AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #14

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials

Y-AH10-0000-G732

B. SECONDARY
Agriculture--Pests of plants--Philippines

2. TITLE AND SUBTITLE
Rodent Research Center,Laguna,Philippines: 1973 annual progress report

3. AUTHOR(S)
(101) Denver Wildlife Research Ctr.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	101p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Interior

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAA-714

11. PRICE OF DOCUMENT

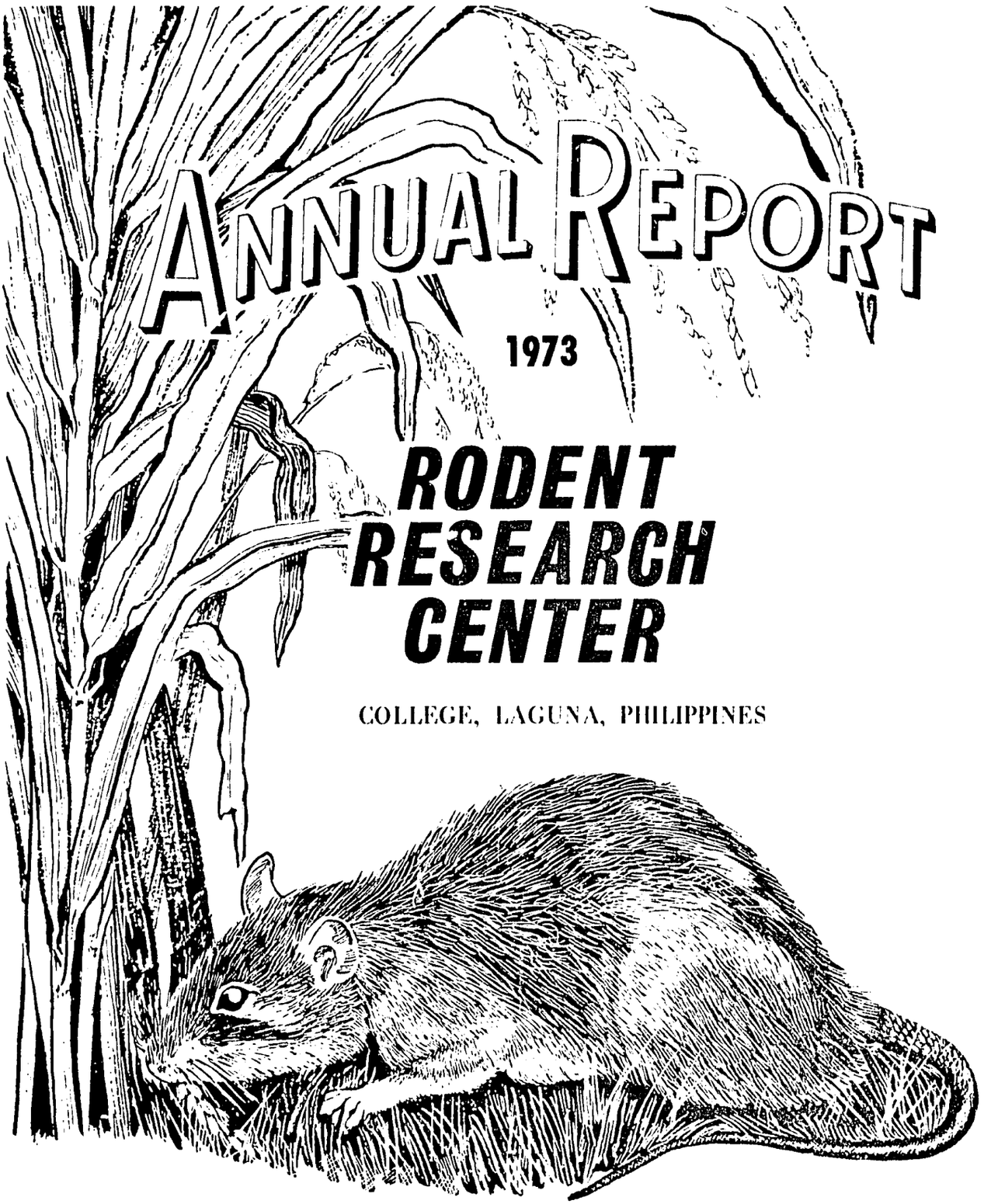
12. DESCRIPTORS
Pest control
Philippines
Rodents

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA RA(ID)1-67 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)



ANNUAL REPORT

1973

RODENT RESEARCH CENTER

COLLEGE, LAGUNA, PHILIPPINES

COOPERATING AGENCIES

REPUBLIC OF THE PHILIPPINES:

National Economic and Development Authority
Bureau of Plant Industry
University of the Philippines at Los Baños

UNITED STATES:

Agency for International Development
Denver Wildlife Research Center
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RODENT RESEARCH CENTER*
1973 ANNUAL PROGRESS REPORT

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*RESULTS INCOMPLETE AND NOT FOR PUBLICATION, RELEASE, OR USE WITHOUT AUTHORITY OF THE RODENT RESEARCH CENTER BOARD.

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ABSTRACT

During 1973, Rodent Research Center personnel engaged in control-methods evaluation studies and rodent damage surveys in the Philippines and other SE Asian countries. Staff changes during 1973 included the addition of five new members to the Filipino professional staff, four of whom received specialty graduate training as USAID participants or NEDA scholars. Two U.S. positions were vacated; one will be filled during 1974. The staff increases, coupled with building rennovations completed in late 1972, provided the means for greater participation in the training of Filipino agricultural technicians, extension agents, and key farmers. More than 2000 such individuals received classroom or field training in rodent control from Center personnel during the past year. Center personnel participated in the formulation of rat control recommendations for use in conjunction with the Philippine national rice production program - "Masagana 99".

Data collection for a three-year study of the incidence of rodent damage in sample paddies throughout the Philippines was completed and analysis of data was begun. The damage index, on a national scale, based on the percentage of cut tillers measured before harvest, has averaged less than 5 percent throughout these surveys; however approximately 90 percent of approximately 1500 paddies examined each year have shown measurable damage. Additional work on means of predicting the possible magnitude of damage from early surveys will be considered.

A study of the toxicity of various bait preparations indicated that use of concentrates with a higher percentage of toxicant than is available in some commercial concentrates may reduce the loss of toxicant to sloughing and settling.

Rice presented in a wet or moldy condition to Rattus r. mindanensis was consumed as readily as dry rice in the laboratory. This study, in conjunction with other tests, will contribute to the design of future bait stations.

Work was completed on a study of rats moving onto a 2 hectare ricefield that was baited throughout one crop with untreated rice. Consumption increased during the period after transplanting and reached a peak of 68 kg/week during the 11th week. During the 13th week, when grain heads became fully developed, bait take decreased abruptly to 15 kg/week and declined until harvest. These results coincided with those of previous studies and suggested that rat control by baiting during the last few weeks of a rice crop may be difficult.

Competition for use of bait containers was found to be a factor potentially limiting bait consumption in dense rat populations. In a field study conducted with populations of R. r. mindanensis, three-fold increases in bait consumption were obtained by substituting several small bait containers for one large one.

Intensive trapping, conducted at intervals throughout the rice crop on a one hectare area, was used to simulate the rapid population reduction achieved by baiting with acute toxicants. An average of 85 percent of the estimated rat population was removed during each of four trappings (at 7, 9, 11, and 14 weeks after transplanting). Recovery of the population was rapid, particularly during the earlier crop stages. The results suggested that rapid immigration of rats to depopulated areas may be important in explaining the previously recorded failures of acute-toxicant baitings in reducing damage on small areas.

Two field evaluations of sustained baiting with anticoagulant rodenticides were undertaken. One study aimed at evaluation of the technique for use by individual small farmers was conducted on 6 areas of 9 paddies each; the areas averaged about 1.5 hectares. Six similar areas which received no treatment were also evaluated. A second study compared two methods of eliciting farmer participation at the village level. Two villages (barrios) having a history of high rat damage were chosen in Central Luzon. One village received the intermittent services of an extension technician who provided literature, worked with village leaders, and conducted meetings with farmers. The second village received only extension literature. Both studies suggested that sustained baiting, properly conducted, can be a useful technique for reducing rat damage.

An ecological study of a mixed rodent species community was begun near Calapan, Mindoro, on an area which encompassed ricefields, coconut groves, and a village. Observation of rat distribution and food habits in relation to macro- and micro-climatic factors was carried out for one crop season. Preliminary reduction of the species distribution data showed that R. r. mindanensis and Suncus murinus were found in all habitats, R. exulans in coconut and shrub only, R. argentiventer in ricefields only, and Mus musculus inside barrio houses. In R. r. mindanensis and especially R. argentiventer, breeding corresponded with the development of the rice crop.

Preliminary studies were begun on the food habits of Lonchura punctulata, L. leucogaster, and L. malacca, three species of Philippine weavers. Individuals of these species, when found near ricefields, foraged most actively in early morning and late afternoon, and ate rice as a major portion of their diet. Individuals of each species consumed about three grams/day/bird of polished rice or palay in laboratory studies.

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** Agency designations: UPLB, University of the Philippines at Los Banos; BPI, Bureau of Plant Industry; NEDA, National Economic and Development Authority; USAID, U.S. Agency for International Development.

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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. Additional support and cooperation are furnished by the National Economic and 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 a senior member 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 adaptive 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.

Staff

The Center staff includes 10 biologists whose aggregate training covers the areas of agricultural biology, ecology, physiology, toxicology, control methods evaluation, mammalogy, ornithology, wildlife management, and entomology. Ten additional staff members are assigned as full time support personnel by participating agencies. Three trainees: Mr. Brijendra Singh Thapa of the Entomology Section, Department of Agricultural Education and Research, Nepal, Mr. Young-Moo Shin of the Institute of Plant Environment, Office of Rural Development, South Korea and Ir. Rochman of the Plant Pests and Diseases Division, Central Research Institute for Agriculture, Indonesia, spent a total of about 15 months as participant staff members at the Center.

Mr. Nelson Swink, who helped initiate the Center's program and served as leader of the USAID team for nearly five years, accepted a new position with the U.S. Department of Interior. He is currently State Supervisor of Wildlife Services, Fish and Wildlife Service, Annapolis, Maryland.

Mr. Richard West, USAID biologist at the Center since 1970, died in a fishing accident in Batangas, Philippines on October 6, 1973. Mr. West, a specialist in control methods development and evaluation, had been a staff member of the Denver Wildlife Research Center for 10 years, and had been instrumental in establishing an active field evaluation program in the Philippines.

Research

Research was centered around development and evaluation of improved techniques for sustained baiting with chronic toxicants in growing rice. This included work with bait formulation, bait acceptance, bait station design and arrangement, and evaluation of sustained baiting at the small farm and village (barrio) levels.

Work on ecology and population dynamics of *Rattus rattus mindanensis* and *R. argentiventer* was continued at several locations and a study on recovery of rat populations after population reduction was completed. Preliminary planning for a study of the relationships of border marshlands to rat population outbreaks in lowland rice areas was initiated.

With support from the Philippine Department of Agriculture and Natural Resources, Center biologists have undertaken a study of bird damage control involving several species which damage seeded and mature rice. Preliminary work focused on study of the food habits of three major pest species (*Lonchura punctulata*, *L. malacca*, and *L. leucogaster*) and trials of several damage survey techniques. Subsequent work will include the screening and evaluation of repellents and toxicants.

Training

Training activities were aimed toward up-dating the knowledge of vertebrate pest control of extension technicians, and to a more limited extent, toward providing experience in the research methodology for professional vertebrate biologists in the Philippines and other countries of Southeast Asia. Over 300 visitors from many countries were briefed on Center activities or given assistance in planning rodent control on research programs. Center staff members participated in the training of more than 2000 agricultural technicians or inspectors from the Bureau of Plant Industry and Agricultural Extension and from the Philippine National Bank. Sessions on rat control were presented in Agricultural

Production Workshops held at IRRI and UPLB and in regional field training courses sponsored by the BPI. Three research trainees from Nepal, Indonesia, and Korea spent several months at the Center participating in on-going research programs, observing BPI's operational rat control programs in various parts of the country, and developing project plans for their future work. Two students completed M.S. degrees at the Center under NEDA/USAID fellowships; one staff member completed an M.S. degree at the University of California (Davis) as an AID Participant. Several staff members taught or participated in teaching courses in Vertebrate Pests, Mammalogy, and Wildlife Management at UPLB, while others served as graduate advisors for students in Applied Zoology.

International Activities

Center staff members worked with personnel from five Asian countries (Nepal, Vietnam, Thailand, Indonesia, and Korea) on training and cooperative study. They also participated in the Ad-hoc Panel on Vertebrate Pest Management in Asia and the Far East which met in Bangkok under the sponsorship of FAO. Excluding conference participation and travel to the U.S., staff travel included four trips to Vietnam, two trips to Thailand, and two trips to Indonesia. Preliminary plans were made to participate in an international workshop on field rat control to be sponsored in early 1974 by the Philippine Bureau of Plant Industry and the RP-German Crop Protection Strengthening Programme.

RESEARCH ACTIVITIES

National Surveys for Rat Damage in Lowland Rice

Introduction

In 1970, a three year study was undertaken cooperatively with the Bureau of Plant Industry to assess rat damage in lowland rice. The survey method together with some provincial data was discussed in detail in the 1971 Annual Progress Report. Comprehensive review of data from these surveys was begun after the 1972 data were received and compiled; work on these data is still in progress.

The surveys were primarily conducted to provide quantitative measures of losses due to rat damage based on the estimated percentage of cut stems (tillers) at harvest as the primary index. A more convenient index, the number (or percentage) of hills showing damage, has been used in some experimental evaluations. The relation between these two indices was determined for each province and season where sufficient data were collected. Teams conducting damage surveys were also requested to provide information on habitats adjacent to survey paddies and on control practices in survey barrios. These data provide the basis for preliminary examination of the general effect of habitat and barrio rat control.

Methods

One sample barrio was randomly selected per 12,000 hectares of lowland rice in a province. Ten sample paddies within 2 weeks of harvest were randomly selected in each barrio. A damage index was then computed based on tiller counts of 100 random hills per paddy using the equation:

$$\% \text{ damage} = \frac{\text{No. damaged tillers x No. damaged hills}}{\text{Total tillers in damaged hills}}$$

This index estimates the percent of the tillers cut and is not to be equated with actual yield loss. The relation between this index and yield has been studied by Guerrero (1971) and others, but has not yet been clearly established. Early damage may result in significant yield losses that are not detected in pre-harvest tiller counts (Rodent Research Center, April 1973 Monthly Report).

Damage means were determined for barrios and provinces for each season. Paddies for which adjacent habitat had been recorded and those for which information was determined on rat control were used to

calculate provincial means; wet and dry season data were compiled separately. The relationship between the number of damaged hills and percent tillers cut was established for each province by determining the regression equation and the coefficients of correlation (r) and determination (r^2). Again data were classified by season.

Definition of terms. Some terms were defined to simplify classification of the data:

a) Season: Timing of wet and dry season crops vary annually according to condition. Crops planted in the rainy months, usually May to September, were considered as wet season crops while those planted during the drier months, usually December to April, were surveyed for the dry season.

b) Adjacent Habitat: The area immediately bounding the survey paddy was recorded. Paddies which had wasteland or edges or a canal or transport dike on at least one side were recorded as adjacent to uncultivated land or transport dikes, respectively. Those recorded as adjacent to ricefields had paddies on all sides.

c) Off-season Control: This term refers generally to organized rat control carried out between crop seasons, usually during the summer months. Such programs may involve poisoning or may involve only physical removal of rats from weedy, uncultivated areas.

d) In-crop Baiting: This term refers to the use of toxic baits during the period when rice crops are growing. Most reports probably refer to single baitings with acute toxicants such as zinc phosphide or 1080, and also include short-term use of chronic toxicants such as warfarin. It is very unlikely that continuous baiting with chronic toxicants (as described elsewhere in this report) occurred on any of the survey areas.

Results and Discussion

Table 1 summarizes the provincial and national damage indices by season from 1970 to 1972. As previously discussed in the 1972 Annual Progress Report, the three years' data suggested a general decline in wet season damage, with little overall change in dry season damage. Dry season damage was generally lower than that of the wet season.

It had been postulated that the extent of damage was directly related to the number of tillers cut in a hill and the number of hills attacked. Thus, the damage indices were computed based on these two variables. However, it might be more convenient to estimate the indices from hill counts if the assumed relationship were true. Table 2 shows

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

Province	1970 Wet Season	1971 Dry Season	1971 Wet Season	1972 Dry Season	1972 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
Isabela	1.23				
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	4.53	1.65	3.22	4.31	2.47

* Estimates of national losses were calculated by weighting provincial estimates for planted lowland rice hectarage at each season as reported by the National Food and Agricultural Council.

Table 2. Relation between percent damaged hills (X) and percent tillers cut (Y) based on 100 sample hills per paddy.

Province	Dry Season				Wet Season			
	Regression line (Y = a + bx) a/	r	r^2	Sample Size	Regression line (Y = a + bx)	r	r^2	Sample Size
Albay	.04 + 0.16X	0.97*	0.94	100	.02 + 0.24X	0.91	0.83	100
Bohol	-.004 + 0.12X	0.92	0.85	200				
Bulacan	0.11 + 0.16X	0.95	0.90	60	.09 + 0.18X	0.83	0.69	170
Camarines Sur	-0.26 + 0.12X	0.97	0.94	200	-0.88 + 0.18X	0.95	0.90	200
Cotabato	-1.25 + 0.32X	0.91	0.83	402	-1.76 + 0.37X	0.90	0.81	502
Iloilo	-0.33 + 0.28X	0.87	0.76	75	-0.28 + 0.36X	0.96	0.92	480
Isabela					-0.10 + 0.12X	0.98	0.96	100
Laguna	0.59 + .07X	0.53	0.28	100				
Mindoro Or.	-0.36 + 0.17X	0.94	0.88	100	-0.86 + 0.21X	0.92	0.85	150
Negros Occ.					0.53 + 0.03X	0.47	0.22	100
Nueva Ecija	-0.18 + 0.40X	0.93	0.86	50	-0.14 + 0.34X	0.93	0.86	410
Pampanga	0.27 + 0.18X	0.91	0.83	50	-0.76 + 0.32X	0.91	0.83	150
Pangasinan	0.11 + 0.13X	0.91	0.83	50	-0.35 + 0.34X	0.70	0.49	350
Zamboanga del Norte					-1.27 + 0.21X	0.88	0.78	12
Philippines	-0.75 + 0.26X	0.84	0.71	984	-0.63 + 0.26X	0.37	0.76	1858
	Combined Seasons							
	-.68 + 0.26X	0.86	0.75					

a/ Y is percent tillers cut, a is the y-intercept and X is the percentage of hills attacked.

