous. However, in both villages, the field staff observed a high incidence of *B. benegalensis* burrowing under the fence during the latter part of the *T. Aman* season when the field areas lack standing water. Indeed, the level of damage caused by this species was not visually different between the field within the CTBS and the surrounding fields. No crop damage assessment was carried out around the CTBS units due to the very low capture rates.

Table 22. Sowara CTBS captures during *Boro* cropping season

WEEK	***Suncus murinus***	***Rattus rattus***	***Bandicota benegalensis***	**Frog**	**Snake**
1	1				
2		1			1
3	1				
4		1	1	1	
5		1		1	
6		1			
7					
8					
9					
10					
11					
Total	2	4	1	2	1

Table 23. Jakunipara CTBS captures during *Boro* cropping season

WEEK	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Mongoose	Snake
1			2			1
2					2	
3			2			
4			1			
5	1		1			
6						
7				3		
8						
9						
10						
11						
Total	1	0	6	3	2	1

Table 24. Sowara CTBS captures during *T. Aman* cropping season

WEEK	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Frog	Snake
1						
2	1				3	
3					1	
4					1	
5						
6						1
7						1
8						
9						
10						
11						
Total	1	0	0	0	5	2

Table 25. Jakunipara CTBS captures during *T. Aman* cropping season

WEEK	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Frog	Snake
1						
2	1				5	
3					2	
4					1	
5			2			1
6						
7						2
8					1	
9						
10						
11						
Total	1	0	2	0	9	3

LTBS

The LTBS units were more successful overall in capturing rodents and other animals (Tables 26 to 29). In both villages there was a marked contrast in capture rates between the *Boro* and *T. Aman* cropping seasons, with higher captures during the former seasons. This contrast is particularly marked in the case of the two major field pests (*B. benegalensis* and *R. rattus*) and less so for the other species. A similar though less pronounced seasonal difference was observed in the CTBS captures.

Examination of the capture dates (data not shown) revealed that *Boro* season captures in both villages were considerably higher during the first half of the season than the second half. The drop off in captures coincides with the period when the fields are inundated following summer rainfall. Captures are evenly spread through the *T. Aman* season. No evidence was seen of any mass migration of rodents from village to field or *vice versa*, nor of any obvious preferred directionality of movement (village to field or field to village).

The lack of any *Mus musculus* among the captures is highly significant. This is the most abundant rodent in the village habitat. Its absence from the LTBS traps was not due to trap mesh size which was small enough to retain this species. Moreover, the LTBS did capture one specimen of the primarily field-dwelling *Mus terricolor* which is only about 40 % of the body weight of *M. musculus*. The house mouse apparently does not enter the field habitat, even on an occasional basis.

Higher LTBS captures during the *Boro* season might be due to one or more of several factors. One possibility is that village populations are high at this time, following the extended fallow period between the *T. Aman* harvest and the onset of monsoonal rain. Another is that field rats in particular are concentrated around the margins of the upland habitat (vegetable fields and village areas). Further analysis of the LTBS capture data might help to identify the likely cause of the pattern.

For two reasons we decided against carrying out crop damage assessment in relation to the LTBS units. Firstly, capture rates were only sufficiently high during the *Boro* season to warrant this activity, and from farmer discussions it was clear that the *Boro* crop suffered minimal rodent damage in all areas during 2004. Additionally, in both seasons visual examination of the rice fields adjacent to the LTBS units and others in similar but ‘unprotected’ areas did not suggest any consistent difference between the two categories. In part this is due to a high level of variability in the level of damage between fields (field damage is discussed in a separate section). At any rate, the scale of damage assessment effort required to test whether the LTBS had an impact on rice yield loss seemed unreasonable given the potential benefits.

Table 26. Sowara LTBS combined captures during *Boro* cropping season, indicating direction of apparent movement (village to field *vs.* field to village).

Direction	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Mongoose	Squirrel	Frog	Snake
V to F	1	24	7	2	1	0	1	2
F to V	2	20	9	0	3	1	3	0

Table 27. Jakunipara LTBS combined captures during *Boro* cropping season, indicating direction of apparent movement (village to field *vs.* field to village).

Direction	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Mongoose	Frog	Snake
V to F	5	11	21	6	1	8	1
F to V	4	19	16	1	0	10	6

Table 28. Sowara LTBS combined captures during *T. Aman* cropping season, indicating direction of apparent movement (village to field *vs.* field to village).

Direction	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	Mongoose	Frog	Snake
V to F	1	5	3	1	1	2	5
F to V	1	3	0	2	0	1	3

Table 29. Jakunipara LTBS combined captures during *T. Aman* cropping season, indicating direction of apparent movement (village to field *vs.* field to village).

Direction	*Suncus murinus*	*Rattus rattus*	*Bandicota benegalensis*	*Bandicota indica*	*Mus terricolor*	Mongoose	Frog	Snake
V to F	1	0	3	2	0	0	22	13
F to V	4	5	3	4	1	3	25	13

Discussion

The CTBS method as implemented in this trial is not an effective method of rodent control in the Comilla rice cropping system. This is probably due to a combination of factors including the field topography and several aspects of the biology of the major pest species. In particular, the highly fossorial nature of *B. benegalensis* limits the effectiveness of any barrier system where the field complex is not inundated (as occurs through much of the *T. Aman* season), while the propensity of this species to attack only the ripening stage of a rice crop makes it a poor candidate for the standard CTBS method which relies on removing adult animals from a population prior to the onset of breeding activity. The other major pest species, *R. rattus*, is certainly attracted to rice at earlier stages of growth (especially the booting stage). However, this species is a highly efficient climber and there are concerns over whether this species might climb the plastic barrier more readily than the more terrestrial Ricefield Rat, *R. argentiventer*. This might be particularly critical in the absence of a moat surrounding the barrier. Whether the CTBS method can be adapted in any way to make it effective in Bangladesh requires further thought and field testing.

The LTBS was quite effective at catching rats during the first half of the *Boro* season but less so at all other times. Although this might be a useful method for rodent control during the *Boro* cropping season, this crop typically receives little rodent damage, presumably because other foods are available in abundance. Accordingly, the considerable cost and effort involved in setting up an LTBS on a sufficient scale to control rodent numbers would probably not be repaid by an adequate increase in rice yield. And while rodent control at this time might yield other benefits in terms of rodent control in the village habitat, the results of our intensive trapping experiment suggests an alternative and no doubt cheaper way of achieving the same end.

One potential benefit of CTBS or LTBS methods is that they might foster a co-operative community-based approach to rodent management. This aspect was not explored in our study due to the limited scale of the trials and the need to get detailed monitoring information from this first implementation of TBS methods in Bangladesh. Arguably, other aspects of rodent control, such as coordinated house trapping activities, might be better candidates for community-based rodent management in Bangladesh.

Figure 65. Photograph of LTBS under construction

Figure 66. Photograph of completed CTBS

Figure 67. Photograph of LTBS separating rice fields from an upland vegetable area

Figure 68. Photograph of multi-capture trap situated in TBS fence

Figure 69. Photograph of village staff collecting rodents captured from TBS multi-capture traps

Intensive rodent trapping as a means to reducing rodent populations and their impacts on rural agricultural communities

Introduction

Since the development of effective rodenticides, intensive or sustained trapping has not often been considered as a primary method of rodent control. Commonly cited reasons include 1) a belief that rats will become 'trap-shy' and thus increasingly difficult to catch; and 2) an expectation that the population will compensate for the mortality by various means including earlier onset of breeding, a higher rate of survival of young animals and an increased rate of emigration from 'uncontrolled' habitats.

A study undertaken by some of the present authors in small villages of south-eastern Africa showed that sustained, intensive trapping could be effective in suppressing rodent populations and reducing damage to stored foods. In the African case study, two main pest species were involved, one resident in the houses, the other resident and breeding in the fields but invading the village habitat. In this study, ten traps were set each night in every household. However, no experiments were conducted to determine an 'optimum' trapping intensity (i.e. best result for cost and effort expended).

As reported in an earlier section of this report on rodent population dynamics, the small mammal community in our Bangladesh study area can be divided into three groups as follows.
1) species that are confined to the village habitat – *Mus musculus* and *Rattus exulans*;
2) species that have their highest population in the village habitat but also utilize field habitats to a lesser extent – *Rattus rattus* and *Suncus murinus*; and
3) species that are primarily 'field' pests but are also encountered in the village habitat on an occasional to a regular basis – *Bandicota benegalensis, Bandicota indica* and *Mus terricolor*. Within this group, *B. benegalensis* stands out on two counts: 1) its apparent pattern of seasonal movement between the field and village habitats in response to inundation of the rice fields; and 2) the extent of damage that it causes to rice stores and house walls and foundations.

Traps of various kinds (kill traps, cage traps) are available in rural Bangladesh yet few people in our study villages either possessed such traps or advocated their use for rodent control. When questioned about the utility of trapping, people generally referred to their lack of effectiveness and the capacity of 'clever' rats and mice to evade capture.

We decided to conduct a large scale trial of intensive trapping in two of our four study villages in Comilla District, using the other two villages as experimental controls. We treated each entire village as an experimental unit because of the compact and discrete nature of the village habitat—allowing for free and easy movement of rodents within villages but limited opportunities for dispersal between them.

Materials and methods

In April 2004 we provided two to three kill traps (same design as used in ecological survey) to every household in each of Sowara (n = 96 households) and Jakunipara (n = 480). Initially we selected a total of five villagers to work as trapping assistants and monitors (two in Sowara, three in Jakunipara). Each staff member was allocated responsibility for a particular section of their village. Subsequently, two more staff were added in Jakunipara to more equitably distribute the tasks. Because all daily household activities are carried out by women, all trapping staff were female.

The village trapping staff were given intensive training over several weeks in methods of trap setting, species identification and data recording. Once trained, they performed the following tasks:
1) every evening, visits to each household to encourage participation in the experiment, assist with trap setting and discuss any issues arising;
2) every morning, visit all households to record the number and species of rodent (and shrew) captured by each household (and assist with safe disposal through burial in field).
3) twice every month (every 15 days), collect all captures and deliver to the core project team for dissection (see below);
4) as required, record information on lost or damaged traps and provide replacement traps as appropriate.

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Core project staff maintained regular contact with the village trapping staff as a means of monitoring the accuracy of the data and in order to keep abreast of any trends or developments. The system proved extremely effective—the village trapping staff developed a high level of expertise, maintained an excellent standard of data recording, and proved an outstanding conduit for sharing of information between the villagers and the core project team.

Figure 70. Photograph of some members of the rodent project team and the village members who were recruited to undertake data collection for the intensive trapping trial

Figure 71. Photograph of kill trap setting in households

Figure 72. Photograph of village staff collecting and recording data from rodents captured during intensive trapping trials

After six months of intensive trapping a preliminary analysis of the data revealed a major and sustained decline in capture rates for both treatment villages. Discussions with the village trapping staff suggested that the Sowara and Jakunipara communities were aware of this trend but were divided as to its cause — some people believed that the trapping had reduced the rodent population but others attributed the trend to reduced effectiveness of the traps ("rats becoming smarter"). Another alternative hypothesis that needed to be tested is that rodent populations had declined in all villages due to some other, uncontrolled factor (e.g. spread of a new disease among all rodents).

We tested the hypothesis that rodent and shrew populations had been reduced in the two treatment villages by using tracking tiles to obtain an independent estimate of animal abundances. The tracking tiles were made from thin metal plates coated in soot by suspension above a naked flame. A pre-trial test was conducted by allowing captured rats, mice, shrews and cockroaches to run across tracking tiles placed inside a cardboard box. After examination of these tiles it was decided that we could distinguish three categories of small mammal tracks: 1) *Mus musculus*; 2) *Rattus* species and *Bandicota benegalensis*; and 3) *Suncus murinus*. Cockroach tracks were very different from any of the small mammals. To record activity on the tracking tiles, a plastic overlay sheet was marked with a grid of 5 X 2 equal sized-cells. Activity was scored by counting the number of cells marked by each species. The activity was scored jointly by the village trapping staff and members of the core project team. The data can be analysed either as a simple proportion of visited vs. non-visited tiles, or as 'area of visitation' (i.e. percentage of cells marked by tracks).

The tracking tile experiment was conducted in all four villages in Comilla District. In each village 10 houses were selected. Two tiles were placed in each house, one at ground level and one in an elevated position (i.e., top of wall or in ceiling). The trial was conducted over four successive nights. Each day the tiles were freshly coated in soot and set at dusk, and examined the following morning. The tracking tile monitoring was initiated in early December and repeated every two weeks thereafter; this monitoring is ongoing.

The possibility that all small mammal populations had declined over the study period due to some extraneous factor was tested further by conducting a single period of strictly controlled kill-trapping in each of the four villages. This was carried out in November 2004 with two kill traps set in each of 10 houses for four successive nights.

The routine of intensive trapping and monitoring was maintained throughout the remainder of the project in Jakunipara and is ongoing. In Sowara, intensive trapping was stopped the end of November 2004 through the collection of all kill-traps. This was undertaken in order to investigate the rate of recovery of the rodent population if trapping ceased. To monitor this process of recovery in Sowara we continued to set tracking tiles; we also reinitiated the population monitoring regime used during the original habitat survey (i.e. 20 kill-traps set in 10 houses for 4 nights per month; this low intensity trapping was considered unlikely to hinder recovery of the population). Trapping in Sowara then recommenced the beginning of March 2005.

As noted above, every fortnight the village trapping staff collected all captured rodents for 2-3 days (or until such time as the pooled sample per village was approximately 100 individuals). These were taken by the core project team for measurement and recording of reproductive status.

Results

The key results are presented in terms of trap success (i.e. number of captures as a proportion of trapping effort). Trapping effort is calculated rather simplistically as the number of traps distributed multiplied by the number of nights per trapping period (e.g. per month). This calculation makes several major assumptions, most importantly that all households set their traps every night and that each trap was set only once. In reality, a certain proportion of households did not set their traps each night, while some people would reset a trap that captured an animal during the course of the night. Based on our own observations of trapping activity during field visits and information from the village trapping staff, we suspect that the number of trap nights was actually considerably lower than the values presented here. Moreover, as the number of captures fell and remained low, we suspect that a proportion of households became less diligent about trap setting. Thus the trap success values presented here are almost certainly underestimates of the true values (e.g., 10 % trap success could well be 15 %). This point will be taken up again at the end of this discussion.

