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Changes in farmers' knowledge, attitudes and practices after implementation of ecologically-based rodent management in the uplands of Lao PDR

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ABSTRACT

Rodents are a severe and chronic pest for farmers in the upland farming system of Lao PDR where upland rice is the predominant subsistence crop. Farmers participated in developing and implementing a series of ecologically-based rodent management (EBRM) strategies designed to reduce the impact of rodents in their upland farming system. These were tested in replicated Treatment and Reference sites in two provinces of northern Laos. A survey was conducted with farmers to determine their knowledge, attitudes and practices prior to and after the implementation of EBRM. This paper reports on the results of the post-implementation survey and compares results with the pre-implementation survey. The survey revealed that rodents remained the most important pest for these farmers. The mean estimated yield loss of upland rice was 12%. There was a significant reduction in the yield loss from pre- to post-treatment, but the time by treatment interaction was not significant. Trapping rodents in the fields remained the most important control strategy for these farmers and also was considered the most effective method. There was an increase in effort expended by farmers in controlling rodents post-treatment on Treatment sites in Luang Namtha, but no difference for other sites. The money spent on controlling rodents was lower on all sites post-treatment except for Treatment sites in Luang Namtha. Farmers on the Treatment sites in Luang Namtha had the lowest effort during the pre-treatment period and thought they needed to increase their rodent management efforts because of their involvement in this project. As a result of the project, farmers were more aware of the problems of rodents and were interested in adopting EBRM strategies.

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1. Introduction

Rodents are among the world's most important pests and cause significant damage to agricultural production (Prakash, 1988; Buckle and Smith, 1994; Singleton et al., 1999). Rodents cause particular problems for subsistence and poor rural farmers in Southeast Asia where they can cause severe crop damage leading to food shortages (Singleton, 2003).

The uplands of Lao PDR (Lao People's Democratic Republic, referred to here as Laos) are characterised by a variety of geographic and ecological communities that support 38 rodent species (Aplin et al., 2006). There is a complex patchwork of natural forest, re-growth and cleared agricultural areas in the upland agricultural system with many of the rodent species causing little or no damage to crops (Aplin et al., 2006). There are, however, 14 rodent species that are key crop pests in the spatially and temporally variable agroecological habitats, and include species that belong to the genera *Rattus*, *Bandicota* and *Mus*, with *Rattus rattus* complex (see Aplin et al., 2003) the most dominant species found in a wide range of environments throughout Laos (villages, fields, regenerating forest areas) (Aplin et al., 2006; Khamphoukeo et al., 2006).

Rodents are considered the most important constraint to rice production for 98% of farmers in the upland farming system of Laos (Brown and Khamphoukeo, 2007), and have been described as the pest they have least control over (Schiller et al., 1999). A survey of farmers in 2005 reported that the estimated yield loss caused by rodents was around 19%, but individual farmers report yield losses ranging from 0 to 100% (Brown and Khamphoukeo, 2007). Severe losses are particularly noted during outbreaks associated with bamboo flowering (known locally as *nuu khii* outbreaks) (Douangboupha et al., 2003). In many situations, farmers often lack effective technologies to prevent chronic or severe rodent damage and are constrained by lack of time or money to implement effective management. Therefore, it is important to develop appropriate rodent management strategies that focus on managing pest species

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to reduce crop losses while not harming native rodents that inhabit the forest community and provide important ecosystem services.