* r represents the coefficient of correlation, r^2 the coefficient of determination.

the relationship between number of damaged hills (X) and percent damaged tillers (Y). In both seasons, most correlation coefficients (r) were highly significant, indicating a generally close correspondence between these two variables. However, the coefficients of determination (r^2), which measure the proportion of the variance in Y explained by X, were not always high. Coefficients of determination ranged from 0.22 (Negros Occ., Wet Season) to 0.96 (Isabela, Wet Season). This means that in estimating damage, some precision may be lost if only the number of damaged hills is recorded instead of actual tiller counts. However, number of damaged hills might still be used as a convenient index in evaluating and comparing control methods.

Table 3 suggests the relationships of adjacent habitats to rat damage. Sample paddies adjacent to uncultivated lands generally received more damage than those surrounded by ricefields and those adjacent to water transport dikes. Paddies completely surrounded by other rice paddies and paddies adjacent to water transport dikes had about the same intensity of damage. These findings correspond to field observations and relate generally to the survey of rat activity in different habitats reported in 1972.

The 3-year means suggesting the effects of different rat control practices on tiller cuttings are presented in Table 4. Generally, these data indicate significantly lower damage in areas reporting off-season control or in-crop baiting than in areas with no organized control efforts. A combination of these two control programs seemed to be more effective than any of the single programs in further reducing rat damage.

Table 3. Three year average seasonal damage in paddies adjacent to different types of habitat. The number of sample paddies under each condition is enclosed in parenthesis.

Province	Rice Field	Uncultivate land	Water transport dikes	ANOVA F-test
		Dry Season (Mean % Damage)		
Albay	0.67 (58)	1.85 (15)	0.66 (26)	HS
Bohol	0.22 (11)	0.27 (80)	0.19 (9)	HS
Camarines Sur	0.42 (94)	0.39 (6)	-	NS
Cotobato	2.18 (108)	-	4.97 (294)	HS
Iloilo	-	-	10.62 (3)	-
		Wet Season (Mean % Damage)		
Albay	1.04 (56)	4.74 (13)	1.37 (29)	HS
Bulacan	2.23 (70)	-	-	-
Cotobato	3.17 (285)	2.75 (3)	4.11 (9)	HS
Iloilo	2.58 (302)	-	-	-
Negros Occ.	0.72 (36)	0.93 (7)	0.17 (4)	HS
Nueva Ecija	1.89 (150)	-	-	-
Pampanga	4.60 (60)	-	1.68 (40)	HS
Pangasinan	7.36 (107)	9.91 (11)	5.66 (47)	S

NS - No significant difference
HS - Highly significant difference
S - Significant difference

Table 4. Three-year mean provincial damage as affected by rat control practices. The number of paddies reporting type of control is enclosed in parenthesis.

Province	Off-Season	In-Crop Baiting	Off-Season Control and In-Crop Baiting	None	ANOVA F-Test
Albay	-	0.57 (119)	-	3.17 (39)	HS
Bohol	0.28 (7)	-	-	0.25 (93)	NS
Bulacan	2.30 (60)	-	1.46 (30)	-	HS
Camarines Sur	1.61 (10)	0.43 (70)	0.38 (30)	-	HS
Iloilo	0.61 (10)	-	-	0.46 (303)	NS
Negros Occ.	0.48 (10)	-	-	0.77 (10)	HS
Nueva Ecija	0.87 (78)	-	-	-	-
Pampanga	3.60 (79)	-	0.98 (6)	2.44 (10)	S

HS - Highly significant difference

S - Significant difference

NS - No significant difference

Ecological Relations Between Small Mammal Populations in Philippine Ricefields and Adjacent Habitats

Introduction

When two or more potentially destructive rodent species are present in a region where rodent control programs will be undertaken, it is desirable to understand the ecological relationships between the pest species as well as their dynamic interactions with the physical and biological environments. As pointed out by Barbehenn *et al.* (1972) various control approaches may have differential action among sympatric rodent species leading to changes in the relative importance of these pests.

This work was designed as a preliminary study of the ecology of *R. r. mindanensis*, *R. argentiventer* and *R. exulans*, the species usually present in ricefields and adjacent areas of Mindoro and Mindanao. After the ecological phase of the study is completed, differences in the response of these species to control methods applied will be measured.

Methods

An area encompassing several hundred hectares of ricefields along with adjacent grasslands, coconut groves and village houses in Calapan Oriental Mindoro was selected for the study. Four one-hectare quadrats were used as permanent sites for study. Two quadrats were located within the wide ricefield area, one in an adjacent grassland and the other in an adjacent grove.

The study site was visited approximately every 6 weeks from the preplanting to the harvest period. Rats were collected by various means: drives, live- and snap-trapping, clubbing, and flooding or excavating burrows. Rats inside and adjacent to the quadrats were caught alive, measured, ear-tagged, and released. Those caught by snap traps in habitat similar to but outside that of the quadrats, those caught within the quadrats and accidentally killed, and rats killed by farmers were autopsied for data on growth and reproduction. Stomachs of representative animals were removed and preserved in 70% alcohol for later determination of food habits during each collection period. Samples of adrenal glands and testicles were collected from males and preserved during necropsies.

Air and soil temperature and relative humidity at 10 cm above the ground, soil surface and 10 cm below the surface were measured in early morning, noon, and dusk on a typical day within each collection period. A hygrothermograph placed within a rice paddy was maintained throughout each collection period and gross daily records of air temperature, relative humidity, daylength, and rainfall were derived from the nearby Calapan weather station. Relative light intensities were indexed using light sensitive Ozalid papers. Changes in the biotic and gross physical environment in the study area were noted in detail as the study progressed.

Results and Discussion (Preliminary)

Since data analysis is still in progress, this section reports only results and summarized observations derived from the collection of rat specimens. Table 5 shows the number of small mammals caught in three different habitats throughout the collection period. R. argentiventer tended to stay close to the ricefield habitat while R. r. mindanensis was present in all habitats studied. Failure to capture R. argentiventer in the coconut groves and dwelling areas while adjacent rice was in prebooting to maturing stage may be due to a direct preference for a ricefield environment. This species was referred to by Sumangil (1969) as the "Common Ricefield Rat" because it comprised the bulk of his collections from ricefields in Cotabato and Mindoro during 1969. Because R. r. mindanensis associates with villages, Sumangil has referred to this species as the "Common House Rat." Certainly, this species is now known as a major pest of rice and other field crops throughout the Philippines. Its relations with R. argentiventer in areas where the two are sympatric, however, have not been clarified (Barbehenn, et al., 1972-3).

The Table also shows the apparent restriction of R. exulans to the coconut and shrubs habitats. The low numbers of this species caught in all of the habitats probably reflects a true density in areas of sympatry with the largest species, since all available means of catching rats were exploited and collections were done day and night. In areas where the other species are missing or in low populations, R. exulans may become a major rice-field pest. Thus, this species may be particularly responsive to competitive pressures. Barbehenn et al. (1972-3) speculated that this was the case on Palawan.

Suncus murinus was represented in all habitats with greater numbers occurring in the ricefield area. Mus musculus was caught only inside barrio houses. No R. norvegicus were collected in the area, although the species is known to occur in the nearby city of Calapan.

Table 5. Total numbers of five species of rodents collected in three different but adjacent habitats from June through December 1973 in Bo. Sapol, Calapan, Oriental Mindoro.

STAGE OF RICE CROP	RICEFIELD HABITAT					ADJACENT GRASSLAND HABITAT					ADJACENT COCONUT AND DWELLING AREAS				
	R.a.*	R.r.m.	R. ex.	S.m.	M.m.	R.a.	R.r.m.	R.ex.	S.m.	M.m.	R.a.	R.r.m.	R.ex.	S.m.	M.m.
Pre-planting period; seed beds, plowed fields (10-17 June 1973)	117	68	1	2	0	16	5	0	0	0	6	22	1	0	0
Young rice (3-12 August)	14	35	0	14	0	99	31	0	4	0	2	21	3	3	0
Pre-booting/ booting rice (22-30 Sept)	13	9	0	10	0	6	13	2	4	0	0	41	2	3	3
Mature rice (5-8 Nov)	13	7	0	2	0	2	10	0	6	0	0	23	0	7	0
Pre-planting period; seed beds, plowed fields (11-16 Dec)	99	35	0	7	0	0	6	0	0	0	2	44	6	10	3
TOTAL	256	154	1	35	0	123	65	2	14	0	10	151	12	23	6

* R.a. = *Rattus argentiventer*; R.r.m. = *Rattus rattus mindanensis*; R. ex. = *Rattus exulans*; S.m. = *Suncus murinus*; M.m. = *Mus musculus*

Table 6 presents a summary of necropsy results obtained from the specimens, listed according to month of collection. Although R. argentiventer and R. r. mindanensis are best represented in the samples, breeding in all species and habitats appear most pronounced during the months of August through December. Breeding in R. argentiventer and R. r. mindanensis appears even more restricted, mostly between September through November, and corresponds with the development of the rice crop (Figure 1). This is particularly pronounced with R. argentiventer and may indicate a high sensitivity of this species to environmental or social stress. The increase in numbers of rats captured in the ricefields from November to December (13 to 99 R. argentiventer; 7 to 35 R. r. mindanensis; 2 to 7 S. murinus), a month after harvest, probably reflects the intense breeding and rearing of young during the wet season crop.

Stomach samples will be analyzed upon completion of current work on methodology. Further analyses of the measurements of physical and biotic factors considered in the study, together with the data on recaptured animals, are being conducted and correlated with other observations.

Table 6. Numbers of males and females, and percentages of pregnant female rodents collected in ricefields and three adjacent habitats in Bo. Sapol, Calapan, Oriental Mindoro, according to species and month of collection.

	Rattus argentiventer			*Rattus rattus mindanensis*			*Rattus exulans*			*Suncus murinus*			*Mus musculus*		
	M[a]	F[b]	%P[c]	M	F	%P	M	F	%P	M	F	%P	M	F	%P
Ricefield Area															
June	62	55	0	30	38	0	1	0	0	0	2	0	0	0	0
August	4	10	0	18	17	13	0	0	0	7	7	100	0	0	0
September	3	10	90	7	2	50	0	0	0	8	2	100	0	0	0
November	5	8	88	3	4	75	0	0	0	0	2	100	0	0	0
December	51	48	17	19	16	21	0	0	0	4	3	67	0	0	0
Adjacent Grassland, Waste															
June	7	9	0	4	1	0	0	0	0	0	0	0	0	0	0
August	39	60	0	12	19	7	0	0	0	3	1	100	0	0	0
September	3	3	0	7	6	40	1	1	100	3	1	0	0	0	0
November	0	2	50	5	5	20	0	0	0	4	2	100	0	0	0
December	0	0	0	0	6	17	0	0	0	0	0	0	0	0	0
Adjacent Coconut Grove															
June	4	2	0	12	10	0	0	1	0	0	0	0	0	0	0
August	0	2	0	10	11	0	1	2	0	3	0	0	0	0	0
September	0	0	0	19	19	16	0	1	0	2	0	0	0	0	0
November	0	0	0	15	8	43	0	0	0	6	1	0	0	0	0
December	1	1	0	12	22	5	0	1	0	2	2	50	0	0	0

Table 6 (Cont.)

Barrio Houses

June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	2	2	50	0	1	0	0	1	100	1	2	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	4	6	0	3	2	50	3	3	100	0	3	67	

[a]M = male; [b]F = female; [c]%P = percentage of females pregnant

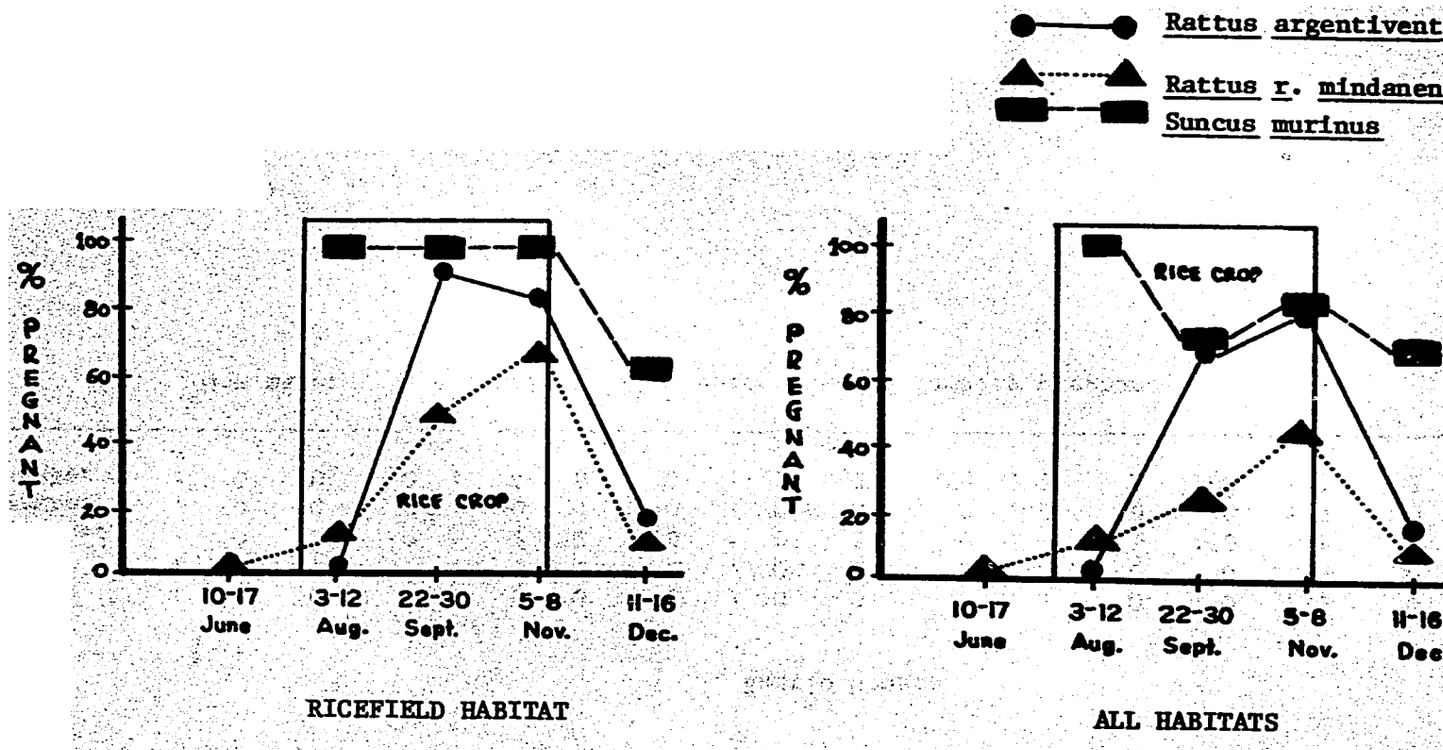

Figure 1. Gross prevalence of pregnancy of Rattus argentiventer, Rattus r. mindanensis and Suncus murinus in a ricefield habitat and adjacent grassland and coconut areas in Bo. Sapol, Calapan, Oriental Mindoro. The rectangular blocks represent the duration of the wet season rice crop.

Response of Ricefield Rats to Population Reduction

Introduction

Baiting with acute toxicants during the growing season is a rat control technique widely practiced on many of the small rice farms in Southeast Asia. This approach has often failed to reduce rat damage to crops satisfactorily (Fernando, et al., 1967; Wood, 1971). West, et al. (1972) evaluated multiple baiting with zinc phosphide as a technique for small-farm rat control and found that plots receiving three baitings during the growth period of the crop had about the same level of rat activity and damage as reference plots. They speculated that poor bait acceptance or failure to reach a major portion of the population with this baiting method might account for these results.

Alternatively, good protection has been reported using various methods of sustained baiting with chronic toxicants in growing rice (Telle et al., personal communication; Wood, 1971; Sanchez et al., 1972; others). On the basis of these reports and a variety of field observations of tropical rat populations, we hypothesized that rapid re-invasion of areas baited with acute toxicants accounts for the apparent ineffectiveness of such approaches in reducing crop damage.

To obtain additional information about re-invasion following rat population reduction, we conducted intensive removal trapping at intervals throughout one rice crop, the succeeding post-harvest period, and the post-transplant period of the next crop on a small farm near Pila, Laguna. The use of this technique provided information on the numbers, species, sex, and age of rats removed, as well as data to calculate initial rat population densities at each period.

Methods

Three traps (Victor 4-way rat traps modified with screen treadles) were set at each of 144 grid points on a 12 x 12 row permanent grid. Points were spaced at 10 m intervals, thus the grid boundaries enclosed 1.21 hectares. Traps were baited with polished rice and were set nightly for 3 to 5 nights depending on the observed rate of population decline.

The first trapping was conducted at 7 weeks after transplanting (WAT) of the 1972 wet-season crop. The depleted population was allowed to recover for one week, then a second trapping was conducted. Six trappings were conducted during a period of about 6 months.

Data were collected as in an ordinary removal method. Animals were arbitrarily classified into young or sub-adult and adult according to weight and physical characteristics. It was assumed that, within the short trapping period, the population was closed; that is, movement into or out of the area was insignificant. With this assumption, densities and corresponding 95% confidence limits were estimated following Zippin (1958). All estimates were then expressed on a hectare basis. The proportions of R. exulans, young animals, and males in the population at each period were tested for deviation from expected values using the Chi-square distribution.

Results and Discussion

The trapping schedule in relation to the growing rice crops is shown in Table 7. The first two trapping periods were somewhat longer since high population densities prevented immediate decline in daily catches.

Table 7. Trapping schedule inside a 12 x 12 grid spaced at 10 meter-interval between grid points.

Trapping Period	Duration of Trapping (Days)	Crop Condition
1	5	Pre-booting (7 WAT*)
2	5	Booting (9 WAT)
3	3	Ripening stage (11 WAT)
4	4	Mature rice (14 WAT)
5	3	3 weeks after harvest
6	3	active-vegetative phase of next crop (4 WAT)

* WAT = weeks after transplanting

Estimates of density at each period together with numbers of rats removed by trapping are presented in Table 8. The higher densities at 7-9 WAT (90 and 97 rats/ha) may be partially explained by an influx of rats from nearby farms which were at different stages of cultivation at that time. Estimated densities at the third and fourth periods were about half those of the first two periods. As expected, only a few rats (2/ha.) remained in the fields after harvest. Harvesting operations, which temporarily removed food and harborage, forced the resident animals to move to adjoining unharvested fields, coconut groves, and wasteland. LaVoie, et al. (1970), however, found that such displacements of rats during land preparation occurred over relatively short distances (100 m) if other harborage was available, enabling the older rats to return, together with new animals, to initiate population growth during the next crop.