In both villages the trap success fell rapidly after the onset of intensive trapping (Table 30; Figures 73 and 74). In Jakunipara trap success was 15.3% in the first month with approximately even captures of three species (*Rattus rattus*, *Bandicota benegalensis* and *Mus musculus*; Figure 73). Trap success was 4.4% in the second month and remained below 3% in all subsequent months. The detailed record for the first month of trapping in Jakunipara highlights the rapidity of the fall in trapping returns. It also perhaps illustrates a ‘learning’ process with an increase in trapping effectiveness over the first two weeks.

In Sowara the initial trap success was lower (7.9%) and the decline did not occur until after two months, perhaps reflecting a difference in the nature of interaction between trainers and villagers in the two communities (Figure 74). However, the final result was comparable in both villages, with eventual stabilization of trapping success at around 2%. Compared with Jakunipara, very few *B. benegalensis* were captured at Sowara and this fact alone probably accounts for some of the differences in trapping results between the two villages. The composition of the trap captures did notably change through time in Jakunipara where increasing proportions of mice were captured with time (Figure 75). This trend is not significantly apparent in the data from Sowara before the cessation of trapping (Figure 76). This result indicates that the trapping results could be biased towards higher capture rates of relatively larger animals.

It is interesting to consider the number of captures per household in each of the two villages (Table 30). During the first two months residents of Jakunipara caught an average of 8 animals per household; this declined in all subsequent months to less than two animals per household per month. In Sowara the initial two months saw an average of 16.5 captures per household, with subsequent monthly values of just over two. The consistently higher monthly household captures in Sowara is probably due to the fact that a larger number of traps were distributed per household in Sowara (where most houses had three traps) compared with Jakunipara (mostly two per household).

Table 30. Captures from intensive village-wide trapping in two villages from April 2004 to February 2005

Month	Jakunipara		Sowara	
	Overall trap success	Captures per house	Overall trap success	Captures per house
April	15.3	6.0	7.9	7.1
May	4.4	2.0	10.1	9.4
June	2.4	1.4	4.0	3.6
July	2.7	1.6	2.5	2.3
August	2.6	1.5	2.3	2.2
September	1.7	1.0	1.6	1.4
October	2.3	1.3	2.4	2.2
November	1.8	1.0	1.4	1.3
December	1.8	1.0	No trapping	
January	1.7	1.0	No trapping	
February	1.7	1.0	No trapping	
March	Data not yet entered		3.6	3.3

Figure 73. Trap success of intensive trapping in Jakunipara village

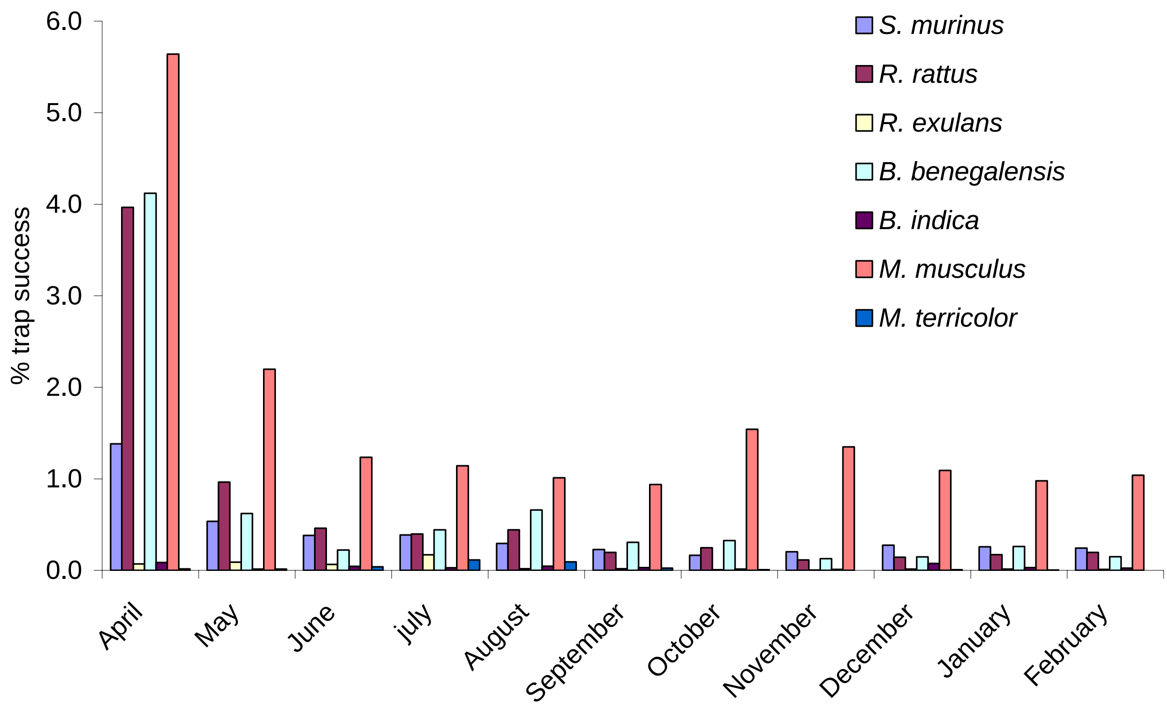


Figure 74. Trap success of intensive trapping in Sowara village, trapping ceased the end of November and recommenced the beginning of March

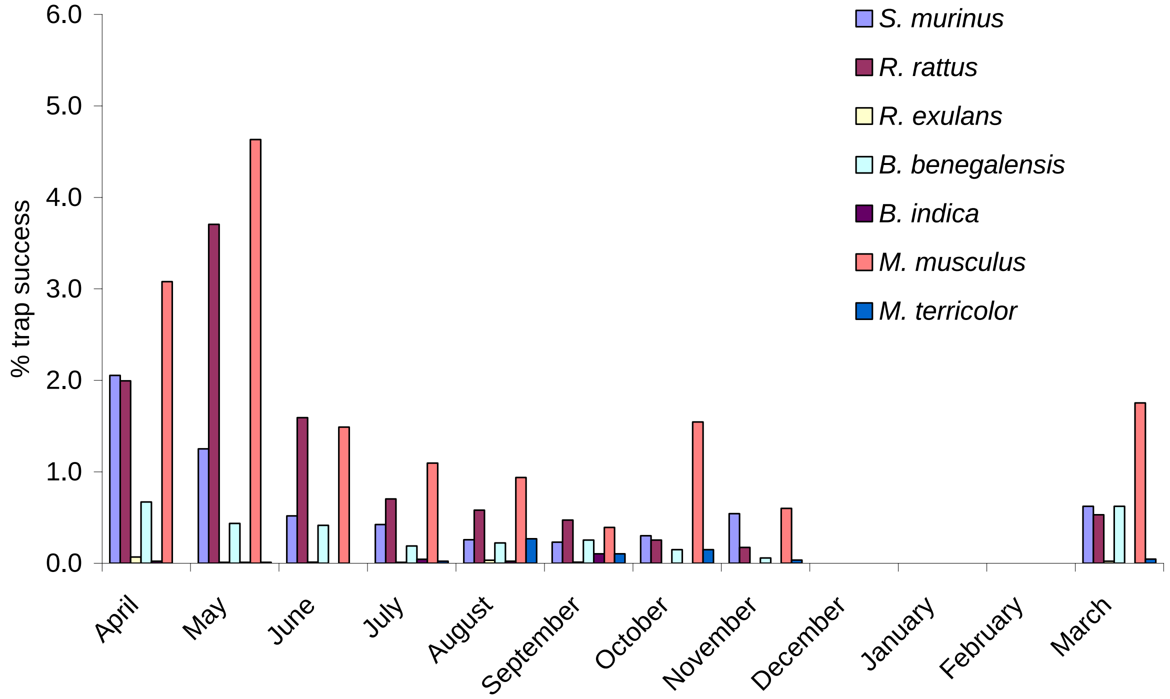


Figure 75. Species composition of rodents caught through intensive trapping in Jakunipara village

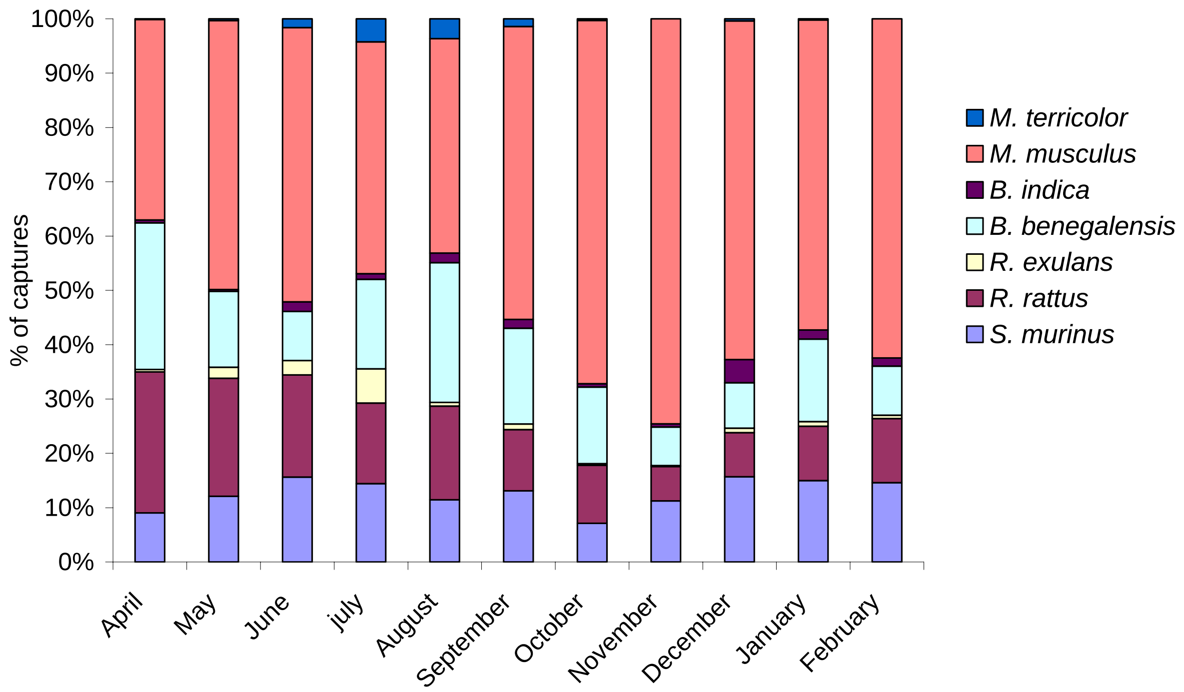
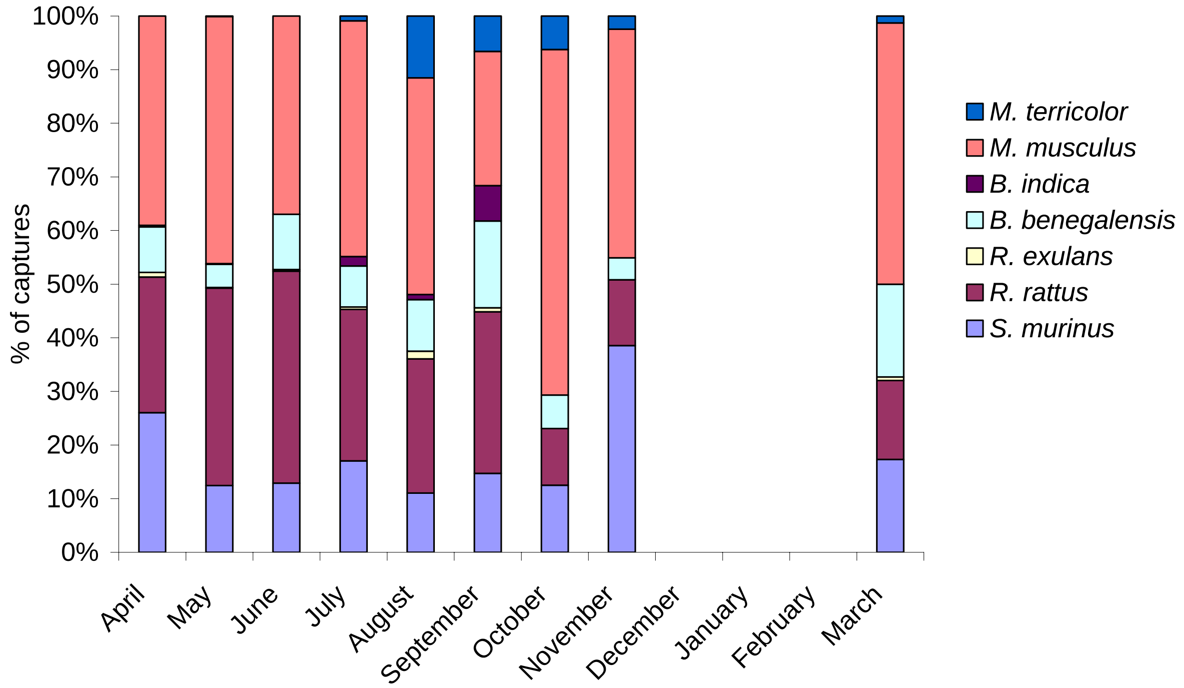


Figure 76. Species composition of rodents caught through intensive trapping in Sowara village



As explained earlier, the tracking tile experiment was conducted to determine whether the decline in capture rates was due to increasing trap shyness on the part of the rodents and shrew. If this was true, we would not expect to see any consistent difference in tracking tile visitation between the 'treatment' villages where intensive trapping was taking place and the 'control' villages where no trapping had occurred. The results show a clear difference in the pattern of tile visitation between the treatment and control villages (Table 31). The contrast is most pronounced for the larger species (rats and shrew), less so for *Mus musculus*.

Table 31. Monitoring of rodent activity with tracking tiles placed in village households to assess the impact of intensive trapping on rodent activity in two villages (treatment) compared to the rodent activity found in two villages where no trapping occurred (control).

