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9. ABSTRACT

Results of the Rodent Research Center's 1974 rat damage surveys, control method evaluations, and preliminary bird damage studies. The surveys of Philippine ricelands showed twenty-four provinces as having over 5000 hectares of severely affected ricelands, and twenty-five had less than 1000 hectares severaly affected. These data and those of previous surveys were used to estimate minimum losses of rice due to rats. Evaluations of two field trials revealed that the sustained baiting procedure using anticoagulants can provide very good protection in riceland areas in which Rattus rattus mindanensis and R. argentiventer previously have been responsible for lower production. Studies of three species of Philippine weavers, Lonchura malacca, L. punctulata, and L. leucogaster, suggest that these birds can consume 7-10 grams of rice grain per bird-day. Acute toxicity and cage studies indicate that the birds are more sensitive to fenthion than to methyl carbamate, and that L. leucogaster is the least sensitive to either compound.

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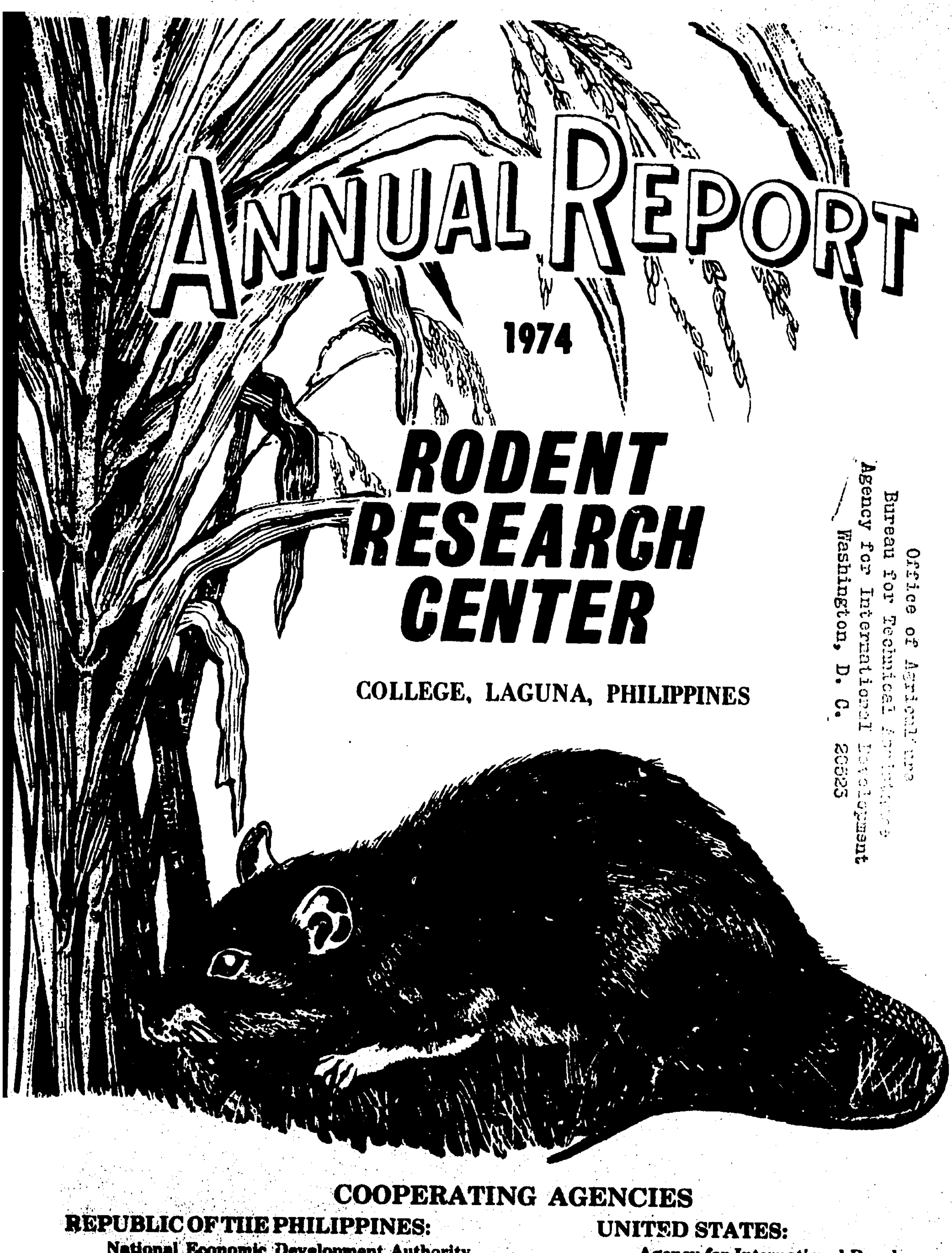

ANNUAL REPORT

1974

RODENT RESEARCH CENTER

COLLEGE, LAGUNA, PHILIPPINES

COOPERATING AGENCIES

REPUBLIC OF THE PHILIPPINES:

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

UNITED STATES:

Agency for International Development
Denver Wildlife Research Center
Fish and Wildlife Service

RODENT RESEARCH CENTER*
1974 ANNUAL PROGRESS REPORT

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COOPERATING AGENCIES:

Republic of the Philippines -

National Economic and Development Authority
Bureau of Plant Industry
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United States -

Agency for International Development
U.S. Fish and Wildlife Service
Denver Wildlife Research Center
(Work Unit DF-104.2)

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ABSTRACT

During 1974, Rodent Research Center personnel engaged in control method evaluations, rat damage surveys, and preliminary bird damage studies. Filipino staff changes included the addition of one laboratory assistant, one information clerk, and two biologists. One U.S. position (biologist) was filled. Training continued at the Center, with over 1000 individuals, mostly Filipino agricultural technicians, extension agents and key farmers, receiving classroom or field courses in rodent control from Center personnel. In addition, six Center-affiliated scholars began M.S. degree work and three began Ph.D. degree work at the University of the Philippines at Los Banos. Sustained baiting with chronic rodenticide, a rat damage reduction procedure that includes innovations developed and tested at the Center, was adopted for use in the Philippine national rice production program, Masagana-99, and will serve as the technical basis for the Bureau of Plant Industry rat control program in non-Masagana-99 ricefield, corn, and wasteland areas.

A national survey of Philippine ricelands identified twenty-four provinces as having over 5,000 hectares with severe rat damage or high damage potential; twenty-one had 1-5,000 hectares of severely effected ricefields; and twenty-five had less than 1,000 hectares that were severely effected. These data were used with previous surveys to estimate minimum field losses of rice to rats on a national basis.

Two field trials indicated that the sustained baiting procedure using anticoagulants can provide highly beneficial protection in ricefield areas where Rattus rattus mindanensis and R. argentiventer had limited production in the past. In the first trial, a single farmer harvested 84 cavans per hectare and made a net profit of about ₱2900 per hectare on 12 hectares of protected ricefields, while the reference area farmer harvested only 2.5 cavans per hectare, and lost about ₱650 per hectare. In a second trial, 135 hectares of ricefields were protected: the farmers had significantly lower rat activity and damage than farmers in the 100 hectare reference area. The farmers in the treated area harvested almost twice as much as the reference area farmers (42 vs. 23 cavans per hectare) and made almost three times the profit (₱1454 vs. ₱530 per hectare). Since other production efforts were similar, we attribute most of the difference in yields to effective rat control in the treated area.

Cage studies that were conducted on three species of Philippine weavers, Lonchura malacca, L. punctulata and L. leucogaster, suggest that these birds can consume 7-10 grams of rice grain per bird-day. Acute toxicity and cage studies indicated that the birds are more sensitive to fenthion than methyl carbamate, and that L. leucogaster is least sensitive to either compound.

A study on the effects of toxicant concentration on bait acceptance by R. r. mindanensis for three acute and four chronic rodenticides suggested that encapsulated norbormide is well accepted over a wide range of concentrations. A study of the distribution of small mammals in an upland cropping area revealed that Mus musculus were mostly found in houses, that R. exulans were present in all habitats, but especially abundant in coconut in coconut groves; and that R. r. mindanensis and Suncus murinus were common in ricefields, cornfields, ground level vegetable plots, coconut groves, and sugarcane areas. Observations in marshland areas revealed localized breeding populations of R. r. mindanensis exceeding 1 rat/m^2, suggesting that these areas may be involved in the erratic rat outbreaks that have occurred in the Philippines in the past. And, a human taste panel found a rat meat sausage formulation at least as tasty as formulations using pork, suggesting that the dense rat populations which frequently occur in uncultivated areas could serve as an acceptable supplementary protein source.

RODENT RESEARCH CENTER STAFF - 1974

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* Staff member was assigned to the center during part of 1974
** 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; PSI, Philippine Sugar Institute.

A farmer adds bait containing anticoagulant rodenticide to a station during a field trial of the sustained baiting procedure. Since there are only four-six baiting points per hectare, a farmer can check the stations twice weekly with a minimum of effort.

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, The Philippine Council for Agricultural Research and the Philippine Atomic Energy Commission. USAID is represented by personnel from the Denver Wildlife Research Center of the Department of Interior, U.S. Fish and Wildlife Service. 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 vertebrate 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, 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 control methods on Philippine pest species, while training has assumed increasing importance at the Center.

Staff

The Center staff includes nine 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. Two trainees: Nguyen Thi Dau and Le Quang Dinh, from Vietnam, spent a total of about 6 months as participant staff members at the Center.

Miss Maria Lourdes Paez was assigned to the Center in early May with the principal responsibility of organizing and maintaining the library. Mrs. Nenita J. Briones entered on duty in October as a laboratory technician. Dr. Russell F. Reidinger, AID/FWS research physiologist, joined the Center staff in April.

Mr. Gregorio Llaguno, USAID participant trainee in pharmacology at the University of California (Davis) left in mid-year to join the teaching staff of the College of Veterinary Medicine at U.P. Diliman.

Research

Research continued on the evaluation of improved techniques for sustained baiting with chronic toxciants in growing rice. Two major field trials in areas adjacent to marshes, where rats had limited production in the past, were conducted.

A national survey was conducted to determine the extent of ricefield and marshland areas with heavy rat damage or infestation. A study was completed on the distribution of vertebrate species in an upland crops area in Batangas. Preliminary work was begun on the effect of concentration on the acceptance of rodenticides, and on the preference of rats for several rice varieties.

With support from the Philippine Department of Agriculture Center biologists initiated preliminary studies on damage potential, damage assessment methodology, and evaluations of two potential control chemicals for three major pest bird species (*Lonchura punctulata*, *L. malacca*, and *L. leucogaster*).

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. Again, several hundred visitors from many countries were briefed on Center activities, or given assistance in planning rodent control or research programs. A slide show was developed which presented an overview of Center activities to many of the visitors. Center staff members participated in the training of more than 1000 agricultural extension personnel from the Bureau of Plant Industry, Bureau of Agricultural Extension, Department of Agrarian Reform, Philippine National Bank and the Agricultural Credit and Cooperatives Institute. Sessions on rat control were presented in agricultural production workshops held at IRRI and UPLB. Two research trainees from Vietnam 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. One student completed an M.S. degree at the Center in cooperation with the College of Forestry, UPLB, and six began their M.S studies this year. Three previous graduates, who joined the staff of the Center, began pursuit of Ph.D. degrees; one under a PCAR grant, the others with UPLB's reduced fee privilege. Several staff members taught or participated in teaching courses in Vertebrate Pests, Mammalogy, and Wildlife Management at UPLB, while others served as graduate advisers for students in Applied Zoology.

International Activities

Staff members participated in a number of regional workshops on pest management, including: the "Regional Training Seminar on Field Rat Control and Research" held from 4-15 March 1974; and, the "Conference on Plant Protection in Tropical and Sub-Tropical Areas" held from 4-15 November 1974, both in Manila. The Center also provided training on rat biology and control to 12 Vietnamese trainees, who attended a two week rice production course at the Department of Agronomy, UPLB. Finally, Center staff provided information to a number of countries regarding damage appraisal methodology, species identification, and current findings in control approaches.

Preparation of stations during a field trial of a baiting procedure.

RESEARCH ACTIVITIES

Estimates of Ricefield and Wasteland Areas with High Rat Population Levels or Substantial Crop Damage in Philippine Provinces

Introduction

National surveys were conducted from 1970 through 1972 by Rodent Research Center (RRC) and Bureau of Plant Industry (BPI) staff to gain information about rat damage to rice in the Philippines. The damage index, based on the percentage of cut tillers determined before harvest, averaged less than 5 percent. Approximately 90% of about 1500 paddies examined each year showed measurable damage, while about 7% of the paddies had over 10% cut tillers (Sanchez et al, 1971). Although these surveys helped establish estimates of loss, they did not provide information on the extent of rat damage. The need for such information led to the current survey. This one, conducted during 1973 and part of 1974 by BPI and RRC personnel, provides estimates of the total hectares of rice during wet season and dry season (palagad) crop periods and of wasteland areas that have high rat densities or damage for each province. The data were also used, along with those obtained from the 1970-1972 surveys, to estimate the rice losses to rats in the Philippines and will be used to establish priority areas for future national rat control programs.

Methods

Data on the extent of rat damage were collected principally by BPI technicians for all major rice growing areas, and were analyzed by the BPI Plant Protection Division. A number of factors were considered in determining the total hectarage of severely affected ricefields and wasteland areas for each province, including: the presence of high rat densities as determined by drives, trapping; and, field appraisals indicating a consistently high level of damage when compared with the national average. BPI and RRC personnel conducted additional field examinations in areas where excessively high damage was reported or where data was inconsistent with past records on file at the BPI. If these survey teams roughly confirmed the extent of damage or infestation, the hectarage was included in the total tally for that province. If not, the hectarage was excluded. Confirmation and analyses of the data required almost ten months of work.

Only areas having severe rat damage or rat damage potential were considered. Hectarage was tabulated and the total determined by summation for each province. Provinces were separated into three major groupings, based on the extent of damage: those having over 5,000 hectares affected; those having 1-5000 hectares affected; and, those having less than 1000 hectares affected. For provinces reporting 5,000 or more hectares of ricefields with high damage potential, data for wet season and dry season plantings were also determined. These figures were then compared with the total area under rice production for each province. For provinces reporting over 1000 hectares of affected ricefields, estimates of wasteland areas with high rat populations were made.

Twenty-four provinces had over 5,000 hectares of ricefields with high rat damage or high damage potential (Table 1); an additional twenty-one provinces had between 1,000-5,000 hectares of severely infested ricefields (Tables 2); and, twenty-five provinces had less than 1,000 hectares of severely infested ricefields (Table 3). In general, about 636,000 hectares or 40% of the total areas planted to rice in the twenty-four major rice-growing provinces, were judged to have high damage or high rat population levels. An additional 271,000 hectares of fallow or wasteland areas were also found heavily infested. Wet season and dry season crops showed similar overall proportions of severe infestation -- 385% and 42.4%, respectively, although there was considerable variability between seasons at the provincial levels.

The provinces most severely affected were those in the major rice producing regions on the islands of Luzon, Mindanao, Mindoro, Palawan, Panay, and Leyte (Figure 1). Of these, the most extensive areas were within the Central Luzon provinces of Nueva Ecija, Pangasinan, Bulacan, Tarlac and Pampanga (277,000 hectares, or about 44% of the total hectares affected).

No relationships between total rice area and percent of infestation was readily apparent, although a scatter diagram suggested that the two may be inversely related. Additional studies are needed to determine whether such a relationship exists. It is interesting that Nueva Ecija, the province with the most hectareage planted to rice (255,000) also had the greatest total area of infestation, while Iloilo, with the second largest total rice producing area (223,000) had only 21,800 hectares (or 10%) severely affected. Iloilo was ranked as having the thirteenth highest total ricefield area with high rat damage or rat damage potential.

Table 1. Provinces that had 5,000 or more hectares of ricefields with a high level of rat damage or population levels, according to a recent Bureau of Plant Industry survey. Provinces are listed in order of decreasing total ricefield hectarage with significant infestation.

Province	Riceland (1000 ha)									Infested Waste and Fallow Areas (1000 ha)
	Wet Season			Dry Season			Combined			
	Total	Infested	(% of Total)	Total	Infested	(%)	Total	Infested	(%)	
Nueva Ecija	190.0	71.0	(37)	65.0	28.0	(43)	255.0	99.0	(39)	3.5
Pangasinan	65.0	49.5	(76)	24.0	10.2	(42)	89.0	59.7	(67)	0
Bulacan	81.0	32.0	(40)	27.0	17.0	(63)	108.0	49.0	(45)	1.5
North Cotabato	29.4	25.1	(86)	20.6	18.0	(87)	50.0	43.1	(86)	35.0
Davao Norte	36.3	23.3	(34)	23.1	18.8	(82)	59.4	42.1	(71)	11.9
Zamboanga del Sur	99.4	28.5	(29)	14.8	9.0	(61)	114.2	37.5	(33)	16.5
Tarlac	93.3	30.0	(32)	14.0	6.0	(43)	107.3	36.0	(34)	2.0
Pampanga	75.6	21.0	(28)	35.0	12.0	(34)	110.6	33.0	(30)	2.5
Mindoro Or.	47.9	17.6	(37)	25.3	9.5	(38)	73.2	27.1	(37)	6.0
Palawan	29.3	23.4	(80)	12.1	3.6	(30)	41.4	27.0	(65)	7.5
Mindoro Occ.	31.2	19.2	(62)	5.7	4.2	(74)	36.9	23.4	(62)	5.4
South Cotabato	34.9	13.5	(39)	12.0	8.3	(69)	46.9	21.8	(46)	24.0
Iloilo	181.0	16.7	(9)	42.0	5.1	(12)	223.0	21.8	(10)	0
Sultan Kudarat	13.0	11.8	(91)	5.4	4.1	(76)	18.4	15.9	(86)	30.0
Laguna	30.0	11.7	(39)	25.8	3.5	(14)	55.8	15.2	(27)	7.5
Zamboanga del Norte	56.0	6.3	(11)	32.0	4.2	(13)	88.0	10.5	(12)	0
Leyte	10.5	9.5	(90)	1.0	1.0	(100)	11.5	10.5	(91)	45.0
Maguindinao	27.9	9.2	(33)	6.4	2.5	(39)	34.3	11.7	(33)	16.5
Surigao del Norte	13.0	10.2	(78)	0.8	0.2	(25)	13.8	10.4	(76)	2.4
Surigao del Sur	12.6	6.4	(51)	9.5	3.7	(39)	22.1	10.1	(46)	14.0
Agusan del Sur	12.0	8.4	(70)	1.1	0.9	(82)	13.1	9.3	(71)	9.4
Agusan del Norte	7.0	6.7	(96)	1.5	1.2	(80)	8.5	7.9	(93)	12.0
Bukidnon	12.6	5.4	(43)	3.5	1.7	(41)	16.1	7.1	(44)	9.8
Lanao del Norte	10.6	5.6	(53)	3.2	1.5	(47)	13.8	7.1	(51)	8.2
Total	1,199.5	462.0	(38.5)	410.8	174.2	(42.4)	1610.3	636.2	(39.5)	270.6

Table 2. Provinces that had 1-5,000 hectares of ricefields with a high level of rat damage or population levels, according to a recent Bureau of Plant Industry survey. Provinces are listed in order of decreasing total rice hectarage with significant infestation.

