RODENT RESEARCH CENTER *
1972 ANNUAL PROGRESS REPORT

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ABSTRACT

During 1972, Rodent Research Center personnel again participated with the Bureau of Plant Industry in a national rat damage survey in lowland rice areas throughout the Philippines. Examination of 100 hills in each of 1693 sample rice paddies during the 1971 wet season and 1972 dry season revealed that approximately 2.5 percent of the tillers (stems) had been cut by rats. More than 90 percent of the paddies surveyed had rat damage; 5.4 percent of the paddies showed more than 10 percent of the tillers cut at the time of harvest. Tiller-cutting by rats ranged from 0 to 40 percent in the sample.

Work on census techniques and control methods evaluation continued. In live-trapping studies, so few animals were recaptured that data were not suitable for calculating population estimates. Comparison of snap-trap lines and similarly placed lines of inked tracking-tiles suggested that, if carcasses are not required, inked tiles may be used to provide a sensitive, repeatable population index with somewhat less effort than trapping. Preliminary work suggested that snap-trap grids (400 to 500 traps per hectare) may be one of the more practical means of making actual estimates of rat populations in rice fields.

Continued observations on the reproduction of R. r. mindanensis appeared to confirm that breeding was related to habitat quality rather than season. Pregnant females or newborn young have been found during every month, wherever ricefields or associated habitats provided adequate food and cover.

Tiller-cutting rates of field-caged R. r. mindanensis, made in six different ages of rice during wet and dry seasons, indicated that heaviest cutting occurred during the earlier growth stages. After panicles had matured, feeding shifted entirely to the grain. Cutting rates in developing rice averaged about 80 tillers/rat/night (range: 1-309) and about 6 tillers/rat/night (range: 1-20) in mature rice, indicating that the actual damaging capacity of a population declines as rice matures. Feeding pattern variation among animals may partially explain the difficulty in relating observed crop damage to population sizes.

Locating bait stations within paddies showed promise as one means of improving bait acceptance. In six preliminary tests, rats generally accepted bait placed within the cover of paddies better than bait placed on dikes. In subsequent field trials in-paddy baiting platforms were pre-baited for 3 days in 4 hectares of growing rice. Bait, containing 1% (w:w) of a fluorescent marker, was then exposed for two days to simulate baiting with an acute toxicant. Of 29 rats subsequently trapped in the central one hectare of the baited area, 23 (79 percent) were marked. In another trial, the fluorescent rice bait was placed on dikes with no pre-baiting (a common method of using acute toxicants in rice). Only 3 of 10 rats caught in the central hectare were marked.

Preliminary field tests of sustained baiting with chronic toxicants, coupled with mid-crop exposure of zinc phosphide, were made at four small (3 to 5 hectares) rice farms. The rats readily accepted anticoagulant bait, and apparently, many rats from peripheral areas were drawn to the baited areas along with resident animals. The effect of drawing in outside animals resulted in the consumption of rather large amounts of bait from the stations and appeared to create a zone of reduced damage around the baited area. In each case, zinc phosphide was introduced at a time when early damage was noticed despite the anticoagulant baiting; in each case, this damage stopped at about the same time or shortly after the zinc phosphide treatment. However, we are still uncertain whether this noticeable early damage stopped spontaneously or as a result of the treatments with acute or chronic toxicants. Damage at each location was lower than expected when compared with damage to the adjacent untreated areas or to previous crops on the same areas.

Three twelve-day workshops on vertebrate pest management were conducted in Korea, Thailand, and the Philippines. The major objectives of the programs were to present the principles and strategies involved in protecting agricultural crops; to review, explain, and demonstrate the range of existing techniques; and to suggest ways of identifying and defining problems, quantifying damage, and organizing research on local problems. Classroom laboratory, and field sessions contributed toward these goals. Eighty-five trainess from eight Asian countries participated in the programs.

RODENT RESEARCH CENTER STAFF - 1972

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**Agency designations: UPCA, University of the Philippines, College of Agriculture; BPI, Bureau of Plant Industry; NEDA, National Economic Development Authority; USAID, U.S. Agency for International Development.

INTRODUCTION

The Rodent Research Center was established in June, 1968 as a joint undertaking of the Government of the Philippines (GOP) and the United States Agency for International Development (USAID). The GOP is represented at the Center by personnel from the Bureau of Plant Industry and the University of the Philippines at Los Banos, College of Agriculture. Additional support and cooperation are furnished by the National Economic Development Authority, the National Food and Agricultural Council, the National Science Development Board, and the Philippine Atomic Energy Commission. USAID is represented by personnel from the Denver Wildlife Research Center of the U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife. The Center's activities are determined with the advice of a Board composed of senior members of each of the cooperating agencies.

Program and Facilities

The Center's programs are aimed at the goal of reducing rodent damage to agricultural crops in the Philippines and other countries of Southeast Asia. To help achieve this goal, the overall program has emphasized not only adpative research and control-methods evaluation, but also the development of a technical backstop capability to advise regional plant protection agencies and a training capability to encourage rapid use of new findings. During the year, backstop activities have included trouble-shooting visits to specific problem areas, species identifications, quality testing of government rodenticide stocks, advice to several agencies on the organization of damage evaluation surveys, control programs, and adaptive research plans, and limited data analysis for agencies involved in cooperative programs. Current research has become more directly focused on field evaluation of various control methods on Philippine species, while training has become an increasingly important activity as the Center's staff and capabilities have increased.

Renovation of a portion of the Center's facilities this year provided some additional office space, a classroom for use in training sessions, a laboratory and animal room for use by graduate students and trainees, and additional library space. These facilities, which can accommodate up to 40 students, saw immediate use (a few days after completion) in the Vertebrate Pest Management Workshop held in November.

Research

Research was centered around continued evaluation of control methods using locally available rodenticides with modified baiting techniques. Studies involved exposing anticoagulant baits during the growing season and comparing bait take on dikes with that in paddies. Additional work on the occurrence of rats in habitats associated with ricefields at planting were undertaken.

Responses of rice plants to mechanical injury and tiller-cutting by caged rats were studied to provide a better understanding of rodent damage and how it affects crop yield. The Center assisted the Bureau of Plant Industry during the third National Damage Survey, and aided workers in South Vietnam in conducting rat damage surveys in that country. Other projects included consideration of various means to improve estimates of yield loss from crop damage surveys and tests of methods to estimate or index rat populations under field conditions.

Training and Extension

Approximately 300 people from 25 countries visited the Center during 1972. About one third received detailed briefing on programs or research; the remainder -- many of them teachers, farmers, or students -- had tours and more general presentations.

Three workshops on vertebrate pest management research in Asian countries were conducted for 85 participants during October and November. Sessions were held in South Korea (October 2-13), Thailand (October 16-27), and the Philippines (November 6-17), and involved the participation of trainees from Indonesia, Laos, Malaysia, Nepal, and South Vietnam in addition to those from host countries.

Several reports incorporating RRC findings were distributed by Philippine agencies. In addition, a Bureau of Sport Fisheries and Wildlife pamphlet entitled, "Rats -- Lets's Get Rid of Them" was translated into Pilipino and revised with appropriate illustrations for distribution to farmers and extension workers.

During August, the Center participated with a provincial task force in providing training for more than 200 key farmers, barrio leaders, provincial personnel of extension agencies, and municipal officials of Laguna who were organized to undertake rodent control activities after the heavy rains and disastrous flooding of Laguna de Bay. In addition, Center personnel presented lectures in rodent biology and control to 79 trainees attending two Rice Production Training Courses of the International Rice Research Institute.

RESEARCH ACTIVITIES

Rat Damage Surveys

Introduction

Our study in connection with methods and data from the National Damage Survey conducted by BPI will be completed next year. After complete analysis of the three year's data, improvements for subsequent surveys in the Philippines and other rice-growing countries can be recommended Available results from preliminary analyses are reported.

Cooperative studies with scientists in other Southeast Asian countries were initiated in 1972 with damage surveys conducted in South Vietnam. Surveys conducted by local plant protection service technicians were patterned after those developed at the Center. Results collected in three provinces of South Vietnam were analyzed in the Philippines and reported back to the Government of South Vietnam. Additional cooperative work is anticipated for 1973.

Methods

No changes were made in the sampling techniques employed in the National Damage Survey in the Philippines; this method has been described in Center progress reports for 1970 and 1971. Considerable effort has been devoted to potential ways to improve survey methods; we expect to summarize the variety of ideas for methods improvement in a later report.

In South Vietnam, three provinces (Long-An, An-Giang, and Phong-Dinh) were selected for the initial surveys. During each crop period, one sample hamlet was selected at random for each 10,000 hectares of rice planted in the province. From each of the sample hamlets, 10 sample paddies were randomly selected. Transplanted crops were surveyed by the transect method used in the Philippines (10 random hills in each of 10 random rows) In floating rice, ten 500 m transects were chosen randomly in each sample hamlet. Along each transect, ten 1-m^2 plots were surveyed for cut tillers.

