AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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BATCH #14

1. SUBJECT CLASSIFICATION	A. PRIMARY: Serials	Y-AH10-0000-G732
	B. SECONDARY: Agriculture--Pests of plants--Philippines	

2. TITLE AND SUBTITLE
Rodent Research Center,Laguna,Philippines: 1971 annual progress report

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

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1972	87p.	ARC

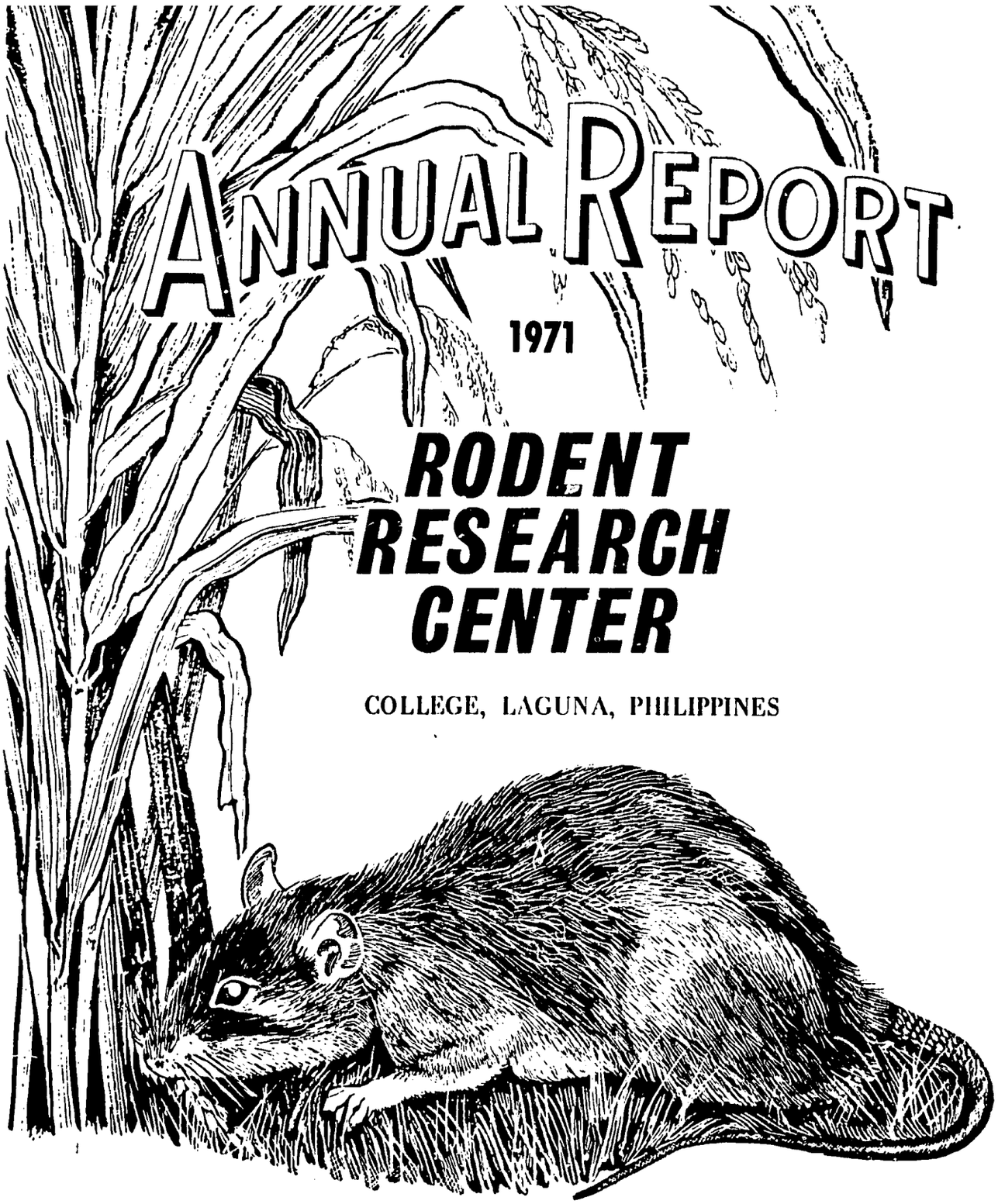
7. REFERENCE ORGANIZATION NAME AND ADDRESS
Interior

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

9. ABSTRACT

10. CONTROL NUMBER PN-RAA-713	11. PRICE OF DOCUMENT
12. DESCRIPTORS Pest control Philippines Rodents	13. PROJECT NUMBER
	14. CONTRACT NUMBER PASA RA(ID)1-67 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)



ANNUAL REPORT

1971

RODENT RESEARCH CENTER

COLLEGE, LAGUNA, PHILIPPINES

COOPERATING AGENCIES

REPUBLIC OF THE PHILIPPINES:

National Economic Council
Bureau of Plant Industry
University of the Philippines, College of Agriculture

UNITED STATES:

Agency for International Development
Denver Wildlife Research Center
Bureau of Sports Fisheries and Wildlife

RODENT RESEARCH CENTER
1971 ANNUAL PROGRESS REPORT*

PRINCIPAL INVESTIGATORS:

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Republic of the Philippines -

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Agency for International Development
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Denver Wildlife Research Center
(Work Unit DF-104.2)

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TABLE OF CONTENTS

	Page
ABSTRACT	iv
RODENT RESEARCH CENTER STAFF — 1971	vi
INTRODUCTION	1
Program	1
Research	2
Training and Extension	2
RESEARCH ACTIVITIES	4
The National Damage Survey for Losses of Growing Rice to Rats in the Philippines	4
Preliminary Observations on Rat Damage to Rice Varieties FK178A and IR22 in Relation to Age With Notes on the Subsequent Retillering of IR22	12
Comparison of Population Sampling Techniques Used on Philippine Rodents	15
Comparative Study of Populations of *Rattus rattus mindanensis* on Rainfed and Irrigated Ricefields of Luzon, Philippines	29
Acceptance of Common Food Items by *Rattus rattus mindanensis* and *Rattus argentiventer*	38
Laboratory Evaluation of Lethal Agents	45
Weatherability of Zinc Phosphide Treated Bait	49
Evaluation of Aerial Dispersal of Zinc Phosphide Baits for Rodent Damage Control	53
Field Trial of Multiple Baiting with Zinc Phosphide to Protect Growing Rice from Damage by Rats (*Rattus rattus mindanensis*)	57

Page

MISCELLANEOUS STUDIES AND OBSERVATIONS 63

Growth of Young Rats In Relation to Litter Size 63

Bait Placement Study 65

Ricefield Rats Are Not Entirely Dependent Upon Burrows for Daytime Refuge or Nesting 65

Artificially Flavored Rice Not More Attractive to Rats Than Natural Rice 67

Radio-tracking Studies with Rattus argentiventer 67

Rat Damage to Bananas 68

GRADUATE STUDENT RESEARCH (Abstracts) 69

Burrows and breeding of ricefield rats in Cotabato, Philippines. 1971. Jesus P. Sumangil. Unpublished thesis, Colorado State University. 38 pp. 69

Seasonal food habits of Rattus rattus mindanensis (the Philippine ricefield rat) in Central Luzon. 1971. James R. Tigner. Summary of thesis project, University of Colorado. 70

The reproduction and seasonal abundance of the common ricefield rat, Rattus rattus mindanensis Mearns, at Siniloan, Laguna. 1971. Bernardo E. Marges. Summary of thesis project, University of the Philippine College of Agriculture. 71

Estimating population parameters of the ricefield rat (Rattus rattus mindanensis). 1971. Edwin A. Benigno. Summary of thesis project, University of the Philippines College of Agriculture.

PUBLICATIONS AND MANUSCRIPTS (Abstracts) 74

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Page

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A comparative chromosome study of Rattus rattus mindanensis and Rattus argentiventer. Doris H. Wurster and G. C. Atwell. Unpublished manuscript. 16 pp. 75

SUMMARY OF ACCOMPLISHMENTS 76

LITERATURE CITED 79

ABSTRACT*

During 1971, Rodent Research Center personnel continued to participate with the Bureau of Plant Industry in a national survey for rat damage to lowland rice. Examination of cut rice tillers (stems) in 1577 sample paddies in major rice producing provinces during the 1970 wet season and 1971 dry season revealed an estimated loss of 3.4 percent of the national crop. More than 80 percent of the paddies surveyed had rat damage amounting to 5 percent or less; nearly 7 percent of the paddies had more than 10 percent. Damage estimates in paddies surveyed ranged from 0 to 58.1 percent.

Preliminary work on census techniques and control methods evaluation for populations of Rattus rattus mindanensis was continued. Results from snap-trapping, live-trapping, food consumption, burrow counts, activity tiles, and nocturnal observations were compared at four different crop periods; however, small samples made reliable comparisons difficult. Comparison of the responses of R. r. mindanensis populations to snap-traps and inked tracking-tiles suggested that inked tiles might provide more reliable data for use in evaluating control methods.

A two year study of rat populations in rainfed and irrigated riceland was completed; data have been partially analyzed. In both areas, the reproductive pattern appeared to relate to the habitat provided by the rice crop. Birth rates (births/rat/year) were calculated as 10.67 for the irrigated and 8.23 for rainfed areas in 1970, and 15.63 and 9.79 for the two areas in 1971. Increased birth rates in 1971 suggested that rodent productivity may have increased in some areas of the country this year.

No major food preferences were indicated in a series of laboratory and field tests with Rattus argentiventer and R. r. mindanensis. Both species readily accepted most of the materials tested, suggesting that many items could be used as toxicant carriers or bait for traps. Bait carriers should be selected more on the bases of availability, preservation characteristics, cost, and ease of applying toxicant, than on anticipated preferences by rats.

*This research was conducted with funds provided by the Republic of the Philippines and the Bureau of Technical Assistance, Agency for International Development, United States Department of State.

Additional laboratory data on the toxicity of zinc phosphide were obtained to supplement work completed last year. In virtually all laboratory tests, we have found wide variation in susceptibility of the species tested -- both among animals from the same population and among different populations. These results, coupled with results from bait weathering tests completed this year, suggested that baits prepared with 2% zinc phosphide retain adequate toxicity even after moderate exposure to rain.

A field evaluation of dry-season baiting using aerially dispersed corn, treated with zinc phosphide (2%), was conducted in Central Luzon. This trial did not effectively demonstrate major reduction of rat populations. The dry season baiting probably had little carry-over effect to the next cropping season; however, subsequent baiting activities by local residents and heavy floods precluded complete evaluation of the test.

Multiple baiting with zinc phosphide -- treated coconut or polished rice (1%) along dikes in growing rice did not reduce rat population activity or provide measurable protection of the rice crop. The study indicated that bait acceptance may be a major factor limiting the effectiveness of acute toxicants as now used for rice protection in the Philippines.

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

INTRODUCTION

The Rodent Research Center was established in June, 1968 as a joint undertaking between 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 College of Agriculture, with additional support and cooperation furnished by the National Economic Council, the National Food and Agricultural Council, the National Science Development Board, and the Philippine Atomic Energy Commission. USAID is represented by personnel from the Denver Wildlife Research Center of the U. S. Department of Interior's Bureau of Sport Fisheries and Wildlife. The Center's activities are guided by policies established by a Board composed of members from each of the cooperating agencies.

The Center has three objectives aimed at reaching the goal of reducing rodent damage to agricultural crops in the Philippines and other countries of Southeast Asia; (1) conducting research on crop protection for rice and other agricultural crops damaged by rats, (2) assisting in the training of Filipino scientists in rodent research, and (3) bringing research findings to the farmers through extension workers. These objectives were further pursued in 1971.

Program

An *ad hoc* Committee appointed by the Rodent Research Center Board submitted a report which defined the Center's organizational structure, staffing patterns, goals, and programs, as well as the equipment and space requirements needed to reach these goals in the next few years.

The Board acting upon the nomination from the Dean of the U.P. College of Agriculture appointed Dr. Fernando F. Sanchez, former Chairman of the Department of Entomology and Zoology, to the position of Director, Rodent Research Center.

Mr. Gerry C. Atwell accepted a position in May with the Bureau of Sport Fisheries and Wildlife's Kodiak National Wildlife Refuge, Kodiak, Alaska after spending two years at the Center. A new staff biologist, Mr. Michael W. Fall, arrived at the Center from the Denver Wildlife Research Center in May.

Research

The research effort was centered around continued evaluation of control methods, using standard rodenticides exposed by modified baiting techniques. These studies involved multiple baiting during the growing season and aerial dispersal of bait using the acute toxicant, zinc phosphide. Additional work involving habitat management was undertaken. Control methods evaluation has also been an area of emphasis in our studies. Damage surveys and pre- and post-treatment population or activity estimates were used in the field tests. A technique using inked tracking-tiles has been adapted to Philippine tests conditions and has proven quite useful.

Preliminary studies on rice-varietal preferences were continued and a study was initiated to determine the capacity for recovery of plants damaged by rats at different stages of growth. The Center provided assistance to the Bureau of Plant Industry for the National Rice Damage Survey, now in its second year. Damage trend studies continued in Central Luzon and on Mindanao Island; data were examined for correlation between relative rat population size measured by trap success and estimated damage. However, this phase of the work was terminated because the census method was not supplying reliable data; modified methods are now being tested.

Biological data collection continued during the year, with population studies, reproductive biology, and food habits information being compiled from selected locations.

Bait preference, bait enhancement, bait weatherability, and species susceptability tests were carried out in both the laboratory and field; preliminary behavioral studies were initiated in order to determine differences among ricefield rodents which may influence the success of control programs for multi-species populations. Two research papers were published during the year; several manuscripts are in various stages preparatory to publication.

Training and Extension

Mr. Jesus P. Sumangil, Supervising Plant Pest Control Officer, assigned to the Center by the Bureau of Plant Industry returned from Colorado State University where he completed the requirements for a master's degree in Wildlife Ecology. Mr. Agapito M. dela Paz, Center

staff member from the Bureau of Plant Industry, left in August for Bowling Green State University to do graduate work in ecology. Mr. Gregorio V. Llaguno of the University of the Philippines College of Agriculture, Department of Entomology left in September for the University of California at Davis to do graduate work in pharmacology and toxicology. All were recipients of USAID training grants. Four graduate students at the UP College of Agriculture continued studies in conjunction with the Center's program and received a stipend from the National Economic Council of the Philippine Government. A graduate student at the University of Colorado, Mr. James R. Tigner, completed a thesis study of rodent food habits in cooperation with the Rodent Research Center and the Denver Wildlife Research Center.

The Center provided training and review of damage-appraisal techniques for approximately 40 Bureau of Plant Industry technicians in preparation for the addition of five new provinces added to the National Damage Survey. Center personnel also presented lectures on rodent biology and control to two Rice Production Training Courses at the International Rice Research Institute at Los Banos. A total of 78 trainees attended these two presentations.

Several news releases concerning research findings and damage survey statistics were provided to the University of the Philippines and the Bureau of Plant Industry for use by their extension sections.

Approximately 175 visitors to the Center during the year received detailed briefings on our program and activities. Nearly 100 other people toured the Center — many of them teachers, students, and farmers' association groups.

RESEARCH ACTIVITIES

The National Damage Survey for Losses of Growing Rice to Rats in the Philippines.

Introduction

An essential part of any pest management research program is a reliable, quantitative method of determining crop losses. When losses can be determined, the economic constraints on various practical protection methods can be estimated. Also, damage estimates are useful for evaluating control measures, by comparing pre- and post-treatment damage or damage on treated and reference plots.

In 1968, a method of estimating rice losses to rats was developed by the Center, involving examination of 100 randomly selected hills in a paddy, for tillers (stems) cut by rats. Cut and uncut tillers were recorded for all damaged hills; fields with mature rice were surveyed within three weeks of harvest. Counts made in this manner provide for calculation of minimum estimates, since further damage may occur after the survey. However, some damage, particularly that occurring in early growth stages, may be partially concealed by plant regeneration.

In 1968, 10 barrios were sampled in two municipalities in Cotabato; ten randomly selected paddies were surveyed for each sample. To obtain information on annual damage trends, this survey was enlarged and repeated in 1969; five additional barrios were selected for survey in each of four provinces in Central Luzon.