Province	Estimated Area of Infestation (1000 ha) Combined Riceland (Wet Season and Dry Season)	Wasteland Areas
Batanes	4.8	0
Marinduque	4.8	1.7
Ifugao	4.5	0
Lanao del Sur	4.4	2.5
Aurora	4.2	2.1
Camarines Sur	4.0	1.2
Sorsogon	3.7	2.4
Abra	3.5	0
Samar West	3.2	2.4
Misamis Occidental	3.0	2.6
Albay	2.4	0.9
Negros Oriental	2.3	0
Rizal	2.2	1.6
Cavite	2.1	0
Davao City	2.0	1.8
Davao del Sur	1.7	1.2
Zamboanga City	1.6	1.7
Batangas	1.6	0.8
Misamis Oriental	1.4	1.5
Camarines Norte	1.4	1.4
Quezon	1.3	1.2
Davao Oriental	1.2	2.3
Total	61.3	29.3

Table 3. Provinces that had less than 1,000 hectares of ricefields with high levels of rat damage or population levels, according to a recent Bureau of Plant Industry survey. Provinces are listed alphabetically.

Province	Province (Continued)
Aklan	Isabela
Antique	Kalinga-Apayao
Basilan-Sulu	Mountain
Bataan	Negros Occidental
Benguet	Nueva Vizcaya
Bohol	Quirino
Cagayan	Romblon
Camiguin	Samar East*
Capiz	Samar North*
Catanduanes	Siquijor
Cebu	South Leyte
Ilocos Norte	Zambales
Ilocos Sur	

*Based on limited information - may have additional ricefield areas with high damage.

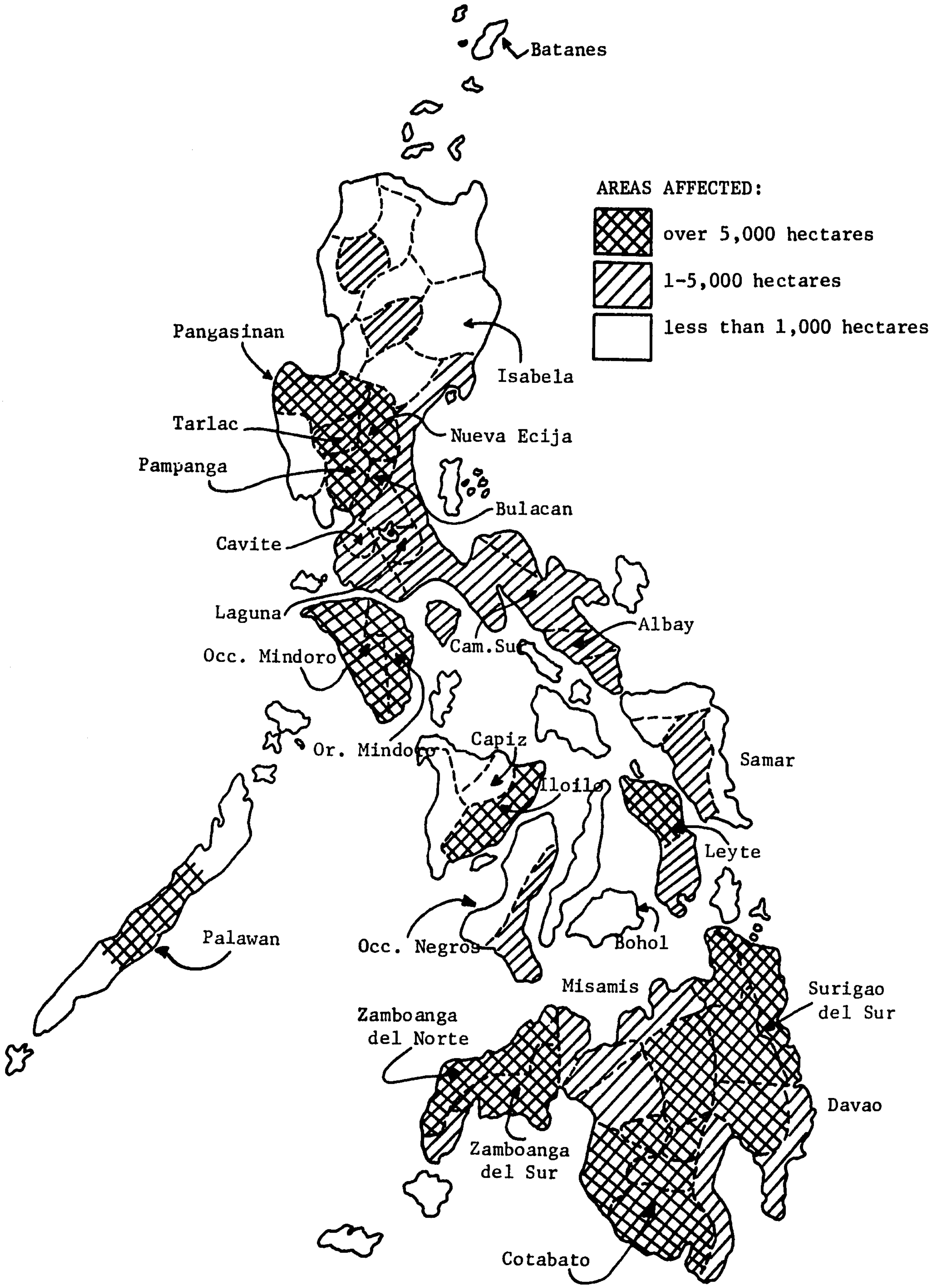

Figure 1. Geographic distribution of provinces with high rat damage or high rat population levels.

There is no doubt that a survey of this type, conducted with limited resources, required the use of subjective determinations in many situations. As such, the data must be viewed critically. Nevertheless, these data are the first that summarize the general distribution of rat infestations in ricefield and wasteland areas on a national basis and can be used to establish priority areas for the initial crop protection efforts.

In addition, the data, along with those from previous surveys, provide a basis for the estimation of actual rice losses to rats on a national scale. This assessment is also essential in determining the potential return on effective rat damage reduction investments. The BPI, using these data and those from previous surveys, estimated that national field losses amount to at least ₱35 million per crop season (assuming average field damage to rice before harvest of 3.5%, 500,000 hectares planted during one season, an average yield of 40 cavans/ha, and a price of ₱50.00/cavan).

It is important to note that this estimate, although it suggests tremendous financial losses to ricefield rats yearly in the Philippines, is probably a very conservative one. The estimate assumes, for example, that a 3.5% loss of tillers to rats at harvest is equivalent to a 3.5% yield reduction. Although the relationship between cut tillers and yield reduction has not been clearly established, limited data indicate that percentage yield reduction may be much greater than the proportion of tillers visibly cut at harvest. The estimate excludes loss of input investments by farmers, including irrigation fees, insecticides, herbicides, fertilizers, and labor. In all situations where rats damage rice, a portion of these investments are lost.

More refined estimates of national losses to field rats would require additional data collection. For the present, the estimated national loss of ₱35 million per crop appears a reasonable, if conservative, figure against which to gauge inputs for efforts at damage reduction.

Small Mammal and Bird Populations in Barrio Cale, Tanauan, Batangas: An Upland Crops Area

Introduction

A detailed ecological study of a productive multiple cropping area in Batangas is being conducted by personnel of the International Rice Research Institute in Los Banos. Preliminary reports indicated very low pest numbers and damage in the study areas. If these reports are true, an understanding of vertebrate pest-crop interrelations in multiple cropping systems could provide valuable information on which to base pest management practices in these and other areas. We initiated the current study to determine the distribution, relative abundance, feeding habits, and dynamics of rodent and bird populations in the Barrio Cale system.

Methods

Trapping was conducted in areas planted to various crops during the third week of each month. For each trapping period, five rice or corn fields, five plots of trellised vegetables, five ground vegetable plots, and five houses were selected from among IRRI's fifty sample families' holdings for use as trapping sites. Sampling was random, with replacements. During the first week each month, five snap-traps were set for 3 consecutive nights inside each house, five in the adjacent yard, and five in each of the other types of sample plots. Two other areas, one designated as a permanent coconut area and the other as a permanent sugarcane areas, were allotted 50 traps each per night during each period. Captured rats were necropsied and stomach samples gathered. To aid with the food habits study, plant specimens found in the barrio were collected and dried for future reference. Bird species were recorded from sightings and calls along a permanent line across the fields once a month.

Results and Discussion

Barrio Cale is a relatively small agricultural community around 5 km from the highway leading to Manila. Medium-sized houses cluster along the main feeder road while agricultural fields extend from backyards to open spaces further back. These houses are usually of two stories, with the lower level commonly used as storage for rice and other harvested crops. Chickens and a few dogs roam the backyard and nearby fields and some houses have a cat or two.

Although seasonal planting patterns are evident, some crops may be found at any given time of the year. Trellises, covered with climbing vegetables (principally patola), are located in sizeable areas behind almost every house. Other crops are planted beneath these trellises, including cassava, corn (usually used as feed for domestic animals), long beans, cowpeas, ginger, taro, yam and upland rice. Fences not only divide farms and define boundaries, but are also the sites for rows of banana, "malunggay" trees, and mango trees, whose fruits and greens add to the family's produce. Sugarcane occupies large areas of land while rice, corn and other crops occupy smaller areas. Rice is usually planted for home use only. A major portion of the family income comes from the vegetable crops that regularly supply not only Tanauan market in Batangas but also the Divisoria Market in Manila. Sometimes vegetables, like bitter melon and cowpea, are planted between rows of rice or corn, or, three or four vegetables may be planted one after the other on the same plot in a pattern of relay intercropping. Areas under coconut groves are commonly planted with ground crops. Table 4 shows the conditions of the crops planted in each of the trapping sites during each trapping period. Table 5 indicates Pilipino equivalents for uncommon English names of produce listed in Table 4.

Four rodent species: Rattus r. mindanensis, R. exulans, R. norvegicus and Mus musculus, plus the common shrew, Suncus murinus were collected in the area. Table 6 shows the number of each species caught in various habitats during each trapping period. Most of the animals were collected from house/yard and coconut habitats. These are the more stable areas; i.e. they are less subject to the drastic changes of complete cleaning, plowing, planting and harvesting than are the other sites. Although areas beneath coconut trees are planted, patches of undisturbed shrubs and the coconut trees themselves offer stable harborage for small mammals. Except for one adult male that was collected in a coconut grove about 50 m from the nearest house, all house mice (M. musculus) came from houses, indicating that the species lives in close association with the farmers. R. exulans abound in all the habitats but were most prevalent in the coconut area. They were the principal rodents caught high on the trellis wires -- most likely the principal rodent pests of trellis vegetables. Their climbing propensities, well suited to the floral structure of Barrio Cale, could be a major factor in their abundance in the area. R. r. mindanensis were collected in all habitats except on the trellis wires. They were most frequently caught in coconut, sugarcane, and the house/ yard habitats. The common shrew, S. murinus were collected everywhere except on the trellis wires, but were taken most frequently in houses and backyards. From previous experience and from the data gathered in the study, we suspect that these animals have wide food preferences. R. norvegicus was collected only in one housing compound in the barrio, once in the month of May and again in December. These animals are most

Table 4. Condition of various agricultural crops found in sample areas during each trapping period in Bo. Cale, Tanauan, Batangas

CROP	APR	MAY	JUN	JUL	AUG	SEP
Trellis vegetables: loofah X wing-beans X bottle gourd X lima beans	majority fruiting	fruiting some bottle gourd, w-beans newly planted	fruiting; some young bottle gourd and w-beans	fruiting; some newly planted loofah	fruiting	fruiting; some loofah planted
Rice	field prepared	majority being planted	newly planted	vegetative stage	booting to maturity	booting to maturing; most being harvested
Corn	field prepared	being planted; some under trellis	newly planted	growing	harvested	harvested
Sugarcane	newly planted	newly planted	vegetative stage	vegetative stage	vegetative stage	vegetative stage
Eggplant		some being planted	newly planted some under trellis		fruiting	fruiting
Hyacinth bean	-	some planted; some on trellis	some planted	some planted	-	-
Sweet pepper	-	-	some planted	some planted	some planted	some harvested
Yard long bean X cowpeas	-	some planted	some planted; some greens harvested	-	-	-
Ginger X taro X yam	-	planted under trellis	planted	-	-	-
Cassava	some newly planted	some planted; some under trellis	some planted	some harvested	-	some planted
Other crops: garlic, tomatoes, and bitter melon	-	-	-	bitter melon planted	bitter melon harvested green	tomatoes and garlic planted; bitter melon harvested

Table 4. (Cont.)

CROP	OCT	NOV	DEC	JAN (1975)
Trellis vegetables: loofah X wing-beans X bottle gourd X lima beans	fruiting	fruiting	fruiting	fruiting
Rice	other harvested	-	-	-
Corn	-	planted	newly planted	growing
Sugarcane	reproductive stage	flowering	flowering	flowering
Eggplant	fruiting	fruiting	fruiting	fruiting
Hyacinth bean	some harvested	some harvested	harvested	
Sweet pepper	harvested	harvested	harvested	harvested
Yard long bean X cowpeas	harvested	harvested; some planted	fruiting; harvested	fruiting; harvested
Ginger X taro X yam		harvested	harvested	harvested
Cassava	-	some harvest	-	-
Other crops: garlic, tomatoes, and bitter melon	tomatoes planted	-	tomatoes harvested	tomatoes harvested

Table 4.(Cont.)

CROP	OCT	NOV	DEC	JAN (1975)
Trellis vegetables: loofah X wing-beans X bottle gourd X lima beans	majority fruiting	fruiting some bottle gourd, w-beans newly planted	fruiting; some young	

Table 5. Pilipino equivalents of uncommon English names used in Table 4

Bottle gourd = upô

Bitter melon = ámpalaya

Cassava = kamoteng-kahoy

Cowpeas = paáyap

Ginger = luya

Hyacinth bean = batao

Lima bean = patani

Loofah = patola

Sweet pepper = sili

Taro = gabi

Wing-beans = kalimismis

Yam = ubî

Yard-long beans = sitao

Table 6. Small mammal species caught during 3 days of snaptrapping in various habitats each month in Bo. Cale, Tanauan, Batangas. Dashes indicate species not caught in a trapped habitat; blanks represent untrapped habitats.

MONTH	SPECIES*	HABITAT							
		Coconut	Sugarcane	Cornfield	Ricefield	Vegetable Trellis	Ground Vegetables	House & yard	Total
APRIL	R.r.m.	11	5	6		–	6	7	35
	R. ex.	12	8	16		1	4	5	46
	Mus	–	–	–		–	–	9	9
	S.m.	4	–	1		–	–	10	15
MAY	R.r.m.	4	2		–	–	–	2	8
	R. ex.	12	6		6	–	4	4	32
	Mus	–	–		–	–	–	9	9
	S.m.	–	1		–	–	–	13	14
	R.n.	–	–		–	1	–	6	7
JUNE	R.r.m.	4	2			–	1	3	10
	R. ex.	6	–			4	–	6	16
	Mus	–	–			–	–	6	6
	S.m.	3	–			–	1	18	22
JULY	R.r.m.	1	–		–	–		2	3
	R.ex.	2	–		2	1		–	5
	Mus	–	–		–	–		2	2
	S.m.	1	1		–	–		8	10
AUG	R.r.m.	1	1		–	–		4	6
	R.ex.	4	–		2	–		–	6
	Mus	–	–		–	–		10	10
	S.m.	1	1		15	–		4	21

*R.r.m. = *Rattus rattus mindanensis*
R.ex. = *Rattus exulans*
Mus = *Mus musculus*
S.m. = *Suncus murinus*
R.n. = *Rattus norvegicus*

Table 6. (Cont.)

MONTH	SPECIES	HABITAT							
		Coconut	Sugarcane	Cornfield	Ricefield	Vegetable Trellis	Ground Vegetables	House & Yard	Total
SEPT	R.r.m.	1			2			–	3
	R.ex.	2			–			–	2
	Mus	–			–			2	2
	S.m.	2			–			7	9
OCT	R.r.m.	3	–		1	–	–	–	4
	R.ex.	1	–		1	1	1	1	5
	Mus	1	–		–	–	–	10	11
	S.m.	2	1		1	–	4	5	13
NOV	R.r.m.	2	9	–			–	6	17
	R.ex.	3	–	1			1	–	5
	Mus	–	–	–			–	1	1
	S.m.	6	–	–			1	1	8
DEC	R.r.m.	7	3	–		–	–	–	10
	R.ex.	7	1	2		2	5	–	17
	Mus	–	–	–		–	–	14	14
	S.m.	4	1	2		–	–	1	8
	R.n.	–	–	–		–	–	1	1
JAN	R.r.m.	5	8	1			–	–	14
	R.ex.	5	3	3			–	–	11
	Mus	–	–	–			–	2	2
	S.m.	6	4	2			2	–	14

likely migrants from Divisoria or Tanauan market, carried to the barrio via the transport trucks and jeeps which frequently parked at that house.

Our monthly catches were too low to correlate shifts in distributional patterns among rodent species with the planting and harvesting of various crops. We did, however, observe a significant increase in numbers of fallen nuts in the coconut study area and its bordering trees, when nearby fields were being harvested and cleared of crops.

Breeding appeared to be a continuous process among the species encountered although collection levels are too low to allow statistical comparisons. S. murinus had a high prevalence of pregnancy throughout the year.

Rodents did not appear to inflict noticable damage to the crops. A cursory examination of a sugarcane field at harvest showed less than 1% damage. Farmers were not concerned about field damage and used no rodent control measures to protect their crops. The farmers were, however, concerned with "big" rats (most likely R. r. mindanensis and occasionally R. exulans) that ran along the beams of their houses and "small" ones (M. musculus) that damaged their sacks of stored rice. The on-going examination of stomach samples from collected specimens should provide additional information on the food preferences and habitat ranges of the rodent species in Barrio Cale.

Table 7 lists twenty-nine bird species seen or heard during monthly visits to the area. Eighteen species were observed during April, but the number of species gradually declined each month until October, when only nine species were counted. By December, numbers of species increased again to thirteen. Most birds (range 105-126) were counted during the summer and rainy season (April-July), while less than half that number were typically seen or heard during the monsoon and early dry seasons (August-December).

Three species, Passer montanus, Pycnontris goiavier and Halcyon chloris, were observed during each month of the year. These species accounted for 53% of the total number of birds counted during the nine month study. P. montanus, a potential rice pest that is more common in towns and near houses than in open agricultural fields, was the most common species observed. It is interesting that mannikins (Lonchura sp), common bird pests of irrigated rice, were seldom recorded.

Table 7. Bird species recorded monthly from sightings and calls heard along a permanent line crossing agricultural fields in Bo. Cale, Tanauan, Batangas.

