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

FOR AID USE ONLY
BATCH 42

1. SUBJECT CLASSIFICATION
A. PRIMARY: Serials — Y-AH10-0000-G732
B. SECONDARY: Food production and nutrition--Pests of plants--Philippines

2. TITLE AND SUBTITLE
Rodent Research Center,Laguna,Philippines: 1975 annual progress report

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

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1976	96p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Interior

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

9. ABSTRACT

During 1975, the Rodent Research Center engaged in control method evaluations, rat damage surveys, and preliminary bird toxicity studies. Preliminary studies were begun on the effectiveness of modified sustained baiting procedures in reducing rat damage to coconuts and corn. In the coconut tests, cost/benefit was about 1/20 at current coconut values. Damage to all corn test plots was low, but additional studies are needed to determine the effectiveness of the procedure when rat damage limits corn production. Studies continued on means of reducing rat damage to rice, and preliminary observations were made on rat damage to sugarcane. Damage in sublethal electric-fenced rice plots averaged 0.69% cut tillers while it averaged 13.5% in two reference plots. Extent of sugarcane damage appeared influenced by such factors as lodging, cane variety and hardness, and harvest practices. A research approach was designed for the development of effective damage reduction procedures in sugarcane. A trapping study collected only Rattus rattus mindanensis and Suncus murinus. In studies on the toxicity of three compounds to Passer montanus and Lonchura punctulata, carbofuran was highly toxic to both species while fenthion was least toxic to P. montanus and mthyl carbamate to L. punctulata.

10. CONTROL NUMBER
PN-AAC-789

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)

PASA RA(ID)1-67Res.

PN-AAC-789

ANNUAL REPORT

1975

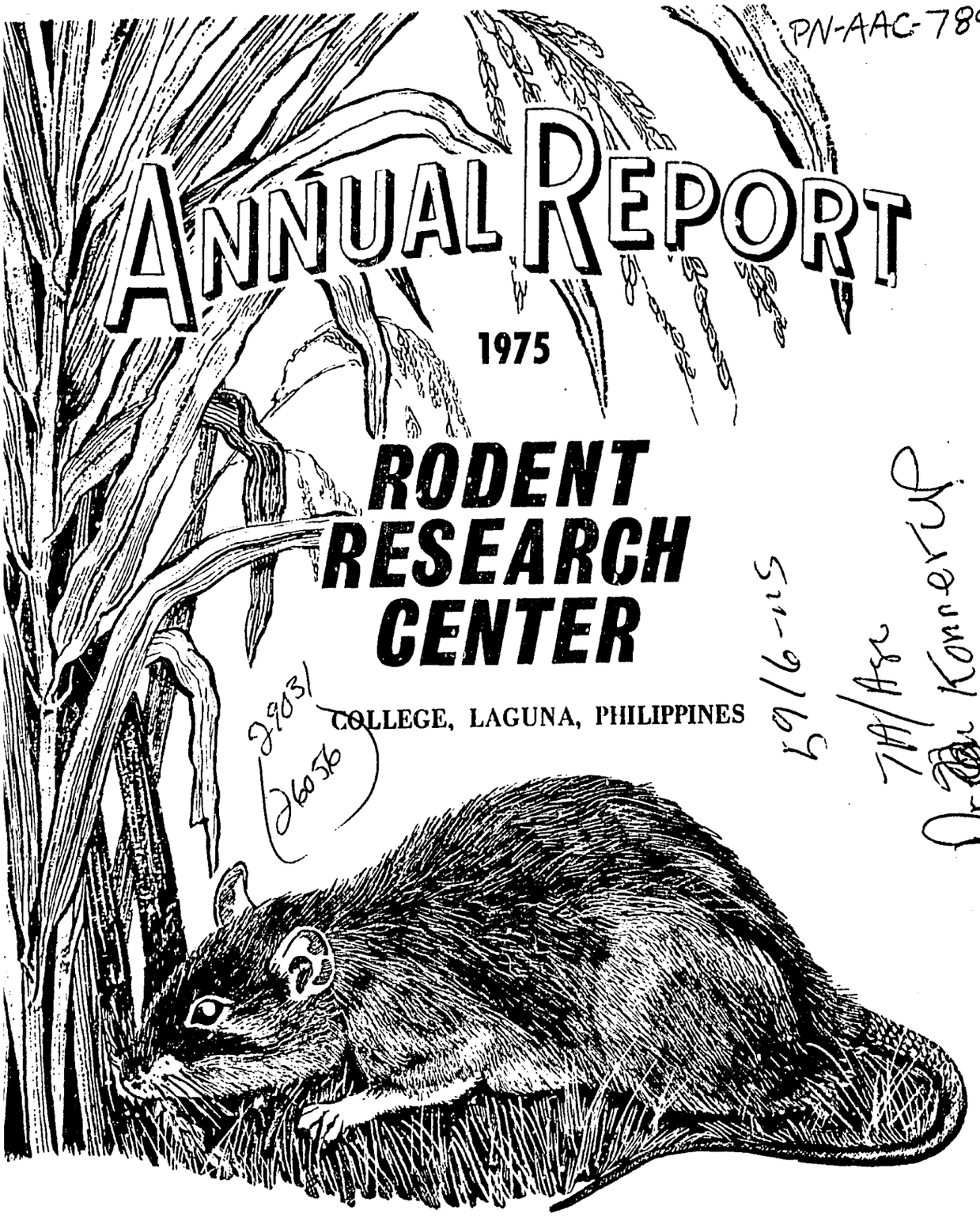
RODENT RESEARCH CENTER

COLLEGE, LAGUNA, PHILIPPINES

29031
(26056)

5916-US

TA/Agr
Dr. Konerup



COOPERATING AGENCIES

REPUBLIC OF THE PHILIPPINES:

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

UNITED STATES:

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

RODENT RESEARCH CENTER*
1975 ANNUAL PROGRESS REPORT

PRINCIPAL INVESTIGATORS:

Fernando F. Sanchez, Jesus P. Sumangil, Edwin A. Benigno, Michael W. Fall, Melanda M. Hoque, Justiniano Libay, Bernardo E. Marges, Russell F. Reidinger, and Danilo C. Sanchez.