A structured survey of farmers was undertaken in 2005 to gather baseline information on the knowledge, attitudes and practices of farmers to rodent management (for details, see Brown and Khamphoukeo, 2007). Similar surveys have been conducted in other countries in Southeast Asia and Africa (Makundi et al., 2005; Sudarmaji et al., 2003; Tuan et al., 2003; Brown et al., 2008). This baseline survey was conducted prior to the implementation of ecologically-based rodent management strategies (EBRM) (Singleton, 1997; Singleton et al., 1999) that were developed through a participatory active learning framework through three cycles of workshops and field trials involving farmers, extensionists and researchers (for details, see Brown et al., 2007). The key ecologically-based rodent management strategies principles for rodent management in this complex system are to encourage farmers to work together as a community at key times prior to the onset of breeding of the major rodent pest species (Brown et al., 2007). Rodent management activities in the field environment were conducted from sowing of crops through to maximum tillering stage of rice crops, and in village environment were conducted from harvest to minimise the rodent damage to grain stores as rats migrated from fields to grain stores in villages. The main practices recommended for the upland system were to set traps continuously, use pitfall traps (holes dug into the ground 1–1.2 m deep and 0.5 m wide at the opening), establish bait systems (plastic fence set with traps surrounding piles of seed/grain to encourage rats) and for farmers to work together to hunt rats in grain stores and throughout the village (community rat campaigns). At the end of the two-year project and after implementation of the ecologically-based rodent management strategies on farmers' fields, the survey was modified and repeated to gauge changes in knowledge, attitudes and practices. This paper details changes in farmers' perceptions and knowledge of rodents as crop pests after their involvement in the study and examines differences between farmers on Treatment (where the ecologically-based rodent management strategies were trialled) and Reference sites (where farmers continued their normal rodent management). This is the first published study to examine changes in knowledge, attitudes and practices after the implementation and participation of farmers in designing appropriate ecologically-based rodent management strategies.

2. Materials and methods

A survey of farmers' knowledge, attitudes and practices was conducted in October 2006 with 200 farmers from 10 villages across two provinces of northern Laos (Luang Prabang and Luang Namtha provinces). This was a follow-up survey, so the surveys were repeated with the same farmers that were interviewed in the original survey conducted 18-months previously (reported in Brown and Khamphoukeo, 2007), except that the two villages from Houaphan province (included in the baseline survey) were not re-surveyed. There were 15 male and 5 female farmers surveyed from each of the villages.

There were five sections to the survey. (1) Background information on the farmers, such as age, sex, ethnic group, education level and farm size. (2) General questions about crop pests including limits to production, main pests and most important pests to control. (3) Rodent management practices including whether rodents are a major problem, crops damaged by rodents, occurrence of damage, rodent control methods, effectiveness of rodent control methods, timing of control, time and money spent controlling rodents in the previous season and estimates of losses from rodents. (4) Farmers' beliefs in rodent management scored using a 5-point Likert scale (Babbie, 2005) on the importance of controlling rodents, importance of increasing yields, importance of controlling rodents together with other farmers and importance of chemicals for controlling rodents. (5) General questions on rodent control such as whether rodent control was conducted individually or as part of a group, who organised the group, would the farmer work with other farmers in the future and whether farmers had heard of the trap-barrier system (TBS; a physical structure used to capture rats and reduce damage to the nearby crop, successfully implemented in lowland irrigated rice cropping systems in Indonesia and Vietnam; Singleton et al., 2005; Brown et al., 2006).

The follow-up survey in October 2006 was essentially the same as the baseline survey (Brown and Khamphoukeo, 2007) except for some additional questions relating to which rodent control methods farmers intended using in the future, why they would use them, what the most effective method was and whether farmers would work together with other farmers to control rodents in the future. Two additional questions on the beliefs were: "How important is it to you that you spend less time and money controlling rodents?" and "How true is this: By using the recommendations from the rodent project you have spent less time and money controlling rodents?"

The survey was translated from English to Lao, and then pre-tested. There were 53 questions, and each survey took about 45 min to administer. The surveys were conducted from October to December 2006. To compare changes from pre- to post-treatment implementation, data were analysed drawn from the baseline survey (Brown and Khamphoukeo, 2007) with the data collected in this post-implementation survey. Data from Houaphan were excluded from these analyses. Each village was characterised as "Treatment" or "Reference" so that comparisons could be made between treatments and over time to determine the impact of the implementation of ecologically-based rodent management strategies. Differences between the two provinces were also examined (Luang Prabang and Luang Namtha). Key changes in effort expended in rodent control were examined. Analysis of variance was used to examine differences between variables between treatment type (Treatment or Reference sites) and over time (pre-treatment survey and post-treatment survey). If necessary, data were normalised through transformation prior to analysis. Statistical analyses were conducted using S-Plus Version 6 (Insightful Corp., Seattle). Measures of variation are reported as ± 1 standard error (SE) throughout.