Results and Discussion

In the Philippines, provincial and national averages for wet season crops have shown general decline during the period of the study while dry season damage has remained about the same or has increased (Table 1). Dry season damage indices have been consistently lower than those during the wet season surveys. This difference may relate to differences in the available reservoir habitats other than rice or to the quality and availability of alternative foods; however neither hypothesis has been adequately investigated. Data on tiller-cutting in individual rats (reported in a subsequent section) showed that greater numbers of tillers were cut in wet season field trials, suggesting possible variation in the forage quality of rice herbage during different seasons.

The suggestion is sometimes made that rat damage might stimulate the growth of additional tillers since this occurs with some types of insect damage. Thus, estimation of the percentage of cut tillers would require counting tillers in both damaged and undamaged hills to avoid bias. Examination of accumulated data from 8900 hills (100 hills from 89 paddies) showed a mean of 14.6 tillers in hills from which rat damage had been recorded and 14.3 tillers from hills with no evident damage; the difference was not statistically significant. Preliminary work with data from samples of 50, 100, and 500 randomly selected hills per paddy, similarly, showed no differences in the total numbers of tillers in damaged and undamaged hills except in cases where water supplies were insufficient. These results suggest that the procedure of counting tillers only in damaged hills may be validly used in most situations, since the total tillers in the paddy sample can be estimated from the total tillers in damaged hills.

Table 1. Estimated percent of mature rice tillers cut by rats in the Philippines during 1970-1972.

Province	1970	1971		1972	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Albay		1.48	1.84	1.94	
Bohol		0.17		0.26	
Bulacan	3.71		1.98		
Camarines Sur	2.75	1.09	0.86	0.39	
Cotabato	8.08	2.88	3.41	2.95	1.97
Iloilo	2.64	3.09	0.41	13.63	0.21
Mindoro Or.	4.30	2.14	0.77		
Negros Occ.	0.72		1.05		0.34
Nueva Ecija	2.68		2.53		0.54
Pampanga	9.49		3.31		
Pangasinan	7.58		9.47		4.77
NATIONAL AVERAGE	4.20	1.58	2.43	1.56	

After analysis of the data from this study are completed, recommendations on the design and methods of future surveys will be made.

South Vietnam -- Rat damage to rice was below 10 percent (range: 0.2 to 9.6) in all hamlets surveyed, regardless of variety or manner of planting. Mean damage was generally highest among transplanted TN (high yield) varieties and lowest in floating rice (Table 2). As in the Philippines, damage estimates form these surveys are much lower than previous subjective reports; however measurable damage appeared in most of the fields sampled.

Table 2. Rat damage to rice in South Vietnam based on surveys in three provinces under four crop conditions.

Province	Crop Type	No. Hamlets Surveyed	Mean Percent Tillers Cut
Long-An	TN Early Crop	20	1.76
Long-An	TN Late Crop	20	2.02
An-Giang	TN Early Crop	4	2.32
An-Giang	Floating Rice	19	1.38
Phong-Dinh	TN Early Crop	6	3.08
Phong-Dinh	Local Varieties	3	2.02
Phong-Dinh	Floating Rice	6	0.42

Response of rice plants to mechanical injury

Introduction

Field observations have indicated that rice plants often regenerate stems that have been cut by rats. If cutting occurs early, some of the regenerated tillers mature at about the same time as normal tillers and contribute to the yield. When plants are older at the time of damage, regenerating tillers are often too immature at the time of harvest to make much contribution to yield. Some tillers die after cutting, and this fraction appears to increase as the plants age. Plants may compensate such losses by producing larger grain heads or heavier grains on the remaining undamaged stems. The plants capacity to compensate for rodent damage will influence the accuracy of estimates of yield loss based on the percent of cut tillers, and may also provide a means for more effective timing of rodent control operations. To obtain some preliminary information on the reduction in rice yield caused by varying damage intensity at different ages, two tests were conducted by mechanically cutting tillers in plots of growing rice.

Methods

In the first test, three groups of 4-one-m^2 plots were randomly selected in an irrigated paddy of IR-12 rice 8 weeks after transplanting (WAT) during the dry season. Treatments consisted of: (1) clipping 3 tillers per hill on all hills, (2) clipping 6 tillers per hill on half the hills selected at random, (3) and no clipping. Fourty-eight tillers were cut in each plot -- about 20 percent of the total tillers.

In the second trial, five tillers were cut from each hill in 4-one-m^2 plots at 4, 9, and 14 WAT. Four additional plots served as references. All plots were randomly selected in a paddy of irrigated C4 rice during the wet season. Eighty tillers (about 45 percent of the total) were cut in each plot.

In both trials hardware cloth cages were placed over all plots to prevent uncontrolled rat or bird damage. At maturity the rice was harvested, threshed, dried, and weighed. Weights were standardized to 14 percent moisture content.

Results and Discussion

In both trials the reduction in yield was less than the amount of mechanical damage inflicted (Tables 3 and 4). The pattern of damage in the first trial (3 tillers cut in all hills versus 6 in one-half the hills) did not appear to have an effect on yield. In the first trial (IR12 - dry season) most of the cut tillers regenerated, but in the second trial, (C4 - wet season) none of the tillers cut at 9 and 14 WAT regenerated (it was not possible to determine if those cut at 4 WAT died or regenerated). Compensation for damage was probably due to increased number and weight of grains in undamaged panicles. Studies at IRRI (1972) have shown that CO_2 enrichment after heading increased yields because more grains on each head filled. Compensation for mechanical damage occurring as late as 14 WAT probably took place in the same manner.

These trials indicated some of the potential difficulties in estimating yield reduction from the percent of cut tillers determined at harvest. If evidence of early damage disappears through retillering or deterioration of dead tillers (LaVoie et al.,1970), severe early damage may cause significant reduction in yield but would not be detected in pre-harvest tiller counts, resulting in underestimates. Conversely plant compensation for later damage (between 8 WAT and the time surveyed) would cause overestimates. Because the time of rat damage may vary considerably, more precise estimates may require more than one damage survey.

Table 3. Results of cutting 20 percent of the tillers in 1 m^2 plots at 8 weeks after transplanting.

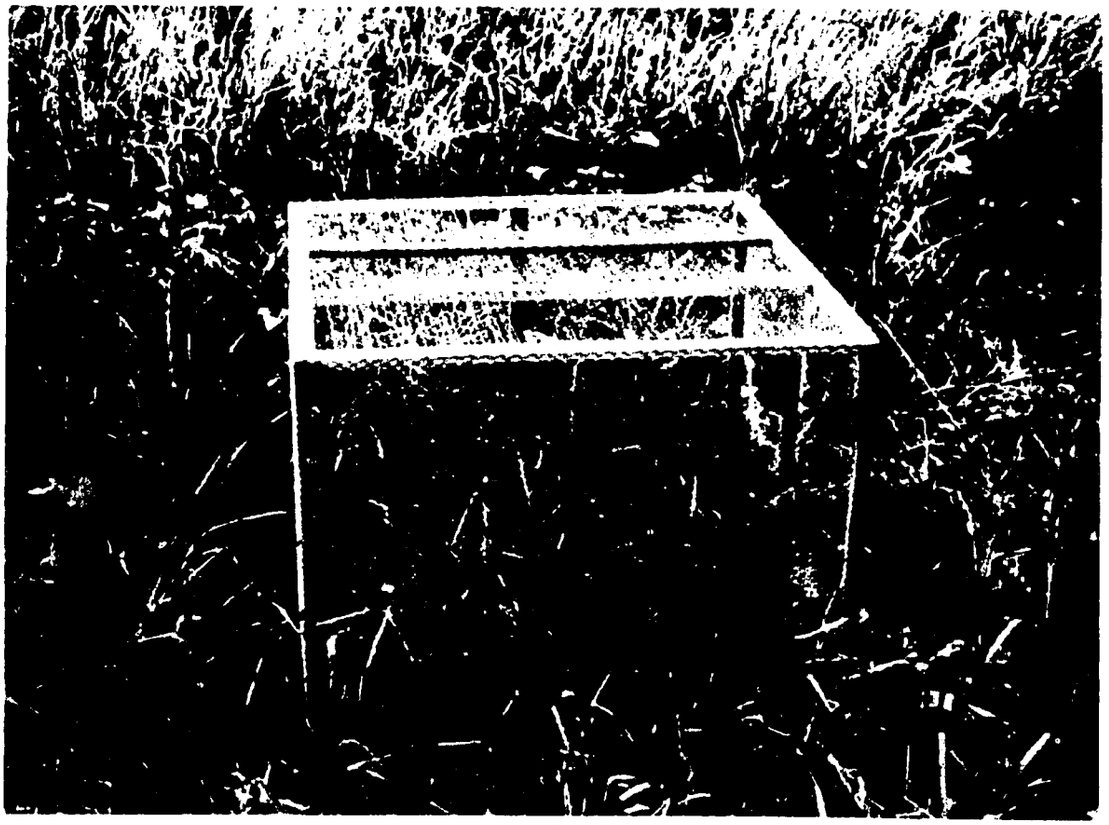
Mechanical damage treatments	Grams per plot ($\bar{X} \pm$ SE)	Percent reduction	Percent of tillers showing damage at harvest
3 tillers/hill	270 ± 15*	8.5	5.0
6 tillers/half the hills	268 ± 5	9.2	3.5
None	295 ± 8	-	0

*None of the means were significantly different ($P > 0.1$)

Table 4. Results of cutting 45 percent of the tillers in 1 m^2 plots in three different ages of rice.

