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ABSTRACT: Two large (approx. 160 ha) trial sites incorporating ricefields and village housing were selected in Laguna Province, Philippines. Flocoumafen 3.5-g wax block baits (Storm^{R}) were applied to one site, initially as two area-wide pulses of 80 to 100 blocks/ha and later as spot treatments, to areas of particularly high rat infestation. Baiting in and around the village houses was already carried out during the first two applications. On average, only 1.175 kg/ha/season of flocoumafen block bait gave good rodent control resulting in significant decreases in crop damage (% cut tillers) compared to the untreated area. The overall yield increase was estimated to be 13 t of grain, equivalent to total added benefit of P39,000 (approx US$ 1,950) or P253 (approx. US$ 13) per ha. Few domestic animals were attracted to the bait and no casualties were reported. Only one dog was seen eating bait but this animal did not develop symptoms of poisoning. None of the wild animals observed regularly during the trial showed significant decreases in numbers after baiting. With the exception of two shrews (Suncus sp.) all animal carcasses found were those of the target rodent pests. It is concluded that flocoumafen gave excellent rat control with no observable effects of non-target animals.

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INTRODUCTION

The importance of rodent damage to rice in Southeast Asia has been known for some time (Sanchez etal. 1978). In the Philippines, the monetary losses from an average of only 4.5% cut tillers has been estimated to be about P405 million (Schaefer 1975). Similar losses in rice due to rodents have also been reported from neighboring countries (e.g., Buckle et al. 1984, Indrarto 1984, Lam 1982, Tongtavee 1984). Consequently, many rice farmers in this region often use rodenticides as part of their pest control programs. Acute poisons (e.g., zinc phosphide) and multiple dose chronic anticoagulants (e.g., warfarin) have been widely used; however, the more potent single-feed anticoagulants are now becoming established. These new rodenticides combine the advantage of killing rodents with a single feed while lacking the bait shyness associated with acute poisons.

One of the new single-feed anticoagulants is flocoumafen. Many field trials with ready-to-use flocoumafen baits have also confirmed its high activity against rice rats in several Asian countries (Shires, pers. comm.). For example, a recent field trial in the Philippines demonstrated that only 50 (5 g) wax block baits per ha, applied at weekly intervals, provided good rat control in small rice fields (Hoque and Olvida, unpubl.).

While flocoumafen shows excellent potential for controlling both field and commensal rodent pests, few accounts of its possible effects on non-target species have yet been published (Boonchaniwiwat etal. 1987). The trial reported here was carried out to investigate the efficacy of a new single-feed anticoagulant, flocoumafen (4-hydroxy-3 (l,2,3,4-tetrahydro-3-[4-(4-trifluoromethyl-benzyloxy) phenyl]-1 -napthyl) coumarin), which has been reported to be both highly palatable and potent against most rodent pests, including those tolerant to warfarin (Bowler et al. 1984, Buckle 1986, Garforth and Johnson 1987, Rowe et al. 1985); and also, to assess the risks to non-target species arising out of a rodent control campaign with flocoumafen in a rice farming community.

MATERIALS AND METHODS

Description of the Trial Sites

Two trial sites were selected in Laguna Province, Luzon, Philippines. One site was baited with flocoumafen, while the other was left as an untreated control. The flocoumafen-treated site was located at Tubuan village, near Pila and consisted of 154 ha of irrigated rice fields, in the center of which was 6 ha of village housing interspersed with coconut groves, fruit trees and vegetable plots. The untreated reference site was about 5 km from the treated site of San Roque village near Victoria. This area was very similar in size and general habitat to the treated site, except that the village was a ribbon development at one end of the rice fields. For operational purposes, both treated and control sites were divided into 4 sub-plots; one of these was the village area and the other three were areas of rice fields.