The repeated trapping, resulting in the removal of 243 rats from the grid area, indicated the capacity of a population of rats on a small farm to recover numbers rapidly. The rate of population recovery in the fields increased from the early vegetative stage at 0 to 4 WAT to the booting stage of rice at 7 to 9 WAT, then slowed toward maturity at 11 to 14 WAT. Thus, from a negligible number of rats during land preparation, density rose to 36 per hectare in just four weeks; while the population depleted after sampling at 7 WAT was back to its original level in a matter of two weeks (9 WAT). The apparent rate of recovery was reduced by about half between 9 to 11 WAT based on an equivalent two-week recovery period. Rate of recovery was further reduced between 11 and 14 WAT when the population failed to recover fully even in a period of three weeks.

These results suggest that the observed ineffectiveness of baitings with acute toxicants in growing rice (West, et al., 1972) could be explained by rapid recovery of rat populations. Movement of rats from adjacent farms and wastelands appears to provide a means for significant population recovery throughout most of the growing period of rice. Since immigration rather than birth controls the recovery of such populations, the rate of recovery is more rapid and is an important consideration in designing control strategies in which the small farm is taken as the operational unit. We speculate that small-farm control programs based on single or periodic reduction of rat populations, without regard to population recovery, will prove unsatisfactory in reducing damage to rice. Sustained baiting with chronic toxicants (discussed elsewhere in this report) provides one means of dealing with continuous immigration of animals while avoiding the difficulties with bait shyness sometimes encountered when acute toxicants are used repeatedly.

Table 8. Size and composition of a mixed rice-field rat population subjected to repeated removal trapping at different stages of rice development.

Trapping period	Estimated population per hectare ± 95% C.I.	Rats removed per hectare	Proportion of		
			Young and Sub-adults	Male	*R. exulans*
7 weeks after transplant	90 ± 16	76	0.43 n.s.	0.54 n.s.	0.06 **
9 weeks after transplant	97 ± 13	83	0.26 *	0.62 **	0.00 **
11 weeks after transplant	47 ± 15	43	0.19 **	0.57 n.s.	0.11 **
14 weeks after transplant	38 ± 8	25	0.48 n.s.	0.46 n.s.	0.03 **
3 weeks after harvest	2	2	1.00 n.s.	1.00 n.s.	0.00 n.s.
4 weeks after transplant (2nd crop)	36 ± 6	14	0.71 n.s.	0.38 n.s.	0.48 n.s.

n.s. - Not significant
* - Significant at 5%
** - Significant at 1%

Feeding and Movement Patterns of Rats During Application of Surplus Food in Ricefields.

Introduction

Laboratory and cage studies have shown that the number of rice stems cut nightly by individual rats decreases when grain heads begin to mature. In previous field trials conducted on small farms (Sanchez, et al., 1972), consumption of anticoagulant bait also decreased at about this time. In these trials it could not be determined whether the decrease in consumption was the result of a reduced rat population due to the use of poison bait or if the age of the rice was influencing bait consumption. We speculated (Sanchez, et al., 1972) that rats from some distance outside the baited areas made trips to bait stations during the early vegetative period of rice growth, serving to rapidly replace animals that died from poisoning and leading to continuous increases in bait consumption.

To investigate further the relation between bait consumption and development of rice, we exposed polished rice which contained no toxicant throughout the dry season crop and subsequent post-harvest period in a ricefield area near Pila, Laguna. Chemical marking agents and snap-trapping were introduced to study the distribution of animals feeding at the bait stations.

Methods

A 5 x 5 grid composed of points set at 35 m intervals was established within a 3-hectare rice farm. The grid, which enclosed 1.96 hectares, was surrounded by rice on the north, east and west sides. A grove of coconuts boardered the farm on the south side, while narrow strips of coconut plantings were also located between ricefields on the east and west edges of the farm.

Baiting stations were used to hold polished rice at each grid point. The stations were constructed removing the ends from used one-quart oil cans and attaching the cans to 8 x 8 x 1/4 inch plywood platforms backed with two 6 x 2 x 1 inch strips of plastic foam. Thus, stations placed in the paddy could float, avoiding difficulties with fluctuating water levels. Three hundred grams of polished rice were placed at each station and replenished twice weekly. Unconsumed rice was recovered, dried, and weighed to determine the take by rats. The number of stations placed at each grid point was adjusted to maintain an excess of available food. At the peak of consumption on the grid, some points had up to 25 stations.

Measurement of bait consumption was begun during the second week after transplanting of the rice. Rice was harvested during the sixteenth WAT; measurements of bait consumption were continued for an additional four weeks.

During the seventh WAT the polished rice was replaced for 4 nights with rice containing 0.5 percent tetracycline hydrochloride (TC). This material causes bones and teeth of animals consuming effective doses to fluoresce under ultraviolet light. A dose of 50 mg/kg provides marking detectable for several months. Thus, an adult R. r. mindanensis (150-200 g) consuming a few grams of treated rice from the stations daily during the four days of treatment or up to 10 g (about one-half to two-thirds of average daily food consumption) during one of the days would be adequately marked.

During the latter part of the thirteenth WAT, the polished rice was replaced for three nights with rice containing 0.6 percent DRC 6082 (8-anilino-1-napthalenesulfonic acid). This material stains protein, resulting in fluorescence under ultra violet light. Animals fed on treated bait can be detected for more than a week later by examining the mouth lining and gums with ultra violet light.

Snap trapping was conducted at intervals through the crop to obtain marked rats. On each occasion, a line of 40 traps spaced at 10 m intervals was set in each direction from the center of the grid. The four lines were maintained for one night. Traps had modified screen treadles and were baited with grains of polished rice. Animals captured were examined to determine age, sex, and species. Lower jaws (for assay of TC) and mouth linings and gums (for assay of DRC-6082) were examined with ultra violet light for the presence of characteristic fluorescence.

At harvest, surveys were made of 50 hills in seven randomly selected rice paddies on the grid to determine the percent of rice tillers that had been cut by rats.

Results and Discussion

Bait consumption increased rapidly from 2-12 WAT despite two brief periods of levelled consumption between 4-8 WAT (Figure 2). These two periods probably reflect rat control by the farmers who saw damage and rats during these weeksand responded with intensified trapping efforts that yielded around 300 rats. Trapping before and after this period was sporadic and mostly ineffective. Addition of TC to bait was at the end of this period (7 WAT) and so was not responsible for the even consumption.

The general increase in consumption probably reflects use of the stations by increasing numbers of rats. This might be due to either decreased bait aversion of rats within the grid or by an influx of rats from outside the grid to feed at the stations. If decreased bait aversion by rats already within the grid had caused the surge in consumption, all stations should have been equally affected. Bait consumption increased in a gradient from the center to the periphery of the grid, however, as would be expected if the increased consumption was caused by an influx of rats from outside the perimeter of the grid (Figure 3).

TC marking (at 7 WAT) and consequent trapping studies also support the concept of rat influx. During the initial trap night (8 WAT), eighty per cent of the R. r. mindanensis collected in the area between the edge of the grid and 100 m beyond it were marked, the same per cent as those collected within the grid (Table 9). This shows that the rats beyond the grid to 100 m were feeding at the bait stations during the seventh WAT, and in about the same proportions as those within the grid. Only 7 per cent of the rats trapped over 100 m from the grid were marked indicating little use of the stations by these rats at this time.

Subsequent trapping showed a rapid drop in the proportion of TC marked rats in the area within the grid to 100 m beyond it. Since it is unlikely that rats lost the dye or that there was differential mortality of marked animals, this finding indicates that there was additional movement of rats from beyond the grid + 100 m into the grid area between 7-13 WAT. This movement is further supported by the presence of DRC 6082 in 27% of the R. r. mindanensis trapped over 100 m from the grid during 14 WAT. The DRC 6082 was added to the bait during the thirteenth WAT. R. exulans showed a similar but more erratic pattern in the marking trapping studies, possibly indicating a more erratic influx pattern of R. exulans from the coconut area.

From this data, we suggest that bait stations service not only rats within the grid in which they are placed, but that rats for a considerable distance beyond the grid learn to feed at the stations. Thus, an increasing movement of rats from surrounding areas into the grid causes increasing bait consumption during the first 12-13 WAT. The peripheral rats become most familiar with perimeter stations and use these most intensely. This suggestion carries several corollaries for the design and tests of future rat control studies: first, it suggests that baiting stations placed in restricted areas can affect rat populations in a relatively wide area surrounding the stations; second, it suggests that the position of bait stations within a grid can influence the amount of bait consumed.

The dramatic decrease in bait consumption 13-14 WAT also warrants consideration (Figure 2). Previous studies in which this was observed also involved use of toxicants (Sanchez et al., 1972). It was thought that the

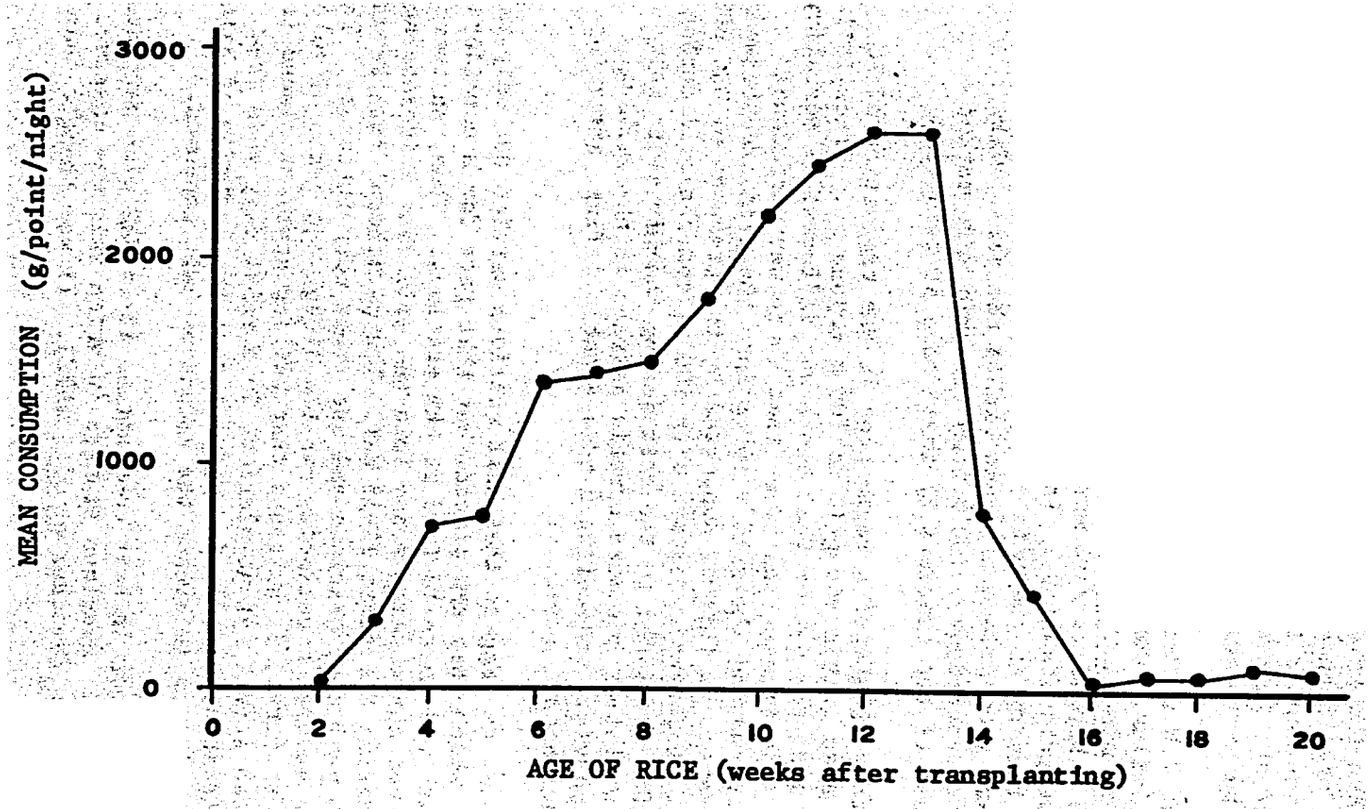

Figure 2. Weekly changes in mean food consumption by rats at 25 baiting points placed in a grid pattern at 35-m intervals on a two-hectare rice farm near Pila, Laguna, Philippines.

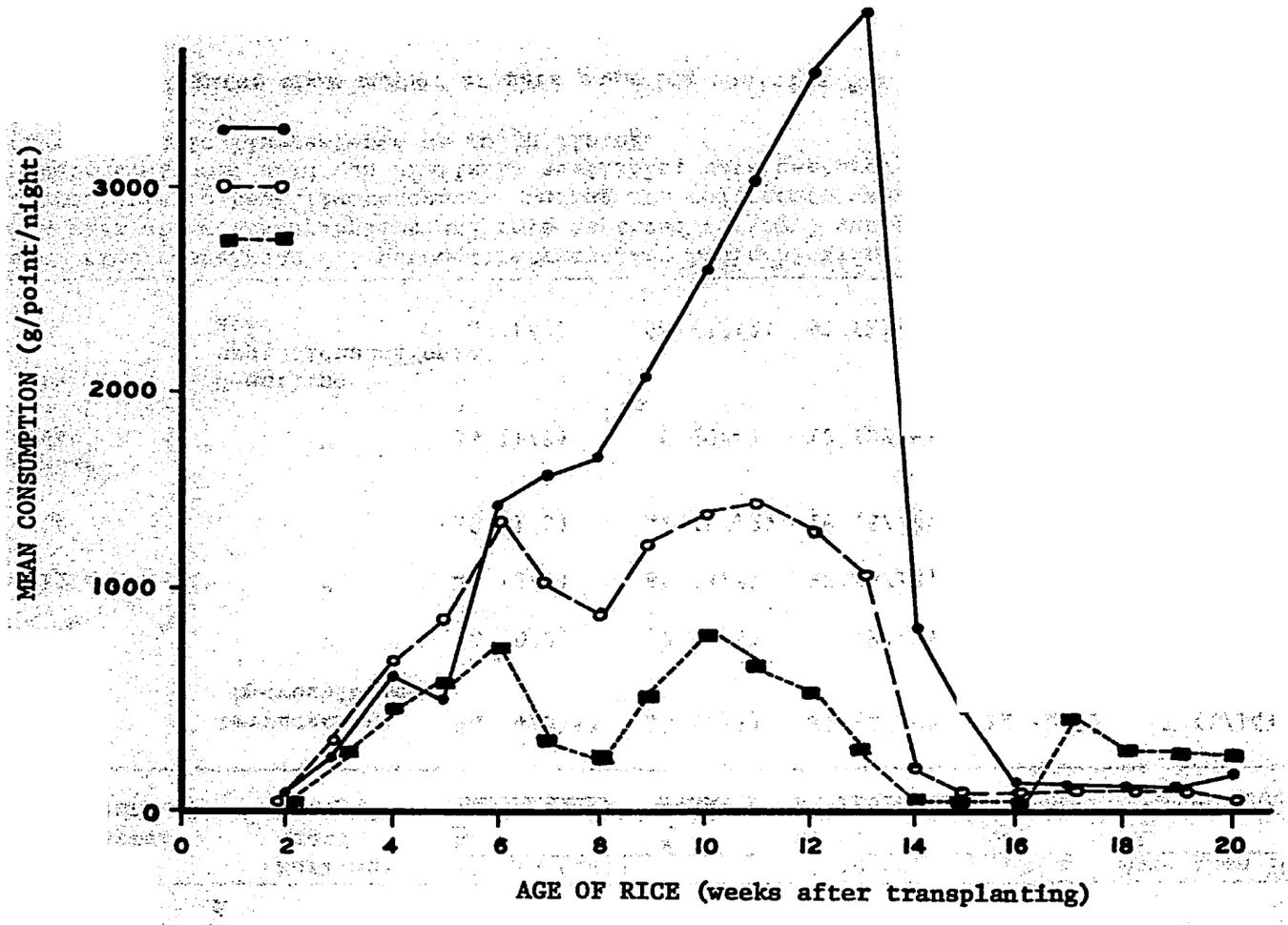

Figure 3. Relation of baiting point position to changes in mean food consumption by rats at 25 baiting points placed in a grid pattern at 35-m intervals on a two-hectare rice farm near Pila, Laguna, Philippines.

Table 9. Percentages of *Rattus rattus mindanensis* and *Rattus exulans* marked by fluorescent dyes introduced for 3 day periods during a sustained application of untreated rice bait to a two-hectare rice field.

Age of Rice (weeks after transplanting)	Marking* Agent Assayed	Within Field		Field edge to 100 m		More than 100 m from field	
		R. r. mindanensis	*R. exulans*	*R. r. mindanensis*	*R. exulans*	*R. mindanensis*	*R. exulans*
8	tetracycline hydrochloride	80 (4/5)**	33 (1/3)	80 (8/10)	12 (1/8)	7 (1/14)	0 (0/3)
9	"	0 (0/2)	22 (2/9)	53 (8/15)	10 (1/10)	0 (0/12)	0 (0/8)
11	"	40 (2/5)	60 (3/5)	38 (5/13)	14 (2/14)	0 (0/15)	0 (0/15)
14	"	20 (1/5)	42 (5/12)	28 (5/18)	4 (1/25)	7 (1/15)	0 (0/10)
6 weeks post-harvest	"	33 (1/3)	0 (0/4)	12 (2/16)	0 (0/3)	0 (0/26)	0 (0/9)
14	8-anilino-1-napthalenesulfonic acid	20 (1/5)	58 (7/12)	61 (11/18)	12 (3/25)	27 (4/15)	0 (0/10)

* Polished rice containing 0.5 percent tetracycline hydrochloride was available in excess during the seventh week after transplanting and rats captured during 5 successive trapping periods were examined for characteristic bone fluorescence. During the thirteenth week, rice containing 0.6 percent 8-anilino-1-napthalenesulfonic acid was similarly available; rats captured during the fourteenth week were examined for characteristic fluorescence on mouth lining.

** Parenthetical figures show number of rats assaying positive for the marker over total number of rats examined.

decreased consumption of bait and tiller cutting might be due to a reduced rat population from the effects of the toxicant. This was obviously not the cause of the dramatic drop in consumption observed in this study, since no toxicants were used. Aversion to DRC 6082 is a possibility since it was added to the bait during the 13 WAT. Additional studies are needed to determine the aversion of rats to this compound in the field. Effects of trapping might also be considered, but are probably not realistic possibilities: the trapping design was not nearly the intensity required for depletion trapping studies; and, the high level of bait consumption during most of the trapping periods suggest a rat population sufficiently great to be essentially unaffected by the numbers trapped. We suggest that the decrease in bait consumption could have been caused by a switch from bait to newly headed rice during the 14 WAT or to a general decrease in home range as the ricefield habitat became more fully developed. Both of these suggestions are consistent with the marking and consumption data from this and other studies. Future tests, perhaps employing radiotelemetry and quantifying key habitat features such as per cent cover, and food availability and usage may give further insight into the causes of declines in bait consumption during the heading period of rice development.