POSITION			CONTROLS		TREATMENTS	
			Anandapur	Sahapur	Jakunipara	Sowara
Ground	*Mus*	mean	43.1%	71.9%	50.0%	40.6%
		sdev	22.7%	11.4%	10.2%	3.7%
	Rats	mean	56.9%	56.3%	21.3%	21.9%
		sdev	6.6%	27.3%	13.6%	7.5%
	Suncus	mean	48.1%	48.8%	10.6%	11.3%
		sdev	12.6%	32.3%	9.4%	10.9%
Elevated	*Mus*	mean	61.3%	70.6%	38.8%	41.3%
		sdev	14.4%	21.8%	4.3%	12.0%
	Rats	mean	26.9%	53.1%	13.8%	16.3%
		sdev	5.5%	31.3%	13.1%	5.2%
	Suncus	mean	0	0	0	0
		sdev	0	0	0	0

Note: Results are shown separately for tiles placed on the ground and in elevated positions (top of wall or ceiling). The values are percentages of tiles visited by each species (i.e. visited vs. not visited). The sample size in each case is 40 (10 tiles over 4 nights). Very similar results are obtained by analysing the percentage area visited (i.e. each tile divided into 10 cells). The category 'Rats' includes *Rattus* spp. (*R. rattus* and *R. exulans*) and *B. benegalensis*.

Figure 77. Photograph of a tracking plate containing footprints of *B. benegalensis*

Figure 78. Villagers collecting and recording data from tracking plates used to monitor rodent activity

The results of the limited kill-trapping in the four villages confirm that rodent and shrew numbers remained high in the two 'control' villages of Anandapur and Sahapur (Table 32). Further evidence of the impact of the intensive trapping can be found particularly in the sections of this report which describe changes in the levels of damage, loss and contamination of stored grain and the results from farmer diaries that show decreasing levels of damage to house structures, personal possessions etc.

Table 32. Monitoring of rodent activity with limited numbers of kill trapping placed in village households to assess the impact of intensive trapping on rodent activity in two villages (treatment) compared to the rodent activity found in two villages where no trapping occurred (control).

Trap success (%)	Trap nights	*Mus musculus*	*Rattus rattus*	*Bandicota benegalensis*	*Suncus murinus*	Total
Sowara (treatment)	160	6.3	2.5	1.9	0.6	11.3
Jakunipara (treatment)	160	6.3	0.6	0.0	0.0	6.9
Anandapur (control)	160	8.1	12.5	3.8	25.6	50.0
Sahapur (control)	160	31.9	9.4	1.3	10.0	52.5

Figure 79. Photograph showing villager baiting kill traps with leftover boiled rice

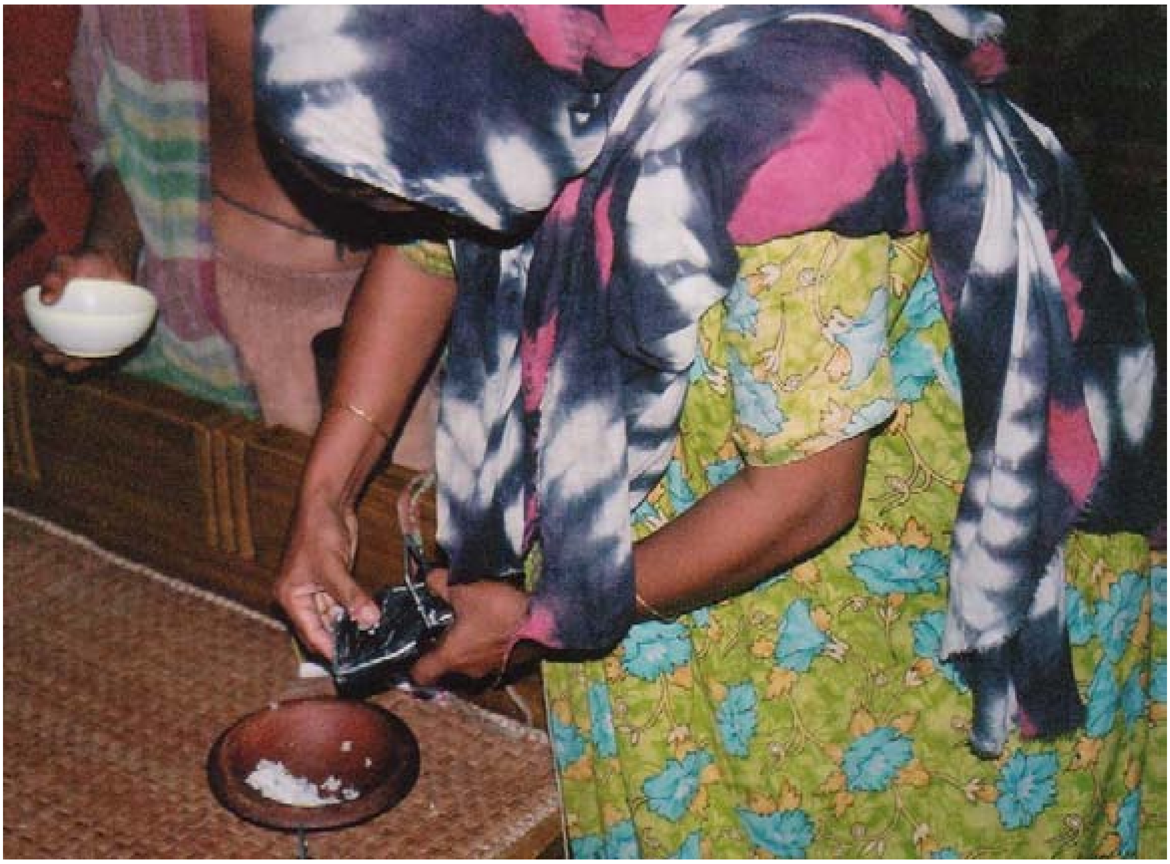


Figure 80. Photograph of captured rodent from intensive trapping campaign

Breeding data collected from the intensive trapping in Sowara and Jakunipara have provided further evidence of when rodents breed over the seasons. The larger data sets (monthly sample sizes were approximately 100 animals) that can be derived from the intensive trapping suggest that breeding is not uniform for *S. murinus* (Figure 81) and *B. benegalensis* (Figure 82). The breeding pattern for these two species may not be entirely linked to food availability and be at least partially determined by environmental cues such as rainfall. Breeding in *M. musculus* continues throughout the year, where a marked increase in breeding during December could be attributed to the storage of grain from the *T. Aman* crop (Figure 83). Breeding for *R. rattus* appears to be nearly continuous, and arguably follows food availability patterns present in the village related to rice storage seasons (Figure 84). These data are roughly supportive of data collected during habitat monitoring trials presented previously in this report. However, as yet, these data do not complete one seasonal cycle, and efforts to do so are ongoing.

Figure 81. Breeding condition of female *Suncus murinus* captured from households where intensive village-wide trapping was initiated

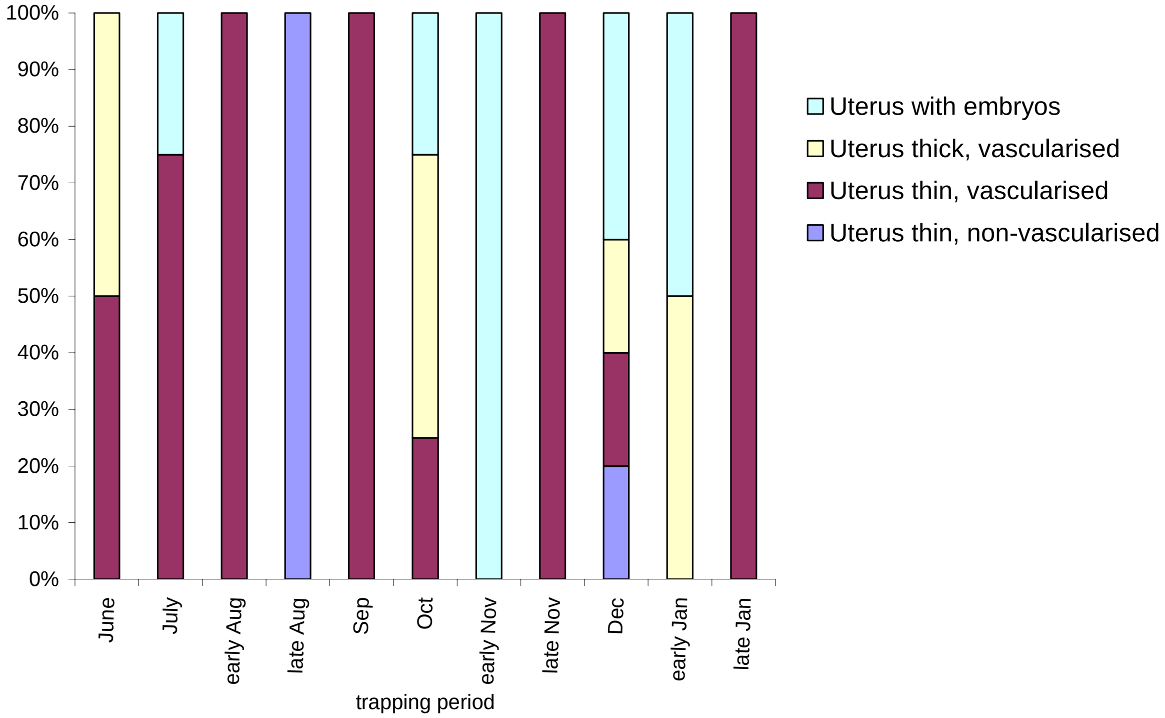


Figure 82. Breeding condition of female *Bandicota benegalensis* captured from households where intensive village-wide trapping was initiated

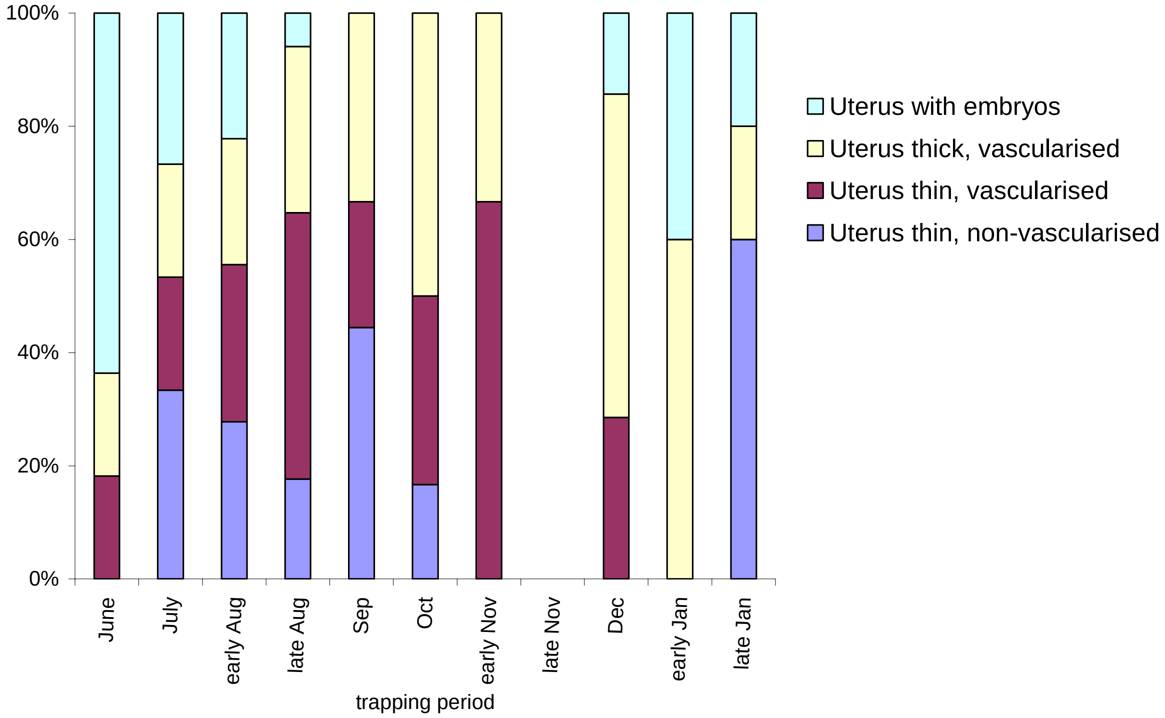


Figure 83. Breeding condition of female *Mus musculus* captured from households where intensive village-wide trapping was initiated

