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A Review of the Biology and Management of Rodent Pests in Southeast Asia

Grant R. Singleton and David A. Petch

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Acronyms and Abbreviations

ABS	Active Barrier System
ACIAR	Australian Centre for International Agricultural Research
AARD	Agency for Agricultural Research and Development , Ministry of Agriculture, Indonesia
BIOTROP	Regional Center for Tropical Biology
BORIF	Bogor Research Institute for Food Crops, Indonesia
CRC	Cooperative Research Centre for Biological Control of Vertebrate Pests, Canberra, Australia
CRIFC	Central Research Institute for Food Crops, Indonesia
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
DFCP	Directorate of Food Crop Protection, Ministry of Agriculture, Indonesia
EFS	Environmentally Friendly System
FAO	Food and Agriculture Organization
HFRS	Haemorrhagic Fever with Renal Syndrome
IPC	Integrated Pest Control
IPM	Integrated Pest Management
IRRI	International Rice Research Institute, Philippines
M-99	MASAGANA 99 (national rice production program of the Philippines)
MARDI	Malaysian Agricultural Research and Development Institute
MORIF	Maros Research Institute for Food Crops, Indonesia
NCPC	National Crop Protection Center,
PCO	Pest Control Officer
PICA	Predict, Inform, Control, Assess (management strategy for rodents)
BPI	Bureau of Plant Industry, the Philippines
PPS	Plant Protection Service
SEWS	Surveillance and Early Warning System
SURIF	Sukamandi Research Institute for Food Crops
UPLB	University of the Philippines, Los Baños
USDA	United States Department of Agriculture
WHO	World Health Organization

CHAPTER 1

Introduction

'World-wide, 3.5 million rats are born everyday. In India, where the human population exceeds 600 million, rats outnumber man ten-fold.' — R.L. Semple (1982)

Rodents are arguably the most important mammalian pest at the global level. This technical report will focus on the impact of rodents in Southeast Asia where rats have been identified as either the most important (Geddes 1992) or one of the major constraints to agricultural production (Grist and Lever 1969; Hopf et al. 1976; Hoque et al. 1988).

Hoque et al. (1988) identified 29 species of rodents of economic importance in Southeast Asia. Most cause economic losses to crops pre- or postharvest. Some however, are of importance simply because they transmit disease to humans or to domestic stock. Diseases of livestock will be discussed in Chapter 6. The primary emphasis of the other chapters will be on the economic impact and management of rodents in agricultural areas in Southeast Asia, particularly in rice cropping systems.

The focus on the association between rodents and rice is simply because the staple food of rodents is generally grain, and rice is the single most important food crop in Southeast Asia. The importance of rice to the people in the region is underlined by two facts:

(i) Rice provides 35 to 60% of the total food energy for the three billion people living in Asia.

(ii) More than 90% of the world's rice is produced **and eaten** in Asia (Kush 1993).

The current conservative estimate is that rodents in rice growing regions typically cause annual losses preharvest of between 5 and 15%. The highest reported impact by rodents in Southeast Asia is in Indonesia where around 17% of rice production is lost (Geddes 1992). In countries such as India, rodents cause even higher losses postharvest.

The preharvest losses caused by rodents is a problem dating back hundreds, and probably thousands, of years. The chronic and prolonged nature of rodent depredation has led to a level of acceptance by growers. Many farmers have taken the view that for every 10 rows of grain sown, two are planted for the rats.

This situation cannot be tolerated under current population pressures. Asia's population was 3.1 billion in 1990 and is likely to increase to 4 billion by 2025 (Lampe 1993). This is in a region where poverty is prevalent. To meet the food requirements of Asia's population in 2025 the production of rice will need to increase by 70% (Kush 1993). There is little scope for increasing the area of land devoted to rice production. Indeed, there is likely to be a loss of arable land because of urban encroachment and loss of soil fertility. Given the effect of rats on rice production in Southeast Asia, there is a pressing need to improve the management of rodent pests in the region.

Concern about the damage caused by rats in Southeast Asia, led to a meeting of an expert panel on rodent control in rice crops in September 1990 at IRRI, Philippines (Quick 1990). Two of the recommendations from this meeting were:

(i) More research was required to reduce the use of rodenticides, and incorporate Integrated Pest Management (IPM) principles.

(ii) More research was required on the potential of biological control. Such research requires a multi-disciplinary team of researchers; only one was identified — CSIRO, Division of Wildlife and Ecology, Canberra.

Both recommendations are fundamental to the strategy of rodent management that underpins the research imperative of the Rodent Research Group at CSIRO, Australia (see Redhead and Singleton 1988a; Singleton and Redhead 1989)

Also highlighted at the meeting was the general demise of the infrastructure for training and research on rodent management in countries such as the Philippines which previously had good programs in place. Coupled to this was the fact that approximately two-thirds of the 'rodent experts' at the meeting were either retired, about to retire or no longer active in rodent research. The prospects for progress in methods of rodent management, or in implementing existing management technologies, in Southeast Asia did not look promising.

ACIAR recognised the need for a review of the rodent problem in Southeast Asia and commissioned the authors of this technical report to:

(i) review the national strategies for the control of rats;

(ii) review the ecological data available on the principal pest species and identify the main gaps in knowledge;

(iii) determine the emphasis being placed on ecologically sustainable control of rodents through a reduced use of chemicals;

(iv) review the data available on economic losses caused by rodents; and

(v) identify zoonotic diseases that present risks to humans and commercial livestock.

We were interested also in determining which countries possessed the best infrastructure to accommodate research on biological control — in particular, development of research into sterility caused by immuno-contraception.

This report provides details of our findings. We will be concentrating on the five countries that we visited; Indonesia, Laos, Malaysia, the Philippines and Thailand. In the case of Malaysia, we will be restricting our considerations to Peninsular Malaysia because there is very little published information on rodent pests in Sabah and Sarawak. Some information is given for Vietnam. Although we did not visit that country, we have been able to obtain information on a recent rodent problem and have included this information where appropriate.

The report is not meant to be exhaustive. Rather, the aim is to provide a focus for future research directions on rodent management in Southeast Asia, and to provide a resource for scientists and managers involved in rodent management in the region.

CHAPTER 2

Pest Species of Rodents and Their Impact

'Although damage of 10% (at the district level) may not sound alarming it becomes disastrous if all the rice in one village is completely damaged. I have personally been in such villages during the initial phase of the survey in the Viengkham district. Some farmers visited have not had a rice harvest for two successive years.'
— Walter Roder (pers. comm. 1993 — Lao/IRRI project)

In this chapter, the major rodent pest species, their economic impact, and the crops they effect in Indonesia, Laos, Malaysia, the Philippines and Thailand are reviewed and brief mention made of a recent rodent problem in Vietnam. Less detailed information on rat problems in other Southeast Asian countries is provided in Hoque at al. (1988).

The main pest species of rats in Southeast Asia are the rice field rat, *Rattus argentiventer*, the black rat, *Rattus rattus diardii*, the wood rat, *Rattus tiomanicus*, the Norway rat, *Rattus norvegicus* and the little Malay rat (or the Polynesian rat), *Rattus exulans*. Descriptions of these rats are provided by Sody (1941) and Marshall (1977).