Application of Flocoumafen Baits

A commercial Storm wax block bait formulation was used during the trial. Each block weighed 3.5 g and contained 0.005% flocoumafen on a rice cereal base. The block baits also contained a bright blue warning dye and a human taste deterrent. All baiting was carried out by local villagers who had received prior instructions on bait techniques. Four groups of villagers, each supervised by a member of the research team, were assigned to one of the four sub-plots. The group allocated to the village area applied baits in all

coconuts groves and fruit and vegetable plots. In addition, all householders were given 10 blocks and instructed to place half of them inside and half outside the house in such a way that they would be well concealed from children and domestic animals. The three groups baiting the rice fields laid one block every 10 to 15 m along each bund. This resulted in a bait usage of only 80 to 100 blocks/ha (about 280 to 350 g of bait/ha).

Bait was applied on five occasions. All of the treated area was baited on the first two occasions 14 days apart but subsequent applications were made to sub-plots where there was still heavy rat infestations (See Table 1).

Table 1. The timing of bait applications, sub-plots treated and amounts of bait used during the trial.

Date (1987)	Days after first bait application	Areas treated	Bait used (kg)	
			Field	Village
13 July	0	I,II,III,IV (village)	50.3	3.75
27 July	14	I,II,III,IV (village)	58.3	1.95
10 Aug*	28	I,II	23.8	0
28 Aug*	46	I,II,III	19.5	0
5 Sept*	54	I,II,III	29.0	0
Total			181	5.70

'Applications on 10th August to 5th September in the areas listed involved only partial (spot) baiting.

Table 2. Farmer estimates of crop damage by rodents during the previous season and actual damage levels recorded at the end of the trial in the flocoumafen-treated and untreated reference sites.

Area	Crop Damage (% Cut Tillers) Mean	S.D.	Range	Sig.Diff.
Previous season - Farmers' estimates				
Flocoumafen treated	7.6	10	0.1-22	ns
Untreated reference	6.3	7.6	0.5-33	ns
Current season - actual assessment				
Flocoumafen treated	0.9	1.7	0-17	sig P=0.01
Untreated reference	3.2	3.7	0-33	

Evaluation of Efficacy

Estimating bait acceptance

Baits laid by farmers along fixed transects in the rice fields were counted immediately after baiting and then daily for the next four days. Any missing baits were assumed to have been eaten by rats. The baits consumed in 20 randomly selected houses were also monitored for three consecutive days after baiting.

Assessing crop damage

Estimates of crop damage by rodents were made in 50 separate paddies as each group of rice fields reached maturity. Twenty-five rice hills were examined along a transect across each paddy and the number of tillers either undamaged or cut by rats was counted and recorded. A total of 235 and 175 individual paddies was examined in the treated and untreated areas respectively.

Monitoring Environmental Safety

Survey of farmers

Prior to baiting, questionnaires were completed by each farmer in both the treated and reference areas in order to obtain information on: (i) the species and numbers of domestic animals; (ii) rodenticide usage; (iii) perceptions about rodent problems; (iv) crop losses. A similar post-treatment survey was also conducted to obtain information on: (i) effects on domestic animals; and (ii) crop yields. Assessing safety of baiting in and around houses

Immediately after the first and second bait applications, 20 randomly selected houses were visited for three consecutive days to assess the correctness of bait concealment; level of activity of domestic animals around bait points; and length of time baits remained uneaten. All three assessments were made using a simple scoring system. Estimating bait attractiveness to non-target animals

Baits were deliberately placed in exposed position near four houses where domestic animals were active. A total of 86 man-hours were spent observing these baits and recording the number and species of animals approaching and trying to eat them. Animals attempting to eat the baits were dissuaded from doing so in order to prevent unnecessary casualties. Searching for carcasses

From 3 to 32 days after the first bait application, a total of 15 man-hours was spent searching the rice fields and village for animal carcasses. In addition, any carcasses found during other activities such as wildlife monitoring were also recorded. Farmers' reports of animal carcasses were first verified by a member of the research team before being recorded.