Age of time of damage	Gram yield per plot ($\bar{X} \pm SE$)	Percent reduction	Percent of tillers showing damage at harvest
No Damage	280 ± 5	-	0
4	260 ± 16	7	0
9	205 ± 24*	27	37
14	186 ± 8*	34	45

*Significantly different from undamaged ($P < 0.1$).



Exclosure used to prevent uncontrolled rat and bird damage in studies on plant response to mechanical injury.

Occurrence of rats in habitats associated with ricefields at planting

Introduction

In many areas, it has appeared difficult to accurately assess, at the time of planting, the intensity of rat damage that might occur. Since the shelter in the fields themselves is virtually eliminated in the process of preparation for planting, animals residing in the field area at this time are forced to other shelter, such as dike burrows, straw piles, grassy threshing mounds, and field edges. To gain initial understanding of the importance of these specific harborage areas in the survival between crops and re-invasion of paddy interiors we conducted survey trapping in five types of habitat at two locations near Pila and Santa Cruz, Laguna. At one site, additional observations on movement were made by attaching miniaturized radio transmitters to five rats. At an additional site near Pila, Laguna 14 straw piles were excavated at the time of planting and the resident rats captured.

Methods

Habitat types available before planting at each of the two locations were catalogued and areas for trapping were selected. Five snap traps were set at each of 15 threshing mounds and 30 straw piles. In each of the other habitat types, designated as canal banks, paddy dikes, and field edges, ten traps set at 10-m intervals were set in 7 or 8 randomly chosen transects. The five rats used to carry the radio transmitters were live-trapped from paddy dikes at the Santa Cruz site after snap trapping was completed; procedures were those described by Fall, West and Kolz (in press).

Results and Discussion

At Santa Cruz, threshing sites appeared to have the greatest amount of rat activity (Table 5). These mounds, usually located in the corners of paddies, occur in areas where hand-threshing is common. Because of weed growth between crops and the general lack of disturbance of these areas during land preparation, they appear to provide shelter for many animals during this critical time.

Many rats were also trapped on paddy dikes and canal banks at both locations; however it appeared that many of these animals were finding harborage elsewhere and were trapped while foraging or traversing the dikes. Limited observations with the radio tracking equipment seemed to confirm this since most animals trapped on paddy dikes were resting in other locations during the day. Movements of animals in mature rice have

generally averaged less that 100 m in our previous work. Animals monitored under these conditions of very sparse vegetative cover moved 100 to 250 m from capture locations to daytime cover.

Straw piles were apparently a major source of field shelter during the planting period at Pila. These piles were made in the paddies during the previous harvest and averaged about 6 per hectare. Usually farmers intend to burn the straw, but untimely rains often prevent it. The piles remain usually until they have decomposed sufficiently to be worked into the soil. Excavation of the strawpiles resulted in the capture of 16 rats, one of which was a pregnant female.

Field edges appear to play a varying role in supplying rats. At Sant Cruz, the edge areas were coconut groves with thick, shrubby vegetation under the trees. Trap success was relatively high here. Because of the obvious daytime rat noise in the area we suspected that this was a major source of daytime shelter and that many animals were moving considerable distances to forage among the rice plantings. After our study, local farmers killed many rats in several sections of the grove by beating the vegetation with sticks to force animals into the open.

Damage surveys were conducted in 10 paddies in each area near the time of harvest. Although the levels related generally to the trapping results at the period of planting (five percent of the tillers cut at Santa Cruz, one percent cut at Pila), we could see no obvious relation of damage to the reservoir habitats. It appears that the relatively long movements made by animals foraging from the reservoir habitats result in a wide distribution of animals as the rice crop develops. Since damage occurring before about 7 or 8 weeks is not detected in the harvest surveys the early relationship of animals to the reservoir habitats is apparently obscurred. Using periodic damage surveys throughout the crop or yield measurements at harvest might be useful in assessing the damage reduction to be gained by clearing specific reservoirs. It also appears that removal of reservoirs such as straw piles or threshing mounds by an individual farmer from his own paddies might have minimal impact on his losses unless his neighbors took similar actions over a rather wide area.

Table 5. Summary of three nights' trapping in habitats associated with newly planted rice fields at Santa Cruz and Pila, Laguna.

Location	Habitat	Units Surveyed	Traps per Unit	Rats Captured	Mean Trap Success (Corrected for Sprung Traps)
Santa Cruz	Threshing Sites	15	5	58	37.1
	Field Edges	7	10	39	26.1
	Paddy Dikes	8	10	41	24.1
	Canal Banks	[illegible]	10	23	13.9
Pila	Straw Piles	30	5	39	10.1
	Canal Banks	5	10	19	8.4
	Paddy Dikes	7	10	13	6.5

Keeping ditch banks and coconut groves clear of excess vegetation is one means of reducing rodent populations in reservoir areas.

Tiller-cutting behavior of rats in growing rice

A manuscript covering this work has been prepared, and copies will soon be available. A summary of the study follows:

The rate at which field-caged rats (*Rattus rattus mindanensis*) cut tillers was measured in six different ages of rice under both wet- and dry-season conditions. More cutting occurred during the earlier growth stages (6-12 weeks after transplanting), while tillers were still developing; after the panicles had matured, feeding shifted to the grains and significantly less tiller cutting was observed (Table 6). Cutting rates in developing rice ranged from 1 to 309 tillers/rat/night and were generally higher during the wet-season crop. The variation in behavior among animals may partially explain the difficulty of relating observed crop damage to the number of animals present.

Table 6. Rice tillers cut by rats caged for 24 hours in growing rice of six different ages under wet- and dry-season conditions. Six rats were used in each test.

Weeks after transplanting	Dry Season		Wet Season		Over-all Age Mean**
	Range	Mean	Range	Mean	
6	7 - 226*	71	11 - 252	130	101 c, d
8	13 - 199	44	1 - 129	40	42 a, b
10	21 - 138	70	32 - 309	164	117 d
12	32 - 119	66	30 - 97	54	60 b, c
14	4 - 46	24	4 - 37	23	23 a, b
16	1 - 7	3	2 - 20	9	6 a
	Mean = 46		Mean = 70		

*Data are expressed as tillers cut per rat per night.
**Means followed by the same letter are not significantly different by Duncan's New Multiple Range Test at the 0.05 protection level.

Early rodent damage may appears more critical than cutting nearer harvest because more tillers are cut per minute of rat feeding.

Comparison of In-Paddy Baiting and Dike Baiting Using a Fluorescent Marker

Introduction

In one of the common approaches to rodent control in rice fields in the Philippines, baits prepared with acute toxicants (usually zinc phosphide) are exposed on or along paddy dikes in small piles a few meters apart. A controlled field test of this approach indicated that it has little effect in reducing rat (*R. r. mindanensis*) activity or damage measured at harvest (West, Fall, and Libay, 1972). Other workers have also reported observations on the ineffectiveness of such methods in reducing crop loss (Wood, 1971; Fernando, Kawamoto, and Perera, 1967).

Findings in other Center studies have suggested the need for continuous protection of rice because of immigration of rats during the crop period. The role of acute toxicants in such situations is not clear, but because of their potential use for direct population reduction and in integrated crop protection programs, we have continued investigation of means to improve their effectiveness.

Several lines of evidence which we have not yet reported in detail and experience with other species led us to suspect that major improvements both in bait acceptance and number of animals affected could be gained by distributing stations within the paddies and by exposing untreated bait for several days ("prebaiting") before acute toxicants are introduced.

This study was conducted as a preliminary comparison of the two approaches. Other tests, along with biological observations will be reported at a later time. It should be noted, that in using a marking agent to index the potential contact of animals with an acute toxicant, we do not assume that all of the marked animals would have been killed. However, at the concentration used, rats would need to ingest about three times as much material to become marked with the dye as that which would contain one lethal dose unit (LD_{50}) of zinc phosphide. In either case, effective bait consumption would need to be only a small fraction of the total daily food intake.

Methods

Two four-hectare areas were baited with polished rice containing one percent (w:w) tetracycline hydrochloride (TC), a chemical which causes bones and teeth to fluoresce under ultraviolet light. Age of rice in both areas was somewhat variable, ranging from about 9 to 12 weeks after transplanting. In the first test, at La Paz, Tarlac,

plywood platforms (10" x 10" x 1/4") were arbitrarily placed in paddy interiors throughout the area at the approximate rate of 25 per hectare. The platforms were supported one to two inches above water level by short stakes. Untreated polished rice was placed on each platform and consumption was measured for three days, then treated rice was placed on the platforms for an additional two days. In the second test area at Pakil, Laguna, TC-treated rice was placed in small piles on or along the dikes in the four-hectare area at the rate of one kilogram per hectare and was exposed for two days.