3. Results

3.1. Characteristics of farmers and their farms

Male farmers had a mean age of 44.6 years (±1.0, range = 20–82, $n = 146$), had been farming for 22.8 years (±1.1) and had 4.4 years of education (± 0.2, max = 11). Female farmers had a mean age of 38.5 years (±1.6, range = 18–75, $n = 54$), had been farming for 18.8 years (±1.6) and had 3.1 years of education (± 0.3, max = 8). There was no treatment by sex interaction ($F_{1,192} = 0.720$; $P = 0.397$), nor treatment by education interaction ($F_{1,192} = 3.342$; $P = 0.069$).

The majority of farmers owned their own land (196 of 200 farmers, 98.0%), with only four farmers renting. There were four principal ethnic groups represented by the farmers: Lao Lum (47.5%), Thai Dam (39.0%), Kha Mu (7.0%) and Lao Theung (6.5%) (Table 1).

The mean area of lowland rice was 0.8 ha (±0.07) and upland rice was 0.6 ha (±0.05) per farmer. These were traditional varieties of rice. Other crops included Job's tear (a local variety of sorghum) (0.14ha ± 0.02), modern variety rice (0.11ha ± 0.02), corn

Table 1
Summary of responses from farmers after the implementation of rodent management strategies on treatment sites from 10 villages in Luang Namtha and Luang Prabang. Farmers were asked the following questions: (1) What was the main (number 1) pest on your farm (ranked in order of importance)? (2) Which pest caused the most damage to your crops? (3) Which is the most important pest to control? (4) Which crops suffered the most rat damage (ranked in order of importance)? (5) The perceived yield loss is shown (calculated from ratio of yield without rat damage and yield with rat damage). Only the most common response is provided. The number of farmers who responded for each category is shown in parentheses (there were 20 farmers interviewed per village).

Village	Treatment	Sample size (n)	Main Ethnic Group	(1) No. 1 Pest	(2) Pest that causes most damage?	(3) Most important pest to control?	(4) Crop most damaged by rats	(5) Yield loss (% ±SE)
Luang Namtha								
Bomphiang	Treatment	20	Thai Dam	Rats (16)	Rats (14)	Rats (17)	Rice (15)	9.5 ± 2.2
Houakhoua	Treatment	20	Thai Dam	Rats (16)	Rats (15)	Rats (15)	Rice (15)	8.5 ± 1.3
Namngeng	Treatment	20	Thai Dam	Rats (17)	Rats (16)	Rats (17)	Rice (14)	7.3 ± 1.4
Namthouang	Treatment	20	Lao Loum	Rats (17)	Rats (15)	Rats (18)	Rice (12)	14.4 ± 5.5
Donmoune	Reference	20	Kha Mu	Rats (17)	Rats (20)	Rats (20)	Rice (17)	21.9 ± 4.7
Papoua	Reference	20	Thai Dam	Rats (17)	Rats (20)	Rats (20)	Rice (16)	10.0 ± 1.4
Luang Prabang								
Hadsoua	Treatment	20	Lao Loum	Rats (18)	Rats (20)	Rats (19)	Rice (16)	14.7 ± 5.2
Latahay	Treatment	20	Lao Loum	Rats (19)	Rats (19)	Rats (20)	Rice (19)	8.1 ± 1.2
Houailo	Reference	20	Lao Loum	Rats (19)	Rats (20)	Rats (20)	Rice (14)	17.5 ± 7.1
Hadkho	Reference	20	Lao Loum	Rats (19)	Rats (20)	Rats (20)	Rice (19)	8.8 ± 2.1
	Treatment	**120**		**Rats (103) 86%**	**Rats (99) 83%**	**Rats (106) 88%**	**Rice (91) 76%**	**10.3 ± 1.3**
	Reference	**80**		**Rats (72) 90%**	**Rats (80) 100%**	**Rats (80) 100%**	**Rice (66) 83%**	**14.5 ± 2.1**
	Total	**200**		**Rats (175) 88%**	**Rats (179) 90%**	**Rats (186) 93%**	**Rice (157) 79%**	**12.1 ± 1.2**

(0.05ha ± 0.01), other crops (0.03ha ± 0.01) and beans (0.01ha ± 0.01).