As an introduction to the magnitude of losses caused by rats in rice crops, an overview of economic losses is provided for each of the five countries (Table 2.1). The importance of these losses, and their impact on the economy of each country, are even greater when the size of rice holdings, the percentage of holdings sown to rice and the amount of land devoted to each method of rice production (dryland, irrigated, rainfed, deep-water) are taken into account (Table 2.2). As an interesting comparison, figures for Vietnam have been included in Table 2.2. The rice production of Vietnam increased markedly between 1989 and 1992 (Lam 1993; see Table 2.12). It is now one of the most productive rice growing countries in Southeast Asia.

The average size of rice holdings in each country is of particular interest because rat damage is typically patchy in its distribution. This magnifies the potential losses of individual families. It is not unusual for rural families to experience losses of greater than 50%. Indeed, in some areas losses of up

Table 2.1 Estimates of damage caused by rats to rice crops in five countries in Southeast Asia.

Country	Year	Estimate of annual losses	References
Java Indonesia	1980	US$40 million (regional estimate) (248 000 ha damaged and 160 000 t of rice lost; 17% of rice production)	Indrarto (1984)
Indonesia	1987	US$1 billion (figures were from the Food Crops Statistic Division of Central Bureau of Statistics (1988); estimated loss, assuming 17% damage, was 8.21 million t)	Geddes (1992)
South Sulawesi, Indonesia	1983–1992	US$5 million (figures from the Plant Protection Center, Maros — regional estimate; 16 900 t of rice lost, 16.9% of production)	Ir Shagir (1994 pers. comm.)
Laos	1991	Kip 6.2 million (US$44 000) (cost of bounty) (Luang Prabang Province only)	Onchaum (pers. comm.)
Malaysia	1982	RM 43 million (US$17.3 million) (based on losses of 5% and production loss in 1982 of 87 332 t)	Lam (1982)
Philippines	1975	US$67.3 million (based on losses of 5% in 1975; losses of <0.52% were claimed to be achieved between 1976 and 1980)	Hoque et al. (1988)
Thailand	1989	Bht 6 billion (US$2.3 million) preharvest loss; Bht 5 billion (US$2.0 million) postharvest loss (survey from Thai Office of Agriculture Economics — lowland rice only)	Tongtavee et al. (1990)

Table 2.2 Summary of size of rice holdings (ha), the percentage of holdings sown to rice and the amount of land ('000 ha) devoted to each culture method (after Huke and Huke 1990).

Country	Ave Farm Size	% Sown	Dryland	Irrigated Wet	Irrigated Dry	Rainfed	Deepwater
Indonesia	0.96	37	1486	1295	2895	2112	467
Laos	2.20	86	279	38	6	363	0
Malaysia							
Peninsula	2.10	20	1	218	183	29	0
Sabah	3.40	19	11	6	1	58	0
Sarawak	3.50	30	84	12	1	172	0
Philippines	2.78	39	165	999	839	1393	8
Thailand	4.20	59	241	1251	638	7731	340
Vietnam	0.70	75	407	1565	1616	1201	410

to 100% have been reported. Moreover, losses of these magnitudes may occur over consecutive years as has been observed in Laos (Walter Roder — Lao/IRRI project, pers. comm.), Malaysia (Tuan Haji Embi Yusof, Deputy Director MARDI, pers. comm.), and Indonesia (Achmed Mohammed bin Fagi, Director SURIF, pers. comm.). Therefore average annual losses in production from rats of just 5% for a particular country still present a substantial problem. Our conclusions concur with those of Fall (1990) who reasoned that average losses by rodents have little meaning for individual producers of rice. When farming families in Southeast Asia are so dependent on rice for their annual diet and income, losses of greater than 30% are often devastating. High losses two years in a row can be catastrophic.

The data on economic losses caused by rodents generally lack rigour. The vegetative recovery of rice plants that have had tillers cut by rats, and the changes in the capacity of plants to regenerate as they mature, further complicates estimates of losses (see Buckle et al. 1985; Wood 1994). It is not surprising therefore that estimates of losses caused by rats may vary considerably within a country and sometimes within a local region. For example, a survey in 1982 in Indonesia of 48 randomly selected fields covering 1141 ha indicated that losses were around 17%. This represented a loss of production of 760 t. Official figures from the same area in the same year, but covering 100 000 ha, was 790 t. Official losses were underestimated by 100 times (Buckle 1990). This may explain why the estimate for Indonesia in 1980, which was based on the number of hectares damaged, was so much lower than the estimate in 1987, which was based on the value of the national rice crop and assumed 17% damage by rats. However, it was not clear from the report of the 1980 estimate of losses whether it was confined to specific regions of rice production, or whether it was for the entire country. Therefore in Table 2.1 we have supplied notes on how the estimates of losses were determined.

2.1 Indonesia

2.1.1 Magnitude of the rodent problem

Rats cause substantial economic losses to rice, as well as to most other crops including oil palm, sugar cane, maize, cassava, soybean, groundnut, coconut, mung bean and sweet potato. The damage by rats to rice is by far the greatest agricultural problem in Indonesia (Geddes 1992).

The major rodent problems occur in irrigated lowland rice. Van der Laan (1981) observed that during 1961 to 1970, rats were the major pest of rice production in the districts of Subang and Cirebon (West Java). Rats also are significant pests of other crops such as tidal rice and deepwater rice in Sumatra and Kalimantan. Rodents appear to be seriously affecting crops in the newly settled transmigration areas in Sumatra. The principal rodent pest of rice crops in Indonesia is *Rattus argentiventer*. In Sumatra, where there is greater diversity of crops, *Rattus exulans* is just as great a problem as *R. argentiventer* (Ir Rochman, pers. comm.). There are also minor problems caused by *R. rattus diardii* and *R. norvegicus* inhabiting houses throughout Indonesia. Other rodent species are pests of rice and other crops in Irian Jaya. Because of the small area of rice grown in Irian Jaya, and the different methods of cultivation compared to the rest of Indonesia, we will not consider rodent problems in that region.

South Sulawesi — a case study

In South Sulawesi there are 700 000 ha planted to rice per year of which 600 000 is rainfed, lowland rice. Around Pinrang and Sidrap (the rice-bowl of Sulawesi) there are 100 000 ha of irrigated land which produce two crops per year. Some rainfed areas also produce two crops but this is usually a low percentage of available cropping land.

A network of 154 'IPM observers' have been reporting crop losses from the Pinrang and Sidrap region to the Plant Protection Center at Maros every 2 weeks since 1983/84. These observers record the amount of crop damage and apportion the likely cause of damage to insects, diseases or rodents. Four categories of infestation by rats are reported:

1. Very light damage — losses <5%
2. Light to medium damage — losses 5–24%
3. Heavy damage — losses 25–75%
4. Crop failure — losses >75%

Based on an average yield of 5.2 t/ha, an economic estimate of yield loss was calculated at harvest. From 1983/84 to 1991/92, an average of 16 900 ha were infested per year by rat damage, with an estimated average annual economic loss of 10.1 billion rupiah (US$4.7 million) (Data courtesy of Ir Shagir, Plant Protection Center, Maros) (Table 2.3).