After exposure of treated bait in each area, intensive snap trapping (20 lines of 20 traps each, spaced at 5-m intervals) was conducted on the central one hectare of the plot for three days. Teeth and jaws of trapped rats were excised, cleaned, and examined under ultraviolet light to determine whether the animals had eaten treated bait.

Results and Discussion

Approximately 79 percent of the animals trapped in the area where in-paddy baiting was used showed evidence of bait consumption. In the area where dike baiting was used, about 30 percent of the animals trapped were marked although only about one-third as many animals were captured (Table 7). These results seem to substantiate the finding of West et al., (1972) that dike baiting was relatively ineffective. They also suggest that the approach using pre-baited, in-paddy stations might provide major improvement in results from the standpoint of population reduction. The approach certainly warrants further investigation.

Table 7. Rats marked by tetracycline hydrochloride-treated bait exposed by two baiting methods.

Baiting Method	No. Captured	No. Marked	Percent Marked
In-Paddy	29	23	79
On Dike	10	3	30

Measurement of bait take at the stations in Tarlac indicated that nearly a ten-fold increase had occurred by the fourth day when treated bait was exposed (Table 8). Similarly, only half of the

stations on the four hectares were in use after one night, while on the fourth night all had activity. We have no ready explanation for the drop in activity and bait consumption on the fifth night. Were this attributable only to bait aversion, we would have expected the drop to have taken place upon first exposure of the treated bait Similar results have been found in studies of other rat species and may relate to developing competition among animals using the food source.

Table 8. Bait consumption at 100 in-paddy stations on four hectares at La Paz, Tarlac.

Day	Type of Bait	No. of Stations With Rat Activity	Total Grams Taken
1	Untreated Rice	50	1095
2	"	62	1885
3	"	84	2265
4	TC-treated Rice	100	9910
5	"	54	760

An increase of bait station density might have improved results further; however we concluded that 25 per hectare approaches, or perhaps surpasses, the number that one farmer could effectively maintain. Of course, any of a variety of cheaper materials or methods of construction could be used to prepare the stations. The factors which we believe contributed to the improved results at La Paz were the establishment of resting points above water level, openess of the platforms which made bait readily available, location within the cover provided by growing rice, and pre-baiting for several days.

Platforms placed in the paddy and pre-baited for three days were more effective in marking rats with a fluorescent marker than bait placed on dikes without pre-baiting.

Straw piles provide food and cover for rats between crops.

Preliminary field trials of integrated approaches to rice protection

Introduction

Although toxic baits, physical removal of animals, and field cleaning have been recommended as methods of rat control in the Philippines for many years, damage is often excessive even in areas receiving control. The greatest reliance for damage control in growing rice has been placed upon fast acting poisons, such as 1080, 1081, and in recent years, zinc phosphide. Many workers have attributed the ineffectiveness of these materials to the development of "bait shyness" by rats. Favorable results have been reported for approaches making use of intensive application of chronic toxicants or anticoagulants (Wood, 1971; Philippine-West German rat control applied research project, 1972), when large areas (20 to 100 hectares or more) have been treated. However, sustained baiting over large areas of rice land has proven difficult in the SE Asia context because of the small farm sizes, varying crop conditions, and the need to organize many landowners in simultaneous, intensive activity at a time when their labor must be divided among many agricultural tasks.

There is an increasing need for individual farmers in SE Asia to have cheap, effective means of dealing with problems in their fields. While recognizing both the desirable and beneficial aspects inherent in well-organized and maintained area-wide cooperative programs, we have begun an intensive investigation of methods and programs for damage control on individual small farms, with particular reference to costs and labor required.

Preliminary work was begun with four field trials in Laguna Province in which the use of chronic toxicants, acute toxicants, field cleaning, and physical removal of rats were used in combination on three to five-hectare farms. These trials were exploratory attempts to determine the usefulness of particular approaches or combinations and were not intended as replicates or comparative trials. The description and general results of each trial are, therefore, presented separately; tabular summaries are presented together at the end of the section.

Trial 1

This work was conducted on a five-hectare farm at Pila, Laguna during the dry season. The farm was bounded on three sides by coconut groves and on one side by rice of about the same age. The area had a history of moderate rat damage and the owner was highly receptive to using improved methods of rat control.

Shortly before planting, hired laborers cut and burned weeds and debris in most of the grove area and killed as many rats as possible in the process. During the period from planting to harvest, grass in the groves was maintained relatively short. Laborers were used several times to cut grass on paddy dikes and canal banks and to kill rats that could be flushed from burrows by systematic flooding.

At the time of transplanting, bait stations were located at 100 m intervals around the periphery of the farm and along canal banks and paddy dikes within the farm, maintaining approximately 100 m between stations. Ten stations were required along the periphery, while thirteen were required for the interior. Each station consisted of an empty, one-quart, plastic oil can with both ends removed, which was staked in position by two small strips of bamboo. The bait used in these stations was a proprietary wax-bound, maize base mixture, formulated in one-inch cubes and containing 0.05 percent warfarin (w:w). Tests of this material in Malaysia have been described by Wood (1971). Bait was replenished twice weekly throughout the crop;three to twelve cubes were placed in each station depending on apparent consumption.

After about 8 weeks, careful examination revealed minor damage in some of the paddies and we decided to treat the area with zinc phosphide using pre-baited in-paddy stations. Using an approach similar to that tested at La Paz, Tarlac, we established platform stations (with oil cans stapled to them for bait containers) in paddies throughout the farm at a rate of 10 per hectare. Untreated, polished rice was exposed for three nights, then replaced by two percent (w:w) zinc phosphide-treated rice for an additional four nights. The amount consumed at each station was measured.

We used several approaches to help evaluate the effect of these measures. Inked tracking tiles were used to index rat activity along dikes before and after the treatment with zinc phosphide. Six rats were also fitted with radio transmitters a few days before these treatments; their locations were checked daily for as long as the radio signals could be located. During the week of harvest, we examined 50 hills in each of ten paddies to determine the proportion of tillers that had been cut by rats. Through the cooperation of the farm owner, we maintained a rough total of the numbers of rats killed in the cleaning operations and the approximate time and costs associated with each phase.

Results -- The wax-base cubes appeared well-accepted and bait take from the anticoagulant stations remained about the same from the first through the seventh week. Between the seventh and ninth weeks bait loss approximately doubled, but began to decline when the rice was 12 weeks old (Table 9). The anticoagulant bait loss did not decline

immediately after the zinc phosphide baiting which occured during the 9th and 10th weeks after transplanting. The amount of zinc phosphide treated bait taken was considerably less than the amount of pre-bait lost (Table 10). Likewise there was no difference in the number of tracking tiles used in the pre- and post-zinc phosphide treatment surveys (Table 11). However, at harvest only 0.4 percent of the tillers showed evidence of rat damage (Table 12). Of the six rats fitted with transmitters, 3 were found dead during the time the zinc phosphide bait was exposed. Approximately 500 rats were killed during the cleaning work done by the laborers, which cost approximately ₱135.00 per hectare (Table 13).

Trial 2

This trial was conducted near Santa Cruz, Laguna during the dry season on a 3.5-hectare irrigated rice farm. The farm was surrounded by weeds and stubble remaining after the wet-season harvest and was several hundred meters away from any other plantings. Anticoagulant baiting began four weeks after rice was transplanted, using the same bait material and types of stations that were described for Trial 1. Sixteen stations were used on this farm, eight around the periphery and eight spaced throughout the interior on dikes, canal banks, and threshing mounds. When rice was 5 to 6 weeks old the grass on dikes and along a two-meter wide band at the field edges was cut very short

Again, some damage was evident a few weeks after anticoagulants had been in use. This was perhaps aggravated by the farm's irregular water supply and uncontrolled weed growth which provided excellent rat cover within some of the paddies. When the crop was about eight weeks old the owner spread a bait compounded from rough rice, corn meal and 1081 (fluoracetamide) in small piles along paddy dikes. Over a period of several days, he distributed about 9 kilograms of this material.

At ten weeks after transplanting, we also baited with acute toxicants. Thirty-five in-paddy stations similar to those previously described, were prebaited for two days. Then treated bait was exposed on fifty open platforms spaced through the paddies. Half of the stations were baited with polished rice containing two percent zinc phosphide (w:w), the other half were baited with polished rice containing one percent gophacide (w:w). Daily bait take was recorded for each station. At harvest the proportion of cut tillers was estimated by examining 50 hills in each of 10 paddies.