The National Damage Survey for rat damage in lowland rice areas was first conducted in 1970 by personnel of the Bureau of Plant Industry. This survey, with the Center's assistance, was repeated in 1971. Each year, the tiller-counting method was used to survey ten paddies in each of the sample barrios in major rice-producing provinces of the Philippines (Figure 1). The barrios surveyed in 1968 and 1969 were incorporated into the National Survey.

Methods

The ten provinces with 60,000 or more hectares of lowland rice planted in the wet season were surveyed in 1970. In each province having 60,000 to 72,000 hectares of rice, five barrios were sampled. In those provinces having more than 72,000 hectares, the number of barrios sampled was increased arithmetically (1 barrio per 12,000

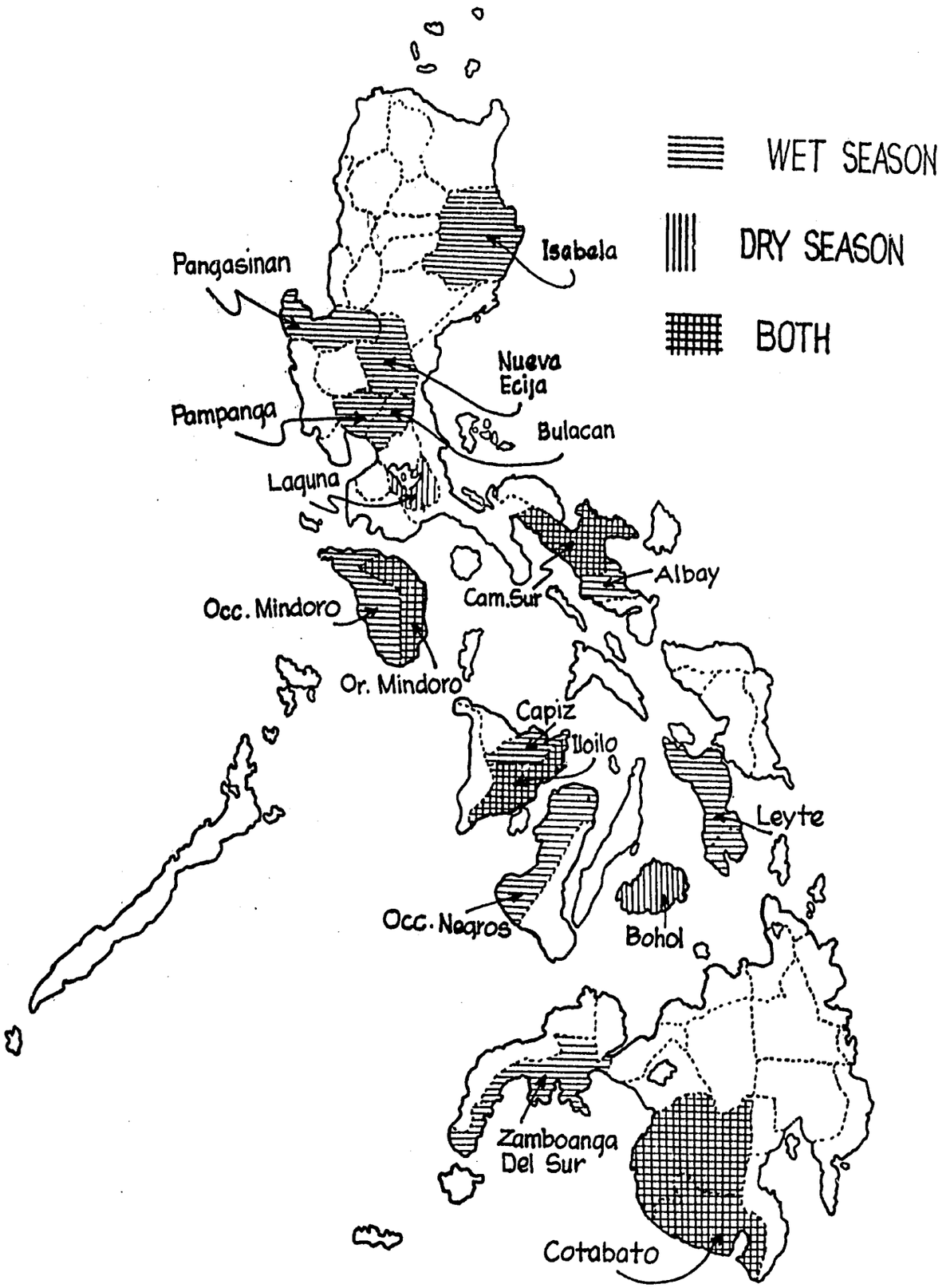

Figure 1. Major rice producing provinces included in a national survey of rat damage. Shading indicates periods when samples were collected.

hectares), corresponding to the number of hectares of lowland rice within the province as reported by the National Food and Agriculture Council. Sample paddies were randomly selected; once selected, the same paddy was used in subsequent surveys.

A dry season survey in six provinces, containing 20,000 hectares or more of irrigated lowland planted with rice, was begun in 1971. Ten barrios were randomly selected in each province for the survey regardless of the rice hectarage of the province. Five provinces with at least 40,000 hectares of wet season rice were added to the wet season survey in 1971. In each of these provinces 10 barrios were sampled. Estimates of national losses were calculated by weighting provincial estimates for planted rice hectarage at each season.

Results and Discussion

Results from survey-paddies were tabulated as percent damage (= percent of the individual panicled stems or tillers cut by rats). Averages for provinces, barrios, and rice varieties were determined from these data. In each case some paddies were excluded from the calculations because of incomplete information. National damage estimates were calculated by averaging the estimated percent damage for each barrio in the weighted provincial samples.

Table 1 summarizes currently determined national and provincial averages. Comparison of wet season figures in provinces where 3 years' data were available suggested considerable annual variation. This variation was consistent with observations in our other field studies and may, to some degree, be exaggerated by the relatively small samples. In the three provinces where wet season damage estimates have been determined, for 1969, 1970, and 1971, the 1970 estimates were the highest. From the two provinces where the 1971 survey data have not been completed, it appears that Pangasinan will fit this same trend, but Nueva Ecija will not. In most cases (Iloilo was an exception), dry season damage figures have been lower than those for the preceding and succeeding wet seasons.

One of the most notable results of these damage surveys has been the low average estimates compared to those of previous reports. This effect is clearly shown in the 1970-71 data summarized in Table 2, indicating that only about 7 percent of the sample paddies and about

Table 1. Estimated percent damage to ripening rice by rats in the Philippines. Results are based on counts of cut tillers in one hundred hills in each survey paddy.

Province	1969 Wet Season	1970 Wet Season	1971 Dry Season	1971 Wet Season
Albay				1.84
Bohol			0.17	
Bulacan	1.08	3.71		1.98
Camarines Sur		2.75	1.09	0.86
Capiz*				
Cotabato	3.89	8.08	2.88	3.41
Iloilo		2.64	3.09	0.34
Isabela*		1.23		
Laguna			1.48	
Leyte*				
Mindoro Occ.*				
Mindoro Or.		4.30	0.68	0.77
Negros Occ.		0.72		1.50
Nueva Ecija*	7.53	2.68		
Pampanga	2.20	9.49		3.31
Pangasinan*	0.79	7.58		
Zamboanga del Sur*				
NATIONAL AVERAGE	**	4.20	1.58	***

*Data from 1971 wet season not yet available.
**No national average was calculated for 1969.
***The 1971 damage surveys are still in progress.

Table 2: Frequency of damage levels found in paddies and barrios during the 1970 wet and 1971 dry season surveys involving 1577* sample paddies in 167 barrios.

Damage Level (percent of tillers cut)	Paddies No.	Paddies Percent	Barrios No.	Barrios Percent
0	172	10.9	3	1.8
2 percent or less	912	57.8	83	49.6
5 percent or less	1285	81.5	133	79.6
More than 10 percent	107	6.8	14	8.4
NATIONAL AVERAGE: (Wet and Dry Season Combined)		3.4 percent		
Range: (all sample paddies)		0 - 58.1 percent		

*Of the 1670 paddies selected for sampling, 93 could not be used in the calculations because of incomplete data.

8 percent of sample barrios had more than 10 percent damage. Damage in one paddy in Cotabato was estimated at 58.1 percent, but about 80 percent of both paddies and barrios had less than 5 percent damage. While it can be calculated from current rice prices (with the assumption of rather broad limits) that a loss of 85 million pesos* could be attributed to field damage by rats, such a figure is difficult to translate to practical economic data for the small farmer.

In situations where heavy damage occurs infrequently and at unpredictable intervals, the economic incentive for continuous, labor-intensive management programs may be very low. Control methods introduced in such situations must have low cost and be sufficiently effective to reduce the low average damage. In areas with predictably high damage, less efficient, more costly methods may be acceptable and highly beneficial. Predictability remains a major difficulty, because rodent populations, crop damage, and the efficiency of various control methods have proven, so far, highly variable.

The variation in damage to different rice varieties (Table 3) ranged from 0 to nearly 10 percent; some of this variation may be attributed to sampling. Other observations indicated that damage estimates from contiguous paddies may also be quite variable. Two varieties, Camoros and FK178-A, with only 6 paddies of each in the sample had no damage reported. While this effect might also fit the pattern of variation seen among the figures for other varieties, the observation was of sufficient interest that a choice test under field conditions (reported separately) was arranged. FK178-A was heavily damaged under the test conditions, but after the IR22 was destroyed, suggesting that varietal preference should not be ruled out as a factor in the variable damage patterns observed in this survey.

*Calculated value was based on a price of ₱20 per cavan of unmilled rice and an estimated national production of 40 cavans/hectare for the 1970-71 season.

Table 3. Rodent damage to rice varieties included in the 1970-71 National Damage Survey. The number of tillers cut by rats was determined for 100 hills in each of 1577* survey-paddies.

	Wet Season		Dry Season	
	No. of Paddies	Cut Tillers (percent)	No. of Paddies	Cut Tillers (percent)
Arabon	2	0.38	-	-
BE3	60	1.22	-	-
BPI76-1	-	-	5	4.72
C4-63	151	4.06	99	2.62
C18	1	0.80	1	0.56
Cainto	60	1.22	5	0.16
Camoros	6	0	-	-
FK178-A	6	0	-	-
Inano	1	1.08	-	-
Intan	5	5.81	2	1.88
IR5	255	5.29	4	1.15
IR8	75	2.52	54	2.66
IR11 (FB24 x Dgwg)	3	3.21	-	-
IR12-1178	2	2.29	9	1.70
IR20	308	3.93	115	2.23
IR22	16	3.88	47	1.22
IR400 (Peta/4 x TNT)	1	1.71	-	-
IR253 (Malagkit)	-	-	7	0.67
Khao Bai Sri	3	6.10	-	-
Malinis	6	7.39	-	-
Peta	6	1.41	5	0.17
Piniling Hirang	1	9.72	-	-
Raminad	1	0.26	-	-
Seraup Ketchill	17	4.13	-	-
Tjeremas	2	2.27	1	1.60
Wagwag	42	2.70	-	-
Not calculated or undetermined	170*		116*	

*In 286 additional paddies included in the survey, damage could not be calculated or variety was not determined.

Figure 2. Rodent Research Center field team and Bureau of Plant Industry technicians conduct damage survey in Central Luzon.

Preliminary Observations on Rat Damage to Rice Varieties FK178-A and IR22 In Relation to Age With Notes On Subsequent Retillering of IR22.

Introduction

Data from the National Rice Damage Survey (1970-71), conducted by the Bureau of Plant Industry with the Center's assistance, indicated two varieties (FK178-A and Camoros) that had not been damaged by rats. To test the possibility that this observation represented more than a sampling effect, arrangements were made with the International Rice Research Institute to plant two field plots of FK178-A; two additional plots of IR22 were planted for comparison. The plots were located on an experimental area where heavy rat damage was anticipated. Following heavy, initial cutting by rats, three 1 m^2 plots of IR22 were protected from further cutting in order to observe the recovery potential of the damaged plants.

Methods

Four adjacent six by eight-meter plots (two for each variety) were planted on September 3, 1971. Plot positions were randomly selected; however, the plantings were made on a section of the farm where heavy rat activity was expected. Our plots were surrounded by other experimental and demonstration plots, 2 to 3 weeks older, that were enclosed by electric fences to deter rats. All plots were irrigated. Each plot consisted of 27 rows of 24 hills — 648 hills per plot. Cultural practices were carried out according to standard recommendations, except that no efforts were made to protect the plots from rat damage.

Weekly observations were made starting the first week after transplanting. When rat damage began, all plants were examined weekly to determine the number of tillers cut. After heavy damage had accumulated, three, 1 m^2 wire exclosures were placed in plots containing IR22 to prevent further rat cutting. Each exclosure covered 25 hills. It had been observed that high yielding varieties retiller after early cutting and often produce some harvestable rice. The rice produced from the retillered plants inside the wire exclosures was harvested, dried, and weighed. The yield in cavans per hectare was calculated from the samples obtained.

Results and Discussion

Results of the weekly damage surveys are presented in Table 4. Slight cutting was noted on FK178-A during the fifth week, but none was seen on the IR22. No further damage was recorded until the 9th week when FK178-A had 0.34 percent damage and IR22, 0.03 percent. Heavier cutting was noted on older rice in the adjacent plots. The cutting continued at a low level during the tenth week, then rapidly increased. By the end of the eleventh week, damage was severe on both varieties; 88.4 percent of the tillers were cut on IR22 and 33.1 percent on FK178-A. During this time, several of the adjacent plots were harvested, possibly concentrating rat activity in our four plots.

During the 12th week when most of the IR22 had been cut by rats, three 1 m^2 hardware cloth exclosures were placed in one IR22 plot to determine whether cessation of further rat feeding could result in partial recovery of the plants by retillering. Cutting was still occuring in the FK178-A plots; adjacent rice had been harvested or had been cut by rats. By the 14th week the FK178-A was totally destroyed; it was noted that cutting also continued on newly erupted tillers of IR22, except inside the wire exclosures.

Table 4. Development of rat damage on two rice varieties. Damage was determined by weekly examination of all stems for rat cutting.

Weeks After Transplanting	Percent Damage	
	IR22	FK178-A
4	0	0
5	0	0.01
8	0	0
9	0.03	0.34
10	3.58	0.48
11	88.41	33.11
12	95.00	60.00
13	-	-
14	-	100.00

At the end of the 17th week, rice in the exclosures was harvested, dried to the standard 14 percent moisture content, and weighed. The average yield per square meter was 31 g or 7.03 ± 0.81 cavans of rough rice per hectare (standard error indicated).

The available data suggest that rice cut this severely at this stage of development could not yield enough grain to meet production costs — even when rat cutting was completely stopped. The IR22 was cut before FK178-A, but as food became less available, FK178-A was cut and eaten until it was totally destroyed. Further tests of varietal preferences and the recovery potential of partially damaged rice will be made.

Comparison of Population Sampling Techniques Used on Philippine Rodents

Introduction

Estimates of the numbers of animals in populations at different places or at different times have many uses in population management. Such estimates are used in field studies to determine the potential bait consumption of different rodent populations, to assess monthly and annual population trends, to measure the effect of new control methods in field trails, and to survey the relationships between the size of the rodent population and other factors, such as rice damage, reproductive rates, or animal movements.

Many methods of estimating population numbers have been developed; an extensive literature covering the theoretical and practical aspects of sampling rodent populations exists. But, much of the previous work was done with sylvan, pastoral, or urban rodents in temperate zones where populations often were of relatively low density. Although the methods of population sampling under such conditions are well-developed, the problems of their application to dense agricultural rodent populations in the tropics are not completely understood.

Methods of determining population estimates fall into three major categories:

Removal of animals from an area: this is usually done with traps, although other methods, such as excavating burrows or driving animals into an enclosure can also be used. The number of animals removed per unit effort or rate of removal may be used to indicate relative population size.

Recapture of marked animals: this method has many uses in wildlife population studies and has been widely applied. With rodents, animals are usually captured with live traps, marked by eartags or toe-clipping, and released. The proportion of marked animals recaptured at a later time may be used to estimate the total population present.