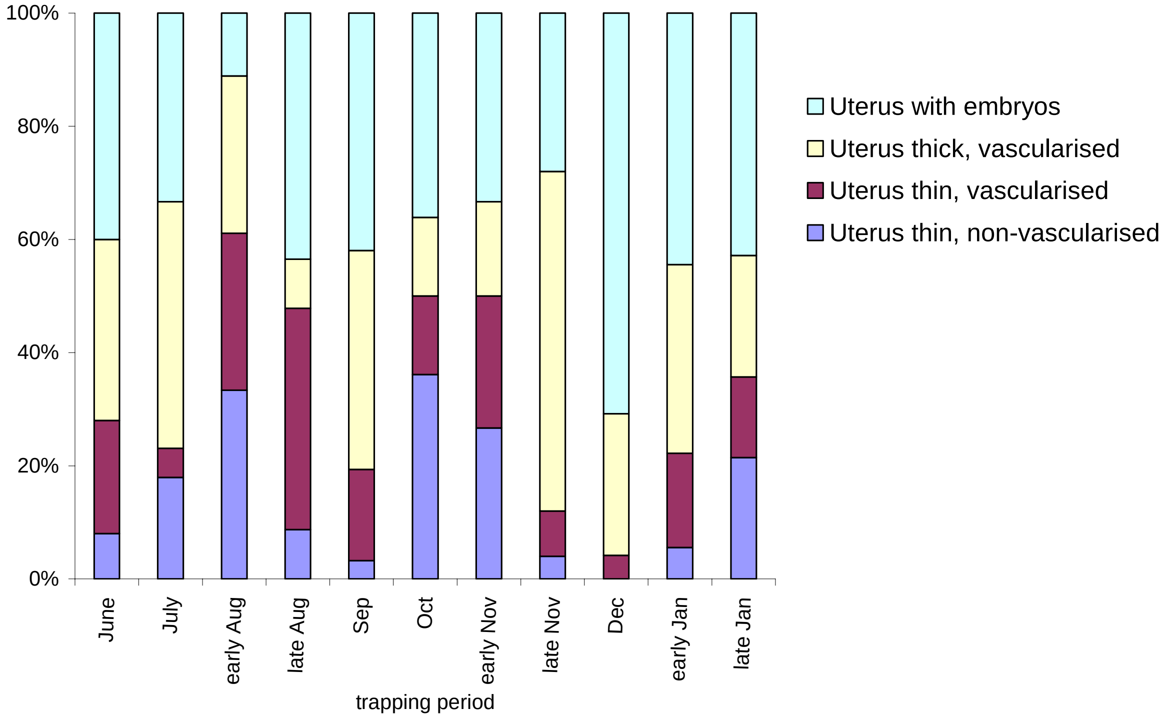
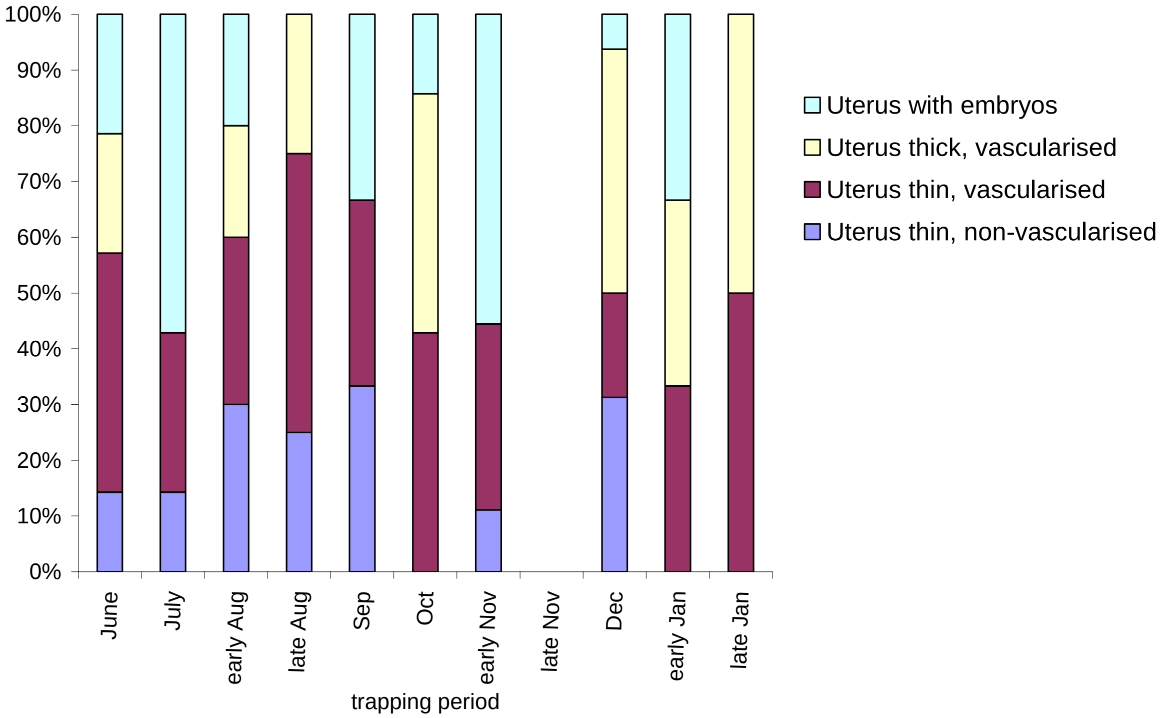


Figure 84. Breeding condition of female *Rattus rattus* captured from households where intensive village-wide trapping was initiated



Discussion

The intensive trapping carried out in Jakunipara and Sowara clearly resulted in a dramatic reduction in the rodent population in each village. The results of the tracking tile experiment indicated that the declining capture rate was not due solely to increasing 'trap shyness', as suggested by some village participants (and by common rodent dogma), but rather reflected a genuine decrease in population density, at least for the two main rat species (*R. rattus* and *B. benegalensis*) and the shrew. In the case of mice (*Mus musculus*), the result is less obvious. The data from Jakunipara indicate a change in species composition over time with higher proportions of mice captured in latter months. Evidence from many rodent management situations is that once larger rodents are effectively removed from an environment, mouse populations can go up in absence of competition from the larger animals. Our data from Jakunipara on changes in the rodent community would support this phenomenon, as does feedback from the village community members who have reported that they feel the rat population has been more affected by the trapping than the mouse population. Although the mouse population has been significantly reduced by the traps (which are designed to kill larger animals) the results of this trial indicate that it may be useful to use a combination of small and large kill traps, the smaller traps perhaps having more impact on the mouse population through increased sensitivity to lighter animals. Further research would be required to verify whether interspecific competition is important in the different habitats found around rural villages and whether intensive trapping could affect species utilisation of available food and harbourage resources.

The effectiveness of the intensive trapping regime is further corroborated by the decline over the trapping period in the rate of damage, loss and contamination of stored grain, and by the decline in the damage to household structures, clothing and other possessions (data presented elsewhere in this report).

A point of critical interest is the intensity of trapping that brought about this result. As noted earlier, there are reasons to believe that the true trapping effort was less than the two to three traps per house per night that we had hoped for. But how much less is difficult to say. One indication of the possible discrepancy in trapping effort is provided by the controlled trapping experiment that was conducted in each village in November 2004. For this experiment, a total of 160 trap nights were set by project staff in each of Sowara and Jakunipara. The trap success in each case was considerably higher than the overall trap success from intensive trapping (Sowara: 11.3 vs. 1.4 %; Jakunipara: 6.9 vs. 1.8 %). If this result is due solely to the number of traps being set during this period, it would imply that only 20 to 30 % of the traps were set in the wider village during this period. However, because other factors such as skill in trap placement might also determine the trap success, we believe that these values represent a *minimum estimate* of the actual trapping effort. The observed reduction in rodent and shrew populations in each village thus was brought about by the setting, on average, of 1-3 traps per household per night. Moreover, we might anticipate that the initial trapping effort was towards the upper end of this range, falling through time as people in the villages observed falling capture rates. Importantly however, even the upper limit is substantially less trapping effort than the only previously published study of this kind (south-eastern Africa), in which a total of ten traps were set per household.

Finally, we should qualify these conclusions with the comment that factors other than the intensive trapping also might have contributed to the reduction in rodent populations. The most obvious of these is improvements in general village hygiene that were actively encouraged through demonstration and indirectly through increasing awareness about rodent pest problems through interaction with project staff.

Farmer diaries

Introduction

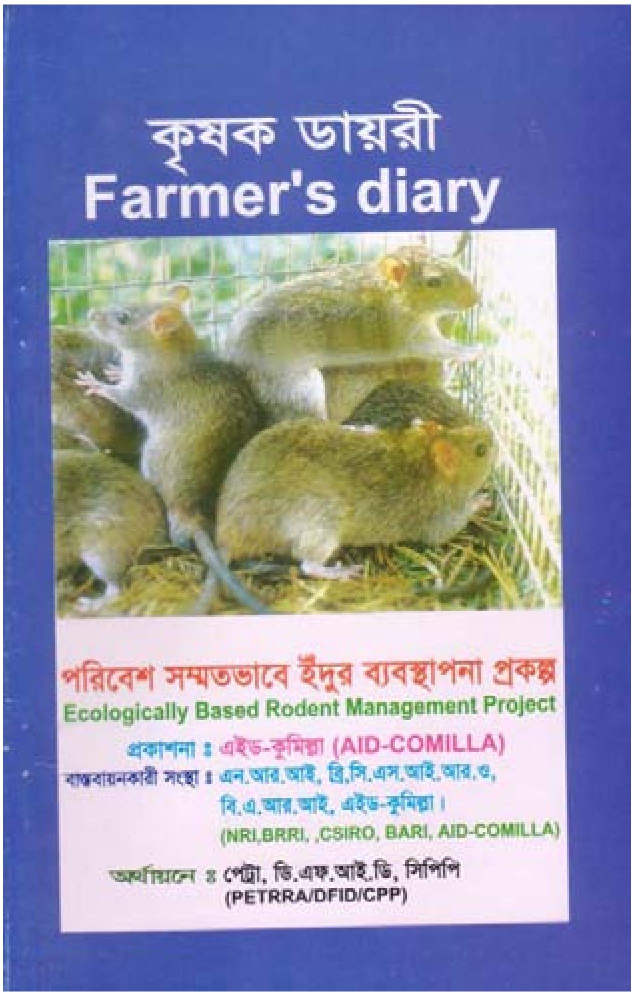
One issue identified at the commencement of this project was that farmers and villagers were not able to quantify the scale of their rodent problem or the amount of time and money invested into rodent management activities. Getting small-scale farmers to consciously think about rodents, or indeed any pest problem, can be difficult, and perhaps one of the most simple ways to encourage awareness of a problem and its solutions is to use a personal diary to record relevant activities. We had hopes that a diary could assist in precisely quantifying rodent damage levels as well as the costs and benefits of traditional management activities. A diary could also be used to compare intervention and non-intervention villages, identifying potential savings and/or costs that could be derived from the rodent management intervention strategies described in previous sections of this report.

Materials and methods

We were concerned that introducing something such as a diary would be difficult for farmers to initially embrace. Although many people in the villages would have learned to write, they would not do so regularly in their lives, and would perhaps not be comfortable writing things down through lack of experience. Coupled with a potential lack of appreciation of what would be achieved by keeping a personal diary, we felt that it would be essential that farmers received guidance and support from each other and the project staff. We, therefore, designed a system whereby farmers would be assigned to groups of five people. Each group would assign a leader and would meet on a weekly basis. The regular meetings would provide an opportunity to help complete the diaries, the leader giving assistance to those who were having trouble, as well as supplying a platform for group discussion. Project staff would occasionally attend these meetings as well have fortnightly meetings in each of the villages with all the people involved in the farmer diary groups. Of course, project staff were available for further discussion during their other data collection activities in the villages. The diaries were implemented in the two treatment and two control villages, with the initial objective of selecting approximately 30 people in each village (six groups of five people, with three male and three female groups, giving a total of 120 diaries from the four villages) to be directly involved in the group monitoring meetings. The diaries were to be periodically collected by the rodent project staff to extract the data into Excel spreadsheets. The diary activities were initiated at the same time as the intensive trapping programme commenced in the two treatment villages (April 2004).

The diary was produced locally in Bengali, providing several pages of factual information about rodents and their damage at the beginning followed by some instructions on how to complete the diaries and the type of information that should be written down (Figure 85). The rest of the diary was essentially blank for writing down information. The information to be collected related to two main issues: 1) rodent damage and 2) rodent management. Under rodent damage we suggested that farmers write down information related to damage to their houses, personal possessions within their houses, granaries, rice and vegetable fields and any other things that they believed were damaged by rodents. The farmers were expected to estimate the cost of repairing the damaged items, both in monetary terms and in time spent to repair the item. Under rodent management we suggested that farmers write down information related to activities they specifically did to control rodents such as use of poisons, traps, hunting, digging burrows, and hygiene/cleaning. Again, farmers were expected to estimate the cost of their actions in time and money and additionally indicate the success of the action through the number of rodents killed, where relevant.

Figure 85. Photograph from the cover of the farmer diary used to record labour and financial expenditure on activities related to rodent damage and management



Results

A total of 208 diaries were completed, which was significantly more than originally planned. As many more diaries than needed were printed, it was agreed from the outset that diaries would be given to anyone in the villages that wanted one as a means of information dissemination. Although the plan was to restrict the number of people directly involved in structured diary monitoring, more people in the villages wanted to take part, and, hence, more farmer diary groups were set up to accommodate demand. This initial enthusiasm of farmers did wane with time, particularly in the two control villages where no intensive trapping was taking place. This came as no surprise as the benefits of the diary would be particularly obtuse for people in the control villages where we were asking them for a considerable effort without any obvious benefit to themselves. We, therefore, agreed to pay the farmer group coordinators in the control villages a small fee to keep the groups going. No such problems were encountered in the two treatment villages.

A comparison of rodent damage and rodent management activities in the treatment and control villages showed quite clear differences for some issues, whereas others were roughly similar (Tables 33 and 34). As there is scope for subjective interpretation, there are some oddities in the data which are difficult to explain such as much higher levels of house repair in Jakunipara when compared to the other three villages. Although it could be argued that the intensive trapping should reduce the expenditure on household repairs, it could also be argued that the project has raised awareness about particular problems, and encouraged better hygiene and maintenance levels. Longer monitoring periods would be required to understand whether the baseline rates of household repair are different among the villages or whether people interpret the repair activities differently. Additional results related to household repairs are discussed at further length below. Of particular note when comparing treatment and control villages is that the intensive trapping has reduced the use of rodenticides in the treatment villages when compared to the control villages. The intensive trapping has also had a notable positive impact on the preparation of vegetable fields, household cleaning (Table 34), repairing rice stores, rice fields and bunds, furniture and baskets (Table 33). On balance, treatment villages have recorded considerably more effort on trapping than that reported in the control villages (Table 34), imparting credibility to the quality of the diary data overall and making it feasible to assess the costs and benefits of the intensive trapping. This analysis indicates that the intensive trapping is no more costly (both in time and money) than what is traditionally undertaken for rodent control. However the benefits of the intensive trapping (both in numbers of rodents killed and in reduced damage levels) recorded by the treatment villages are significantly better than the traditional system of rodent management recorded by the two control villages.