Species	April	May	June	July	August	September	October	November	December	Total
1. *Accipiter trivirgatus* (Crested Goshawk)	-	-	-	-	-	-	-	1	-	1
2. *Acridotheres cristatellus* (Crested Mynah)	3	2	-	-	1	-	-	-	-	6
3. *Anthus novaeseelandaie* (Richard's Pipit)	-	1	-	-	-	1	1	-	2	5
4. *Aplonis panayensis* (Phil. Glossy Starling)	-	-	-	13	3	-	-	-	-	16
5. *Artamus leucorhynchus* (White-breasted wood-swallow)	1	1	4	1	-	-	-	-	1	8
6. *Bustatur indicus* (Gray-faced Buzzard)	2	-	-	-	-	-	-	-	-	2
7. *Centropus viridis* (Philippine Coucal)	1	-	3	3	1	-	-	-	1	9
8. *Cisticola exilis* (Golden-headed Fantail Warbler)	10	10	8	12	6	1	2	-	-	49
9. *Columba livia domestica* (Domestic Dove)	-	-	-	-	-	7	-	-	10	17

Table 7. (Cont'd)

Species	April	May	June	July	August	September	October	November	December	Total
10. Corvus macrorhynchus (Large-billed Crow)	1	1	1	-	2	-	-	-	-	5
11. Geopelia stratia (Zebra Dove)	-	-	-	-	2	-	-	-	-	2
12. Halcyon chloris collaris (White-collared Kingfisher)	13	20	13	4	2	1	1	1	3	58
13. Hirundo rustica (Barn Swallow)	-	-	-	-	-	1	4	-	-	5
14. Lalage nigra (Pied Triller)	-	-	-	6	6	-	-	-	-	12
15. Lanius cristatus (Brown Shrike)	2	-	-	-	-	9	5	4	3	23
16. Lanius schach nasutus (Schach Shrike)	-	-	-	3	-	-	-	1	1	5
17. Lonchura malacca (Chestnut Mannikin)	1	-	2	-	-	-	-	-	-	3
18. Lonchura punctulata Nutmeg Mannikin)	-	3	-	2	1	-	-	5	4	15
19. Megalurus palustris (Striated Canegrass Warbler)	5	11	10	-	-	4	2	3	1	36

Table 7. (Con't.)

Species	April	May	June	July	August	September	October	November	December	Total
20. *Merops viridis* (Chestnut headed Bee-eater)	-	6	12	6	1	-	-	-	-	25
21. *Montacilla cinerea* (Gray-Wagtail)	1	-	-	-	-	-	-	1	-	2
22. *Nectarinia jugularis* (Olive-backed Sunbird)	1	5	-	-	-	-	-	-	1	7
23. *Orthotomus atrogularis* (Common Tailor-bird)	1	4	3	4	1	1	-	-	-	14
24. *Passer montanus* (Tree Sparrow)	30	32	28	30	18	10	18	15	10	191
25. *Pcynonotus goiavier* (Yellow-vented Bulbul)	23	13	16	12	10	22	8	5	7	116
26. *Rhipidura javanica* (Malaysian Fantail)	1	4	1	1	-	-	-	-	1	8
27. *Saxicola caprata* (Pied Chat)	12	13	5	8	6	1	2	2	-	49
28. *Streptopelia bitorquata* (Philippine Turtle Dove)	-	-	2	-	-	-	-	-	-	2

Table 7. (Con't.)

Species	April	May	June	July	August	September	October	November	December	Total
29. *Streptopelia tranquebarica humilis* (Dwarf Turtle Dove)	2	-	-	-	-	-	-	-	-	2
Total Number of Birds	110	126	108	105	60	58	43	38	45	693
Total Number of Species	18	15	14	14	14	11	9	10	13	29

Two Field Trials of Sustained Baiting in Ricefield Areas Adjacent to Marshland Habitat

Introduction

Sustained baiting with chronic rodenticides to reduce rat damage in ricefields was evaluated at the small farm and barrio levels last year (Sanchez et al, 1973). These tests were conducted on Luzon in areas surrounded by ricefield habitat, with varying histories of rat damage, and where R. r. mindanensis was the major pest species. Since the result of these trials showed that sustained baiting can provide economically beneficial protection, we decided to continue evaluation of the method in more of the highly varied conditions under which rice is grown in the Philippines. Of particular interest to us were the areas where rat damage appears to limit rice production. National rice damage surveys conducted from 1970-1972, for example, have shown that fields adjacent to uncultivated land are generally more susceptible to extensive rat damage than those surrounded by other ricefields, especially areas located along rice-marshland interfaces (Sanchez et al, 1973).

During 1974, we carried out two trials of sustained baiting in areas along marshes where rat damage was reported by farmers to have limited production in the past. One was conducted in Laguna Province, adjacent to marshes bordering Laguna de Bay to determine if damage reduction by baiting was economically beneficial. A second trial near Calapan, Mindoro, was performed to determine the effectiveness of sustained baiting in areas where R. argentiventer, a species found in ricelands throughout SE Asia, was common. A site was chosen adjacent to marshland habitat where heavy damage had been reported in the past. Since this was our first trial within the range of R. argentiventer, rat activity data as well as rice production figures were collected.

Trial I - Two farms along the Pagsanjan River, Barrio Wawa, Lumban.

Habitat Description and General Methods

The first trial was conducted on two farms, totalling 27 hectares, that were planted with C-4 and IR-8 rice varieties during the dry season. The farms were located on opposite sides of the Pagsanjan River in Barrio Wawa, Lumban. The first was nine hectares, bounded by the bank of the river on one side by marshland habitat consisting of water hyacinth and tall grasses on the side opposite the river bank, and by mostly uncultivated ricefield overgrown by water hyacinth and shorter grasses on the remaining boundaries. This farm was chosen for sustained baiting with chronic toxicants because it had better road access than the other one (which we could reach only by boat), and will be referred to as the "sustained baiting area." The second farm was 18 hectares, again, bounded by river bank on one side, marshland on the opposite side, and uncultivated farmland overgrown with water hyacinth and short grasses on the remaining boundaries. In this area, we simply requested that the owner provide us with production figures and we provided no information on rat control. We did, however, visit the farm several times to observe the farmer's rat control activities. In this area, the farmer chose to protect 12-hectares with an electric fence, and we will refer to this portion of his fields as the "fenced area." The remaining six hectares received had almost no effort directed toward rat control. One section, at least 200 meters from the electric fence, was followed for reference and will be referred to as the "unprotected area."

Rat Control Activities and Evaluation Methods

Sustained Baiting Area

In the area employing sustained baiting, we provided the farmer with a detailed explanation of sustained baiting as described by Sanchez et al, 1973, showed the farmer how to construct bait stations from coconut husks and bamboo stakes available locally, and provided some technical assistance on the proper use of the program during the growing season. In addition, the Bureau of Plant Industry provided anticoagulant rodenticides for the trial.

The program was carried out by farm staff. This resulted in several minor modifications of our recommendations: baiting points were spaced at 25 m intervals throughout the ricefields rather than 50 m or greater; at several times during the crop period, bait stations were placed in about 3 hectares of marsh and uncultivated land surrounding the farm in addition to those placed in the rice paddies; bait consumption was checked daily rather than once or twice weekly and the amount of bait added was recorded (at our request); and, baiting began almost seven weeks after transplant rather than at the time the rice was transplanted due to a delay in acquiring materials. Nevertheless, the critical aspects of the sustained baiting, such as adjustment of the number of stations at each baiting point to the intensity of rat activity, were carefully followed. We believe that the effects of the modifications were minor, but some early damage was noted.

A variety of chronic toxicants were used during the course of the trial, including, warfarin* in oats (USAF surplus rodenticide) and racumin or tomorin with rice bait at 0.025% concentrations.

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* Use of chemical names or trade names for identification purposes throughout this report does not imply endorsement or recommendation of commercial products by The Rodent Research Center or cooperating agencies.

Our observations on the area included periodic notes on the rat control activities of the farmers and notes on signs of rat activity (tracks in mud; counts of dead rats; qualitative notes on damage and an estimate of rat densities in surrounding areas using drives). In addition, we conducted a damage appraisal at the onset of harvest to determine percentage of cut tillers. Because we were interested in the damage patterns that occurred in this field, we conducted damage appraisals in each of the eighty-two paddies. After harvest, we obtained production costs and harvest records from the farmer.

Fenced Area

This area included twelve hectares of ricefields surrounded by an electric fence. The fence consisted of seven lead wires spaced about 2 cm apart and was operated from 1700-2200 each day, starting at about eight weeks after transplant (when the farmer first noted rat damage). The fence was operated each evening until harvest by two men who also patrolled the fence and removed electrocuted rats that had caused short circuiting.

In addition to the electric fence, the farmer baited daily with an acute toxicant, 1081 or fluoracetamide (Rentokil brand), and used cyanide fumigation inside the fenced area. The 1081 was mixed with shrimp or snails and placed on banana stalk sections at 25 m intervals, along paddy dikes. Cyanogas dust was used to fumigate burrows at intervals through the crop.

We made periodic visits to this area to record rat control activities. In addition, we selected at random ten of the one hundred paddies within the fenced area for damage appraisal at harvest. We also obtained production costs and harvest figures from the farmer.

Unprotected Area

The remaining six hectares of ricefield outside the fence received no direct rat control attention by the farmer except for the dikes bordering the electric fence. There, a row of 1081 bait spots were placed daily at 3- to 5-m intervals.

In this area, we performed damage appraisals in each of the twenty-six paddies within the two hectares that were at least two hundred meters from the electric fence. These appraisals were made at two weeks before the planned date of harvest. Since damage was extensive and ongoing in this area, we also visited the field at the time of actual harvest and obtained a second damage appraisal in some paddies. We obtained production costs and harvest figures from the farmer at the end of the growing season.

Results

Sustained Baiting Area

Bait consumption, as reflected by the numbers of stations and amounts of bait added, increased rapidly for the first two weeks and then declined sharply (Table 8). During the twelfth week after transplant, the sixth week of baiting, both numbers and amounts of bait were again greatly increased, from 11.1 to 66.7 stations per hectare and from 1.00 to 5.78 kg of bait added per hectare, weekly. This increase was, at least in part, a response by the farmer to rapidly intensified rat activity when Typhoon Besing passed through the area earlier in the week. Rising floodwaters apparently forced many rats from the marshland into the farmer's fields and adjacent areas. Bait added per station remained relatively constant at about 90g/station/week, during this period, indicating that the total numbers of stations placed was an appropriate response to the increasing rat population. During the final five weeks of baiting, the numbers of stations and amounts of bait added decreased rapidly until, at harvest, there were only 6.1 stations/hectare with about 0.11 kilograms per hectare of bait replaced.

Varying degrees of rat activity were noted in the ricefield during most of the growing season. Although we saw some tiller cutting before baiting was started, we saw little additional damage for several weeks after the onset of baiting. The frequency of rat tracks in muddy ricefields also declined rapidly after about three weeks of baiting and remained low until Typhoon Besing. At about three weeks after baiting, the odor of decaying rats became strong in marshy areas adjacent to the ricefields. This odor served as a confirmation to the farmer that his program was working and was probably quite helpful in encouraging him to continue the trial. Dead rats were not observed in the ricefields until five weeks after the onset of baiting.

During the seventh week of baiting, after the typhoon, rat tracks and damage were again noted, particularly in the paddies adjacent to the marsh. Two drives in small sections of marshland at that time captured 51 rats, suggesting densities ranging between about 100 to 1000 rats per hectare. Rat activity and damage continued but decreased in intensity until harvest. Flocks of Lonchura malacca (Philippine weavers), varying in size, but totalling about 500 individuals in the area began taking maturing grains within two weeks of harvest.

Damage appraisal was conducted in these fields five days before the start of harvest. Cut tillers damage averaged 5.6 per cent, with the greatest damage in paddies rice bordering the marshland (Table 9).

Table 8. Summary of the numbers of bait stations and amounts of bait added during the dry season crop in nine hectares of ricefields employing sustained baiting with chronic toxicants at Barrio Wawa, Lumban.

Week After Transplant	Average No. of Stations/ha	Bait Added (Weekly)	
		Total (kg/ha)	Mean (g/station)
1-6	0	0	0
7	7.9	1.17	147
8	50.8	5.56	109
9	46.0	5.00	109
10	21.4	2.06	96
11	11.1	1.00	90
12	66.7	5.78	87
13	46.0	4.00	87
14	24.6	2.06	84
15	13.5	1.56	116
16	8.7	0.50	57
17	6.1	0.11	23
Total Bait Use	-	28.80	-

Table 9. Relationship between damaged tillers and the proximity of rice paddies to the marshland at Barrio Wawa, Lumban.

Rows from Marshland	No. of Paddies in Row	Mean percentage of tillers cut ± standard error of the mean/paddy	Pange in percentage of tillers cut/paddy
1	5	30.2 ± 5.57	17.0 - 46.1
2	7	10.6 ± 2.85	3.0 - 20.4
3	7	7.9 ± 2.25	1.0 - 19.0
4	7	7.2 ± 1.95	1.4 - 16.2
5	7	3.2 ± 0.96	0.0 - 6.9
6	7	4.5 ± 0.98	0.7 - 9.4
7	7	3.4 ± 0.68	1.0 - 5.5
8	7	2.3 ± 0.61	0.0 - 3.7
9	7	1.8 ± 0.50	0.0 - 3.7
10	8	1.9 ± 0.85	0.0 - 6.2
11	8	2.0 ± 1.09	0.0 - 9.3
12-16	5*	0.7 ± 0.27	0.0 - 1.4
Total	82	5.6 ± 0.89	0.0 - 46.1

*one paddy in each row

Production figures for each of the areas are presented in Table 10. In the sustained baiting area, total costs per hectare averaged ₱1324. The farmer's greatest investments were for plowing, harrowing and irrigation. We estimate that his costs for rat control, if he had followed our recommendations and performed the labor himself, would have been about ₱37. per hectare. This estimate is based on the cost for preparation and use of 28.5 kg./ha. of bait at ₱1.30 per kg. (Sanchez et al, 1972). It is considerably lower than any other production investments made by the farmer. He had a yield of 84 cavans per hectare, and realized a net profit of ₱2876 for each of his nine hectares.

Fenced Area

During our visits to the area enclosed by the electric fence, we observed up to one-hundred rats killed by the barrier in a single night, but nightly kills varied greatly. We also observed burrows and rat tracks along dikes within the fenced area and some freshly cut tillers on each visit. Damage averaged 13.2 ± 1.24 (mean ± Std. error) percent tillers cut at harvest in the ten paddies appraised.

Total production costs for this area were ₱2248 per hectare. Harrowing, harvesting and threshing fees and the cost of fertilizer constituted expensive inputs. Rat control, however, was the farmer's major investment. This cost ₱630 per hectare for the purchase, construction, maintenance and operation of the electric fence and for the use of poisons.

The farmer obtained a yield of 59 cavans per hectare from ricefields within the fenced area. His profit, above production costs, was ₱702 per hectare.

Unprotected Area

Our observations on the area with no rat control indicated abundant rat activity at each visit. Damage averaged 15.4 ± 2.58 percent tillers cut in the twenty-four paddies examined at two weeks before the planned harvest. At harvest, however we estimated that over 90% of the crop had sustained damage, although each of several random samples indicated 100% tillers cut. As a result of the extensive damage, the farmer decided to harvest about 1 week early to save as much of the remaining crop as possible, thus reducing the number of mature grains. His yield was 2.5 cavans per hectare.

Table 10. Estimated per hectare production costs (pesos) for three ricefield areas using different types of rat control in Barrio Wawa, Lumban.

Activity	Area with No Rat Control	Area Within Electric Fence		Area Using Sustained Baiting
		Actual*	Maintenance*	
Plowing	235	150		211
Harrowing		270		188
Seeds	100	90		158
Planting	33	135		119
Weeding	70	54		83
Insecticide	16	50		61
Fertilizer	0	252		61
Irrigation	325	128		160
Harvesting & Threshing	0	439		107
Hauling Fee	0	50		0
Miscellaneous	0	0		139
Rat Control				
Electric Fence (Actual Cost)	-	630	-	-
Electric Fence (Maintenance Cost)	-	-	341	-
Sustained Baiting**	-	-	-	37
Yield (Cavans)	2.5	59	59	84
Gross Value (Pesos)	125	2950	2950	4200
Production Costs (Pesos)	-779	-2248	-1959	-1324
= Net Profit (Pesos)	-654	+ 702	+ 991	+2876

*Actual = actual cost to farmer, including purchase of generator & installation of electric fence

Maintenance = estimated cost to farmer assuming repeated use, including cost for maintenance & operation of electric fence

**Estimated costs to farmer if he had carried out his own control operations.

The production costs for this area indicate irrigation fees as the major investment. Nothing was spent for fertilizer or rat control. Since his yield was low, harvest-related expenses were negligible. The farmer lost ₱654 per hectare in this area.

Discussion and Conclusions

Production figures indicate that the ricefields with no rat control also received no investments in fertilizer and less insecticides than the other areas. Although arguments could be made that use of these materials might have increased the potential yield of fields, our observations strongly indicate that rat damage, which included most of the existing rice stand, was the limiting factor in the farmer's yield. Since rat damage appeared to be the major constraint on yield, the use of additional fertilizer and insecticide might only have increased total investment costs and further increased the farmer's losses.

The area within the electric fence represented the farmer's best rice production efforts. His investments in each phase of rice production were similar to or greater than the cost for each of the other areas. His major investment was the electric fence for rat control, which included purchase and installation of the fence as well as its operation and maintenance, or about ₱7559 to protect 12 hectares (including minor costs for purchase and use of acute toxicants within the fenced area). Even if only operational and maintenance costs (assuming a yearly replacement of one-fourth of the fence parts) are considered, the cost for rat control is still high: about ₱4096 for the 12 hectares, or ₱341 per hectare (shown as estimated maintenance cost for the electric fence in Table 10).

Even with the great investments for rat control, our data indicates the barrier provided economically feasible and beneficial protection of the crop. The cost for the electric fence, including its installation and the purchase of the generator, would have paid for itself if it prevented the loss of 151 cavans or about 13 cavans per hectare of rice. The farmer harvested 59 cavans per hectare of rice from the fenced area, compared to 2.5 cavans per hectare in his unprotected area, with a net profit of ₱702 per hectare. He lost ₱654 per hectare in the unprotected area. Although we do not know how much of the farmer's yield within the fenced area can be directly attributed to protection from rats, our damage appraisals indicated a major difference: only 13.2 percent cut tillers within the fenced area compared with over 90% cut tillers within the unprotected area at harvest. It thus appears that the electric fence lifted the major constraint on the farmer's yield by greatly reducing rat damage to this crop. It is likely that employment of a barrier designed and operated with a better understanding of the behavior of ricefield rats could further reduce construction and operational operational costs, provide better protection of the crop, and greatly increase the farmer's profit.