Direct observation of animals or signs of their activity: this class of methods involves counting. Burrows, droppings, food consumed, tracks, or the animals themselves may be counted. The numbers are subsequently compared with other counts to indicate changes.

All of these methods require assumptions about the subject populations, all have certain limitations, and all provide different degrees of other information about reproductive condition, movement, population turnover, and behavior of the animals.

During 1971, Center personnel initiated considerable preliminary work aimed at understanding the application of census techniques and evaluation methods to populations of Rattus rattus mindanensis. In one study, conducted in a area at Cabuyao, Laguna, several indices of population size were compiled at four different times during the year. Field observations were made in booting rice (October), post-harvest fields (February), weedy fields during dry season (May), and during planting (June). At each period, information was collected on trap success $\left(\frac{\text{No. of Rats Captured}}{\text{No. of Trap-nights}}\right) \times 100$ and percentage of sprung traps with both snap-traps and live-traps. In addition, attempts were made to estimate relative food consumption, relative number of burrows, nocturnal activity, and behavior toward "activity tiles" placed along dikes.

In another study, made in conjunction with the National Damage Survey, trapping was conducted in ricefields of six barrios to determine the relationship between trap success and rat damage.

Comparison of the responses of Rattus rattus mindanensis to snap-traps and inked "tracking tiles" placed in post-harvest ricefields and rough areas were made at La Paz, Tarlac, during the period of April to June.

A series of field operations using large numbers of snap-traps to remove rapidly most of the animals from small areas provided some additional information on relative density, relationship between tracking tiles and traps, and the causes of the high percentage of sprung traps that have been previously observed. This work is incomplete and will be continued during 1972.

Methods, Results, and Discussion

Comparison of Census Techniques, Cabuyao, Laguna. The objective of this study was to make preliminary comparisons of the use of snap-traps, live-traps, activity tiles, feeding stations, burrow counts, and night

observations to gain relative density information on R. r. mindanensis. The field area was divided into sixteen 1 km^2 plots; different plots were selected for each period. Operations such as snap-trapping and live-trapping were conducted in different plots; other operations such as measurement of food consumption, burrow counting, and night observation were conducted together in the same plots.

At each period, 50 snap-traps (Victor 4-way) and 50 live-traps (cage-type with baited hook) were baited with roasted coconut, placed in adjacent plots in 5 lines of 10 traps each, and checked for 3 nights. Traps were 25 m apart; lines were separated by at least 50 m (one paddy or more). Rats captured in live traps were marked and released, but the low recapture rates precluded calculation of population estimates.

In another adjacent plot, 10 feeding stations containing rough rice (palay) were placed along dikes 50 to 100 m apart. Food consumption at the stations was recorded daily for 6 days. Activity tiles (vinyl floor tiles about 23 cm x 23 cm) were placed along dikes in another plot in the same pattern as the traps. Frequency and type of rodent sign associated with the tiles was recorded each morning for 3 days. Burrow counts were made in the same plots where activity tiles and feeding stations were placed. Approximately 1000 m of paddy dike and 1000 m of water transport dike were examined at each period. No attempt was made to categorize different types of burrows. Night observations with a red spotlight and binoculars, and with a night-vision device were made for 3 nights (the last 3 nights of feeding station operation). One observation system was used on five of the ten stations, the other system on the remaining five. Each station was quietly approached to within about 15 m; after a few moments of silence, observations were made for 10 minutes during which all rats visiting the site were recorded.

Generally, the findings indicated little relationship among the results of the various census techniques. This effect probably resulted from small samples of each method and variations among rat populations in different parts of the large study area. Table 5 shows results of some of the trials.

Number of burrows per 100 m of dike was highest in February, soon after harvest. The low figures at planting and booting stages could result from recent repairing of dikes by the farmers, however, the low figure during May (fallow-fields) cannot be readily explained biologically and probably reflects sampling variation.

Table 5. Comparison of Several Census Techniques for *Rattus rattus mindanensis* on a Rainfed Area Near Cabuyao, Laguna at each of Four Sampling Periods.

Time and Crop Stage	No. of Burrows per 100 m of Dike[1]	Consumption of Rough Rice[2] (g/station/day) $\bar{X} \pm SE$	Trap Success[3] $\left(\frac{\text{No. of Rats}}{150 \text{ Trap-nights}}\right) \times 100$		Sprung Trap Percentage[4] $\left(\frac{\text{No. of Sprung Traps}}{150 \text{ Trap-nights}}\right) \times 100$	
			Snap-Traps	Live-Traps	Snap-Traps	Live-Traps
October (booting rice)	1.55	13.33 ± 3.01	6.67	4.00	30.67	7.33
February (post-harvest)	12.76	9.00 ± 1.26	6.00	7.33	16.67	6.00
May (weedy-fields)	3.00	10.67 ± 2.32	16.67	11.33	11.33	0.67
June (planting)	0.30	12.67 ± 4.54	6.00	8.67	7.33	4.67

1/ Approximately 1000 m or more of paddy dikes and 1000 m or more of water transport dikes were examined during each period. Results were combined.

2/ Rough rice (palay) was placed in excess in trays and distributed along dikes. Ten such trays were exposed for 6 days during each census period.

3/ Snap-traps and live-traps were placed in adjacent areas in 5 lines of 10 traps each. Traps were 25 m apart; lines were at least 50 m apart. Traps were baited with roasted coconut and were checked for 3 nights during each period. Trap success is a ratio of the number of rats caught to trapping effort.

4/ Sprung trap percentage is a ratio of the number of sprung traps to trapping effort.

Consumption of rough rice (palay) from the feeding stations was uniformly low at all seasons. No consistent daily trend was evident in the results; the average amounts consumed (9.00 g/day - 13.33 g/day) at the stations were in the same range as the daily consumption of one adult R. r. mindanensis. The figures, however, probably result from several rats sampling small amounts. Several factors may explain these low intakes: the rat population in the study area was generally low during all seasons; baiting in the area by farmers (virtually unavoidable in field studies) may have led to the development of bait shyness; placement of stations on dikes may have slowed the rate at which bait use developed; or preference for other available foods may have led the population to direct most of its feeding activity elsewhere.

Trap success with live-traps and snap-traps corresponded roughly at all four sampling periods; however, the values are generally low, averaging less than trap successes for R. r. mindanensis in other locations. One indication of difference between the two types of traps was in the number sprung with no catch; the percentage of snap-traps sprung averaged more than three times that of live-traps. Several factors such as rain, temperature, or small invertebrates can affect the snap-trap mechanism more easily; in this case, we believe the high number of sprung snap-traps was probably caused by rats. Live-traps are less readily approached and entered, but capture more of the animals that actually pull on the bait. Snap-traps may be sprung by animals directing attention to parts other than the baited trigger or approaching from the back of the trap; thus many animals that do not approach the trap from the front may spring the trap without being captured.

Data from the activity tiles indicated use at all seasons; however, tracking was best observed when the paddies were wet. When growing rice was present, rats often used tiles for feeding platforms. The apparent attraction of rats to the flat surfaces may relate to their tendency to use higher parts of the paddy for pathways and to build feeding or resting platforms out of cut vegetation. These findings may have additional uses in developing practical control methods. The modification of inking part of the tiles, reported in a following section, improved the consistency of the results achieved with this method.

Night observations made at the feeding stations with the night vision device and red light were generally unsatisfactory in providing information on relative abundance. Probably a major reason for this was the poor use of the stations. Inability to distinguish between rats, and the tendency of a rat which found the station to make several brief

exploratory visits in a short time greatly increased the variability of the results. In many cases, evening activity of the rats lasted only from about 5:30 pm to 8:30 pm, making comparative samples of activity at the 10 stations virtually impossible when one waited for darkness to avoid disturbing the rats.

The resolving power of the night vision device proved inadequate for distinguishing individuals or observing behavior. In addition, the instrument was cumbersome to use in the field. Observations with a red spotlight and binoculars, while suffering some of the same limitations were more practical for Philippine field situations.

Relationship between trap success and estimated rat damage within barrios. In three barrios included in the 1970 wet-season segment of the National Damage Survey, 25 snap-traps baited with coconut were placed in each of four lines. Lines were 100 m apart; traps were placed at 25 m intervals. In three other barrios included in the 1971 wet-season survey, 10 traps were placed in each of five lines with the same spacing between lines and traps as in 1970. In all cases trapping was conducted for three nights. Each trapping site was arbitrarily situated in riceland within the confines of the barrio. Damage surveys were conducted in 10 paddies randomly selected throughout the barrio.

Trap success did not show direct relation to the damage estimate for the barrio (Table 6). Sampling techniques were probably the main cause for this lack of correlation. The use of relatively small numbers of traps, while adequate for many purposes in temperate rodent populations, retains little sensitivity when applied to denser tropical populations because more animals may be exposed to each trap.

In Nueva Ecija, all animals caught were *R. r. mindanensis*. In Cotabato, 22 were *R. r. mindanensis* and 19 were *R. argentiventer*. Other investigators have reported the latter species difficult to trap (Wood, 1971; Harrison, 1958). Our own observations confirm this trap-shyness, thus species-composition estimates from these trapping data are probably unreliable, and trap success as it relates to damage cannot be compared between the two species.

Damage estimates within barrios were often highly variable. At Sta. Arcadia, for example, damage in individual paddies ranged from 3 to 42 percent; damage in the paddies where trap lines were located probably varied within this range. Because the area trapped was relatively large (500 m x 250 m, or 500 m x 625 m), various animal densities may also have been encountered. One might expect a direct relationship between the number of rats and the amount of damage; however, no correlation has been observed in comparison of damage estimates with relative population

Table 6. Comparison of trapping results and rat damage estimated in six barrios in Nueva Ecija and Cotabato.

Province	Barrio	No. of Trap-nights	Trap Success for All Species $\left(\frac{\text{No. of Rats}}{\text{No. of Trap-nights}}\right) \times 100$	Percent of Tillers Cut by Rats
Nueva Ecija				
	Sta. Arcadia	150	61.3	22.21 ± 4.54
	Bangad	150	58.0	1.44 ± 0.38
	Matungal-tungal	150	34.0	1.66 ± 0.25
South Cotabato				
	Bukay Pait	300	6.3	1.45 ± 0.22
	Dumadalig	300	3.0	1.68 ± 0.57
	New Iloilo	300	4.3	2.02 ± 0.16

indices based on trapping, tracking tiles, or visual observation. A similar situation was found by Hood et al. (1968 unpublished report, Denver Wildlife Research Center) for populations of Rattus exulans and Rattus rattus in Hawaii. It appears that a better approach for examining relationships between rat population and damage would be to use smaller areas where damage surveys involving each paddy and intensive censusing of rodents could be conducted together.

Comparison of Inked Tracking-Tiles and Snap-Traps in Post-harvest Ricefields and Rough Area at La Paz, Tarlac. Preliminary results of activity tiles at Cabuyao. coupled with the suggestion of Lord et al. (1970) that inking one half the surface of vinyl (designated in this report as "tracking tiles") tiles facilitated recording rodent tracks, led to a preliminary evaluation of this technique for R. r. mindanensis. Snap-traps, baited with fresh coconut, were used for comparison.

Two 1000 m lines were established in each area. Twenty-five tiles and 25 traps were alternately spaced along each line at 20 m intervals. Distance between lines was at least 50 m; a particular line was used for only one census. Each census involved three nights. White vinyl tiles (approximately 23 cm x 23 cm) were inked each afternoon by spreading a small amount (about 1/2 cc) of printer's ink and a few drops of home made coconut oil (to prevent drying) over half the tile with a rubber roller. Tracks were recorded as present or absent each morning. During the morning check, acetone and cotton were used to remove tracks from the un-inked portion of the tile; traps were checked each morning at the same time.

The means shown in Table 7 were calculated on the basis of six line-nights — 2 lines for 3 nights. The corresponding standard deviations were calculated from the variance within these line-night samples. Although trap success might be expected to decrease on the second and third night complicating the comparison, this type of systematic change was not apparent, probably because of a very low number of traps in relation to the number of rats in the area. In only one of the 18 lines were both the second and third night's trap success lower than the first.

Inked tracking-tiles, used at this spacing, provided less variable results than snap-traps used in the same manner (Table 7). By using tracking tiles, minor population changes might be detected more reliably.

Table 7. Use of inked tracking-tiles and snap-traps exposed to rats for three nights during three different periods at three locations in La Paz, Tarlac, Philippines. Two census lines were placed in each area during each period. Each line had 25 traps and 25 tiles alternating at 20 m intervals; lines were located 50 m or more apart.

Area, Habitat, and Location	Date	N (Line-nights)	Tracking Tiles $\bar{X}$ (percent use/line/night)	Tracking Tiles S.D.	Tracking Tiles C.V. (%)	Traps $\bar{X}$ (percent capture/line/night)	Traps S.D.	Traps C.V. (%)
Plot 1-Rice Stubble	14-16 April	6	91.3	5.9	6.5	36.2	12.0	33.1
	20-22 April	6	63.3*	9.3	14.7	34.7	7.1	20.5
	18-20 May	6	94.6	3.2	3.4	51.7	6.6	12.8
Plot 2-Rice Stubble	14-16 April	6	65.3	9.1	13.9	20.1	13.0	64.7
	20-22 April	6	64.7	14.9	23.0	39.8	6.4	16.1
	18-20 May	6	76.4	9.1	11.9	33.7	13.7	40.7
Plot 3-Grassland	14-16 April	6	73.7	17.4	23.6	26.6	11.5	43.2
	20-22 April	6	76.7	13.2	17.2	29.3	14.4	49.1
	18-20 May	6	84.0	12.2	14.5	29.3	12.0	41.0

*This reduction in use of the tiles was presumed due to the Philippine Bureau of Plant Industry's aerial application of toxic bait on April 16 and 17.

With the tiles, the coefficient of variation never exceeded 25 percent, while in five of the nine trials, the coefficient of variation for snap-traps exceeded 40 percent. In situations where carcasses are not required, tiles may prove useful in providing reliable data on relative abundance.

One difficulty with the tiles was that no numerical estimate of the population could be made; tracking patterns may be different for various populations at different times. For pre- and post-treatment evaluation of control method effects, however, the technique appears very useful. Light rain did not prevent use of tracking tiles, but heavy rain rendered them unusable. Such losses due to rain have been very rare, even during the rainy season.

Grid Trapping For Population Estimates by the Removal Method. One of the problems apparent from the previous studies was the variability of data based on small samples. In addition, dense tropical rodent populations tend to "flood" some measuring systems (as in the trap-lines at La Paz, Tarlac), making it difficult to discriminate even large changes in populations. Preliminary work, begun in late 1971, gave some indication that sampling procedures involving larger numbers of units (traps or tracking tiles) may improve data.

Because of the difficulty and expense of using large numbers of live-traps, snap-traps and the removal method (discussed by Davis, 1964 and Zippin, 1958) were chosen to obtain further estimates of relative abundance of *R. r. mindanensis*. In initial trials, using grids of about 500 traps per hectare (1 trap per 20 m^2), estimates fell in the range of 35 to 200 rats per hectare in mature or post-harvest rice, substantiating previous observations of great variation in the numbers of rats in different locations.