Annual average loss to rice production caused by rats in the 'rice bowl' of South Sulawesi is approximately 16.9%. The number of hectares damaged by rats varies markedly between years (range: 1985 — 6000 ha; 1988 — 38 000 ha). This is a measure of rat incidence which provides a qualitative indication of rat density. These data indicate that although rats cause a chronic economic problem, there are episodic outbreaks of rat populations that cause acute economic losses. A sequence of only nine years is insufficient to determine whether these outbreaks follow a cycle. Interestingly, in the two periods of high rat densities, rat damage was high for two consecutive years. A sequence of two years of high rodent numbers also occurs during major mouse plagues in Australia (Redhead 1988; Singleton 1989; Singleton and Redhead 1989).

In summary, rodents are currently the number one preharvest problem to rice production in South Sulawesi. Previously tungro virus was the greatest problem, but changes in crop rotations and time of transplanting have greatly reduced the impact of tungro virus. Synchrony of planting and improved hygiene around crops also have reduced losses caused by rats but the problem is still substantial.

Indonesia in general

Data collected by the forecasting centres of the Directorate of Food Crop Protection in Indonesia indicate that rats cause losses of around 17% per annum to rice crops in Indonesia (Geddes 1992). The value of the Indonesian rice crop taken from 1987 figures is 9819 billion rupiah (approx US$4.64 billion) (Geddes 1992). The potential harvest if losses to rats were excluded would be worth approximately US$5.6 billion. Annual losses to rats therefore amount to about US$1 billion.

A recent publication by the Natural Resources Institute (the scientific unit of the U.K. Overseas Development Administration) examined the 'Relative importance of preharvest crop pests in Indonesia' (Geddes 1992). Estimates of pest importance were

Table 2.3 Incidence of rat damage and estimates of yield losses and economic losses caused by rats to irrigated rice (100 000 ha) in the rice-bowl of South Sulawesi. Data courtesy of Ir Shagir, Plant Protection Center, Maros.

Year	Incidence of rat damage ('000 ha lost to damage[a])	Yield loss ('000 tonne)	Economic loss (billion rupiah)
1983/84	25.8	51.7	15.5
1984/85	21.6	43.1	12.9
1985/86	6.1	12.2	3.7
1986/87	9.1	18.2	5.5
1987/88	11.0	22.0	6.6
1988/89	38.1	76.2	22.9
1989/90	19.5	39.0	11.7
1990/91	10.0	20.0	6.0
1991/92	10.8	21.7	6.5
Mean	16.9	33.8	10.1

[a] In South Sulawesi, 700 000 ha of rice are sown annually, of which 600 000 are lowland rice.

determined over four agro-climatic zones: SUB-MONTANE (altitude 1000 to 2000 m), WETLAND (dry season less than 4 months), DRY (dry season >4 months) UNIRRIGATED and DRY IRRIGATED. The ranking of preharvest pests was based on their relative economic importance. The two main factors considered were the actual losses to crops with existing control measures and the cost of control measures (Geddes 1992). Rankings were obtained from 72 scientists and bureaucrats drawn from 27 institutions within Indonesia, 13 scientists from IRRI and 7 agricultural scientists from the United Kingdom. Only two of these people were identified as rodent biologists (Ir Rochman, Bogor RIFC and Dr A. Toerngadi, Agricultural University, Bogor).

Rats were ranked as the most important non-weed pests in three of the four agro-climatic zones; they ranked fourth in the sub-montane zone. The number one ranking was both for all crops and for rice alone. The report concluded: 'Rats are the most important preharvest pest in Indonesia as a whole'. The ranking for pests of rice crops in Indonesia found through a survey of experts working in agriculture in Indonesia by Geddes (1992) are shown in Table 2.4.

The report by Geddes also had a compilation of the responses from IRRI scientists on preharvest pests of rice crops for other Southeast Asian countries (Myanmar, Thailand, Vietnam, Cambodia, Laos, Malaysia, Indonesia, the Philippines) over all ecosystems. Again rats were ranked as the most important pest (Table 2.4).

In Indonesia, rats are particularly a problem for the small land holder. The patchy nature of rat depredation means that, if affected, a land holder is likely to lose most of his crop. The small farmer is also constrained in the ways in which he can combat rats. Most single farmers in Indonesia (and elsewhere in Southeast Asia for that matter) have less than two hectares in which to grow all their crops. They also have very limited labour with which to undertake all the activities required of their farms. This means that they generally cannot plant all the farm at once and the resulting asynchronous planting substantially extends the availability of food to rodent pests.

A similar situation exists on a larger scale for much of the lowland irrigated rice. For example, in West Java the large irrigation area (250 000 ha) serviced by the Jatiluhur reservoir is divided into five areas (approx. 50 000 ha each). Because of the need to ration the water from the reservoir there is a staggered planting of rice throughout the irrigation district. There is a two week break between the planting of rice in each of the areas and this happens twice a year. Thus, there is almost a continuous food supply throughout the year for rodent pests of these crops.

2.1.2 Structure of rodent research

Rodent research comes under the umbrella of the Ministry of Agriculture. The Ministry is split into the Agency for Agricultural Research and Development (AARD) and the Directorate of Food Crop Protection (DFCP). AARD has a number of institutes including the Central Research Institute for Food Crops (CRIFC). Rodent research is conducted within CRIFC at the Bogor, Sukamandi and Maros Research Institutes for Food Crops (BORIF, SURIF and MORIF).

One rodent specialist is located at BORIF and apart from his work at Bogor on the efficacy of various rodenticides, he oversees research on rodent problems in tidal rice at a transmigration region in Sumatra. The rodent research effort is not high. As is often the case in Asia, the rodent group is under the direct supervision of an entomology research group.

Rodent research at SURIF is supervised by entomologists and the rodent field work is conducted by the farm manager of the research farm. A project assessing the effectiveness of using early maturing rice varieties and aromatic rice varieties as 'trap crops' (see Lam 1988, for details of the concept) was planned for 1993.

Rodent research at MORIF only began in 1994 and is again supervised by entomologists. The research emphasis is similar to SURIF. The effect of 'trap crops' on rat numbers is being assessed using fenced areas which have rice at the tillering and emergent stages (rows of rice are resown weekly). The study site is 20 ha with a 5 × 5 m fence plus two multiple capture traps located per hectare.

DFCP staff also have some involvement in rodent control through the Jatisari Forecasting Center. Their main role is extension and conducting training courses for staff involved in integrated pest management at 10 crop protection centres located in Indonesia. The scientist in charge of rodent control, Dr Joko Priyono, was involved in a collaborative research study with Japanese scientists on the population ecology of *R. argentiventer* from 1985 to 1992. The aims and scope of this study are outlined in Murakami et al. (1990).

2.1.3 Are rodent pests viewed as a priority by the Indonesian Government?

Dr Fagi, Director of CRIFC since March 1994 and prior to that Director of SURIF, considers rats to be the number one pest of rice crops in Java. To quote him, he recognises that at present the research on

Table 2.4 Ranking of the various pests of preharvest rice crops in Indonesia and through Southeast Asia as a whole, modified from Geddes (1992).