Results -- There was no anticoagulant bait taken the first four days of exposure, but animals soon began to feed at the stations and bait loss steadily increased until the rice began to head (see Table 9, 12 weeks after transplanting). The farmer's elective dike-baiting (8 weeks) and our baiting in paddies at 10 weeks did not appear to change the rate of consumption of anticoagulant bait. Both baitings were conducted because of evident rat damage in the paddies; however, there was no apparent change after the farmer's dike-baiting. Bait consumption appeared minimal, no dead rats were found by searching the dikes and paddies, and damage continued. Baiting with zinc phosphide and gophacide was probably somewhat more effective because damage appeared to virtually stop and several dead rats were found in the paddies. Aversion or bait shyness may have caused the decline in consumption when acute toxicants were exposed (Table 14); however "location shyness" could also account for this result, since many of the toxicant locations had not been pre-baited. The grass cutting required 62 man-hours and did not appear to affect the occurrence of rat damage (Table 13). The proportion of cut tillers estimated in the harvest surveys averaged 12.5 percent.

Trial 3

This trial was conducted during the wet season at Lumban, Laguna in four hectares of rice which was centered within a wide area of rice about the same age. Anticoagulant baiting started about 4 weeks after transplanting using the same type of warfarin bait and bait stations as in the previous trials. In this case, however, baiting points were established on six threshing mounds within the four hectares. Several of the small oil-can stations were placed at each site and were replenished twice weekly.

Zinc phosphide baiting was begun about one week later, using the in-paddy platforms as in trials 1 and 2. Pre-baiting was done for three days, followed by two days exposure of the two percent zinc phosphide-polished rice bait.

At eight weeks after transplanting and again at thirteen weeks, weeds on all of the dikes and threshing sites were closely trimmed. Provision was made to kill rats which were flushed, but this had limited success. No attempts were made to flush or excavate rats from burrows.

In this area, rat activity was indexed by placing tracking tiles along dikes in the central 9 paddies. This was done before and after zinc phosphide baiting, 4 weeks after baiting, and about 10 weeks after baiting -- just before harvest. The proportion of tillers cut was estimated by examination of 500 hills in each of the 10 central paddies. Similar surveys were made in 10 reference paddies located 200 meters or more from the edge of the treated area. The larger number of hills examined in this trial was related to another study.

Results -- Consumption of anticoagulant bait began immediately and continued to increase after the zinc phosphide application at about 6 weeks after transplanting (Table 9). Initially, there was a major decrease in activity (shown by the tracking-tiles), but by harvest, this had returned again to the initial level (Table 11). Anticoagulant loss continued to increase until about the time rice began heading; consumption of prebait (20 kilograms) and zinc phosphide bait (0.9 kilograms) were also relatively high. Seventy man-hours were expended in clearing grass on dikes and threshing mounds.

The evident damage to young rice stopped shortly after the zinc phosphide baiting; however the pre-harvest surveys showed that 2.0 percent of the tillers examined had been cut by rats. On the adjacent untreated paddies, cutting averaged 4.6 percent. A survey in this same baited area during the previous wet season (1971) showed an average of 12.1 percent of the grain-bearing tillers had been cut by harvest time.

Trial 4

This trial was conducted during the wet season crop on the same five-hectare farm used for Trial 1. Again baiting with chronic and acute toxicants, cleaning of reservoir habitats, and physical removal of animals were all employed, but with minor changes in approach.

Anticoagulant baiting points were established the fourth week after transplanting at 100-meter intervals along the periphery of the rice fields. In the coconut area, a second band of baiting points was established 50 meters inside the groves and staggered between those on the field edge. No baiting was done in the farm's interior. The test material was a commercially-formulated, grain-base, particulate bait containing 0.005 percent diphacinone. Each oil-can station was charged with 115 grams of this material and checked twice weekly. As consumption changed, additional bait stations were added or removed from each baiting point.

Zinc phosphide baiting was confined to a three-hectare section of the farm which showed more evident damage to young rice about one week after anticoagulant baiting had begun. In-paddy stations were used at the rate of 25 per hectare and were pre-baited for three days before exposure of the two percent zinc phosphide bait.

Tracking tiles were used before and after zinc phosphide treatments, and harvest surveys for cut tillers were conducted in the same manner as in Trial 1. An additional ten paddies, initially presumed outside the treatment area (100-300 meters away), were also surveyed at harvest.

Results -- The diphacinone bait used in this study was also well-accepted (however, the tests were not designed to compare this material with the wax cubes). Bait take reached a peak during the third week (a week after the zinc phosphide treatment), then slowly decreased until harvest (Table 9). Tracking tiles again indicated little effect from the zinc phosphide treatment on overall activity. The early damage we had observed occurring on the three-hectare section stopped at about the same time anticoagulant consumption began to decline.

The grass-cutting on dikes and groves during this crop was again estimated to have cost about ₱135.00 per hectare. Approximately 200 rats were killed from planting to harvest by the laborers.

Pre-harvest damage surveys on the farm indicated an average of 1.0 percent of the mature tillers were damaged (Table 12). Tiller-cutting in the ten paddies surveyed outside the farm average nearly the same (0.9 percent.)

Discussion

There are many questions raised by these trials which invite detailed discussion. Similarly there are, no doubt, additional details of approach or of site ecology which, if more fully explained, would help in readers' interpretation of the limited data that we have presented. Since some of the work bearing on the understanding and interpretation of these data is still in progress, a detailed discussion will be delayed. Instead, we shall focus briefly on several speculative ideas drawn from this exploratory work which may help point some directions for future study of small-farm rat control.

The intensive cleaning of dikes and edge areas probably had only a limited effect in actual prevention of damage, yet it was a costly activity. In all of the trials, it appeared that the area from which rats were drawn extended outside the farm boundaries, and that clear areas were not effective barriers. However, in Trials 1 and 4 on the 5-hectare farm, maintenance of short vegetation in the groves probably prevented build-up of the farm population between crops. It was obvious there, also, from the amount of bait consumption that, despite the large numbers of rats killed by the farmer, animals continued to move in from surrounding areas -- probably in response to reduced population pressure on the farm itself. On the 3.5 hectare area where Trial 2 was conducted, the farmer had made what could only be termed a "high-risk" choice in planting within an area that provided good cover, but limited food for the rats produced during the previous crop. Growth

of weeds and the variable water levels in these paddies provided excellent rat cover within a relatively short period after planting. Without intensive control efforts, this crop would probably have been virtually destroyed by rats; under the circumstances the occurrence of 12.5 percent damage should be considered a good result.

We initially failed to understand the continued increases in consumption of anticoagulant bait in the early trials and entertained a hypothesis of defective materials (which we rejected after a series of lab tests). It then became obvious that recruitment of animals to the stations was keeping ahead of the mortality caused by the slow-acting anticoagulants. Rapid recruitment may have also obscured the major effects of the zinc phosphide baitings. We suspect that some rats were moving back and forth over rather long distances to use the stations and that the area of effect in each case extended some distance outside the farm. This could explain the low damage which occurred in the reference paddies surveyed in Trial 4.

In each trial, some early damage was observed after anticoagulant baiting began; this was one of the primary reasons for conducting zinc phosphide baitings. In retrospect, it appears that some of this early damage might have been eliminated by beginning the anticoagulant baiting a few weeks earlier -- at planting or shortly before. The rather large amounts of untreated pre-bait and zinc phosphide bait consumed in some of the trials suggested that we were not reaching the entire population with the anticoagulant materials. An important minor observation is that consumption could apparently be increased at a baiting point by using several small stations. This reduces labor considerably and may provide a means to reach a greater proportion of animals during the earliest crop stages. Improvement in the method of exposing anticoagualant bait may eliminate the apparent need for acute toxicants in this type of program.

There was some indication that bait acceptance with either acute or chronic toxicants was greatly reduced after mature grain heads became available. It may also be recalled that data on tiller-cutting rates suggested a potentially great reduction in the capacity of a rat population of given size to cause damage in a mature rice crop. Combining these observations, we would speculate that baiting might be discontinued during the last two or three weeks of a rice crop without encountering a significant change in results.

Table 9. Weekly take of anticoagulant bait (kilograms) from all stations in the four field-trials conducted in Laguna Province during 1972.

Weeks after transplanting	Trial No. 1	2	3	4
1	1.17			
2	1.40			
3	1.69			
4	1.71	.24		3.1
5	1.48	.56	5.40	7.10
6	1.78	.62	5.19	9.25
7	1.68	1.11	6.40	7.92
8	2.56	3.24	7.06	7.62
9	3.49	4.92	6.76	7.61
10	3.40	4.60	7.78	5.58
11	3.24	3.98	3.18	4.22
12	1.29	1.68	.64	4.00
13	.93	.86	.08	3.63
14	.30	.42	.18	2.82
15	.63	.54	.06	1.12
16 (harvest)	.54	.33		.11
17	.40	.22		
18	.24	.57		
19	.30			
20	.45			
21	.28			
TOTALS	28.98	23.92	41.85	64.17

Table 10. Take (grams) of pre-bait and zinc phosphide-treated bait in Trial 1 at Pila from 50 in-paddy stations.

Day	Type of Bait	Active Stations	Grams Taken
1	Untreated	11	199
2	"	26	260
3	"	32	373
4	Zinc Phosphide	4	13
5-7	"	18 (3 day total)	56 (3 day total)

Table 11. Proportion of tracking-tiles showing rat activity before and after baiting in Trials 1, 3, and 4.