An example of the graphic method of estimating population numbers from removal trapping data is shown in Figure 3. Daily catch (on the ordinate) is plotted with total previously caught (on the abscissa); the regression line, extended to its intersection with the abscissa, gives an estimate of the population exposed to the traps. A more precise estimate with confidence limits may be calculated from the data. In this example the population was estimated at 37 rats. Differences in home range size and activity patterns between different rodent populations may make precise comparisons difficult; however,

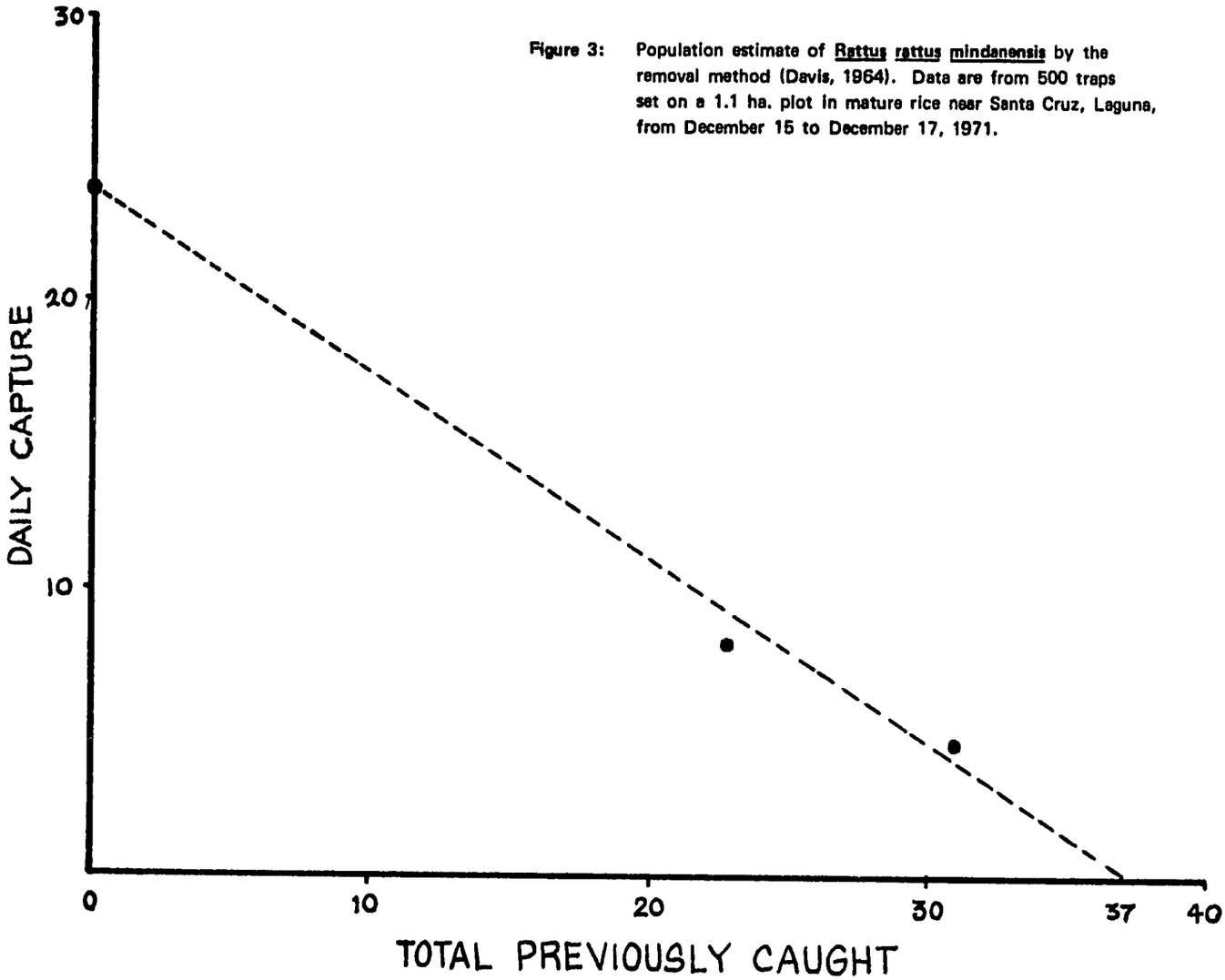

Figure 3: Population estimate of *Rattus rattus mindanensis* by the removal method (Davis, 1964). Data are from 500 traps set on a 1.1 ha. plot in mature rice near Santa Cruz, Laguna, from December 15 to December 17, 1971.

differences in population size can be readily quantified.

Results from traps and tracking tiles used simultaneously in the same area (Figure 4) were compatible. Apparently the tracking tiles detected a greater increment of the rat activity directed toward them than the traps. The decline in sprung traps as the rat population was reduced suggests that the high percentages of sprung traps observed in previous trapping studies was related to the activity of the rat populations.

The tracking tiles require less labor compared with either snap-traps or live-traps and have the advantage of being more sensitive to over-all rat activity. However, we still lack sufficient information to determine how reduction in the number of tracked tiles relates to various rat population levels. In other words, eighty percent reduction of activity in an area with 200 rats per hectare may indicate a considerable number of animals remaining in the rice crop; fifty percent reduction in an area with 35 rats per hectare would reflect a much lower population level. Work with these census and evaluation techniques will be continued.

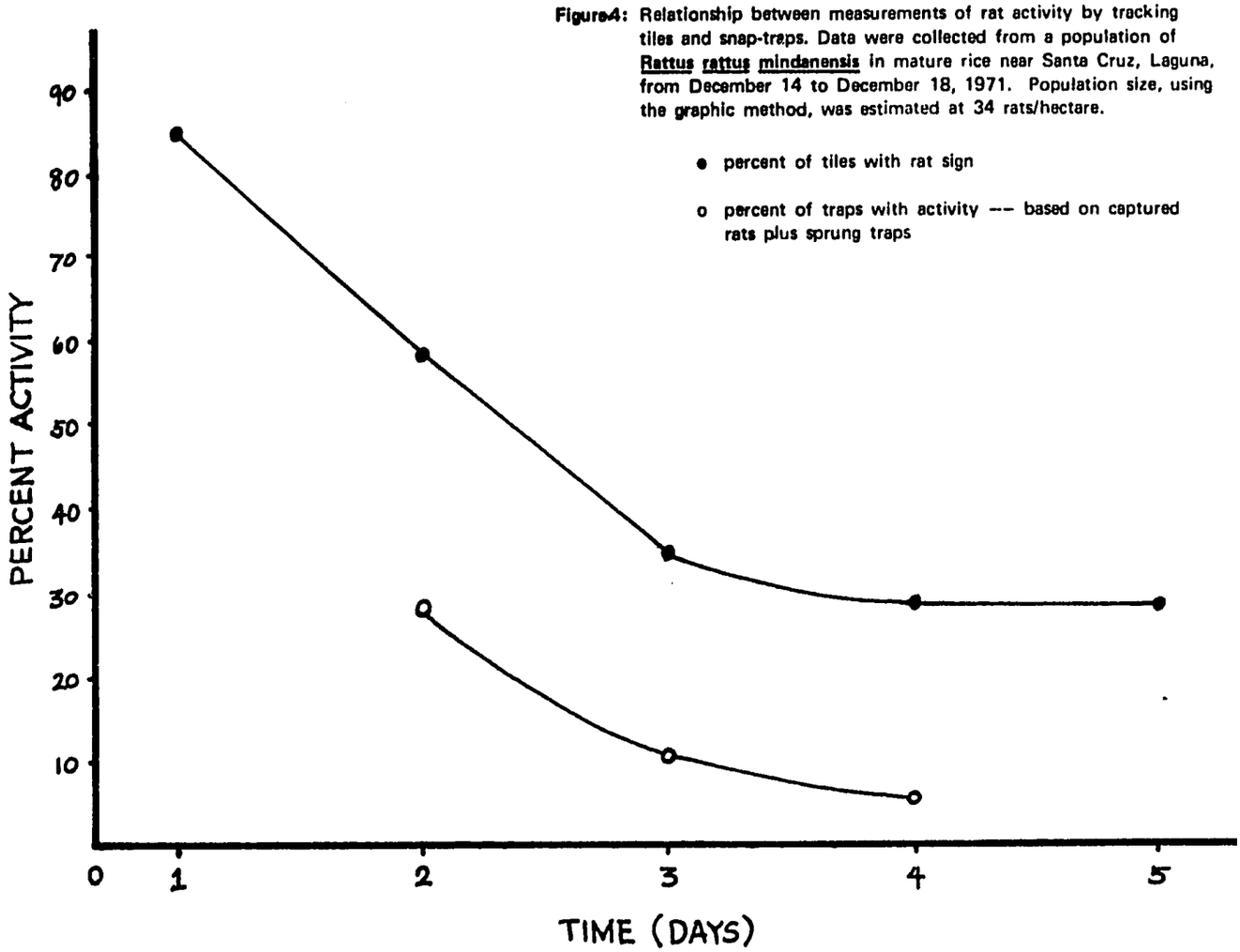

Figure 4: Relationship between measurements of rat activity by tracking tiles and snap-traps. Data were collected from a population of **Rattus rattus mindanensis** in mature rice near Santa Cruz, Laguna, from December 14 to December 18, 1971. Population size, using the graphic method, was estimated at 34 rats/hectare.

● percent of tiles with rat sign

o percent of traps with activity -- based on captured rats plus sprung traps

Figure 5. Preparation of a tracking tile to determine rodent activity.

Figure 6. Inked tile showing rat tracks.

Comparative Study of Populations of *Rattus rattus mindanensis* on Rainfed and Irrigated Ricefields of Luzon, Philippines

Introduction

During 1970 and 1971, monthly collections of *Rattus rattus mindanensis* were made in two areas on Luzon. The major objective was to determine seasonal reproductive and population changes of the species on rainfed and irrigated sites in selected lowland ricefields. An initial assumption of the study, based on previously reported work in the Philippines and carried through the initial phases of work, was that breeding peaks were largely seasonal and somewhat correspondent throughout the country. During the past year, from information developing from this and related studies, it began to appear that reproduction and population changes in this species in Philippine rice lands tended to correspond most closely with environmental changes, particularly those associated with the crop cycle. The relationship with environment was thereafter studied more closely, and some modifications were introduced in the study. Two additional objectives were added:

1. To develop preliminary information on environmental and population variables related to reproduction.

2. To assess the need for a more detailed study relating reproduction to environmental changes.

Collections in irrigated paddies were made southeast of Laguna de Bay in Laguna province in three continuous municipalities — Siniloan, Pangil, and Pakil. This site, 1 km x 6 km, was subdivided into six 1 km^2 sections. The sections were randomly assigned numbers, then sampled in sequence. When all the areas had been trapped, the sequence was repeated. A rainfed collection site was selected in Central Luzon in Cuyapo, Nueva Ecija. The area, 2 km x 3 km, was also divided into six 1 km^2 sections. Monthly trapping sites were chosen in a manner similar to that on the irrigated site. A few sections which proved to be unsuitable for the study were subsequently eliminated from the two areas.

Methods

Collections were generally made with snap-traps during the 3rd week of each month. Traps were set along paddy dikes in 2 to 4

lines of 50 to 100 each and baited with coconut. The space between traps was about 8-10 meters; the distance between lines varied, generally being about 100 m. The lines were usually checked for two or three nights. The number of specimens collected per month in each area ranged from about 15 to over 100. Generally, the monthly samples consisted of more than 50 animals. During the first 1 1/2 years of the study carcasses were brought to the laboratory, frozen, and examined later. Subsequent necropsies were conducted in the field as soon as specimens were collected.

Because sexual characters develop at different rates in each individual and in different populations, depending upon local conditions, chronological age is generally not a good measure of sexual maturity. Characters often used for differentiating animals presumed to be capable of breeding are perforation of the vagina for females, and descent of the testes, visible epididymal tubules, or active sperm in males. In addition to the recording of these characters in the monthly samples, three subjective age categories were also used.

Juvenile: male — testes abdominal, small size
female — mammae not visible, vagina imperforate, small size

Sub-adult: male — medium to adult size, testes abdominal or not well developed, no active sperm present, epididymal tubules not visible
female — medium to adult size, vagina perforate, mammae not developed

Adult: male — adult size, testes scrotal, epididymal tubules visible
female — adult size, mammae developed, perforate vagina

Several technicians were involved in collecting field data over the two-year period, causing some variation in the assignment of subjective age categories. Because analysis of the data is not complete, only adults identified by the subjective classification have been included in this summary. Presumably, further analysis of the data using weight and size classifications will not greatly modify the tentative conclusions suggested here.

Data collected in 1970 were summarized in the Center's 1970 annual report. Additional comparative information from 1970 has been included in this year's section. Recalculation of several values resulted in minor changes from those reported previously; these changes are not mentioned specifically in this summary. Climatic data were obtained from the Philippine Weather Bureau monitoring stations nearest the two study areas. Although no analysis has been made yet, 1971 monthly temperature and rainfall data are included for preliminary comparison (Table 8).

Results and Discussion

Results of the 1971 monthly census of the rainfed and irrigated areas are presented in Tables 9 and 10. Brief comparisons will be made of several of the tabular categories.

Paddy condition showed one annual crop in the rainfed area and two in the irrigated. Crop cycles were not well-followed by the chronological trapping schedule, particularly in the irrigated area.

Trap success averaged about 15 percent in both areas but was somewhat more variable in the rainfed location. There, it ranged from 3.5 to 48.7 percent, while in the irrigated area the range was from 7.9 to 33.8 percent. Reliable interpretation of trapping results was difficult, particularly with the variable conditions encountered in this study; however, it appeared that the rat populations in the rainfed area fluctuated more than those in the irrigated area.

Weights and lengths for both males and females in the irrigated area averaged considerably more than those from the rainfed area. This trend was also noted in the data from 1970. This difference could be related to nutritional factors, or to age structure and mortality patterns of the two populations. Similar size differences among populations of *Rattus norvegicus* have been reported by Davis (1949).

Prevalence of pregnancy (percent pregnant) was based on the number of adult females found pregnant each month. Annual prevalence was calculated by averaging the estimates from the montly samples.

Table 8. Monthly changes in rainfall and temperature determined by the Philippine Weather Bureau stations at San Miguel, Tarlac and Sta. Cruz, Laguna for the period January to December, 1971. San Miguel and Sta. Cruz data relate to the rat populations at Cuyapo and Siniloan, respectively.

Month	Sta. Cruz, Laguna		San Miguel, Tarlac	
	Monthly Mean Air Temperature (C)	Monthly Rainfall (mm)	Monthly Mean Air Temperature (C)	Monthly Rainfall (mm)
January	24.7	12.5	24.3	2.3
February	25.4	25.6	26.2	0.3
March	25.6	82.7	27.0	19.5
April	27.3	18.3	28.8	37.3
May	28.3	229.8	28.1	255.6
June	27.8	251.1	27.4	267.5
July	27.5	314.6	27.0	242.0
August	27.7	165.8	27.3	88.4
September	28.0	208.5	26.9	365.8
October	26.9	418.5	26.6	335.1
November	26.3	340.9	26.1	180.4
December	26.0	449.6	25.5	91.1

Table 9. Summary of 1971 monthly census of ricefield rat (*Rattus rattus mindanensis*) populations in the vicinity of Cuyapo, Nueva Ecija, Philippines.

Date	Paddy Condition	No. of Trap Nights	Trap Success (%)	No. of Males	No. of Ad. Males	$\bar{X}$ Wgt. Ad. Males	$\bar{X}$ Lgth. Ad. Males (mm)	No. of Females	No. of Ad. Females	$\bar{X}$ Wgt. Ad. Females (g)	$\bar{X}$ Lgth. Ad. Females (mm)	No. Preg. Females	Prevalence of Pregnancy (%)	$\bar{X}$ Live Embryos
Jan. 21-22	post-harvest	400	14.50	32	13	140	362	26	18	141	344	5	27.77	5.60
Feb. 24-25	dry fields	400	27.00	55	11	148	366	53	28	138	362	3	10.71	5.33
Mar. 21-23	dry fields	600	16.50	35	12	167	369	64	46	154	371	0	0.00	0.00
Apr. 24-26	short grass	600	16.00	36	5	132	360	60	17	117	354	0	0.00	0.00
May 25-28	short grass-forbs	400	28.75	52	9	138	369	63	42	152	372	0	0.00	0.00
June	plowing	300	35.00	56	31	154	373	49	25	152	367	0	0.00	0.00
July 25	plowing/ planting*	115	48.70	26	12	167	318	30	15	173	379	1	3.33	**
Aug. 21-22	young rice	400	3.50	9	9	129	342	5	1	**	**	1	100.00	**
Sept. 21-22	booting rice	400	10.25	19	19	165	365	22	22	155	364	3	13.64	5.00
Oct.23-24	milk stage rice	390	3.85	2	2	162	329	13	13	173	342	12	92.31	7.33
Nov. 19-21	harvesting	392	4.34	10	3	165	344	7	6	213	376	3	50.00	8.00
Dec. 18-21	post-harvest	400	5.50	12	4	168	342	10	7	103	303	5	71.43	7.40
Total or Annual Mean		4797	15.55	344	130	153	359	402	240	150	363	33	30.77	6.91

*Adjacent rough area was trapped to avoid destruction of new dikes.