3.2. Crop pests

The main factors that limited rice production were pests (86.0%) followed by drought (7.5%). The main pests in their fields and grain stores were rodents (87.5%) followed by snails (5.0%) and insects (4.5%) (Table 1). The pests that caused most damage to their crops were rodents (89.5%) followed by insects (4.0%) and the pest that was most important to control was rodents (93.0%) followed by snails (4.5%), insects (1.0%) and wild pigs (1.0%). The crops that suffered the most damage was rice (82.5%) followed by corn (6.0%).

When farmers were asked "are rodents a major problem in your crops?" all but one farmer replied yes (99.5%). Most farmers suffered rodent damage to rice (96.5%). The mean estimated yield without significant rodent damage was 2645.7 kg/ha (±113.0) and the mean yield with significant rodent damage was 2364.8 kg/ha (±108.9), equivalent of a loss of 280.9 kg/ha (±26.8). The mean estimated yield loss attributed to rats was 12.1% (±1.2) and yield loss was greater on Reference sites (14.5% ± 2.1) compared to the Treatment sites (10.3% ± 1.3), but was not significant ($F_{1,182} = 2.65$; $P = 0.106$).

3.3. Rodent management practices

Farmers considered that the most effective method of controlling rodents was trapping (54.5%) followed by rodenticide (12.5%), cats (9.5%) and digging burrows (6.5%) (15% of respondents gave no response) (Table 2). A higher percentage of farmers on the Reference sites considered trapping to be more effective compared to Treatment site farmers (Treatment sites (T) = 51.7%, Reference sites (R) = 58.8%). However, a higher percentage of farmers on the Treatment sites considered that digging burrows was more effective ($T = 9.2\%$, $R = 2.5\%$). The rodent control methods that farmers intended to use in the future were trapping (57.5% of respondents), rodenticides (15.5%), cats (10.0%) and digging burrows (7.5%) (Table 3). Similarly, a higher percentage of farmers on the Reference sites considered trapping was likely to be more effective in the future compared to Treatment site farmers ($T = 50.0\%$, $R = 68.8\%$). However, a higher percentage of farmers on the Treatment sites considered that digging burrows was likely to be more effective ($T = 10.0\%$, $R = 3.8\%$). There were also differences between perceptions of the usefulness of rodenticides ($T = 17.5\%$, $R = 12.5\%$) and cats ($T = 13.3\%$, $R = 5.0\%$).

3.4. Farmers' beliefs in rodent management

Farmers had strong views about most questions on beliefs, and importantly, there were some differences according to treatment category (Table 4).

When farmers were asked "how important is it to you that you spend less time and money controlling rodents?" the majority responded with "important to me" (47.5%) or "very important to me" (34.0%). When farmers were asked "How true is this: By using the recommendations from the rodent project you have spent less time and money controlling rodents?" the majority responded with "always true" (42.0%), or "in most cases true" (38.5%).

Farmers mostly applied rodent control individually (77.5%), but some applied as part of a group (3.0%) or a combination of

Table 2
Responses by farmers to the question "What is the single most effective method of controlling rats?" grouped by Province and Treatment category, from 10 villages in Luang Namtha and Luang Prabang provinces, Laos.

Province	Treatment	Sample size (n)	No response	Cats	Plastic sheet	Digging burrow	Trapping	Rodenticide	Sanitation
Luang Namtha	Reference	40	37.5	20.0	0	5.0	17.5	20.0	0
	Treatment	80	16.3	13.8	5.0	13.8	30.0	21.3	0
Luang Prabang	Reference	40	0	0	0	0	100.0	0	0
	Treatment	40	5.0	0	0	0	95.0	0	0
Total	Reference	80	18.8	10.0	0	2.5	58.8	10.0	0
	Treatment	120	12.5	9.2	3.3	9.2	51.7	14.2	0
All sites	**Both**	**200**	**15.0**	**9.5**	**2.0**	**6.5**	**54.5**	**12.5**	**0**

Table 3
Responses by farmers to the question "What methods will you continue to use in the future?" grouped by Province and Treatment category, from 10 villages in Luang Namtha and Luang Prabang provinces, Laos.