Monitoring wildlife populations

Three permanent transects about 4 km long were selected to give a good coverage across both the treated and reference areas. For each assessment period, wildlife were monitored on three consecutive days by trained observers walking the length of the transects and recording the numbers of each species seen. In the treated area all observations were carried out between 1600 to 1700 h and in the reference area between 0700 to 0800 h. Seven periods of wildlife monitor-

ing were carried out altogether: the first at 17 days prior to baiting, the second 7 to 9 days after the first bait application, and the remaining five at 14 days intervals up to 25 days after the last bait application. A total of 126 man hours (i.e., 6 hours/day x 3 days x 7 occasions) were spent monitoring wildlife.

Statistical Analysis of Data

The mean percentage (p) cut rice tillers for each transect was calculated and transformed to arcsine√p values before being analyzed by factorial analysis of variance (ANOVAR). The significance of differences between means was then assessed using a Duncan's Multiple Range Test (DMRT).

Data collected during the wildlife monitoring sessions were used to calculate the mean number of each species (or group) observed per day in the treated and reference areas. These data were then transformed to log x (or log x+1) values and analyzed by a split plot ANOVAR. The significance of individual differences in mean levels between areas and observation periods was then assessed using a DMRT.

RESULTS

Efficacy of Flocoumafen

Bait consumption/acceptability

The cumulative % bait take following the first and second applications are shown in Fig. 1. In the village area, more of the bait was consumed by rats during the first (88%) than during the second (59%) application. However, in the rice fields, a similar amount of bait was consumed during both applications (78% to 85%). Overall bait take was very high showing that the Storm blocks used in the trial were readily accepted by rats. Crop damage assessment

Estimates of the levels of rat damage experienced during the previous growing season were provided by farmers in the pre-treatment questionnaire. These showed that the mean percentage damage was similar in both areas (Table 2). In contrast, data collected during the present study, showed that there was significantly higher levels of damage in the untreated site (3.2 + 3.7%) compared to the site baited with flocoumafen (0.94 + 1.7%). As expected, there was considerable variability in damage levels between individual fields within the same site. The range in damage levels was however, less in the flocoumafen-treated area (0 to 17%) than in the untreated reference area (0-33%). Categorization of the fields into damage classes (Fig. 2) showed that about 90% of the flocoumafen treated area had less than 2% cut tillers and only 6% had greater than 5% damage. By comparison, only about 50% of the untreated reference area had less than 2% cut tillers and about 20% had greater than 5%.

Environmental Impact of Flocoumafen

Domestic animals

The pre-treatment census covering all households in the treated and reference sites showed that there was a large number of domestic animals in both areas (Table 3).