Rank	Indonesia	Southeast Asia
1	Rats (*Rattus* spp.)	Rats (*Rattus* spp.)
2	Stemborer (various species)	Tungro virus (vector-*Nephotettix virescens, N. nigropictus*) Brown Planthopper Stemborer (various species) Rice blast (*Pyricularia oryzae*)
3	Bacterial leaf blight (*Xanthomonas* pv. *oryzae*	Gall midge (*Orseolia oryzae*) Sheath blight Brown spot (*Drechslera oryzae*)
4	Brown planthopper (*Nilaparvata lugens*)	Rice Bug Birds (various species)
5	Tungro virus	Hispa (*Dicladispa armigera*) Bacterial leaf blight Leaf folder (*Cnaphalocris medinalis*)
6	Rice Bug (*Leptocorisa oratius*)	Golden apple snail (*Pomacea canaliculata*) — Philippines Ufra disease (*Dityenchus angustus* nematode)
7	Rice blast (*Pyricularia oryzae*)	
8	Narrow brown leaf spot (*Cercospora oryzae*)	
9	Sheath blight (*Rhizocotonia solani*)	
10	Narrow brown leaf spot (*Cercospora oryzae*)	

rats at SURIF is 'based on instinct rather than on a good scientific background'. Dr Ibrahim Manwan (Director of CRIFC until February 1994 and current Member of the Board of Management of IRRI) strongly believes rats are a major problem for rice growers in Indonesia. He also emphasises that rats are an important problem in Indonesia in other crops. He is concerned, not only by the current lack of expertise in rodent pest management in Indonesia, but also by the lack of training in rodent biology and in vertebrate pest management.

Dr Hasnuddin, Director of MORIF, considers rats to be the major preharvest pest to rice crops in South Sulawesi. He is keen for an increase in research effort in rodent control especially directed toward reducing chemical use in management operations. He stressed that community interest in tackling the rodent problem is high, with the provincial governor requesting an increase in research effort.

2.2 Laos

2.2.1 Magnitude of the rodent problem

About one quarter of the four million people who live in Laos are dependent upon shifting cultivation in upland areas of the country. This type of rice cultivation accounts for about 40% of the rice growing area in Laos but only for about 20% of rice production. The major rodent problems for rice in the Lao PDR occur in the areas where upland rainfed rice is grown. A survey of rice farmers in Luang Prabang and Oudomxay Provinces conducted by Roder et al. (1992) (Table 2.5) revealed that most respondents nominated weeds as the principal contraint on rice production with rodent pests coming second. There are some rodent problems in rainfed lowland and irrigated lowland rice but they are minor compared to those experienced in the uplands (J. Schiller — Lao/IRRI Project. pers. comm.).

The slash-and-burn agriculture associated with upland agriculture in Laos results in a very different crop management system to the other agro-geographic regions in Southeast Asia. In the uplands, there has historically been an eight year fallow between crops. Villagers therefore generally have to move house every couple of years (every year in some cases). However, in recent years there has been an emphasis on reducing the relocation of villages. Official policy is to eliminate shifting cultivation by the year 2000 (Fujisaka 1991). This has

Table 2.5 Major constraints to upland rice production as indicated by survey of farmers in Luang Prabang and Oudomxay Provinces Lao PDR (from Roder et al. 1992).

	Percentage of respondents				
		Luang Prabang			
Constraint	Oudomxay (32)[a]	Vienkham (53)[a]	Pakseng (20)[a]	Xieng Ngeun (24)[a]	Average (129)[b]
Weeds	81	83	95	83	85
Rodents	12	85	80	38	54
Insufficient rainfall	47	49	10	83	47
Land availability	47	11	45	62	41
Insects	69	34	20	29	34
Labour	31	25	25	17	24
Soil fertility	31	26	0	29	21
Erosion	9	9	15	25	15
Domestic animals	16	21	15	8	15
Wild animals	6	22	10	4	11
Disease	6	19	5	0	8
Suitable varieties	0	0	0	0	0

[a] Number of farmers from each province.
[b] Total number of farmers surveyed.

led to a fallow of only 3 or 4 years between crops for the same patch of land. The immediate effects on rodent population dynamics of this more intensive farming and more frequent clearing are not yet evident. One would suspect that the community composition of rodent species will change. Those best adapted to a commensal life and to high levels of disturbance will thrive. These are likely to be the species that have high reproductive potential and cause the most damage to rice crops. Changes in community dynamics of rodent species following dramatic changes in farming practices warrant close scrutiny.

The magnitude of rodent damage to rice crops in the upland regions varies markedly between years. For example, rats caused heavy losses in 1991 after several years with only minor losses. In 1991, it was common for growers to report losses of greater than 50% of their rice crops. The Luang Prabang Provincial Government responded to these losses by providing an incentive for farmers to kill rats. A bounty of 10 kip (700 kip = US$1) was paid for each rat tail deposited with the authorities. Over 600 000 tails were collected by growers (see Table 2.6).

An assessment of rat damage at the village level was conducted also in 1991 (see Table 2.5). These assessments can be misleading because of the patchy nature of damage. Some villages suffered losses of up to 100% of their rice cops (Walter Roder, pers. comm.) and for these people the losses were catastrophic.

We spent two days visiting and interviewing villagers in the upland region of Luang Prabang province. A detailed set of questions was asked to farmers from each village. We have included a summary of their responses because of the dearth of published information on rat problems in Laos, especially those in upland Laos (Tables (2.7–2.10). These interviews provide a valuable catalogue of an important problem that has not been previously assessed by wildlife biologists.

Table 2.6. The area of upland rice damaged by rats and the number of rat tails collected in Luang Prabang Province, Laos 1991 (Data courtesy of Dr Walter Roder).

District	Area damaged (ha)	Percentage of total crop	Rat tails '000
Luang Prabang	24	<1	0
Xieng Nguen	21	<1	8
Pak Ou	8	<1	0
Nambak	589	9	22
Ngoi	1009	15	42
Pakseng	623	14	25
Phone Say	556	10	4
Viengkham	1131	16	230
Phonkhoun	218	15	0
Other tails (direct to Agricultural Service)			215

All farmers expressed strong concern for the losses they suffered from rodents, especially during 1991. A common theme in the answers was that the 1991 outbreak of rodents was associated with the flowering of one or more bamboo species. Indeed the local name for mouse is 'norkey' which literally translates as mouse of bamboo flower.

The following quote probably summarises the general opinion: 'If there is no bamboo flowering, there is 5 to 10% damage to upland rice crops. If bamboo is flowering, then there is 60 to 70% damage of the crop. After bamboo flowering, rats eat the fruit of the bamboo and the rats breed quickly. The pattern of the plague is the appearance of big rats and then small mice.'

After visiting the areas affected by the 1991 plague and talking to government officials and villagers, we were not convinced of this link between the bamboo flowering and rodent outbreaks. The story appears to have developed only over the last ten years or so and may have come across from northern Thailand (Walter Roder, pers. comm.) One would expect that if there were a well established relationship between bamboo flowering and the appearance of rodent plagues, then the story would be enshrined within the folklore of the local people. They are very careful observers of the environment and it is extremely unlikely that such an important relationship would have gone unnoticed prior to the past decade. It may be that the bamboo/rodent story

Table 2.7 Responses by Lao Government officials and villagers from Luang Prabang, Laos, to questions on rodents in agricultural systems.