Province	Treatment	Sample size (n)	No response	Cats	Plastic sheet	Digging burrow	Trapping	Rodenticide	Hunting in rice store	Sanitation
Luang Namtha	Reference	40	20.0	10.0	0	7.5	37.5	25.0	0	0
	Treatment	80	10.0	20.0	2.5	15.0	26.3	26.3	0	0
Luang Prabang	Reference	40	0	0	0	0	100.0	0	0	0
	Treatment	40	0	0	0	0	97.5	0	2.5	0
Total	Reference	80	10.0	5.0	0	3.8	68.8	12.5	0	0
	Treatment	120	6.7	13.3	1.7	10.0	50.0	17.5	0.8	0
All sites	**Both**	**200**	**8.0**	**10.0**	**1.0**	**7.5**	**57.5**	**15.5**	**0.5**	**0**

individually and with a group (14.0%). For farmers who controlled as part of a group, these activities were organised by farmer groups (7.8%), extension staff from Plant Protection Department (7.8%) or others (1.5%). When asked if farmers would work together in the future, 70.0% responded with "yes", 18.0% responded "no" and 11.0% responded "maybe".

Some 55.0% of farmers had heard of the trap-barrier system, but 44.0% had not.

3.5. Changes from pre- to post-treatment implementation

There were significant reductions in yield loss across all sites from pre- to post-treatment for both Luang Prabang and Luang Namtha (overall, 19.4% yield loss pre-treatment ± 1.1; 12.1% post-treatment ± 1.2) (arcsine square root transformed data; $F_{1,366} = 26.72$; $P < 0.001$) and a significantly lower yield loss on Treatment sites (14.4% ± 0.9) compared to Reference sites (18.3% ± 1.6) ($F_{1,366} = 5.04$; $P < 0.05$) (Fig. 1). The treatment by time interaction was not significant ($P = 0.771$), however, after taking into account changes on Reference sites, the relative reduction in yield loss was 29.9% on Treatment sites in Luang Namtha and a small increase of 6.8% on Treatment sites in Luang Prabang.

Overall, the reduction in the effort expended by farmers in controlling rodents from pre-treatment (43.2 days/ha/year ± 6.3) to post-treatment (24.8 days/ha/year ± 3.0) was not significant (ln+1 transformed data; $P = 0.415$) and there was no difference between treatments ($P = 0.524$) (Fig. 2). The time by province by treatment interaction was significant ($F_{1,379} = 6.61$; $P < 0.05$) with a 283% relative increase in effort for the Treatment sites in Luang Namtha after taking into account changes on Reference sites and a 52% relative decrease in effort for Treatment sites in Luang Prabang after taking into account changes on Reference sites. The reduction in

Table 4
Responses of farmers to their beliefs about rat management in a five-point Likert scale, for the knowledge, attitudes and practices survey of farmers after the implementation of rodent management practices in treatment sites, from 10 villages in Luang Namtha and Luang Prabang provinces, Laos. Two series of questions were asked in the following formats: "How true is this …" and "How important to you is …". The percentage of responses for each question is provided ($n = 200$). Bold numbers refer to most common response.