The total investment for rice production by the farmer who employed sustained baiting was much less than that for the fenced area. The major difference in cost was for rat control: ₱630 per hectare for the electric fence vs. ₱37 per hectare estimated costs for sustained baiting. Despite the difference in costs, sustained baiting resulted in the lowest level of rat damage, only 5.6 percent tillers cut at harvest. We have no doubt that many factors which cannot be controlled in a field trial such as this one may have contributed to the farmer's success. But our experience with the unprotected crop this season as well as this farmer's past history of high rat damage (Table 11), suggest that damage would have greatly reduced the farmer's yield if he had not used effective rat control. By employing sustained baiting, the farmer eliminated, at an extremely low cost, rat damage as the major constraint on his rice production efforts, and achieved a good return on his production investment.

We conclude from this trial that rat damage severely limited production in an unprotected ricefield adjacent to marshland with a resultant net loss to the farmer; that, in another area, the partially effective use of an electric barrier provided economically feasible and beneficial reduction in damage; and, that on one farm, where rat damage had limited production for several seasons, great economic gains and highly effective reduction in rat damage were obtained by the use of a sustained baiting program. We suspect that rat damage limits production in many other ricefields, particularly those adjacent to non-cultivated habitat in the Philippines, and that similar production and economic gains could be made by the proper use of sustained baiting with chronic toxicants in these areas.

Trial II: Barrio Tagumpay, Baco, Mindoro Oriental

The second trial was conducted on 241 hectares of ricefields interspersed with marshy habitat in Barrio Tagumpay, Baco, Mindoro Oriental. Since this represented our first evaluation of sustained baiting with chronic toxicants in an area where *R. argentiventer* is the major pest species, we collected data on rat activity with tracking tiles in addition to recording bait use, damage indices, and production costs.

Habitat Description

Two ricefield areas planted in the wet season were chosen for similarity of surrounding habitat and size. They were each roughly rectangular, and positioned so that the corner of one almost touched a side of the other. The areas were separated by a road and a section of marsh at the point of nearest contact, and by additional ricefields

Table 11. A summary of past yields (cavans per hectare) and rat control practices on a 9-hectare farm where sustained baiting with chronic toxicants was used during the 1974 dry season.

Year	Season	Rat Control Practices	Harvest (cavans per hectare)
1972	Dry	New area - none	70
1973	Wet	None - total loss due to floods	0
1973	Dry	Acute poisons along dikes	45
1974	Wet	Electric fence and acute poisons on dikes	35
1974	Dry	Chronic poison, sustained baiting	84

or hilly coconut groves in either direction from this point. The road curved around one-half of the perimeter of one and bounded a single side of the other. Each area was further surrounded by hilly coconut groves, banana groves, and ricefields. Each also contained, within its boundaries, three large (at least 100 m diameter) sections of marshy, unfarmed land. Both were primarily planted with IR-20, although some IR-1561, C-4 and C-12 were also grown. One of the areas, consisting of 106 hectares planted by thirty farmers, was randomly chosen as the "reference area." The other, 135 hectares planted by seventy-seven farmers, employed sustained baiting and will be called the "treated area."

Sustained Baiting and Evaluation Methods

Treated Area

Planting in the treated area began on July 15 (considered as the first day of transplant), but continued through August 30. About 30% of the fields were planted by broadcasting seeds rather than by transplanting.

At three weeks after transplanting (WAT), the seventy-seven farmers in the treated area were asked to attend a meeting where they were given detailed instructions on the use of sustained baiting with anticoagulants as reported by Sanchez et al (1973). They were given instructions on how to make bait stations from coconut husks, how to adjust of numbers of stations at a feeding point to the intensity of rat activity, and how to use chronic toxicants. Bait for the study was supplied by the Bureau of Plant Industry as USAF-surplus oats with warfarin at 0.025%. Farmers were asked to keep records of the amounts of bait that they placed in stations. In addition, the area was visited regularly by a technician who provided additional advice and consultation as required for the proper implementation of the procedure.

Our data was collected from the treated area in the following manner. Rats were captured in ricefield and uncultivated lands adjacent to the study sites at two WAT to determine the species composition. Tracking tiles were used to determine levels of rat activity before, during, and after the use of anticoagulants; i.e., at pretreatment (5 WAT), tillering (8 WAT), booting (11 WAT), heading (15 WAT), and post harvest (18 WAT) stages. Ten inked tracking tiles were placed at 50 m intervals along five parallel transects which were separated by 200 meters each; a total of fifty tiles were used. Tiles showing evidence of rat activity were recorded as positive; unmarked tiles were considered negative. The tiles were checked, cleaned, and re-set for three consecutive days.

We also performed damage appraisal in fifty-one randomly selected paddies, using the percent damaged hills index as described by Sanchez et al (1973). Appraisals were conducted within two weeks of harvest of the paddies.

Records were obtained from each of the farmers on daily amounts of bait added to the stations. Fifteen of the seventy-seven farmers, representing 27.5 hectares, were randomly selected and asked to supply us with past yield records for their farms. Current production costs were provided by a group of 12 farmers, randomly selected, after harvest.

Reference Area

Rats were captured in fields adjacent to the reference area at two WAT to determine species composition. In the reference area, we provided no information on the sustained baiting procedure and no technical assistance on rat control during the growing season. We did, however, visit the area periodically to observe rat control attempts by the farmers and after harvest, we requested information from them on their activities. We also collected rat activity data using tracking tiles and conducted damage appraisals in 41 paddies, as described for the treated area. After harvest, we collected past yield information from ten randomly selected farmers who again represented 27.5 hectares of rice. In addition, eleven farmers from the reference area were randomly selected to provide current production figures.

Results

A total of 82 rats were captured in fields adjacent to the treated and reference areas. These specimens were returned to the laboratory and were all identified as *R. argentiventer*.

Bait Replacement in the Treated Area

Since bait was replaced daily and only a small excess was maintained over consumption, we considered our measurements of bait replacement as approximate measures of bait consumption. The only obvious, although minor, exceptions to this were during the 13th and 15th WAT (Table 12) when bait was replaced primarily because it was water soaked.

Baiting began during the 5th WAT with 516 stations, one each at approximately 4 baiting points per hectare. Consumption during this week totalled 532 kg, or about 3.9 kg per hectare (Table 12). During the 6th WAT, consumption further increased to 645 kg, or about 4.8 kg per hectare. Numbers of bait stations in use were also increased, and by the last day of this week, 1000 stations had been

Table 12. A summary of bait added to stations on 135 hectares of ricefields employing sustained baiting with chronic toxicants during the wet season crop in Barrio Tagumpay, Baco, Mindoro.

Week After Transplant*	Average No. of Stations/ha	Bait Added (Weekly)	
		Total (kg/ha)	Mean (g/station
1-5	0	0	0
6	4.1	3.9	951
7	5.8	4.8	828
8	5.9	3.5	593
9	5.0	1.4	280
10	3.8	1.1	289
11	3.1	0.18	58
12	1.8	0.05	28
13	1.5	0.14	93
14	1.5	0	0
15	1.5	0.13	87
16	1.5	0	0
Total Bait Use	-	15.3	-

*Calculated from date of first transplanting, although transplanting occurred from 14 July through 30 August.

placed at the 516 original baiting points. This number of baiting stations was maintained for only two more days, when numbers were decreased gradually until, by the 10th WAT, only 516 were again operating in the fields. Stations were further removed until the 12th WAT, when only 200 stations remained; these were maintained for the rest of the growing season.

Bait consumption reached its highest level during the 7th WAT, when 645 kg total or 4.8 kg per hectare were consumed. It dropped rapidly until the 11th WAT when only 25 kg or 0.18 kg per hectare was consumed. This pattern of bait consumption appeared only slightly affected by the passage of Typhoon Onian during the 10th WAT, which brought heavy rains and floods in both the treated and the reference areas (see Figure 2). Six additional typhoons passed through the area in subsequent weeks: one each at 12, 14, 16 and 17 WAT and two during the 15th WAT. None of these had obvious effects on bait consumption. Declines in the average bait consumption per station (Table 12) may indicate that more stations were maintained than the level of rat activity required during most of the trial.

Rat Control Activities in the Reference Area

Although we provided no information to the farmers in this area regarding rat control, at least one farmer attempted to use sustained baiting with anticoagulants in his fields. When interviewed later, this farmer reported that he had "copied" the procedure from the farmers in the treated area. Other farmers reported using an aggregate of minor control activities including flooding burrows, clubbing rats, and baiting with acute toxicants.

Rat Activity Data

Tracking tile data (Figure 2) were normalized ($\sqrt{\text{actual data} + 0.5}$ and treated as a factorial experiment with a completely randomized design. Stages of rice growth (periods) and treatments were compared by HSD (Honestly Significant Difference; Table 13). Major assumptions in the design were that sampling periods were independent time replicates, and that tiles placed on consecutive nights were independent samples.

Rat activity did not differ significantly between the treated and the reference areas before the use of chronic toxicants (5 WAT). After the sustained baiting procedure was implemented, activity in the treated dropped significantly below the activity in the reference area. It remained lower until harvest (post treatment). After harvest, rat activity rose above the pretreatment levels and did not differ significantly between areas.

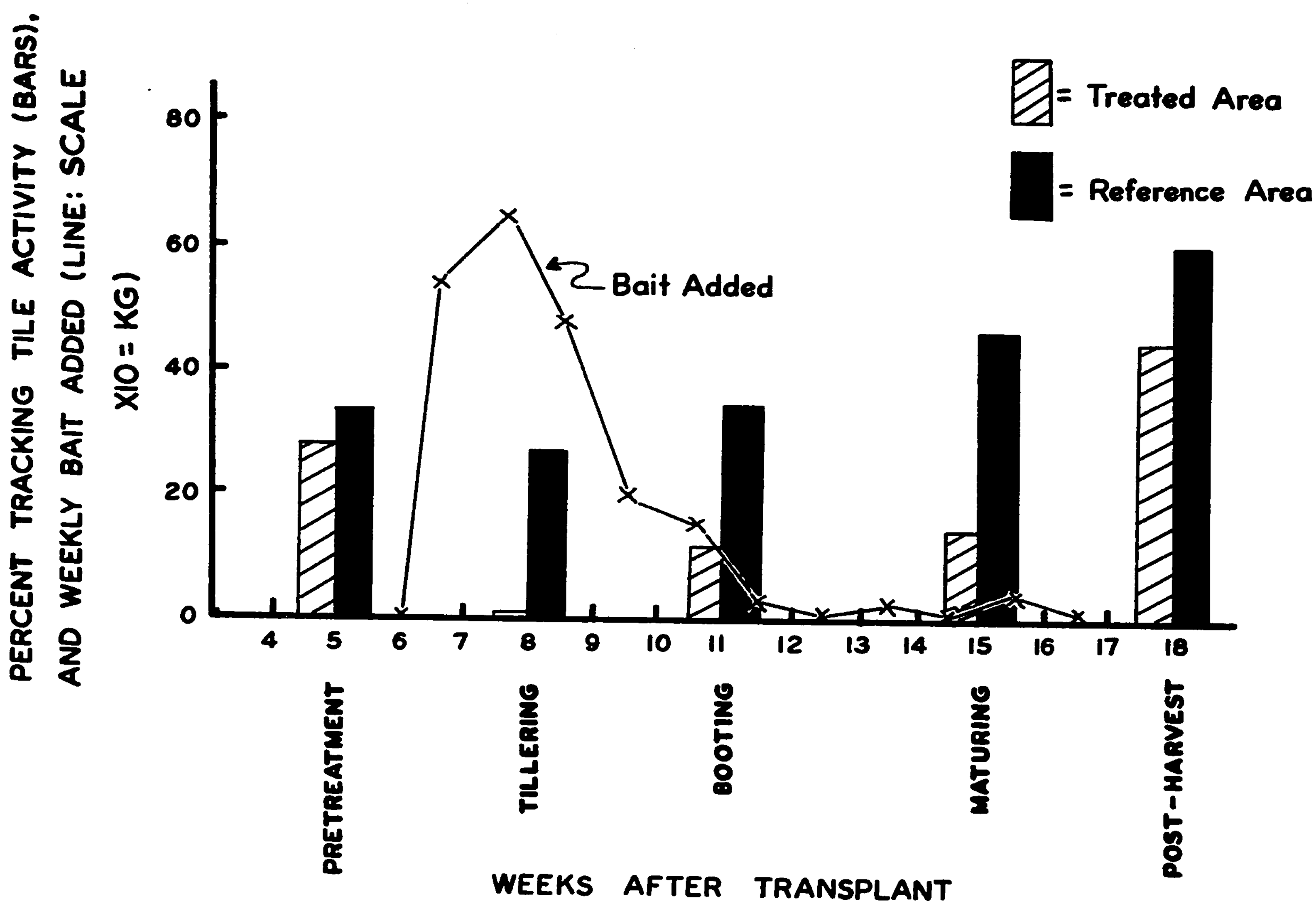

Figure 2. Rat activity and bait use on a 135 hectare ricefield area employing sustained baiting and a 106 hectare reference area in Barrio Tagumpay, Mindoro Oriental. Activity estimates were based on the percentage of positive tracking tiles during each period; bait use was estimated by the total bait added weekly to all stations.

Table 13. A comparison of the numbers of tracking tiles showing rat activity in a 135 hectare ricefield area that employed sustained baiting and a 106 hectare reference area in Barrio Tagumpay, Baco, Mindoro.

Weeks After Transplanting	Crop Period†	Mean No. of Positive Tiles: Treated Area Actual	Treated Area (Normalized)	Reference Area Actual	Reference Area (Normalized)	Period Mean Actual	Period Mean (Normalized)††
5	Pretreatment	13.7	3.76	16.4	4.09	15.0	3.93 a
8	*Tillering	0.4	0.88	13.0	3.64	6.7	2.62 b
11	*Booting	5.4	2.41	17.0	4.18	8.7	2.92 b
15	*Maturing	7.0	2.74	22.6	4.80	14.8	3.97 a
18	Post-harvest	22.4	4.78	30.0	5.52	26.2	5.15 c
	Treatment Means	9.8	2.91	19.8	4.45	14.3	3.72

† $HSD_{0.05}$ = 0.99; treatment means for starred (*) periods are significantly different
†† $HSD_{0.05}$ = 0.59; period means with different letters are significantly different

SV	d.f.	SS	MS	F
Period	4	26.65	6.66	56.76 HS
Treatment	1	16.75	16.75	142.70 HS
Period x Treatment	4	5.50	1.38	11.72 HS
Error	19	2.23	0.12	
Total	28	51.14		

Damage appraisal

Hills having cut tillers averaged 27.6 ± 2.92 percent (mean ± standard error) in the 41 paddies that were sampled in the reference area. This was significantly higher (Student's t = 8.9; $P<0.001$) than the average 4.00 ± 0.47 percent for 51 paddies that were sampled in the treated area. Although percent cut tillers were not analyzed in this study, a regression equation was available for the relation between percent tillers cut and percent damaged hills for the 1970-1972 Mindoro wet season crops (r = 0.92, Sanchez et al, 1973). Based on this equation, percent cut tillers averaged 4.9 percent in the reference area, and 0.2 percent in the treated area.

Yield Data

Yield data for this and the previous wet season crop was supplied by 15 farmers in the reference area and 10 farmers in the treated area, randomly chosen. There was not a significant difference between the reference and treated area yields during the wet season crops previous to the study, and there was not a significant change in yields of the reference area between the study crop (1974 wet season) and the previous wet season crop. The treated area, however, yielded significantly more rice than the reference area during the study crop, and also significantly more rice than it had produced during the previous (1973) wet season (Table 14). Each of the farmers listed rat damage as their major production problem during the 1973 wet season.

Production Costs

Production investments were determined from data provided by farmers in both areas, and compared using Student's t tests (Table 15). Weeds were reported to be a consistently more serious problem in the treated than the reference area. This is reflected in the different costs of weeding for farmers in the two locations (₱130 vs ₱93 per hectare, treated vs reference areas, respectively); weed control was the only production input differing significantly between the two groups when rat control was excluded. The results of these investments were the maintenance of low levels of weeds in both areas. Two farmers in the treated area reported the use of irrigation, while other farmers reported that ample rainfall during the period of the study made irrigation unnecessary for them. Two of the farmers from the reference area sample applied fertilizers, while none of the farmers in the treated-area sample reported fertilizers applications. Our own observations suggested that fertilizers were seldom used by either group. Total production investments, again excluding rat control, were similar for both areas: ₱641 ± 31.9 (mean ± standard error) per hectare for the treated area vs. ₱629 ± 25.9 per hectare for the reference area. The similarity of variances around means for these samples are a further indication of the relatively homogenous rice-growing practices of the farmers.

Table 14. A comparison of yields between an area using sustained baiting and a reference area during the 1974 wet season crop in Barrio Tagumpay, Baco, Mindoro. Data were also compared with the previous wet season crop.

Area	Wet Season Yield Means (cavans/ha) ± Standard Error	
	1974 (this study)	1973
Reference (10 farmers)	23.3 ± 3.64[a]	21.5 ± 2.70
Treated (15 farmers)	42.3 ± 4.52[a,b]	17.7 ± 3.60[b]

a,b - yields with the same letter are significantly different: for a, $P<0.01$; for b, $P<0.001$

Table 15. A comparison of production costs between farmers (12, randomly chosen) using sustained baiting and those (11, randomly chosen) in a reference area during the 1974 wet season crop in Barrio Tagumpay, Baco, Mindoro. Costs are presented in pesos per hectare (one peso = ca. $0.14 U.S.).

Production Factor	Treated Area Mean ± s.e.$_{\bar{x}}$ (Range)	Reference Area Mean ± s.e.$_{\bar{x}}$ (Range)	Significant Difference (Student's t)
Land Preparation	223 ± 12.9 (140-300)	228 ± 18.2 (140-320)	no
Seeds	76 ± 1.4 (70- 80)	73 ± 3.0 (60- 90)	no
Transplanting	118 ± 4.6 (80-140)	129 ± 4.1 (120-160)	no
Weeding	130 ± 11.9 (60-200)	93 ± 8.0 (60-140)	P<0.05
Insecticides	60 ± 5.4 (35- 87)	62 ± 4.5 (35- 90)	no
Herbicides	25 ± 6.1 (0- 55)	23 ± 4.8 (0- 35)	no
Rat Control (by farmers)	0 -	6 ± 2.5 (0- 25)	no
Irrigation	7.1 ± 4.8 (0-45)	0 -	no
Fertilizer	0 -	4 ± 2.9 (0- 24)	no
Subtotal Production Cost	641 ± 31.9	629 ± 25.9	no
Rat Control (all methods)	20 (estimate)	6 ± 2.5	-
Total Production Cost	661	635	-
Gross Value of Crop	2115	1165	-
Net Profit	1454	530	-
Yield (cavans/ha)	42.3	23.3	

We estimated that the costs for sustained baiting would have been about ₱20 per hectare, if the farmers had carried out the baiting procedure themselves, using commercial rodenticides. This estimate is based on the costs for preparation and use of 15.1 kg of bait per hectare at ₱1.30 per kg (Sanchez et al, 1972). Materials for the construction of bait stations were available on the farms, and labor would have been supplied by the farmers at negligible cost. This estimate is similar to the ₱25. per hectare for rat control reported by the single farmer in the reference area who copied the sustained baiting procedure. He also used zinc phosphide, which may explain the slightly higher than average cost.