** Means could not be calculated because of insufficient sample; data are included in anuual totals.

Table 10. Summary of 1971 monthly census of ricefield rat (*Rattus rattus mindanensis*) populations in the vicinity of Siniloan, Laguna, Philippines.

Date	Paddy Condition	No. of Trap Nights	Trap Success (%)	No. of Males	No. of Ad. Males	X Wgt. Ad. Males (g)	X Lgth. Ad. Males (mm)	No. of Females	No. of Ad. Females	X Wgt. Ad. Females (g)	X Lgth. Ad. Females (mm)	No. Preg. Females	Prevalence of Pregnancy (%)	X Live Embryos
Jan. 21-24	Planting/pre-planting	600	10.50	28	15	178	373	35	23	220	399	12	52.17	6.58
Feb. 23-27	young rice	685	14.74	43	33	227	398	58	33	206	398	3	9.09	8.00
Mar. 24-27	booting rice	1200	7.92	51	49	228	390	44	35	212	399	14	40.00	8.57
Apr. 27-30	booting rice	820	10.37	46	44	193	388	39	30	216	401	24	80.00	8.62
May 26	mature rice	525	15.43	40	23	202	384	41	24	184	383	16	66.67	9.06
June 29-30	harvesting	400	25.50	52	17	204	399	50	24	198	401	11	45.83	9.09
July 27-28	plowing	400	33.75	65	10	216	387	70	42	199	385	2	4.76	9.00
Aug. 22-23*	ratoon/grass/forbs	360	27.50	49	38			50	30			3	10.00	6.67
Sept. 25-26	grass/forbs	304	18.42	33	28	229	401	23	21	223	395	12	57.14	6.00
Oct. 23-24	booting rice	320	19.38	85	29	221	401	27	16	199	400	0	0.00	0.00
Nov. 19-20	plowing/planting	320	15.31	22	16	226	400	27	17	206	395	0	0.00	0.00
Dec. 22-23	pre-planting	400	9.75	22	19	240	389	17	13	224	382	0	0.00	0.00
Total or Annual Mean		6334	15.27	486	321	216	392	481	308	207	395	97	29.79	8.09

*Autopsy specimens were rejected because of deterioration.

Monthly prevalence in the rainfed area varied widely, due largely to the small number of adult females captured during periods of low population density. Breeding appeared largely restricted to the period of land preparation, crop culture, and harvest. Since the entire study area was not at the same cultural stage simultaneously, some variation may have been introduced by movement of animals from one part of the area to another.

In the irrigated area, monthly prevalence of pregnancy remained less variable and had a narrower range. During the February to July period (first crop), some correlation with the agricultural cycle can be observed from the data in Table 9; however, the cycle of the second crop was not well reflected in the sample. Since planting times were more variable during this period, the random sampling procedure did not follow the progression of any particular crop. The lack of breeding in October, November, and December may have related to high rodent populations in the general area during these months.

Number of live embryos tended to be greater in females from the irrigated area; this was apparent from the annual means and from the monthly values. Monthly estimates were highest in the samples from areas with mature rice, harvesting, or post-harvest plowing — May, June, and July, respectively. This same trend occurred in data from the rainfed area — for the months of October, November, and December.

Table 11 summarizes population dynamics data for the two areas for 1970 and 1971. Annual prevalence of pregnancy was nearly the same for both areas in each of the two years; however, estimates for both areas were about fifty percent higher in 1971. Annual incidence figures are estimates of the number of times an adult female become pregnant during the year. Estimates of the number of live embryos produced per female per year were calculated from the annual incidence of pregnancy and the mean number of live embryos per female. The increases in these figures for both areas in 1971 were largely reflections of the higher annual pregnancy rates.

Annual productivity estimates are greatly affected by variation in the estimated proportion of adult females (those capable of bearing young) in the population. In both areas, the proportion of adult females in the populations decreased in 1971. This change reflected the presence of more immature animals in the populations during that

Table 11. Comparison of populations of *Rattus rattus mindanensis* on rainfed and irrigated sites on Luzon, Philippines, based on data collected at monthly intervals during 1970 and 1971.

	Irrigated		Rainfed	
	1970	1971	1970	1971
Annual Prevalence of Pregnancy	22.3	29.8	19.6	30.8
Annual Incidence of Pregnancy	4.5	5.9	3.9	6.2
No. of Months without Breeding	4	3	8	4
Ave. No. of Viable Embryos/Female*	7.7	8.1	7.4	6.9
Embryos/Female/Year	34.6	47.8	28.9	42.8
Age Ratio (% Adult)	70.4	65.0	64.1	49.6
Sex Ratio (% Male)**	43.8	50.3	44.4	46.1
Adult Females (% of Total)	39.6	32.3	35.6	26.7
Birth Rate (Births/Rat/Year)	10.67	15.63	8.23	9.79

*The 1971 estimates are based on *in utero* counts of normal embryos; 1970 data were based upon total *in utero* embryos and corrected by an estimate of 20% uterine mortality published for closely related species.

**Sex ratios for 1970 are calculated for number of adults captured; ratios for 1971 are based on total animals captured.

year and was not due to any major changes in sex ratio. Birth rates (births per rat per year) calculated from the 1971 data were about 46 and 19 percent higher on the irrigated and rainfed areas, respectivel than those calculated for 1970. These data, from two limited study areas, suggest that somewhat higher productivity levels might also have occurred in other areas of the Philippines during 1971.

In each area and in each year, there were some months in which no breeding took place. In March, April, May, and June, no pregnant females were collected on the rainfed area in either year; during 1970, pregnant animals were also absent in the collections of January, February, July, and August. On the irrigated area in 1970, no breeding was observed during the months of January, February, July, and August. In 1971, pregnant females were captured during these months, but not during October, November, and December. Sampling in the large study areas may have actually covered several populations with different breeding patterns, particularly in the irrigated area where planting times could be spread throughout the year. Breeding may take place in every month under favorable environmental conditions. Averaging figures over the entire year presents a combined picture of the average productivity of all the populations being sampled in the study areas; information about the annual changes in one particular population might not be reflected in these data.

We speculate that the annual changes in population size and breeding activity relate more to habitat, food, and to microclimatic factors than to month or season. Previous studies that have indicated seasonal breeding peaks in particular areas might be interpreted in this fashion, particularly if one knew more about the ecological and agricultural conditions of the areas where the studies were conducted.

In rainfed areas, the seasonal cycle and crop cycles correspond more closely than in irrigated areas, because farmers generally wait until the rains begin to start land preparation and planting. Planting in irrigated areas, in some cases, is also related to season, since availability of irrigation water may depend upon flow from mountain sources and may be reduced at certain seasons. This was the case in parts of the irrigated study area. Breeding may be reduced or terminated when resources of the area are reduced or when competition for resources, such as food or nest sites, is high. The endocrine effects of increased competition and stress among rodents in high populations reported by Christian and Davis (1964) provide a possible mechanism by which the changes we observed could occur.

Acceptance of Common Food Items by *Rattus rattus mindanensis* and *Rattus argentiventer*

Introduction

A variety of food items are used by farmers as toxicant carriers. Most commonly grain, such as palay (rough rice), polished rice, or binlid (a material consisting of broken rice pieces) are used, but other vegetable foods are sometimes employed and occasionally even animals, such as snails. Camote (sweet potato) and coconut chunks are often used to bait traps. Laboratory feeding tests were conducted to compare the reaction of the two common species of ricefield rats to a variety of food items. In such tests, animals' reactions may indicate specific preferences as well as provide information on more general patterns, such as preference for grains or succulent vegetables. Feeding tests were used also to gain basic consumption information on common foods; comparative trap success was used in evaluating the relative acceptance of several food items in the field.

Methods

Twenty five *R. r. mindanensis* and 25 *R. argentiventer* were individually caged for the test. Each night, five rats of each species were given a candidate food in addition to water and regular laboratory ration. Dry materials were supplied at the rate of 20 g/animal; succulent materials were given in 40 g amounts so that each rat would have an excess of the test material. Each candidate food was offered to a particular animal only once. Five of the 35 food items were tested for acceptance each night. The test was then repeated exposing each item to five different rats.

Live trapping was then used to compare field acceptance of some foods readily available in the Philippines. For *R. r. mindanensis* five materials were tested by setting five lines of 25 traps each at 25-m intervals; each food item was used to bait a different line on each of five nights. Twelve different baits and 200 traps were used for comparative trapping on *R. argentiventer*; forty traps were placed at 10 m intervals in each of five lines. Every fourth trap in all lines was baited with the same food for two nights. In both tests, all trapped animals were released immediately.

Results and Discussion

No major preferences were indicated by the laboratory tests (Table 12). Virtually all the materials tested were readily accepted by most rats (an exception was the failure of either laboratory group to feed on dried anchovy). The cereal grains, as a group, generally appeared somewhat more acceptable than the other foods tested. Shrimp, radishes, carrots, and green Indian mango were the most variable, both in amount eaten and in percent acceptance. In general, there was little consistent difference by weight in the amount of dry and moist or succulent food consumed. However, data have also been expressed by volume (determined by water displacement) to facilitate comparison of materials such as mango and papaya with high water content.

In the field trials (Table 13), more than twice as many R. r. mindanensis were caught in traps baited with coconut compared to traps in which other materials were used. This result was not statistically significant because of the high variation between traplines. Additional experience in trapping this species with other materials strengthens our opinion that these results indicate little real difference in preferences. Trap success with R. argentiventer (Table 14) was generally so low that any differences between materials could not be discerned. These trapping results confirm our previous impression and the reports of Harrison (1958) and Wood (1971) of the "trap-shyness" of this species.

The data suggest that many items could be used as toxicant carriers or bait for traps. Bait carriers should be selected more on the bases of availability, preservation characteristics, cost, and ease of applying toxicant, than on anticipated acceptance by rats. Bait acceptance under ricefield conditions has been highly variable in many of our observations. This variation probably relates as much to bait placement, activity patterns, and the animals' previous experience with toxic baits as to food preference factors. If "bait-shy" animals are encountered, prebaiting with non-toxic bait or use of chronic toxicants may offer a more immediate solution than simple change of bait base. When rice begins to mature, bait consumption sometimes appears to decrease regardless of acceptance levels during the earlier stages of plant growth.

Trap success, especially with snap-traps, probably does not depend solely upon the bait. In other studies we have caught animals by the tails, hind legs, and other parts of the body with snap-traps, suggesting they were not investigating the bait when captured.

Table 12. Comparison of the reaction of *Rattus argentiventer* and *Rattus rattus mindanensis* to various food items. Generally, ten individuals of each species were exposed to each material for 24 hours. The regular laboratory rations and water were available *ad libitum* throughout the test.

MATERIAL	*Rattus rattus mindanensis*			*Rattus argentiventer*		
	Percent Accepting	Weight (g) $\bar{X} \pm$ S.E.	Volume (cc) $\bar{X} \pm$ S.E.	Percent Accepting	Weight (g) $\bar{X} \pm$ S.E.	Volume (cc) $\bar{X} \pm$ S.E.
Binlid (rice shorts)	100	12.41 ± 1.85	8.32 ± 1.24	100	7.41 ± 0.70	4.96 ± 0.47
C4, palay (unmilled)	100	9.28 ± 1.51	8.44 ± 1.37	100	6.77 ± 0.68	6.16 ± 0.62
C4, polished	100	9.05 ± 1.72	6.70 ± 1.27	100	5.15 ± 0.60	3.81 ± 0.44
IR22, palay	100	12.62 ± 1.43	11.48 ± 1.30	100	6.86 ± 0.68	6.24 ± 0.62
IR22, polished	100	11.99 ± 1.57	8.87 ± 1.16	100	6.86 ± 0.49	5.08 ± 0.36
Malagkit, palay	100	13.72 ± 0.56	12.48 ± 0.57	100	5.80 ± 0.91	5.28 ± 0.83
Malagkit, polished	100	11.86 ± 2.28	8.78 ± 1.69	100	5.12 ± 0.56	3.79 ± 0.41
Pinipig (crushed, roasted rice)	100	6.65 ± 0.80	4.92 ± 0.59	100	4.34 ± 0.85	3.21 ± 0.63
Oats (hulled)	100	7.57 ± 0.89	6.06 ± 0.71	100	4.83 ± 0.70	3.86 ± 0.56
Wheat	90	8.10 ± 1.25	5.99 ± 0.92	100	4.68 ± 0.84	3.46 ± 0.62
Sorghum	100	8.61 ± 1.93	8.61 ± 1.93	90	4.60 ± 1.05	4.60 ± 1.05
Corn, hard	100	8.05 ± 1.24	6.68 ± 1.03	100	3.69 ± 0.65	3.06 ± 0.54

Table 12 (Cont.)

Corn, hard, boiled	100	9.50 ± 2.24	7.88 ± 1.86	100	5.23 ± 0.97	4.34 ± 0.80
Corn, fresh, on cob	100	10.72 ± 1.36	10.08 ± 1.28	100	10.25 ± 1.57	9.64 ± 1.48
Corn, roasted, on cob	100	8.63 ± 1.16	7.77 ± 1.04	90	6.10 ± 1.33	5.49 ± 1.20
Soybeans, green	90	5.63 ± 1.13	6.19 ± 1.24	100	8.92 ± 1.72	9.81 ± 1.89
Mongo beans, green, in pods	100	9.89 ± 2.12	9.69 ± 2.08	100	10.78 ± 1.85	10.56 ± 1.81
Mongo beans, dry	100	3.00 ± 0.66	2.31 ± 0.37	100	3.58 ± 0.54	2.76 ± 0.42
Coconut, cooked	100	7.10 ± 1.04	8.31 ± 1.22	100	3.11 ± 0.88	3.64 ± 1.03
Coconut, fresh	90	8.77 ± 1.65	8.51 ± 1.60	100	6.59 ± 0.53	6.39 ± 0.57
Coconut, grated	100	10.47 ± 1.14	10.16 ± 1.10	80	3.11 ± 0.68	3.02 ± 0.66
Camote, fresh	100	23.30 ± 2.26	21.44 ± 2.08	100	15.30 ± 2.53	14.08 ± 2.33
Carrots	70	6.25 ± 1.90	6.12 ± 1.86	100	7.64 ± 1.77	7.49 ± 1.73
Radishes	100	4.48 ± 1.43	4.48 ± 1.43	80	5.80 ± 2.15	5.80 ± 2.15
Cassava, fresh	100	16.33 ± 1.01	14.21 ± 0.88	100	11.18 ± 0.91	9.73 ± 0.79
Ube, fresh	80	2.56 ± 0.86	2.46 ± 0.82	90	3.59 ± 0.56	3.45 ± 0.82
Peanuts	90	7.40 ± 1.59	6.96 ± 1.49	80	3.31 ± 1.40	3.11 ± 1.32

Table 12 (Cont.)

Sugarcane, fresh, rind removed	100	13.11 ± 3.70	12.06 ± 3.40	100	12.25 ± 2.15	11.27 ± 1.98
Papaya, fresh	93	22.91 ± 3.13	21.99 ± 3.00	93	16.83 ± 2.34	16.16 ± 2.25
Mango, ripe	80	8.38 ± 2.93	8.13 ± 2.84	90	8.03 ± 2.95	7.79 ± 2.86
Indian mango, unripe	70	2.70 ± 1.12	2.62 ± 1.09	70	3.15 ± 1.04	3.06 ± 1.01
Banana, fresh	90	16.96 ± 2.72	18.15 ± 2.91	90	10.02 ± 2.03	10.72 ± 2.17
Chico, fresh	100	7.85 ± 2.12	7.30 ± 1.97	70	3.27 ± 1.00	3.04 ± 0.93
Shrimp	70	6.59 ± 1.94	6.06 ± 1.78	60	4.80 ± 2.24	4.42 ± 2.06
Dried Anchovy	0	0	0	0	0	0

Table 13. Comparison of several common food materials as bait for live-trapping *Rattus rattus mindanensis*. Each material was exposed in one of 5 alternating traplines of 25 traps each during a 5-night trapping period. Tests were conducted in booting rice at Pila, Laguna.