Period	Proportion of Tiles Showing Activity		
	Trial 1	Trial 3	Trial 4
Before Acute-toxicant Treatment	25	51	52
After Acute-toxicant Treatment	22	25	59
Four Weeks After Treatment		32	
Ten Weeks After Treatment (harvest)		52	

Table 12. Estimated rat losses (percent of total tillers cut) in 10 randomly chosen paddies during three successive crops. Data were collected in the five hectares farm used in Trials 1 and 4 at Pila, Laguna.

Paddy No.	Wet Season 1971 (Pre-treatment)	Dry Season 1972 (Trial 1)	Wet Season 1972 (Trial 4)
420	2.6	0.5	1.2
427	3.7	0	0.7
430	5.6	1.4	0.4
610	1.3	0.3	0.1
616	1.2	0.5	1.9
618	1.0	0.1	1.8
622	1.0	0.3	2.8
804	0.9	0.2	0.4
819	2.6	0.6	0.4
821	0.9	0.2	0.3
AVERAGE	2.1	0.4	1.0

Table 13. Owner-estimated costs for cutting grass and killing rats in each of the four trials. Costs were based on man-hours or man-days involved on each area and exclude meals and transportation provided laborers.

Trial	Hectares	Cost per Hectare* (pesos)	Rats Killed
1	5.0	135.00	500
2	3.5	18.00	0
3	4.0	18.00	8
4	5.0	135.00	200

*₱1.00 = $0.15 U.S. ca.

Table 14. Daily take of pre-bait and treated bait in Trial 2. Thirty-five stations were used for prebaiting on days 1 and 2; 50 stations were used to expose zinc phosphide and gophacide on days 3 and 4.

Day	Type of Bait	Active Stations	Grams Taken		
			Zinc Phosphide	Gophacide	Total
1	Untreated	31			346
2	"	34			846
3	Treated	47	328	229	557
4	"	38	114	52	166

Table 15. Estimated costs per hectare of materials and labor for chemical baiting in each of four trials in growing rice.

Trial	Anticoagulant Baiting[a]		Acute-toxicant Baiting[c]	
	Material Cost[b] (pesos)	Labor (man-hrs)	Material Cost (pesos)	Labor (man-hrs)
1	7.80	21	5.40	2
2	9.20	15	6.60	2
3	14.10	5	8.25	2
4	17.30	13	5.40	2

[a]Since the studies were done with experimental baits which are currently unavailable to most farmers, we have estimated equivalent costs of using bait prepared from low-grade polished rice and locally available anticoagulant concentrates. Considerable data indicate that such baits are accepted as well as those tested.

[b]₱1.00 = $0.15 U.S. ca.

[c]Excludes elective baiting by farmers.

Oil cans opened on both ends were used to expose anticoagulant bait.

Costs of Rodenticides in the Philippines

The costs of chemical rodent control methods for the farmer are made up of two components, materials and labor, both of which may vary considerably with the type of control method or chemical chosen. A number of rodenticides are available for retail purchase in the Philippines as either technical materials, concentrates, or prepared bait formulations. During the year, purchases or price determinations were made at retail outlets in several parts of the country to learn the rodenticide costs that a farmer might encounter in conducting his own rodent control program. Because of the variety of materials available and the variability of prices among different distributors, these figures, collected over a period of several months, do not necessarily reflect current local prices. No attempt to include every retail product was made; no endorsement or recommendation of specific chemicals or commercial products by any participating agency was intended or implied.

Table 16 summarizes cost data for several commercially formulated rodenticides. Prices of these materials ranged from ₱5.00 to ₱92.80 per kilogram for the commercial formulations encountered. Most of the higher priced materials are packaged in small quantities and sold principally for household or other non-agricultural uses. A few of the materials are marketed specifically for agricultural use.

Table 17 shows cost information for several materials that are available as concentrates to be mixed with a bait carrier by the purchaser. If low grade polished rice (usually available at ₱1.00/kg) or other similarly priced materials available to farmers can be used as bait carriers, most of the rodenticides, anticoagulants in particular, can be used at relatively low cost.

To determine actual application costs for various materials, the method of use must be considered. For example, use of anticoagulants continuously throughout the period of a rice crop could not be compared directly with a single application of one of the acute materials. If prebaiting were used prior to exposure of acute toxicants, an additional cost associated with untreated bait should be considered.

Table 16. Philippine Retail Costs of Pre-formulated Rodenticides Available as Baits, Pastes, or Tracking Powders.

Commercial Baits, Pastes, and Powders[a]	Active Ingredient	Percent Active Ingredient	Unit Sold	Retail Cost per Unit	Cost per 1 kg of Prepared Material (pesos)[c]
KG-22	warfarin	0.05	1000 chunks	164.17[b]	10.64[b]
Racumin (Ready-Made) Bait	racumin	1	250 g	4.90	19.60
Ratoxin	warfarin	0.05	1 kg	5.00	5.00
Nora	coumarin (warfarin?)	0.05	60 g	0.80	13.33
Rat Killer Pearl	warfarin	0.05	50 g	0.90	18.00
Dethmor	warfarin	0.025	50 g	0.85	17.00
Zelio Poison Grains	thallium sulphate	2	25 g	1.80	72.00
Rat'n Roach	phosphorus	2	2 oz	3.00	52.86
Stearn's Electric Paste	phosphorus	2.5	1.5 oz	3.95	92.80
Zelio Paste	thallium sulphate	not specified	1 oz	2.20	77.53
Racumin Tracking Powder	racumin	0.05	250 g	2.20	8.80
1080 (no commercial name on package)	sodium fluoracetate	not specified	50 g	1.00	20.00

a Use of trade names does not imply endorsement or recommendation of commercial products by Philippine or U.S. Government agencies.

b Estimated local cost.

c ₱1.00 = $0.15 U.S. ca.

Table 17. Philippine Retail Costs of Rodenticide Concentrates Available for Formulation

Commercial Rodenticide[a]	Percent Used in Prepared Bait[b]	Percent Active Ingredient in Commercial Concentrates	Cost per Kg of Concentrate (Pesos)[c]	Toxicant Cost for 1 Kg of Prepared Bait	Total Cost of 1 kg of Prepared Bait (pesos)[d]
Zinc phosphide	2	94	35.00	0.78	1.71
1080	0.12	90	35.00	0.87	1.87
warfarin	0.025	0.5	7.00	0.35	1.30
racumin	0.025	0.5	6.90	0.34	1.30
tomorin 2	0.025	1.0	9.15	0.23	1.20
chlorophacinone	0.004	0.25	191.56	2.95	3.93

a Use of trade names does not imply endorsement or recommendation of specific chemicals or commercial products.

b Percents chosen are those commonly used and do not represent recommendations

c ₱1.00 = $0.15 U.S. ca.

d Calculation based on the use of low-grade polished rice @ ₱1.00/kg.

TRAINING ACTIVITIES

Introduction

Center staff members were involved in a variety of extension and research training in addition to the actual research program. Nearly 300 persons from twenty-five countries visited the Center and were briefed on activities, given advice and literature on rodent control, or provided with assistance in program planning. These visitors included, farmers, government officials, chemical company representatives, professional agriculturists, and students. Requests for Rodent Research Center reports, staff publications, or technical information were received from twenty-one countries.

Vertebrate Pest Management Workshops

Recently, there has been an effort by several countries in Asia to begin adaptive research on their local vertebrate pest problems. The shortage of trained personnel and the diffuse sources of technical information have added to the local difficulties of understanding, planning, and organizing research and operational vertebrate management. The recurrence of similar problems and pest species in the region suggests that these countries could benefit from the identification of common goals. In order to reinforce the interest shown by the various countries and to stimulate regional dialogue on vertebrate pests, workshops were held in Korea, Thailand, and the Philippines with additional participants from Laos, Malaysia, Indonesia, Vietnam, and Nepal. The three workshops were jointly sponsored by the Rodent Research Center and the Denver Wildlife Research Center, with the support of the U.S. Agency for International Development. Additional support was provided by the workshop host countries and local scientists and extension personnel.

The major objectives of the workshops were to present the principles and strategies involved in protecting agricultural crops; to review, explain, and demonstrate the range of existing techniques; and to suggest ways of identifying and defining problems, quantifying damage, and organizing research on local problems. Classroom, laboratory, and field sessions, as well as informal discussion among instructors, participants, and local lecturers contributed toward these goals. The establishment of new professional relationships and international friendships among participants from various countries is anticipated to have a beneficial effect on future cooperative work and information exchange on common problems.

The first workshop was held at Suwon, Korea at the training facilities of the Office of Rural Development. The second program was held at the Ministry of Agriculture facilities on the campus of Kasetsart University at Bang Khen, Thailand. Students from Thailand and Laos attended the session. The third workshop was held in the newly renovated training rooms of the Rodent Research Center at the University of the Philippines in Los Banos. Trainees at this workshop came from Indonesia, Malaysia, Nepal, Philippines, and Vietnam. In all, 85 men and women participated in the program.