Based on average yields and production costs, the farmers in the treated area made an average profit of ₱1454 per hectare -- almost three times the ₱530 per hectare averaged by farmers in the reference area (Table 15).

Discussion

The bait use pattern in this trial was similar to that observed in other studies of the sustained baiting procedure (Sanchez et al, 1973). As described previously, it can be explained by increasing numbers of rats finding and using the stations during the initial period, followed by decreasing numbers of rats feeding at the stations as mortalities due to the toxicant exceed the rate of influx of new animals.

Tracking-tile data showed that a dramatic drop in rat activity occurred in the treated area several weeks after baiting was started. Activity gradually increased for the remainder of the growing. Since tiles were placed along transects unrelated to the positions of the bait stations, these data may also indicate that a major effect of the baiting procedure, in addition to reduction of rat numbers, was to concentrate rat activity in areas around the feeding points, thereby reducing activity in other portions of the fields. If rat activity was not restricted in this manner, we would have expected the tracking tiles to reveal an activity pattern similar to that observed for bait use. We suspect that rat activity does closely follow bait consumption patterns in areas near the bait stations.

Additional studies should be performed to determine the degree to which tracking-tile data reflect population densities or rat distribution in the ricefields; and, to determine the effects of bait stations on these factors. The activity patterns observed in this study, again, confirm the importance of early and continuous baiting throughout the growing season for the effective reduction of rat damage in ricefields when chronic toxicants are employed.

The increasing rat activity in both the treated and the reference areas during the majority of the growing season may indicate a reduction in the use of bait stations when grains begin to mature. This has also been suggested by previous studies. Again, additional work is required to develop a better understanding of rat behavior during the latter stages of rice development.

The post-harvest increases in rat activity in both the treated and reference fields are probably due to the localized effect of the sustained baiting procedure and probably reflect high population pressures from surrounding habitat. They certainly emphasize the need for continued baiting during future cropping seasons.

Bait consumption averaged 15.3 kg per hectare for this study -- considerably lower than the 37.3 kg per hectare averaged in six field plots using sustained baiting during the 1973 wet season crop near Sta. Cruz, Laguna (Sanchez et al, 1973). These plots, however, averaged only 1.21 hectares and were separated by at least several hundred meters. It may be that protection of larger areas, such as the 135 hectares in this trial, requires less bait per hectare because of lower peripheral population pressure. The lower bait consumption could also have been due to basic differences in rat population pressures between the study sites. Less activity, due to either of the above possibilities, is indicated by the tracking tile data, which averaged 55.6 to 81.7 percent marked in the Sta. Cruz trials while it ranged from 0.7-60 in this study. In the trial of Barrio Wawa, Lumban, reported earlier in this Section total bait consumption per hectare was about 29 kg, almost twice as much as that required for this trial. Again, population pressure due to smaller hectarage (9.0 hectares) or area differences may have been responsible for this difference.

Yields for both areas were considerably lower than the potentials for the rice varieties planted. Our data from reference area farmers provide some insights on the relative importance of investments as limiting factors in production. The two farmers with highest yields in the reference area were compared with those of the remaining farmers that had been randomly selected for the production figures survey (Table 16). All of these farmers made similar investments for production inputs except for the use of the sustained baiting procedure for rat control and the use of fertilizer. Only the two farmers with the highest yields used fertilizer; only the farmer with the highest yield also employed sustained baiting. Application of fertilizer without the use of an effective rat control program appeared to have increased yield by almost 50% over the average for farmers not using fertilizer, resulting in over twice the net profit (see "farmer with second highest yield," Table 16). The net

Table 16. A comparison of production investments between two farmers with highest yields and the other nine reference area farmers who had been randomly selected for the production investments survey. Costs are presented in pesos per hectare (one peso = ca. $ 0.14 U.S.)

Production Factor	Farmer with Highest Yield	Farmers with Second Highest Yield	Other Farmers
Land Preparation	170	300	227 ± 19.7
Seeds	75	70	73 ± 3.6
Transplanting	140	120	129 ± 4.8
Weeding	100	80	94 ± 9.8
Insecticides	55	60	63 ± 5.5
Herbicides	35	0	25 ± 5.0
Rat Control	25*	9**	3 ± 1.8**
Irrigation	0	0	0
Fertilizers	24	24	0
Total Production Cost	624	663	625 ± 31.7
Gross Value of Crop	2625	1350	955
Net Profit	2001	687	330
Yield (cavans/ha)	53	27	19.1± 1.7***

* Included baiting with acute toxicants and use of sustained baiting procedure

** Included baiting with acute toxicants only

*** Based on a sample size of eight: yield figures were not obtained from one farmer.

gain was considerable (₱357 per hectare for ₱24 investment in fertilizer). The yield obtained by the farmer who used both fertilizer and the sustained baiting procedure was 53 cavans per hectare -- nearly twice that obtained by the farmer who used only fertilizer and almost three times that of the remaining farmers. His profit, ₱2001 per hectare, was over twice that of the farmer using fertilizer, and over six times that of the remaining farmers. These data tend support the contention that rat damage was the limiting factor to rice production in these fields. The data also suggest that, in areas where rat damage limits production, effective control procedures are essential before the full benefit of other investments can be realized. Since none of the farmers in the treated areas were known to have used fertilizers, and since our data suggest that the sustained baiting procedure effectively reduced rat damage, we suspect that these farmers could have produced more rice and realized greater profits if they had used even small amounts of fertilizer.

The argument is frequently raised that effective rat damage reduction requires the coordinated efforts of farmers over a large continuous area of riceland. This rationale has been used as the basis for major government rat control operations in many countries of Southeast Asia, and as an excuse by many farmers for not attempting rat control in their own fields. Previous evaluations of the sustained baiting procedure at the small farm level have indicated that it could provide effective and economically beneficial protection on this scale (Sanchez et al, 1973). The relatively high yield obtained by the one farmer in the reference area who carried out a baiting program is a further indication that this procedure will provide good protection for the small farmer -- regardless of the activities of his neighbors.

Although these comparisons on specific aspects of our data raise important theoretical questions that will require future studies, a major conclusion from this trial was that the sustained baiting procedure reduced R. argentiventer damage in ricefields where rats had apparently limited production in the past. This conclusion was based on both rat activity and damage appraisal data. The treated area had significantly lower rat activity during the period when anticoagulants were used, but not before or after treatment. The percent of hills damaged in the reference area was almost seven times greater than that in the treated area within two weeks of harvest.

Because the habitats, original levels of rat activity, and all production factors except rat control were very similar in the treated and reference areas, we also concluded that the baiting procedure was the major factor responsible for raising the average yield of the treated area to nearly twice that of the reference area, providing the treated-area farmers with nearly three times the profit.

Since a yield increase of less than one-half cavan per hectare would have paid for the cost of the baiting procedure, and since farmers in the treated area harvested almost twenty cavans per hectare more than farmers in the reference area, we also concluded that the sustained baiting procedure provided highly economical protection. Because only marginal increases in yield are required to pay for the cost of the procedure, farmers in other ricefield areas where R. argentiventer is a major pest could probably benefit from a similar approach. Additional trials, particularly in other SE Asian countries where R. argentiventer damages rice, should be undertaken.

Preliminary tests for varietal preference by rats

Introduction

During the national rice damage surveys in 1970 to 1971, two varieties, FK 178-A and Camoros, were found to be undamaged by rats. Subsequent tests comparing rat damage to FK 178-A and IR-22 (Sanchez et al, 1971) showed that although rats preferred IR 22 until 12 weeks after transplanting, FK 178-A plots were also totally destroyed by 14 weeks after transplanting when food became less available.

In 1974 some "rat-resistant" varieties, from several areas in Sumatra, were introduced to the Center by Dr. A. T. Perez, field adviser of the International Rice Research Institute. These varieties called Sipaet, Sipahit, Sipahet, Sipahid, and Ranka Medu, were claimed by farmers to be resistant to rats. The local names mean bitter, presumably referring to the stalk (tests by RRC staff found no strong bitter taste detectable by humans). These varieties are grown in lowland, upland or tidal swamp conditions in many provinces of Sumatra. The present collection of varieties now in the IRRI germ plasm bank came from 6 to 8 provinces of Sumatra: Riau, North Sumatra, South Sumatra, Aceh, Bengkaku and West Sumatra, indicating wide distribution of these varieties.

Dr. Perez provided us a small sample of Sipaet variety which we used for comparison with a local high yielding variety C4-137. The preliminary test for rat acceptance was conducted during the maximum tillering stage of both varieties. The tests were made on potted plants.

Materials and Methods

Potted rice plants of C4-137 and Sipaet varieties with equal number of tillers were paired. Each pair was enclosed in a wire cage (1 m x 1 m x 1 m) made of 1/2 in. chicken wire mesh. A rat was introduced into each cage late in the afternoon and removed early the next day. Only rats with high-cutting tendencies (at least 50% damage hill in a training test) were used. These rats were chosen from a group of 20 rats previously exposed for one night to potted C4-137. A total of 10 rats were introduced to 10 pairs of the rice varieties.

The total number of tillers cut in one night were counted in each of the potted plants. These counts were later expressed as per cent tillers cut and analyzed using paired t-tests.

To test whether rats learn to choose between the two varieties, the experiment was repeated a day after the first test. The same test animals were used. Separate paired t-tests were conducted for each test.

Results and Discussion

Results in Table 17 show that rat damage to Sipaet never exceeded that of C4-137. A sign test as well as a paired t-test showed significant differences in damage to the two varieties. In both tests, the mean damage to Sipaet was about half that of the C4-137 variety.

As in previous tests, we suspect that these results indicate the ability of rats to express food preferences and that under field conditions of no choice these varieties would still suffer damage. Nonetheless, differences in varietal preference bear further investigation, particularly oriented to discover factors which allow rats to discriminate differences among varieties.

Table 17. Percent of tillers cut per hill of paired Sipaet and C4-137 potted plants exposed to rats for one night.

Pair No.	First Night		Second Night	
	Sipaet	C4-137	Sipaet	C4-137
1	100	100	28	72
2	100	100	14	81
3	29	46	15	60
4	19	52	100	100
5	19	81	32	72
6	100	100	8	28
7	14	67	31	81
8	87	100	27	88
9	8	80	63	85
10	13	68	100	100
Mean	48.9	79.3	41.8	76.7
Paired t-test	-3.44**		-4.70**	

** significant at 1%

A Comparison of Methods for Studying Food Habits of Philippine Rats

Introduction

Food habits may influence such factors as the distribution of a species, its micro-environmental requirements, and its willingness to accept a carrier bait when other food sources are available. Since these are important considerations in developing procedures that use chemicals to reduce damage by pest species, and since an understanding of food habits could provide critical information for the development of non-chemical control methods, the Center has been active in the investigation of the food habits of Philippine pest rats during the past several years.

Procedures for the identification and quantitation of materials in the stomachs or fecal pellets of mammals, however, vary greatly. Some, such as the works of Harrison (1954) and Lim Boo Liat (1966, 1972), provide only crude estimates of weights and volumes of food items which are identified to basic types. Other procedures involve elaborate histological examinations, which allow identification to genus or species, and precise measurements of volumes and weights.

Since a myriad of procedures are available, we chose to compare four, representing varying degrees of sophistication, to determine their most useful applications for our work.

Materials and Methods

R. r. mindanensis were herded in an area adjacent to maturing rice in Famy, Laguna. The area contained primarily *Scirpus grossus* stands with lesser amounts of *Ipomea aquatica* ("kang-kong"), *Sacciolepis indica*, water lily and other herbs and grasses. Some of the more common plants mixed with cultivated rice (*Oryza sativa*) in adjacent paddies and on dikes were *Echinochloa crusgalli*, *E. colonum*, *Paspalum conjugatum*, *Cyperus iria*, *Monochoria vaginalis*, *Alternanthera sessilis* and *Leersia hexandra*. A reference collection of these species was made, and reference slides prepared as appropriate for the procedures tested.

Some of the collected rats were returned to the laboratory and maintained for the preparations of reference slides, or for comparison of methods with rats on known diets. Stomachs were immediately taken from the remaining rats, and wrapped in cheese cloth. Only sexually matured animals were included in the study. Stomach samples were then randomly assigned to four groups, until each group included 20 samples.

Each group was then randomly selected for one of the four procedures to be tested and stomach contents of each samples of the group analyzed accordingly.

The following are summaries of the four procedures studied:

Harrison's Procedure (Harrison, 1954, Lim Boo Liat, 1966, 1972)

Stomach or intestine contents were washed in saline water (0.85% physiological saline) in petri dishes and directly examined under a binocular microscope while still fresh. Contents were identified as to basic type (rice starch, plant tissue and fiber, insects or animal matter), and the relative proportions of each estimated to the nearest 10 percent.

Fall's Procedure (Fall et al, 1971)

Stomachs of animals selected for this study were preserved in 70% ethyl alcohol. Materials of different colors and textures were segregated under a dissecting microscope for each stomach and a small amount of each component was prepared on a slide, occasionally using hematoxylin to enhance contrast. Segregated components were weighed (wet) to the nearest 0.1 gram and total weight of stomach contents was determined by summing weights of the components.

Reference slides (and photomicrographs) were made by teasing a small amount of material on a slide, dehydrating in alcohol, clearing in xylol and mounting in piccolyte. Staining was unnecessary. Reference materials were also obtained by depriving live rats of food for 18 hours (*R. rattus* and *R. exulans*), and allowing them to feed on known food items. These rats were killed and their stomachs prepared as reference slides.

Williams' Procedure (Williams, 1962)

Slides of the stomach contents were either prepared from newly sacrificed animals, or from stomachs that were stored in a preservative solution.

For slide preparation, stomach contents were removed, washed and screened through a piece of fine bolting silk (number 000) that had been stretched over the mouth of a funnel. This treatment removed fat, gastric juices and many of the small unidentifiable cells of leaf mesophyll. The material was then placed in a small container with 1% iron solution for 5 to 20 minutes. The fragments were then screened out of the mordant and washed for 2 to 3 minutes. Staining was done by dripping a small amount of 1% hematoxylin through the fragments until the desired color was achieved. The fragments were then washed as before and mounted on slides using 10 x 24 mm cover slips.

Analysis of materials were carried out under the low power of a compound microscope. Ten randomly selected fields were examined disregarding those containing no fragments. Identification of items in each field was attempted by comparing cell patterns with those in the reference collection. Frequency of occurrence and relative amount of each food items were recorded.

The reference collection was prepared in the following manner. Herbaceous plants in the study area were collected and identified. Pieces of epidermis from both abaxial and adaxial surfaces of leaves and from stems were obtained either by stripping the epidermis directly or by scraping away the overlying layers until the desired surface was reached. Fragments obtained were fixed, washed and treated with 1% hematoxylin solution until the material assumed the desired intensity of color. They were then mounted on slides with the non-resinous medium (Williams, 1959).

Tigner's Procedure (Tigner, 1972)

Stomachs were collected and preserved in 75% ethanol or methanol with 25% glycerol. Contents were carefully removed and, after exclusion of the mucosa and macroparasites, weighed while still wet. Volumes were determined by water displacement. Contents were then placed in a high-speed blender, transferred to a filter funnel with fine bolting silk and thoroughly washed with tap water. The filtered fragments were treated with 1% sodium hypochlorite for about one minute, washed, neutralized with 2% acetic acid and washed again. The material was then treated with an iron alum mordant, stained with 1% hematoxylin, rinsed in tap water to remove excess stain, and mounted on slides in a resinous mounting medium under a 22 x 40 mm glass cover slip.

Two slides of each stomach were examined with a compound microscope, and plant and animal components were identified by comparing with photomicrographs and the original reference slides. Ten spots (fields of the microscope) were examined per stomach, five spots on each slide at low (100 X) magnification. The percent of field occupied by each food item (equated with percent volume) was recorded together with the frequency of occurrence. The percent of field was determined by an actual count of the number of squares in a 10 x 10 grid (total area = 1 mm^2 at 100 X) that a particular food item occupied.

Reference slides were prepared from plants that were collected in the study area, pressed, and stored prior to slide preparation. The specimens were cut into small fragments, soaked for about 2 weeks in a solution of equal parts of water, glycerol and 95% ethanol, then ground in a high-speed blender, washed with water, treated with 1% sodium hypochlorite and prepared in the same manner as the sample slides.

Results and Discussion

The results clearly showed that the use of histological techniques markedly increases the accuracy in identification of food items found in the stomachs of rats. The technique used by Harrison (1954) and Lim Boo Liat (1966, 1972) suggested that the stomachs analyzed averaged 68% rice grains, 30% plant materials and 2% insect matter. Upon careful re-examination with a compound microscope, these basic types turned out to be mixtures of various food-stuffs.

These results were similar to those obtained by Fall's Procedure: 98.3% rice (grains, rice seed coat and other rice tissues), 1.2% unidentified items and traces of insects and other plant items like E. colonum. As revealed by Williams and Tigner's Methods, most of the green, leafy components were rice seed coats. Hence, the 30% plant material that we recorded using Harrison's method were most likely also rice, suggesting a total of 98% rice. Since Fall's procedure uses only one or two temporary mounts to identify the items composing each segregated component, some of the food items identified with the more sophisticated techniques were overlooked.

Williams' and Tigner's Procedures presented a clearer, and remarkably similar, view of the total species eaten by the sampled animals (Tables 18 and 19). Items were more easily identified on slides because diagnostic features (particularly epidermal structures) were more apparent. Leaves of C. iria and Digitaria sp., for example, which were undetected by Harrison's and Fall's techniques, were shown to be relatively common food items. The percentages of unidentified plant materials were small enough to be insignificant. These procedures employ the use of a non-resinous medium to mount stained materials directly from a water base. The medium is not available in this country, so considerable time must be spent dehydrating samples with alcohol.

A principal disadvantage of these more sophisticated procedures is that the washing process, intended to remove fats, gastric juices and other unidentified fragments also removes the starch components. Based on the other procedures, we suggest that starches (which are a major portion of rice heads, for example) compose about 70% of the stomach contents of the samples analyzed. Almost all Oryza sativa were identified as rice seed coats, with only the occasional appearance of starch granules. Even if we assume that rats eat one rice seed coat for each rice grain taken, the relative proportions composing the total stomach contents would differ greatly because seed coats represent surface areas of the grains, while the starch granules actual volumes. Consequently, we suspect that the per cent volumes of O. sativa in Tables 18 and 19, although similar, were actually under-estimates. Figures derived from stomachs used in Harrison's and Fall's Procedures, i.e., 98-99% rice, amy more closely represent the actual proportion of the stomach contents that they occupied.