Question: How true is this:	Treatment	Always not true (%)	In most cases not true (%)	Maybe true (%)	In most cases true (%)	Always true (%)
Rat control must be done during rice growing season?	T	0.8	6.7	7.5	**48.3**	35.8
	R	3.8	5.0	11.3	**40.0**	38.8
By controlling rats, a farmer can increase his rice yields?	T	0.0	3.3	1.7	**59.2**	35.0
	R	0.0	3.8	1.3	**48.8**	45.0
Rats can be controlled?	T	0.8	5.0	20.0	**45.8**	26.7
	R	2.5	2.5	10.0	41.3	**42.5**
Rats can cause severe yield losses?	T	0.0	2.5	1.7	**61.7**	33.3
	R	0.0	0.0	1.3	43.8	**53.8**
Rats can be only controlled if farmers work together with other farmers?	T	0.0	4.2	5.0	**55.0**	35.0
	R	0.0	6.3	1.3	43.8	**47.5**
Rats have to be controlled after harvest or in the fallow season?	T	5.8	9.2	15.8	**35.8**	32.5
	R	10.0	2.5	10.0	26.3	**48.8**
Chemicals used to control rats are safe (for humans, other animals and the environment)?	T	**62.5**	0.8	23.3	10.8	1.7
	R	**75.0**	0.0	15.0	5.0	2.5
By using the recommendations from the rodent project you have spent less time and money controlling rats?	T	4.2	7.5	6.7	**44.2**	35.8
	R	3.8	3.8	10.0	30.0	**51.3**
Question: How important to you is…	Treatment	Completely not important to me (%)	Not important to me (%)	No opinion (%)	Important to me (%)	Very important to me (%)
…controlling rats?	T	0.0	1.7	2.5	**53.3**	40.8
	R	0.0	3.8	0.0	37.5	**57.5**
…increasing yields by controlling rats?	T	0.8	0.0	3.3	**48.3**	46.7
	R	0.0	1.3	0.0	40.0	**57.5**
…it that rats can be controlled?	T	0.0	0.0	2.5	43.8	**52.5**
	R	0.0	2.5	0.8	**57.5**	38.3
…it to you that rats can cause severe yield losses?	T	0.0	1.7	2.5	**60.8**	34.2
	R	0.0	1.3	3.8	36.3	**57.5**
…it to you that rats can only be controlled if farmers work together with other farmers?	T	0.8	2.5	2.5	**58.3**	35.0
	R	0.0	0.0	6.3	41.3	**51.3**
…it to you that the rats have to be controlled after harvest or in the fallow season?	T	7.5	11.7	10.8	**40.8**	28.3
	R	7.5	8.8	3.8	37.5	**41.3**
…it to you that you spend less time and money controlling rats?	T	0.8	5.0	13.3	**52.5**	26.7
	R	3.8	0.0	10.0	40.0	**45.0**

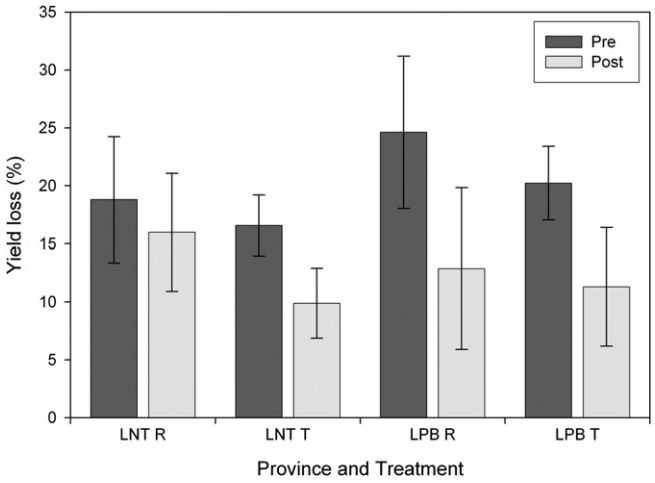

Fig. 1. Mean yield loss (±95% confidence limits) from rodents for each Province (LNT, Luang Namtha and LPB, Luang Prabang), treatment type (Treatment or Reference) and pre- and post-treatment implementation derived from a survey of farmers from 10 villages in northern Laos.

