

Synthesis and Conclusions

'In order to achieve long term control (of rodents), the dynamics of the pest population must be taken into account. Methods that affect population dynamic processes (birth, death, immigration, emigration) need to take account of density dependence, which regulates many animal populations. The spatial dynamics of the species concerned must also be considered.' — R.H. Smith (1994)

In this chapter we return to the objectives of this Technical Report and synthesise the key points that have emerged from our review of the literature on rodents in Southeast Asia and visits to research institutes in Indonesia, Laos, Malaysia, the Philippines and Thailand.

8.1 National Strategies for Rodent Control

The Philippines in the late 1970s and early 1980s developed a commendable national strategy for rodent control which was part of the national rice program, MASAGANA 99. The infrastructure was in place to support this national program through the instigation of a National Crop Protection Center, the provision of training and research supervision from staff of the Denver Wildlife Center, and the development of a field network of pest control officers coordinated through the Bureau of Plant Industry. Unfortunately less than 15% of rice farmers adopted the recommended control practices. Better adoption rates may have followed if there had been a more concerted extension program and more consideration of what growers would adopt. The fact that growers were unlikely to act if rat damage was less than 20% (Dizon 1978) is an important lesson. Of further concern are the developments over the past 5 to 10 years. There has been a general demise of the infrastructure supporting the control program, the loss of trained personnel and cessation of research on rodent pests.

Although the Malaysian national program is not as well defined as the Filipino program, the problem of farmer apathy and preference to use inefficient chemicals which kill rats at the site of poisoning rather than use recommended anti-coagulants which do not (highlighting the importance of visual cues) evokes a similar theme. Both situations highlight the

imperative to consider the cultural and social background of the end-users of a management program.

Cultural and sociological influences are important aspects of any pest control program whether it be directed at invertebrates (Norton and Heong 1988) or vertebrates (Norton and Pech 1988; Posamentier 1990). Rodent control in Asian countries is no exception. In an integrated rodent management program implemented in Indonesia as part of the FAO inter-country program of integrated pest management, two key factors were identified. One was the support and active involvement of a village leader or another prominent person. The other was the active participation of a large group of villagers in the coordination of management operations (van Elsen and van de Fliert 1990). Unfortunately, this program lacked another key element — the involvement of a vertebrate biologist experienced in rodent management.

In Table 8.1 we present comparisons of the relative magnitude of the rodent problem and the current infrastructure for managing these problems in the five countries we visited. Apart from the FAO program, which was not evident in our visits to West Java and South Sulawesi, Indonesia has no semblance of a national or regional program to control rats. The situation is the same in Laos. The Philippines still has a national rodent control program but its adoption rate is low. Malaysia and Thailand have loosely structured programs. In the case of Malaysia there is no economic imperative to reduce rodent losses at the national level. The Malaysians appear to be primarily concerned with dampening the high variation in losses caused by rodents.

Curiously, the future development of an effective national rodent control program is probably brighter for Indonesia than the other countries we visited because high and middle ranking officials plus

Table 8.1 Comparison of degree of rodent problem, current infrastructure for control of rodents and gaps in knowledge in the five countries in Southeast Asia.

Country	Problem	Infrastructure	Knowledge of rodents
Indonesia	high (17% per year)	limited	low to medium
Malaysia	low (<5% per year), high in places	good	medium to high
Laos	high — upland low — lowland	minimal	minimal
Philippines	moderate, high in places	once very good, now limited	medium
Thailand	moderate, patchy	good	medium

village leaders recognise the magnitude of the problem caused by rats, and their will to address the problem is growing (see Table 8.2).

8.2 Ecology of Rodent Pests — the Gaps

An understanding of the population dynamics, habitat use and factors that influence breeding, survival and movements of rats is essential for the development of an effective, economic and sustainable management program. Compared to the temperate regions of the world where changes of season have a marked influence on the population dynamics of rodents, seasonal effects are less pronounced in the tropics. It is not surprising therefore that pest species of rodents tend to cause chronic problems in the tropics. However, changes in agricultural practices, such as increasing the number of rice crops produced per year or increasing the amount of arable land in a region, can rapidly lead to marked increases in the magnitude of rodent problems. There have been well documented cases of this occurring in the Philippines and Malaysia. Also, the recent rat plagues in Laos and Vietnam could be related to changes in the management of rice crops.