Question	Mr Thongsavanh Taipagnavong, Salakham Research Farm, Vientiane	Mr Onchanh; Mr Honmpheng, Agricultural Services and Lao/IRRI Project, Luang Prabang
Size of rats and local name	Not asked; he provided the 1980 FAO report and was involved in organising the visit of Dr Chaturvedi (India)	Norkey (small and mouse like), Norway (rat) and American Norway (the BIG one). The villagers think Norkey comes from the flower of bamboo (literal translation is mouse from bamboo flower)
Which have been the problem years for rats and mice?	1990/91; other notable years were 1979 (?), 1983, 1986/87 Problem every year in wet season; some years sow seed 2 or 3 times	1990/91; another notable year was 1987. Only some damage at sowing; main damage at booting stage (Sept/Oct)
Level of losses caused by rodents	Severe in uplands	1991 — 4237ha damaged (10 448 families surveyed); bounty cost 6 220 760 kip
What is the reason for eruption of rodent populations?	Bamboo flowering	(i) weather — after a dry year (ii) flowering of bamboo (iii) rats invade from neighbouring countries (e.g. Vietnam)
Which bamboo species is responsible for rodent increases?	Not asked	Highlighted those that flower in Feb/Mar and flower for 1.5 months
Are there losses to stored grain?	Major problem in uplands; minor problem in lowlands	Yes; no details
How are the rodents controlled?	(i) Bounty system — 10 kip/tail (ii) Recommend warfarin or zinc phosphide — not used widely as too expensive and farmers need training	Answer same as for Mr Thongsavanh Future management recommendations: (i) Same bounty system as in 1991 (ii) Native traps, especially pitfalls (iii) Traditional traps + pitfalls 'Only work on first day then rats too clever'

Table 2.8 Responses by Lao Government officials and villagers from Luang Prabang, Laos, to questions on rodents in agricultural systems (cont.).

Question	Mr Boonghame, Deputy Director, Agricultural Services, Luang Prabang	Head of Agricultural Staff Pak Seng Province
Size of rats and local name	Small and large rats; he would not estimate the ratio of small to large tails collected	'Thumb' (Norkey) rat and 'wrist' (no local name) rat; more of the smaller animals
Which have been the problem years for rats and mice?	1990/91; outbreaks have occurred on average every 5 or 6 years. Outbreak in western part of Luang Prabang Province in 1992	1991; problem with 'wrist' rat every 6 or 7 years in Pak Seng Province according to the older farmers in the district
Level of losses caused by rodents	Quoted same figures as Mr Onchanh	1991: 45% damage; rice increased in price from 100 kip/kg to 250 kip/kg; 60 kg of zinc phosphide distributed at 1200 kip/kg
What is the reason for eruption of rodent populations?	(i) Forest destroyed so rats have nowhere else to live and eat (ii) Very few predators have not been killed off by the farmers (iii) Old people claim that rats are a problem when bamboo flowers (but it didn't flower in 1991!)	No reason given, but bamboo and dry weather were intimated as possible causes
Which bamboo species is responsible for rodent increases?	There was no widespread flowering of bamboo in 1991	May 'bong' and May 'sot' which flower in April/May (sow rice in mid May/June)
Are there losses to stored grain?	Yes; no details	Not asked
Do rats show signs of disease? Do people get diseases during rodent outbreak?	No increase in disease in people during an outbreak	No obvious signs of disease in rats
Do the people use rats as a food source?	Not applicable	Eat medium sized rat
How are the rodents controlled?	Did not recommend zinc phosphide (too expensive and a 'bad' poison) Recommended driving rats into nets around each padi and using pitfall and bamboo traps. Also highlighted the need to: reduce harbourage by weeding rice fields; use local traps; not kill predators	Did not recommend zinc phosphide as it is too expensive and there are problems with secondary poisoning.
How do you rank rodents as an agricultural pest?	Number 1 problem in upland rice is weeds. Number 2 problem is white grub and rats	Important problem; no ranking given

Table 2.9 Responses by Lao Government officials and villagers from Luang Prabang, Laos, to questions on rodents in agricultural systems (cont).

Question	Bakor Villagers Luang Prabang Province (30 families)	Kamu Villagers Luang Prabang Province (51 families)
Size of rats and local name	'Thumb' rat and 'wrist' rat; small rat is more common	'Calf' rat and 'wrist' rat; also smaller rat
Which have been the problem years for rats and mice?	From 1970 to 1993, only one outbreak in 1989; expect moderate damage every 3 years	1991; problem at sowing in 1993
Level of losses caused by rodents	In non-rat years yield is 1.5 t/ha; in problem years yield is between 200 and 500 kg/ha	In non-rat years there is enough rice for 7 months — in 1991 there was only enough for 5 months; in other years there is commonly a loss of 20%
What is the reason for eruption of rodent populations?	Not known; likely to have a problem when May 'bung' bamboo flowers	Not asked
Which bamboo species is responsible for rodent increases?	May 'song' May 'hok' and May 'bung'	Not asked
Are there losses to stored grain?	Not asked	Wrist rat causes losses to stored grain
Losses to other crops?	Also damage to maize and opium crops	Also to maize
Do rats show signs of disease? Do people get diseases during rodent outbreak?	No indication of disease caused by rats	No problem with disease
Do the people use rats as a food source?	Hunted rats are used for food	Rats are eaten
How are the rodents controlled?	After 1980, district agronomists recommended zinc phosphide mixed with chicken meat and placed in the ricefield. Rats are also hunted with a crossbow	Mixture of maize and zinc phosphide which is considered effective; local traps are also used for control
How do you rank rodents as an agricultural pest?	Main pests are white grub, army worm and grasshopper. Rat is the most important pest after panicle stage	Rats are the primary pest

is an argument of convenience, deflecting the blame to an act of nature rather than to the farm management of the hill tribes. However it is difficult to be definitive when reviewing the cause of an outbreak that occurred two years earlier and when so little is known about the animals involved.

There is much work to be done to ascertain whether any of these stories about the relationship between rodent plagues and bamboo flowering are true. There is so little known about the biology of the rodents that even the identity of the main pest species is uncertain. From talking to farmers and officers of the Agricultural Services and Extension Agency, it appears that there are three sizes of pest rodents. The largest one is assumed to be a bandicoot, probably the great bandicoot, *Bandicota indica*, the middle sized one the ricefield rat, *Rattus argentiventer*, and the smallest probably a species of *Mus* (*M. caroli* or *M. cervicolor*).

2.2.2 Structure of rodent research

The magnitude of the rodent problem in the Lao PDR is recognised at both the provincial (particularly upland provinces) and national levels of government. Research effort is weak and there is no indication that this will change in the short term. This is despite the widespread recognition of the rodent problem. The best resource of information on the biology of rodent pests was Mr Thongsavanh Taipagnavong, Deputy Director of the Agricultural Extension Agency, Salakham Research Farm, Vientiane.

2.2.3 Are rodent pests viewed as a priority by the Laotian Government?

We met with Mr Kou Chansina, the Director General of Agriculture and Extension. He was well informed on the rodent problems in Laos and asked whether we could recommend management strategies following

Table 2.10 Responses by Lao Government officials and villagers from Luang Prabang, Laos, to questions on rodents in agricultural systems.