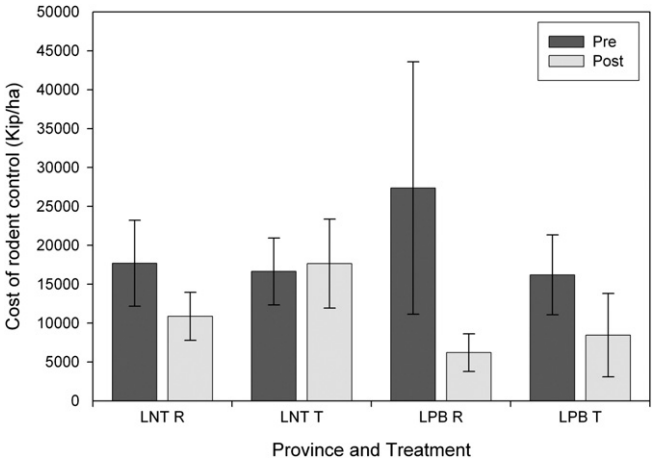

Fig. 3. Money spent on rodent control (Kip/ha; ±95% confidence limits) for each Province (LNT, Luang Namtha and LPB, Luang Prabang) (dry and wet season data combined) derived from a survey of farmers from 10 villages in northern Laos.

effort was larger on Reference sites (30.4 fewer days/ha/year; 61.8% reduction) than on Treatment sites (10.2 fewer days/ha/year; 25.9% reduction), but the relative reduction was largest on Treatment sites in Luang Prabang (44.8 fewer days/ha/year; 75.9% reduction).

Overall, the money spent on rodent control was significantly lower post-treatment (12,158 Kip/ha/year ± 1382, equivalent to USD 1.16) than pre-treatment (18,900 Kip/ha/year ± 2030, equivalent to USD 1.80) (square root transformed data; $F_{1,387} = 18.93$; $P < 0.001$) (Fig. 3). There was a significant time by treatment effect ($F_{1,387} = 4.69$; $P < 0.05$) and a significant time by province effect ($F_{1,387} = 9.00$; $P < 0.01$). The money spent on rodent control was lower on all sites post-treatment except for Treatment sites in Luang Namtha. After taking into account changes on Reference sites, the relative increase in money spent on rodent control was 72.6% on Treatment sites in Luang Namtha and 130.2% on Treatment sites in Luang Prabang.

There was no difference in yield loss according to whether farmers controlled rodents individually or as part of a group over time, between treatments or between provinces ($P > 0.05$). However, the participation rate of different activities changed from pre- to post-implementation, with more farmers conducting individual actions post-treatment (Fig. 4).

4. Discussion

Rodents clearly remain a significant pest for farmers in the upland farming system of Laos. The survey revealed that through participation in this research, farmers are starting to see more effective rodent control and become increasingly aware of the benefits of the management of rodents using an ecological approach.

The estimated yield loss caused by rodents was 12% with slightly less damage on Treatment sites than on the Reference sites. There was a significant reduction in the yield loss from pre- to post-treatment, but the overall time by treatment interaction was not significant. There was, however, a 30% reduction in yield loss on Treatment sites in Luang Namtha.

Farmers were spending less effort in managing rodents post-treatment on all sites except Treatment sites in Luang Namtha,

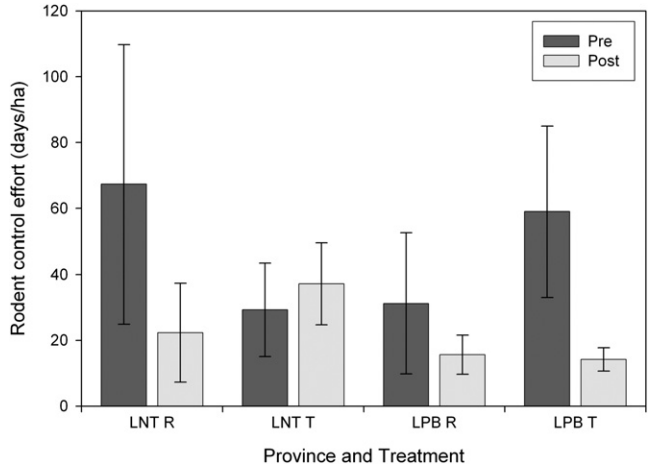

Fig. 2. Mean effort spent by farmers to control rodents in the past year (number of days effort per ha; ±95% confidence limits) for each Province (LNT, Luang Namtha and LPB, Luang Prabang), treatment type (Treatment or Reference) and pre- and post-treatment implementation derived from a survey of farmers from 10 villages in northern Laos.

