Ecologically-based rodent management: its effectiveness in cropping systems in South-East Asia

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Abstract

Ecologically-based rodent management (EBRM) has re-emerged as a paradigm for large scale rodent management campaigns. This concept has been tested in replicated, village-scale experiments over 4 years on rodent pests in lowland irrigated rice crops. In Indonesia, villages that practised EBRM had a mean increase in rice yield of 6%, whereas production levels were maintained in Vietnam but control costs were reduced. In both countries there was a substantial reduction in rodenticide use in villages practising EBRM. These studies provide strong evidence of the effectiveness of EBRM. The findings also highlighted the need to include end-users early in the development of management strategies. Lessons learned from these studies were extrapolated to the development of strategies for rodent management in intensive organic piggeries and poultry holdings in Europe. The challenge for these producers is not only the identification and then integration of different management actions based on our understanding of the ecology of specific rodent species, but also the integration of ecology, sociology and economics.

Additional keywords: *Rattus argentiventer*, Indonesia, Vietnam, field populations, rice, population ecology, economics

Introduction

Knowledge of the population biology, social behaviour, taxonomy and community ecology of rodent pests is an important foundation for developing effective management strategies. This was identified in the 1950s (Chitty, 1954; Davis & Christian, 1958).

However, field studies rarely progressed beyond alpha-level descriptive population studies (see Krebs, 1999) and there was a period of stagnation in rodent pest management from the 1970s to the 1990s (Singleton *et al.*, 1999). The re-emergence of the recognition of rodents as important agricultural pests in Asia (see Singleton (2003) for a review) and Africa (Leirs, 2003) and the need for environmentally-sensitive approaches to management, led to a reassessment of approaches to rodent management that were often loosely described as integrated pest management (Singleton, 1997). The concept of ecologically-based rodent management (EBRM) was developed as a formal description of the sound ecological basis required for developing management strategies for rodent pests (Singleton *et al.*, 1999).

Ecologically-based rodent management (EBRM), with a strong emphasis on socio-economic input, has been an important paradigm for research on rodent management over the past 5 years in many regions of the globe (see Singleton, 2003; Stenseth *et al.*, 2003), with recent economic analyses associated with the approach indicating positive outcomes (Stenseth *et al.*, 2003; Davis *et al.*, 2004). Given the strong theoretical push for EBRM in recent years, it is timely to review the progress of a 4-year field assessment of EBRM in South-East Asia. Studies of the effectiveness of EBRM in this region have included socio-economic and environmental dimensions in projects aimed at managing rodent pests at the village level. This paper reports on the promising results that have emerged from replicated village-level studies conducted for 3 to 4 years in lowland irrigated rice agro-ecosystems in Indonesia (Jacob *et al.*, 2003) and Vietnam (Brown *et al.*, 2003). The dominant rodent pest species in each country was the ricefield rat (*Rattus argentiventer*). The lesser ricefield rat (*Rattus losea*) also was present in reasonable numbers in Vietnam.

The need to take a wider ecological perspective for rodent management of commensal populations is gaining stronger impetus also. In agricultural areas where rodents cause significant impacts in and around farm buildings, especially in intensive animal production facilities, control activities over the previous 25 years tended to focus on choice of rodenticide and its carrier, structure and placement of bait stations, and genetic and behavioural resistance to rodenticides (e.g. Quy *et al.*, 1992; 2003; Inglis *et al.*, 1996; Pelz, 2001). A greater emphasis on ecologically-based management of commensal rodents has emerged in recent years both in developed (Cowan *et al.*, 2003; Endepols *et al.*, 2003) and developing countries (Belmain *et al.*, 2003). This paper will conclude with a discussion of how ecologically-based rodent management principles could be applied to intensive organic farm holdings in Europe based on our experiences of EBRM in broad-scale field experiments in Asia.

Materials and methods

Study sites

The Indonesian study was conducted in a monoculture of lowland irrigated rice near Cilamaya (06°14'S, 107°34'E), West Java. The climate in the region is tropical with low annual variation in average temperature (28 °C). The region has a dry (May to October)

and wet (November to April) season with greater than 75% of the rainfall in the wet season. There are two rice crops grown per year, a wet season and a dry season crop (see Jacob *et al.* (2005) for details). The average family holding is 1–1.5 ha.

The Vietnamese study was conducted near Tien Phong village, Vinh Phuc Province, in the Red River Delta (21°08' N; 105°45' E). The climate in the region is sub-tropical with summers hot and wet and winters cool and dry. The region has a dry (October to April) and wet (May to September) season with most of the rainfall in the wet season. There are two main rice crops grown per year, the spring rice season and the summer rice season (see Brown *et al.* (2004) for details). Other crops are vegetables (broccoli, cabbage, kohlrabi, onion, pumpkin, tomato) and flower crops (chrysanthemum, rose), which are grown throughout the year. The average family holding is 0.5–0.7 ha.