Bait	Trap Success $\left(\frac{\text{No. of rats}}{\text{No. of Trapnights}}\right) \times 100$
Coconut	13.60
Papaya	6.40
Cassava	6.40
Camote	5.60
Banana	1.60

Table 14. Comparison of several common food items as bait for live-trapping *Rattus argentiventer*. Each material was exposed for 2 nights of a 6-night trapping period on a grid containing 200 traps. Materials were tested in groups of four and were alternated in successive traps. Tests were conducted in maturing rice at M'lang, Cotabato.

Bait	Trap Success $\left(\frac{\text{No. of rats}}{\text{No. of trapnights}}\right) \times 100$	Night Used
Fresh corn on cob	6.00	1 & 2
Fresh corn and grated coconut (1:1)*	4.00	5 & 6
Bread	3.00	1 & 2
Roasted coconut, cubed	3.00	3 & 4
Fresh corn and pineapple (1:1)*	3.00	5 & 6
Fresh coconut, cubed	2.00	3 & 4
Sardines	2.00	1 & 2
Roasted corn	1.00	3 & 4
Grated cassava and grated coconut (1:1)*	1.00	5 & 6
Anchovy, dried	1.00	1 & 2
Snails	1.00	3 & 4
Cubed pineapple	0.00	5 & 6

*Materials were mixed and tied into small gauze packets.

Laboratory Evaluation of Lethal Agents

Introduction

A balanced program of long-term management of rat populations will probably include the use of toxicants. Because of the major field tests conducted with zinc phosphide, laboratory studies this year were limited to this toxicant and one experimental compound DRC-4570. The dose calculated to be lethal to at least 50% of a population (the LD_{50}) was again used as an index for comparing toxicity. Values for zinc phosphide were obtained (by the standard method of gavage with oil-suspended toxicant) on *R. r. mindanensis* from two populations on Luzon and on *R. exulans*. The LD_{50} of DRC-4570 to *R. r. mindanensis* was also obtained by the same method. A test was conducted to determine the toxicity of zinc phosphide-treated rice to *R. r. mindanensis*.

Methods

Animals were trapped in the field and brought to the animal quarters at the Center where they were allowed to adapt to caging and a standard animal ration. Animals for gavage tests were deprived of food for several hours to avoid toxicant dilution in the stomach; toxicants were suspended and administered in home-made coconut oil. LD_{50}'s were calculated by the moving average method (Thompson, 1947; Thompson and Weil, 1952; Weil, 1952) or the Litchfield and Wilcoxon (1949) method. The latter method was preferred, but the former was used when few animals were available for a test.

In the test using zinc phosphide-treated rice, ten animals were given a quantity of rice bait calculated to supply a specific level of toxicant per unit of body weight. The LD_{50} was then determined by the same method used for gavage tests. Only animals that consumed all the bait presented at the test levels were used in calculations; this restriction resulted in the availability of only six animals at each of four dosage levels: 12, 18, 28, and 42 mg/kg.

Results and Discussion

Results of extensive laboratory comparisons of the toxicity of several compounds on species of Philippine rats were reported in the Center's 1970 Annual Report. Additional information for zinc phosphide and the LD_{50} of DRC-4570 are reported this year (Table 15). In virtually all the laboratory tests, we have found wide variation in susceptibility

of the species tested — both among animals from the same population and among different populations. The confidence intervals shown with the tabular data are indicative of the variation.

Most of the laboratory data previously developed were based on toxicity of oil suspensions administered by gavage. The test using treated rice appears to confirm that the gavage method, which is simpler to use, results in similar values. Apparently the toxic action of zinc phosphide is slow enough to overcome any major differences due to slower ingestion of treated bait.

In determining the optimal toxicant concentration of field baits, other factors such as rate of degradation and potential food consumption of target animals must be considered in addition to the range of toxicity. The variable toxicity of zinc phosphide, as shown by these results, coupled with its relatively slow action and weathering characteristics (reported in another section) led us to recommend a 2% concentration (by weight) for future field tests.

Table 15. Toxicity of zinc phosphide and DRC-4570 determined on several collections of Philippine rats.

Compound	Species	Location Trapped	Carrier	LD_{50} (95% confidence intervals indicated)
Zinc Phosphide	*R. r. mindanensis*	San Antonio, Nueva Ecija	Coconut oil	18.0* (12.0-27.0)
"	"	Pagsanjan, Laguna	Coconut oil	16.0** (11.9-21.6)
"	"	Pagsanjan, Laguna	Rice	21.2*** (16.5-27.2)
"	*R. exulans*	Pagsanjan, Laguna	Coconut oil	14.3** (9.7-21.0)
DRC-4570	*R. r. mindanensis*	Pagsanjan, Laguna	Coconut oil	27.0* (18.0-40.5)

*Thompson and Weil method, gavage
**Litchfield and Wilcoxon method, gavage
***Thompson and Weil method, free-feeding

Figure 7. Gavage procedure for conducting laboratory bioassay of chemicals.

Weatherability of Zinc Phosphide Treated Bait

Introduction

The stability of zinc phosphide on baits has been investigated by several workers; results have not been consistent. Crabtree (1962) stated that zinc phosphide coated grains exposed to rains lost 50 percent of their toxicity in 12 to 24 hours and lost most of their lethal characteristics in two or three days. Hayne (1951) found that cracked corn containing 2 percent zinc phosphide showed only 50 percent loss of toxicant after a 27-day exposure to rain and snow. Doty (1945) reported that baits used on Hawaiian sugar plantations deteriorated rapidly if they became wet. Elmore and Roth (1943) showed that grain baits containing 0.6 percent zinc phosphide lost 23 percent of the chemical when exposed to two days of heavy rain. Our tests were conducted to determine whether rice baits containing zinc phosphide remained lethal after weathering and to determine the actual toxicant loss that occurred during exposure to Philippine climatic conditions.

Methods

The test were conducted in three phases. In the first phase polished rice containing 0.75 percent zinc phosphide was exposed for two rainy days. In the second phase similar bait was exposed for seven days during which little rain occurred. Corn oil at a concentration of 0.5 percent was used as an adhesive in both phases. Following exposure periods of 12, 24 and 48 hours in the first phase and 48, 72 and 168 hours in the second, bait samples were collected and used for bioassay. The bioassay consisted of offering 10 grams of rice to 10 individually-caged rats (*Rattus rattus mindanensis*) overnight. Amounts consumed were recorded for each animal and lethal effects were noted.

Although the results of bioassays clearly indicated that weathered baits would still kill rats, additional information on rate of toxicant loss appeared desirable. Phase three consisted of gas chromatographic analysis of toxicant loss using the following formulations:

A. Polished rice mixed dry with 2% zinc phosphide.

B. Binlid (rice pieces) mixed dry with 2% zinc phosphide.

C. Polished rice coated with 1% home-made coconut oil, then mixed with 2% zinc phosphide.

D. Binlid coated with 1% home-made coconut oil, then mixed with 2% zinc phosphide.

Fifteen 25-g samples of each formulation were placed at random in a circle with a radius of 2.5 m; a rotating lawn sprinkler was placed at the circle's center. The rice was placed on screen wire on bare ground; the binlid on three layers of cheese cloth also on bare soil. The screen wire and cheese cloth allowed maximum exposure but facilated recovery of the samples.

The sprinkler was operated daily during a 1 1/2 to 2-hour period to simulate about one inch of rain every 24 hours. The water pH was 7.0. The amount of water delivered was checked in six rain gauges set around the sprinkler. Five samples of each formulation were collected after 24, 48, and 72 hours exposure. Five additional samples of each formulation were saved with no exposure and five more were exposed for 72 hours with no rain.

The samples exposed to water were air-dried in a vented hood for 6 to 8 hours, then frozen. After all samples were collected, dried, and frozen they were packed in dry ice and sent via air-freight to the Denver Wildlife Research Center for gas chromatographic analysis of zinc phosphide content. Analysis was conducted on a pooled sample consisting of 1-g aliquots from each of the five samples collected for each formulation and exposure period. Regrettably, it was impossible to repeat bioassay tests on samples weathered in phase three, precluding determination of the relationship between mortality and toxicant loss.

Results and Discussion

Bioassay results showed weathering for 48 hours had little or no affect on the toxicity of the bait (Table 16). Longer exposure, even with small amounts of rain, for 72 and 168 hours appeared to decrease toxicity as indicated by the higher bait consumption and reduced mortality.

Table 16. Bioassay results of rice containing 0.75 percent zinc phosphide after exposure to the elements.

Phase	Exposure time in hours	Precipitation in inches	Ave. grams bait consumed per rat (10 rats)	Percent mortality
1	0	0	2.1	100
	12	1.34	2.3	100
	24	1.34	3.8	90
	48	1.37	2.4	100
2	48	0	2.0	100
	72	0.17	6.8	80
	168	0.34	5.0	60
Untreated	168	0.34	9.5	0

Gas-chromatograph analysis of zinc phosphide-treated baits showed a considerable loss of toxicant (up to 70% loss in 3 days). The greatest loss occurred shortly after treatment (Table 17). In three of the four formulations analyzed, the loss of 72 hours was only slightly more than the 24-hour loss. This suggests that the zinc phosphide loss was caused by sloughing rather than hydrolysis. Baits containing no oil generally lost more toxicant than that treated with oil, especially during the first 24 hours of exposure.

Bioassays suggested that polished rice baits treated with 0.5% vegetable oil and 0.75% zinc phosphide retain ample toxicant after 24-hour exposure to insure a lethal dose to rats with moderate bait consumption. With a minimum LD_{100} of 30 mg/kg, and assuming a 40% loss of toxicant after a 24-hour exposure of two percent treated bait (polished rice), the maximum amount of bait needed to kill a 150 g animal with a single feeding would be 0.38 g (21 rice grains averaging 18 mg). In many situations where acute toxicants are used, it would be desirable for bait to remain toxic for 2 or 3 days. Considering the toxicant loss from weathering, potential bait consumption of target animals, and the range of toxicity, a concentration of 2% was recommended for future field tests with zinc phosphide-treated grain baits.

Table 17. Gas chromatograph results obtained with rice and binlid treated with zinc phosphide and exposed to weathering.

Treatment	Time exposed in hours	Water applied in inches	Percent zinc phosphide in bait	Percent zinc phosphide lost
2% Zn_3P_2 Rice with oil	0	0	2.34*	-
	24	1 1/16-1 1/8	1.35	42
	48	2-2 3/8	1.09	53
	72	3-3 3/8	0.71	70
	72	0	2.02	14
2% Zn_3P_2 Binlid with oil	0	0	1.55*	-
	24	1 1/16-1 1/8	0.86	45
	48	2-2 3/8	0.86	45
	72	3-3 3/8	0.72	54
	72	0	0.98	37
2% Zn_3P_2 Rice without oil	0	0	2.00*	-
	24	1 1/16-1 1/8	0.74	63
	48	2-2 3/8	0.64	68
	72	3-3 3/8	0.61	70
	72	0	0.63	69
2% Zn_3P_2 Binlid without oil	0	0	1.48*	-
	24	1 1/16-1 1/8	0.78	47
	48	2-2 3/8	0.79	47
	72	3-3 3/8	0.76	49
	72	0	0.63	57

*All baits were prepared to contain 2.00 percent zinc phosphide by weight; variation in zinc phosphide content in non-exposed samples was assumed to reflect preparation error. Percent loss was calculated from the values indicated by gas chromatography of non-exposed samples.

Evaluation of Aerial Dispersal of Zinc Phosphide Baits for Rodent Damage Control

Introduction

Aerial application of chemically treated bait for dry-season rodent control in and near some croplands is a commonly-used procedure in some areas of the Philippines. Although large numbers of rats are usually reported to be killed, no detailed estimates of population effects are available. During early April, zinc phosphide bait was aerially broadcast in a 4-km^2 area along the Chico river at Barrios Guevara and Macalong, La Paz, Tarlac, to determine the percent reduction of the rodent population following baiting, and to determine whether population reduction during the dry season could measurably reduce rodent damage to the succeeding rice crop.

Methods

The test area consisted of uninhabitated land (cultivated and uncultivated) extending for about two kilometers away from the river. Primary grass species in the non-cultivated area were cogon (*Imperata cylindrica*), sacate (*Leersia hexandra*), talahib (*Saccharum spontaneum*), and common reed (*Phragmites australis*). Rice stubble existed throughout the cultivated area; harvest was completed in January. The bait used was whole-kernel yellow corn, coated with home-made coconut oil (1%) and dusted with zinc phosphide (2%). It was distributed in 10-m swaths at 30-m intervals at the rate of 1.6 kg per ha of actual baited surface.

A 100-ha (1 km^2) section centered in the baited area, was used to monitor the rat population. A similar 100-ha unbaited area, separated from the treated area by a 500-m strip, was used for comparison. The two areas each contained about 50 ha of cultivated and about 50 ha of uncultivated land.

Ten transects were located in each of the four 50-ha portions. The transects were located at 50-m intervals and lay parallel to the boundary of the cultivated and uncultivated land. Three days before baiting, 25 snap-traps and 25 inked tracking-tiles, similar to those described by Lord *et al*. (1970), were placed alternately at 20-m intervals on two randomly-selected transects in each area in an attempt to estimate relative abundance of rodents. Three days after baiting, the relative abundance was estimated again using traps and tracking tiles on two different randomly-selected transects in each of the four areas.

Just before harvest of the subsequent rice crop (about nine months after baiting), ten paddies in each cultivated portion of the baited and unbaited areas were examined to determine the percentage of rice tillers cut by rats. Five paddies were chosen along the edge of the uncultivated section; 5 were 100 m from the uncultivated area.

Results and Discussion

A doubling of trap success in the cultivated portion of the reference area after baiting suggested that traps (at least, under the test conditions with this particular design) could not provide reliable data about changes in the rat population of the area (Table 18). Tracking-tile data showed a 30 percent reduction in activity in the baited-cultivated area, and about a 60 percent reduction in the uncultivated. No change was noted on the unbaited area. Many dead rats were observed in the baited areas; bait seemed to be readily accepted. Despite this initial effect, tracking tiles indicated heavy rat activity in the area one month after treatment (Table 18).

Table 18. Effect of dry season aerial baiting with zinc phosphide-treated corn on rat populations of cultivated and uncultivated areas at La Paz, Tarlac. Baiting was made in mid-April, 1971.

	Baited		Reference	
	Cultivated	Uncultivated	Cultivated	Uncultivated
Percent Trap Success				
Pre-treatment	35.3	62.9	20.5	25.0
Post-treatment	34.7	29.3	39.9	29.4
1 Month Post-tr.	51.7	45.5	33.8	29.3
Percent Tiles Active				
Pre-treatment	91.3	100.0	65.8	73.8
Post-treatment	63.3	41.3	64.7	76.7
1 Month Post-tr.	94.6	98.0	83.3	76.5

The damage survey in the subsequent rice crop showed only minor losses through most of the baited and unbaited areas (Table 19); however, this probably related to the sequence of events following the April test. During floods in late October and early November, farmers and local extension personnel apparently reduced the rat population in both areas by placing acute toxicants on emergent areas and at the edge of the flood waters. These control operations probably masked any effect the earlier baitings may have had.

In 1971, the uncultivated area seemed to have played a minor role in supplying rats for the adjacent cropland. Substantial losses (Table 19) occurred only in the paddies closest to the uncultivated portion of the treated area. Light damage was found throughout the reference area, even in paddies adjacent to the uncultivated portion. A large barrier dike, that remained above eater during the flood, separated the cultivated and uncultivated portions in the reference area and probably provided rats some refuge from the flood waters. Portions of the dike were baited from boats during the flood. Local observers indicated that baiting during November was more intense in the reference than in the treated area, but it could not be determined if this was the major reason for differences in rice damage.

Table 19. Percent of rice tillers cut by rats in reference and treated areas at La Paz, Tarlac. Baiting was made in April; damage surveys were made in January, before harvest of the subsequent crop.