Individual variation and spacing behaviour

Whatever the direct cause, we know that some species of rats respond well to broadscale cultivation of rice crops. We also know that the onset of breeding of rats is linked to specific stages of development of the rice crop. These are population responses. Little attention has been paid to why

individuals respond differently. In studies of small mammals in non-tropical regions it is often these individual differences that provide the essence of understanding how populations are regulated or limited (e.g. Lidicker 1975; Krebs 1985; Cockburn 1988). Factors that influence spacing behaviour and mating systems have been of particular interest (e.g. Lambin and Krebs 1991).

Landscape ecology

Knowing what influences spacing behaviour is important also for understanding how and why rats use different habitat patches. In the tropics, where land holdings of less than 1 to 2 ha are the norm, land use patterns of humans generally result in a patchy landscape. We therefore need to know how these population patches are interconnected by the migration of rats, the relative demographic importance of each habitat patch and how these patches in combination influence the overall population dynamics of the species we are trying to control. This metapopulation approach to rodent control is occasionally discussed (see Smith 1994) but good field studies of tropical rat populations are lacking.

Community dynamics

At the next level up, we need to know what other species of rodents are living in the various habitat patches that occur in, and adjacent to, rice crops. If control operations effectively manage a particular rat species are there other species that may attain pest status? For example, in the Philippines, *R. argentiventer* is the major pest species on some islands. *R. r. mindanensis* is present on these islands

Table 8.2 Comparison of each country's interest and ability to collaborate in an ACIAR project on rodents focused on habitat use, population processes and disease.

Country	Interest ^a	Standard of Resource		Commitment
		Physical	Human	
Indonesia	high	limited to moderate	limited to moderate	3 scientists (entomologists) 2 technicians
Malaysia	high	moderate	high	1 scientist (mammalogist) 1 technician
Laos	high	poor	poor	unskilled
Phillipines	low	limited	limited	none
Thailand	high	moderate	moderate	uncertain

^aInterest expressed by high ranking government officials — not just scientists.

but is not considered a pest. On islands such as Luzon where *R. argentiventer* does not occur, *R. r. mindanensis* is an important pest to rice growers. A similar story is emerging with *R. r. diardii* which is now considered a pest in some oil palm plantations in Malaysia where *R. tiomanicus* has been controlled. Apparently, *R. tiomanicus* usually excludes *R. r. diardii* from oil palm plantations (Y. M. Lam, pers. comm.; Wood 1994).

Effect of disease on rodent population dynamics

Diseases of rodents are covered in detail in Chapter 6. There have been virtually no field studies in Asia to systematically survey the diseases present in rat populations, let alone consider the effect of specific diseases on the population dynamics of rats.

Effect of predators on population dynamics

The potential of vertebrate predators to control populations of rodents is reviewed in Chapter 8. Predators are likely to have a sustained effect only in combination with other control measures that maintain rodent populations below certain densities. Promising results have been reported through the combined use of predator nest boxes and rodenticides in oil palm plantation in Malaysia (Smal et al. 1990). Whether similar results can be obtained for controlling rat populations in rice fields is open for investigation.

8.3 Ecology of Rodent Pests — Research Priorities

There is still much to be learned about the population ecology of the major rodent pest species in

Southeast Asia. The relative knowledge available in each country on the biology of these species is summarised in Table 8.1. Malaysia has made the best progress through detailed studies of the ecology of the wood rat *R. tiomanicus* in oil palm plantations and good studies on aspects of the population ecology of the rice field rat *R. argentiventer*. Even in Malaysia, however, there are major gaps in our knowledge of the population dynamics and habitat use of the rice field rat. A better understanding of processes that influence increases in rat populations and that limit the growth of these populations, will provide a strong basis for cost effective and sustainable strategies for managing rodent pests. Therefore a first priority is to develop high quality, replicated, descriptive studies of the population dynamics of rat populations. Of particular interest are factors that limit breeding, reduce survival and influence dispersal. This would require monthly live-trapping studies of rats at designated trapping sites and regular kill samples at adjacent sites to assess breeding status and litter sizes.

The study of habitat use through mark-release-recapture studies and radio-telemetry is a high priority for the reasons outlined in section 8.2. Eventually, attention needs to be directed at rodent species of secondary importance, to anticipate which, if any, may become a greater problem after the main pest species has been effectively managed.

Also of interest are the interactions between diseases (micro- and macro-parasites) and rodent populations. Such studies would require an enormous input of personnel and time. As a first step, the focus should be on identifying which murine diseases are endemic to particular regions. Where possible these surveys should include samples taken

at different stages of the seasonal dynamics of rat populations. These studies would also provide essential information on potential biological control agents.