This study also provides information on the value of using untreated bait as an alternative to ricefield crops as a food source for rats causing damage. In this study, polished rice was added ad libitum at stations, it was untreated except for the addition of marking agents for seven nights, and consumption at the stations was high during most of the study. Despite the availability and use of this alternative food source, pre-harvest damage surveys on seven paddies within this two hectare grid averaged 4% damage to tillers (Table 10). Although the study does not allow comparison with the amount of damage that would have occurred if no alternative food was offered, the 4% level of damage is approximately equal to the average observed for rat damage to ricefields by the national survey conducted during the 1972 dry season, and is therefore significant.

Table 10. Summary of pre-harvest damage surveys of seven paddies randomly selected from within a 1.96 hectare ricefield area. The area was supplied throughout the rice crop with polished rice placed at bait stations.

Paddy No.	Tillers cut by rats* (percent)
1	1.38
2	4.86
3	9.30
4	4.13
5	4.00
6	1.45
7	2.71
Mean =	3.97

* Fifty randomly selected hills were examined in each paddy to determine the percentage of tillers that had been cut. Such surveys provide an index to damage which occurs during the latter half of the crop, but the relationship to yield reduction has not been clearly established.

Reducing Interactions Among Rats at Bait Stations to Improve Bait Acceptance

Introduction

A widely used practice of exposing toxic baits for rodent control involves the placing of large quantities of material in containers or bait stations which are accessible to rats. Depending on the situation, this may be done to protect the bait from weather or to decrease the potential hazard to non-target species. The types of containers recommended have varied widely, from locked boxes , pipes, or hoppers (Johnson and Bjornson, 1964) to bamboo tubes (Alfonso and Sumangil, 1970). Previous investigators have noted that unfamiliar rats may be driven away from food sources (Barnett and Spencer, 1951) and that social interaction around bait stations may slow the rate of feeding (Elton and Ranson, 1954). Calhoun (1963) in discussing the behavior of Norway rats (R. norvegicus) at food sources postulated that such conflicts among animals were related to crowding rather than contention for food. From these and other published studies of rat behavior, one might deduce that the effective feeding space at a baiting point rather than the number of animals actually present might limit the amount of bait consumed over a given time period. Chitty (1954), however, believed that surface bait stations could accommodate large numbers of rats, despite fighting. He observed that by the development of staggered feeding schedules, a rat population could make full use of food exposed at stations.

In an initial series of evaluation trials we used sustained baiting with chronic toxicants to reduce R. r. mindanensis damage to growing rice on small farms. In using single stations placed at 100 m- intervals along paddy dikes and irrigation canals (a density of about 5 stations per hectare), we suspected that overcrowding at the stations might be limiting the amount of bait consumed. We have sought, therefore, practical means of improving bait acceptance which do not generate major increases in cost. This paper reports observations on the apparent limiting effects of social interaction on the amount of food consumed from typical bait stations and provides preliminary information on a potential means of greatly increasing the amount eaten at a particular baiting point.

Methods

We established four baiting points in each of two parallel lines on paddy dikes at 50-m intervals in 1-4 week-old, transplanted rice; the lines were about 150 m apart. At every other point along each line, we placed a one-liter can opened on both ends and stapled to a 20 x 25 x 0.6 cm piece of plywood. At each of the alternate points, we placed a "baiting hut" of a type commonly used to expose chronic toxicants in the

Philippines. The hut consisted of a wooden tray, 30 x 17.5 x 3.8 cm, with a metal roof made from half of an 18-liter can, 35 x 22.5 x 22.5 cm, cut diagonally lengthwise. A 2.5 x 5 x 32.5 cm stake, nailed to each end of the tray supported the roof and anchored the hut to the ground (Figure 4).

Initially, 200 g of untreated polished rice was placed in each station. The amount of rice at each baiting point was gradually increased to maintain an excess over consumption. At the baiting points with small stations, increases in available bait were made by adding additional cans, each containing 200 g (Figure 5). At the huts only additional bait was added. Fresh rice was placed at all baiting points 5 times during a 17-day period. At each visit, unconsumed bait was recovered, dried, and weighed; the value obtained was then subtracted from the original amount to index bait consumption.

To study the behavior of rats at the stations we used a closed circuit television system, consisting of a camera equipped with an infra-red source and 4 x telephoto lens, a videotape recorder, and a television monitor. The baiting points of each type having the highest consumption were selected -- two with huts and one with small bait cans. Monitoring was done at one but on the 10th night, at a second hut on the 16th night, and at the cans on the 17th night. The camera equipment was set about 2 m above ground level and about 6 to 8 m away from the center of the baiting point. Power was supplied by a portable generator located about 100 m from the camera site. Equipment was prepared during late afternoon; observations were made for the first 2 1/2 hours after the onset of darkness.

Results and Discussion

Greater bait consumption was immediately apparent at the baiting points having small stations. The effect remained clear and consistent throughout the seventeen nights of observation, with consumption at the points with small stations averaging nearly three and one-half times that at the huts (Figure 6). When the experiment was terminated, an average 1074 g per night per point was being consumed at the points with cans while the consumption of huts averaged 313 g per night per hut. Consumption was continuing to increase at all of the points when the observations were completed. Although bait in both huts and cans occassionally became wet from the intermittent rain that occurred, this did not appear to inhibit consumption and we considered the protection afforded by both types of containers adequate.

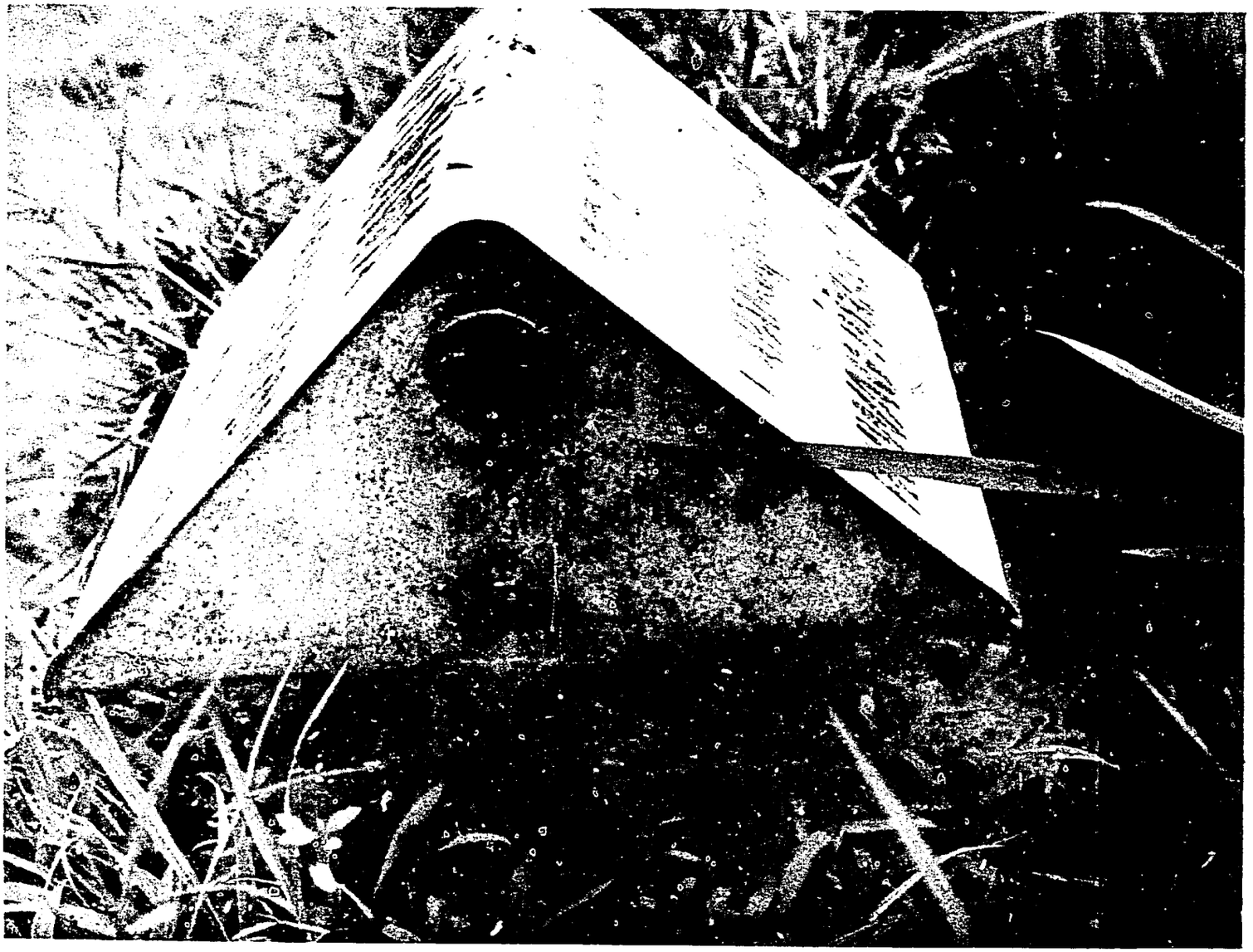

Figure 4. A "baiting hut" of the type typically used to expose chronic toxicants in the Philippines. During five hours of observation with a closed circuit television system, no more than two rats were seen feeding at the hut simultaneously, despite considerable rat activity around the baiting point.

Figure 5. Use of small stations (in this case discarded plastic oil cans) at a point allows adjustment of available feeding surface to rat intensity. From six to fifteen rats were observed feeding simultaneously at one point with 24 stations, resulting in much higher bait consumption than at points containing a single station.

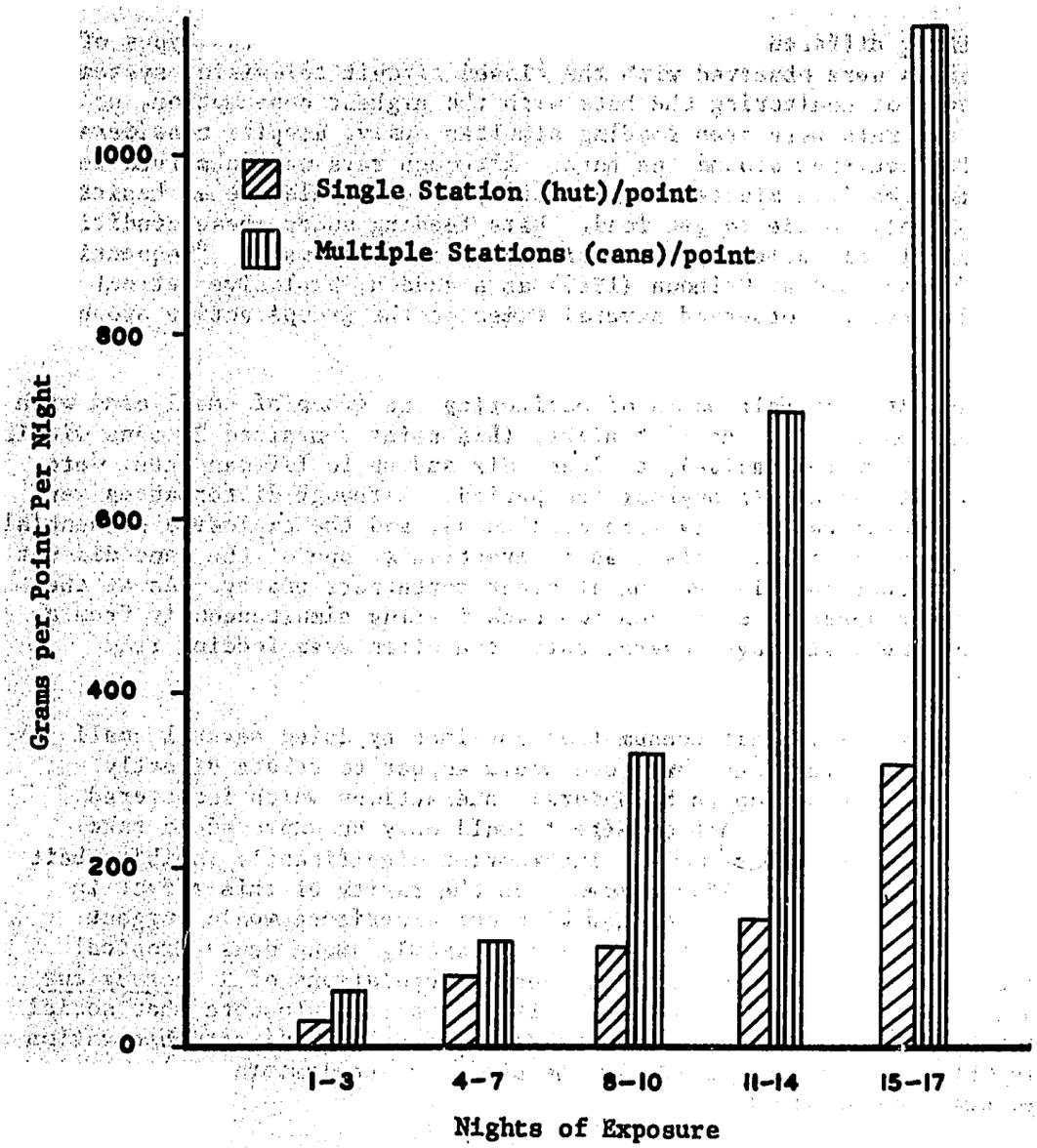

Figure 6. Nightly bait consumption from two types of baiting points set in ricefields.

Striking differences in the behavior of rats at the two types of baiting points were observed with the closed circuit television system. In five hours of monitoring the huts with the highest consumption, no more than two rats were seen feeding simultaneously, despite considerable rat activity centered around the huts. Although rats were observed to spend as much as five minutes inside a hut, most animals seemed hesitant to go completely inside to get food. Rats feeding under these conditions appeared highly disturbed by the activity of other animals. "Sequential reaction," described by Calhoun (1963) as a sudden, explosive retreat by a group of rats, was observed several times in the groups active around the huts.

In two and one-half hours of monitoring the group of small cans with highest consumption (by the 17th night, this point contained 24 cans within a circle of about 1-m radius), at least six and up to fifteen rats, were feeding simultaneously throughout the period. Although disturbances were observed, feeding was notably more continuous, and the explosive sequential reactions were not seen. Often, an interaction at one of the cans did not appear to disturb animals feeding at other containers nearby. As at the huts, we never observed more than two rats feeding simultaneously from a single container, although several rats were often seen feeding from adjacent ones.

The increase in bait consumption obtained by using several small containers rather than one large one would appear to relate directly to a functional reduction in behavioral interactions which interfered with feeding activity. Such an effect could only be expected to take place in situations where social interaction significantly inhibits bait consumption. Chitty's (1954) comments on the rarity of this effect in his census baiting studies, coupled with our experience would suggest that such situations probably occur more commonly among dense tropical field rat populations than in the temperate populations of R. norvegicus which have been more widely studied. It is important to note that social limitation of bait consumption can be detected only by direct observation or, as Chitty (1954) suggested, by the use of a supplemental bait station placed near the original.

Another factor, which may have contributed to increased bait consumption at the cans, was the easier access to bait provided by the cans themselves. The differences in consumption between the two types of baiting points on the initial check support this speculation. Although no attempt was made at quantification, the latency of feeding for individual rats appeared somewhat greater at the huts, and we observed an apparent hesitancy of some animals to feed under the sheltering roof of the huts.

To the extent that these effects can be generalized from the situations which we observed, several implications for rodent control practices are evident. Since the increased consumption at the points having the cans occurred immediately and lasted throughout the period of bait exposure, the procedure might be used to advantage with either chronic toxicants, such as warfarin, or in schedules using prebaiting (untreated bait) followed by acute toxicants, such as zinc phosphide. We suspect, partially from experience with trials of sustained baiting with chronic toxicants (Sanchez et al., 1972), that the major increases in bait consumption seen at both types of baiting points over the seventeen-day period were due to recruitment of animals from outside the initial area of effect. The concentration of activity at the stations probably reduced the home range size of animals which did all or part of their feeding at the artificial food sources. This would, in turn, result in a net movement of peripheral animals toward the stations (due to complementary home range expansion), and, over a period of time, probably resulted in the location and use of baiting points by increasing numbers of animals. If toxicants were used, such major increases in bait consumption would not be expected. The more gradual increases experienced in our previous baiting trials probably resulted when the rate of recruitment of new animals exceeded the rate of mortality of established animals.

It might appear that a more efficient way to apply the principle of increasing bait consumption by reducing the inhibitory effects of social interaction would be by scatter-baiting techniques such as those employed by Wood (1971), with wax cubes containing anticoagulants, or by Swink, et al. (1972-3) with leaf "torpedos" containing zinc phosphide. This is not necessarily the case, since scattered baits require animals to search separately for each particle, while fixed stations allow animals to learn the location of dependable food sources.

When labor costs are considered it seems apparent that some savings are realized by concentration of bait at centralized baiting points. Use of stations also eliminates the need for making bait packages, which Swink et al. (1972-3) considered to entail excessive labor. In practice, we found little difference in the time required to service the two types of baiting points tested, except for those activities associated with measuring bait consumption. We were convinced, however, that distributing the aggregations of cans individually would have involved considerably more effort.

The huts required about one man-hour of labor to construct (about ₱2.00* for a farm laborer) and had a materials cost of ₱2.50 each. Although the discarded cans we used for the small station were obtained at no cost and the labor involved in constructing an individual station was negligible, the cost of the plywood platforms was about ₱0.30 each.

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* One peso (₱) equals approximately $0.15 (U.S.).

Thus, a comparable cost (based on the use of a maximum of 10 cans per baiting point) would be about ₱3.00. For operational use, both large and small stations of various types might be constructed more cheaply. It is likely that in most operational situations fewer of the small cans would be required to achieve maximum effect, since toxic, rather than untreated, bait would be used.

We conclude that under certain conditions of relatively high rat density, major increases in bait consumption (more than three-fold in this experiment) can be obtained by the simple procedure of making it possible for more animals to feed without disturbance at baiting points. That such increases could be obtained by a procedural change derived from the study of rat behavior is of particular note at a time when considerable efforts, on a worldwide scale, are devoted to seeking chemical means of improving bait acceptance. These results illustrate the importance of continued attention to simple behavioral principles as attempts are made to adapt control methods to rat species other than *R. norvegicus*.