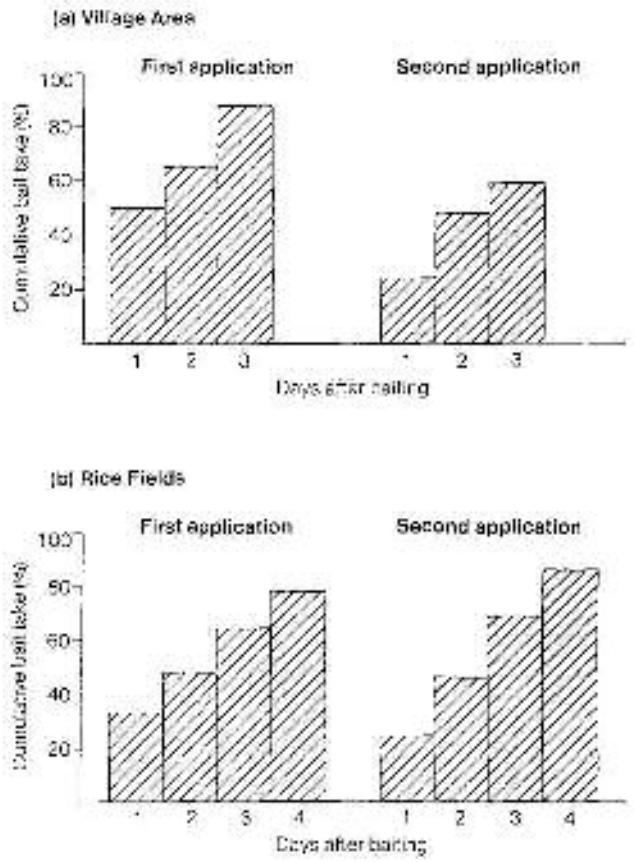

Fig. 1. Percentage cumulative bait take in village and rice fields after the first two area-wide applications.

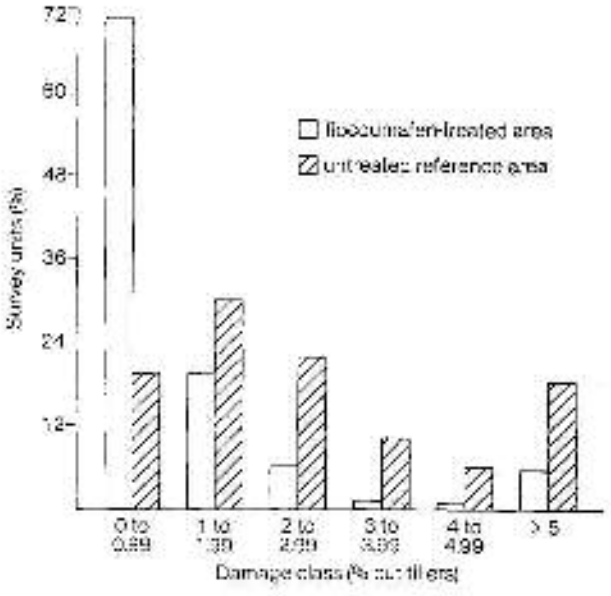

Fig. 2. Frequency distribution of % crop damage (cut tillers) losses in both the flocoumafen-treaied and untreated reference sites.

Table 3. Numbers of domestic animals in the treated and untreated control communities reported in the pre-baiting census of all households.

	Total Number of Animals	
	Treated	Untreated control
Dogs	190	95
Cats	185	114
Pigs	72	23
Chickens	485	633
Ducks	887	633
Goats	10	13
Doves	21	41
Water buffalo	40	5
Cattle	39	2
Horses	3	2
Turkey	2	0
Geese	2	0
Monkey	1	0

Table 4. Observations on behavior of domestic animals around baits deliberately placed in exposed situations.

Animals	Total no. observed	No. approaching the bait	No. investigating the bait	No. trying to eat the bait
Dogs	10[1]	2	1	1
Chickens	59	2	3	4
Ducks	36	3	3	1
Doves	11	0	0	0
Cats	2	0	0	0
Pigs	2	1	0	0

[1] One dog ate the bait.

Studies on the exposure of domestic animals to baits laid in the village yielded some very interesting results.

i) Investigations into the level of bait concealment in and around houses showed that about 50% of the blocks were well concealed during the first application but that this figure rose to 80% during the second application. Of the remaining blocks, only about 1 to 5% were fully exposed.

ii) The activity of domestic animals during both applications in the village was either high or moderate in over 80% of the houses where detailed observations were made.

iii) For the first and second application, about 50 and 40% of baits were completely consumed and 26 and 12% were partly eaten by rats within 1 day. On the third day after both applications, only about 10 and 20% of the blocks still remained; some of these had also been partly eaten by rats. Results from the detailed observations on blocks deliberately placed in hazardous situations demonstrated that very few domestic animals were interested in the bait. Of the 120 animals recorded (6 species) only one dog, four chickens and one duck tried to eat the bait (Table 4). None of the other animals appeared to even investigate the bait.