	Adjacent to Uncultivated Area	100 m from Uncultivated Area
Baited Area	9.36	1.02
Reference Area	1.84	1.78

Consideration of the toxicological properties of zinc phosphide and the feeding patterns of R. r. mindanensis suggested that insufficient bait was available for major reduction of this rat population. At the baiting rate of 1.6 kg per ha, about 8000 kernels of corn were scattered on each baited hectare. The method of formulation deposited about 4 mg of toxicant on each kernel at the time of treatment. Laboratory studies

showed that more than one kernel would be needed to kill some R. r. mindanensis. With some highly toxic materials such as 1080, many rats would probably be killed before consuming an entire kernel, rendering the above baiting rate adequate. With slower acting or less toxic materials, such as zinc phosphide, many kernels could be consumed or cached by rats before toxic effects began. The problem, in this case, might have been solved by using more bait per hectare or by adding untreated corn to the bait mixture to disperse the treated kernels more widely.

The population in the study area appeared to have been reduced by subsequent control operations carried out by farmers and extension personnel during a flood in late October and early November. Such floods occur annually at somewhat variable times between September and November. Late flood occurence coupled with the localized control operations probably precluded recovery of the rat population in time to damage rice crops severely. The same sequence of events, had they taken place two months earlier, may have provided insufficient protection for the rice.

These results emphasize the need for careful consideration of the annual change in environmental variables, the condition of local rat populations, and the characteristics of individual toxicants in designing effective control programs for particular locations. The difficulties in precise evaluation of population changes and the need for more effective census techniques are also evident.

Field Trial of Multiple Baiting With Zinc Phosphide to Protect Growing Rice From Damage By Rats (Rattus rattus mindanensis)

Introduction

One control method presently suggested for reducing rat populations in ricefields is baiting with acute toxicants during the dry season followed with chronic toxicants during the growing season (Sumangil et al. 1970). Because of the high costs of using chronic toxicants, preliminary studies were conducted at this laboratory to evaluate the effectiveness of baiting during the growing season with polished rice treated with acute toxicants. After single baitings, trap success for ricefield rats (R. r. mindanensis) was generally reduced about 65 percent; not an adequate population reduction to prevent substantial damage before harvest. The present study was conducted to determine the effectiveness of multiple baitings with zinc phosphide-treated bait in reducing rat populations and damage in growing rice.

Materials and Methods

Six 20-hectare study sites were selected within a continuous area of several hundred hectares of irrigated riceland between Sta. Cruz and Lumban, Laguna. All sites were at least 100 m apart. Within each site, rodent activity was censused by placing tracking tiles in a central block of nine contiguous rice paddies; the blocks averaged about 1.5 ha each. For each census, vinyl floor tiles (23 cm x 23 cm) similar to those described by Lord et al. (1970), were partially covered with printer's ink and placed for two nights along the paddy borders; one at the paddy corners and two along each side, for a total of 64 tiles per nine-paddy block. Tiles were checked and cleaned in early morning, then reset in late afternoon to avoid daytime disturbance. Rat activity was expressed as percent of tiles showing tracks.

The first census was conducted in each site 5-10 weeks after transplanting of the rice (before panicles emerged and rat damage began). After the second day's census, the entire site was baited in the afternoon with a test preparation of polished rice treated with zinc phosphide (1.0% by weight) and home-made coconut oil (0.5% by weight). Bait was placed in 6-g piles at 5-m intervals along dikes, beside all dike intersections, and near all noticeable burrow entrances; this resulted in an approximate bait application rate of 1 kg/ha. Earlier studies indicated that about 0.75 g of this bait would be lethal to most adult rats (R. r. mindanensis); thus, each bait pile contained at least eight lethal doses. Weathering tests indicated the bait would be adequately toxic for 2 or 3 days, even if exposed to rain.

The fifth and sixth days after baiting, a census was again conducted at each site. The seventh day, the entire site was baited with 1-cm^3 chunks of fresh, mature coconut dusted with zinc phosphide (1% by weight), placed in the same manner as the rice bait. Again, a census was conducted the fifth and sixth days after baiting. Within 2 weeks of harvest, a fourth census was conducted and, because activity remained high, all of the six 20-hectare sites were baited again with the initial preparation of zinc phosphide-treated rice. A fifth census was conducted the fifth and sixth days after this third baiting.

Six blocks of nine contiguous paddies, each corresponding to a baited area but at least 100 m from it, served as reference plots. Censuses were conducted on these plots, in the same manner as on the treated plots, before the first, after the second, and before the third baiting on the corresponding treated area. The censuses between the first and second baitings and after the third baiting were eliminate because reference estimates had been made only 5 days earlier. At harvest, 100 randomly selected hills (10 hills from each of 10 rows) in each of the 108 paddies (treated and reference) were examined to determine the percent of the rice tillers cut by rats.

Results and Discussion

Although many farmers attempt some rodent control with rice baits and acute toxicants, the baiting method we tested incorporated several refinements not generally used. These included uniform baiting on a relatively large area (owned by several farmers), baiting before the appearance of rat damage, alternating bait bases, using coconut oil to increase the weatherability of bait, and placing additional bait near noticeable sites of rat activity.

However, the data indicate that even this intensive baiting did not appreciably reduce the population or prevent rice damage (Table 20). Only the census following the first baiting in replicates 1, 2, and 4 showed significantly ($P<.05$) less rodent activity in the treated than in the reference plots. Although damage at harvest was significantly ($P<.05$) less in the treated than in the reference plots in two of these replicates (1 and 4), it was significantly higher in the third plot (2). The mean percentage of tillers cut in all treated and reference plots was almost identical (5.0% vs 5.3%). We must conclude that the baitings had no important influence on damage.

Table 20. Effect of multiple baiting with zinc phosphide on activity of *R. r. mindanensis* as indicated by censuses with tracking tiles, and on damage to rice at harvest.

Replication	Time of Baiting (Weeks After Transplant) 1st	2nd	3rd	Before 1st Baiting	Between 1st and 2nd Baiting	After 2nd Baiting	Before 3rd Baiting	After 3rd Baiting	Percent of Rice Tillers Cut (9-Paddy Ave.
1. Treated	10	11	16	87.7	48.4	39.8	57.0	51.8	6.0
Reference*				83.6		77.2	58.6		14.5
2. Treated	5	6	13	77.6	44.5	63.2	52.3	63.8	12.1
Reference*				75.8		83.2	78.9		4.1
3. Treated	6	7	14	30.2	41.9	24.2	63.3	82.7	4.0
Reference*				41.7		44.7	50.0		1.5
4. Treated	9	10	14	75.4	42.0	82.0	57.6	65.6	1.7
Reference*				84.4		63.3	54.3		3.8
5. Treated	6	7	13	91.4	88.3	86.7	86.5	68.1	2.7
Reference*				89.4		93.3	86.7		3.8
6. Treated	6	7	13	76.6	66.4	76.2	82.0	65.5	3.4
Reference*				98.4		93.8	74.8		3.9
Mean									
Treated				73.1	55.2	62.0	66.4	66.2	5.0
Reference				78.8		75.9	67.2		5.3

*Activity estimates on the reference areas were not made between the first and second, and after the third baitings because reference estimates had been made only 5 days earlier.

Many factors probably contributed to the unsatisfactory results of this multiple baiting. Fernando et al. (1967) stated that ricefield rats (Gunomys) in Ceylon have developed increasing bait shyness to the traditional rodenticides. Wood (1971) noted that in Malaysia the commonly adopted poisoning procedures using zinc phosphide on grain generally spare enough rats for damage to continue. In the Philippines, farmers do considerable individual baiting; bait acceptance could be one of the largest single factors reducing the success of population management with acute toxicants.

It should be noted that damage estimates for most of the treated and reference areas were relatively low. The owners of virtually all of the 54 reference paddies used some form of chemical control to protect their rice. Damage in the reference plots may have been considerably higher had this not been the case. The baiting method tested thus appeared to offer no improvement over the aggregate of local methods the adjacent farmers were employing; its effectiveness was not compared with situations in which no local control existed.

There was no apparent correlation between damage and tracking tile use at any growth stage, indicating that tracking tiles could not presently be used to predict damage. Previous work at this laboratory has shown a similar lack of correlation between trap success and damage in rice; work by personnel of the U.S. Bureau of Sport Fisheries and Wildlife (G. A. Hood et al. 1968 unpublished report Denver Wildlife Research Center) showed no correlation between trap success or activity boards with damage by rats (Rattus spp.) to sugarcane in Hawaii. Although the reasons for this lack of correlation are not known, variation in the response of different populations to growing rice and the lack of precision in census methods probably contribute. Tracking tile use was generally lower in mature rice than in young rice. We suspect this reflects the rats' establishment and use of more definite paddy runways and a decrease in the use of dikes as the rice ages.

The method of baiting used in this study requires little effort and expense. The cost for each treatment was ₱2.65 per hectare: ₱1.00 for 1 man-hour of labor, ₱1.30 for 1 kg of polished rice or coconut, and ₱0.35 for 10 g of zinc phosphide. The low cost of toxicant was a major reason for these low figures; this would be the only

direct expense if a farmer furnished his own bait and labor. While effectiveness remains the most important criterion for evaluating Philippine rice protection methods, the direct cost and personal labor required of small farmers are also major considerations in developing workable approaches.

We suspect that bait acceptance is a major factor limiting the effectiveness of acute toxicants as now used for rodent population reduction in Philippine ricefields; methods to improve acceptance need further investigation. Some possible approaches are baiting in the paddy, use of bait stations, and pre-baiting. Use of non-chemical approaches such as habitat management, either alone or with acute and chronic toxicants, should also be investigated. However, these approaches will add costs that may prove excessive for the improvements in effectiveness gained. The potential problem of genetic resistance to anticoagulant rodenticides (Jackson, 1969) may further impair effectiveness if one material is used repeatedly over an extended period. Both bait acceptance and genetic resistance to toxicants should be considered in the design and testing of improved control programs.

Figure 8. Preparation of zinc phosphide bait for field trial.

MISCELLANEOUS STUDIES AND OBSERVATIONS

Growth of Young Rats In Relation to Litter Size

Several studies have described growth rates of young rodents. It is known that both litter size and laboratory confinement may affect the growth and age of maturation of young rats. In a study where we attempted to correlate age of young animals with physical measurements, five female R. r. mindanensis were allowed to rear litters in outdoor nest boxes. Saw dust, treated with a residual insecticide (chlordane), was mixed with the dirt immediately surrounding the box to prevent ants from disturbing the young. Noticeably pregnant females were released into the boxes immediately after capture. Food consisted of palay, camote, anchovy, and water ad libitum. At 23 days of age the young animals were weighed and measured as shown in Table 22. Litter size at weaning varied from 2 to 11 and averaged 7.4. The animals in the litter of two were more than four times as heavy at weaning as those in the litters of 11.

Table 22. Means of weight and physical measurements of R. r. mindanensis at 23 days after birth as related to litter size.

Litter size	Weight	Total length	Tail length	Hind foot length	Ear length	Distance from anus to genital opening	
						Females	Males
2	66.9	269.0	143.0	37.0	18.0	--	27.0
6	24.4	198.2	95.2	28.7	16.0	9.0	15.3
7	27.6	190.6	88.4	28.0	15.7	8.8	19.0
11	14.7	156.6	74.1	23.5	13.7	8.4	12.2
11	11.4	140.2	68.8	20.6	12.8	6.3	10.2

Weights of 72 young from 15 litters of the R. r. mindanensis colony at the Philippine Atomic Energy Commission (Table 23) showed no relationship with litter size.* The parent animals' diet at PAEC was nutritionally different from that in our study and may partially explain the differences in growth observed in the two situations. Considerable variation occurred in the weights of young in litters of the same number, making comparison of small samples difficult. Additional data are needed to formulate any conclusions.

Table 23. Weight of 21 day old R. r. mindanensis in the Philippine Atomic Energy Commission colony as related to litter size.

Litter size	Average weight
3	20.2
3	25.0
3	29.7
4	15.6
4	23.4
4	24.7
4	35.5
5	18.5
5	24.4
5	27.9
5	29.2
6	25.2
7	21.2
7	24.0
7	26.8

*Thanks are extended to Dr. Benjamin dela Cruz, Philippine Atomic Energy Commission for permission to use his data.

Data on the age at first breeding may show that weight or other morphological characters can be used as indices of physiological age. Studies to determine age (chronological and physiological) correlates, could be applied to establish the age structure of natural populations. These data indicate that variation due to litter size, physical conditions, and nutritional factors may be a major consideration in designing such studies.

Bait Placement Study

In a comparison of food consumption using four bait placement techniques in the field, the initial take from bamboo tubes averaged less than that of three other methods in which bait was openly exposed. Twenty-four fresh coconut cubes were exposed daily for three days by each of four methods: in bamboo tubes placed on top of dikes, on banana leaves placed on top of dikes, on the ground on top of dikes, and on the ground on the side of dikes. Each method of placement was alternated at 10-m intervals along paddy dikes in booting rice in an area where *R. r. mindanensis* occurred. The average number of coconut cubes eaten each night for each method of placement were; dike side, 14.7; banana leaf, 10.0; dike top, 8.7; and bamboo tube, 5.0. The reduced consumption from bamboo tubes indicates this method of bait placement may reduce effectiveness even though it affords the bait protection from the weather.

Ricefield Rats are Not Entirely Dependent Upon Burrows for Daytime Refuge or Nesting

On several occassions we have observed rats seeking refuge or nesting outside of burrows. During eight days of radio-tracking 11 *R. argentiventer* in maturing rice in Cotabato, 33 daytime locations were determined. Of these only 13 were in burrows; the remainder were in standing rice or uncultivated grassland. Transmitter signal characteristics indicated these animals were not moving and probably not feeding. One rat did not enter a burrow after being chased in one paddy for 30 minutes by five people. Likewise, we have found several *R. r. mindanensis* nests not associated with burrows. While some were located adjacent to dikes, many were located within the paddy several meters from a dike. No intensive investigation for

Figure 9. Typical paddy nest of Rattus rattus mindanensis opened to expose young rats.

similar nests of R. argentiventer has been made. These observations suggest that some rat populations could probably adapt to a ricefield culture lacking paddy dikes or places for burrowing.

Artificially Flavored Rice Not More Attractive to Rats Than Natural Rice

Rice treated with 4% of a commercially supplied flavoring agent having the odor of the native variety Milagrosa, was not more acceptabl to rats than untreated rice. Two gauze packets, one containing six grains of flavored rice, the other six grains of untreated rice, were offered to fasted rats. The packet opened first was recorded to determine preference. Of 19 R. r. mindanensis tested, 18 opened the untreated rice packet first; ten of 17 R. argentiventer opened the untreated rice packet first. In field tests, similar packets were used to bait 50 snap-traps with each kind of rice. In three nights of trapping the untreated rice caught six R. r. mindanensis and three R. argentiventer, while the flavored rice caught one R. r. mindanensis and no R. argentiventer.

Radio-tracking Studies With Rattus argentiventer

Day and night monitoring of signals from transmitters placed on four R. argentiventer in Cotabato made it possible to follow the movement of each during a five day period. The animals were trapped in a 3.5 hectare field of dough-stage C4 rice that had been 65 percent eaten by rats. Damage and other signs (burrows and active animals) indicated an extremely high rat population. An uncultivated area on two sides of this rice contained short grass; the other two sides were bordered by IR22 booting rice where no rat damage could be found. Two of the animals, one an adult male and the other a young female, did not move from an area 50 m in diameter. The young female never used a burrow while the male spent one day of five in a burrow. The movements of the other two rats, one young female and one adult female, were more sporadic. The young female spent the first three nights feeding in an area of 100 m^2 adjacent to the trap site. The next two nights it was in the booting rice and also in a 2-m wide irrigation ditch separating the two fields, but still within 10 m of the trap site.