COOPERATING AGENCIES:

Republic of the Philippines -

National Economic and Development Authority
Bureau of Plant Industry
University of the Philippines at Los Banos
College of Agriculture

United States -

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

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

TABLE OF CONTENTS

	Page
ABSTRACT	iii
RODENT RESEARCH CENTER STAFF - 1975	v
INTRODUCTION	1
Program and Facilities	1
Staff	1
Research	2
Training	2
International Activities	3
RESEARCH ACTIVITIES	5
Crown-Baiting in Coconut Trees Using Anticoagulant Rodenticides to Reduce Rat Damage	6
Assessing Rat Damage to Corn	16
Protection of Corn Crops from Rat Damage Using Sustained Baiting with Anticoagulant Rodenticides	24
The Importance of Farmer Attitudes for Successful Implementation of the Sustained Baiting Program	33
Observations of Rat Damage to Sugarcane in the Philippines	38
Observations of Rats in Marshland Habitats	45
Preliminary Trial of a Sublethal Electric Barrier Designed to Reduce Rat Damage to Agricultural Crops	53

Page

Preliminary Evaluations of Coulometric Field Event Recorders for Measuring Rat Activity at Bait Stations in the Philippines 59

Biological and Toxicological Studies on Philippine Pest Bird Species 67

TRAINING ACTIVITIES 70

Workshops and In-Service Training 71

International Training 72

Graduate Training 72

Staff Instruction at UPLB 73

RESEARCH UTILIZATION 74

INTERNATIONAL ACTIVITIES 75

THE CENTER LIBRARY 81

SUMMARY OF ACCOMPLISHMENTS 82

LITERATURE CITED 88

ABSTRACT

During 1975, Rodent Research Center personnel engaged in control method evaluations, rat damage surveys, and preliminary bird toxicity studies. Filipino staff changes included the addition of one clerk-typist, one part-time biologist took a full-time university position, and another left the Center to attend medical school. One U.S. position was moved to Denver. Training continued at the Center, with over 3000 individuals, mostly Filipino agricultural technicians, extension agents and key farmers, receiving classroom or field courses in rodent control from Center personnel. In addition, six Center-affiliated scholars continued M.S. degree work and three continued Ph.D. degree work at the University of the Philippines at Los Banos. Sustained baiting with chronic rodenticides, a rat damage reduction procedure that includes innovations developed and tested at the Center, was included as a required practice for farmers participating in the Philippine national rice production program, Masagana-99. Implementation of the national rat control program was initiated through massive in-service training of government technicians and rat control officers in current methodology.

Preliminary studies were begun on the effectiveness of modified sustained baiting procedures in reducing rat damage to crops other than rice. In coconuts, a method was adapted in which bait is placed monthly in tree crowns. During the first 9 months, rat damage was reduced to negligible levels in treated plots and production increased by about 5.4 nuts per tree per month, over twice pretreatment levels. Cost/benefit was about 1/20 at current nut values. In corn, a method was tested which followed closely the procedure recommended for damage reduction in rice. In three, 2-hectare treated plots, damage averaged 94% less than in three reference plots and treatment was economically beneficial. Damage was low in all plots, however, and additional studies are required to determine the effectiveness of the procedure in situations where rat damage limits corn production. A method was also adapted which allows prediction of corn loss in grams from known ear lengths and lengths of rat damage on the ear.

Studies continued on means of reducing rat damage to rice. Two small plots were protected from rat damage by using a sublethal electric fence from the 10th week after transplant to harvest. Damage in the fenced plots averaged 0.69% cut tillers while it averaged 13.5% in two reference plots. In a field trial on implementation of the sustained baiting procedure, farmers in a barrio followed the rat control innovation carefully until commodity support was stopped (at 4 weeks after transplant), then reverted quickly to traditional control methods.

Preliminary observations were made on rat damage to sugarcane. Extent of damage appeared influenced by such factors as lodging, cane variety and hardness, and harvest practices. A wide diversity of control

practices are followed to reduce rat populations, but the effectiveness of almost all have been untested. A research approach was designed for the development of effective damage reduction procedures in sugarcane.

During the first four months of a trapping study in two marshland communities along Laguna de Bay, only Rattus rattus mindanensis and Suncus murinus were collected in sedge and only R. r. mindanensis in lotus. Adults weighed more and were longer than those collected in rainfed ricefield areas. Trap success varied with conditions of adjacent ricefields and perhaps with water levels and changes in microhabitat flora. Coulometric field event recorders for measuring rat activity at bait stations were tested in the laboratory with good results; in the field, however, they gave highly varied results and additional studies are planned. In studies on the toxicity of three compounds to Passer montanus and Lonchura punctulata, carbofuran was highly toxic to both species while fenthion was least toxic to P. montanus and methyl carbamate to L. punctulata.

RODENT RESEARCH CENTER STAFF -- 1975

BELEN, ROSALIA M.*	UPLB	CLERK-TYPIST
BENIGNO, EDWIN A.	UPLB	BIOMETRICIAN
BERNARDO, PACIFICO V.	UPLB	PLANT PROPAGATOR
BRIONES, NENITA J.	BPI	LABORATORY TECHNICIAN
CASTRO, FRANCISCO	BPI	NEDA SCHOLAR
DE LA PAZ, AGAPITO	BPI	NEDA SCHOLAR
DIZON, ROMEO C.	BPI	NEDA SCHOLAR
ESTIOKO, BIENVENIDO R.	PSI	PCARR SCHOLAR
FALL, MICHAEL W.	USAID	BIOLOGIST
GALANG, RENATO S.	UPLB	PREPARATOR; DRIVER
GELI, ARSENIA B.	UPLB	SENIOR CLERK
GELI, ROBERTO C.	UPLB	PREPARATOR
HERBANO, ALBERTO	BPI	CLERK
HOQUE, MELANDA M.	UPLB	BIOLOGIST
LIBAY, JUSTINIANO	USAID	FIELD TECHNICIAN
MANZANILLA, DEOGRACIAS M.	UPLB	PREPARATOR; DRIVER
MARINO, MAX	BPI	DRIVER
MARGES, BERNARDO E.	BPI	BIOLOGIST; PCARR SCHOLAR
PAEZ, MARIA LOURDES C.	BPI	INFORMATION CLERK; LIBRARIAN
REIDINGER, RUSSELL F.	USAID	BIOLOGIST
RUBIO, ROBERTO P.	UPLB	GRADUATE STUDENT; INSTRUCTOR
SANCHEZ, DANILO CA.	USAID	FIELD TECHNICIAN

SANCHEZ, FERNANDO F.	UPLB	DIRECTOR
SAPIN, NARCISO N.	UPLB	PREPARATOR
SENEVIRATNE, A. G.		SRI LANKA TRAINEE
SULTAN, ZOSIMO	BPI	NEDA SCHOLAR
SUMANGIL, JESUS P.	BPI	BIOLOGIST; DEPUTY DIRECTOR
TUAZON, ESTER	BPI	NEDA SCHOLAR
TUCAY, RIZALINO	BPI	NEDA SCHOLAR
WIJEYARATNAM, C.		SRI LANKA TRAINEE

* Staff member was assigned to the center during part of 1975

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

INTRODUCTION

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

Program and Facilities

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

Staff

The Center staff includes eight biologists whose aggregate training covers the areas of agricultural biology, ecology, physiology, control methods evaluation, mammalogy, ornithology, wildlife management, biometrics, and entomology. Ten additional staff members are assigned as full-time support personnel by participating agencies. Two trainees, A. G. Senevirante and C. Wijeyaratnam, from Sri Lanka, spent a total of 4 months as participant staff members of the Center.

Miss Rosalia M. Belen was assigned to the Center in early September as a clerk-typist. Mr. Michael W. Fall, AID/FWS wildlife biologist, was reassigned to the Denver Wildlife Research Center in November.