Table 33. Summary of financial and labour costs per household associated with rodent damage to various items reported in farmer diaries by villagers in two villages involved in intensive trapping (Jakunipara and Sowara) and by villagers from two villages not involved in trapping programme (Anandapur and Sahapur)

Item	Input	Jakunipara n=73	Sowara n=45	Anandapur n=48	Sahapur n=42
House wall	Cost (taka)	54.5	5.7	18.5	23.3
	Repairing time (minutes)	622.8	203.4	419.2	284.6
House floor	Cost (taka)	24.0	4.0	16.1	25.1
	Repairing time (minutes)	518.2	215.1	272.2	208.9
Rice store	Cost (taka)	35.5	19.2	73.4	124.4
	Repairing time (minutes)	100.3	34.5	162.5	179.0
Basket	Cost (taka)	21.9	22.2	30.2	35.8
	Repairing time (minutes)	29.1	19.0	51.1	44.4
Furniture	Cost (taka)	66.3	39.8	71.6	116.2
	Repairing time (minutes)	35.0	27.1	105.7	110.2
Clothes	Cost (taka)	113.5	116.8	109.6	110.0
	Repairing time (minutes)	48.4	28.0	76.5	83.2
Home garden	Cost (taka)	33.9	51.0	79.5	49.6
	Repairing time (minutes)	22.8	15.7	138.1	33.6
Rice field	Cost (taka)	43.4	12.7	140.1	136.2
	Repairing time (minutes)	23.5	13.2	135.9	92.2
Vegetable field	Cost (taka)	9.9	12.0	66.8	39.3
	Repairing time (minutes)	14.6	12.8	127.2	36.4
Bunds	Cost (taka)	28.4	14.5	16.0	19.2
	Repairing time (minutes)	102.7	51.0	108.3	88.7
Irrigation canal	Cost (taka)	1.4	4.7	17.1	6.5
	Repairing time (minutes)	4.9	19.2	71.6	10.8
Other	Cost (taka)	89.9	64.8	102.6	144.1
	Repairing time (minutes)	34.4	24.8	91.7	59.5
	Total cost (taka)	**522.7**	**367.2**	**741.5**	**829.8**
	Total time (minutes)	**1556.7**	**663.6**	**1760.0**	**1231.5**

Table 34. Summary of financial and labour costs per household involved in certain activities related to rodent management reported by villagers from two villages involved in intensive trapping (Jakunipara and Sowara) and by villagers from two villages not involved in trapping programme (Anandapur and Sahapur)

Activity	Input	Jakunipara n=73	Sowara n=45	Anandapur n=48	Sahapur n=42
Trapping houses	Cost (taka)	78.5	82.9	0.0	0.0
	Time (minutes)	2162.8	2094.9	0.0	0.0
	Result (rats killed)	17.5	22.2	0.0	0.0
Trapping rice field	Cost (taka)	2.5	5.0	0.0	0.0
	Time (minutes)	65.8	88.0	0.0	0.0
	Result (rats killed)	0.4	1.6	0.0	0.0
Trapping vegetable field	Cost (taka)	1.5	4.5	0.0	0.0
	Time (minutes)	72.8	82.2	0.0	0.0
	Result (rats killed)	0.4	1.7	0.0	0.0
Flooding burrow	Cost (taka)	0.2	0.0	1.5	2.9
	Time (minutes)	37.0	57.6	66.4	91.9
	Result (rats killed)	0.2	0.4	0.6	0.6
Digging (house/bund)	Cost (taka)	2.9	2.0	8.3	5.5
	Time (minutes)	57.1	54.6	76.2	64.1
	Result (rats killed)	0.2	0.4	0.5	0.5
Cleaning house	Cost (taka)	1.6	3.2	8.3	0.0
	Time (minutes)	2644.9	3268.8	4927.2	5553.3
	Result (rats killed)	0.1	0.0	0.0	0.0
Cleaning rice field/bund/canal	Cost (taka)	49.9	45.3	65.7	69.5
	Time (minutes)	280.2	520.0	639.8	561.7
	Result (rats killed)	3.3	0.0	7.5	0.0
Cleaning vegetable field	Cost (taka)	18.1	11.3	53.1	30.2
	Time (minutes)	199.5	349.5	661.1	759.9
	Result (rats killed)	0.0	0.0	0.0	0.0
Hunting	Cost (taka)	4.2	6.2	3.9	1.3
	Time (minutes)	27.9	177.8	60.8	36.1
	Result (rats killed)	0.9	0.5	1.3	0.9
Lanirat (chronic poison)	Cost (taka)	1.2	1.3	4.9	0.8
	Time (minutes)	16.7	10.4	62.6	21.4
	Result (rats killed)	0.6	0.9	3.1	1.5
Zinc Phosphide (acute poison)	Cost (taka)	0.8	0.9	11.8	7.4
	Time (minutes)	0.7	1.4	32.8	11.1
	Result (rats killed)	0.0	0.1	0.5	0.0
	Total cost (taka)	**161.5**	**162.7**	**157.5**	**117.6**
	Total time (minutes)	**5565.3**	**6705.2**	**6527.0**	**7099.5**
	Total result (rats killed)	**23.7**	**27.9**	**13.6**	**3.6**

Further evidence that the intensive trapping intervention has resulted in improved cost-benefits can be seen through a temporal assessment of farmers' recordings of their actions over the duration of the trial. The diaries in the four villages were implemented over a 33-week period, and breaking down the data presented in Table 33 on a weekly basis indicates a marked decline in repair actions over time in treatment villages. The data presented in Figure 86 indicates that the number of households undertaking repair of their houses significantly declines over time in the village of Jakunipara. Household repair is, by far, the most frequent activity reported in the diaries. However, other activities also appear to decline, particularly in the early stages of the intervention trial with regard to repairs to furniture and baskets stored within the house (Figure 87). Other activities, such as vegetable fields, are driven by the cropping system and do not follow the same pattern. In contrast, there appears to be no similar decline in the control villages, where the percentage of households engaging in repairs to houses remains relatively constant in the village of Anandapur (Figure 88).

Figure 86. Temporal summary of households in Jakunipara (treatment village) involved in recording various repair activities within a farmer diary. Activities coincided with the commencement of village-wide intensive trapping of rodents

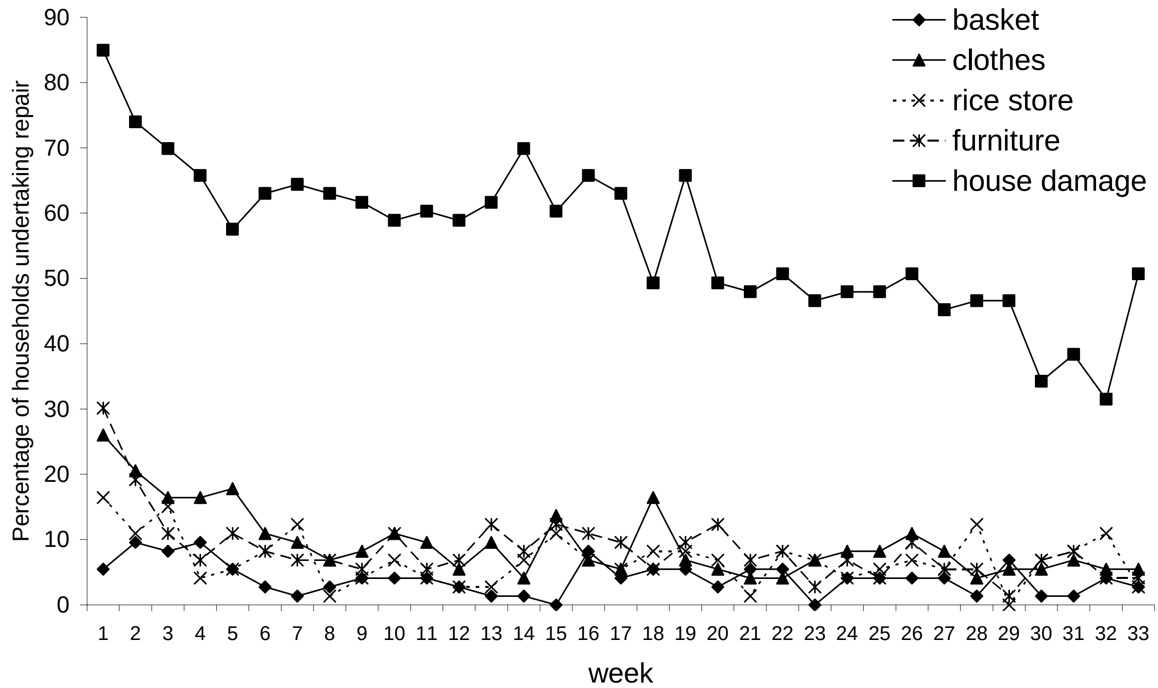


Figure 87. Further temporal summary of households in Jakunipara involved in recording various repair activities within a farmer diary. Activities coincided with the commencement of village-wide intensive trapping of rodents

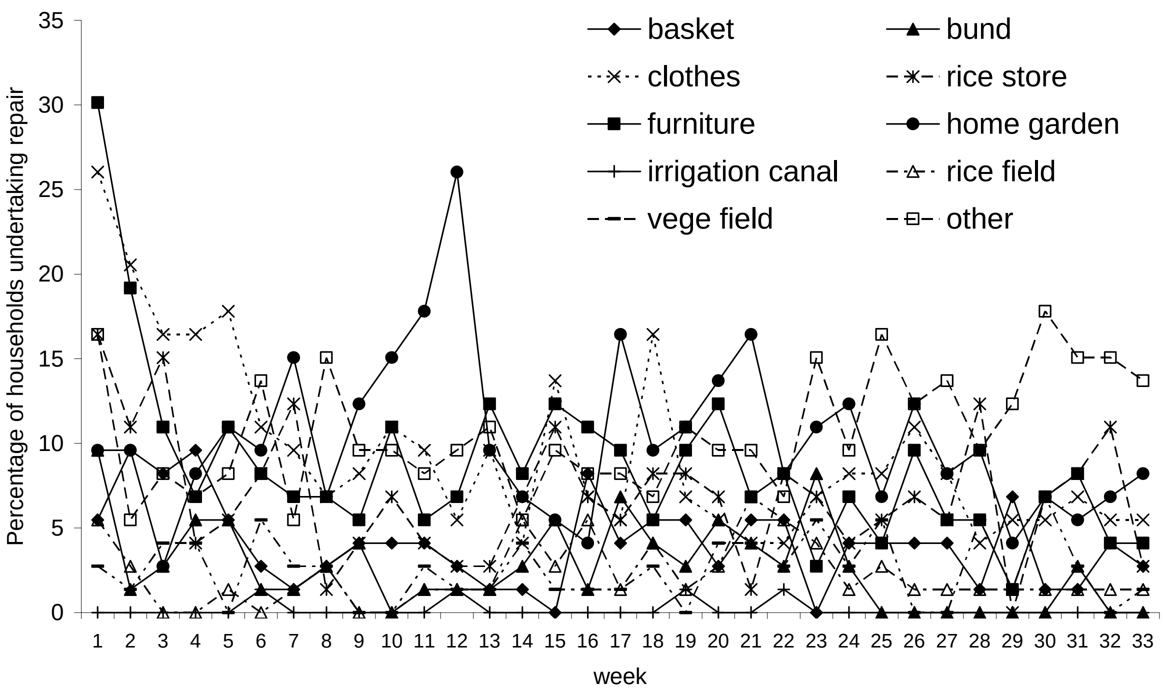
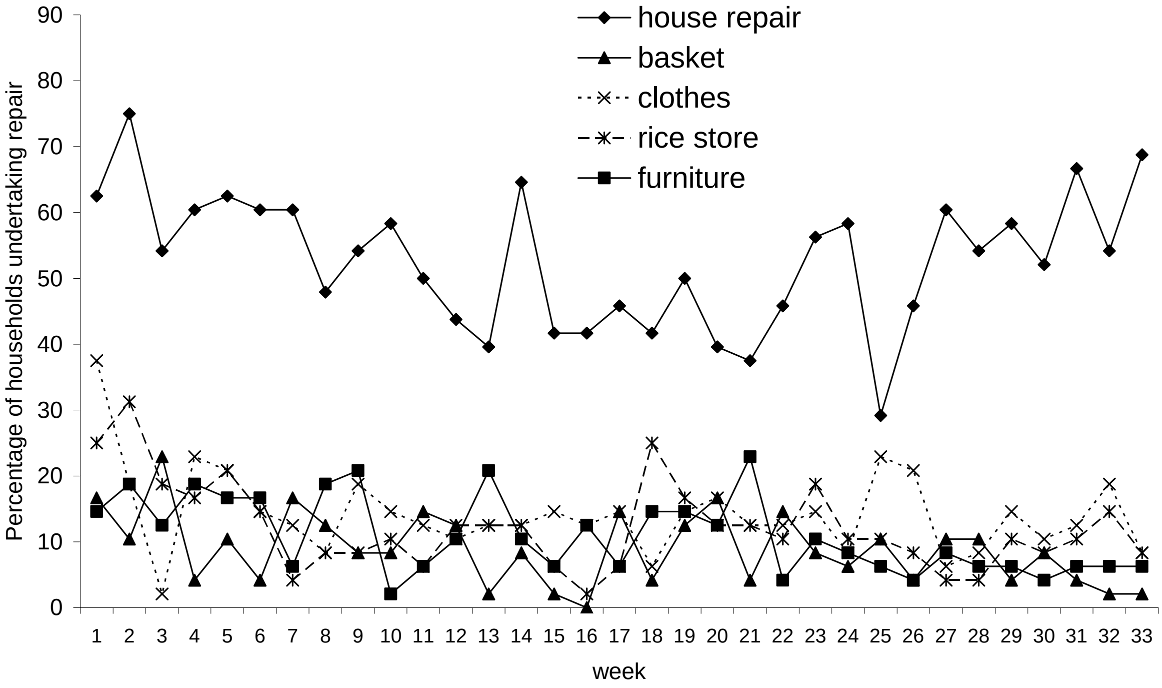


Figure 88. Temporal summary of households in the village of Anandapur (control village) involved in recording various repair activities within a farmer diary



Discussion

The farmer diaries have been a very successful method for demonstrating the success of the rodent management interventions. We believe they provide conclusive evidence that the intensive trapping led to better rodent management by reducing damage levels to a range of issues, as observed by farmers themselves. Resources that farmers usually put to rodent management (for buying poisons or repairing damaged items) was significantly reduced. The intensive trapping, therefore, had many benefits with no additional overall costs compared to costs of previous time and money spent by the villagers on their traditional rodent management. We believe the diaries have also been beneficial in raising awareness about rodent management by getting villagers to think about how to quantify their problems and actions in a way that allows them to monitor improvements and changes to their livelihoods. Effective rodent management must be based on effective monitoring, and even if farmers discontinue using diaries on a regular basis, we believe the experience will help them mentally monitor their actions in perhaps a more structured and coherent fashion, making them more able to quantify the impacts of their actions on a variety of pest management issues.