Experimental design

Two treated and two non-treated villages were selected at each site after assessing changes in rodent abundance and rodent damage to rice crops for 12 months in Indonesia and 10 months in Vietnam prior to applying the treatments. The villages were a minimum of 800 m apart and the cropping area was 100 ha in Indonesia and 100 to 150 ha in Vietnam. EBRM methods were identified through farmer consultations based on their cropping calendars and the biological knowledge of the rodent populations obtained from the pre-treatment studies and previous 3-year field studies conducted in nearby regions (Brown *et al.*, 1999; Leung *et al.*, 1999).

In Indonesia, the treatments were imposed from October 1999 to September 2002. The main EBRM actions imposed by farmers were as follows:

1. Plant their crops within two weeks of each other (synchrony of cropping);
2. One trap-barrier system (TBS) with a lure crop planted three weeks early, for every 10 ha of rice crop (8 TBS used per season per village) (see Singleton *et al.* (1998) for details of TBS technology);
3. Construct grassed embankments in fields, < 30 cm wide, and keep vegetation low;
4. A 2-week community campaign to hunt or poison rats after the dry season crop was planted. The campaign concentrated on two primary source habitats for rats – main irrigation channels and vegetable gardens near houses;
5. Maintain good hygiene around villages through reducing refuse and cover.

In Vietnam, the treatments were imposed from February 2000 to November 2002. The main EBRM actions imposed by farmers were as described for Indonesia except there was no community campaign at a specific time of the year. The stronger commune structure in Vietnam meant that community rodent control was already being conducted prior to our study. However, farmers changed the timing of their actions based on information we provided on the breeding ecology of the rodents. Previously, most of the communal control activities were conducted at the booting stage of the rice as a reaction to high levels of rodent damage. After our consultation with the farmer co-operatives, communal actions were conducted 4–6 weeks earlier at the seedling stage of rice.

In both countries, we worked closely with farmers on the treated sites. Farmers

were provided with advice on how and when to apply treatments and were then left to conduct the integrated management actions (farmer participatory research). They also were provided with the materials for the trap-barrier systems.

In both countries, farmers on the untreated sites continued their normal rodent control practices.

Surveys of knowledge, attitudes and practices of farmers

Surveys of the knowledge, attitudes, and practices of farmers on rodent pests were conducted on 30 farmers per village prior to the farmer meetings to identify EBRM. The surveys were repeated at the completion of the study (see Sudarmaji *et al.* (2003) and Tuan *et al.* (2003) for details).

Results and discussion

Impact of ecologically-based rodent management in Indonesia and Vietnam

In Indonesia, EBRM returned a mean yield increase of 404 kg ha^{-1} (6.1%) over six crop seasons in 4 years (Table 1) and a marked reduction in rodenticide usage. Also of environmental importance was the reduction in use of the ecologically disastrous method of mixing a cocktail of chemicals with used sump oil and spreading it on the flood-irrigated crop. Rats get the oil on their fur and get poisoned when they preen themselves, but this chemical cocktail is lethal also for invertebrates and amphibians living in the rice agro-ecosystem. A benefit-cost analysis of EBRM during this study for all seasons and years averaged 25:1 but varied considerably from year to year between a low of –2:1 to a high of 63:1 (Singleton *et al.*, 2005). These estimates included the costs of labour and materials used for all rodent control activities.

In Vietnam, there was no significant difference in yield between EBRM and traditional rodent management. However, there was a marked reduction in usage of rodenticides (Table 1; Singleton *et al.*, 2003) and plastic fencing in villages that practised EBRM. This provided environmental benefits as well as economic gains. A benefit-cost analysis provided a positive benefit of EBRM because the costs for rodent control were significantly reduced in the villages where EBRM was adopted (Brown *et al.*, 2005). The benefit-cost ratio on untreated sites was around 3:1 each year, whereas on treated sites the ratio increased from 3:1 at the beginning to 17:1 in the final year of the project. This occurred through fewer farmers applying rodenticides (cost of US $5.71 per ha) and fewer farmers establishing plastic barrier fences to keep rodents out of their fields (cost of US $12.50 per field per season) on treated sites.