Mr. Pedro Alviola, part-time biologist at the Center, took permanent teaching responsibilities in the Zoology Department at the University of the Philippines at Los Banos. Miss Maria Ellen Gajo, graduate assistant and part-time biologist at the Center, entered medical school at the University of the Philippines at Diliman.

Research

Research continued on the evaluation of improved techniques for damage reduction in growing rice and preliminary studies were initiated on adaptation of the sustained baiting procedure to other crops.

In rice, a preliminary study was conducted on the importance of farmer loans or commodity assistance for successful implementation of the sustained baiting program. Preliminary trials were also conducted on the use of a sublethal electrified barrier to protect ricefields from rat damage. In corn and coconuts, studies were carried out on the effectiveness of modified sustained baiting procedures in reducing rat damage. A method was devised for predicting weight loss of corn from ear length and length of rodent damage. In sugarcane, field observations were made on extent and nature of rat damage, farmers, industry staff and researchers were interviewed, and a research approach was devised for developing means of reducing rat damage to these crops.

Preliminary observations were also made on marshland- rat-ricefield interrelations with the hope of reducing levels of chronic damage to crops adjacent to marshland and perhaps predicting or preventing future rat outbreaks. Studies were continued on toxicity and repellency of several chemicals to Philippine pest bird species.

Training

Training activities were aimed toward up-dating the knowledge of vertebrate pest control of extension technicians, and to a more limited extent, toward providing experience in the research methodology for professional vertebrate biologists in the Philippines and other countries of Southeast Asia. Again, several hundred visitors from many countries were briefed on Center activities, or given assistance in planning rodent control or research programs. Center staff members participated in the training of more than 3000 agricultural extension personnel from the Bureau of Plant Industry, Bureau of Agricultural Extension, Department of Agrarian Reform, Philippine National Bank and the Agricultural Credit and Cooperatives Institute. Sessions on rat control were presented in agricultural production workshops held at IRRI and UPLB. Two research trainees from Sri Lanka spent several months at the Center participating in on-going research programs, observing BPI's operational rat control programs in

various parts of the country, and developing project plans for their future work. Three staff continued their pursuit of M.S. or Ph.D. degrees, one under a PCARR grant, the others with UPLB's reduced fee privilege. Six additional students who are working for their M.S. degrees and one for his Ph.D. at the UPLB will conduct their research at the Center and have graduate advisers who are Center staff. Several staff members taught or participated in teaching courses in Vertebrate Pests, Mammalogy, and Wildlife Management at UPLB, while others served as graduate advisers for students in Applied Zoology.

International Activities

The Center Director was named an expert consultant on vertebrate pest management for Southeast Asia by the Food and Agriculture Organization (FAO) and attended his first consultation in April. He also summarized chemical methods for control of rats in a seminar in Tokyo sponsored by the Food and Fertilizer Technology Center in October. One staff member visited Nepal and made preliminary observations on problems species, extent of damage caused by rodents to the local crops, and helped plan continuing research on vertebrate damage control. He also visited Indonesia and helped to plan a rodent control program for the Luwu Integrated Development Area in South Sulawesi.

Corn, preferred over rice by about one-fifth of the population and grown on about one-fourth of the cropped land of the Philippines, is often severely damaged by rats.

RESEARCH ACTIVITIES

Crown-Baiting in Coconut Trees Using Anticoagulant Rodenticides to Reduce Rat Damage

Introduction

Rat damage to growing coconuts has been a significant problem in most areas where this crop is grown. It is particularly significant in the Philippines which has been the world's leading supplier of copra. Damage occurs at all stages of growth and may be subject to seasonal changes in intensity when groves are adjacent to harvested crops such as corn, rice, or sugarcane. Banding and ground baiting with acute or chronic rodenticides are often used for rodent control in plantation areas, but small farmers are often unaware of rat damage and use no control at all. Studies of these control techniques which have been conducted in the Philippines and elsewhere usually indicate good results, but cost factors are typically high. Recently, experimental work in Colombia indicated that crown baiting could be used to good advantage for short-term damage reduction (Woronecki et al., 1973; Elias, 1973). This study was designed as a preliminary test of crown baiting in the Philippines, using the individual tree as the unit of evaluation and realization of long-term damage reduction as the principal objective.

Bait for the study was provided by the BPI office at Calapan, Mindoro. The study was begun in March 1975, and will continue through February 1976; this report summarizes data through December 1975.

Materials and Methods

A 150-hectare site with a history of chronic rat problems was selected at Barrio San Gelacia, Victoria, Oriental Mindoro. Coconut trees are native varieties, 10-25 years old, from 15-20 meters tall. Four plots (numbered I-IV), each 1 hectare with 100 trees, were chosen. Two (Plots I and III) were randomly assigned as treated plots while the remaining two (Plots II and IV) were designated as reference plots. Plots are separated by at least 150 meters and are at least 200 meters from the nearest edge of the coconut grove. A slough transects the grove, surrounds Plot IV on three sides and Plot I on one side, and separates this plot from a small calamansi (citrus) plantation. A second slough borders one side of Plot II. Both sloughs, and their weedy banks, however, are separated from the experimental plots by at least several rows of coconut trees. The plot sites were chosen because tree varieties, ages, surrounding habitat, and crop management practices were similar, and because records maintained by the farmers indicated similar levels of nut production and rat infestation in the past.

In each of the plots, 25 trees were randomly chosen for detailed studies. These trees were numbered 1-25 in Plot I, 26-50 in Plot II, 51-75 in Plot III, and 76-100 in Plot IV. In the treated plots, a single packet of poisoned bait was placed in the fronds of every numbered tree each month; i.e., 25 of the 100 trees in each treated plot were baited. Packets consisted of 0.025% warfarin mixed with binlid and placed in a small plastic bag. Packets were placed in trees by climbers (who were collecting data) or by using a long bamboo pole. No baits were used in reference plots.

During the first month, packets contained 100 g of baits. This was increased to 200 g for the following 5 months, then reduced to 150 g as copious amounts were uneaten. Thus, during the first 9 months, 38.75 kg of bait were used per treated plot, or 4.3 kg per month per plot.

Twenty-five rat traps were set in each plot for 3 nights prior to baiting to determine species composition. Relative levels of rat activity were determined monthly by placing inked tiles at the base of 24 randomly selected coconut trees in each plot for 3 consecutive nights and recording the number of tiles with rodent tracks.

Before baiting, all fallen nuts were removed from the plots. Thereafter, monthly records were kept on the numbers of fallen nuts (damaged and undamaged) in each plot and under each numbered tree. To avoid errors, fallen nuts were removed from the area after they were counted.

The farmer had kept careful records on individual tree production for his entire farm, including the study plots, since July, 1973. He used these records as accounts of nut production and to determine wages for harvesters. During the period of treatment, we recorded the number of nuts harvested from each of the numbered trees and from each of the plots. In addition, we maintained harvest records for each tree north of a numbered tree to determine if effects extended beyond trees containing bait. Other economic data are also being collected and will be presented at the end of the study.