Of the five days in which this rat was monitered, one (the second) was spent in the feeding area (damaged rice) and two (first and fourth) in a burrow located in the booting rice, 50 meters from the trap site. The other two days were spent in a paddy of booting rice adjacent to this burrow. This animal's activity was interesting in that it traveled through the booting rice to reach the dough-stage rice, and did not begin to feed in the booting rice until panicles emerged. The adult female spent the first day and night near the trap site feeding in the rice at night and resting in a burrow during the day. The second, third, and fourth nights were spent in rice 50 to 75 meters from the trap site. A different burrow was used in this area during the second and third days. The fourth and fifth days were spent above ground 150 meters from the trap site in the uncultivated field. During the fifth night this animal was located in both the rice and the rough area.

Rat Damage to Bananas

In conjunction with studies on Mindanao, a visit was made to two banana plantations near Davao. The objectives of our visits were to identify the rat species and observe reported damage. Thirty snap-traps set in one plantation caught only two *R. exulans* and one *R. r. mindanensis*; however, from reports of personnel at the plantations, we suspect *R. exulans* was the most prevalent species. Rat nests and young are frequently found in the maturing banana bunches; records at the plantation showed that in some areas 16% of the harvested bunches had signs of rat activity such as claw marks, feces, or feeding. Usually, actual losses are minor, but the packing company feared rat signs may adversely affect marketing this high-value product. The company records the number of bananas rejected and reasons for rejection; however, rat damage is not presently included. Current control consists of treating burrows along water drainage ditches with cynogas.

Burrows and breeding of ricefield rats in Cotabato, Philippines. 1971. Jesus P. Sumangil. Unpublished thesis, Colorado State University. 38 pp.

ABSTRACT: Burrows of ricefield rats (*R. argentiventer*) in ricefields adjoining grasslands in two barrios in Buluan, Cotabato, and rat reproductivity in the adjacent locality encompassing the study area were studied from January to December, 1960. Dike systems of varying shapes and sizes retained rain water in paddies and created large and convenient space for burrowing. Most paddy dikes extended far beyond maximum water levels and were generally broad in size to accommodate, usually simple but often elaborate, burrows. Various types of burrows showed varying degrees of occurrence and occupancy; their functional types were classed into three categories. Old, unplugged (open entrance) burrows contained the least number of rat occupants; their use was mainly related to protective cover. New, unplugged burrows showed considerable activity both for cover and nesting. New, plugged burrows (closed entrance) were primarily used by females with young. Movement of rats into ricefields from surrounding wastelands during the booting stage of rice indicated a high degree of habitat preference; this was related to the presence of preferred food and superior cover during the entire period of cultivation. These movements increased the potentials for crop loss and also insured the irruptive capacity of the population. Movement was found to maintain a reverse mechanism where increased competition for food and cover after harvest caused movements into the surrounding grassland habitats. The main breeding period coincided with the rainy season and rice cultivation; breeding activity was much reduced during the summer months. There was a small loss among litters at pregnancy as shown by a mean of 7.55 embryos at late gestation and a mean of 6.27 young in 3-week old weanlings. The incidence of pregnancy, or the number of times pregnancy occurred per mature female per year, was estimated to be 1.78 ± 0.272, which gave an approximate average annual productivity of 17 rats per mature female. The monthly rate of occurrence of both classes of new burrows in paddy dikes showed significant correlation ($r=0.919$) when compared to monthly prevalence

of pregnancy. A similar degree of correlation was obtained when rate of litter recovery in new burrows (r=0.867) and the proportions of pregnant and lactating rats in new burrows (r=0.737) were compared to prevalence of pregnancy. These support previous observations that burrows exert considerable influence on the irruptions of rat populations in ricefields in view of the availability of adequate space in paddy dikes for breeding purposes. A possible approach to rodent control would be to modify the habitat and increase competition for breeding space. Reduction in size of paddy dike may reduce the rate of increase of rat populations in ricefields.

Seasonal Food Habits of Rattus rattus mindanensis (the Philippine Ricefield Rat) in Central Luzon. 1972. James R. Tigner. Unpublished thesis, University of Colorado.

Food habits of the Philippine ricefield rat (R. r. mindanensis) were studied for 12 months, June, 1970, through May, 1971. This investigation was a part of a rat damage control program of the U.S. Agency for International Development and its contractor the U.S. Bureau of Sport Fisheries and Wildlife.

Plant and animal reference material and rat stomachs were collected each month by personnel of the Rodent Research Center, College, Laguna, Republic of the Philippines, and shipped to the Denver Wildlife Research Center for preparation and examination. Twenty-five stomachs were examined microscopically every month (except October when only 14 were available) to determine the quality and quantity of the contents. Contents of additional stomachs were pooled each month and chemically analyzed for nutritional components and gross energy.

Although 34 food items were consumed by the rats, only 11 contributed 1% or more to the total year-long diet. Of the 11 materials, five were present in most months and contributed the greatest percent volume. Oryza sativa (rice), insect matter,

Digitaria sp., Ipomoea aquatica, and Echinochloa colonum were the food items most commonly taken. Non-diagnostic parts of plants, thus unidentified, comprised 42.5% of the total year-long volume. Rice seed and unindentified plant parts occurred in inverse proportion. When rice seed was available, it comprised about 75% of the diet. The only rice seed available from late December through February was that portion left in the paddies after harvest. During the dry season, December through June, there is little growth of plants and the rats took a higher percentage of unidentifiable plant parts. Stomachs from June and September contained large amounts of insect matter; high protein, fat, and gross energy levels reflect this increased ingestion of animal tissue. In the months of November, December, January, and February, large amounts of rice seed were found in the stomachs; these stomachs also had the highest levels of nitrogen-free extract. February stomachs contained the least protein.

It was thought that perhaps rat weights would reflect the quality of the food the animals were eating. However, mean animal weights fluctuated throughout the year with the adults being heaviest in spring and fall. Even through the dry season, the rats were able to maintain relatively consistent weights. Numerical levels of the rat population at this time were unknown, however. The sex ratios favored females, particularly in the dry season. Juvenile animals were most common in December and least common in September and October.

The Reproduction and Seasonal Abundance of the Common Ricefield Rat, Rattus rattus mindanensis Mearns, at Siniloan, Laguna. 1971. Bernardo E. Marges. Summary of thesis project, University of the Philippines College of Agriculture.

Collections of at least 50 rats are being made at two-week intervals on irrigated ricefields at Siniloan, Laguna. Animals are generally collected by snap-traps; supplemental collections are made by hand-capture of animals in grassy areas. Fresh specimens are

weighed, measured, and examined for reproductive condition. Skull ossification is also determined. Estimates of sexual maturity are based on perforation of the vagina in females and the presence of scrotal or fully descended testes in males.

Preliminary results indicate that the ricefield rats in the study area follow a seasonal breeding pattern activity that begins in September; my data have indicated a peak occuring in November, with 48 percent of the females pregnant. Little or no breeding occurred during the months of August and January.

Environmental factors, such as rainfall, air and water temperature, and the growth-stage of rice plants are also being investigated. These factors, if correlated with the breeding activity, may help understand the mechanisms that trigger reproduction in this species. Field collections will be completed in July, 1972.

Estimating Population Parameters of the Ricefield Rat (Rattus r. mindanensis). 1971. Edwin A. Benigno. Summary of thesis project, University of the Philippines College of Agriculture.

Livetrapping is being conducted twice a month in a permanent grid set up in a selected rice growing area in Siniloan, Laguna. Data for the estimation of population parameters are obtained by means of the capture, release and recapture method. Prevailing farm practices and weather conditions are also noted.

To date only 3 out of the 85 marked rats have been recaptured. Two of them were recaptured 3 months after their release while the other one was recaptured within the same trapping period. All were recaptured only once and within 20 meters from the point of first capture. The first juvenile rat was captured in November. The number of juvenile rats caught has increased since then. These developments may indicate either: (1) the population is more dynamic than as previously assumed, or (2) the sample taken is not sufficient.

As this study progresses, it is expected that the characteristics of this natural rat population will be more meaningfully understood. A number of available estimating procedures will be used in computing different parameters. Estimates with the least variances shall be considered the best descriptions of this particular population.

PUBLICATION AND MANUSCRIPTS (Abstracts)

Destruction of rice tillers by rats in relation to stages of rice development in Luzon. 1970. G. K. LaVoie, F. N. Swink, and J. P. Sumangil. Philippine Agriculturist 54: 175-181.

ABSTRACT: To determine the extent of rat damage to growing rice, counts of damaged tillers were made from the time of transplanting to harvest in 35 paddies located in three provinces of Luzon. Tiller destruction by rats during the vegetative growth period was light, but it increased appreciably during the reproductive and ripening stages. In preharvest samples of paddies where surrounding rice had been harvested, damage was significantly greater than those paddies where surrounding rice had not been harvested.

Movement of the riefield rat, Rattus rattus mindanensis, in response to flooding and plowing as shown by fluorescent bone labeling. 1971. G. K. LaVoie, G. C. Atwell, F. N. Swink, J. P. Sumangil, and J. Libay. Philippine Agriculturist 54: 325-330.

ABSTRACT: In laboratory studies acceptance and marking ability of demethylchlortetracycline (DMCT) as a bone-labeling compound were found excellent for Rattus rattus mindanensis. DMCT-induced flourescence in the lower mandible degraded in formalin but persisted up to 6 months in frozen storage.

A 15-hectare area in Central Luzon was baited with DMCT on polished rice; bait consumption was good. Five weeks later, immediately after flooding and plowing the baited area, animals were snap-trapped at distances up to 400 meters away. Thirty-two percent of the rats trapped were positive for DMCT and 74 percent of these were trapped within 100 meters of the baited area. These results indicate that land preparation displaces rats, but that most do not move far.

A Comparative Chromosome Study of Rattus rattus mindanensis and Rattus argentiventer

Doris H. Wurster* and G. C. Atwell.

Unpublished manuscript. 16 pp.

ABSTRACT: Karyotypes of nine Rattus rattus mindanensis from Luzon, Philippines, and nine Rattus rattus argentiventer (Rattus argentiventer of some authors), eight from Mindoro, Philippines, and one from South Vietnam, were examined. The major goal of this investigation was to determine whether the terms R. argentiventer and R. r. mindanensis, (referring to the two major pest rodents of the Philippines) might be used synonomously. The diploid chromosome number of both species was 42; the fundamental number (total number of major chromosomal arms) was 60 in each case. The autosomal complements of the two species were identical in appearance; however, the size of the sex chromosomes differed consistently. The X chromosome of R. r. argentiventer was acrocentric and was the sixth or seventh largest element of the haploid complement; the Y chromosome was also acrocentric and was usually the third in size from the smallest acrocentric autosome. The X chromosome of R. r. mindanensis was acrocentric and was the third largest element of the haploid complement; the Y chromosome was the smallest element of the complement and was acrocentric. The karyotype of the R. r. argentiventer specimen from South Vietnam was identical in every way to those of the argentiventer specimens captured in the Philippines. We conclude that there is a karyotypic basis on which to place these two forms in separate taxonomic categories. While the two forms should not be separated as distinct species solely on the basis of karyotype, our evidence strengthens the position of classical taxonomists who, on other grounds, feel that argentiventer is a separate species. To our knowledge, the karyotype of the form mindanensis has not been described previously.

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SUMMARY OF ACCOMPLISHMENTS

1. One Filipino staff member assigned to the Center from the Bureau of Plant Industry returned from Colorado State University after completing the requirements for a Master's degree in Wildlife Ecology. Two other Filipino staff members left for advanced degree training — one in ecology at Bowling Green State University and one in toxicology at the University of California at Davis. These students were recipients of USAID participant training grants.

2. The Rodent Research Center Board appointed Dr. Fernando F. Sanchez as Director, Rodent Research Center. Dr. Sanchez was formerly Chairman, Department of Entomology and Zoology, College of Agriculture University of the Philippines.

3. The second year of the National Damage Survey was completed. Five additional provinces were included in the survey, requiring training for about 40 Bureau of Plant Industry technicians.

4. Assistance was provided to the Bureau of Plant Industry in preparing a proposal to establish four field stations, to extend the adaptive research and extension capabilities of the Bureau. The proposal was approved by the Rodent Research Center Board and submitted to the National Science Development Board for consideration.

5. A major field study was conducted to evaluate an aerial baiting during the dry season using whole-kernel corn bait treated with zinc phosphide (2%). Damage reduction to the subsequent rice crop by this baiting could not be demonstrated, primarily because of insufficient bait and subsequent control activities by local farmers and extension personnel.

6. In another field trial, bait acceptance appeared to prevent multiple treatments of zinc phosphide bait from protecting growing rice from rat damage. None of 18 baitings, three in each of six plots, had a measurable effect on the rat populations.

7. A comparative study of census techniques was completed; however, adjustment of sample sizes to adequately survey dense tropical rodent populations remained a major difficulty. Adaptive studies of other census techniques are in progress.

8. Studies comparing rat populations from rainfed and irrigated sites were completed. Animals were larger and birth rates were higher in both years in the irrigated area. From these data and ongoing studies it appears that "seasonal" changes in rat populations may actually relate to habitat changes. In areas with patchy irrigation or out-of-phase crops, this cycle may be disrupted.

9. Weathering studies indicated that bait containing two percent zinc phosphide and one percent vegetable oil would remain toxic for at least 24 hours even under extremely wet field conditions. Devices used to protect bait, such as bamboo tubes, may not be necessary and may reduce initial bait consumption of acute toxicants.

10. Field work was completed for a study of the food habits of Rattus rattus mindanensis. A University of Colorado graduate student, cooperating with the Rodent Research Center, completed the study in April, 1972.

11. Food consumption tests did not demonstrate any preference among the two test species for a particular food and suggested that bait acceptance may be more dependent upon placement than the item used.

12. The following staff research papers were published:

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

LaVoie, G. K., G. C. Atwell, F. N. Swink, J. P. Sumangil, and J. Libay. 1971. Movement of the ricefield rat, Rattus rattus mindanensis, in response to flooding and plowing as shown by fluorescent bone labeling. Philippine Agriculturist 54: 325-330.

LaVoie, G. K., H. P. Tietjen, and M. W. Fall.* 1971. Albinism in Thomomys talpoides from Colorado. Great Basin Nat. 31: 181.

Fall, M. W.* 1971. Seasonal variations in the food consumption of woodchucks (Marmota monax). J. Mammal. 52: 370-375.

Fall, M. W.*, A. B. Medina, and W. B. Jackson. 1971. Feeding patterns of Rattus rattus and Rattus exulans on Eniwetok Atoll, Marshall Islands. J. Mammal. 52: 69-76.

Sanchez, F. F.* 1971. DDT toxicology in relation to insects and allied forms. Proceedings of Phil. Assoc. for the Advancement of Science. 15 pp.

Bato, Sofronio and F. F. Sanchez* 1971. The biology and chemical control of Callosobruchus chinensis (Linn.)(Bruchidae, Coleoptera). Philipp. Ent. 2 (2): 173-187.

*Research completed before joining Rodent Research Center staff.

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Hayne, D. W. 1951. Zinc phosphide: its toxicity to pheasants and effect of weathering upon its toxicity to mice. Mich. Agric. Expt. Sta. Quart. Bull. 33(4): 412-425.

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Litchfield, J. T. and F. Wilcoxen. 1949. A simplified method of evaluating dose-effect experiments. J. Pharmacol. Exptl. Therapeutics 96(2): 99-113.

Lord, R. D., A. M. Uilches, J. I. Maiztegui, and C. A. Soldini. 1970. The tracking board: a relative census technique for studying rodents. J. Mammal. 51(4): 828-829.

Sumangil, J. P., P. J. Alfonso, F. N. Swink, and J. Morales. 1970. More effective control of rats. In: The Philippines Recommends for Rice — 1970: 32-33. National Food and Agriculture Council.

Thompson, W. R. 1947. Use of moving averages and interpolation to estimate median-effective dose. I. Fundamental formulas, estimation of error, and relation to other methods. Bacteriol. Rev. 11(2): 115-145.

_____, and C. S. Weil. 1952. On the construction of tables for moving-average interpolation. Biometrics 8 (3): 51-54.

Weil, C. S. 1952. Tables for convenient calculation of median-effective dose (LD_{50} or ED50) and instructions in their use. Biometrics 8 (3): 249-263.

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

May 8, 1972