A Preliminary Study of Prolonged Prebaiting as a Means of Reducing Rat Aversion to Acute Toxicants

Introduction

A common problem in rat control using acute toxicants is bait aversion. This probably occurs when rats become "bait shy" after nibbling a new bait at an unfamiliar station and receiving shortly afterward a sublethal nervous reaction. We felt that prolonged prebaiting might accustom the rats to feeding stations and make them less hesitant to consume lethal quantities of bait immediately after the toxicant was added. To test this, we undertook a preliminary study using two chemical marking agents to identify population members that fed at prebaited stations before and after treatment with zinc phosphide.

Materials and Methods

A central area within a large section of irrigated ricefields near Victoria, Laguna, was chosen for the test. A total of 36 baiting points were placed in a 6 x 6 grid with 50 m between points. Thus, the grid enclosed 6.25 hectares. Stations were the floating oil can variety (described previously); the number at each point was adjusted periodically to maintain an excess of bait. The stations were checked twice weekly, and uneaten bait was collected, dried, and weighed. Three hundred grams of polished rice bait was placed in each station during each visit. Baiting was initiated 2 WAT of the rice and continued for 6 1/2 week before the marking experiment was undertaken.

After the pre-baiting period, the untreated rice was replaced with polished rice containing 1% tetracycline hydrochloride (TC) for one night. This compound, which causes fluorescence of the growing bone tissue under ultraviolet light, marked rats feeding at the baiting stations that night. The treatment was followed by one night of baiting with untreated rice and snap-trapping along four 100 m transects within the grid. The next night bait was again treated, this time with 2% zinc phosphide as a toxicant and 1% DRC-6090 as a marking agent. DRC-6090 (the sodium salt of 8 amino-1-napthalenesulfonic acid) adheres to protein and causes a yellow fluorescence of the mouth lining under ultraviolet light. Baiting with untreated rice was then resumed and continued for an additional four weeks. Snap-trapping on the four transects was repeated on the night following the zinc phosphide/DRC 6090 treatment to identify animals which fed on the treated bait and survived.

Results and Discussion

Bait consumption declined when TC-treated bait was placed in the stations (Figure 7 and Table 11), but 83% (20 of 24) of the adult rats trapped on the grid one night after TC treatment were marked (Table 12). This suggests that although TC reduced the total amount of bait taken, most rats on the grid was still feeding at the stations, but eating less. Bait consumption declined further between treatments and dramatically after the zinc phosphide/DRC 6090 treatment (Figure 7 and Table 11). There are at least three possible explanations for this decrease: 1) aversion to the zinc phosphide/DRC 6090 despite prolonged pre-baiting resulted in reduced consumption, 2) snap-trapping after TC treatment effectively reduced the rat population, or 3) there was little bait aversion and zinc phosphide killed a significant number of rats, effectively reducing the population. Both the amount of bait taken and the trap success declined, making the first possibility unlikely, and suggesting that the rat population was reduced due to either a trapping effect or good acceptance of zinc phosphide. Previous work suggests that the numbers of animals removed from the area by trapping would be negligible under usual population conditions in ricefields, making the second of these possibilities unlikely. All dead or dying rats (seven) collected after baiting with acute-toxicant were marked with both TC and DRC-6090, suggesting good acceptance of zinc phosphide; and, only two of twelve rats trapped contained chemical markers after treatment with the toxicant, suggesting that most rats which fed on the treated bait ate lethal quantities. Thus, the data favors the interpretation that the reduced consumption was the result of a reduced rat population due to the effect of the toxicant.

The decrease in percentage of TC marked rats that were trapped after zinc phosphide baiting compared to the trapping period immediately following the TC treatment (from 83% to 56%) is puzzling, unless we speculate that not all animals active within the grid area used bait stations during the prebaiting period. Thus, the zinc phosphide treatment would have killed mostly rats which were habitually feeding at the stations and most likely to have been marked by TC. If this is the case, placing baiting points at intervals shorter than 50 m might result in use of the stations by a greater proportion of the resident rats and, with the addition of toxicants, effect better control.

Although this study is preliminary, it indicates that prolonged pre-baiting may serve to familiarize rats with bait stations and make them more likely to accept acute quantities of a toxicant when it is added at a later time. However, use of anticoagulants at low concentrations with a short pre-baiting period also results in good bait acceptance and has the additional advantage of lower cost. The study clearly demonstrates the value of chemical marking agents as a research tool for field evaluation of bait acceptance.

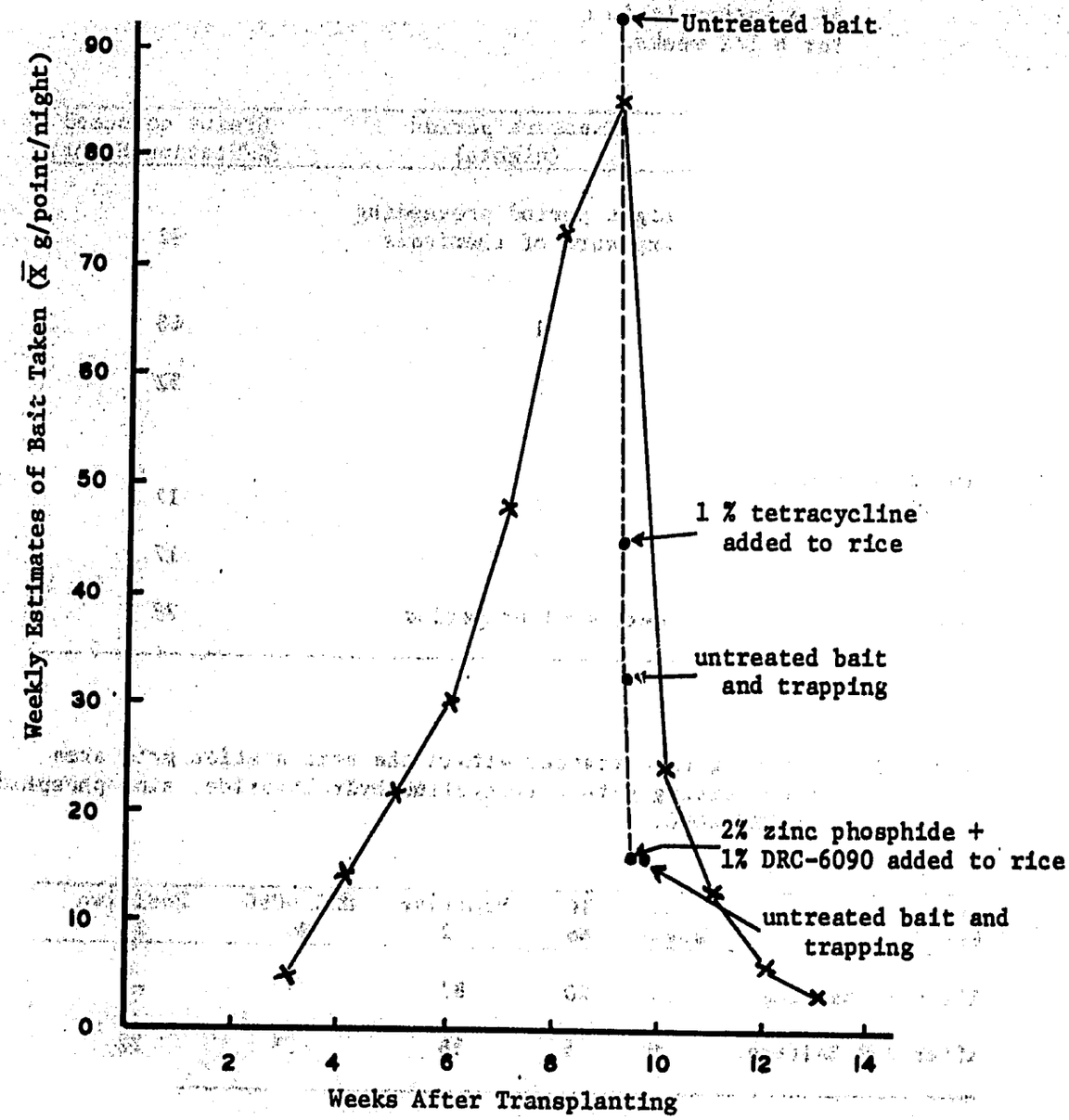

Figure 7. Weekly estimates (X) of mean grams of bait taken per station per night for the ten week duration of the prolonged prebaiting study. Dots (.) show mean grams of bait taken per station for the nights before, after and while treated bait was used.

Table 11. Average daily bait consumption with 36 stations spaced at 50 m intervals in a 6 x 6 station grid after pre-baiting for 6 1/2 weeks.

Bait Material	Exposure period (nights)	Grains consumed ($\bar{X}$/Station/Night)
Untreated	3 night period preceeding exposure of chemicals	92
1% tetracycline hydrochloride	1	45
Untreated	1	32
2% ZN_3P_2 + 1% (naphthalenesulfonic acid)	1	17
Untreated	1	17
Untreated	next 4-night period	23

Table 12. Surviving rats trapped within the bait station grid area after baiting with tetracycline hydrochloride, zinc phosphide, and DRC 6090.

Trapping Period	No Caught	TC No.	Positive %	DRC 6090 No.	Positive %
After TC Baiting	24	20	83	-	-
After ZnP Baiting	9	5	56	2*	22

* also TC positive

Acceptance and Relative Toxicity of Bait Prepared with Commercial and "Spiked" Anticoagulant Concentrates*

Introduction

In field evaluation trials using several commercial anticoagulants on polished rice, we noted that some materials were excessively powdery because a portion of the mixture of toxicant and inert carrier (usually talc) did not adhere to the surface of the grain. Sloughing and settling of the excess powder often occurred during transport. We suspected that such bait might have reduced toxicity due to physical loss of part of the toxicant and might be less acceptable to rats because of the powdery condition. Such a problem might be avoided by using an oil or other adhesive in mixing bait, by using a more finely granulated carrier, or by reducing the amount of inert powder in the commercial concentrate. Preliminary information on the latter approach is presented for two locally available anticoagulant concentrates containing warfarin and coumatetralyl, along with comparative information for a third material, coumachlor, which is marketed in more concentrated form.

Methods

Commercial concentrates of three anticoagulant rodenticides (warfarin -- 0.5 percent, coumatetralyl -- 0.5 percent, and coumachlor 2 -- 1 percent) were purchased from local sources and mixed as recommended on the labels to produce baits containing 0.025 percent active ingredient (by weight). Spiked concentrates of warfarin and coumatetralyl were prepared by the addition of technical rodenticide to bring the concentration to 2 percent. These concentrates were then used to prepare bait which also contained 0.025 percent active ingredient. Whole polished rice was used as the bait for all compounds. Finished bait was then offered to individually caged rats (*R. r. mindanensis*) *ad libitum*. Amounts eaten were determined by periodic weighing; measurements were continued until all rats had died.

Results and Discussion

Results of the tests are summarized in Table 13. Bait prepared with coumachlor concentrate was well accepted and was not excessively powdery. Baits prepared from 0.5 percent concentrates of coumatetralyl and warfarin both showed considerable sloughing of powder in the food

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* Use of registered names does not imply endorsement or recommendation of specific chemicals or commercial products by Philippine or U.S. government agencies.

dishes -- the latter to a somewhat greater degree. Warfarin bait prepared from the commercial concentrate had better initial acceptance than the corresponding coumatetralyl bait. Rats ate lethal amounts of all the baits prepared according to manufacturers' recommendations; death times averaged about 10 to 12 days.

Table 13. Amounts of bait consumed daily by individually caged *Rattus rattus mindanensis*. Five rats were used for each toxicant.

Toxicant	Percent Active ingredient		Average daily Consumption in grams for the period (day)			Average No. Days to Death
	In Concentrate	In bait	1	2-7	8-13	
Coumachlor (Commercial)	1.0	0.025	6.0	2.6	6.0	9.8
Warfarin (Commercial)	0.5	0.025	5.2	3.1	3.8	11.6
Warfarin (Spiked)	2.0	0.025	11.8	7.3	3.4	8.4
Coumatetralyl (Commercial)	0.5	0.025	0.8	2.6	4.0	10.0
Coumatetralyl (Spiked)	2.0	0.025	1.8	4.7	2.2	12.8

Use of 2 percent concentrates resulted in improved acceptance for both coumatetralyl and warfarin and virtually eliminated the problem of sloughing. Average number of days for mortality was reduced by about 3 days for warfarin and increased by about 3 days for coumatetralyl. Death times were more variable for rats feeding on coumatetralyl baits prepared wite either commercial or spiked concentrates. One rat consumed 50 g of the former over a 25-day period, while another rat ate 80 g of the latter material over a 24-day period before its death. The greater variability observed with these baits suggests that, under field conditions, a greater proportion of animals would ingest fairly large amounts of bait before dying.

Further studies are needed to determine the best means of preparing baits with these material for the variety of rat species against which they find use. In the case of R. r. mindanensis, which occurs as a rice pest throughout the Philippines, it appears that some advantage could be gained by the use of concentrates with a higher percentage of toxicant to prepare rice bait.

Acceptance of Wet or Moldy Rice Baits by R. r. mindanensis Under Laboratory Conditions

Introduction

Philippine conditions, particularly during the wet season result in bait becoming damp or wet and, after a few days of exposure, moldy. Because of the unpalatable appearance of such bait (to humans), a variety of protective baiting containers have been devised. Since rats themselves track moisture and soil into bait stations, such devices are only partially effective. Some commercial rodenticides are premixed with mold inhibitors, for example dehydracetic acid and its sodium salt. Our field observations have suggested that, in sustained baiting programs, wet or moldy baits are generally consumed from rice-field bait stations. However, the question remained whether the acceptance of bait by individual rats was reduced.

Methods

Eighteen female R. r. mindanensis, accustomed to feeding on dry polished rice without alternative food, were assigned to one of three treatment groups. One group received soaked rice (under water for 6 hours prior to test); a second group received moldy rice (wet daily and exposed in an open bait container in a field of growing rice for 5 days prior to test); a reference group continued to receive dry rice. Food consumption of the treatment groups was measured for three days, and expressed in grams/rat/day (dry weight). Test materials were replenished each afternoon; water was available ad libitum. Analysis of variance was conducted using three-day means for each animal, with the null hypothesis being, "wet or moldy bait does not significantly reduce the consumption of R. r. mindanensis under the conditions of test."

Results and Discussion

Animals readily consumed substantial amounts of all the materials presented. Analysis of varinace indicated no difference among treatments and the null hypothesis was accepted at the 0.01 level (Table 14). The laboratory test results support field observations and suggest that rats accustomed to feeding on dry rice bait would continue feeding if bait becomes wet or moldy. It should be noted that toxic baits exposed directly to rainfall might lose some of their toxic properties either through deterioration of the toxicant or through leaching (West, et al., 1972-3).

Table 14. Acceptance of wet and moldy polished rice by *Rattus rattus mindanensis*.

	Mean Consumption* (g/rat/day)	S.E.
Dry Rice (Reference)	7.11	1.21
Soaked Rice	7.33	0.43
Moldy Rice	6.94	0.62

*Average of 6 animals fed for three days.

ANOVA

SV	df	SS	MS	F
Treatment	2	0.4591	0.2292	1 (n.s.)
Error	15	61.1038	4.0735	
Total	17	61.5629		

Replicated Field Trials of Sustained Baiting on Small Farm Units

Introduction

Baiting with anticoagulant rodenticides in growing rice has been used for rodent control in many Southeast Asian countries, usually following the application of bait containing acute toxicants. Some investigators have tested the use of intensive applications of anticoagulants on large areas (20 to 100 hectares) throughout the period of the rice crop (or longer) with favorable results (Wood, 1971; Philippine-German rat control applied research project, 1972). Sanchez, et al. (1972) discussed four preliminary trials of sustained anticoagulant baiting in combination with other control techniques on small farms (3.5 to 5 hectares) and suggested that the results appeared economically beneficial based on subjective comparison with surrounding areas and previous crops.

To gain more information on the uses and benefits of sustained baiting with anticoagulants on small hectarages, we carried out a one-crop baiting program on six areas (averaging 1.21 hectares) near Sta. Cruz, Laguna, during the wet season of 1973.

Methods

Six blocks, each containing nine contiguous rice paddies, were selected for treatment and six as reference plots. The blocks were located within a wide area of continuous riceland, averaged 1.21 hectares in size, and were separated from one another by at least several hundred meters. All of the paddies within some blocks were owned by one individual, while other blocks were comprised of paddies owned by several farmers. All blocks were planted with high-yielding rice varieties, mostly either IR-20 or C-4.

At the time of transplanting, approximately 5 baiting points/hectare were chosen arbitrarily at convenient locations along dikes and old threshing mounds in each of the treated blocks. The points were at least 50 meters apart. At each point one (or in a few cases where rat activity appeared high, two or three) bait station was placed and filled with 100 g of low-grade polished rice containing 0.025 percent coumachlor. The stations were made from open, discarded oil cans stapled to an 8 x 8 x 1/4 inch plywood base. The coumachlor was prepared from Tomarin 2 concentrate* according to manufacturers directions.

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

Treated plots were visited twice weekly until all of the paddies in the plots were harvested. During visits, stations were checked for bait consumption. If only a portion of the bait was taken at a point, bait was replenished with an amount approximately equal to the quantity taken. If all of the bait was taken, however, the bait was resupplied at the depleted stations and an additional baited station placed at the point. By following this procedure, some points soon contained six stations and all bait was still taken between visits. The amount of bait was then increased at these stations. If total consumption continued, additional stations were again added until the amount of bait placed at the point slightly exceeded consumption. Thus, the intensity of baiting related directly to the rat feeding activity at the points, with only a slight excess of bait not taken between visits. Although this baiting method was used because it encourages large numbers to feed at baiting points by reducing interaction between the rats (as presented elsewhere in this report), the method also made it unnecessary to keep weigh-back records to determine bait consumption: it is based on weekly records of the amount of bait placed at the stations.

Rat activity was determined in the treated and untreated plots three times during the study using forty inked tracking-tiles. These were set along dikes and intersections for one night each plot. Times were chosen arbitrarily within various stages of growth of the rice: young rice, 1-4 WAT; growing rice, 10-12 WAT; and mature rice, 13-16 WAT. Tiles were examined the following morning for the presence or absence of rat tracks, and results expressed as the percent of the tiles showing presence of rat activity.

Rat damage to rice was assessed 7 WAT and at the time of harvest by examining one hundred randomly selected hills in each paddy for presence or absence of damage. Results are presented as percent of hills with damage. Data from the pre-harvest surveys were used in conjunction with the regression equations presented elsewhere in the report to calculate estimates of the percent of rice tillers (stems) cut by rats. Yield estimates were obtained by harvesting a 1 x 5 m plot located in the center of each paddy. Rice was hand-threshed in the field, then taken to the laboratory, dried, weighed and returned to the farmer. Results were standardized to 14 percent moisture and expressed in cavans/hectare (setting one cavan equal to 50 kg.).