Predator studies are not to be discouraged but we do not see them as a high priority given the resources required to do well designed predator-prey studies and the low likelihood of predators being a major regulating factor of rats in rice fields

Once the descriptive phase has been completed, it is then essential to develop replicated field experiments to evaluate critically the key factors postulated to influence population processes. Ideally, these should consist of experiments that compare different manipulations of a factor. This replicated experimental approach is basic to our development of effective wildlife management but has been rarely used in previous studies of rodent pests in Southeast Asia.

Social and cultural factors have been identified as important for the development of management strategies of rodents. During the descriptive stage of population studies these factors need to be noted. Whereas during the final development and implementation of control strategies, social and cultural factors become an integral part of the research program.

8.4 Rats as Vectors of Disease

In addition to the economic benefits that can be derived from the control of rodent pests there are also important public health considerations for rodent pest management. As vectors of disease, rodents are second to no other mammalian group, and carry a wide variety of viral, bacterial and parasitic diseases (Chapter 6). As humans and livestock are in regular contact with rodents — through rodent control activities, (unintentionally) shared housing arrangements and the use of rodents as food by both humans and their domestic animals — the potential for transmission of zoonotic disease is high. There is however, only a small body of literature examining the importance of rodents as carriers of zoonotic disease in Southeast Asia and much of this work is restricted to determining whether or not rodents are infected with certain diseases. There is little real investigative work into the exact role that rats play in the epidemiology and transmission of human and animal disease. It must be assumed, however, that rodents are an important link in the transmission of many diseases and that they also act as important reservoirs for disease thus frustrating many attempts of disease control. The imperative for rodent control on the basis of the control of zoonotic disease must rank very high.

8.5 Concluding Comments

A clear message that came through from our visits to research groups in Southeast Asia and from reading the literature, is that there is little exchange of ideas, of research progress or of the challenges that respective countries or even regions within countries, face in their efforts to reduce the depredation of rodents in agricultural areas. We hope that this report will begin to break down the barriers to information flow. An important role for an ACIAR funded project on rats in the region would be to promote communication between those involved in efforts to manage rodent pests in Southeast Asian countries.

Throughout this report we have highlighted the generally poor infrastructure and scarcity of good quality educational courses for both scientists and technicians in rodent management. The one area that has been covered reasonably by most countries is the technical detail associated with the application of chemicals, although the knowledge of how to use these chemicals effectively under field conditions varied considerably between countries. We have not addressed chemicals and their use in any detail because there are sufficient publications and texts on rodenticides and their use (see Meehan 1984; Prakash 1988; Buckle and Smith 1994), and better qualified people than us in this area of rodent control. However, the general interest of scientists and government officials that we spoke to was not in the prospects for rodenticides, but the prospects for non-chemical methods. There was a general acceptance of the need for a better understanding of the population ecology of rodent pests and the processes that influence the population dynamics of these animals. It was in this area that we received the most requests for assistance in training because of inadequate levels of education available in the affected countries.

Training of scientists from Southeast Asian countries in the areas of rodent ecology, epidemiology and approaches to biological control would be another key responsibility for Australian scientists involved in an ACIAR-funded project. It is the development of expertise in these areas that hold the key to achieving:

- (i) less reliance by farmers from developing countries on chemicals for controlling rats;
- (ii) management strategies that are sustainable and environmentally benign.

Our research for this report has provided the clear message that rats are the number one preharvest pest

of rice crops in Southeast Asia. At the moment the major concern is the loss of income from the depredation caused by rats, the exceptions being the localised heavy losses which result in severe hardship for rural people. With the likely addition of another billion mouths to feed in Southeast Asia by the year 2025, a loss of 10% of the crop to rodents will add considerably to the anticipated shortages of food for humans and will inevitably lead to loss of life. Add to this the diseases that rodents transfer to humans and their livestock, and the challenge to control the depredation of rodents becomes an even greater imperative. An imperative that can be embraced only through the advent of a greater will by Asian governments to tackle the problem through the development of better trained specialists in rodent research and management, and the promotion of research beyond the routine assessment of the efficacies of rodenticides.

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Appendix

Rat Control in Rice Fields

Adapted from 'The Philippine Recommends for Rice — 1976' and specially reproduced for the MASAGANA 99 rice Program.