Although farmers were requested to report any suspected poisonings of domestic animals, only one case was recorded. This involved a dog that had eaten an unknown number of blocks while the farmer was baiting his rice fields. When this dog was examined several days later it did not, however, show any symptoms of poisoning. As a precautionary measure, the dog was given 10 vitamin K, tablets (10 mg) and checked daily for the next two weeks. No symptoms of poisoning were observed at any time and the farmer was happy that the dog's health had not been affected. This was the only incident reported during the trial.

Wildlife Populations

Of the 24 bird species seen during the 95-day observation period, only eight were recorded regularly. The fluctuations in the numbers of these eight species at both sites throughout the trial are shown in Fig. 3. With the exception of tree sparrows, which showed a marked increase in numbers in the flocoumafen-treated site, no statistically significant differences were observed between treated and reference areas in the abundance of any bird species.

In addition to birds, the only other wild vertebrates frequently observed during the trial were skinks (Mabuya spp.) frogs (Rana spp.) and toads (Bufo spp.). The numbers of these animals also varied with time (Fig. 3) but again no significant differences between sites were observed.

Carcass Recovery

Only a few dead rodents were found either during the routine searches or reported by farmers (Table 5). All of these except for two shrews (Suncus spp), were pest species, i.e., R. r. mindanensis, R. norvegicus and M. musculus. No carcasses of non-target wild birds were found during the trial.

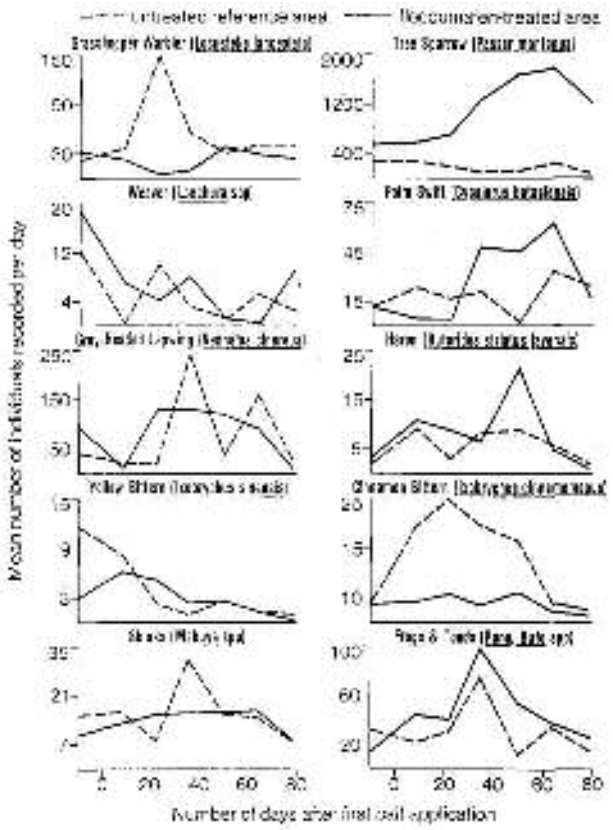

Fig. 3. Temporal variation in the numbers often commonly observed species of wildlife in both the flocoumafen-treated and untreated reference sites.

Table 5. Carcasses reported by farmers and observed by researchers as due to flocoumafen poisoning in both the rice fields and village.

Species	Reported by farmers	Observed by researchers
Rattus rattus mindanensis (Rice rat)	8	35
Rattus norvegicus (Norway rat)	0	2
Suncus luzonensis (Shrew)	2	0
Mus musculus (House mouse)	0	1

DISCUSSION AND CONCLUSIONS

Efficacy of Flocoumafen

The application of 3.5 g flocoumafen block baits (Storm) provided a very effective rodent control when applied over a large area. Only 1.175kg/haofbaitwassufficienttoprotect the rice crop from rat damage for the entire growing season. This extremely low bait usage was achieved by carefully planning an application regime that considered both the high potency of flocoumafen and the level of the rat population. The first two applications of 80 to 100 blocks/ha afforded good control over most of the area and only three subsequent spot treatments were required in areas of particularly high infestation. These mainly occurred in rice fields near the large irrigation canals and in areas bordering uncultivated land (marshes) or coconut groves. In such areas, baiting was extended beyond the paddies in an attempt to contain migrating rats. Similar good results were obtained within the village areas where only two applications of ten blocks per house (total = 70 g of bait/house) were made.