Capital costs as well as actual results of harvest and sales were obtained from the farmers for all farms included wholly or partially in the experimental plots. Portions of nine farms were included in the six treated plots, while eight farms were included in the reference plots. In analyzing the data, each farm was considered as a unit for calculating data means. Thus, areas of farms not directly subjected to experimental

rat control treatment were included in the calculations for the treated plots. We believe that errors introduced in this manner are negligible because the effects of sustained baiting extend for a considerable distance beyond the area of treatment (as discussed elsewhere in the report). If error was introduced by this approach, our assessment of the effects of treatment would be biased in the direction of conservatism.

All aspects of the baiting study were carried out by participants in the study. There was no attempt to prevent or interact with the regular rodent control activities on either treated or untreated plots. These activities included an aggregate of minor control efforts, such as cleaning dikes, digging burrows to kill rats, or occasional dike baiting with acute toxicants.

Results and Discussion

Bait consumption, expressed as the weekly mean amount of bait placed at points, increased rapidly during the first four WAT, then decreased gradually during the following fourteen weeks (Table 15). We speculate that the initial surge in consumption was caused by the increasing numbers of rats, located both within the plots and their surrounding area, that found and used the stations. The surge was countered by an increasing mortality rate as larger numbers of rats feeding at the stations consumed lethal quantities of anticoagulant. By the 4 WAT, a momentary balance in bait consumption (8.1 kg/point) was achieved as anticoagulant mortalities lowered the number of feeding rats just as rapidly as incoming rats acted to raise it. Thereafter, losses to anticoagulant exceeded the rate of influx of new rats into the treated plots, and population numbers and bait consumption declined. Untreated baiting studies presented earlier in this report support these speculations and suggest that bait consumption would probably have continued to increase dramatically for a considerable time following 4 WAT if anticoagulants had not been used. Of the total bait consumed, less than 2% was taken after 14 WAT, suggesting that baiting could have been discontinued at this time without significantly affecting the results.

Indices of rat activity also support the contention of a smaller population in the treated plots than in those left untreated (Table 16). Estimates of crop damage, for example, revealed that 4.4 vs 10.6 percent of the hills were damaged by rats at 7 WAT and 11.4 vs 17.0 percent at harvest, treated vs untreated plots respectively. At harvest, this calculates at 2.33 vs 3.79 percent tillers cut in the treated vs the untreated plots. Although the quantitative relationship between rat population density and tracking tile activity is uncertain, there was considerably more tracking tile activity in the untreated than in the

Table 15. Weekly placement of anticoagulant bait (kilograms) from all baiting points in treated rice-field plots near Sta. Cruz, Laguna.

Weeks After Transplanting	Bait Placed at Stations (Kg/hectare)						
	Plot I (1.56 ha)	Plot 2 (1.30 ha)	Plot 3 (1.12 ha)	Plot 4 (1.05 ha)	Plot 5 (1.08 ha)	Plot 6 (1.16 ha)	$\bar{X}$
1	1.03	2.50	0.54	2.86	2.13	2.76	1.97
2	1.67	3.16	2.14	3.29	7.22	3.88	3.56
3	5.64	6.39	5.89	5.24	4.35	5.60	5.52
4	9.04	2.50	14.51	13.71	3.43	5.43	8.10
5	5.26	0.46	12.77	4.67	3.80	2.16	4.85
6	5.51	3.70	1.38	12.67	3.38	1.72	4.73
7	6.03	2.96	3.12	7.90	3.10	1.72	4.14
8	9.23	1.19	3.57	2.48	1.30	1.47	3.21
9	4.94	2.12	0.80	1.95	3.10	1.29	2.37
10	1.22	2.46	0.98	1.24	2.13	1.21	1.54
11	0.90	1.96	0.58	0.24	1.76	1.64	1.18
12	1.15	2.31	1.07	0.33	2.04	1.55	1.41

Table 15 (Cont.)

Weeks After Transplanting	Bait Placed at Stations (Kg/hectare) Plot I (1.56 ha)	Plot 2 (1.30 ha)	Plot 3 (1.12 ha)	Plot 4 (1.05 ha)	Plot 5 (1.08 ha)	Plot 6 (1.16 ha)	$\bar{X}$
13	0.51	1.46	0.27	0.95	11.11	0.69	0.83
14	0.32	1.00	0.45	0.19	0.32	0.52	0.47
15	0.26	0.35	0.27	0.09	0.28	0.39	0.27
16	0.51	0.15	0.00	0.00	0.00	0.30	0.24
17	0.00	0.15	0.00	0.00	0.00	0.17	0.16
18	0.00	0.04	0.00	0.00	0.00	0.00	0.04
Total	53.21	34.87	48.35	57.81	39.44	32.50	44.36

treated plots at each of the rice growth stages, particularly in mature rice (81.7 vs 66.4 percent). Rat activity in the treated plots throughout the study supports further the suggestion of continued invasion of rats throughout the growing season and emphasizes the need for continued rat control efforts.

Table 16. Indices of rat activity in experimental rice field plots near Sta. Cruz, Laguna. Six treated plots were baited regularly with a chronic rodenticide throughout the crop period, while six untreated plots were subject to an aggregate of minor rat control activities carried out by farmers.

	Means for Treated Plots	Means for Untreated Plots
Hills Damaged at 7 weeks (%)	4.4	10.6
Hills Damaged at harvest (%)	11.4	17.0
Tillers cut at harvest (calculated %)	2.33	3.79
Yield estimated from 5 m^2 plots (cavans*/hectare)	62.2	59.8
Tracking tiles- young rice (% active)	64.3	67.4
Tracking tiles- growing rice (% active)	55.6	65.4
Tracking tiles- mature rice (% active)	66.4	81.7
Bait supplied (kg/hectare)	44.3	-
Baiting points/hectare	5.1	-
Stations/baiting point (maximum during crop)	6.2	-

*Rice harvested from yield plots was threshed, dried to 14% moisture, and weighed. Data were expressed as cavans per hectare assuming 50 kg = 1 cavan.

Capital costs and yield estimates based on detailed records kept by the farmers indicate comparable efforts and costs to the nine farmers whose paddies were located in the treated plots and the eight farmers with paddies in the untreated plots in some areas of farming activities (Table 17). All farmers, for example, had hauling expenses since the plots are located some distance from the road and rice sacks had to be carried by hand. In areas where differences in cost of farming activities are noticed, probably indicating a difference in effort on the part of the farmers, farmers in the untreated plots generally spent more than those in the treated plots. Feeding costs, for example, were high for all farmers because a system of contract weeding is practiced in the area. Since the contract is for both weeding and harvesting, the farmer must contract for the weeding to assure available harvesters. Nevertheless, farmers in the untreated plots invested more heavily than those in the treated plots (₱266 vs ₱150), probably reflecting a greater effort by these farmers at weed control. Both areas also suffered from brown plant hopper infestation, but untreated area farmers invested more in the purchase of insecticides (₱55 vs ₱37, for farms in untreated vs treated plots, respectively), again probably reflecting a greater effort by farmers in the untreated areas to control insects. Untreated area farmers also invested more heavily in fertilizers.

The cost of our rat control treatment (₱53) in the treated plots is based on the use of low grade polished rice at current prices (₱1.00/kg and Toumarin 2 concentrate at ₱9.15/kg). Bait take was exceptionally high in this study compared to previous trials, so baiting costs would usually be somewhat lower. The cost could be reduced even further by using a cheaper bait, such as rice shorts (binlid) at ₱0.36/kg (current price). The estimate does not include the labor cost of the farmer (less than 20 hours/hectare/crop) required to maintain the baiting program, since the general practice of the farmers is to exclude their personal labor from costs.

Both estimated yields (Table 16) and actual yields reported by the farmers (Table 17) were greater in the treated than in the untreated plots. Since unmeasured variables could have contributed to the relative yields in a field study such as this, we do not attribute the difference in yield solely to the rat control carried out in the treated plots. On the other hand, factors that were measured, such as investment in fertilizer, insecticide and weed control, revealed a greater effort by farmers whose paddies fell within the untreated plots to increase yield. If their efforts were successful, the difference in yield between the untreated and the treated plots was somewhat less than if these variable had been kept constant for all plots, and the effect of rat control on yield was even greater than we are reporting. In either case, the study demonstrates that rat control using sustained baiting with anticoagulants as part of a pest management program on the small rice farm is both economically feasible and beneficial.

Table 17. Summary of mean production cost, yield, and profit in relation to rat control costs for farmers with fields all or partially included in experimental plots. Treated plots received regular applications of bait containing a chronic toxicant, while untreated plots received an aggregate of minor rat control activities out by farmers. All figures are expressed on a per hectare basis.

	Means for treated plots (9 farmers)	Means for untreated plots (8 farmers)
Land preparation	₱216**	₱210
Seeds	77	76
Planting	87	95
Fertilizer*	133	140
Insecticide*	37	55
Herbicide*	14	11
Weeding	150	266
Cleaning and repair of dikes	16	7
Rat control by owner*	3	1
Irrigation fees	25	15
Harvesting and threshing	719	741
Hauling produce	91	95
Yield (cavans***)	69.5	66.0
Gross	₱3475	₱3300
Farmers' cost	1568	1712
Farmers' cost plus RAT CONTROL treatment*	1621	-
Net	₱1854	₱1588

* Figure excludes costs for agricultural labor associated with application of materials.

** ₱1.00 = $0.15 U.S., ca.

*** For these calculations, one cavan is assumed equal to 50 kg and could be sold after harvest for ₱50.00.

Area-wide Sustained Baiting in Ricefields -- a Field Trial of a Barrio Program

Introduction

In conjunction with other trials using anticoagulant baiting throughout the rice crop, we undertook a trial evaluation at the barrio (agricultural village) level. The purposes of the trial were threefold: to gain experience with the performance of this control method on a larger scale, to obtain preliminary economic information for drafting "Masagana 99" recommendations, and to evaluate the role of the agricultural technician in area-wide rodent control. The province of Pangasinan was selected for the test because of its history of heavy rodent damage during the wet season. The two barrios within this province with the highest mean damage during the three years of the BPI National Damage Survey were chosen as test sites. These villages, San Vicente and Bactad East, both in the municipality of Urdaneta, Pangasinan, had averaged 9.75 and 12.19 percent damage to the rice tillers at harvest, respectively. In both barrios, the availability of public irrigation water during a portion of the wet season resulted in well coordinated planting and harvest schedules. During previous years (with the possible exception of 1972), high-yielding IR varieties had been widely planted in the area. During the period of this study, however, farmers had planted one of the older, late-maturing varieties (BE-3, with a 5 month growing period) over much of the area. They apparently expected to sell the crop at a higher price based on the good eating quality of this variety; however, prices had stabilized by harvest and both BE-3 and IR-20 (planted on less than 20 percent of the area in the two barrios) were sold for the same price (₱40.00/cavan).

Because we could not be assured that one barrio would serve as a reference by minimizing rat control, we chose to emphasize the role of an agricultural technician in this study. San Vicente was randomly chosen as the barrio to receive major services of the technician. Services included extension material and careful help with planning and implementing a sustained baiting program. Thus, San Vicente was designated as the "treated" area. Farmers in Bactad East also received extension materials, but minimal help with control. They did not carry out a sustained baiting program with chronic toxicants, and the barrio was designated "untreated".

Methods

Center staff members, under the leadership of an agricultural technician who had visited the area a few days prior to this trip, attended pre-planting meetings on rat control at both barrios where the damage problem, various techniques of control, and the use of

sustained baiting were discussed in Ilokano dialect. Farmers were shown examples of bait stations made from simple materials and told where they could buy rodenticides. They were encouraged to try sustained baiting and were given detailed instructions, similar to the recommendations included in the appendix but printed in Ilokano.

After this meeting the farmers in Bactad East received no further help or encouragement in organizing a baiting program. However, a Bureau of Agricultural Extension technician assigned to the barrio made several visits and encouraged rat control activities of individual farmers. Some individuals obtained small quantities of zinc phosphide from the Barrio Captain (who apparently obtained the acute toxicant through the Bureau of Plant Industry). Many of the farmers grouped together to clean roadsides and kill rats living there, apparently at the urging of the barrio council. As nearly as we could determine, no one in this barrio baited his fields with anticoagulants throughout the crop, although some individuals bought anticoagulant concentrate and baited intermittantly.

In San Vicente, the Bureau of Plant Industry technician assigned from the Center staff continued to work closely with the farmers and barrio officers. He spent about 50 percent of his time encouraging and helping to coordinate rat control activities and some additional time helping the barrio with other agricultural problems as requested. Several additional meetings were held and most of the farmers were visited individually several times during the 5-month crop season. As far as we could determine, virtually all the farmers in the barrio obtained anticoagulant bait and used it more or less continuously from planting to harvest. Farmers used a variety of bait containers (mostly bamboo tubes or old oil cans which they obtained at minimal costs). They baited primarily with coumatetralyl concentrate purchased in Urdaneta and mixed with rice shorts (binlid) that were obtained locally for about ₱0.36/kg. Some farmers had sufficient binlid on hand and required no purchase of bait material. As expected, farmers did not follow the printed instruction exactly, but devised a variety of additional patterns for placing bait stations. The most common pattern was to place one or two stations along the center section of each paddy dike. This most frequently resulted in about two to three times as many baiting points as suggested. Farmers did appear to use additional stations as required to maintain excess bait at a baiting point. We believe that the effects of these rearrangements were negligible from the standpoint of rat control, but that some additional labor was required to visit the extra points. Since the farmers lived near the area, they visited their fields almost daily, generally carrying some rat bait and checking the containers. Farmers were asked to keep records of the amount of rodenticide purchased, the amount of bait material used, and the number and cost of bait stations constructed.

Approximately three weeks before harvest, snap-trapping was carried out in both barrios to assess rat activity and damage surveys to assess the percentage of tillers cut during the growing period. Trapping was conducted in each barrio for three nights using two transects of 50 traps spaced at 10 m intervals; transects were at least 100 m apart. A third similar transect was set for the first night in Bactad East to increase sample size, but was mistakenly discontinued for the latter two nights.

Pre-harvest damage surveys were conducted in six randomly selected paddies of BE-3 and four randomly selected paddies of IR-20 in each barrio. Methodology followed that of the BPI National Damage Survey, with examination of 100 randomly chosen hills in each paddy for evidence of rat feeding. Similar surveys were conducted independently in each barrio as part of the National Damage Survey for 1973. In this case, 10 paddies were randomly selected from the barrio without regard for the variety planted.

Nearly all farmers in both barrios maintained cost records for their production activities in conjunction with other national programs. After harvest, we interviewed 15 randomly selected farmers from each barrio to determine the extent of their rat control activities, sources of materials, the amount of money spent on agricultural operations, and the rice yields obtained. We talked with farmers informally at first, then helped examine their records and complete a questionnaire form.

Results and Discussion

Rat damage surveys conducted by Bureau of Plant Industry technicians in both barrios San Vicente and Bactad East reveal a history of high wet season damage since the surveys were begun in 1970 (Table 18). The sharp drop in damage between 1971 and 1972 for both barrios may relate to the reduced planting of high yield varieties. Damage to rice tillers in San Vicente where sustained baiting was carried out during this study (1973) was about 80 percent less than that in Bactad East.

Pre-harvest trapping data indicates that rats were present in fair numbers in both barrios during the period of this study (Table 19). Trap success in San Vicente ("treated" barrio), however, averaged about half (4.67 vs 8.57 percent) that in Bactad East indicating a reduced rat population in the treated area. The presence of rats at pre-harvest, however, suggests that rats were moving into the San Vicente fields from outside areas during the sustained baiting program, a suggestion consistent with observations from previous studies.

Table 18. Summary of wet season rat damage surveys conducted by Bureau of Plant Industry technicians in barrios San Vicente and Bactad East (Urdaneta, Pangasinan). Tiller counts were made in 10 randomly chosen paddies in each barrio within 2 weeks of harvest. The experimental baiting program was carried out in San Vicente's 1973 wet season crop.

Date	San Vicente (percent of tillers cut by rats)*	Bactad East (percent of tillers cut by rats)
1970	11.88	10.46
1971	12.64	19.93
1972	4.74	6.19
1973	1.05	5.16

* One hundred randomly selected hills were examined in each paddy to determine the percentage of tillers which had been cut. Such surveys provide an index to damage which occurs during the latter half of the crop, but the relationship to yield reduction has not been clearly established.

Table 19. Summary of pre-harvest trapping ricefields in two barrios in Urdaneta, Pangasinan. Farmers in San Vicente carried out a supervised program of sustained baiting with chronic toxicants, while those in Bactad East used "traditional" methods of rat control.

Date	No. of traps	No. of rats captured*	Trap success (percent)
San Vicente			
11/27/73	100	6	6.00
11/28/73	100	7	7.00
11/29/73	100	1	1.00
3-day total	300	14	4.67
Bactad East			
11/27/73	150	21	14.00
11/28/73	100	5	5.00
11/29/73	100	4	4.00
3-day total	350	30	8.57

* Records include 42 *Rattus rattus mindanensis*, 1 *R. norvegicus*, and 1 *R. exulans*. Eleven shrews (*Suncus murinus*) were also captured but were excluded from calculations of trap success.

Our pre-harvest damage surveys (Table 20) show considerable reduction in tillers cut by rats in San Vicente and suggest that the high yield variety (IR-20) received greater damage than the older variety (BE-3), confirming previous observations. Damage to BE-3 was about ten times greater in Bactad East than in San Vicente (1.61 vs 0.15 percent) while damage to IR-20 approached one-hundred times greater in Bactad East (12.37 vs 0.16 percent). Thus, the baiting program appeared to reduce damage to both varieties. In general, the mean of 0.15 percent tiller cutting damage found for San Vicente and 5.91 percent for Bactad East compared favorably with the Bureau of Plant Industry estimates for rat damage in the two barrios, 1.05 and 5.16 percent respectively (Table 18). The inclusion of different proportions of high yield varieties in the samples may account for some of the differences observed in these estimates.

The significance of extension work in focusing attention of the farmers on baiting activities with chronic toxicants is summarized in Table 21. Virtually all farmers whom we interviewed in San Vicente were carrying out a sustained baiting program using anticoagulants, while only 40 percent of the farmers in Bactad East used anticoagulants, and these only sporadically. The Table also suggests a problem in assessment of the effectiveness of the method by the farmer. Since anticoagulants act over several days, the farmers found few carcasses of dead rats in their fields and tended to disbelieve that the baitings have effect. The increase in bait consumption during initial weeks is confusing and has led us to similar feelings in the past. Despite continued assurances of the technician in San Vicente, farmers also engaged in physical control to a high degree (mostly digging burrows and cutting grass in waste areas to drive out rats). We speculate that many farmers continued the baiting program not because they believed the bait killed rats, but because they wanted to please the technician (who they knew was working hard to help them).