Stakeholder workshop and discussions with target institutions

Introduction

Many complex issues are involved in developing sustainable research programmes, building the capacity of institutions and disseminating knowledge to stakeholders. Because rodent research capacity was considered to be relatively low and dated in Bangladesh, it was unknown whether institutionalised rodent management recommendations would continue to be relevant for the existing rodent pest problems suffered by farmers. The Department of Agriculture Extension has a single national approach related to rodent pest management which is to organise a rodent bounty campaign during one month of the year. The campaign is usually meant to happen during the month of September, but can be delayed for several months occurring with no reference to when rodent populations are lowest and, therefore, having the most impact. The campaign is advertised in advance and encourages individuals to regularly collect the tails of rodents. A tally is kept by local DAE officers, and those individuals who collect the most tails win prizes. Although we had concerns about the minimal impact of such a campaign on the rodent population, we were perhaps more concerned that collection of tails would discriminate against the use of anticoagulant poisons (animals die in burrows), while encouraging the use of more toxic acute poisons (animals die in the open near bait) so that tails could be collected. Acute poisons are not only more dangerous to use but are far less effective in killing high percentages of the rodent population and encourage bait/site shyness. The DAE bounty campaign is, therefore, unlikely to provide real long lasting benefits with regards to reducing the rodent population, while potentially causing great harm by encouraging the use of relatively dangerous poisons and perpetuating attitudes of poor rodent management practice. Discussion with a number of stakeholders including the DAE, NGOs and farmers about the project activities was important to disseminate the project outputs as well as discuss wider issues of sustainability, capacity building and continued research on rodents.

Materials and methods

A one day workshop was organised on 24 July 2003 as an opportunity to disseminate project results and initiate dialogue with key stakeholders involved in rodent management. It was agreed that the workshop should take place in Comilla, as opposed to Dhaka, to keep the agenda focussed on local institutions that could more immediately draw on the project's activities, inviting a maximum of 50 people. It was expected that the morning of the workshop would be used to make a series of presentations about the project and the afternoon would be used to gain feedback from the participants. The latter objective involved breaking the participants into four homogenous groups, e.g. NGO and DAE staff, female villagers, male villagers, and scientists/researchers, to discuss particular issues, each group reporting back to the meeting .

Results

Attendance was good with 45 participants in total (Table 35). After the usual introductions, the morning focussed on presenting seven presentations as follows:

- Farmer knowledge attitudes and practice
- Rodent ecology, summarising species and habitats
- Rodent ecology, breeding ecology, population changes
- Storage losses
- Suncus ecology
- Parasitology and disease
- Rodent damage phenology in rice fields

Each presentation was formally presented by different Bangladeshi colleagues involved in the project. The afternoon session focussed on first developing questions to discuss in groups. Through discussion, six questions were proposed:

1. Squirrels damage crops, should squirrels be included in this project?
2. What is the best bait to catch rodents?
3. How will studies of movement of rats help with strategies for management?
4. Are farmers concerned about diseases that rats may carry?
5. Why do we need to know about where rats breed at different seasons?
6. Why do some farmers have higher damages to stored grain than others?

The first two questions were posed by farmers, and the last four questions were posed by project team members. Participants broke into four groups to discuss each issue, and the conclusions from each group are summarised below:

Table 35. List of individuals attending stakeholder workshop on ecologically-based rodent management, held on 24 July 2003 at the Bangladesh Academy for Rural Development, Comilla.

Name	Designation / Type of Participant	Organisation / Address	Sex
Mrs. Ayesha Akter	Farmer	Anandapur, Comilla	Female
Mrs. Ferdousi Mamotaj	Farmer	Jakunipara, Comilla	Female
Mrs. Joshna Begum	Farmer	Jakunipara, Comilla	Female
Mrs. Shahina Begum	Farmer	Sowara, Comilla	Female
Md. Jahangir Alom	Farmer	Anandapur, Comilla	Male
Md. Habibur Rahman	Farmer	Sahapur, Comilla	Male
Dr. Nazira Q. Kamal	CSO & Head Entomology division	BRRI	Female
Mr. Adrian N. Meyer	Rodent expert	NRI , UK	Male
Mr. Azad Chowdhury	IT Specialist	IRRI, Bangladesh	Male
Dr. Ken Aplin	Rodent expert	CSIRO, Australia	Male
Dr. Steve Belmain	Team Leader	NRI, UK	Male
Shaikh Murshidul Islam	Research Associate	BRRI	Male
Md. Nazmul Islam Kadry	Social Scientist	AID- COMILLA	Male
Md. Adnan-al-Bachchu	Research Associate	BRRI	Male
ATM Hasanuzzaman	SO	BARI	Male
Md. Yousuf Miah	Head. Vertebrate Pest Division	BARI	Male
Mohammad Harun	Research Officer	AID- Comilla	Male
Md. Zahangir Alom Paramanik	Research Associate	BRRI	Male
Ms Jamillah	VSO	AID- Comilla	Female
A.K. Azad	Consultant	AID- Comilla	Male
Md. Majibur Rahman	Farmer	Batania	Male
Mrs. Khodeja Akter	Farmer	Batania	Female
Md. Abdur Razzak	Research Associate	BRRI	Male
Shah Md. Ashadud Dowla	Project coordinator	DCPUK	Male
Mohammad Azizul Haque	MSc student	BAU	Male
Md. Samshul Alom	MSc student	BAU	Male
Md. Mofazzel Hossain	SO	BRRI	Male
AKM Murshedur Rahman	MSc student	BAU	Male
Md. Dulal	Farmer	Sowara, Comilla	Male
Abu Taher	Farmer	Sowara, Comilla	Male
Md. Munnaf	Farmer	Jakunipara, Comilla	Male
Mrs. Sharmin Kader	Executive Director	DRISTI, Comilla	Female
Md. Maksudur Rahman	Entomologist	AID- Comilla	Male
Dr. Grant Singleton	Rodent expert	CSIRO, Australia	Male
Rokeya Begum Shafali	Executive Director	AID-COMILLA	Female
Abu Baker	Research Assistant	AID-COMILLA	Male
Noel Magor	Project Manager	IRRI-PETRRA	Male
Arefin Shamsul Haque		BRRI	Male
Omar Faruque Tapos	Photo Journalist		Male
A.R. Gomasta	Director(Research)	BRRI	Male
Dewan Intajul Islam	DD, Agriculture, Comilla	DAE, Comilla	Male
Md. Belal Ul Islam	Vertebrate Pest Specialist	DAE, Khamarbari, Dhaka	Male
Dr. S.M. Zahurul Haque	Associate Professor, Microbiology	Comilla Medical college	Male
Dr. Gary C. Jahn	PI, LITE Project	IRRI, Philippines	Male
Lokman Hakim	Executive Director	PAGE	Male

Scientist group

Q-1: At first, we should examine through experimentation that the squirrel is harmful and to what extent it affects people's lives. Squirrel damage is likely to be very low, affecting some trees, fruit and nut crops. Squirrel populations are declining and the government would like to see them a protected part of nature that does little harm. At the moment, there is no plan to include them in rodent management project for these reasons and the fact that the project has limited resources and must concentrate on the more important issues.

Q-2: The best bait to catch rodents is something that is smelly and fresh (fish, coconut, mango) and should be readily available in the environment. The type of bait will vary with the seasons. For example moist baits may be more attractive when it is dry. Different species may be attracted to different baits with *R. rattus* perhaps liking fruit more often and *B. benegalensis* liking snails and fish.

Q-3: Rats move anywhere and can move quite large distances. The studies of their movement help us to know where, when and why they move. This helps target rodent management activities to where the rats are, and helps assess the scale of the problem, how many rats are there, and hence, how much of an effort will be required to control them.
Q-4. Farmers are not concerned about diseases that rats might carry in Bangladesh. The main reason is their lack of knowledge regarding disease. So, it is our responsibility to inform them through training activities regarding rat-borne diseases.
Q-5. Yes, we need to know where rats breed in different seasons in order to effective target the timing and location of rodent management.
Q-6. Some farmers have higher rat damage in their storage than others because of plenty of food sources in that area; safe refuge and fewer disturbances compared to others farmers' storage.

NGO and DAE group
Q.1. Squirrel should be included in this project to find out control methods other than killing.
Q. 2. Dry fish works best because of its intense smell.
Q. 3. In the rainy season, fields are inundated by water. Rats take shelter in high lands like house, roadside, dam. Rats can be easily and effectively controlled/managed at this situation.
Q. 4. So, far we know most of the farmers are not concerned about rats carrying diseases due to lack of information.
Q. 5. Yes, We need to know about breeding sequence of rats, which may be the key point for rodent control without using rodenticides.
Q. 6. Lack of knowledge about proper storage of grain and management practices of rodent, they need training for overcoming this problem.

Female farmer group
Q.1. Squirrel should be included in this Ecologically Based Rodent Management Project.
Q. 2. The suitable bait of rat is coconut meat.
Q. 3. The knowledge of rat movement study will help us to establish/set rat traps.
Q. 4. All farmers are not aware of the rat diseases. So this should be informed to them through training.
Q. 5. Yes, we need to know where rat breeds in different seasons. We know that rat is continuing it's breeding in *Boro* season in the wider bunds of field, dark place of a house, pond bank near to house, big bund, road side and during *T. Aman* season in paddy field, small bush, stack of straw etc.
Q. 6. Some farmers have higher damage to stored grain than other farmers because: a) Some farmer's place/setup their stored paddy in dark place, unclean areas; b) Mud-built houses receive more rat damage than others.

Male farmer group
Q.1. Actually squirrels damage our crops. So that according to our group opinion, squirrel should be included in the rodent management project. For example, it damages our crops like green coconut, coconut, guava, papaya, mango and jackfruit etc.
Q. 2. Most of the rat can be captured with some special type of food/bait like coconut, mango, banana and dry fish etc.
Q. 3. Rat management would be easier, when we know different types of information: As for example, by observing footprint, runway in hilly area, bushy area and on the ceiling on roof etc.
Q. 4. We understood from today's workshop that about 60 rat borne diseases can be transmitted through rats. We are able to be informed from scientists regarding the disadvantages of rats. So, we are specially helped and learned a lot.
Q. 5. Rats can continue its breeding in different cropping season at crop field, bund and in road side.
Q. 6. Some farmers have highest rat infestation than others because of their: a) Mud built houses; b) Polluted environment; c) Straw built houses and d) Haphazard use of different resources.

Figure 89. Photograph of stakeholder workshop on ecologically-based rodent management held at the Bangladesh Academy for Rural Development, Comilla, 24 July 2003

Figure 90. Photograph of female villagers presenting their report back to the stakeholder workshop

Figure 91. One of many newspaper articles reporting on the stakeholder workshop held to discuss rodent management in Bangladesh

ATTUNED TO THE RHYTHMS OF TOMORROW

The Bangladesh Today

1, No. 371 DHAKA, MONDAY, JULY 28, 2003, SRABAN 13, 1410 BS, JAMADIUL AWAL 26, 1424 HIJRI

Dr Nazira Quarashi, CSO of Entomology Division BRRI and Country Coordinator of Ecologically based Rodent Management Project, Dr AR Gomasta and Director of Research of BRRI, Dr Noel P Magor of PETRRA, among others, were present at a workshop on Ecologically Based Rodent Management held at the BARD in Comilla on Thursday.

Workshop on Ecologically Based Rodent Management held

A day-long workshop on Ecologically Based Rodent Management for Diversified Rice Based Cropping Systems organised by Bangladesh Rice Research Institute (BRRI), NRI (UK), CRIRO (Australia), BARI, AID-Comilla and funded by IRRI PETRRA (DFID), CPP Project was held on Thursday at BARD, Comilla.

Dr Nazira Quaraishi Kamal, CSO and Head of Entomology Division, BRRI and Bangladesh Country Coordinator of Ecologically Based Rodent Management in Bangladesh Project presented overview of the Rodent project, its objectives and methods.

Dr AR Gomosta, Director (Research) BRRI and Dr Noel P. Magor, PETRRA Manager and IRRI representative, were present at the workshop as guests.

Dr. Steve Belmain, Dr Grant Singleton, Dr Ken Aplin, Adrim Meyer and IRRI insect ecologist Dr Gery and Jan Wee addressed the workshop.

Six key-note papers on ecologically based rodent management were presented in the workshop.

It is the first project programme in Bangladesh about rodent management for diversified based cropping systems.■

Discussion

The workshop provided an effective forum for disseminating information about the project to staff from other institutions and to the villages involved in the project. It also served as a means of receiving feedback and raised a number of important issues that the project team had not considered, such as real or perceived problems with squirrels by farmers. Informal discussions particularly with the DAE at this workshop and during subsequent meetings between project team members and DAE officials tried to put in context the value of the national DAE programme of rodent bounties whereby people are encouraged to collect rodent tails during one month of the year. Although there is some recognition by DAE experts that the existing bounty programme is probably not that effective, the DAE continues to operate the rodent bounty to raise awareness about rodent problems and to be seen to be “taking action” about rodent pests. It is likely that the national rodent bounty campaign will continue unless a viable alternative can be found, and scrapping the bounty will be met with political resistance from within and outside of the DAE even in the face of evidence that it may be doing more harm than good by encouraging the use of acute poisons. The rodent project extension funded by the CPP that is currently ongoing is attempting to work more closely with the DAE, and it is hoped that it may be possible to convince key players that there is an alternative to the rodent bounty campaign system through the encouragement of continual trapping programmes. For this to succeed, it will be necessary to address the constraint of the national provision of more effective kill traps at affordable prices. This is not an insurmountable task as demonstrated by CPP research in South Africa, and with the right encouragement, it should be possible to develop a commercially viable local industry to produce efficient, durable and affordable traps for Bangladesh.