Results and Discussion

Three nights of trapping before the baiting period resulted in the capture of 59 animals for 300 trap nights, or about a 20% trap success. Thirty-four were taken from the treated plots, 25 from the reference plots. *Rattus rattus mindanensis* was most common (49%), followed by an almost even distribution of *Suncus murinus* (20%), *Rattus argentiventer* (17%), and *Rattus exulans* (14%). Since all traps were placed at the

ground level, we do not know or assume that the same distribution of rats occurred in the tree canopy, nor can we deduce which species damage nuts. Since crown baiting in the treated plots resulted in an almost total reduction in rat activity, as measured by tracking tiles at the ground level, we can conclude that there was considerable movement between rats at the ground and canopy levels.

Rat activity, as indicated by tracking tiles, was similar in all plots at the onset of the study (average 26% vs 30%, treated vs reference plots respectively; Figure 1). By the second month after baiting, activity in the treated plots had dropped to a negligible level and remained low thereafter. In contrast, rat activity in the reference plots increased during the rainy season (4-7 months after baiting began in treated plots; by the sixth month, 60% of the tiles were tracked), then returned to about initial levels of activity. This increase could have been related to either population or environmental factors and deserves future research attention.

Numbers of fallen nuts in the treated plots decreased in a manner similar to rat activity; i.e., by the second month, numbers of dropped nuts had reached a negligible level and remained low thereafter (Figure 2). In reference plots, there was a sharp increase in fallen nuts at the beginning of the rainy season (from averages of 30-58 nuts per month, 4-5 months after baiting in the treated plots). The average number then decreased for 2 months, but had risen again to 59 fallen nuts per month by the 10th month of the study. Since there was no clear-cut correlation between the fallen nuts and harvest periods in the reference plots, we assume that harvesting practices have little effect on rat damage activities. A significant number (42%) of fallen nuts in the reference area had no obvious signs of rat damage (Figure 2). Since the monthly numbers of all fallen nuts, whether obviously damaged or not, was greatly reduced by the baiting program, we conclude that rats were responsible, whether directly or indirectly, for the loss of significant numbers of fallen, undamaged nuts in the reference plots. Of the nuts that did fall in the treated areas, however, 89% had no signs of rat damage; this loss may have been the result of other factors.

During the period of study reported here, there were two post-treatment harvests (the first during the 4th month after baiting; the second during the 8th month). For numbered trees in the treated plots, harvests during treatment were about two and eight times the last pre-treatment harvest, respectively, while the number of harvested nuts remained about the same or increased only slightly in reference plots. North trees followed the same pattern as the numbered trees, only differences were less accentuated (Table 1).

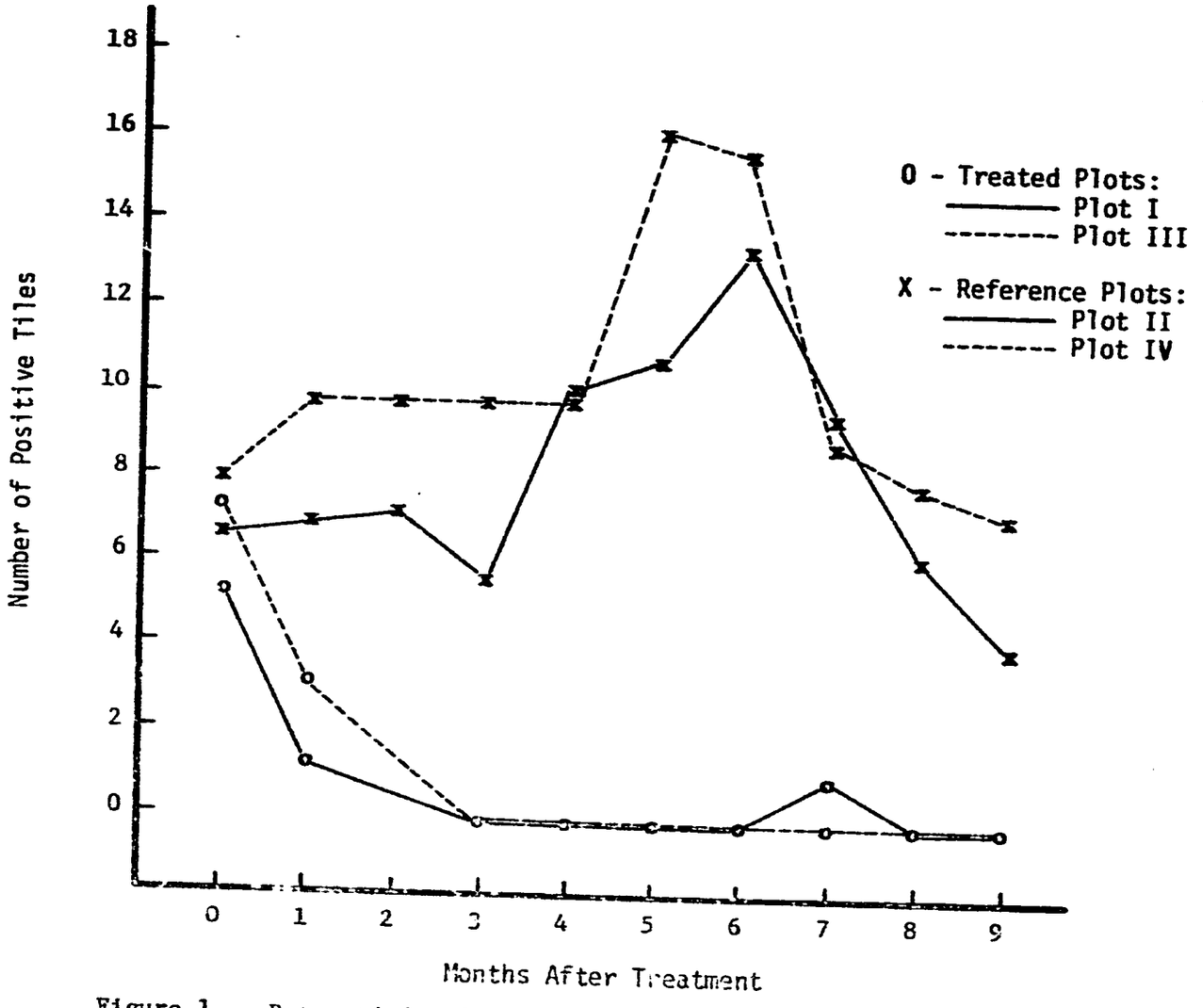


Figure 1 . Rat activity in two treated and two reference coconut plots near Victoria, Oriental Mindoro. Plots were one hectare and one hundred trees each. Twenty-five trees in each treated plot were crown baited monthly with anticoagulants; reference plots were not baited. Activity estimates are based on average numbers of twenty-four tracked tiles per plot for three consecutive nights each month.