A summary of mean production costs reveal that farmers in San Vicente generally invested more in all phases of rice production than those in Bactad East (Table 22). This may have been due, in part, to the presence of the technician. The efforts resulted in a much greater yield (77.8 vs 58.2 cavans per farmer) and net profit (₱2585 vs ₱1948 per farmer).

The results suggest a major reduction in rat damage in the San Vicente barrio as a result of the sustained baiting program using anticoagulants. However, because the relationship between cut tillers and yield reduction is uncertain and because many variables in this field study were uncontrolled, the actual monetary increase (or the benefit part of the benefit/cost ratio) attributable directly to the results of rat control cannot be assessed. Nevertheless, the data provides a strong argument for this approach to rat control, and further evaluations are planned.

Table 20. Summary of pre-harvest damage surveys in randomly selected paddies of IR-20, a high yielding rice variety, and BE-3, an old variety in two barrios in Urdaneta, Pangasinan. Farmers in San Vicente carried out a supervised, sustained baiting program of rat control, while farmers in Bactad East used traditional methods of control.

Location	Variety	Tillers cut by rats in sample paddies* (percent)		
San Vicente	IR-20	0		
		0.51		
		0.11		
		0		
			$\bar{X}$ = 0.16	
	BE-3	0		
		0.06		
		0		
		0.05		
		0.77		
		0		
			$\bar{X}$ = 0.15	Over-all $\bar{X}$ = 0.15
Bactad East	IR-20	13.04		
		18.67		
		14.81		
		2.96		
			$\bar{X}$ = 12.37	
	BE-3	1.94		
		1.12		
		0.21		
		2.15		
		2.16		
		2.06		
			$\bar{X}$ = 1.61	Over-all $\bar{X}$ = 5.91

* One hundred randomly selected hills were examined in each paddy to determine the percentage of tillers which had been cut. Such surveys provide an index to damage which occurs during the latter half of the crop, but the relationship to yield reduction has not been clearly established.

Table 21. Rat control activities of farmers in Barrios San Vicente and Bactad East, Urdaneta, Pangasinan. Fifteen randomly selected farmers were interviewed in each barrio.

Location	Baiting with anticoagulants (%)	Baiting with acute toxicants (%)	Physical control activities (%)	No control attempted (%)
San Vicente	100	0	86	0
Bactad	40	33	60	0

Table 22. Summary of mean production cost, yield, and profit for sample farmers in a barrio (San Vicente, Urdaneta, Pangasinan) which carried out a supervised, sustained baiting program and a nearby barrio (Bactad East, Urdaneta, Pangasinan) which used "traditional" rat control methods.

	Means for "treated" barrio (San Vicente)	Means for "untreated" barrio (Bactad East)
Land Preparation	₱127*	₱80
Seeds	70	55
Planting	70	51
Fertilizer**	75	69
Insecticide**	26	13
Herbicide**	23	11
Rat Control**	13	2
Irrigation fee	0	4
Harvesting and threshing	129	96
Yield (cavans)	77.8	58.2
Gross	₱ 3113	₱ 2329
Farmers' cost	528	382
Net	₱2585	₱ 1948

* ₱1.00 = $0.15 U.S., Ca.

** Figure excludes costs for agricultural labor associated with application of materials.

Food Habits of Three Species of Philippine Weavers of the Genus Lonchura

Introduction

The Philippine weavers, known as "maya" in most Filipino dialects, are well-known by local farmers because of their destructive feeding on rice and other small grain crops. Three species of Philippine weavers, also called mannikins, are quite common in the Luzon provinces. These are the nutmeg mannikin -- L. punctulata (Sharpe), the white-breasted mannikin -- L. leucogaster (Tweedale), and the chestnut mannikin -- L. malacca (Martens). The latter two species are widely distributed throughout the country (McGregor, 1909; Du Pont, 1971). These birds are rather small, measuring 4 inches from the tip of beak to the end of tail and have an average weight of 11 grams. They are gregarious and are usually seen in flocks (Delacour and Mayr, 1946); flocks of 500 individuals are not uncommon.

Methods

Birds were collected from January to March in two localities, one at the International Rice Research Institute (IRRI) experimental plots at Los Banos, Laguna, and the other in Barrio Maytalang I, Lumban, Laguna. The latter site provided most of the birds and observations. In this area, the birds were collected from fields of dough stage rice where Echinocloa sp. weeds were abundant in the paddies. The roosting area of the weavers was located about one kilometer from the ricefields and was composed primarily of reeds (Phagmites australis (Cav.) Trin. ex Steud), locally known as "tambo". Some birds were also collected in the roost.

Birds were collected with 40- and 60-ft. mist nets, 1.5 inch mesh. Those caught in the morning were placed in a holding cage and brought to the laboratory for food consumption experiments. Those caught in the afternoon were killed for study. Crops were removed immediately and placed in a 10% formalin solution. Crop contents of 54 L. leucogaster, 39 L. punctulata and 10 L. malacca were examined under a dissecting microscope, and the weight of each major food item measured separately.

Observations on the feeding behavior of the weavers in the ricefields were made every hour from sunrise to sunset for one week using 7 x 35 mm binoculars.

In the food consumption experiment, 30 birds (12 L. punctulata, 12 L. leucogaster, and 6 L. malacca) were placed in individual cages. Each bird was first offered rough rice (palay) for 7 days then polished rice for 7 days with water ad libitum. The initial weight of the food given each day was 25 grams. Twenty-five grams of food was provided daily to each bird. Food was replenished at night to minimize disturbance and insure availability of food for early morning feeding.

Results and Discussion

Only 2 main food items were found in the 103 crops examined: rice (Oryza sativa) and Echinocloa seeds (Table 23). Some crops had traces of other weed seeds of insignificant quantity, but no attempt was made to identify these minor items. A paired t-test of the mean weights of each food item showed that L. leucogaster and L. punctulata crops contained significantly more rice than Echinocloa, while L. malacca contained equal amounts of both foods. The amount of rice found in the crops was about equal for all species; however, considerably more Echinocloa was eaten by L. malacca than the other two species. The crop contents averaged slightly heavier for L. malacca than for the other two species.

Table 23. Crop content analysis of 103 Lonchura sp. collected in dough stage rice where Echinocloa was abundant in some paddies.

Species	Sample Size	Rice		Echinocloa	
		Wt. (g)	%	Wt (g)	%
L. leucogaster	54	0.60	60.0	0.40	40.0
L. punctulata	39	0.61	63.6	0.35	36.4
L. malacca	10	0.61	46.0	0.71	54.0

The two main food items, rice (Oryza sativa) and Echinocloa, recovered from the crops of these birds were also included in the list of food plants of Philippine weavers made by Manuel (1934).

Gonzales et al. (1968) also reported grass seeds as chief constituents in the stomachs of L. leucogaster. Manuel (1935) reported that "... Philippine weavers frequently visit ricefields when this grain is in head. And during this period the percentage of rice in the food of the birds is more than at other times...".

Individual food consumption of all species averaged about 3 g/day -- roughly one-fourth of the body weight (Tables 24 and 25). The slightly greater consumption of rough rice (Table 24) over polished rice (Table 25) may relate to qualitative differences between the two materials or may reflect the birds behavioral or physiological adjustment to caging.

Feeding activity of the weavers in the ricefields at Lumban peaked twice during the day. Morning feeding began just after dawn lasting until about 10:00 A.M., while the second feeding period was in the afternoon at about 3:00 P.M. and lasting until dusk. We did not determine where the birds spent the hours between these major feeding periods.

Farmers in the Lumban area were devoting considerable efforts to bird scaring and were, in some cases, removing most of the Echinocloa heads from the ricefields in an apparent attempt to discourage the birds from feeding in the area.

Table 24. Daily mean consumption in grams of palay per bird.

Days	L. leucogaster 12 birds	L. punctulata 12 birds	L. malacca 6 birds
1	3.23	3.18	3.05
2	2.91	2.47	2.25
3	4.42	4.50	3.72
4	4.75	4.23	3.80
5	4.07	3.62	3.08
6	2.96	2.88	2.97
7	3.12	3.12	2.80
Over all X^1	3.63 a	3.42 a	3.09 b

1 Means followed by the same letter are not significantly different at 5% probability level.

Table 25. Daily mean consumption in grams of polished rice per bird.

Days	*L. leucogaster*	*L. punctulata*	*L. malacca*
1	2.85	2.75	2.70
2	3.00	2.65	3.00
3	2.85	3.25	2.80
4	3.00	3.05	3.00
5	2.95	3.10	2.90
6	3.10	3.10	3.20
7	3.00	2.85	2.90
Over all X	2.96	2.96	2.93

TRAINING ACTIVITIES

TRAINING ACTIVITIES

Introduction

During the year Center staff members participated in a variety of extension and research training programs. In addition, more than 300 visitors from many countries were briefed on the Center's activities, given technical assistance in the form of literature on rodent control, or advice in program planning. Visitors included farmers, government officials, agricultural scientists, chemical company representatives, and students. Numerous requests for technical information on rodent control were filled with Center publications or copies of appropriate material from bibliographic files.

Rice Production Workshops

With the launching of the Philippine Government's "Masagana 99" rice production program in 1973, several hundred agricultural technicians were sent to the Los Banos complex for training. Two-week training courses on rice production and extension, conducted under the auspices of the International Rice Research Institute and the University of the Philippines at Los Banos, offered an opportunity for Center staff members to present current information on rodent biology and control to extension technicians. These short courses were geared towards updating the knowledge and developing the skills of the participants. Staff members participated in 14 two-week courses involving 960 extension workers and technicians from the Bureaus of Plant Industry and Agricultural Extension. In addition, Center staff also taught in four, month-long rice production training workshops for 120 Philippine National Bank Crop and Livestock Inspectors. A session on rodent biology and control was also presented to 27 rice trainees who attended the six-month rice production training course at IRRI. During the year, the Center also participated in the in-service field training of nearly 1,200 field technicians of the Philippine Bureau of Plant Industry and Agricultural Extension and the Department of Agrarian Reform. This field training, conducted under the auspices of BPI was aimed toward updating the knowledge of the trainees on new developments and procedures in agricultural pest control, particularly rodents.

Participatory Research Training

The arrival of Mr. Brijendra Singh Thapa, UNDP fellow from Nepal, during the later part of 1972, initiated a new type of training program at the Center. The trainees, depending on their background and objectives, spend from 2 to 6 months attached to the Center staff and participate in a variety of on-going research and control methods evaluation activities,

work independently on projects related to pest problems in their own countries, or develop work plans or project proposals for presentation to their parent agencies. Reading programs, workshop sessions with staff members, visits to other related agencies and participation in operational rat control activities of the BPI are available for trainees who desire this field experience. Trainees are also given the opportunity to visit and observe studies and control operations in Mindanao, the Visayas and Mindoro Islands to broaden their concept of the complexity of the situations in which rat problems occur.

Mr. Young Moo-shin, a UNDP fellow from the Office of Rural Development in Korea, arrived in May, while Mr. Rochman from the Central Research Institute for Agriculture in Bogor, Indonesia, arrived in July with support from the Netherlands Government. Both men stayed at the Center for about three months. Other trainees are scheduled to arrived in 1974.

Graduate Training

The opportunity for graduate degree work in vertebrate pest management is available in cooperation with the Departments of Entomology and Zoology at the University of the Philippines at Los Banos. A scholarship program funded by the National Economic and Development Authority (NEDA), is available to qualified Filipino citizens. The students hold office at the Center and make use of its facilities in conducting research. Five students, two in 1973, have completed M.S. degrees under this program. Three of the graduates have joined the research staff of the Center, one under the auspices of the Bureau of Plant Industry, the other two under UPLB. One graduate was assigned by the BPI to head a rodent research team in Mindanao, while the fifth graduate currently holds an academic position at Central Luzon State University. Mr. Gregorio Llaguno, USAID Participant Trainee in Pharmacology at University of California (Davis) completed requirements for the M.S. degree and rejoined the staff in mid-1973. Mr. Bernardo Marges, assigned at the Center by the Bureau of Plant Industry, was awarded a doctoral fellowship by the Philippine Council for Agricultural Research to pursue a Ph.D. degree in Crop Protection at UPLB.

Staff Instruction at UPLB

Several Center Staff members hold joint appointments with departments of the University of the Philippines at Los Banos and act as graduate advisors or instructors. During the year, staff

members taught or helped teach courses in Vertebrate Pests, Mammalogy, and Wildlife Management. Some sessions were held in the classroom and laboratories at the Center, and students used equipment and facilities located at the Center to conduct individual research projects. Several college classes from other Philippine colleges visited the Center for special lectures or demonstrations on vertebrate pest control.

RESEARCH UTILIZATION

Research Utilization

Following the initial evaluations of biological aspects of anticoagulant baiting and field trials of the approach on both small farm and barrio units, a meeting was held to formalize national recommendations for control of rats in ricefields. Representatives from the Bureau of Plant Industry, the University of the Philippine College of Agriculture, the German Crop Protection Strengthening Programme, and the Rodent Research Center arrived at a consensus recommendation, a draft of which was submitted to the National Food and Agricultural Council. In early 1974, the recommendations were issued by the Department of Agriculture and Natural Resources for use in conjunction with the national rice production program - "Masagana 99." A copy is included in the Appendix of this report.

To date, more than ten thousand copies of these recommendations have been distributed to farmers and technicians participating in "Masagana 99." In some areas, loans for the purchase of rodenticides or bait materials have been made available to participating farmers under the supervised credit plan associated with the program. It is anticipated that this approach will receive additional emphasis during 1974, and that continued evaluation and, perhaps, further improvements of the approach would be desirable.

INTERNATIONAL ACTIVITIES

International Activities

Center staff members worked with personnel from five Asian countries (Nepal, Vietnam, Thailand, Indonesia and Korea) on training and co-operative studies.

Three researchists, from Nepal, Korea and Indonesia, received training related to pest problems in their own countries or developed work plans or project proposals for presentation to their parent agencies during 2-6 month participatory research training at the Center. Training involving these and individuals from other Southeast Asian countries are summarized in this report in the section entitled "Training Activities". It is anticipated that participant training involving personnel from other countries will continue in 1974.

Three Center staff members took part in the "Ad-hoc Panel on Vertebrate Pest Management in Asia and the Far East", held on 20-27 September 1973 in Bangkok, Thailand, under FAO sponsorship. The Panel, a gathering of pest control experts representing six countries from this region, discussed the extent of known vertebrate damage to a variety of crops in Asia and the Far East, reviewed the current status of vertebrate pest management in some of the countries of the region, and established future research and control activity needs of the region. In discussing resources for research training and extension, the Center was recognized for developing a capability in technical researc on problems of regional significance and for providing leadersl n Southeast Asia.

Excluding conference participation and travel to the U.S., staff travel included four trips to Vietnam, two trips to Thailand and two trips to Indonesia. The trips were made to Vietnam to help Plant Protection Service personnel establish and review damage appraisal surveys on floating rice in two Mekong Delta provinces, and to help train Cadre personnel in appraisal procedures. In addition, a trip was made to help develop a method for surveying rat damage to sorghum and to discuss potential control methods. The trips were made to Thailand to help develop a vertebrate control research program and to assist the Rice Protection Center in a baiting study. The trips were made to Indonesia to consult in the planning of a series of rodent control and research workshops for Plant Protection Service officers in Java, south Sulawesi and north Sumatra, and to assist in the planning of damage appraisal procedures. The trips, in general, resulted in an opportunity to explain the current research findings of the Center on rodent control to organizations involved in vertebrate pest control within the respective countries, and, in addition, provided the opportunity to view some of the damage appraisal and control methods being developed at the Center from a more regional perspective.

GRADUATE STUDENT RESEARCH (Abstracts)

The Toxicity of Four Anticoagulant Rodenticides to Rattus rattus mindanensis Mearns. 1973. Melanda M. Hoque. Unpublished thesis, College of Agriculture, University of the Philippines at Los Banos (abstract).

Four anticoagulants were tested on R. r. mindanensis Mearns to determine the acute median lethal dose, effect of concentration on bait acceptance, and the interaction between concentration and exposure time.

The acute oral LD_{50} in mg/kg for males and females are: diphacinone 1.13, 0.75; pival 99.5, 92.6; warfarin 706,000; and racumin 478,000, respectively. Except for diphacinone the LD_{50} values were higher than previously reported LD_{50}'s of these compounds to R. norvegicus.

Diphacinone had the highest acceptance index followed by pival, warfarin, and racumin. It appeared that as the acceptance index increases, the percentage mortality increased.

The analysis of variance showed significant differences among the main effects of chemical, concentration, and feeding level. The interaction of the four factors, chemical, concentration, feeding level, and sex were insignificant with respect to amount of bait and chemical consumption, and mortality of rats. In general, a slightly higher amount of bait and chemical was consumed by rats at continuous or intermittent feeding until death than at three day feeding. As the concentration increased, there was a corresponding increase in the amount of chemical consumed, the rate of increase varying with the chemicals. The mean days required to obtain 100 percent mortality of rats ranged from 5.09 to 8.46 days but did not vary considerably among chemicals. Most of the animals died from 4th to 8th day.

Laboratory Study on Juvenile Growth of the Common Ricefield Rat (Rattus rattus mindanensis) Mearns. 1973. Lorenza Segui-Ferrer. Unpublished thesis, College of Agriculture, University of the Philippines at Los Banos (Abstract).

Growth and development were studied in the common ricefield rat, R. r. mindanensis Mearns, in the laboratory from November, 1971 through Febraury, 1973. Data were obtained from 87 young born in captivity, from 14 litters. The animals were apportioned into two

groups: Group I, the litters from female rats bred in the field and born in the laboratory, and Group 2, the litters from females bred and born in the laboratory. Morphological measurements were made regularly on nursing and weanling rats and the times of occurrence of certain morphological and behavioral events were noted.

Litter size ranged from 3 to 8 and averaged 6.21 per female; sex ratio of the litter was equal. Average weight and total length of the newborn rats was 3.71 g and 59.33 mm, respectively. Growth in weight was most rapid in the sixth to the eleventh week, while growth in linear dimensions was most rapid in the first 7 weeks. Female rats reached sexual maturity in approximately 6 weeks (perforation of vagina), while male rats developed scrotal testes at about 8 weeks.

Food consumption averaged 5 g/day after weaning and increased to 8.5 g/day during the first and second weeks. Food consumption stabilized at about 12.5 g/day when the young reached 7 to 9 weeks of age.

Some differences in weights and linear dimensions were observed between litters from laboratory and field-bred females. The offspring of lab-bred females were generally larger, heavier, and had a longer period of growth. Weight gain tended to show maximum rate of increase when rats from the lab-bred group were 8 weeks of age and rats from the field-bred group were 70 days of age.

Correlation coefficients and regression lines for the weight, total length, body length, tail length, and hind foot length against age all showed statistically significant differences at 0.01 level.