Table 18. Frequency of occurrence and aggregate volume of food items found in twenty _Rattus r. mindanensis_ stomachs analyzed following William's procedure.

Food Items	Frequencies		Volumes	
	Number	Percent	Sum of Field Occupied	Per Cent Volume
Oryza sativa	20	100	11705	90.0
Cyperus iria	4	20	611	4.7
Echinochloa colonum	1	5	173	1.3
Digitaria sp.	1	5	153	1.2
Insect	2	10	74	0.6
Unidentified plantations	6	30	293	2.2
TOTAL			13009	100.0%

Table 19. Frequency of occurrence and aggregate volume of food items found in twenty *Rattus r. mindanensis* stomachs analyzed following Tigner's procedure.

Food Items	Frequencies Number	Per Cent	Volumes Sum of Field Occupied	Percent Volume
Oryza sativa	20	100	12449	91.5
Echinochloa colonum	6	30	552	4.1
Cyperus iria	7	35	398	2.9
Insect	1	5	100	0.7
Unidentified plant items	3	15	105	0.8
TOTAL			13604	100.0%

From these comparisons, we suggest that the four procedures tested can be placed into two categories based on similarity of advantages and disadvantages. The procedures of Harrison and Fall have the advantage of greater simplicity and, perhaps, provide a more accurate estimate of the relative volumes occupied by major food items in the stomach contents. They do not, however, allow the specific identification of minor food items. The procedures of Williams and Tigner do allow specific identification of more plant items found in the stomach contents. They are more time consuming, however, and may underestimate the volumetric proportion of the stomach occupied by major food items.

We conclude that for studies at the Center where the principal objective is to determine major food item in the diet of rats (for example, in determining what food items compete with bait), the procedures of Harrison or Fall would be most applicable. However, in studies where detailed identifications of all plant species are required (for example, if looking for a critical food item that, if removed, would exclude rats from an area or alter their resistance to diseases or chemicals), then the procedures of Williams or Tigner should be employed.

Effects of Toxicant Concentration on Bait Acceptance by Philippine Rodents

Introduction

Toxicants in various formulations are widely used in the Philippines for the reduction of rat populations in ricefields by baiting. Use of bait materials has been unsystematic, depending primarily on cost and availability of local materials. While provisional recommendations for effective concentrations of various toxicants have been developed, it is probable that these are often not followed in operational control. Since most recommended concentrations were derived from collective experience with Norway rats, the effects on Philippine rodent species of varying concentration is uncertain. This study was designed to isolate the effect of toxicant concentration on the acceptance of bait by *R. r. mindanensis*, a common ricefield pest species in the Philippines. For most of the materials tested, adequate mortality would probably have occurred in cage trials over a fairly wide spectrum of concentrations when an attractive bait is presented against a standard food such as lab pellets. However, adequate bait acceptance continues to be a major problem in field operations where abundant food is available.

In this study, we used rice grains as bait because they are a material commonly used in field baiting and because they are the most abundant natural food in many situations where rodent control is required. Thus, the results are not only useful in assessing the degree to which toxicant concentration itself is a problem in the field acceptance of various materials, but also in providing a standard against which various proposed bait additives or enhancers might be compared.

Methods

Rats used in this study were all adult male *R. r. mindanensis*, collected in uncultivated and marshy areas near Lumban, Laguna, Luzon. They were kept in colony cages for at least one week before testing, where they were fed lab pellets and given water *ad libitum*.

Zinc phosphide, encapsulated norbormide, unencapsulated norbormide, warfarin, racumin, pival and chlorophacinone were tested. The following concentrations were intended for testing against untreated bait: for the chronic rodenticides -- 1) C_0 - Control, 2) C_1 - 1/3 the recommended concentration of the chemical to *R. norvegicus*, 3) C_2 - the recommended concentration, 4) C_3 - 3 times the concentration of C_2, 5) C_4 - 3 times the concentration of C_3, and 6) C_5- 3 times the concentration of C_4; for acute rodenticides -- 1) C_0- Control, 2) C_1- 1/2 the recommended concentration for R. norvegicus, 3) C_2- the recommended, 4) C_3- 2 times the concentration of C_3, 5) C_4- 2 times the concentration of C_3, 6) C_5- 2 times the concentration of C_4. However, calculation errors resulted in C_3 being prepared at 15 times (instead of three times) the concentration of C_2 for warfarin, racumin and piva'; and, C_5 being ten times (instead of three times) the concentration of C_4 for chlorophacinone.

Four rats were used at each concentration for every compound tested. The rats were caged individually. Carrier (rice) was placed in each cage for three days prior to each test, using alternately one of the two dishes that would be utilized on the test night. The amount of rice consumed during this period was recorded to determine average daily pretreatment consumption. Each of the six treatments (concentrations) were randomly assigned in the cages. Each toxicant was treated as a separate, independent test; i.e., there was no attempt to randomize cage position and date of treatment among toxicants. Baits were prepared by mixing measured amounts of technical material with polished rice. On the test night, the animals were offered a free choice in separate dishes of unpoisoned and poisoned rice of equal quantity. For convenience, each test took place during the sixteen hours (4 p.m. to 8 a.m.) that includes the major activity period of wild rats in the laboratory. Food in the dishes was weighed before and after each test to determine consumption.

Results and Discussion

Mean consumption for each of the treatment levels and toxicants are shown in Table 20. Consumption of treated baits were also expressed as a percentage of the total food taken (both dishes) for each toxicant and concentration (Table 21). Analyses of variance were performed on these data, with four replications for each test. Each compound was analyzed separately. Data were normalized as arcsine $\sqrt{\text{percentage}}$ for the statistical analyses, since results were expressed as percentages.

In general, increasing concentrations of toxicants were accompanied by lowered consumption of treated bait. With the acute toxicants, encapsulated norbormide was well accepted by the rats, even at twice the recommended concentration. Unencapsulated norbormide and zinc phosphide were not well accepted. The low acceptance of untreated rice in the reference dishes during the unencapsulated norbormide tests at 0% concentration is unexplained, but may have been the results of sampling error. The mean total consumption for these rats was 12.8 grams during the night of the test, similar to their mean nightly pre-feeding level of 11.8 grams per individual. Nevertheless, the high acceptance of encapsulated norbormide during these trials indicates that this compound and encapsulation procedure deserve further laboratory and field evaluations as a potentially effective tool for rat damage reduction

Table 20. Mean consumption of individually caged male adult rats exposed to one night feeding on treated and untreated polished rice in paired dishes. Animals (4/concentration) were pre-fed rice for three nights before they were exposed to the treatments.

Chlorophacinone Conc %	Chlorophacinone Acceptance g/rat/day T**	Chlorophacinone Acceptance g/rat/day U***	Pival Conc %	Pival Acceptance g/rat/day T	Pival Acceptance g/rat/day U	Racumin Conc %	Racumin Acceptance g/rat/day T	Racumin Acceptance g/rat/day U	Warfarin Conc %	Warfarin Acceptance g/rat/day T	Warfarin Acceptance g/rat/day U
0	7.7	5.0	0	3	9.5	0	2.7	3.2	0	5.2	5.5
.0016	1.0	12.0	.0083	.2	12.0	.0083	1.7	8.2	.0083	2.2	8.5
.005	1.0	5.7	.025	4.5	11.5	.025	.2	14.2	.025	1.5	10.5
.015	1.2	14.0	.375	2.7	7.2	.375	.2	8.0	.375	1.2	11.5
.045	.5	12.2	1.125	0	11.2	1.125	.2	10.5	1.125	1.7	8.0
.435	.7	14.0	3.375	0	13.2	3.375	.7	10.7	3.375	0.0	10.2

Norbormide Conc %	Norbormide Acceptance g/rat/day T	Norbormide Acceptance g/rat/day U	Norbormide* Conc. %	Norbormide* Acceptance g/rat/day T	Norbormide* Acceptance g/rat/day U	Zinc Phosphide Conc %	Zinc Phosphide Acceptance g/rat/day T	Zinc Phosphide Acceptance g/rat/day U
0	11	1.8	0	5.7	8.2	0	6.0	8.7
.5	1.0	11.0	.5	5.7	8.2	0.25	2.0	9.2
1	0.8	13.0	1	2.7	8.2	0.5	0.5	9.5
2	0.2	14.0	2	4.7	5.0	1	0	9.7
4	0.8	13.0	4	2.0	11.2	2	0	11.5
8	0.2	14.0	8	.7	10.5	4	0.5	11.7

*encapsulated, technical material
**Treated
***Untreated

Table 21. Mean consumption of treated bait, expressed as the percentage of total consumption. Rats, four for each test, were prefed polished rice for three days, then given a free choice of treated or untreated rice for a single night.

Toxicant	C_0[a]		C_1		C_2		C_3		C_4		C_5		HSD[d]
	A[b]	T[c]	A	T	A	T	A	T	A	T	A	T	T
Acute													
Norbormide	100	90	10.9	14.4	5.5	11.8	2.1	4.2	4.9	9.0	1.7	3.8	18.5
Norbormide[e]	100	90	42.4	40.6	30.7	30.0	32.8	31.0	11.1	14.1	4.5	8.6	49.1
Zinc Phosphide	100	90	38.9	34.8	2.9	5.0	0	0	0	0	10.0	9.8	35.8
Chronic													
Chlorophacinone	100	90	7.0	13.2	22.4	27.4	8.1	16.4	3.1	7.2	5.2	11.4[g]	12.1
Pival	100	90	1.8	3.9	28.1	31.0	28.4[f]	30.0	0	0	0	0	41.0
Racumin	100	90	15.7	16.7	1.7	3.8	2.8[f]	4.9	3.6	5.6	0	0	21.9
Warfarin	100	90	23.2	24.5	17.7	17.2	13.8[f]	18.5	23.7	25.6	0	0	47.8

a Concentrations. For acute toxicants: C_0, no toxicant; C_1, 1/2 x C_2; C_2, recommend level for *R. norvegicus*; C_3, 2 x C_2; C_4, 2 x C_3; C_5, 2 x C_4. For chronic toxicants, except as indicated: C_0, no toxicant; C_1, 1/3 x C_2; C_2, recommended level for *R. norvegicus*; C_3 x C_2; C_4, 3 x C_3; C_5, 3 x C_4.

b Actual % consumption

c Transformed % consumption = arcsine $\sqrt{\text{percentage}}$

d Highly significant difference, at 5% level.

e Encapsulated Norbormide

f C_3, 15 x C_2

g C_5, almost 10 x C_4

operations in the Philippines.

With all toxicants, increasing concentrations were also generally accompanied by lowered consumption, although results were highly variable. Results of analyses of variance on the transformed data indicate significant decreases in percent of bait acceptance only between the C_0 (reference) and the C_1 (lowest) treatment levels; acceptance was significantly lower between these levels for each of the compounds tested (Table 21). Although great differences in acceptance between other treatment levels were observed for some compounds, such as between C_1 and C_2 for zinc phosphide, these differences were not statistically significant. The statistical insignificance between some of these levels, as indicated by the variances listed in Table 21, was probably due to the high variability in daily food consumption that we have observed with R. r. mindanensis in these and other studies, and low sample sizes.

The results suggest that our experimental design requires greater sensitivity. This could probably be accomplished by increasing the numbers of rats (replications) for each test and, perhaps, by grouping the animals according to pretreatment feeding levels and employing analyses of covariance to normalize the resulting data. Future designs could probably also be improved by standardizing concentration levels and by using an incomplete randomized block design; that is, randomly assigning compounds and treatment levels over days of testing. These changes would allow direct comparison between the relative acceptance of bait treated with different compounds and concentrations.

Observations On An Exceptionally Dense Population Of Rats In Marshland

Introduction

While surveying crop damage by rodents in ricelands bordering the Laguna de Bay marshes south of Manila, Philippines we encountered a exceptionally dense population of wild rats (R. r. mindanensis) in a section of marsh near Mabitac, Laguna Province. The rat densities far exceeded any of our previous observations and were even more remarkable in that extensive nesting was occurring.

We first learned of the dense marshland population in early November, 1973, when farmers from Barrio Lukong, Mabitac, Laguna complained of heavy rat damage in their fields. On our first visit to the barrio, we found that much of the growing rice had been completely destroyed by rats. The barrio's agricultural lands comprised about 450 hectares and were farmed by about 300 individuals. Farmers told us that rat damage of this magnitude was not uncommon during the wet season crops (generally planted from June to August and harvested from October to December). On this first visit, we learned from farmers that rats were inhabiting the marshes, but we were unable to penetrate the area because of the thick vegetation and deep water. The numbers of rats occupying the damaged fields themselves appeared relatively low, based on examination of dikes for active burrows.

Methods

On two subsequent visits, we conducted a series of drives along the fringe areas of the wide marshland to obtain rough population estimates. Areas were arbitrarily chosen in the border vegetation (within 100 m of ricefields), which consisted chiefly of S. grossus, a tall sedge projecting 2 to 2.5 m above the waist-deep water.

In the first series of drives, on 13 November, seven 20 m x 20 m sections (400 m^2) of marsh area were laid out with the help of 20 men from Bo. Lukong. In each section, a 1 m strip of vegetation was clear-cut around the perimeter to form a barrier. Two sections of 2.5 cm-mesh nylon fish-net (approximately 1.3 m wide and 15 m long), tied loosely to pointed bamboo support stakes set at 1.5 m intervals, were placed at one corner of an area. Then, rats were driven to it by cutting the remaining vegetation. Setting the fence, completing the drive, and transfer to a new location required about one hour for each section. In four of the seven drives, some animals were collected alive for transfer to the laboratory. Farmers assisting in the drives killed the remaining animals with sticks or knives and kept the carcasses for use as food. In each section, the number of adults captured, the number of escapes observed, the number of nests, and the number of young per nest were recorded.

A second series of drives was conducted in three sections of marshland approximately 5 m x 5 m (25 m^2), in the same general area on 26 November. About 15 farmers participated in these drives; each operation required about one-half hour. In the period intervening between the two dates, the area had been flooded for 3 days by an approximately 1 m rise in the level of Laguna de Bay. According to farmers, the water had fully receded about four days before our arrival.

Results and Discussion

In the first series of 7 drives, a total of 2748 adult rat were captured (Table 22). Only 23 rats (less than 1%) were observed to escape by swimming under the net or by crossing the clear-cut barrier. The drives, then, provided an extremely efficient means for collecting adult rats from this habitat. Similar results were obtained in collecting 104 rats during the second series of drives which encompassed smaller sections of vegetation (Table 23).

In the earlier drives, 1098 nests were encountered as vegetation was cut. Of these, 587 contained young animals with the average litter size being 3.24. The size of litters in these nests was much lower than that reported previously from embryo counts of the same species in rice land. Sanchez, et al (1971) reported monthly mean litter sizes, of 5.00 to 9.09, while Marges (1972) found monthly mean litter sizes ranging from 6.50 to 11.18. We suspect that the lower litter sizes in this series of collections reflected increased infant and, perhaps, intra-uterine mortality related to the dense populations; however, no carcass examinations were made.

Nests were not counted during the second series of drives, but they were similarly abundant in the three sections of vegetation cleared. It appeared that the intervening flood had caused mortality of the entire litter production of rat populations throughout the area. We could not determine, however, whether adult rats left the area during the flood or simply moved higher up in the vegetation during the period of high water. Although systematic examinations of reproductive condition were not made, virtually all of the animals we personally handled appeared sexually mature.

As indicated in Table 23, densities calculated from the capture data averaged more than 1 rat/m^2 (or 10,000/hectare if extrapolated to a larger area). At the time of these observations, it was impossible for us to penetrate far enough into the marsh to determine the extent of the area occupied by the dense rat population; however, other reports from farmers suggest that dense populations occur commonly along the

Table 22. Adult rats, nests, and litters collected from seven 400 m^2 sections of marshland near Mabitac, Laguna, Philippines.

Section	Adults Rats Captured	Observed Escapes	Number of Nests	Percent of Nests with Litters	Juvenile Rats Recovered	Mean No. of Rats per Litter
1	420	6	202	40.6	316	3.85
2	478	11	172	60.4	320	3.07
3	369	3	256	38.2	417	4.25
4	314	0	106	67.9	208	2.88
5	506	2	79	64.5	122	2.39
6	253	1	182	60.4	311	2.82
7	408	0	101	69.3	208	2.97
TOTAL	2748	23	1098	-	1902	-
MEAN	392.6	3.3	156.9	53.5	271.7	3.24

Table 23. Estimated rat density (adults) in marshland habitat near Mabitac, Laguna, Philippines.

Section	Date	Size of Area (m^2)	No. of Adult Rats Collected or Observed	Estimated Density (rats/m^2)
1	11/13/73	400	426	1.07
2	11/13/73	400	489	1.22
3	11/13/73	400	372	0.93
4	11/13/73	400	314	0.78
5	11/13/73	400	508	1.27
6	11/13/73	400	254	0.64
7	11/13/73	400	408	1.02
8	11/26/73	25	28	1.12
9	11/26/73	25	55	2.20
10	11/26/73	25	21	0.84
			mean density ± s.e.$_{\bar{x}}$:	1.11 ± 0.14

marsh edges and may be forced into crop areas by rising water during the rainy season. By mid-March (during the dry season) water had receded from the area where the drives had been conducted and only short, dry remnants of the marsh vegetation remained. During this time, we observed evidence of rats occupying the lakeward edges of the border marshes, nesting in and feeding on water hyacinth (Eichornia crassipes), pond lily (Nelumbo nucifera), and other vegetation. The wide central areas of the marshland and the seasonal importance of the border marshes as harborage for dense rat populations require further investigation.

Many of the historical rat "outbreaks" in the Philippines as described, for example by Villadolid (1956) and by Crucillo et al, (1954) have occurred in areas adjacent to wide marshlands. We have repeatedly encountered reports of sporadically heavy rat infestations in areas bordering the Liguasan and Libungen marshes on the island of Mindanao, in agricultural areas bordering the Candaba Swamp and Chico River on Luzon, and in the area bordering Lake Naujan on Mindoro. While the less spectacular chronic crop losses due to the constant presence of rats in agricultural areas probably constitutes a more serious economic problem on a national scale, study of the border marshlands may lead to better means of crop protection in areas where rats limit agricultural production and to techniques for predicting and curtailing future "outbreaks."

Rats as a Potential Food Source

Introduction

Protein-calorie malnutrition is a major health problem in the Philippines. A national survey conducted during the 60's by the Food and Nutrition Research Center showed that the mean daily per capita intake of protein was 86.2% of the recommended daily allowance (RDA); calories were 76.5% of the RDA (Quiogue et al., 1969). The actual protein deficit is more severe than the above figures indicate because some of the protein, which would be used for growth and repair in humans with adequate calorie diets, is metabolized to meet energy needs in calories deficient individuals. In addition, two thirds of the protein eaten is from plant sources, and lacks several essential amino acids. This reduces the amount that can be reassimilated and used by the human body.