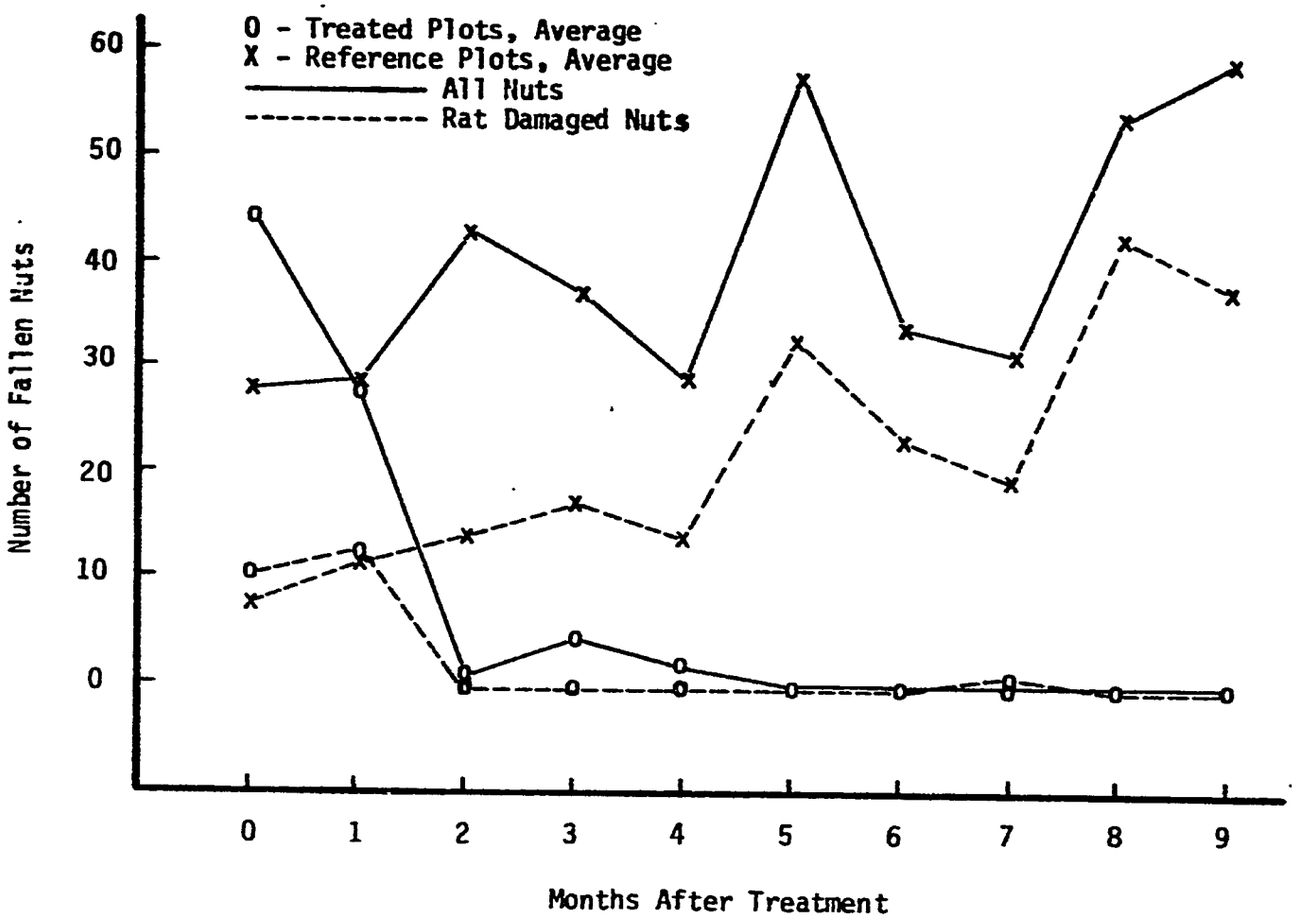


Figure 2 . Number of fallen nuts in two treated and two reference coconut plots, each one hectare with one hundred trees, near Victoria, Oriental Mindoro. Twenty-five trees in each treated plot were crown baited monthly with anticoagulants; reference plots were not baited.

Table 1. Nuts harvested from 25 numbered coconut trees and nearest trees north or numbered ones in two treated and two reference plots near Victoria, Oriental Mindoro. In treated plots, numbered trees were crown baited monthly with anticoagulants; no trees were baited in the reference areas.

		Total Number of Harvested Nuts					
		Numbered Trees					
		Treated			Reference		
Month	Harvest Period	Plot I	Plot III	Avg.	Plot II	Plot IV	Avg.
Mar.	Last pre-treatment	188	207	198	233	272	252
July	First post-treatment	482	457	470	174	249	212
Nov.	Second post-treatment	826	887	856	249	263	256
				North Trees			
Mar.	Last pre-treatment	252	247	250	270	312	291
July	First post-treatment	493	518	505	232	296	264
Nov.	Second post-treatment	742	738	740	267	357	312

Harvested nuts from entire plots for six pre-treatment harvests (20 months) and two post-treatment harvests (9 months) are presented in Figure 3. During the period of treatment, 13,440 nuts (7.48 per tree per month) were harvested from the two treated plots, while only 3,660 (2.03 per tree per month) were taken from the two reference plots, a difference of 9,780 nuts (5.4 per tree per month). Harvests for all plots for the 20 pre-treatment months averaged 2.76 nuts per tree per month, and the highest previous production for any of the plots was 6.0 nuts per tree per month, recorded in December, 1974. If reference plots are used as a baseline, individual tree production had increased 2.7 times by the first and 4.7 times by the second post-treatment harvest. If post-treatment harvests are compared with all pre-treatment harvests, tree production increased by about two- and three-fold, respectively. Since the baiting program was the only major change associated with coconut tree management in the plots, we conclude that most of the increase in nut production was a direct or indirect consequence of the reduced effects of rats. Since treatment took several months to fully reduce rat activity and numbers of damaged nuts and some damage continued at least half-way into the first post-treatment harvest period, we also suggest that increased production associated with the second harvest may more closely approximate the potential benefits from extended use of the procedure.

Although many researchers use fallen nuts as a quantitative measure of loss in determining the economic benefit of potential rat damage reduction procedures in coconut groves, this measure would have greatly underestimated actual losses in our experimental plots. During the 2nd-9th month of treatment, 700 fallen nuts (0.44 per tree per month) were collected in the reference plots, while only 18 (0.01 per tree per month) were taken in treated plots, a difference of 682 nuts (0.43 per tree per month). This represents only 6.4%-11.0% of the estimated post-treatment increases in yield, based on actual production figures. If only obviously damaged nuts were included in the survey, they would represent even less. Since many farmers also use fallen nuts as an indication of losses to rats, and to the extent that this study can be generalized, actual coconut losses to rats in the Philippines may be much greater than presently realized. Part of the difference between production increases and observed numbers of fallen nuts may be explained by early damage to young button-sized nuts (which we observed in the trees but did not quantify), but a wide variety of additional possibilities exists. Further, more detailed, ecological studies on rats in the coconut tree agro-community are needed.