Question	Pon Tong Villagers Luang Prabang Province
Size of rats and local name	Problem with 'wrist' rat in upland regions; problem with 'calf' rat in lowland regions; also smaller rats
Which have been the problem years for rats and mice?	1990/91; also some damage at sowing in 1993
Level of losses caused by rodents	Chronic problem in lowlands (two crops/year) with little damage to dry season crop (yield – 2t/ha) and high damage to wet season crop (yield – 0.7t/ha)
What is the reason for eruption of rodent populations?	Not known but farmers think that bamboo flowers provide enough food for the rats
Which bamboo species is responsible for rodent increases?	*Bambusa tulba* and *Oxythenetera parvifolia;* flower from April to May
Are there losses to stored grain?	Yes, but species unknown
Do rats show signs of disease? Do people get diseases during rodent outbreak?	Not known
Do the people use rats as a food source?	Yes, larger rats are eaten
How are the rodents controlled?	Zinc phosphide was used for 1990/91 outbreak (yield loss about 2/3 without chemical and 1/3 with chemical); crossbows and local traps also used

our visit to Laos. We stressed that a basic understanding of the biology and population ecology of the key rodent pests would be required before worthwhile management strategies could be developed. Mr Chansina was well briefed on the 1991 outbreak of rodents in the upland provinces.

2.2.4 If rats are a high priority why is the research effort so poor?

In Laos the answer is simply lack of resources. The country not only lacks money to put into rodent research but also lacks well-trained vertebrate ecologists.

2.3 Malaysia

In Malaysia there are 400 000 families growing 500 000 ha of rice. The three principle rice growing regions are MUDA, in Kedah State, Penang State and the east coast region. MUDA contains a large irrigation scheme and is regarded as the 'rice bowl' of Malaysia. MUDA consists of 90 000 ha, 25% of the land under cultivation for rice in Malaysia, and produces 50% of Malaysia's rice.

2.3.1 Magnitude of the rodent problem

The main pest species in Malaysia are *Rattus argentiventer* in rice, *Rattus rattus tiomanicus* in oil palm, *Rattus rattus diardii* in stored grain and recently in oil palm, and *Rattus exulans* in houses. We will focus on rat problems in rice crops. Annual losses to rice caused by rodents is generally around 4 to 5% (Tuan Haji Embi Yusof, Deputy Director MARDI, pers. comm.), however, as with other countries in Southeast Asia, the patchy nature of the damage means that individual farmers may lose large proportions, if not all, of their crop. Thus rats can have catastrophic effects on the livelihood of individual farmers.

To get an indication of the densities of rats that can occur in some regions in Malaysia, a study was conducted of two areas that have planting times for rice out of phase by 2.5 months. An 8.3 km fence, plus traps, was constructed between the two areas. As many as 6872 rats were caught on one night and 44 101 rats during a nine week period (Lam et al. 1990a). Rice yields in areas where there was no protection to the crops were 0.8 and 1.1 t/ha, whereas crops that were fenced had yields of 4.2 and 4.3 t/ha (Lam et al. 1990a). This is an extreme case but indicates the effect rats can have when agricultural conditions suit them.

In a study where fields of rice were selected at random, the impact of rats on yields revealed losses ranging from 2% to 10% (Buckle et al. 1985). Another study in Malaysia indicated losses of around 40%; average yields were 4.2 t/ha in nine areas where rats were controlled and 2.5 t/ha where there was no control (Wood 1984a). In larger trials the difference was not as pronounced in some areas, thus reflecting the heterogeneity of habitat use by rats. Overall, however, the average difference in yields was 33% (Wood 1984a).

2.3.2 Structure of research

Scientists at the Malaysian Agricultural Research and Development Institute (MARDI) are responsible for research and a limited amount of development of technologies for the management of rodent pests. In 1992, there were two scientists undertaking research on rodents within MARDI. One working on rice (at the Rice Research Institute, Kepala Batas) and the other on cocoa (at the Cocoa and Coconut Research Center, Perak).

The small team at the Rice Research Institute of MARDI is led by Mr Lam Yuet Ming. Because of the structure of MARDI, Mr Lam must focus on rat problems in rice crops. This focus is restrictive given the mosaic of rice, coconut, cocoa, banana and oil palm in many of the rice growing areas. A study of the way rats use these different crops in time and space would be an essential prerequisite to an understanding of the factors that influence the dynamics of rat populations in rice crops.

In rice, the emphasis of the research is on toxicology and the use of a physical barrier with multiple capture traps located at openings in the barrier (see section in chapter 7 on Active Barrier Fence/ Environmentally Friendly System). In cocoa and oil palm, the emphasis of the research is on avian predators as a mechanism of control. For example, researchers from the Palm Oil Research Institute of Malaysia, Ministry of Primary Industries, have developed predictive modelling of the potential of barn owls, *Tyto alba,* to control wood rats, *R. tiomanicus*, either by themselves or with rodenticides (Smal et al. 1990).

Other research on rodents is conducted in Malaysia by private industry. For example, oil palm estates have in the past funded research of rodent pests (e.g. Wood and Liau 1977; Wood 1984b; Wood and Liau 1984a,b), and are responsible for their own rodent management programs.

2.3.3 Are rodent pests viewed as a priority by the Malaysian Government?

Tuan Haji Embi Yusof — Deputy Director General of MARDI (Research Support and Development), confirmed that rodents cause an average annual loss of about 5% to rice crops, that these losses were extremely patchy, and that often individual farmers suffered substantial (>50%) losses. These foci of damage, which varied in location between years, meant that rats were viewed as an important agricultural pest by the Malaysian Government. However, he did not foresee a likely increase in research personnel working on the problem in the near future.

2.4 The Philippines

2.4.1 Magnitude of the rodent problem

The major rodent problems in the Philippines occur in rice crops where the principle rodent pest species are *Rattus rattus mindanensis* in Luzon and the Visayas and *Rattus argentiventer* in the islands of Mindanao and Mindoro. *Rattus norvegicus* and *Rattus exulans* generally are of minor concern except on the islands of Cebu and Palawan (Fall 1977).

Rodents also cause significant problems around houses and grain stores and to other crops such as coconuts. On the main island of Luzon, *R. r. mindanensis* is also the principle pest species in these situations.

The history of major rat problems in the Philippines is linked to major changes in agricultural practices. For example, in the 1950s, widespread irruptions of rat populations in Mindanao and Mindoro followed a rapid expansion in the amount of land cultivated to rice. Crop losses of 8% of rice production were attributed to rats in 1953/54 valued at US$55.3 million (Sumangil 1990). During the early 1950s rat depredations led to widespread food shortages on Mindanao island (Crucillo et al. 1954). The introduction of two crops a year in the 1960s to regions of the Philippines further exacerbated rat problems because rats responded by having two breeding seasons rather than one.

National losses to rice crops by rats were estimated by the Bureau of Plant Industry in the 1970s. Losses in the early 1970s ranged from 3.2% to 4.5% for wet season crops and 1.65% to 2.47% for dry season crops. Losses were reported in 90% of fields surveyed and losses were greater than 10% in 7% of the crops (Hoque et al. 1988). Average losses of just less than 5% were estimated in 1975 to be worth approximately US$67.3 million. A National Rodent Control Program, based on integrated pest management protocol, was implemented in 1976 and losses fell immediately to less than 1% (see Sumangil 1990). Average annual losses were 0.52% between 1976 and 1980 (Hoque et al. 1988).

The rat problem in the Philippines was still claimed to be under control in the 1990s with annual losses of less than 1%. Success was attributed to the implementation of the National Rodent Control Program in 1976 (Sumangil 1990). The success of the program in the late 1970s was at a time when there was a strong infrastructure of training in rodent pest management through close involvement of researchers from the Denver Wildlife Research Center, USDA. This was combined with an active field program emanating from the Rodent Research Center at UPLB, Los Baños (see section 2.4.2 for details). In the 1990s there is little of this infrastructure remaining, yet the Bureau of Plant Industry claims that national losses caused by rats are being maintained below 1%.