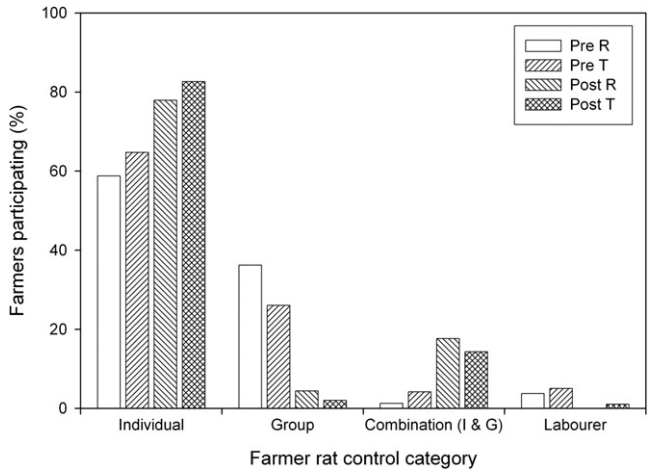

Fig. 4. Farmers' participation in rodent control activities before and after treatment for Reference and Treatment sites (total sample size = 365 farmers) derived from a survey of farmers from 10 villages in northern Laos.

where there was a slight increase. It is possible that the farmers on the Treatment sites in Luang Namtha thought they needed to increase their rodent management efforts, perhaps as a consequence of involvement in this project. Interestingly, farmers at this location had the lowest effort during the pre-treatment period.

The money spent on rodent management showed similar results in that there was no significant time by treatment interaction, but the time by treatment by province interaction was significant because of the increase in money spent on rodent management in Treatment sites in Luang Namtha. The increased effort is likely to have resulted in the reduced yield loss in Luang Namtha. It is not possible to compare these results with other published studies examining knowledge, attitudes and practices for rodent management because this is the first analysis and comparison of ex-ante and ex-post.

A range of rodent management practices was being used by farmers, not just on the Treatment sites, but also on the Reference sites. There was a strong focus on trapping, but farmers also used rodenticides, cats and digging burrows to manage their rodent problems. Some villages had banned the use of rodenticides, particularly around the village environments. Most farmers still applied rodent management individually. This result was a little surprising, especially considering that a strong emphasis was placed on encouraging community-wide or group rodent control activities at key times (Brown et al., 2007). However, as most farmers conducted trapping, it is possible that they may have characterised this as being an "individual" activity even though it was conducted early in the growth of the crop which is consistent with the message of early action.

There appeared to be spill-over benefits from the Treatment sites to the Reference sites because the presence of project activities raised awareness of rodent problems and management solutions. This is known to occur in large-scale field experiments of this type (Brown et al., 2006) where it is almost impossible to clearly delineate individual management practices, particularly in experiments that encourage participatory action research with farming communities. Thus farmers were likely to have been more aware of the problem of rodents and had probably heard about the project activities being conducted in nearby villages. Therefore, it is possible that there was some uptake of the project findings on the Reference sites. In many regards this should be viewed as a positive outcome because it demonstrates diffusion of the rodent management technologies into neighbouring areas.

After farmers implemented ecologically-based rodent management in the upland farming system of Laos they achieved an overall reduction in the effort in controlling rodents (up to 10 days less) but there was an increase in the money spent on applying rodent control on the Treatment sites. Farmers reduced rodent damage from 19.4% to 12.1% (there was a 30% reduction on Treatment sites in Luang Namtha). Farmers considered it was important to spend less time and money controlling rodents. Trapping rodents remained the most important method for managing rodents in the upland areas. Farmers were more aware of the problems of rodents and were interested in adopting the ecologically-based rodent management strategies tested.

Further effort is required to ensure implementation and adoption of the ecologically-based rodent management strategies and also to integrate these with insect, weed and disease management requirements for effective management of their cropping systems to sustainably improve both household livelihoods and food security. It is also clear that more effort needs to be paid to encourage communities to act together in managing rodents.

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