The economic value of individual coconuts in the Philippines varies greatly with supply and demand which makes it somewhat difficult to estimate the potential economic benefit of the procedure. In 1973, farmers earned about 0.40 for each coconut. In 1974, values ranged

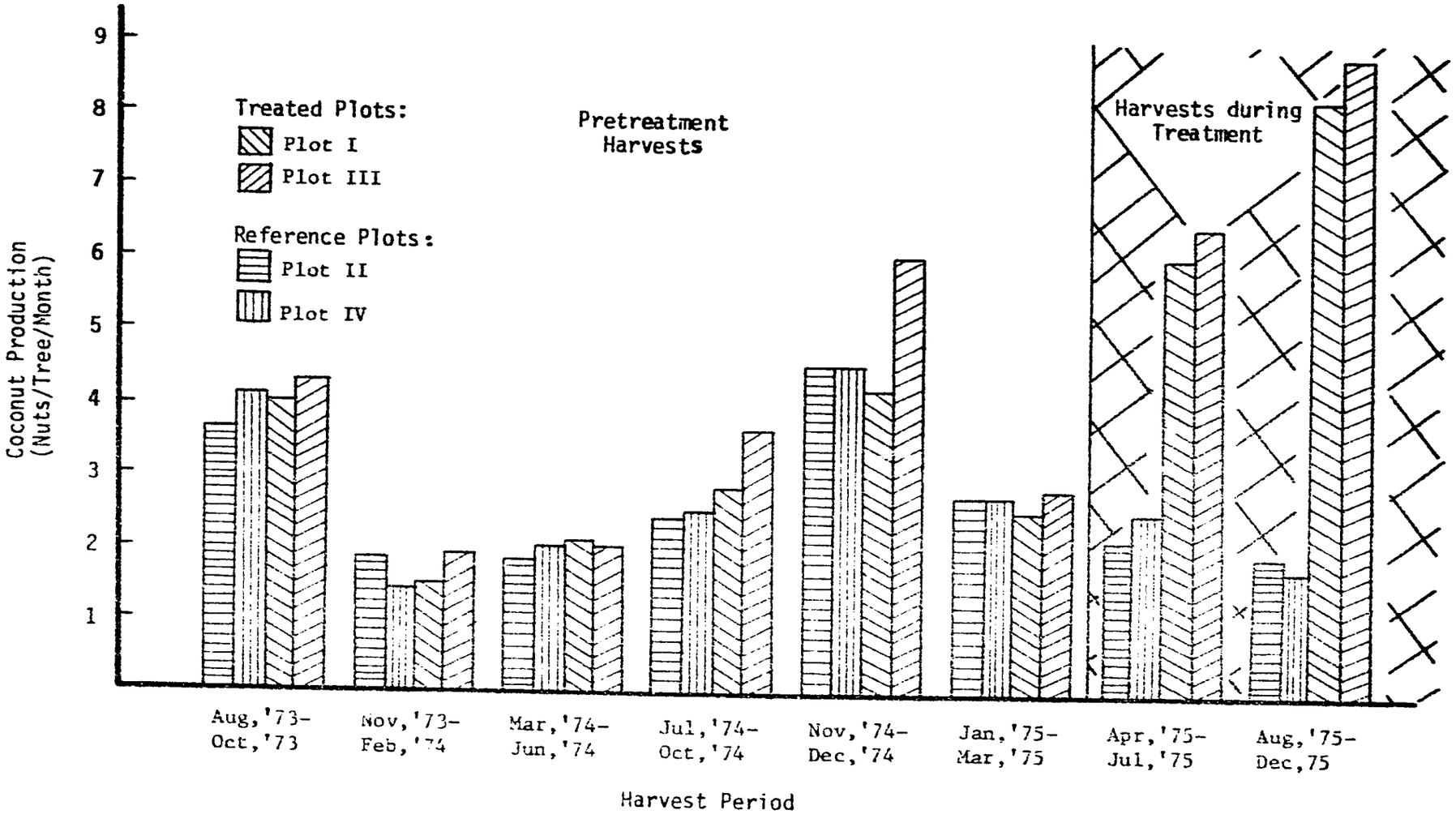


Figure 3. Nut production in two treated and two reference plots near Victoria, Mindoro, for six pretreatment (20 months) harvests and two that occurred during the period of treatment (9 months). One-fourth of the trees in each treated plot were crown baited monthly with anticoagulants. No bait was used in reference plots.

from ₱1.20 to as low as ₱0.15 per nut. In each of our treated plots, we used 4.3 kg of bait per month at a cost of about ₱8.40 (₱0.084 per tree per month). If wages for labor are included (typically the farmer would do the work himself--about 3-4 hours per month), the total cost for monthly treatment of each tree would be about ₱0.11-₱0.12. At current market levels, the farmer would have to increase average tree production by about 0.27 nut per month to pay for the cost of the damage reduction procedure. In the treated plots, average production increased by about 5.4 nuts per month (average for the two post-treatment harvests), representing about a 1/20 cost to benefit ratio. Actual benefits were even greater, because we observed considerable damage reduction in groves adjacent to both treated plots. Future studies with different baiting schedules and placement patterns may further reduce the cost of the method.

We conclude from this preliminary study that sustained crown baiting with chronic rodenticides provided effective protection from rat damage in the treated plots, with good economic return, that the effects of rat damage to coconut production in these plots were much greater than accounted for by dropped nuts (damaged or undamaged), and that the effects of baiting extended considerably beyond the treated plots. Additional studies should be conducted to determine the full range of effects of rats in the coconut agro-community. The method used in this preliminary study, at about ₱0.11-₱0.12 per tree per month, is affordable to the small farmers, but more tests should be conducted to determine the general applicability of the procedure in more of the diverse conditions under which coconuts are grown in the Philippines. Since rat activity was greatly reduced at the ground level by crown baiting, particular attention should be given to the possibility of using this method to protect all crops in multicropping areas where coconuts serve as the primary tree canopy.

Rat damage to a young, "button-sized" coconut in the tree. Farmers frequently judge extent of damage only by the numbers of fallen, matured nuts which probably gives an underestimate of actual losses.

Assessing Rat Damage to Corn

Introduction

Corn (*Zea mays*) is an important crop in the Philippines. It is produced for direct human consumption (about 20% of the population prefer corn to rice), for livestock and poultry feeds, and for by-products such as starch, oil, syrup, dextrins, glucose, and gluten (Carangal, 1970). In 1972 approximately 2,431,700 hectares, comprising about 26% of the cropped area in the Philippines, were devoted to corn, but present production has not met requirements for food, feed, seed and industry. Low production levels result from generally poor yields, in part due to losses from pests and diseases.

Actual national corn losses to pests and diseases are poorly quantified and difficult to determine because loss is frequently relative to intended use. For example, slight damage of an ear of sweet corn may adversely affect its use for direct human consumption but the same amount of damage may be insignificant on an ear intended for grain. Nevertheless, accurate assessments of such losses are important in evaluating crop protection strategies in corn, and national surveys of crop losses, which require good damage assessment methodology, are essential for planning and evaluating national control programs.