The sector of the Philippine population which is most severely affected by protein-calorie malnutrition are the infants (0-11 months) and preschoolers (12-72 months) in the rural areas (Sumabat, 1973). A survey of selected barrios throughout the country showed that over 80% of the preschoolers and 72% of the infants were malnourished to some degree. Of the malnourished preschoolers, 7.2% were severely affected (less than 60% of their normal body weight). These children may have lasting physical and mental defects that are associated with severe malnutrition at an early age (Eichenwald and Fry, 1969).

Fish are currently the most common source of animal protein in the Filipino diet, while pork and chicken are also frequently eaten. Rats, some of the larger fruit eating bats (eg. the "flying foxes"), frogs and other wild animals are commonly eaten by farmers and barrio folk. We have observed rats that were barbecued and sold in marketplaces for ₱2.00 (ca. $0.29) each. Large flying foxes, eg, Pteropis and Acerodon are caught with kites, poles or air guns, and sold for about ₱3.00 each on some of the islands. Harvesters sometimes "herd" rats in the field, skin and clean them, and dry the carcasses on piles of ricestraw for a meal.

These observations indicate that rats and other wild animals are an acceptable food source in many rural areas. They apparently are not fully utilized because lack of refrigeration requires that animals be eaten shortly after they are captured, and acceptable preparations that would retard spoilage have not been developed.

This study was performed in cooperation with the Food Science Laboratory of the UPLB to compare the human sensory characteristics and general acceptability of four sausages formulations, two prepared from pork and two from rat meat. Each of the formulations resulted in sausage that could be stored for extended periods of time, without spoiling and without refrigeration. Analyses of additional data collected will provide information on the weight percent of rat carcasses that are usable meat.

Materials and Methods

R. r. mindanensis were collected live from areas where rodenticides are not used, and returned to the laboratory. Here about ten kilograms of carcasses were obtained by skinning and removing heads, extremities, and viscera from about 400 rats, and frozen for preparation of the sausage.

At preparation, bones were removed from the carcasses and the remaining meat ground twice, using a grinder with a fine grill. Pork lean was also ground, while pork backfat was sliced into small cubes for sausage formations.

Four sausage preparations were used: A, 50% pork lean, 50% pork fat, B, 60% pork lean, 40% pork fat; C, 50% rat meat, 50% pork fat; and D, 60% rat meat, 40% pork fat. Five hundred grams of sausage mixture were prepared with each formulation, using the following additional ingredients (per kilogram):

salt	15 g
sugar	30 g
garlic	10 g
vinegar	10 ml
black pepper	4 g
pineapple juice	10 ml
vetsin	2 g
prague powder	4 g

The seasoning ingredients were added to the lean and fat mixtures, and blended thoroughly by hand in individual stainless steel bowls. Then the mixtures were cured for two days at 2-4°C. After curing, the mixtures were loosely stuffed into artificial casings to allow margin for linking.

The sausages were linked by applying manual pressure on the casings at 7-8 cm intervals. The unlinked ends were tied with coarse ply thread. These formulations were chilled prior to sensory evaluation.

For sensory evaluation, five sausages from each formula were fried in Baguio oil at 275°F (135°C) for 15 minutes. The oil was changed before frying each sausage to avoid contamination in flavor while cooking. Fried samples from each formula were sliced into 4-mm pieces and placed in individual trays. Four slices, one from each of the four sausage formulae, were served simultaneously to a panel of six judges for evaluation. The sausage samples were evaluated for tenderness, juiciness, flavor, off-flavor, and generally acceptability using a "9 point hedonic scale" system of scoring.

Results and Discussion

Mean taste panel scores for the four sausage formulations are presented in Table 24. The flavor of the sausage with 50 percent rat meat (C) was rated "good" (i.e., 7.0) as were both pork lean formulations. The formula D, with 60% rat meat, received the lowest flavor rating, 6.47. This is still considered "good", however.

Off-flavor ratings were observed for all formulations, and they were slightly higher for the sausages made from rat meat (C and D). The scores, however, are all well below 3, the level at which off-flavor ratings are considered perceptible enough to adversely affect the acceptability of a product. Saltiness was rated most satisfactory in the formulations that contained a lower proportion of meat. Formulae using rat meats (C and D), were rated more tender and juicy than the sausages containing pork.

Although statistical analyses are not completed, formula C (i.e., sausage with 50% rat meat) had a higher general acceptability score (7.07) than the other formulations tested, and sausages A and D (50% pork lean and 60% rat meat, respectively) were given the second highest rating (6.97).

Although the use of rats as a food source is frequently proposed as a potential means of permanently reducing rat populations and their damage to crops, we suspect that this approach would be largely ineffective. Other mass extermination programs including the use of acute rodenticides, clubbing, blanketing, flooding or fumigating burrows and a myriad of other rat killing methods, have frequently been employed in the Philippines. They result in large numbers of dead rats, but, as best we can tell, have no permanent effects on rat populations (which recover rapidly by immigration and high fecundity); similarly these approaches have apparently had negligible effects on rat damage to crops.

We also suspect that the small size of rats make them inefficient converters of vegetable matter to protein. Nevertheless, extremely dense

Table 24. Mean taste panel scores for four sausage formulations, two prepared from pork lean and two from rat meat. Six panelists were presented slices of sausage from each formulation, and asked to rate their sensory characteristics on a nine-point hedonic scale (0 = poor; 9 = exceelent).

			Sensory Characteristics			
Formula[a]	Flavor	Off-flavor	Saltiness	Tenderness	Juiciness	General Acceptability
A	7.12	1.20	5.70	6.43	6.37	6.97
B	7.07	1.13	5.13	5.73	5.97	6.90
C	7.00	1.40	5.63	6.73	6.50	7.07
D	6.47	1.33	5.20	6.63	6.80	6.97

[a] A, 50% pork loin, 50% pork fat; B, 60% pork loin; 40% pork fat; C, 50% rat meat, 50% pork fat; D, 60% rat meat, 40% pork fat.

populations of rats (sometimes in outbreak proportions) are commonly reported in many areas of the Philippines, frequently in marshes or uncultivated areas. We suggest that, if rat meat preparations can be formulated that are acceptable and stored for extensive periods without refrigeration, rat catching campaigns in these areas could yield sufficient numbers of animals to produce significant quantities of meat, and provide a supplemental inexpensive source of protein for rural people.

A number of additional studies should be conducted to provide an assessment of the actual potential of rats as supplementary food sources, including: determination of conversion efficiencies of rat carcasses to meat; determination of the protein, carbohydrate, and lipid composition of rat meat; and, certainly, rat carcasses from areas that may serve as food reservoirs, should be analyzed for pesticide residues to determine the possibilities of secondary health hazards. If data from these studies are satisfactory, other formulations of rat meat might be devised that could be prepared and stored successfully in the barrios.

Biological and Toxicological Studies on the Philippine Weaver

Introduction

Studies on the distribution and food habits of three pest species of Philippine weavers, L. malacca, L. punctulata, and L. leucogastra, have already been reported (Sanchez et al, 1973; Alviola et al, 1973). This year, preliminary studies on these species were directed toward an understanding of their damage as a function of crop age, development of damage assessment methods, toxicological studies of promising avicides or repellents, and reproductive characteristics. Similar studies will soon begin on a fourth species, P. montanus, which is also widely distributed in the Philippines and causes damage to crops.

Methods

Damage Potential

Four birds of each species were caged for a three-day adjustment period before the tests. Each bird was then placed in a separate cage with a single, potted rice plant (C-22 rice variety, plants averaging about 8 panicles) at 5:00 p.m. and kept in the cages for twenty-four hours. Cages consisted of wooden frames that were covered with 1.3 cm wire mesh; their sides were about one square meter in area, and 1.5 meters high. Roosting sites, partial shade, and a dish of drinking water were provided in each cage. Both green and mature rice were used.

After the testing period, the following data were recorded for each plant, starting with the tallest panicles: numbers of grains totally or partially eaten, number of grains shattered, and total number of fallen grains. The damage potential for each species was determined as indices of total damaged grains (eaten and shattered), percent of total grain damaged, and weight of mature grains damaged based on the weight of 100 filled grains at 14% moisture content. The percent indices were transformed to arcsine (arcsine $\sqrt{\text{percent}}$), while actual counts were transformed to logarithms. All indices were analyzed as a randomized complete block with 4 replications to test differences among species. Separate analyses were made for each index of damage and degree of grain maturity.

Damage assessment

Five one-square meter plots were picked randomly from a 25 meter square enclosure of maturing rice (C-22 variety). The rice plants in these plots were enclosed by cages, again one meter square per side with a height of 1.5 meters. Five birds were placed in each cage for 48 hours and given water *ad libitum*. After the birds were removed, the 20 tallest rice panicles showing damage were picked from each area. With the use of tally counters, the missing grains were counted. Length of damage on panicles and total length of panicles were measured in centimeters. The relationship between length of damaged panicle sections and the number of missing grains was determined by simple linear regression analysis.

Bioassay

Birds were collected in barrio Maytalang I, Lumban, Laguna. The birds were caught using 20 m mist nets with 3.8 cm mesh. The birds were held in a colony cage and maintained on rough rice and water for a minimum of 5 days before testing. Rice was removed 2-3 hours before the administration of toxicants. The test included control animals to correct for natural mortality.

Toxicology

The acute oral lethal dose to one-half of the test population (LD_{50}) was determined for each of two chemicals: methyl carbamate 75% W.P. (3,5-dimethyl-4-methylmercaptophenyl-N-carbamate) and fenthion 50% E.C. (0,0-dimethyl-0-(4-methylmercapto-3-methylphenyl)-thiophosphate). A single dose of the poison formulated at μg/μl using propylene glycol as carrier was administered by gavage to each of the test animals. LD_{50} values were computed following the method of Thompson and Weil (1952). Four birds were used for each determination.

In a second toxicological study, potted mature rice plants were sprayed separately with fenthion and methyl carbamate at 0.05%, 0.10%, 0.20% concentrations with three replications and a control for each treatment. *L. malacca*, *L. punctulata* and *L. leucogastra* were tested for fenthion, while only *L. malacca* and *L. punctulata* were tested for methyl carbamate. Sprayed plants were placed in a cage with one bird. The days until death of each bird were recorded. Damaged grains were also counted, using tally counters. Birds were considered survivors if they were alive after seven days of exposure to the sprayed plants.

Reproductive Cycle

Observations were made on numbers of new nests, nests with eggs, and nests with fledgelings for *L. punctulata* at four different sites on the UPLB Campus. Site I was an aurucaria tree near the Old Applied Math Building. Site II was a fig tree near Biological Sciences Building. Site III was a pandanus tree in front of the Humanities Building, and Site IV was a rambutan tree near the Physical Plant Building.

Results and Discussion

Damage Potential

Both L. malacca and L. leucogastra damaged rice by picking a seed from the panicle and removed the husk to eat the grain. L. punctulata usually squeezed grain from the husk without taking seeds out of the panicle, especially during the milk and dough stages (lumped together as green rice). L. malacca picked seeds starting from the base of the panicle, while L. leucogastra picked seeds in a random fashion, resulting in damage that was evenly distributed along the panicle. With L. punctulata, rice seeds were starting from the tip of the panicle.

All three species usually fed while perched on panicles. This behavior caused additional damage; some panicles broke when the birds alighted on them and grains were often dropped of loosened (shatter) without being eaten. Only L. leucogatra was observed to feed on fallen grains.

Table 25 summarizes the nature and distribution of damage to rice by weavers under simulated field conditions. Overall damage to green and mature rice were about the same for the 3 species. On the average, L. malacca destroyed 380 green and 379 mature seeds; L. leucogastra destroyed 349 green and 306 mature grains, and L. punctulata destroyed 454 green and 330 mature grains during 24 hours. These figures represented 30-50% of the total grains exposed or 6.98 to 10.35 grams of rice (14% moisture content) per bird-day. Analysis on the transformed indices of each type of damage showed no significant differences of damage potential of the three species. Likewise, the three species were equally destructive to green and mature rice.

Damage Assessment

The relationship between lengths of mature panicle sections having bird damage and the number of grains lost was determined from 100 panicles with varying lengths of damage. Simple linear regression analysis indicated the following relationship:

$$\bar{y} = -17.65 + 7.52\ \bar{x}$$

where $\bar{x}$ = length of damage in the panicle in centimeters

and $\bar{y}$ = no. of grains loss

Estimates of average grain loss for a corresponding length of damage were then tabulated, based on this regression equation. We view this as a preliminary attempt at simplifying bird damage appraisal in the field, and the reliability of the table requires additional study. Once

Table 25. Potential damage on rice hills exposed for twenty-four hours to three species of Philippine Weavers, Genus Lonchura

Type of Rice	Type of Damage	Species: *L. malacca* Mean	Range	*L. punctulata* Mean	Range	*L. leucogastra* Mean	Range
Green Rice	No. of grains eaten	336	70-570	340	190-440	186	60-450
	No. of dropped grains	43	5-120	115	20-300	82	40-130
	Total No. of grains damaged	380	140-620	454	300-600	349	140-640
	Total No. of filled grains	1159	550-1790	1308	690-2260	1209	710-1640
	Percent Damage	35.5	12.1-80.3	41.9	13.2-64.1	29.2	14.9-50.0
Mature Rice	No. of grains eaten	176	120-260	138	90-160	214	180-260
	No. of dropped grains	101	50-180	68	40-130	46	30-70
	Total No. of grains damaged	379	220-540	330	180-500	306	250-360
	Total No. of filled grains	1064	720-1540	850	430-1380	1077	710-1470
	Percent Damage	37.3	20.9-55.2	40.3	30.2-56.8	30.5	23.2-38.5

Once established, a field man may only have to measure length of damage in the field to estimate the amount of rice damage.

Toxicology

Table 26 suggests that L. leucogastra was most sensitive to fenthion, while L. malacca was most sensitive to methyl carbamate. L. punctulata was the least sensitive of the three species to both compounds. The LD_{50} of fenthion on L. punctulata was about twice that for L. malacca and five times that of L. leucogastra. On the other hand, the LD_{50} of methyl carbamate for L. punctulata was about ten times that of the other two species.

Table 27 shows the relative toxicity of these chemicals when sprayed on rice plants. All birds died that were caged with plants sprayed with 0.20% concentration of fenthion. Two days were required for mortality of L. punctulata and one day for the other species. Methyl carbamate sprayed to grains at 0.05, 0.10 and 0.20% concentration killed 67% of the L. punctulata after three days feeding but failed to kill any of the L. malacca. Percent mortality and the acute toxicity studies indicated the same relative sensitivities of these species to both compounds.

Both fenthion and methyl carbamate reduced the number of grains damaged by the three species, but fenthion appeared to be more effective in this regard. Consumption of sprayed grains usually decreased with increasing concentration. The large number of grains damaged by L. leucogastra at 0.20% spray was probably due to the shattering habit of this species.

Reproductive Cycles

Our observations indicate that L. punctulata bred from March through September on the UPLB Campus (Table 28). New nests were first observed in March, but were most common from April-June. Nests with eggs were first seen in April, and were common until August. Nests with young were common from May through September. Future studies will provide additional information on the biotic potential and reproductive behavior of Philippine weavers, which will be required for the development of management programs.

Table 26. Acute oral toxicities of fenthion and methyl carbamate to Philippine Weavers, based on the method of Thompson and Weil (1952). Results are presented as means for the four birds used in each determination. Ranges are in parentheses.

Species	LD_{50} (mg/kg) Fenthion	Mesurol
Lonchura leucogastra	.49 (.25-.98)	1.84 (0.95-3.56)
L. malacca	.89 (.42-.95)	1.28 (.63-.44)
L. punctulata	2.39 (.14-3.93)	18.00 (4.78-67.89)

Table 27. Response of Philippine Weavers to methyl carbamate- and fenthion-sprayed rice plants. Results are averages of three replications for concentration level and compounds. Each bird was exposed individually by placing it in a cage with a sprayed plant until mortality occurred.

Species	Concentration (%)	Fenthion			Methyl Carbamate		
		Grains Damaged	Mortality time* (days)	Percent Mortality	Grains Damaged	Mortality time* (days)	Percent Mortality
L. malacca	0.05	23	1	33	49	-	
	0.10	19	1	67	109	-	
	0.20	35	1	100	57	-	
	Control	176	-	0	173	-	
L. punctulata	0.05	120	2	67	186	2	67
	0.10	80	2	100	45	2	67
	0.20	54	2	100	57	3	67
	Control	172	-	0	324	-	-
L. leucogastra	0.05	85	1	33			
	0.10	52	1	33			
	0.20	157	1	100			
	Control	180	-	0			

* excludes survivors

Table 28. Reproductive data for *L. punctulata* at four locations on the campus of the University of the Philippines at Los Banos.

Months	New Nests						Nests with Eggs						Nests with Young					
	Sites						Sites						Sites					
	I*	II	III	IV	Total	Mean	I	II	III	IV	Total	Mean	I	II	III	IV	Total	Mean
March	2	3	2	5	12	3.0	0	0	0	0	0	0	0	0	0	0	0	0
April	5	3	4	8	20	5.0	3	2	3	4	12	3.00	0	0	0	0	0	0
May	7	2	3	7	19	4.75	6	3	4	6	19	4.75	2	2	2	3	9	2.25
June	3	3	3	9	18	4.50	5	3	3	8	19	4.75	5	3	5	5	18	4.50
July	2	0	1	3	6	1.50	3	1	2	8	14	3.50	7	3	3	10	23	5.75
August	0	0	0	1	1	0.25	2	1	1	5	9	2.25	3	1	2	8	14	3.50
September	0	0	0	0	0	0	0	0	0	2	2	0.50	2	1	1	7	11	2.75
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Site I, an aurucaria tree near the Old Applied Math Building; Site II, a fig tree near the Biological Sciences Building; Site III, a pandanus tree near the Humanities Building; and Site IV, a rambutan tree near the Physical Plant Building.

Center staff provided training in rat control to over 1000 agricultural technicians, extension agents, and key farmers during 1974.

TRAINING ACTIVITIES

TRAINING ACTIVITIES

Introduction

The Center has been increasingly active in training and extension within recent years. During this year, staff members provided resource lectures, laboratories or demonstrations on rodent control to over 1000 government extension personnel and key farmers from the Philippines and other countries. 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. Numerous requests for technical information on rodent control were filled with Center publications or copies of appropriate material from our library.

Workshops and In-Service Training

In preparation for the launching of the Philippine Government's "Masagana 99 - Phase II" and "Masaganang Maisan" programs, several two-week courses were conducted at IRRI and UPLB. In addition, a five-month specialist course on rice production and another on corn production were conducted by the Department of Agronomy, UPLB. The purpose of these courses were to update the knowledge of technicians on the methods and skills in crop management practices and to present principles of agricultural extension, farmer cooperatives, and supervised farm credit. These workshops offered an opportunity for Center staff members to present current information on rodent biology and control. More than 500 technicians from the Bureau of Plant Industry and Bureau of Agricultural Extension (BAE) were involved.