Ms Hoque still regards rodents as a significant problem in rice crops in the Philippines with damage up to 35% in some areas. Scientists at IRRI confirm that rats are still a substantial problem to rice farmers in the Philippines based on regular reports of rat damage that they receive from the main rice-growing regions (G.R. Quick, pers. comm. 1994).

We provide the following case study to illustrate the current rodent problem in the Philippines. During a visit to IRRI in April 1993, we met with a farmer leader from Mindoro. The rice grown in Mindoro is mainly lowland and irrigated. The farmer reported that substantial rat damage occurred to his rice crop in the previous year — in late September 1992 he estimated a harvest of 3.75 t/ha; in December his harvest was 1.03 t/ha. He had a 4.0 hectare farm and he indicated that these rat losses were typical for his village. In general, on Mindoro Island rat damage is highest in the wet season. Damage is variable from year to year, with bad years resulting in losses around 30%. Some farmers had lost virtually their whole crop in some years.

Of interest is that this 'Barangay' (=village) had not seen a government Pest Control Officer (PCO) for years. The PCOs showed very little interest in the rat problem and the farmers were not following the recommended 'sustained baiting strategy'.

2.4.2 Structure of rodent research

Past

In 1968, the National Center for Crop Protection (NCPC) was built as an annex of the University of the Philippines at Los Baños. Initially, the NCPC was in effect the Philippines Rodent Research Center. The role of the center was to conduct research and to train field officers. In the 1970s the NCPC had strong input from staff of the Denver Wildlife Research Center, U.S. Department of Agriculture, through funding from the U.S. Agency for International Development.

In the mid 1970s, the Philippines Bureau of Plant Industry employed rodent pest control officers (PCOs). These officers were trained at the NCPC and were then sent out to the provinces to provide a surveillance and early warning system (SEWS) and an avenue for distribution of rodent baits. The field officers were trained to implement a 'sustained baiting strategy' developed by the Rodent Research Center of the NCPC in consultation with the U.S. Department of Agriculture.

Current

In 1992, the 'sustained baiting strategy' is still the basis for rodent control in the Philippines. This is despite the fact that:

(i) The strategy is poorly adopted by farmers (Ocampo 1980)

(ii) Mr Jesus Sumangil (Plant Protection Section, Bureau of Plant Industry), who coordinated the national rodent control program from its inception, retired in 1991. His retirement coincided with the lapse of the SEWS. Instead, it is left to field technicians to report back to the central agency of the Plant Protection Section in Manila, on an ad hoc basis.

(iii) If a problem is reported the farmers then have to go through a 4-tier system of information flow (village (Barangay) — municipality — province — national) before rodenticides will be issued to them. This causes a time delay in the distribution of anticoagulant rodenticides which leads farmers to take other actions such as rat drives, flame throwing and alternative chemicals.

(iv) Farmers, who prefer to see tangible results for their actions (i.e. dead rats near the site of poisoning), would rather use zinc phosphide than the recommended anti-coagulant rodenticides (anti-coagulants take a minimum of 5 days to kill a rat and the bodies are rarely visible).

In 1994, there is only one person (Maranda Hoque) in the NCPC who maintains an input into control of rodent pests. Unfortunately her input is only via training; there are no funds for research on rodents so her research is on insect pests of vegetable crops.

When there are reports of high numbers, 'sustainable baiting' is rarely implemented. Instead, the traditional method of rat drives is generally used. This is a decision based on political expediency. Provincial or Municipal governments can provide labour (which is cheap) and the farmers can also participate in the exercise. An exercise that produces a tangible (if not effective) result in the form of dead rats. This then appeases the farmers!

2.4.3 Are rodent pests viewed as a priority by the Philippine Government?

Mr Agito de la Pas (Officer-in-Charge of Documentation and Information, Plant Protection Service, BPI) whose current position includes responsibility for rodents and other vertebrate pests of agricultural crops, summed up the view of the Philippine Government with the following statement:

> *'Rats are not a problem in the Philippines. They were a significant problem in the 1950s and 1960s but not now. The problem has been overcome since the introduction of rodent control pest officers.'*

The BPI is responsible for extension and provision of chemicals for implementation of control. Their extension program is based on the 'sustainable poison program'.

2.4.4 Rodent research at the International Rice Research Institute

IRRI scientists have contact with many rice farmers, especially in Luzon. Rat problems are constantly being raised. Although the official average level of rat damage in the Philippines is approximately 1%, there are instances where local rat damage is high. Given the average farm size is 1 ha, it is not unusual for a farmer to lose their only crop to the depredations of rats.

Another concern for IRRI scientists is the high value of their experimental crops. In 1987 a survey of 51 scientists at IRRI suggested that rat damage occurred in 86% of 171 field experiments causing complete loss of data in 6.4% of experiments and partial loss of data in 59.1% (Ahmed et al. 1987). These losses were quantified at US$370 000 per annum. In the past, rice crops at IRRI have been surrounded by steel fences fitted with a single electrified wire . The electric current is sufficient to deter rather then kill rats. Neighbouring farmers, however, in their desperation to control rats have redirected mains-power into their paddy fields. This has led to at least 11 human fatalities (Quick and Manaligod 1990). Interestingly, the survey undertaken by Ahmed et al. (1987) on rat damage to crops at IRRI revealed that complete loss of field data was highest in plots protected by the electric fences.

Currently, Dr Graeme Quick (Leader of Agricultural Engineering) is experimenting with the use of a temporary fence of plastic with multiple-capture live-traps placed every 20 m along the fence. This method has been termed the 'Active Barrier System' (ABS) and is based on a method developed in Malaysia (Lam 1988; Lam et al. 1990a). This approach is considered in more detail in Chapter 7.

2.5 Thailand

2.5.1 Major rodent problems

Rodents cause significant damage to a range of crops in Thailand (e.g. rice, oil palm, barley, soybean, mungbean, coconut, macadamia nut). Of major economic importance are losses in rice and oil palm crops. Fifteen species of rodents have been identified as important pests to agricultural crops. The principal pest in rice crops is *Rattus argentiventer*.

In rice crops, losses are on average 6% in lowland and 7% in upland rice. Damage occurs every year in upland rice whereas damage is more variable in lowland crops. The most recent loss figures were from 1985. There has been no research in upland rice for 5 years. In lowland rice they now expect losses to be <6% because of advances in control methods.

In oil palm plantations, losses caused by rats vary considerably both between years and between plantations. The losses generally range from 6 to 36%. The main pest species are *Bandicota indica* and *Rattus losea* to young (<4 years) palms and *R. tiomanicus* and *R. diardii* to older palms.

2.5.2 Structure of research and control of rodents

Research on rodent pests is conducted by staff of the Agricultural Zoology research group, Division of Entomology and Zoology, Department of Agriculture. The research group is located at Bangken near Bangkok. The unit is directed by Mr Sermsakdi Hongnark and consisted of about 5 research staff plus support staff. The physical infrastructure support was equal to the best we had seen in Southeast Asia (MARDI, Malaysia had similar facilities). This included animal houses and associated laboratories. However, the range of animals studied was diverse, including not only mice and rats but also snails, slugs, crabs, bats and birds.