The Food and Agriculture Organization (FAO, 1970) made a compilation of methods developed in different countries for assessing pest damage to corn, but these were mostly for insects such as the corn borer and the corn earworm. The method for assessing earworm damage (Everly, 1961) requires sampling 25 ears at random in a transect of the cornfield. Two of these ears are then taken at random and the percent damage is computed, based on the average number of damaged and undamaged kernels. This method would probably have little application in assessing damage caused by vertebrate pests because the damage characteristics of insects and vertebrates frequently differ and because sample sizes would probably be inadequate. A method which has been developed to assess vertebrate damage is based on the relationship between length and weight of ear (De Grazio et al., 1969). Although this method was for blackbird damage, it might also be applied to other vertebrate pests, like rats, which cause similar types of damage.

This study was conducted to determine if the method of De Grazio et al., could be modified to provide a reliable means of quantifying rat damage to corn under Philippine conditions.

Materials and Methods

Sample ears of mature, field-dried corn (100 damaged and 100 undamaged) of various sizes were randomly picked from cornfields near Naulian, Oriental Mindoro, and brought to the laboratory for study. Damage on unhusked ears was first visually rated into slight, moderate and severe to determine if a qualitative measure might provide a simple, quick, and reliable estimate of damage.

All ears were then husked and measured. Ears were divided into eight classes according to length. Classes ranged at 1.27 cm (0.5 inch) intervals from 6.35 cm (2.5 inches) to 16.51 cm (6.5 inches). Ear length was based on the total length of the ear with developed kernels. The mean length of damage and the weight of remaining corn were determined in each ear class in the damaged group.

Rat damage was simulated on the healthy ears. For circular type of damage (see Results and Discussion), the method of simulation was patterned after De Grazio et al. One centimeter sections of kernels were shelled and weighed to the nearest 0.1 gram starting from the tip of the ear. The cumulative weight of the shelled kernels corresponding to the length of simulated damage were recorded. These data formed the basis for the regression and correlation analyses between length of circular damage in cm (X) and weight of lost corn in grams (Y), within each ear class. Similarly, the strip type of damage (see Results and Discussion) was simulated by systematically shelling and weighing kernels from fixed widths of strips (2 cm wide and 3 cm long) at one centimeter sections along the length of the strips. The cumulative weights of the shelled kernels were also weighed to the nearest 0.1 gram. Separate regression and correlation analyses were again conducted to find the relationship between size of damage and kernel weight loss.

Results and Discussion

Rat damage was characterized by missing or partially eaten kernels starting from the tip of the ear and extended toward the base. Two types of damage were defined: circular and strip. The circular type of damage had missing kernels around the cob, while the strip type had kernels missing in rows along one side of the cob. The circular type was generally more severe than the strip type. The shape of damage was not always regular.

Visual examination of ears with husks was found to underestimate damage, probably because damage is frequently obscured by the husk.

Corn ears with signs of rat damage ranged from 6.35 cm (2.5 in) to 13.97 cm (5.5 in) in length. Size of damage per ear measured from 15 cm^2 (3 cm x 5 cm) to 25 cm^2 (5 cm x 5 cm) for the strip type, and 4 cm to 9 cm for the circular type (Table 2). In general, the smallest ears (6.35 cm) had the most damage (almost 100%). Healthy ears ranged from 8.89 cm to 15.24 cm in length and were, thus, usually larger than the damaged ears. This difference may be explained by either a preference by rats for immature ears with consequent effects on ear growth, or an actual preference by rats for smaller sized, mature ears. Based on our limited observations of corn fields in Laguna and Batangas provinces, where there appeared to be an absence of newly damaged ears within 3 weeks of harvest, we tend toward the former possibility. Experimental studies are needed, however, to fully understand the nature and effects of rat damage at different stages of ear development. Likewise, a different method may have to be developed for assessing rat damage to green corn.

The weights of shelled corn from damaged and undamaged ears are summarized in Table 3. Generally, more kernels were shelled from the healthy ears, although the mean weights of damaged corn were not always far from the healthy ones of the same size.

Regression equations for estimating weight loss from a known length of damage, based on simulated rat damage on different ear classes, are shown in Table 4. The consistently high values of r^2 in both systems of measurement mean that there is a very strong positive correlation between size of damage and corn loss, indicating hat the regression equations presented give good estimates of loss.

De Grazio et al., (1969) found that the relationship between size of damage (circular type) and loss can be best described by a linear equation ($Y = a + bX$) for ears less than 15.24 cm (6.0 in) long and by a quadratic equation ($Y = a + bX^2$) for longer ears. However, they did not consider the strip type of damage. In this study, only linear equations have been considered for both types of damage, because ears were usually 15 cm or less in length. De Grazio et al. also found that shrinkage due o drying was significant. This was not investigated here and should be the subject of future study.

Corn losses (for the ranges or ear and damage lengths reported here) predicted by using the equations derived in this study and by using the equations of De Grazio et al., are presented in Table 5. The De Grazio et al. equations generally predicted a slightly to moderately higher

Table 3. Weight of shelled corn (g), at 14% moisture content, from damaged and undamaged ears. Corn was collected from a field near Nauhan, Mindoro.

	Ear Length		Shelled Corn (g)	
			Damaged	Undamaged
Class	Centimeters	Inches	Mean ± s.e.	Mean ± s.e.
0	6.35-7.61	2.5-3.0	4.7 ± 1.4	
1	7.62-8.88	3.0-3.5	17.2 ± 2.3	
2	8.89-10.15	3.5-4.0	25.3 ± 4.4	30.2 ± 4.2
3	10.16-11.42	4.0-4.5	27.1 ± 4.3	44.3 ± 2.0
4	11.43-12.69	4.5-5.0	37.5 ± 2.8	41.3 ± 7.7
5	12.70-13.96	5.0-5.5	37.0 ± 3.8	63.2 ± 3.2
6	13.97-15.23	5.5-6.0	53.8 ± 7.5	63.7 ± 5.6
7	15.24-16.50	6.0-6.5	-	82.9 ± 4.8

Table 4. Regression equations and coefficients of determination showing the relationship between size of circular and strip types of simulated damage and weight of shelled corn. Ears were taken from a field near Nauhan, Mindoro.