An independent review of the impact of EBRM in 5 provinces in the Mekong River delta and the Red River delta, reported increased yields, lower rodent population, reduced use of toxic rodenticides, decreased use of plastic fences and decreased rodent control costs. In all the five provinces, the net present values (NPVs) were positive and the benefit-cost ratios (BCRs) were greater than 1. The review also highlighted that EBRM improved the health conditions of the rural poor and provided an impetus for a

Table 1. Summary of the impact of ecologically-based rodent management (EBRM) on crop yields and on the use by farmers of rodenticides, in lowland irrigated rice cropping systems in West Java, Indonesia, and the Red River Delta, Vietnam.

Impact	Country	Percentage (and number) of farmers adopting action				Yield		
		Before EBRM		In final year of EBRM		Mean (SE)		Increase from EBRM
		Control	Treatment	Control	Treatment	Control	Treatment	
						(kg ha^{-1})		
Management actions								
Rodenticide use	Indonesia	98 (60)	95 (60)	88 (50)	46 (50)			
	Vietnam	77 (60)	85 (60)	50 (120)	19 (120)			
Oil plus endosulphan	Indonesia	70 (60)	80 (60)	100 (50)	52 (50)			
Crop yields	Indonesia[1]					6806 (1166)	7227 (1125)	404 (109)
	Vietnam[2]					5042 (89)	4933 (84)	–108 (69)

[1] For six cropping seasons over 4 years with two replicates per treatment. For details see Jacob *et al.*, 2004.

[2] For six cropping seasons over 3 years (post-treatment only) with two replicates per treatment. For details see Brown *et al.*, 2004.

more cohesive interaction among community members (Palis *et al.*, 2004).

Farmers attitudes

In Indonesia, prior to the introduction of EBRM, 90% of all farmers across the 4 villages (n = 240) strongly agreed that effective rodent management required that farmers work together. However, only 68% of farmers did so. A survey after the use of EBRM for three years indicated that 84% of the farmers in villages that adopted EBRM worked together in rodent management whereas only 62% of the farmers did so in the untreated villages (Sudarmaji *et al.*, 2003). The shift to more ecologically benign methods to control rodent populations further highlighted a major change in attitudes of farmers who had practised EBRM.

In Vietnam, farmers believed that rats caused most damage to their crops and that controlling rats was important (Tuan *et al.*, 2003). Prior to the introduction of EBRM, most farmers thought they should control rats during the booting stage of the rice crop, whereas at the end of the project, most farmers on treated sites conducted rodent control earlier in the cropping season compared with untreated sites. Furthermore, there was a reduced reliance on chemicals and plastic fences on treated sites (Tuan *et al.*, 2003).

Ecologically-based management and lessons for intensive animal production facilities

The strong economic, environmental and social impacts of EBRM for broad-scale rodent management in South-East Asia sustained over 3 to 4 years, supports the contention (Singleton *et al.*, 1999) that EBRM can be an effective approach. What lessons can be drawn from this success for rodent management in organic farming systems for pigs and poultry in Europe?

EBRM requires management systems to be developed for specific species under specific production systems. From an ecological perspective it is fundamental to study the breeding ecology and habitat use of the rodents that live in the environs of the production system. Source and sink habitats for dispersal need to be identified (after Hannson, 1977) with particular attention paid to adjoining habitats which may be the source for recolonization after control campaigns. In some situations, effective management of the main rodent pests will require neighbours to work together to minimize the probability of rapid re-infestation. Simply stated, to control rodents at a meta-population level, management actions must focus on the distribution of source habitats at a landscape level relevant for the target species and not on tenure boundaries of farms.

An important issue is the socio-economic impact of particular rodent species to specific production systems. This will determine the threshold of tolerance of producers to rodent infestations and how much they are likely to invest in management actions. If rodent-borne diseases are among the important concerns of producers, as is the case in Denmark (Jensen *et al.*, 2004; Leirs *et al.*, 2004) and the Netherlands (Kijlstra *et al.*, 2004; Meerburg *et al.*, 2004), then epidemiological studies of rodent-

livestock-human-disease interactions will be required.

Once the primary data have been collected then it is important to marry the ecological knowledge with that of the producers to determine which management actions are technically and economically feasible. Another major consideration is the effect of particular management actions on the welfare of rodents and the livestock they need to be acceptable to society. Once a strategy has been identified with input from producers, then pilot studies under an adaptive management framework (see Walters & Holling, 1990) are recommended.

As outlined in the introduction, there have been promising developments in rodent management with stronger consideration of the ecology of rodent pests in agricultural systems in Europe. However, one important lesson from South-East Asia is that effective EBRM also requires strong sociological and economic components. Here lies the challenge: the integration not only of different environmentally acceptable management actions against rodents, but also of ecology, sociology and economics.

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