Outputs

The project had four main objectives for which the results can be summarised as follows:

Understand the current impact of rodents upon rural agricultural communities
For villagers, there were clearly identified problems with rodents damaging rice in the field. Farmers were not able to precisely quantify the amount of damage they experienced. However, farmers were able to recognise that rodents caused damage at different growing times (e.g. seed beds, maximum tillering, before harvest), and rodent damage was more severe during different seasonal crops (highest in *T. Aman* crop). Farmers also suggested that inter-annual damage variation was high and that certain areas were more prone to rodent damage. Research trials on damage phenology, which tracked the pattern of rodent damage, showed that rodent damage was patchy and usually highest in areas of fields adjacent to upland areas (dikes, roads, the village, vegetable growing areas). Rodent damage was strongly correlated to rodent burrowing activity, particularly in the field floor. Active burrow counting could, therefore, be used as a measurement to predict the potential severity of rodent damage, and indices were developed. Farmers also recognised that rodents attacked a number of other field crops, particularly, gourds, pumpkins, coconut, cauliflower, beans, potatoes, chilli, sugar cane, mango, guava and jackfruit. Their damage could lead to very high losses by early damage to flowers and young fruits and later damage during ripening. Stored food, particularly rice, was prone to loss, damage and contamination by rodents. Farmer estimates of rice lost during storage to rodents ranged from 5 to 40%, with an average of 13% (±0.02 sem) estimated loss. Trials were developed to repeatedly measure rodent impacts on stored rice and concluded that losses could be as high as 5% of the total amount of grain stored by a household. Losses to rodents over a three month period per household grain store were typically 35kg; rodent losses over a year would be enough to feed an additional person's dietary intake per household. A further 2.5% of rice was partially eaten by rodents, significantly affecting its nutritional value, and contamination with rodent faeces could be as high as 300 droppings per kg. Rodents commonly lived in people's houses, burrowing into floors and walls and living in roof voids. Damage to foundations regularly undermined structures, causing houses to prematurely fall down during floods. Although households were regularly repaired, it was felt that houses eventually had to be entirely rebuilt as rodent burrow systems became more extensive. Rodent damage was also commonly reported to granary structures, furniture, utensils, clothing, fishing nets, electrical wires and other personal possessions kept in the house. Although many factors contribute to the spread of gastro-enteric disease through food and water and poor hygiene, rodents are a well known reservoir and vector of common bacteria such as Salmonella and Leptospirosis. Rural households did recognise that rodents spread dirt in the environment and that rodents are unclean. However, general awareness about rodent transmitted diseases was very low among the majority of villagers. Some women even admitted serving their husbands food that had been clearly contaminated with rodent droppings. Anthropological assessments of hygiene and food preparation methods indicated that rodents have very high access to prepared foods and drinking water. Controlled trials indicated high contamination levels of commodities and frequent ingestion of cooked rice by *Suncus murinus* caught in villages.

Understand the impact of existing control strategies used by small-scale farmers upon rodent population dynamics, the environment and socio-economic capital
Farmers did use traps and anticoagulant poisons to control rodents. Rodent control was almost always done by individuals with no efforts to coordinate work with neighbours. It was generally accepted by farmers that any benefits of their control activities were temporary. Control was almost always carried out when damage levels and rodent populations were high and over a short period of time. Control was more likely to be carried out in and around households than in the field. Farmers generally reported that they planted one row of rice for rodents to every ten rows planted for themselves as a means of coping with rodent losses in the field. Research trials to monitor rodent population dynamics and breeding rates in a number of distinct habitats (rice fields, houses, vegetable plots, ponds, roadsides, etc.) showed no discernable effect of existing control strategies on reducing the rodent population or damage levels. Rodent breeding was correlated with seasonal food availability, and the only discernable population reduction was attributed to the monsoon season when widespread flooding significantly reduced rodent harbourage. This conclusion indicated existing practices were largely a waste of time and money.

Develop rodent control strategies through farmer participatory research

Intensive village-wide trapping trials with snap traps and a loan system for live traps were initiated in two villages. Highly significant changes were observed with regard to rodent breeding and population dynamics. When compared to two villages where interventions did not occur, it could be shown that the intensive trapping reduced the rodent population by 75%. Independent monitoring with tracking tiles confirmed rodent activity had been reduced by approximately 50% through trapping. Monitoring of rodent damage showed the intensive trapping caused significant reductions in post-harvest losses by more than 60% with even greater reductions in contamination levels of stored food. Trials with farmer diaries in the intervention and non-intervention villages provided further information that showed the financial and time costs spent on various rodent-related activities (repairing houses, irrigation canals, rice field bunds, granaries, furniture, clothing, vegetable fields, rodenticide usage, cleaning houses) were favourably enhanced by the intensive community trapping, saving them time and money when compared to the non-intervention villages. Trials were initiated to demonstrate particular aspects of the environment that could be modified to reduce rodent access to food and harbourage. These included simple measures such as improving hygiene standards, proofing fruit trees (particularly coconut), modifying granaries and haystacks to reduce rodent access. Monitoring trials indicated desirable effects, and modifications were being independently adopted by other village members.

Develop and disseminate policy recommendations to stakeholders involved in rodent pest control

A workshop was held with invited participants from a number of NGOs and the DAE to disseminate the project's findings and to obtain feedback on how activities could be more widely adopted within other institutions and by farmer groups. The DAE sponsored IPM farmer groups found throughout the country were considered an important organisational structure for the dissemination of agricultural knowledge, and it was recommended that IPM groups should be given further information and training on rodent pest management. Regional dissemination 'road shows' co-ordinated by IRRI have served as a platform to disseminate the project findings as has the BRRI Rice Knowledge Bank. Besides improving knowledge through training to extensionists and end users, the project concluded that the existing national strategy of the DAE regarding rodent control (rodent tail collection during a single month of the year when rodent populations are highest) should be abolished not only because it is ineffective but is likely to be detrimental to encouraging safe and sustainable rodent management (tail collection would encourage the use of acute poisons as opposed to anticoagulants).

Contribution of Outputs to developmental impact

The outputs have been achieved, and these demonstrate that rodent pests can be sustainably managed in rural agricultural communities of Bangladesh without large financial expenditure and poison use. The damage and impacts of rodents on the livelihoods of resource-poor people can be greatly reduced, and the cost-benefits to the community are substantial and well-recognised by the community after the management has been implemented. Changes in government institutional practice have been recommended, backed up by evidence collected during the project, and it remains to be seen whether the DAE would consider revising its national rodent management strategy to reflect the research findings. In Bangladesh, most knowledge-intensive agricultural extension work with small-scale farmers has been through local NGOs, and they are expected to be the primary means of disseminating knowledge to farmers for the foreseeable future in Bangladesh.

This project has not yet officially come to conclusion and has been extended with further funding to address constraints to promoting the technology more widely. A training and dissemination model has been developed to reach new villages and involve staff from NGOs and the DAE which will be evaluated, while also providing written and visual materials that can be used to raise awareness and educate extension and end users about rodents. Although the project is continuing, nevertheless, there are some important conclusions that can be made at this stage.

- All Bangladesh farmers and households in the villages we worked with recognised rodents to be a serious pest and experienced a good deal of treatment failure when they tried to control rodents in their crops or houses.
- Knowledge about how to control rodents effectively by farmers and households is generally very poor, resulting in treatment failures that lead to widespread apathy and acceptance of rodent pest damage.
- Men and women are actively involved in rodent control, women at the household level and men in field crops.
- Although, the project has begun a process of collecting information on rodent damage to rice crops, food storage, and potential transmission of gastro-enteric and haemorrhagic diseases, quantitative data on the impact of rodents on people's livelihoods is still required. This process must continue to build up a body of evidence that can be used to convince farmers, providers of agricultural and health extension, and donors on the need to manage rodents and to develop cost-beneficial management strategies. Evidence currently suggests that rodent pest presence is high in households where food is stored openly resulting in very high contamination and loss levels, promoting high rodent numbers inside human dwelling areas, and increasing the risk of disease transmission through proximity. Current methods for measuring damage in rice fields using random sampling are not appropriate for measuring rodent damage which is highly clumped and variable. Damage assessment methods such as Adaptive Sampling should be evaluated for increasing the accuracy of rodent damage assessments to rice crops.
- Good quality and effective rodent traps are not widely available in Bangladesh. Although excellent traps are internationally available, it would be more cost-effective to encourage commercial production locally in Bangladesh. The project team has made some efforts to encourage this, but the issue requires extensive follow-up to identify commercial interest.
- More effective application of rodent management tools is possible. Rodents can be effectively controlled in a cost-beneficial and sustainable way in the rural agricultural situations found in Bangladesh. One challenge for the future is to more accurately assess the costs of doing nothing about rodent pests. People often complain about the costs of doing rodent control, but fail to appreciate the costs of rodent damage to their livelihoods, the health of their families, and reduced profitability of their farms.
- Improving rodent management will be increasingly driven by increasing our knowledge about rodent ecology, behaviour and anthropogenic interactions.
- Scientific and dissemination expertise regarding rodent biology and management is disproportionately low relative to the scale of the rodent pest problems encountered in most developing countries. If left unchecked, rodent pest problems will only increase with agricultural intensification and urbanisation pressures. It is unlikely that rodent pest management can be sustainably improved without continued long-term donor support to research and dissemination institutions to build their capacity and attract young scientists to

the field of applied rodent ecology to understand their localised rodent pest problems and integrate developing country scientists within an international network of rodent researchers.

Biometricians Signature

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:

Name: Professor Charles Krebs
Position: Honorary Fellow and Emeritus Professor, CSIRO Sustainable Ecosystems
Date: 31 March 2005

Appendices

Appendix 1: KAP questionnaire administered to individuals at commencement of project

Rodent Impact and Constraint Assessment
Farmer Knowledge, Attitude and Practice:
Guideline for interview

Date:
Serial No.

DT TN UN V

1. Name of the Respondent / Informant:
2. Address:

3. Sex: 1. Male 2. Female
4. Age:
5. Occupation:
    1. Farmer
    2. Labour
    3. Service
    4. Petty trade
    5. House wife
    6. Others
6. Religion:
    1. Islam
    2. Hindu
    3. Christian
    4. Buddhist
    5. Others
7. Education:
    1. Illiterate
    2. Primary
    3. Secondary
    4. Higher Secondary
    5. Graduate
    6. Madrasa (Religious school)
    7. Adult Education
    8. Others
8. Ethnicity:
    1. From the village
    2. From the locality
    3. From the district
    4. Others:

9. Name of the household head:

10. Sex of the household head: 1. Male 2. Female

11. Number of household member:
    1. Adult male:
    2. Adult female:
    3. Male children:
    4. Female children:
    5. Servant/maid servant:
    6. Others:
    Total =

12. Household income per year:
    1. Below Tk.10000
    2. Tk.10000 – Tk.14000
    3. Tk.15000 – Tk.19000
    4. Tk.20000 – Tk.29000
    5. Tk.30000 and above

13. Building structure (Res. Pattern):
    1. Wall
    2. Clay
    3. Tin
    4. Brick
    5. Wood
    6. Hempen
    7. Bamboo

Roof
1. Tin
2. Hempen
3. Concrete

Floor
1. Clay
2. Concrete
3. Wood

14. Ownership of cultivable land
    1. Yes
    2. No (note: if the ans. is no then ask Q. no.16)

15. Amount of cultivable land
    1. 01 - 49 Decimals
    2. 50 - 99 Decimals
    3. 100 - 149 Decimals
    4. 150 - 199 Decimals
    5. 200 - above Decimals

16. Involvement in sharecropping
    1. Yes
    2. No

17. Amount of sharecropping (in) land
    1. 01 - 49 Decimals
    2. 50 - 99 Decimals
    3. 100 - and above Decimals

18. Amount of sharecropping (out) land

1. 01 - 49 Decimals
2. 50 - 99 Decimals
3. 100 - and above Decimals

19. Information about cultivation:

Rank	Crops	Land Type	When grown	Production Per Decimal	Land under cultivation

20. Information about pest attacking in crops:

Crops	Rank	Pest	Type of damages	Action taken

21.Information about crop storage:

<table>
<tr><th rowspan="2">Rank</th><th rowspan="2">Crops stored at household level</th><th colspan="3">Amount in percentage</th><th rowspan="2">Storage method</th></tr>
<tr><th>Store</th><th>Sell</th><th>Consume</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

22. Information about food storage pests:

Crops	Rank	Pest	Estimated loss in Storage period	Action taken

23. Information about livestock:

Rank	Livestock	Number kept	Location	Food sources

24. Information about livestock pest problem:

Livestock	Rank	Pest	Type of damages	Action taken

25. Information about other rodent problems:

Rank	Other rodent problems	Estimated loss	Repair cost

26. How you control rat? (Narratives)

27. Do you think your methods of rat control are effective?
1. Yes
2. No

28. Why do you think this?
1. Yield improved
2. Damage reduced
3. Others

29. Do you use chemicals/pesticides?
1. Yes
2. No

30. Do you think they were safe?

Correspondence: Dr Steven Belmain, Email: s.r.belmain@gre.ac.uk

1. Yes
2. No
3. May be

31. For whom chemicals are harmful
    1. Human
    2. Animal
    3. Plant
    4. For all

32. How do you assess rat damage in your crops & household?
    1. Unearthed plants/seeds
    2. Visual observation
    3. Droppings
    4. Burrows
    5. Tracks
    6. Damaged plants
    7. Cut tillers
    8. Cut seedlings
    9. Other

33. Rat control must be carried out
    1. Yes
    2. No
    3. May be

34. Rat damage can severely decrease rice yields/production?
    1. Yes
    2. No
    3. May be

35. Rats can be controlled?
    1. Yes
    2. No
    3. May be

36. Rats can only be controlled if farmers work together with other farmers
    1. Yes
    2. No
    3. May be

37. Rats should be controlled at all stages of the growing season
    1. Yes
    2. No
    3. May be

38. Do rodents cause any health problem?
    1. Yes
    2. No
    3. May be
    4. Do not know

39. Information about rodent caused health problems

Rank	Types of health problems	Victims	What happens

40. Do you cover your food?
    1. Yes
    2. No

41. From where drinking water is obtained?
    1. Pond
    2. Tube-well
    3. Hand dug well with cover
    4. Deep bore pump well
    5. Hand dug well with no cover

42. How drinking water is stored?
    1. In plastic water pot with screw cap lid
    2. In plastic bucket with no lid
    3. In clay pot with lid
    4. In brass or metal pot with lid
    5. In brass or metal pot with no lids

43. Is water cleaned in any way?
    1. Yes
    2. No

45. If yes, mention please
    1. Filtering
    2. Alum using
    3. Distillation
    4. Other

46. Are there other types of rodents around you, which do not cause problems for you?
    1. Yes
    2. No

47. Do you have any additional ideas about how rodent problems could be reduced/solved?
    1. Yes
    2. No

49. If yes, mention please:

50. Do you use trap for rat control?
    1. Yes
    2. No

51. How?
52. Where?
53. When?
54. Do you think it is effective?

Additional Notes:

Appendix 2: Summary of key findings from farmer group discussions

Knowledge, attitude and practices about rodents and their impacts

The general consensus is that rats do more harm to homesteads than the agricultural fields. Villagers took different initiatives to minimize the damage caused. The major points raised are summarised below:

- We do not know how many kinds of rats are there.
- Someone said," There are three kinds of rats in the village'
- Other one said," I saw a large rat yesterday in the field. That rat drove me back".
- A kind of rat which can climb trees.
- There are other rats which stay in the thatched roof of the house
- Some rats make holes in the household food stores and carry away paddy.
- Destroy paddy in the field
- Cause harm to the seed plot
- Destroy wood furniture
- Spoil fruits of the garden
- Carry away the hens, eggs etc of the house.
- Cut the book and clothes
- Carry away fry fish removing the pot cover
- Cut wires electricity
- Take away foods by cutting plastic containers.
- Do a lot of harm to coconut wood tree.
- Make holes in costly blankets of homesteads.
- Cause serious harm to various items of a stationery including soaps, biscuits etc.
- Use old gourds as traps.
- By blocking bricks and brick pieces into the rat holes.
- By using broken bottle glass into rat holes
- By rearing cats. They opine that cats are the best means of controlling rats and they live on rats.
- By pouring boiling water into the rat hole
- By using poison
- Since using the new snap traps, the damage of rats is now within tolerable level
- Other one said." If rats spread diseases, it should be eliminated. But I am not sure whether rats spread diseases.
- There are five species of rat in our villages, field rats are big in size, some tree rats are also big in size and some are small in size.
- Rat can swim so that they can easily enter to the flooded crop field and make loops by the cutting the crops.
- Rat does not follow the straight line; they always move in angle to enter into their burrow.
- Rat has four teeth and they are fond of cutting and damaging every thing. Mice are small in size and like to live in congested and dirty environment.
- Rat is harmful for every thing- food, crops, vegetables and houses.
- Rat can make a great loss and they can turn the full storage rice into half.
- When the fields are under water then rat damage is less and rat damage is high during the dry season.
- During the post harvest time the rat attack in our houses increases.
- And during the rainy season the field rats come towards our houses.

Pest management

- In our village there are lots of harmful insects.
- The insects cause serious damage to paddy.
- The paddy plants wither away.
- The caterpillars destroy the field of cauliflower, cabbage and vegetables.
- The caterpillars damage the potato fields.
- In the paddy field one kind of insect harmful for that turns paddy black.
- We use some insecticide such as *Malathion, Tilt*, and *Basudin*
- Many people use ash against insects
- Many people set up replica of human body in the field to deter rodents.
- Lanirat is bought to kill rats
- Poisons are bought in the market and mixed with wheat powder to kill rats

Constraints in agricultural production
- In agriculture the main obstacle is scarcity of land and it's fragmentation.
- There are some problems to produce good seeds.
- Rats spoil the quality of vegetable garden.
- Many people have no oxen for cultivation.
- Beside oxen a lot of time is also required for maintaining crops.
- Many farmers can not remove weeds properly and can not afford fertilizer and insecticides.
- Irregular water supply affects production
- Rats damage seed beds.
- Before harvest, the rats take away the paddy into holes.
- Fertility of the land affects the agricultural production.
- Water damage to our production such as scarcity of water, lack of rainfall or too heavy rainfall,
- Draught, storm, hailstorm, and other natural calamities are also constraints for the agricultural production.
- Various types of pests are major constraints for agricultural production, including rats and insects
- Insect attack in the crop field is one of the constraints of agricultural production.
- Rat is a main constraint in agricultural production. It damages and cuts vegetables like sweet gourd, tomato, bean, potato, and fruit like mango, guava. coconut and crops like rice, wheat etc.

Ethno-ecology-animals
- Rats have no home. They stay in holes.
- Live in pond side.
- Live in coconut trees.
- In rainy seasons the black rats of the field take shelter in our home.
- Other one said, "Making with straws and leaves rats stay in many places".
- They stay in vacant places in homesteads and continue their reproduction.
- Generally rats stay in high places in rainy season.
- House rat bred through out the whole year.
- House rat/ mouse generally live in the place under the roof with their children.
- Rat make burrow in the field walls and live there.
- House rat live in the houses and under the ground and make burrow on the pavement and wall.
- Some make holes in the pond wall and live there with family.
- They move from one place to another place in search of food and also for find their mate.
- Sometime they also move one place to another place for searching of better shelter.
- Rat likes to live in the dirty and unhealthy environment.
- They also live beneath the roof.

Hygiene risks in food preparation
- We cook food in mud store.
- The hearth is outside living quarters and very often so that dogs and rats can enter into it.
- After cooking many of them keep food in meat safe and many keep food in open places.
- Many times rats spoil food by cutting meat safe net.
- Many participants say," They spoil the food".
- Dogs, ducks, hens etc, also discharge their waste around the cooking spot.

Population dynamics
- Rat breeds young after one month.
- Each rat breeds seven.
- Rats move from one house to another for searching foods.
- Rats breed all the year round.
- Rats increase their breeding during the harvest.
- During the rice harvesting time they increase their number through reproduction.
- Mouse can breed through out of the whole year but rats which are big in size take more times for reproduction.
- During the *Boro* season the annoyance of rat is comparatively low, because then most of the fields are in under water.
- After the crop harvesting rat come towards our house to eat and steal our stored rice.
- Mouse never goes to the field. They always stay in the house but field rats are fond of living in the fields. Rats generally live in the high places and beneath the roof.

- House rats always live in the houses. When, the rice is in the ripening stage then all rat rush in to the fields.
- During the crop harvest the number of rat increases. In rainy season they come to our houses from the field. Then they damage more, make burrow in our rooms wall and in floor.

Cropping cycle and seasons
- The cropping cycle has changed due to weather and high quality crop seeds.
- Most plant two rice crops per year using a combination of rain water and irrigation from the Gomti river
- Paddy grown in plenty during the summer.
- 18 to 20 mounds pf paddy are grown in 40 decimals of land.
- In winter season the farmers grow cabbage, cauliflower, radish, bean, potato, gourd, sweet pumpkin, tomato, bringer, pepper and various vegetables.
- Villagers are self reliant in the sphere of vegetables but not in paddy.
- In rainy season many times the harvest is hampered due to drought.
- There are some pieces of land where we produces rice three times in a year that is the *Aus*, *A man* and *Boro,* but these types of land is rare; generally we produces rice two times in a year.
- We produce, bean and various type of gourds and tomato. In winter we produce cucumber and *chichinga* and in summer we produce chilli.
- We also produce mustard and wheat in winter.
- Besides the rice production we also produce other crops and vegetables like tomato, eggplant, bottle gourd and pumpkin.
- We produce various types of gourds, cauliflower and cabbage and other plants and crops during the various time of the year.
- According to Bengali month we plant and produce crops, in March/April we grow various type of gourds, cucumber in may we plant pumpkin. In August /September we grow sweet potato, biter gourd and other vegetables in our field and home garden. In February / March we grow *til, kolai*, wheat etc. and in our area wheat cultivation is rare.

Rodent diseases and transmission
- People say disease means inability to eat any food.
- Diarrhoea occurs, abundantly spreads every where.
- Jaundice is a common disease.
- We do not know that whether rats spread diseases or not.
- Some one said rats cause disease like plague.
- Some one said rats emit waste and urine in our rice stores so this may cause many diseases.
- We do not cover water and salt pots.
- In summer, cooked food is kept open otherwise it may be spoiled due to excessive heat.
- Plague never breaks out in an epidemic form in the village.

Environmental impact on pests
- The control of insects has led to the ground soil becoming harder and less fertile
- Disturbance by insects increases due to the cloudy state of the sky.
- One kind of insect cut down the upper part of the paddy plant.
- Fishes and snakes etc die due to use of insecticide.

Historical climate and seasonal changes
- Floods hardly occur in this area, the last taking place 30-40 years ago by damage the river embankment
- Seasonal changes do not happen due to climate.
- Agricultural activities are regular every year.
- Summer and winter arrive earlier and we do not see other change in the climate.
- Season and climate remain the same, no change observed.
- The weather has changed, so there is some impact of the seasonal change on our crops and plants are affected.
- Now the rainy season is comparatively shorter than the past years. Rainfall is also less in amount and temperature is rising. Due to lack of rain water the growth of jackfruit, mango and other fruits are not satisfactory.

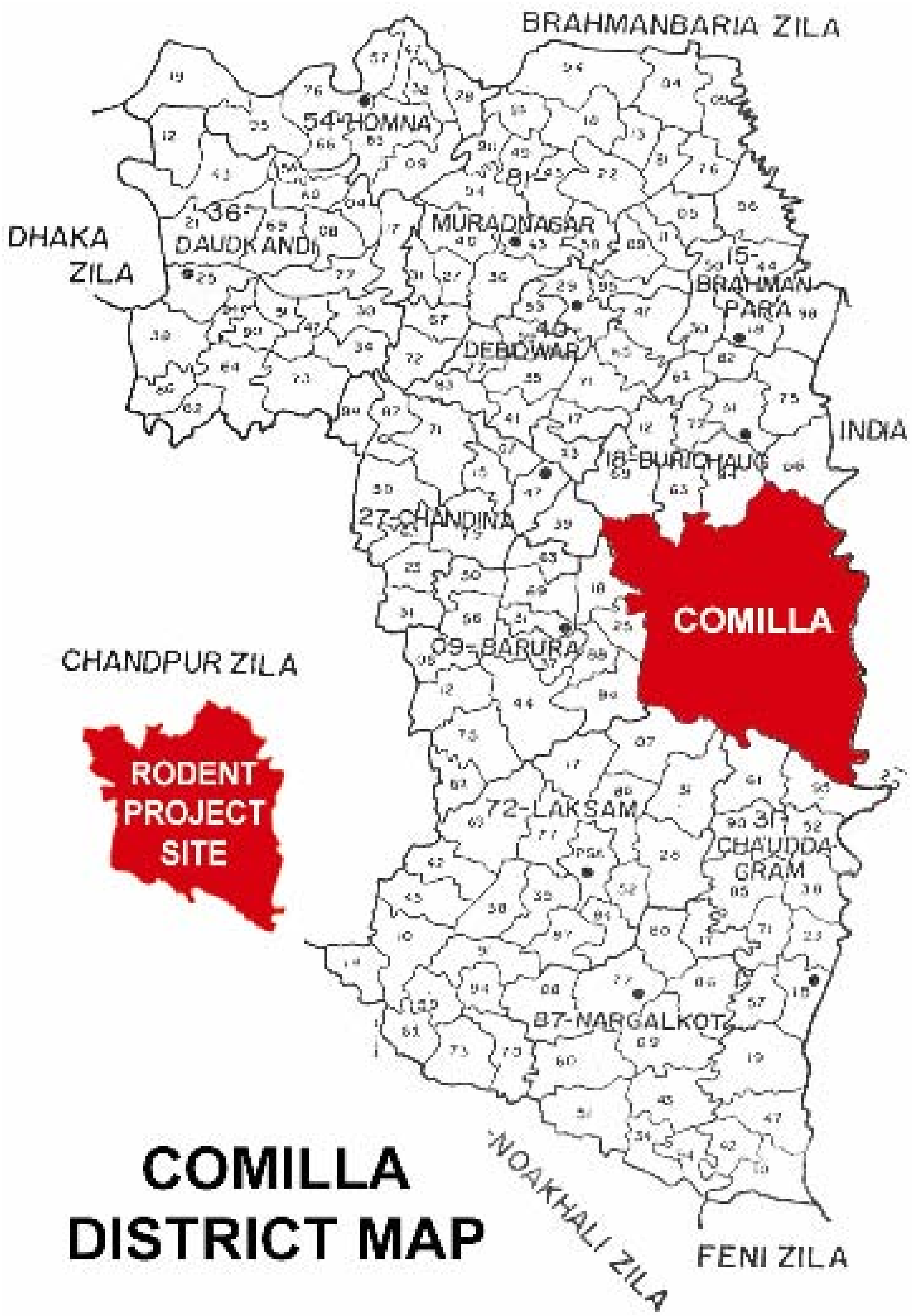
General folklore collected from villagers about rodents

Once upon a time, there was a man who was curious to know who is the most powerful in the world. Therefore, he left home and wandered through the world to find the most powerful. First, he found the fire and asked him “fire, I see you are so powerful because you burn everything and your power is so destructive, then would you please tell me is there anyone who is more powerful than you?” Fire replied “water is more powerful than I am, because water can make me calm and inactive.” Then the man asked water “is there anyone who is more powerful than you are?” Water replied “wind is more powerful than I am because wind can carry me and drop me anywhere he will.” Then the man found wind and asked him “wind, would you please tell me who is more powerful than you are?” Wind answered, “mountain is more powerful than I am because it is an obstacle for me. I could not overcome it and compelled me to change my direction.” At last, the man found the mountain and asked him “would you please tell me is there anybody else who is more powerful than you are?” Then the mountain replied “I think rat is more powerful than I am because it can make a hole in my body and can destroy me”.

A poem about rat destruction

The most destructive rat
Cut and destroyed the book of Mahabharat (book of Hindu mythology)
When the scholar found the destroyed book
He shouted “ah rat! What you have done!
You cut my book and sharpen your teeth,
But why this kind of destruction?
When there are so many things on earth
On which to cut and sharpen your teeth?”

Appendix 3: Maps of research locations


BRAHMANBARIA ZILA
DHAKA ZILA
INDIA
CHANDPUR ZILA
NOAKHALI ZILA
FENI ZILA
54-HOMNA
36-DAUDKANDI
MURADNAGAR
15-BRAHMANPARA
DEBIDWAR
18-BURICHANG
27-CHANDINA
09-BARURA
COMILLA
RODENT PROJECT SITE
72-LAKSAM
31-CHAUDDAGRAM
87-NANGALKOT
COMILLA DISTRICT MAP


FENI
DISTRICT MAP
INDIA
INDIA
LEGEND
RODENT
PROJECT
SITE
COMILLA ZILA
CHAGOLNIYA
NOAKHALI ZILA
29-FENI
PARSHURAM
SONAGAZI
CHITTAGONG ZILA