The schedule for each workshop encompassed about twelve full working days; about seven days were spent in the classroom. Two days of laboratory exercises included determination of LD_{50}'s, bio-assay tests, identification of rodent species, and preparation of museum specimens. Three days were spent in field exercises which included snap-trapping and live-trapping in ricefields and surrounding habitats, testing bait acceptance, making carcass examinations, and conducting damage surveys in rice. Demonstrations included bait preparation, field use of radio telemetry, and techniques for marking animals. Grain storage facilities were visited and inspected for rodent infestation by students at each location. The students also visited farms and local experiment stations where they had an opportunity to ask questions and compare their own experiences. Each trainee received a collection of books, reports, and technical articles for background reading and later reference.

In classroom lectures, the instructors aimed for a balance among basic subjects such as behavior, ecology, and economics, and technical talks on materials, techniques, and data analysis. The concepts of pest management and the interrelationships between agricultural production and crop protection formed themes to tie the diverse topics together. We felt the majority of the students left the sessions with a better understanding of the difficulties to be encountered and with ideas on some practical and potential means for improving crop protection. With continuing support from their governments, these students can provide a valuable resource for dealing with complex agricultural pest damage problems.

Rice Production Training Course - IRRI

Rice production training courses, offered periodically by the International Rice Research Institute, provide a means for presenting current information on rodent biology and control to extension workers and instructors from the rice growing countries of Asia. These workshops, which present and integrate material on all aspects of rice production help participants understand the close-relation between crop protection and the other aspects of agricultural production.

This year, Center staff members participated in one two-week course involving 43 students, most of whom were from the Philippines; and one six-month course, involving 36 students from 15 countries.

An intensified program of approximately 10 two-week workshops, in which resource persons from the center will again participate is planned for 1973.

Disaster Assistance

During the 1972 rainy season, heavy rains caused severe flooding in many parts of the Philippines, causing food shortages and necessitating a massive government action program to assist flood victims. Emergency programs were planned to produce vegetables on high ground, in school yards, and other areas, while plant protection activity was intensified to preserve the remaining rice crops for seed purposes.

During this time, staff members presented two special training sessions on rodent control. In one session, students and UPCA faculty representing a task force to assist the flooded areas of Laguna Province were briefed on use of rodenticides and safety procedures, prior to a special extension program in lake shore towns. In another session, over 200 key farmers, barrio leaders, provincial staff of the Bureau of Plant Industry and Agricultural Productivity Commission were presented a special training program on rodent control. The program was conducted in local dialect to insure understanding by farmer participants.

Participatory Research Training

With the arrival of Mr. Brijendra Singh Thapa, UNDP Fellow from Nepal, a new type of training program was inaugurated at the Center. Trainees will actively participate in several ongoing research projects at the Center or work independently on projects related to pest problems in their own countries. Reading programs, workshop session with Center staff members, and reviews or participation in operational control programs in the Philippines will be arranged according to the needs of participants. Several such trainees are expected to spend varying lengths of time at the Center during the coming year.

Graduate Training

A masters degree program focused on the biology and control of vertebrate pests is available in cooperation with the University of the Philippines at Los Banos, College of Agriculture. Four graduate fellowships have been provided by the National Economic Development Authority to encourage the participation of Filipino students.

Two students have completed degree work in this program during the year and have joined the research staff of the Center, one under the auspices of the Bureau of Plant Industry, the other under UPCA. Two other students are expected to complete their thesis work in 1973. In addition, three staff members are pursuing separate degree programs related to their work at the Center.

Two current staff members have been supported for overseas training as USAID Participant Trainees at Colorado State University in wildlife ecology and at Bowling Green State University in vertebrate pest control. Both have completed their training and have rejoined the project. Another student supported as a USAID participant at the University of California (Davis) in pharmacology is expected to rejoin the staff in 1973.

The Center has cooperated in the research program on food habits of Philippine rats of a Ph D. student at the University of Colorado. This work was completed at the Denver Wildlife Research Center.

NEDA SPONSORED GRADUATE STUDENT RESEARCH
(Abstracts and Proposals)

Reproduction and Seasonal Abundance of the Common Ricefield Rat, Rattus rattus mindanensis Mearns, at Siniloan, Laguna. 1972. Bernardo E. Marges. Unpublished thesis, College of Agriculture, University of the Philippines at Los Banos (abstract).

The reproductive patterns and seasonal abundance of the common ricefield rat were studied in an irrigated ricefield in Siniloan, Laguna from August, 1971 through July, 1972. The study area was planted to two crops of rice every year. Of the two rat species found, the ricefield rat dominated the entire riceland community comprising more than 99 percent of the total collection.

Two age classes were recognized: juveniles and adults. Adults were further subdivided into breeding and non-breeding. The vaginal orifice became perforate at 54.45 grams among females, while the testes descended to the scrotum at 134.93 grams among males. For both sexes the skull ossified at 90.79 grams. The length of the testes was significantly correlated with the body weight. Active sperms were present in the cauda epididymys when the testes reached a length of 22.29 mm. Once sexual maturity was attained males remained fertile throughout the year.

Reproductive pattern was sharply bimodal, corresponding very closely with the crop cycle. Most litters were produced during the reproductive and ripening stages of rice plants, with little or no breeding activity when the fields lie fallow. There was no direct relationship between breeding and seasonal or climatic changes. Mean litter size was 9.67 but decreased significantly during the beginning and termination of the breeding period. There was no tendency for the number of embryos to increase with body weight. The distribution of embryos between the right and left horns of the uterus was entirely independent, with no marked tendency for all embryos to develop on one side or the other. The annual incidence of pregnancy was 5.67 litters; the number of litters produced during the dry season breeding was more than twice that of the wet season breeding. With few exceptions, the sex ratio approximated equality. Of the exceptions most could be shown due to differential trappability of both sexes at certain stages of the breeding period. Productivity was high, about 44 young being produced per female per year.

Seasonal reproduction resulted in high population density by August, September, and October. Sharp decline in density was observed in January, February and March.

Estimating Population Parameters of the Ricefield Rat (Rattus rattus mindanensis Mearns). 1972. Edwin A. Benigno. Unpublished thesis, College of Agriculture, University of the Philippines at Los Banos (abstract).

Livetrapping was conducted twice a month for two crop seasons in a selected rice growing area in Siniloan, Laguna. Data for the estimation of population parameters were obtained independently for each season by means of the capture, release and recapture method.

Monthly population density per hectare and subsequent damage to rice was greater during the wet season. In both seasons, density increased toward maturity of the crop. Density was negatively correlated with the proportion of males in the monthly samples while no significant correlation was found between density and the proportion of juveniles in the sample.

Juveniles were more mobile and exhibited larger home ranges than adults; adult males and females were equally mobile. Harvesting and land preparation without incorporating control did not exert immediate and significant displacement effect on the population.

Trap location, animal behavior, and the prevailing weather conditions affected trappability resulting in variable trap index even within the same trapping period. The problem of few recaptures of marked animals in this study could indicate that the capture, release and recapture method alone may not be practical for assessing population parameters.

Laboratory Study on Juvenile Growth of the Common Ricefield Rat. Lorenza S. Ferrer. Summary of thesis project, University of the Philippines, College of Agriculture.

Data were obtained from fourteen litters of *Rattus rattus mindanensis* which were born in captivity, to selected females that were pregnant when captured or to females that mated and became pregnant in the laboratory.

Each young rat was weighed and measured on the day of it's birth and every subsequent day up to day 21. Thereafter, the animals were weighed and measured at weekly intervals until sexually mature. Criteria for sexual maturity were based upon perforation of the vaginal orifice in the female and complete descent of testes in the male. Results indicated that females become sexually mature at about 40 days and males attain fully descended testes at about 60 days.

Morphological and behavioural changes during the growth of young rats were summarized:

Event	Days of Age
Appearance of vibrissae	2
Appearance of body hair	5
Incisors erupt	8 - 10
Ears open	8 - 11
Displaced young locates mother	9 - 11
Eyes open	14 - 16
Hair obscures genitalia	14
Hair obscures nipple	14
First molar erupts	19
Second molar erupts	21
Third molar erupts	35

Data on daily food intake from weaning to sexual maturity showed that during the first weeks after weaning (at about 21 days) the young rats consumed 3-7 grams with a increase to 7-12 grams at about the 6th week, then stabilized at 11-14 grams.

Litter size averaged 6.2. Sex ratio at parturition was almost 50:50 (44 males and 43 females), but at weaning it was 59:41, with males being more numerous.

Extra-uterine mortality accounted for 8 deaths at birth (2 males and 6 females); two "runts" were eaten by the mother. The only other deaths (one male and 2 females) occurred apparently as a result of weaning.

The Toxicity of Four Anticoagulant Rodenticides to *Rattus rattus mindanensis* *Mearns*. Melanda M. Hoque. Summary of thesis proposal, University of the Philippines, College of Agriculture.

The toxicity of several anticoagulant rodenticides available in the Philippines will be studied using wild *R. r. mindanensis* captured from rice fields. Major objectives will be to: determine lethal doses and mortality times for male and female rats, determine the relation among acceptance, exposure time, and concentration, and establish baseline toxicity indices against which potentially resistance populations might be tested.