<u>The Effects of Feeding Different Doses of an Organophosphate Compound (Guthion) on Red Blood Cell and Plasma Cholinesterase in the Horse.</u> 1973. Gregorio V. Llaguno. Unpublished thesis, Graduate School, University of California at Davis (Abstract).

The tolerance level of Guthion in horses was studied by feeding different doses. Blood samples were taken from the horses for determination of cholinesterase (CHE) activity in whole blood and plasma.

Guthion fed to horses at levels 5 and 15 ppm for thirty days and 25 ppm for seven days failed to produce any signs of organophosphate poisoning. No detectable physical signs of toxicity or any depression of blood CHE activity was observed at these levels. When Guthion was fed for seven days at higher dose levels, such as 50, 75 and 100 ppm, a marked decrease in blood CHE activity was obtained. The red blood cell CHE activity at the above dose levels dropped to 61, 53 and 50% of the pre-treatment control, respectively. The pseudo-cholinesterase activity at the corresponding doses was reduced to 76, 58 and 53% of the control. Inspite of a striking decrease in the blood CHE activity, no physical signs of toxicity were observed at any time.

The time course for the recovery of cholinesterase activity of the red blood cell and plasma after depressions at the higher doses of Guthion was also studied.

A marked decrease in blood CHE activity after seven days Guthion feeding at 50, 75 or 100 ppm was followed by a rapid recovery in enzymatic activity. Consequently, no sign of CHE inhibition was demonstrable at the first two dose levels after ten days post-treatment except for a slight inhibition (7%) in RBC CHE activity at the 75 ppm level. A slightly higher inhibition (17%) in RBC CHE activity was present after 10 days only at 100 ppm Guthion.

SUMMARY OF ACCOMPLISHMENTS

1. Full or part-time Center staff included ten biologists, one biometrician, two field technicians, three trainees from other countries, three graduate students, and eight supporting staff members.

2. Partial reduction of national survey data collected in 1970-1972 with the Bureau of Plant Industry on rat damage to lowland rice suggested (1) a general decline in wet season damage with little overall change in dry season damage; (2) lower damage to paddies surrounded by ricefields or water transport dikes than those surrounded by uncultivated land; (3) lower damage in areas where rat control was practiced; and, (4) a high correlation between the damage hill index and the percent damaged tiller index, with the former less precise as a damage appraisal procedure.

3. An ecological study in areas of mixed habitat provided data on the distribution, reproductive status and food preference of several common rodent pest species, as well as some information on their physical environment. Reduction of the species distribution data showed that R. r. mindanensis and S. murinus were found in all habitats, R. exulans in coconut and shrub only, R. argentiventer in ricefields only, and M. musculus inside barrio houses. Breeding in all species was more pronounced from August through December. In R. r. mindanensis and especially R. argentiventer, breeding corresponded with the development of the rice crop. Other data is being reduced.

4. Intensive removal trapping, which was repeated at two week intervals throughout a crop season to simulate acute toxicant baitings and to provide data on population characteristics of the rats, resulted in rapid recovery of the population after each trapping period. Recovery was probably through influx of rats from adjacent farms and wastelands rather than birth. Thus, we speculate that small-farm control programs based on simple or periodic reduction of rat populations will prove unsatisfactory in rice protection.

5. A study using untreated bait at stations placed in a grid within a ricefield showed that bait consumption increases dramatically from 2-12 WAT, especially at perimeter stations. The increase probably reflects increasing numbers of rats using the stations. Rats trapped after untreated bait was replaced with marked bait for one night revealed that most rats within the grid and many located from the grid to 100 m beyond it were using the stations at 7 WAT, and that

some rats located over 100 m from the grid were using stations at 14 WAT. This suggests that bait stations service not only rats within the grid, but also rats for a considerable distance beyond it. At 13-14 WAT, consumption declined dramatically, suggesting a switch from bait to newly headed rice or a decrease in home range as the ricefield habitat became more fully developed.

6. Under conditions of higher rat density, major increases in bait consumption were obtained by making it possible for more animals to feed without disturbance at baiting points. This was accomplished by adjusting both the number of stations and the amount of bait according to the intensity of feeding at each point. Closed circuit television monitoring showed up to fifteen rats feeding simultaneously at points adjusted this way, while no more than two were observed feeding simultaneously at the same point in the control plot. Fewer "sequential ractions" were observed in the test plots. Success of this baiting procedure probably relates directly to a functional reduction in behavioral interactions that interfere with feeding activity. The procedure appears to have economic and biological advantages over use of "torpedos" or distributing stations throughout the area.

7. Pro-longed prebaiting appears to familiarize rats with bait stations and make them more likely to accept lethal quantities of an acute toxicant when it is added at a later time. Use of two chemical marking agents showed that a high proportion (83%) of rats within the grid were feeding at the stations before zinc phosphide was added, with a dramatic drop in both numbers of rats and bait consumption after zinc phosphide treatment. However, use of anticoagulants at low concentrations with a short pre-baiting period also results in good bait acceptance and has economic advantages.

8. A study testing the preparation of several commercial anticoagulants indicated that some advantage might be gained by using concentrates with a higher percentage of toxicants to prepare bait. This appears to reduce the loss of toxicant to sloughing and settling.

9. Rice presented in a wet or moldy condition to R. r. mindanensis was consumed as readily as dry rice in one laboratory study. If this is true in the field and for other rat species, and when the presence of moisture will not reduce the potency of the toxicant, simpler and cheaper bait stations that are designed without a primary regard for protecting the rice from moisture can be used in crop protection programs.

10. A test at the small farm level showed that rat control in ricefields using sustained baiting with anticoagulants is both economically feasible and benefitial. Although consistently lower in treated plots, rat activity as measured by tracking tile indices was present in both untreated and treated plots throughout the crop season, emphasizing the need for continuous control efforts. Bait consumption in treated plots increased until 4 WAT, then declined to a negligible level by 14 WAT. This pattern probably reflects increasing numbers of animals located both within the treated plots and their surrounding areas finding and using the stations for the first several weeks, but countered by decreasing numbers of rat feeding at the stations by 4 WAT as the chronic toxicant took effect. Capital costs indicate that farmers in untreated plots generally expended more money and presumably more effective effort to increase yield, which may have given a conservative bias to the study.

11. The results of a test of sustained baiting with anticoagulants at the barrio level also suggested a major reduction in rat damage to rice crops, and emphasized the significance of a trained field technician in the implementation of the program. Rat activity in the "treated" barrio, which carried out a sustained baiting program as the result of intensive efforts of a field technician, was about half that in the "untreated" barrio, rat damage was considerably lower and yield was higher. Mean production costs, however, reveal that farmers in the "treated" barrio generally invested more in all phases of rice production (possibly because of the presence of the technician) so actual profit attributable directly to rat control could not be assessed.

12. Preliminary studies on the food habits of L. punctulata, L. leucogaster, and L. malacca, three species of Philippine weavers, indicated that early morning and late afternoon are the major periods of daily feeding activity. Crop examination of birds revealed that rice (Oryza sativa) and Echinocloa seeds are the predominant diet of all three species when collected near ricefields, and caged feeding studies showed that about the same amount of polished rice or palay, about three grams/day, are eaten by individuals of each species.

13. Over three hundred visitors from many countries were briefed on Center activities, given technical assistance in the form of literature on rodent control, or advice on program planning. Numerous requests for technical information on rodent control were filled with Center publications or copies of appropriate material from bibliographic files.

14. Staff members participated in fourteen two-week courses for 960 extension workers and technicians from the Bureau of Plant Industry and Agricultural Extension as part of the "Masagana 99" program. In addition, Center staff taught in four, one month rice production training workshops for 120 Philippine National Bank Crop and Livestock Inspectors. Center staff also participated in the in-service training of 1,200 field technicians of the Philippine Bureau of Plant Industry and Agricultural Extension and the Department of Agrarian Reform.

15. Three participatory research trainees, from Nepal, Korea and Indonesia spent a total of fifteen months participating in a variety of on-going research and control method evaluation activities and worked independently on projects or project proposals related to pest problems in their own countries.

16. Two students completed M.S. degree requirements in vertebrate pest management in cooperation with the Departments of Entomology and Zoology at the University of the Philippines at Los Banos under a NEDA scholarship program. One student completed requirements for the M.S. degree as a USAID Participant Trainee in Pharmacology at the University of California.

17. Some staff members taught or helped teach courses in Vertebrate Pests, Mammalogy, and Wildlife Management at the University of the Philippines at Los Banos, holding some classes and laboratories at the Center.

18. Recommendations for rat control based on the suggestions of representatives from the Bureau of Plant Industry, the University of the Philippines College of Agriculture, the German Crop Protection Strengthening Programme, and the Center were issued by the Department of Agriculture and Natural Resources for use in conjunction with the national rice production program - "Masagana 99".

19. Center staff participated in the "Ad-hoc Panel on Vertebrate Pest Management in Asia and Far East", held in September 1973 in Bangkok, Thailand, under FAO sponsorship. Staff travel included four trips to Vietnam, two trips to Thailand and two trips to Indonesia to discuss current research findings and to aid in various aspects of damage appraisal, workshop planning or control programs.

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

Alviola, P. L. III, F. F. Sanchez, and E. A. Benigno. 1973. Notes on the feeding habits of three species of Philippine weavers of the genus Lonchura. Phil. J. Biol. 2: 149-153.

✓ = released
+ = white slip typed

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Hoque, M. M. 1972-1973. Notes on rodent pests affecting coconuts. Phil. Agriculturalist 56 (7&8): 280-289. ✓

Sumangil, J.P. 1972-1973. The effect of rain and shower in the feeding activity of Cotabato field rats. Phil. Agriculturalist 56 (7&8): 267-273. ✓

Swink, F. N., G. K. LaVoie, G. C. Atwell, J. P. Sumangil, and A. M. dela Paz. 1972-1973. Comparison of three baiting methods for Philippine ricefield rats. Phil. Agriculturalist 56 (7 & 8): 251-257. ✓

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APPENDIX

Appendix

Rat Control in Rice Fields

Adapted from "The Philippine Recommends for Rice-1974" and specially reproduced for the MASAGANA 99 Rice Program. January 21, 1974

Joint Recommendations of the Bureau of Plant Industry; the College of Agriculture, University of the Philippines at Los Banos; the Rodent Research Center; and the RP-German Crop Protection Strengthening Program.

For many years, rats have been a problem for rice growers throughout the Philippines. Field damage by rats costs the nation nearly 100 million pesos per year. Nearly all farmers suffer some rat damage, but losses vary widely. Average losses (based on cut tillers at harvest) are about four (4) per cent. Each year some farmers suffer very heavy damage. Total losses are observed on occasion. Fortunately, such occurrences are rare. Your chances of having heavy damage (over 10 per cent) on your farm are less than 1 in 10. If you plant near areas where rats can live between crops (for example, coconut groves, wasteland, or irrigation canals), your chances of having heavy damage are usually greater.

Rat control, requiring money, time, and effort, is an essential investment. Under most circumstances, the equivalent cost of about one cavan of palay per hectare is enough to protect your crop.

KINDS OF RATS

Approximately 30 kinds of rats occur in the Philippines. Only two, Rattus rattus mindanensis and Rattus argentiventer, are serious pests in major rice growing areas. These two types are difficult to recognize separately. In some regions, Rattus exulans and Rattus norvegicus are also problems. It is not possible, at present, to recommend different control measures for the different species. Most rat control methods affect whatever species is living in your field.

TYPE OF DAMAGE

Most farmers are very familiar with rat damage. Rats may cause extensive damage to seedbeds. Shortly after transplanting, the seedlings are eaten; often several adjacent seedlings in a small area may be affected. As rice becomes older, rats cut tillers and eat portions of the developing head. This damage is dispersed throughout the field and is often difficult to see unless the plants are examined closely.

When rat populations are relatively low, rat damage tends to occur along the dikes. During heavy infestations, more damage occurs in the paddy interior, resulting in "eat-outs." As rice heads mature, rats feed on individual grains, often remaining at one plant for sometime. After harvest, small piles of hulls can be seen on the paddy where rats have been feeding.

RAT CONTROL

The topic of rat control is a popular one among farmers, professional agriculturists, and laymen. Nearly everyone has a favorite theory or story about a new method or procedure that will work in any situation. In fact, no single control method can be used everywhere. In evaluating different methods, it is important to remember that the objective is to reduce crop damage. The number of rats you kill is not so important; it is the number that remain in your paddies that reduce your yield. Other factors, such as cost, practicality, safety for humans and animals, and environmental side effects are also important to consider when a particular control method is chosen.

GENERAL MEASURES

Several general agricultural practices may be helpful in reducing potential rat problems. Cutting weeds along dikes and canal banks and adjacent waste areas, particularly several weeks before planting and during the early stages of rice growth, removes cover which rats need to survive. Planting at about the same time as your neighbors may reduce your chances at heavy damage. Fields maturing much earlier or much later than the surrounding ones often have very heavy rat damage and emergency measures at this stage are usually not successful. Killing rats at any time, by any method may be helpful, but for the farmer who wants to protect his crop, there is no substitute for continuous rat control throughout the crop period. In areas with extremely high rat populations, baiting with acute poisons, before seed-bedding or transplanting, may also be desirable.

SUSTAINED BAITING

Chronic poisons provide a means of carrying on continuous rat control with very little cost and labor compared to some of the other methods. These materials are used at low concentrations in bait, so the additional cost of chemical is small. Rats must eat poisoned bait every day for several days before they are killed.

Because the symptoms develop slowly, over a period of days, rats usually dies in their burrows or in other protected areas. Many people count dead rats after poison baiting. This usually is not possible with chronic poisons. If bait is being consumed and you replace it regularly, you are killing rats. Your efforts will be rewarded by reduced damage.

The major costs of sustained baiting with chronic toxicants are for the bait carrier and for the time required to visit the bait stations regularly. About 10 kilos of bait material is the most that is required under usual conditions to protect one hectare of rice for the entire crop. The labor required is about 1 man-hour each week throughout the crop. Many suitable chemicals are available. The costs for enough chronic toxicant to treat about 10 kilos of bait range from about ₱1.50 to ₱15.00 depending on the material used, the source of supply, and the area of the country.

MATERIALS TO USE

Chronic toxicants require bait material, a chemical concentrate, and bait containers. Most grains can be used for bait material; choose one which is available or can be obtained at low cost in your region. Many farmers have obtained good results using low-quality milled rice or rice shorts. Do not use rough rice (palay), because rats remove the hulls and do not ingest much of the toxicant.

Many chronic toxicants are available in the Philippines as concentrates. Ratoxin, Racumin, Tomorin, Diphacinone, and Liphadione are examples of commercial chemicals which are available at agricultural stores. Prices and package sizes vary considerably, but all of the materials have similar action. When comparing prices, note that some concentrates can be used to prepare more bait material than others. To learn the actual cost of chemical in a finished bait, divide the retail cost of the concentrate by the number of kilos of bait to be treated. Read the label carefully so you can follow the manufacturer's instructions.

Local materials can usually be obtained at little or no cost for making bait stations. Sections of bamboo with nodes at middle or ends, one liter cans, or discarded one quart oil cans, opened on both ends, make good containers. Under very wet conditions it is sometimes desirable to use larger bait stations which afford maximum protection from the weather. In areas with many rats, it is important to use enough stations to allow all of the animals easy access to baits.

PROCEDURES

It is important to have bait material available to all of the rats occupying your field from planting until rice grains mature. Because only a limited number of rats can feed at a single bait container, the number of containers must be selected in relation to the number of rats damaging your fields. The following method, tested under Philippine conditions, will help you relate the intensity of your control efforts to the potential damage to your crop. These procedures are provided as guide for your operations.

1. Mix the recommended concentrate with bait material. Using more chemical than recommended does not improve control and will only increase your expense.

2. Select five baiting locations for one hectare of rice land to be protected. The locations should be at least 50 meters apart for good coverage. Containers can be placed on or along dikes, or supported above water level in the paddy. Also good locations to place bait containers are dike intersections, canal banks, or old threshing mounds.

3. Begin baiting as soon as your fields have been transplanted. Place one container at each location and put 6 tablespoons of bait inside. After three days, check the bait containers. If all of the bait has been eaten , at one location, place two additional containers and place 6 tablespoons of bait in all three. Check again in 3 to 4 days. If the bait is gone, place 3 additional containers at the locations where this happened and maintained about 6 tablespoons of bait in each.

4. Continue to check the bait containers twice a week. If rats continue to consume most of the bait at some of the locations, place increasing amounts of bait in each container. A one liter can will hold up to 18 tablespoons. Try to anticipate increases in consumption so that bait will be left in the containers each time you check; add additional

full containers if necessary. This is important. If bait is not available after rats have learned to come to the stations, there may be heavy feeding on nearby plants.

5. Remove and replace bait that becomes moldy or excessively wet.

6. Because remaining rats will prefer the developing grains to the bait, baiting may be stopped about two weeks before harvest unless bait consumption remains high.

WHAT TO EXPECT

Usually, bait consumption will increase rapidly sometime during the period 3 to 8 weeks after transplanting. This is the period when rats are moving into your paddies. Do not be alarmed by this rapid increase. Continue to replenish the bait and consumption will generally level-off or decline. If your neighbors are also practicing rat control, the increases will not be as great. When rice heads mature, bait consumption usually drops off sharply because animals concentrate their feeding on grain heads. If you have carried out good control throughout the growing period of the crop, pre-harvest damage could be minimal. Remember that chronic toxicants work differently from other materials. Don't become discouraged if you don't find dead rats.

SAFETY

All agricultural pesticides are poisons and should be used carefully. Store pesticides in clearly labeled containers out of reach of children and pets. Do not use mixing cans or spoons used to measure pesticides for any other purpose. Mix chemicals outside your house. Do not breathe the dust or vapors. Do not eat, drink, or smoke while handling chemicals. Wash your hands thoroughly each time you finish your work.

Chronic toxicants are relatively safe compared to other pesticides. They cause breakdown of the process of blood clotting, and animals usually die from internal bleeding. If treated bait or concentrate is accidently eaten, take the person to a doctor or clinic immediately. Treatment for poisoning with chronic toxicants consists of oral doses of Vitamin K, and in some cases, blood transfusion.

COOPERATIVE RAT CONTROL

When a farmer uses chronic poisons, the protective effects of baiting usually extend outside his farm for as much as 200 meters in each direction. Particularly during the first 8 weeks after transplanting, rats from peripheral areas will be attracted to bait containers. If your neighbors also practice sustained baiting, your results will be improved and everyone's costs will be reduced.

TECHNICAL HELP

For additional advice on rat control or for help in securing rat control materials, consult a Bureau of Plant Industry pest control officer or other Masagana 99 farm technician.