In order to assess the potential value to farmers of using flocoumafen for rat control in rice fields, the yield and monetary benefits and losses were estimated for both sites (Table 6). Data on the rice yield at harvest were obtained for the current and previous growing seasons from 30 farmers in the treated area and 20 in the untreated reference area. These data show that a similar average yield was attained in both areas in the previous season (4.64 and 4.92 l/ha) but in the current season a much higher yield was obtained in the flocoumafen-treated area (5.92 t/ha) than in the untreated reference (4.10 t/ha). Because such changes in yield can be affected by many factors, an attempt was made to estimate the losses directly attributable to rat damage. Thus the expected harvest without rat damage was calculated using the following expression:

$$\text{expected harvest} - \frac{\text{actual harvest}}{100\% - \%\ \text{cut tillers}}$$

From the above, the estimated mean losses/ha due to rat damage were calculated to be 0.06 and 0.14 t/ha, which equates to total losses of 9 t and 22 t for the treated and untreated sites respectively, i.e., equivalent to an added benefit of 131 of rice. Based on a typical price for rice of P3 (approx. USS 0.15)/kg, the total added benefit is worth P39,000 (approx. USS 1,950), equivalent to P253/ha. Considering the low bait input required (1.175 kg/ha), farmers will therefore show a net benefit if the cost of flocoumafen bait is less than P253 (approx. US S13)/kg. In addition, the rat infestation was unusually low during this wet season trial and therefore much higher cost benefits could be expected in a more normal season.

Environmental Impact of Flocoumafen

Domestic Animals

Although most baits in and around the village houses were well concealed and/or consumed quickly by rats, there were nevertheless ample opportunities for domestic animals to have access to and eat Storm bait. No instances of confirmed poisoning were recorded however, even though the activity of domestic animals around most houses was moderate to high throughout the trial period. Furthermore, it is unlikely that any poisonings remained unreported, since a friendly relationship existed between researchers and farmers, the latter being assured of compensation for any losses to their livestock. The only incident involving domestic

Table 6. Comparison of the yield and monetary benefits and losses in the flocoumafen-treated and untreated reference areas.

Factors	Storm treated	Untreated reference
Benefits		
Expected harvest without rat damage (l/ha)	5.98	4.24
Actual harvest (t/ha)	5.92	4.10
(Previous season '87 (t/ha)	4.92	4.64
Expected total harvest without rat damage (t/area)	921	653
Actual harvest (t/area)	912	631
Losses		
Yield loss due to rats (%)	0.94	3.19
Total loss (t/area)	9	22
Monetary loss	27,000	66,000
Added benefit due to control		
Total (P)	39,000	0
/Ha/season (P)	253	0

animals concerned one dog that was seen eating baits from the rice fields. This dog did not develop any symptoms of poisoning even though it received only a minimal treatment with vitamin K_t. It was therefore assumed to have eaten only a small number of blocks.

Additional information on the attractiveness of Storm baits to domestic animals was obtained during the detailed studies carried out on blocks deliberately placed in hazardous situations. These observations showed that only one out of ten dogs attempted to eat the blocks, thereby suggesting that the majority of dogs did not find the baits attractive. A similar situation was found with other domestic animals; only 4 chickens and 1 duck were observed pecking at the bait. While a few individuals of these three species may be potentially at risk from exposed baits, adequate concealment of the blocks should reduce even this small risk to a negligible level. In this respect, it was interesting to note that where there was a high activity of domestic animals, householders tended to completely conceal the baits. It was thus concluded that the adequate concealment of blocks, coupled with the relative unattractiveness of Storm baits to most domestic animals, results in an acceptably low risk to non-target animals around houses.