The emphasis of the research is mainly on use of chemicals (Table 2.11) although there has been one population study of *R. argentiventer*. Current research on rodents is in oil palm, barley and soybean crops. There is no current research in rice because they felt that a satisfactory warning system is in place, backed up by adequate control methods.

2.5.3 Are rodent pests viewed as a priority by the Thai Government?

We did not get the opportunity to visit any Government officials other than those at Bangken. We would require further information to clearly assess the priority of the Thai Government for the control of rats in agricultural crops.

2.6 Vietnam

2.6.1 Vietnam — a brief look at a recent rodent problem

Rats have caused damage to rice crops and other agricultural crops in Vietnam for many decades. Recent changes in economic structure to agricultural production has led to a 38% increase in rice production in Vietnam. This increase has occurred mainly in the Mekong and Red River deltas (Table 2.12). Yields have increased also (Table 2.12). Factors leading to these increases include more intensive farming and a general increase from two to three crops per year (L V. Thuyet, Director, National Institute of Plant Protection, pers. comm.). Both of these practices would benefit rodents through increasing food supply and extending the availability of high quality food. The latter would extend the period of breeding of female rats because their breeding season is linked to the stage of crop development (see Lam 1980; Fiedler 1986). It is not surprising therefore, that serious rat problems began to be reported in the Mekong River delta in early 1992.

Rat problems in the Mekong River delta — 1992/93

In the winter-spring season in 1992, the area of damaged rice in the Long-An, Tien-Giang and Dong-Thap provinces was 10 125 ha. At the same time of year, but across 10 provinces, the area damaged by rats was 44 000 ha in 1993 and 31 500ha in 1994. For the whole of the Mekong delta an estimated 100 000 to 300 000 t of rice was lost to rats in 1993. In Long-An province alone, 10 000 ha suffered 10 to 30% damage and 40 000 ha suffered greater than 50% damage. In Ha-Tien and Kien-Giang provinces, 822 ha suffered greater than 80% losses in yield.

Three different species of rat were observed but their generic status was uncertain. We have focussed on changes in agricultural practices, outlined above, as the principal contributing factor to these increases in rat densities. Possible explanations provided by our Vietnamese colleagues were:

(i) The water level of irrigated crops was 0.5 to 0.6 m lower than in previous years. This was

Table 2.11 Summary of recent and current laboratory and field studies presently being conducted on vertebrate pests by the Thailand Agricultural Zoology Research Group.

	Research	Year	Project Leader
1.	Damage appraisal of rice due to rodent pests in the north	1991–92	Sermsakdi Hongnark
2.	The use of difethialone (wax block) for rat control in the rice field	1991–92	Sermsakdi Hongnark
3.	Field trial for the use of bromadiolone for rat control in barley	1991–92	Sermsakdi Hongnark
4.	Study on squirrel control methods in cocoa-coconut plantation	1992–93	Yuvaluk Khoprasert
5.	Field trial on palatability of different zinc phosphide poisoned baits on rodents in soybean	1991–93	Puangtong Boonsong
6.	Efficacy of flocoumafen (wax block) in pomelo plantation	1991–92	Taksin Artchawakom
7.	Field trial on palatability of different zinc phosphide poisoned baits on rodents in oil palm plantations	1991–93	Puangtong Boonsong
8.	Anti-fertility effect of *Pueraria mirifica* against lesser field rat *Rattus losea*	1991–94	Korndaew Suasa-ard
9.	Efficacy test of anticoagulant rodenticide against *Mus* spp. in the laboratory	1991–93	Korndaew Suasa-ard

thought to benefit rat production and their rate of development.

(ii) There was a migration of rats from the Cambodian side of the border because of food and water shortages in Cambodia.

(iii) An increase in the killing of predators (e.g. snakes and birds of prey) had unbalanced the ecosystem.

The control measures that were adopted included the use of zinc phosphide; catching of rats by hand; digging ditches around crops, filling these with water and then pouring oil onto the surface; use of barrier fences; and the use of electric traps. To encourage cooperation by farmers, many local authorities applied a bounty system for rat tails (T. Q. Hung, Director General, Plant Protection Department, Ministry of Agriculture and Food Industry, pers. comm.).

Table 2.12. Yield and production of rice in Vietnam 1985–1993 (from data provided by the National Plant Protection Department, Ministry of Agriculture and Food Production, Hanoi).

	1985	1990	1991	1992	1993
Yield (t/ha)					
Winter/spring rice	3.50	3.78	3.15	4.01	3.88
Early summer rice	3.33	3.38	3.48	3.39	3.57
Summer rice	2.22	2.65	2.85	2.73	2.94
Average	2.78	3.19	3.09	3.33	3.43
Production (million tonnes)					
Throughout Vietnam	15.875	19.225	19.427	21.540	21.900
Red River delta	3.092	3.618	3.118	4.000	4.513
Mekong delta	6.860	9.480	10.351	11.000	10.742

2.7 If Rodents are a High Priority Why is the Research Effort so Poor in Southeast Asia?

The research effort on rodent pest management in Southeast Asia does not match the apparent magnitude of the problem. Countries such as Malaysia and Thailand have good scientific teams working on rodents but in both cases the teams are small and under-resourced.

In Laos the answer is simply lack of resources. The country not only lacks money to put into rodent research but also lacks well trained vertebrate ecologists.

In contrast, the Philippines had a good, reasonably well resourced research effort back in the 1970s and early 1980s. However, this research effort has virtually come to a standstill and the intellectual capital is rapidly being lost.

In Indonesia where the rodent problem is greater than for most other Asian countries, the situation is best summed up Dr Ibrahim Manwan, Director of CRIFC, Indonesia. When asked why so few resources (people and equipment) were allocated to research on rats if they were such an important problem in rice (and other) crops, he made the following points:

(i) Pest management courses in universities are dominated by entomologists and plant pathologists. People trained as entomologists find it too difficult to work on rats. In many young scientists there is also a psychological barrier to working on rats.

(ii) The research on rats over the past 20 years has focused on poisons. The output has been routine testing for national registration, some research on how to use the chemicals and comparisons of their relative efficacies. He saw a definite need in Indonesia for further research on rodent pest management that went beyond 'traditional techniques' of rodent control (e.g. fumigants and poisons).

(iii) Dr Manwan was concerned at the dearth of young and enthusiastic graduate students involved in rodent research. He clearly stated that the greatest challenge facing fresh initiatives in rodent pest management in Indonesia was recruiting young scientist(s) who had the right credentials (academic and general aptitude) for undertaking a collaborative project with rodent population specialists from overseas.

Unfortunately, the lack of trained rodent scientists is not restricted to developing countries. In a preface to a book on 'Rodent Pest Management' that he edited, Professor Ishwar Prakash (1988) wrote,

> *'It is felt this work on rodent pest management will trigger more research effort for the benefit of mankind and help .... in revitalising serious work in this field which, it appears, has dampened during the last few years.'*

It is five years since this book was published and Professor Prakash has since retired along with other eminent workers in the field of rodent biology and control. The replacements have been few. The situation led him to repeat his plea at the 'Rodents and Rice' expert panel meeting held at IRRI in 1990 (Prakash 1990). His main point was that rodents are a global pest and we cannot afford to lose the expertise which will be needed to assist in the fight to control them. A fight that we fear will gain more and more recognition through necessity as years pass by, not only in developing countries but also in developed countries.