JOINT RECOMMENDATIONS OF THE BUREAU OF PLANT INDUSTRY; THE COLLEGE OF AGRICULTURE, UNIVERSITY OF THE PHILIPPINES AT LOS BAÑOS; THE RODENT RESEARCH CENTRE¹; AND THE PHILIPPINE-GERMAN CROP PROTECTION PROGRAMME²

For many years, rats have been a persistent problem of rice growers throughout the Philippines. Field damage by rats costs the nation millions of pesos every year (Figure 1).

Nearly all rice farmers suffer some rat damage, although extent of losses vary. Based on cut tillers at harvest, average losses are approximately four per cent. Each year some farmers suffer very heavy damage, even total losses at times. Fortunately, such occurrences are rare. A typical hectare of rice land may have an average of 20 to 200 rats, but some areas adjacent to swamps, marshes or waste area may have as many as 10000 rats per hectare.

Your chances of having heavy damage (over 10 per cent) on your farm are less than 1 in 10. If you plant near areas where rats can live between crops (for example, coconut groves, wasteland, or irrigation canals), your chances of having heavy damage are usually greater. Even under these conditions, the baiting method outlined in the following pages has been consistently successful.

Rat control is an essential investment, which requires money, time, and effort. Under most circumstances, only the equivalent cost of approximately one cavan of palay per hectare (40 to 60 pesos) is enough to protect your crop.

Kinds of Rats

Approximately 30 kinds of rats occur in the Philippines. Only two, *Rattus rattus mindanensis* and *Rattus argentiventer*, are serious pests in major rice growing areas. These two types are difficult to

recognise separately. In some regions, *Rattus exulans* and *Rattus norvegicus* attack rice crops. It is not possible, at present, to recommend different control measures for the different species. Most rat control methods affect whatever species is living in your field.

General Measures

Several general agricultural practices may be helpful in reducing potential rat problems. Cutting weeds along dikes and canal banks and adjacent waste areas, particularly several weeks before transplanting and during the early stages of rice growth, removes cover which rats need to survive. Transplanting at about the same time as your neighbours may reduce your chances of heavy damage. Fields maturing much earlier or much later than the surrounding ones often have very heavy rat damage and emergency measures at this stage are usually not successful. Killing rats at any time by any method may be helpful, but for the farmer who wants to protect his crop, there is no substitute for continuous rat control throughout the crop period! In areas with extremely high rat populations, baiting with acute poisons before seedbedding or transplanting, is also desirable.

Sustained Baiting

Chronic poisons provide a means of carrying on continuous rat control with very little cost and

¹ The Rodent Research Center is a cooperative research and training center supported by the bureau of Plant Industry, the University of the Philippines at Los Baños, the National Economic and Development Authority, the National Science Development Board, the national Food and Agriculture Council, and the U.S. Agency for International Development.

² The Philippine-German Crop Protection Programme is an integrated crop protection program of the bureau of Plant Industry.

labour compared to some of the other methods. These bait materials are used at low concentration, so the amount of chemical is small. Rats must eat poisoned bait every day for several days, usually less than a week before they are killed.

Because the symptoms develop slowly over a period of days, rats usually die in their burrows or in other protected areas. Many people like to count dead rats after poison baiting. This usually is not possible with chronic poisons. If bait is being consumed and you replace it regularly, you are killing rats! Your efforts will be rewarded by reduced damage. After 10 to 12 weeks of baiting you can expect to have reduced the rat population in and around your rice farms so that you can be assured of a good crop.

Costs are Low

The major costs of sustained baiting with chronic toxicants are for the bait carrier and for the time required to visit the bait stations regularly. Approximately 10 kilos of bait material is the most that is required under usual conditions to protect one hectare of rice for the entire crop. The labour required is approximately 1 man-hour each week throughout the crop. Many suitable chemicals are available. The costs of chronic toxicant, enough to treat 10 kilos of bait, range from 1.50 to 15.00 pesos depending on the material used, the source of supply, and the area of the country.

Materials to Use

Chronic toxicants require bait material, a chemical concentrate and bait containers. Most grains can be used for bait material: choose one which is available or can be obtained at low cost in your region. Many farmers have obtained good results using low quality milled rice or rice shorts. Do not use rough rice (palay), because rats remove the hulls and do not ingest much of the toxicant.