Wildlife Populations

None of the eight bird species, frogs, toads or skinks seen regularly during the trial showed any significant decreases after baiting with flocoumafen. Indeed, the only differences between sites was the significantly higher overall population of birds, frogs and toads in the treated area. Similarly, the general species richness of birds remained relatively unchanged throughout the trial in both sites. Additional evidence to support the lack of environmental impact of flocoumafen was the notable absence of bird carcasses in the trial area. In fact, the only non-target carcasses found during the study were two dead shrews (Suncus sp.). Whether these died through consuming flocoumafen will not be known until residue data for the carcasses are available.

None of the observed carcasses showed evidence of scavenging, although carcasses did tend to decompose rapidly in the hot humid climate, therefore affording little time for scavengers. The small number of rat carcasses found on the soil surface together with their quick decomposition indicate that the secondary hazards associated with flocoumafen baiting are also likely to be minimal.

Overall, it was concluded that flocoumafen wax block baits gave excellent rodent control with significantly increased rice yields and no observable effects on either domestic or wild non-target animals.

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LITERATURE CITED

BOONCHANAWIWAT, S., et al. 1987. Efficacy and environmental impact in Thailand of flocoumafen, a new rodenticide for rat control in rice fields. Int. Cong. PI. Prot. Oct. 5-9, 1987, Manila, Philippines.

BOWLER, J. D., I.D. ENTWISTLE, and A.J. PORTER. 1984. WL108366-a potent new rodenticide. Proc. 1984 Brit. Crop Prot. Conf., pp. 397-404.

BUCKLE, A. P. 1986. Field trials of flocoumafen against warfarin-resistant infestations of the Norway rat (Rattus norvegicus Berk). J. Hyg. Camb. 96:467-473.

BUCKLE, A. P., F.P. ROWE, and H. ABDUL RAHMAN. 1984. Field trials of warfarin and brodifacoum wax block baits for the control of the rice field rat, Rattus argentiventer. in Peninsular Malaysia. Trop. Pest Man. 30:51-58.

GARFORTH, B. and R.A. JOHNSON. 1987. Performance and environmental studies with the new anticoagulant rodenticide, flocoumafen. In: Stored Products Pest Control, British Crop Protection Council Monograph No. 37., T. J. Lawson (ed.). pp. 115-123.

INDRARTO, N. 1984. Five year rat control programme in

Indonesia. Proc. Int. Conf. Pract. Pest Cont. 30 Aug.- 3 Sept. 1982, Hampshire, England, pp. 475-485.

LAM, Y. M. 1982. Rats are rice field pests - their importance and control. In: Rodent Pests of Agricultural Pests of Malaysia, K.C. Khoo, et al. (eds.). M APPS, Kuala Lumpur, pp. 9-17.

ROWE, F.P., A. BRADFIELD, and T. SWINNEY. 1985. Pen and field trials of a new anticoagulant rodenticide flocoumafen against the house mouse (Mus musculus L.) J. Hyg. Camb. 95:623-627.

SANCHEZ, F.F., et al. 1974. Rodent Research Center Annual Progress Report (Philippines). Rodent Research Center, Univ. of the Philippines at Los Banos. 102 pp.

SCHAEFER, J. 1975. Crop gains - Crop Loss (views on the field rat situation in the Philippine rice crops). PI. Prot. News 4:12-16.

TONGTAVEE, K. 1984. Experience with brodifacoum in laboratory and field conditions in Thailand. Proc. Int. Conf. Organ. Pract. Pest Cont. 30 Aug.- 3 Sept., 1982, Hampshire, England, pp. 357-362.