Thirty-two animals (16 males and 16 females) and four dosage levels of each chemical will be used for single-dose treatments by gavage. Acute LD_{50} of each chemical will be determined following standard procedures. Acceptance of anticoagulant treated baits given at varying concentrations for varying time periods will be determined in separate tests. Results will be analyzed following standard procedures in vertebrate toxicity tests. This study will provide information necessary for effective field use of the different materials.

SUMMARY OF ACCOMPLISHMENTS

1. Three, twelve-day workshops on Vertebrate Pest Management were conducted in Korea, Thailand, and the Philippines. Major objectives of the workshops were to present the principles and strategies involved in protecting agricultural crops. Eighty-five trainees from eight Asian countries participated. With continuing support from their governments, these men and women can provide a valuable resource for dealing with complex agricultural pest damage problems.

2. One Filipino staff member assigned to the Center from the Bureau of Plant Industry returned from Bowling Green University after one year of non-degree study in Economic Biology. He was a recipient of a USAID participant training grant.

3. Renovation of the Rodent Research Center Facilities provided classroom, laboratory, and office space and additional animal housing.

4. Two new full-time staff biologists were added late in the year, one supported by the Bureau of Plant Industry, the other by the University of the Philippines. Both men completed master's degrees in vertebrate biology under NEDA fellowships associated with the RRC program.

5. The third year of our study in connection with the Philippine National Damage Survey was completed, with surveys being conducted in both wet and dry seasons. Cooperative damage survey studies were initiated in South Vietnam with the Plant Protection Service. Results indicated that damage is wide-spread and highly variable.

6. A study of tiller-cutting by individually field-caged *R. r. mindanensis* showed highly variable rates ranging from 1 to 309 tillers per rat per night. Heaviest cutting occurred during the earlier growth stages then decreased markedly to 3 per night per rat when the grain was ripe. Rats tended to cut greater numbers of tillers during wet season tests.

7. A comparison of standard snap-trap lines and similarly placed lines of inked tracking-tiles suggested that in situations where carcasses are not required, inked tiles may provide a more precise, less variable index of population activity than snap-trap success. Live-trapping did not provide suitable data for calculating population estimates because too few animals were recaptured. Snap-trap grids (400 to 500 traps per ha) appeared to provide a more accurate way of estimating rat populations in ricefields.

8. Additional observations of the reproductive activity of *R. r. mindanensis* seemed to confirm that breeding in this species is related to the quality of the habitat rather than climatic season. Pregnant females or newly born young have been found in every month of the year, generally associated with growing rice.

9. Untreated bait placed on stations in the paddy was found to be accepted in larger quantities than bait placed on the dikes of corresponding paddies in 5 of 6 trials. A more extensive trial showed that 80 percent of the rats trapped from the central hectare of a 4-hectare test area were marked by exposing a fluorescent bait at in-paddy stations at the rate of twenty-five stations per hectare. A comparative test showed only 30 percent of the resident animals were contacted using the traditional approach of placing bait on dikes.

10. Four field trials using stations established shortly after planting to expose anticoagulant bait suggested that this approach might be useful for small farmers, perhaps in conjunction with other methods. Treated areas ranged from 3.5 to 5 hectares; estimated cost of treatment using local materials ranged from ₱8 to ₱17 per hectare, while reduction in expected damage ranged from about 50 to 80 percent.

11. The following professional papers or reports were published by Center staff members:

Barbehenn, K. R., J. P. Sumangil, J. L. Libay and M. W. Fall. 1972. Distribution of agricultural rodent pests in the Philippines. Proc. 3rd Nat. Pest Cont. Council Conf. 3: 58-59.

Cadapan, E. P. and F. F. Sanchez. 1972. The biology of the true armyworm, Pseudaletia separata (Walker) (Lepidoptera: Noctuidae) Philippine Ent. 2(3): 217-226.

Fall, M. W., G. A. Hood, and J. W. DeGrazio. 1972. A vertebrate pest management workshop program in East Asia. Rodent Research Center, College, Laguna. 27 p. (mimeo.).

Marges, B. E., E. A. Benigno, and P. J. Alfonso. 1972. Studies on reproduction and movement of the ricefield rat (Rattus rattus mindanensis) at Siniloan, Laguna. Proc. 3rd Nat. Pest Cont. Council Conf. 3: 62-63.

Mott, D. F., J. F. Besser, R. R. West, and J. W. DeGrazio. 1972. Bird damage to peanuts and methods for alleviating the problem. Proc. 5th Vert. Pest Cont. Conf. pp. 118-120.

Mott, D. F., R. R. West, J. W. DeGrazio and J. L. Guarino. 1972. Foods of the red-winged blackbird in Brown County, South Dakota. J. Wildl. Mgmt. 36 (3): 983-987.

Sanchez, D. C. 1972. Acceptance of some common foods by the ricefield rats (Rattus rattus mindanensis and Rattus argentiventer) and its relation to selection of bait carriers. Proc. 3rd Nat. Pest Cont. Council Conf.:60.

Sumangil, J. P. 1972. Burrows and breeding of ricefield rats in Cotabato, Philippines. Proc. 3rd Nat. Pest Cont. Council Conf. 61.

West, R. R., M. W. Fall, and J. L. Libay. 1972. Field trial of multiple baiting with zinc phosphide to protect growing rice from damage by rats (Rattus rattus mindanensis). Proc. Crop. Sci. Soc. Phil 3: 143-148.

West, R. R., D. C. Tolentino, and D. C. Sanchez. 1972. Evaluation of aerial dispersal of zinc phosphide baits for rodent damage control. Proc. 3rd Nat. Pest Cont. Council Conf.: 62.

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Fernando, H. E., N. Kawamoto, and N. Perera. 1967. The biology and control of the rice field male rat of Ceylon, Gunomys gracilis. FAO Prot. Bull. 15 (2): 32-37.

International Rice Research Institute. 1972. Annual report for 1971. Los Banos, Philippines 238 pp.

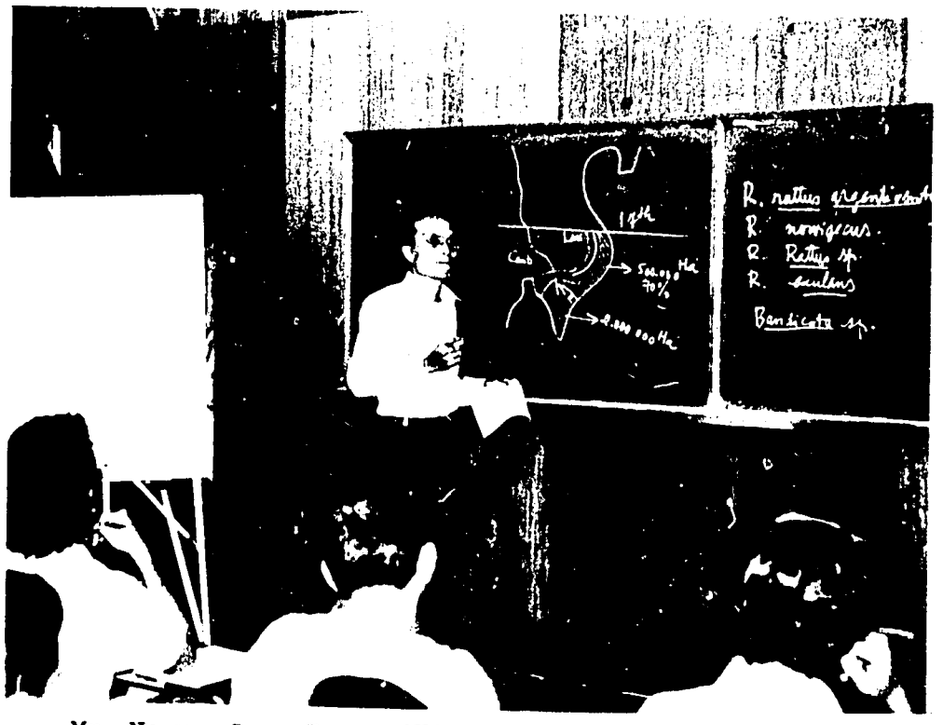
LaVoie, G. K., F. N. Swink, and J. P. Sumangil. 1970. Destruction of rice tillers by rats in relation to stages of rice development in Luzon. The Philippine Agricult. 54(3 & 4): 175-181.

Philippine-German rat control applied research project. 1972. Report for March 1969-Dec. 1971. Bureau of Plant Industry, Manila 96 pp.

West, R. R., M. W. Fall, and J. L. Libay. 1972. Field trial of multiple baiting with zinc phosphide to protect growing rice from damage by rats (Rattus rattus mindanensis) Proc. Crop. Sci. Soc. Phil. 3: 143-148.

Wood, B. J. 1971. Investigations of rats in ricefields demonstrating an effective control method giving substantial yield increase. PANS 17(2): 180-193.

Korean trainees examine a field with damage caused by Apodemus agrarius



Mr. Nguyen Lang Duyen (Vietnam) explains the problems with agricultural pests in his country.