Many chronic toxicants are available in the Philippines as concentrates. Ratoxin, Racumin, Tomorin, Diphacinone, and Liphadione are examples of commercial chemicals which are available at agricultural stores. Prices and package sizes vary considerably, but all of the materials have similar action. When comparing prices, note that some concentrates can be used to prepare more bait material than others. To determine the actual cost of chemical in a finished bait, divide the retail cost of the concentrate by the number of kilos of bait to be treated. Read the label carefully so you can follow the manufacturer's instructions.

Local materials can usually be obtained at little or no cost for making bait stations. Sections of bamboo with nodes at middle or ends, one litre

cans, or discarded one quart oil cans, opened at both ends, make good containers. Under very wet conditions, it is sometimes desirable to use larger bait stations which afford maximum protection from the weather. In areas with many rats, it is important to use enough stations to allow all animals easy access to bait.

Procedures

It is important to have bait material available to all rats occupying your field from planting until rice grains mature: Because only a limited number of rats can feed at a single bait container, the number of containers must be provided in relation to the number of rats damaging your fields.

The following methods, tested under Philippine conditions, will help you relate the intensity of your control efforts to the potential damage to your crop. These procedures are recommended as a guide for your operations.

1. Mix the recommended concentrate with the bait material. Using more chemical than recommended does not improve control and will only increase your expense.
2. Select five baiting locations for one hectare of riceland to be protected. The locations should be at least 50 metres apart for good coverage. Containers can be placed on or along dikes, or supported above water level in the paddy. Other good locations to place bait containers are dike intersections, canal banks or old threshing mounds.
3. Begin baiting as soon as your fields have been transplanted. Place one container at each location and put six tablespoons of bait inside. After three days, check the bait containers. If all of the bait has been eaten at one location, place two additional containers and place six tablespoons of bait in all three, check again in three to four days. If the bait is gone, place three additional containers at the locations where this happened and maintain approximately six tablespoons of bait in each.
4. Continue to check the bait containers twice a week. If rats continue to consume most of the bait at some of the locations, place increasing amounts of bait in each container. A one litre can will hold up to 18 tablespoons. Try to anticipate increases in consumption so that bait will be left in the containers each time you check; add additional full containers if necessary. This is important. If bait is not available

after rats have learned to come to the stations, there may be heavy feeding on nearby plants.

5. Remove and replace bait that becomes mouldy or excessively wet.
6. Because the few remaining rats, less than ten per cent of the original population, will prefer the developing grains to the bait, baiting may be stopped at least two weeks before harvest unless bait consumption remains high. When bait consumption begins to decline, some of the stations at each point may be removed.

What to Expect

Usually, bait consumption will increase rapidly sometime during the period three to eight weeks after transplanting. This is the period when rats are moving into your paddies. Do not be alarmed by this rapid increase. Continue to replenish the bait and consumption will generally level-off or decline. If your neighbours are also practicing rat control, the increases will not be as great. When rice heads mature, bait consumption usually drops off sharply because there are only a few rats remaining. Although the remaining rats concentrate their feeding on grain heads, pre-harvest damage should be minimal. Remember that chronic toxicants work differently from other materials. Don't become discouraged if you don't find dead rats; they die in their burrows.

Safety

All agricultural pesticides are poisons and should be used carefully. Store pesticides in clearly labelled containers out of reach of children and

pets. Do not use mixing cans or spoons used for measuring pesticides for any other purpose. Do not breathe the dust or vapours. Do not eat, drink, or smoke while handling chemicals. Wash your hands thoroughly each time you finish your work.

Chronic toxicants are relatively safe compared to other pesticides. They cause breakdown of the blood clotting process and animals usually die from internal bleeding. If treated bait or concentrate is accidentally eaten, take the person to a doctor or clinic immediately. Treatment for poisoning with chronic toxicants consists of oral doses of Vitamin K, and in some cases, blood transfusion.

Cooperative Rat Control

When a farmer uses chronic poisons, the protective effects of baiting usually extend outside his farm for as much as 200 metres in each direction. Particularly during the first eight weeks after transplanting, rats from peripheral areas will be attracted to bait containers. If your neighbours also practice sustained baiting, your results will be improved and everyone's costs will be reduced.

Technical Help

These recommendations have been approved for implementation beginning in mid-1975 under the national rice production program — MASAGANA 99. Farmers qualifying for MASAGANA 99 loans or supervision may contact MASAGANA 99 rice extension technologists or participating banks for additional details. For additional advice on rat control or for help in securing rat control materials, consult a Bureau of Plant Industry pest control officer or MASAGANA 99 rice extension technologist.

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