Center staff members also presented lectures on vertebrate pest control in seven, one-month Supervised Farm Credit Courses involving over two hundred Philippine National Bank (PNB), loan officers. These courses were conducted under the auspices of the PNB and the Agricultural Credit and Cooperatives Institute. Sessions on rodent biology and control were also presented to the about 50 trainees who attended the six-month Rice Production Course or the Multiple-cropping Courses at IRRI. Sessions on rodent control practices were also presented to 12 Vietnamese trainees who attended a two-week rice production course at the Department of Agronomy, UPLB.

During the year, the Center participated in in-service field training programs for several hundred field technicians from BPI, BAE, and Department of Agrarian Reform. This field training, conducted under the auspices of the BPI was aimed towards updating the knowledge of the trainees on new developments and procedures in agricultural pest control, particularly rodents.

International Training

Participatory research training was initiated at the Rodent Research Center in late 1972. In this program trainees from Asian Countries, depending on their background and objectives, spend from two to six months attached to the Center staff and participate in a variety of on-going research and 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. Trainees are also given the opportunity to visit and observe related studies being conducted by other agencies and to visit operational rodent control programs in various parts of the Philippines. Participants in this program have received support from United Nations Development Programme Projects and USAID and from the governments of the Netherlands, Indonesia, Nepal, South Korea and South Vietnam.

Two Vietnamese participants completed this program in 1974. Mr. Le Quan Dinh and Miss Nguyen Tahi Dau, arrived in July and remained at the Center for about three months, under the sponsorship of the government of South Vietnam and USAID.

Graduate Training

The opportunity for Master's degree work in vertebrate pest management is available through the University of the Philippines at Los Banos (UPLB). Scholarships, funded by the National Economic and Development Authority (NEDA) and developed through the cooperation of the Rodent Research Center board are available, to provide full support to qualified students. Additional support for books and research expenses is provided by the Bureau of Plant Industry. Graduate students have office space at the Center and make use of its facilities in conducting their research; senior staff members or other university faculty members may serve as graduate advisors. Under this program, five students have completed the requirements for the M.S. degree and six others are currently involved. The three M.S. graduates who joined the research staff of the Center are currently pursuing Ph.D. degrees in Pest Management, one under a PCAR Graduate Fellowship, others with UPLB's reduced fee privilege. Mr. Bienvenido Estioko, another PCAR Graduate Fellow, from the Philippine Sugar Institute (PHILSUGIN), is also pursuing Ph.D. degree in pest management at the Center. Mr. Marcelino Dalmacio, who carried out thesis research at the Center, received his M.S. degree in the UPLB College of Forestry in 1974.

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 classes from other Philippine colleges visited the Center for special lectures or demonstrations on vertebrate pest control.

Barrio farmers receive instructions on the use of bait stations in preparation for a field evaluation of a potential control procedure.

RESEARCH UTILIZATION

Sustained baiting with anticoagulants, a method of reducing rat damage to rice crops that includes procedures and innovations developed and tested at the Center, has been included in the interagency rice recommendations for use in the Government of the Philippines' national rice production program, Masagana-99. This program provides non-collateral loans of up to ₱1200 (ca. US $170) per hectare for the purchase of modern farming materials, including seeds, fertilizers, and pesticides. Each farmer works under the supervision of an agricultural technician to insure that the recommended practices are followed. Loans are repaid at each harvest and new loans are made for the next crop. Under the program, participating farmers can borrow up to ₱50 (ca. US $7) per hectare for purchase of chronic rodenticides and materials for sustained baiting. It is anticipated that the program will reach farmers on 74,750 hectares with ₱3,737,500 (ca. US $530,000) provided for initial loans. The Bureau of Plant Industry has also proposed ₱3,266,916 (ca. US $470,000) for government rat control operations on 199,000 hectares of non-program farms and wasteland areas.

An important aspect of the program was the recent administrative reorganization of agencies involved with rodent control to facilitate implementation and on-going evaluation of the program. This new administrative scheme establishes national, regional, and provincial councils to coordinate national rat control activities with a full-time coordinator for each council. This arrangement bring together the formerly separate programs of several Philippine agencies and provides an excellent channel through which subsequent program modifications can be introduced. In addition, the proposal includes a rodent control workshop, to be held at the Rodent Research Center, for the sixty-one regional and provincial rat control coordinators who will work with the new program.

A pilot test of these programs is being planned for Zamboanga del Sur, a province with a long history of high, sometimes irruptive rat infestations. Farmers on almost 50,000 hectares of ricefield and wasteland areas will be involved.

INTERNATIONAL ACTIVITIES

Center staff members participated in a "Regional Training Seminar on Field Rat Control and Research" held from 4-15 March 1974, in Manila. Representatives including those from Bangladesh, Korea, Indonesia, Malaysia, Philippines, Sri Lanka, Taiwan, Thailand, summarized the current status of vertebrate pest problems, research, and control in their own countries, and participated in seminars and training sessions on vertebrate pest management. Four Center staff members presented a total of ten seminars at the conference, ranging in topics from "Rat Anatomy and Physiology" to "Vertebrate Pest Problems in Southeast Asia," and the nearly 60 conferees and observers spent one day at the Center for demonstrations.

Center staff members also participated in a "Conference on Plant Protection in Tropical and Sub-Tropical Areas" held from 4-15 November 1974, in Manila. Representatives discussed a wide variety of problems and needs for crop management in tropical agriculture. Director Sanchez presented two seminars at this conference; other staff participated in working-group discussions on rodent control and on pesticide residue problems at the meetings.

Director Sanchez participated in two pest management workshops at the East-West Center's Food Institute in Hawaii, presenting material on Vertebrate pest problems in developing countries and on graduate training programs in the Philippines. He also visited the Wildlife Research Center at Denver (DWRC) to review Center programs and plan cooperative projects with DWRC staff.

GRADUATE STUDENT RESEARCH

Chemical Protectants for Benguet Pine Seeds Against Rats. 1974. Marcelino Valerio Dalmacio. Unpublished thesis, Dept. of Forestry, University of the Philippines at Los Banos (abstract).

The study was conducted as an initial phase of developing seed protectants against rats for Benguet pine seeds to be used in direct seeding. The effects of seven chemicals on the germination of Benguet pine seeds were studied. Repellent activities of those chemicals at concentrations which had not affected germination adversely or those that reduced it by not more than 15 percent were evaluated on caged *R. r. mindanensis* and *R. argentiventer*. The liquid formulation of endrin at one and two percent active ingredient greatly reduced and delayed germination. Germination value, a term combining speed and completeness of germination, was significantly reduced by 7.5 and 3.75 percent thiram treatments and slightly reduced by 2.0 and 1.0 percent aldrin treatments, respectively. DDT and latex did not affect germination. Dieldrin and vetox were toxic to the seeds; reduction in germination was directly related to chemical dosage. Preliminary feeding tests showed that thiram, aldrin and dieldrin treatments reduced seed consumption by rats by 80 percent or more. The Rhothane formulation of DDT was moderately effective, while DDT and vetox were only slightly effective. Rodent species and weight did not influence seed consumption. In the second test series, 7.5 percent thiram and 2.0 percent aldrin reduced seed consumption by 77 and 78 percent, respectively on the first treatment day; seed consumption on succeeding days was negligible. Good repellency was also obtained with 3.75 percent thiram and 1.0 percent aldrin. Dieldrin at 1.25 percent was only moderately effective. Ecological acceptability was suggested as an additional criterion for evaluating chemical seed protectants. Evaluation of thiram and aldrin treatments in the field was recommended.

Bait stations such as these allow easy access to food by rats, and can be constructed at negligible costs by farmers from locally available materials.

THE CENTER LIBRARY

In May, 1974, the Rodent Research Center established a small, specialized library which has since received the full attention of a newly hired staff member. The library emphasizes acquisition of current materials on vertebrate biology, ecology, and management, although it has gratefully accepted contributions on other subjects. A Library Committee has been established which determines the goals, operational systems, and rules and regulations for use of the library.

The primary function of the library is to make available resource materials, including books, journals, reprints, publications and reference materials, and to organize them for easy accessibility by Center staff and other users. Acquisition to date have been primarily by voluntary contributions from other organizations and persons, although the Center does maintain subscriptions to some journals, and purchases some specialized volumes. In its first year, the library has grown to include 665 books and pamphlets, 53 center publications, 648 reprints, 55 periodicals with a total of 847 volumes, 75 maps and almost 250 photographic negatives. Organization of these materials involves the use of author, numerical, subject, and title indices. A subject cross reference system will soon be started for the reprint collection.

The library has a growing list of users, including Center staff, but also Center scholars and UPLB students, and a few students from other universities. Permanent users are issued library cards and loan materials according to the library policy. The library room is air-conditioned and has work space for persons who require only the brief use of its resources.

In addition, the library fills requests for reprints or other information and maintains a mailing list for the Annual Report. This year, about 160 articles and 152 Annual Reports were mailed, upon request, to researchists, extension personnel and other libraries in the Philippines and many other countries of the world.

Future functions of the library will include periodic literature searches on selected areas of vertebrate pest management, development of appropriate bibliographies, and the distribution of content lists for journals that frequently publish articles on vertebrate biology and control.

SUMMARY OF ACCOMPLISHMENTS

1. Full or part-time Center staff included eleven biologists, one biometrician, two field technicians, one laboratory technician, two trainees from other countries, and ten supporting staff.

2. A national survey conducted with the Bureau of Plant Industry suggested that twenty-four provinces had over 5,000 hectares of ricefields with severe rat damage or high damage potential; twenty-one province had between 1,000-5,000 hectares of severely infested ricefields; and twenty-five provinces had less than 1,000 hectares of severely infested ricefields. Wet season and dry season crops showed similar overall proportions of severe infestation -- 38.5% and 42.4%, respectively. These data will be used to establish priority areas for national crop protection efforts and will help to provide a basis for the estimation of actual rice losses to rats on a national scale.

3. A trapping study of a productive upland crops area in Barrio Calc, Tanauan, Batangas suggested that *M. musculus* were found principally in houses; *R. exulans* was present in all habitats, but particularly abundant in coconut groves; and *R. r. mindanensis* and *S. murinus* were common in ricefields, cornfields, ground level vegetable plots, coconut groves, and sugarcane areas. The numbers of fallen nuts in the coconut study area increased significantly when nearby fields were being harvested. Breeding appeared continuous among all the species encountered. The ongoing examination of stomach samples from collected specimens should provide additional information on the food preferences and habitat ranges of the rodent species in this area.

4. A baiting program using anticoagulants was evaluated on a 12 hectare rice farm adjacent to marshes where *R. r. mindanensis* had limited production for two growing seasons. The farmer was able to harvest 84 cavans/hectare, over twice his two previous harvests. His net profit was about ₱2900 per hectare, with ₱37 per hectare investment for sustained baiting. At harvest about 5.6% of the rice tillers had been cut by rats. A reference area received negligible rat control; over 90% of the tillers were cut by rats in the area and only 2.5 cavans per hectare on his crop. Data strongly suggest that this type of baiting program can provide a critical boost in production by reducing rat damage in situations where it limits yield, and by minimizing it in situations where other limiting factors are involved.

5. Another baiting trial was conducted on Mindoro Oriental in a 135 hectare ricefield area where R. argentiventer was a major pest and where heavy rat damage had limited production in the past. A 106 hectare ricefield with similar habitat and rice production practices was used as a reference area. Rat activity in the treated area was reduced to a level significantly lower than the reference area throughout the growing season. In the reference area, 27.6% of the rice hills were damaged by rats, while in the treated area only 4.0% were damaged. Farmers in the treated area harvested 42.3 cavans per hectare, almost twice the average harvest in the reference area (23.3 cavans per hectare). Pre-treatment and post-treatment rat activity levels and harvests during the past wet season crop, did not differ significantly between the areas. Rat control in the treated area cost about ₱20 per hectare; while farmer profits averaged ₱1,454 per hectare -- nearly three times that of the reference area (₱530 per hectare). Since production investments other than rat control were similar, we concluded that sustained baiting with chronic toxicants provided highly beneficial damage reduction in an area where R. argentiventer had limited production.

6. A study comparing four methods of analyzing food contents of Philippine rats showed that the use of histological techniques markedly increases the accuracy in identification of minor food items in rodent stomachs; however, this technique may underestimate the volumetric proportions of the stomachs occupied by major food items. Simpler methods may provide more accurate volumetric information, but did not allow specific identification of minor food items.

7. A preliminary test of sipaet, a variety of rice from Sumatra that was claimed by farmers to be resistant to rats, received significantly less damage than a local variety (C4-137) in a test with individually-caged rats. These results probably indicated the ability of rats to express food preferences; it is likely that the "resistant" varieties would still suffer damage under no-choice field conditions. Varietal preferences deserve further study to discover factors that allow rats to discriminate differences among varieties.

8. The effects of toxicant concentration on bait acceptance by R. r. mindanensis were evaluated for three acute toxicants and four chronic rodenticides. Of particular interest, encapsulated norbormide was well accepted over a wide range of concentrations. Unencapsulated norbormide and zinc phosphide were poorly accepted, even at low concentrations. In general, increasing concentrations of toxicants were accompanied by lowered consumption of treated bait.

9. Observations in marshland areas revealed localized breeding populations of R. r. mindanensis that exceeded 1 rat/m^2 suggesting that such areas bordering agricultural lands may be involved in the erratic rat outbreaks that have occurred in the Philippines in the past.

10. Preliminary work was begun to develop rat meat formulations that are acceptable and can be stored without refrigeration. A taste panel found that two sausage formulations prepared from rat meats were similar to two made from pork in general sensory characteristics, including flavor, tenderness and juiciness, and rated one of the rat sausage formulations as having the highest general acceptability.

11. Cage studies, conducted on three species of Philippine weavers (L. punctulata, L. malacca and L. leucogaster), indicated that these birds have the potential of removing or destroying 7-10 grams of rice grain per bird-day. They damage both green and maturing rice. Significant differences in feeding patterns were noted, which may allow recognition of damage by different species in field appraisals.

12. Acute oral toxicities of two compounds, fenthion and methyl carbamate were determined for the three species of Philippine weavers, and birds were caged in ricefield plots treated with 0.05-0.20% of these chemicals. Results indicated that all three species are more sensitive to fenthion than methyl carbamate, and that L. leucogaster is least sensitive to either compound.

13. Over three hundred visitors from many countries were briefed in Center activities, given technical assistance in the form of literature on rodent control, or advice on program planning. About 160 requests for technical information on rodent control were filled with Center publications, and others with copies of appropriate material from bibliographic files.

14. Staff members participated in several two-week courses for more than 500 extension workers and technicians from the Bureau of Plant Industry and Agricultural Extension as part of the "Masagana 99 - Phase II" and "Masaganang Maisan" programs. Centers staff also presented lectures on vertebrate pest control in seven, one-month courses for over two hundred Philippine National Bank loan officers, and in the six-month rice production and multiple-cropping courses at IRRI. Center staff also participated in the in-service training of several hundred field technicians from the Bureau of Plant Industry, Bureau of Agricultural Extension, and the Department of Agrarian Reform.

15. Two research trainees from South Vietnam spent a total of six months participating in a variety of on-going research and methods evaluation studies and worked independently on project proposals related to pest problems in Vietnam.

16. One student completed requirements for a M.S. degree in the College of Forestry at the University of the Philippines at Los Banos under a PCAR scholarship program.

17. Staff members taught or helped teach courses in Vertebrate Pests, Mammalogy, and Wildlife Management at the University of the Philippines at Los Banos, with several classes and laboratories held at the Center.

18. Interagency rice recommendations for sustained baiting with anticoagulants were released for use in the Government of the Philippines' national rice production program, Masagana-99. The procedure will also serve as the technical basis for a national rat control program proposed by the Bureau of Plant Industry to cover 199,000 hectares of non-Masagana-99 ricefield and wasteland areas. A pilot test of these programs was planned for Zamboanga del Sur in early 1975.

19. Center staff participated in the "Regional Training Seminar in Field Rat Control and Research", held in March 1974, and the "Conference on Plant Protection in Tropical and Sub-tropical Areas," held in November, both in Manila.

20. A small library was established at the Center to organize and maintain resource materials for staff and other users. The library now includes 665 books and pamphlets, 53 center publications, 648 reprints, 55 periodicals, and numerous reference materials.

21. The following reports were published or presented in proceedings of meetings by Center staff members:

Benigno, E.A. 1974. Population estimation. Rodent Research Center, College, Laguna. 9 pp. (mimeo).

Benigno, E. A. 1974. Response of ricefield rat populations to massive reduction. Proc. 5th Nat. Pest Cont. Council Conf. 5: 60 (Abstract only).

Benigno, E. A. P. L. Alviola III, F. F. Sanchez, M. M. Hoque, and G. V. Llaguno. 1974. Damage potential of three species of Philippine Weavers belonging to the genus Lonchura. Proc. 5th Nat. Pest Cont. Council Conf. 5: 64 (Abstract only).

Fall, M. W. 1974. Field evaluation. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/8: 74-03-05. 2 pp.

Fall, M. W. 1974. Principles of pest management. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/7: 74-03-05. 4 pp.

Fall, M. W. 1974. Technical review-methods and strategies. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/5: 74-03-05. 5 pp.

Fall, M. W. 1974. The use of red light for handling wild rats. Lab. Anim. Sci. 24(4): 686-687.

Hoque, M. H., F. F. Sanchez, and B. M. Rejesus. 1974. The toxicity of four anticoagulant rodenticides to Rattus rattus mindanensis Mearns. Proc. 5th Nat. Pest Cont. Council Conf. 5: 68 (Abstract only).

Llaguno, G. V. 1974. Rat anatomy and physiology. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/2: 74-03-04. 13 pp.

Reidinger, R.F., and D. G. Crabtree. 1974. Organochlorine residues in golden eagles, United States -- March 1964-July 1971. Pestic. Monit. J. 8(1): 37-43.

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Sanchez, F. F. 1974. Summary of Rodent Research Center Program. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/9: 74-03-05. 4 pp.

Sanchez, F. F. 1974. Vertebrate pest management. Proc. Conf. on Plant Protection in Tropical and Sub-Tropical Areas. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 November. WP/25: 74-11-08. 12 pp.

Sanchez, F. F. 1974. Vertebrate pest problems in Southeast Asia. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme,Manila, 4-15 March. RCR/4: 74-03-05. 5 pp.

Sanchez, F. F. 1974. Vertebrate pests and their control in the pest management context. Presented at the Workshop on the Professional Doctorate in Pest Management, Honolulu, Hawaii, 10-14 June. 15 pp (RRC mimeo).

Sumangil, J. P. 1974. Problems related to classification of rats. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/6: 74-03-05. 5 pp.

Sumangil, J. P. 1974. Rat biology: behavioral patterns. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/3a: 74-03-05. 5 pp.

Sumangil, J. P. 1974. Rat biology: ecology. Proc. Regional Training Seminar on Field Rat Control and Research. BPI-RP German Crop Protection Strengthening Programme, Manila, 4-15 March. RCR/3: 74-03-04. 5 pp.

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