Type of Damage	Ear Length			Regression Equation	
	Class	Centimeters	Inches	(Y = a + bX)	r^2
Circular	2	8.89-10.15	3.5-4.0	-2.26 + 4.15X	0.96
	3	10.16-11.42	4.0-4.5	-2.12 + 4.72X	0.89
	4	11.43-12.69	4.5-5.0	-4.15 + 5.45X	0.92
	5	12.70-13.96	5.0-5.5	-6.48 + 5.90X	0.97
	6	13.97-15.23	5.5-6.0	-9.75 + 6.77X	0.90
	7	15.24-16.50	6.0-6.5	-10.00 + 6.57X	0.97
Strip	2	8.89-10.15	3.5-4.0	-0.36 + 0.68X	0.93
	3	10.16-11.42	4.0-4.5	-0.53 + 0.69X	0.94
	4	11.43-12.69	4.5-5.0	-0.38 + 0.69X	0.94
	5	12.70-13.96	5.0-5.5	-0.32 + 0.61X	0.95
	6	13.97-15.23	5.5-6.0	-0.22 + 0.64X	0.93
	7	15.24-16.50	6.0-6.5	-0.95 + 0.63X	0.92
	2 - 7	8.89-16.50	3.5-6.5	-0.27 + 0.64X	0.93

Y = weight of shelled corn in grams at 14% moisture content; X = length of corn damage in centimeters.

Y = weight of shelled corn in grams at 14% moisture content; X = size of damage in centimeters^2.

Table 5. Corn loss predicted by equations from two different studies. Estimates A are based on equations derived from simulating rat damage (circular type) to corn grown in the tropics (this study); estimates B are based on equations derived from simulating bird damage (circular type) to corn grown in the temperate United States (De Grazio et al., 1969).

Damage Length		Predicted Corn Loss (g)					
		10.2 cm (4 in) ear		12.7 cm (5 in) ear		15.2 cm (6 in) ear	
Centimeters	Inches	A	B	A	B	A	B
4	1.57	16.8	15.8	17.1	18.1	16.3	18.7
5	1.97	21.5	21.9	23.0	25.4	22.8	25.6
6	2.36	26.2	27.9	28.9	32.5	29.4	32.6
7	2.76	30.9	34.1	34.8	39.8	36.0	39.9
8	3.15	35.6	30.1	40.7	46.9	42.6	47.2
9	3.54	40.4	46.1	46.6	53.9	49.1	54.7

(range, 1.9% to 15.7%) weight loss than those predicted from our equations. Differences were more pronounced as damage length increased and were greatest in the 12.7 cm class. Use of quadratic equations by them appears to have lessened differences in the 15.24 cm class. Considering that one set of equations was derived from temperate corn of generally longer ear length, and the other from shorter corn grown in tropical Philippines, the degree of similarity between damage loss predictions is striking.

With this in mind, we suggest that the equations derived in the study (Table 4) might be used with good results as a general means of estimating corn loss to rats in the Philippines. For the strip type of damage, the regression equation $Y = -0.27 + 0.64\ X$ (where X = size of damage in cm^2) might have general application. These equations would probably also be applicable to damage caused by other pests, such as some birds, which have similar patterns.

Based on our field observations, we believe that reliable estimates of corn loss might be obtained from surveys of cornfields taken within 3 weeks of harvest (when ears have dried and there appears to be little on-going damage). Since corn is planted in rows, a length of row might be used as a sampling unit. Stone et al. (1972,1973), for example, surveyed bird damage to corn by examining two random 5-meter units of two rows each per field. They recorded the numbers of ears in each unit, measured the length of damage to the nearest 0.25 cm for each damaged ear, and converted these measurements into losses by using tables by De Grazio et al. Since rat damage appeared fairly uniform in the fields that we have observed, a similar approach might apply for assessing rat damage to corn in the Philippines.

Protection of Corn Crops from Rat Damage Using Sustained Baiting with Anticoagulant Rodenticides

Introduction

Sustained baiting with anticoagulant rodenticides has been used successfully to reduce rat damage in Philippine ricefields (Sanchez et al., 1972-1974). Corn is another important cereal crop grown in the Philippines and other Asian countries and, although actual losses have not been quantified, corn is frequently subjected to heavy rat damage. As with rice, traditional methods of control, when used, appear to have little effect in reducing rat damage. This preliminary study was made to determine the biological and economic feasibility of using sustained applications of anticoagulant rodenticides to reduce rat damage in corn.

Some materials and equipment for this study were supplied by the BPI Office, Calapan, Mindoro.

Materials and Methods

Six 2-hectare plots (numbered I-VI), separated by at least 200 meters, were selected within an extensive area planted to field corn in Barrio Apitong, Nauhan, Mindoro. Three plots (II, IV, VI) were randomly chosen for treatment while the remaining three (I, III, V) were designated as reference plots.

In each of the treated plots, eight points near the periphery were arbitrarily chosen (separated by at least 50 meters) for baiting. One bait station, constructed from coconut husk with bamboo (see Sanchez et al., 1974, p. 93), was initially placed at each baiting point and filled with 40 grams of 0.05% warfarin-treated binlid (rice shorts). Stations were checked twice a week and numbers of stations were increased to keep a slight excess over consumption. Baiting was continued until harvest and weekly records were maintained of numbers of bait stations and amounts of bait added at each point. No rodenticides were used in reference plots.

In each of the plots, data were also collected on species composition, levels of rat activity, extent of rat damage, and production investments and yields. Species composition was determined by snap trapping with 50 traps per plot for three consecutive nights prior to baiting in the treated plots. Rat activity was determined with tracking tiles before treatment and at 4 and 8 weeks after planting. Thirty tracking tiles, placed in three transects with 10 tiles each at 20-meter intervals,

were used in each plot for 3 consecutive nights. Relative levels of activity were based on numbers of positive (rat-tracked) tiles.

Damage appraisals were conducted within 1 week of harvest. Sixteen rows were randomly selected in each plot. For each row, the number and location of each hill with one or more ears having rat damage, and the number of damaged ears in the hill, were recorded. Since there was an average of three ears (damaged or undamaged) per hill, we used this figure as the basis for calculation of damage estimates (percentage of damaged ears and estimates of numbers of ears damaged) for entire plots.

Records were maintained by each of the farmers for all production investments and yields. These records were verified whenever possible by our own field observations, and were used by us for calculating economic benefits of the farmers' agricultural practices.

Results

A total of 77 animals were collected during the 3 nights of trapping (900 trap nights) before treatment, or about an 8.6% trap success. Forty-two were taken from the treated plots, 35 from the reference plots. In treated plots, R. r. mindanensis was most common (45%), followed by R. argentiventer (24%), R. exulans (17%), and S. murinus (14%). In reference plots, R. r. mindanensis was also most common (37%), followed by R. exulans (34%), R. argentiventer (14%) and S. murinus (14%). Specimens of all species were taken from each of the experimental plots.

Bait and bait stations were added at baiting points in the treated plots as dictated by consumption, so we assume that records of bait additions closely approximate actual consumption. Stations were increased from their initial levels of 8 per plot to an average of 22 per plot (about 2.8 per baiting point) by the 4th week after planting, but were decreased to 4.7 per plot (about 0.7 per baiting point) or less by the 8th week (Table 6). From the 9th through the 16th week (harvest), consumption had dropped markedly and only about one-half of the baiting points actually contained bait stations. Likewise, the amount of bait added to the stations increased rapidly during the first 4 weeks after planting (from 0.3 kg to 0.9 kg, average for three plots), but decreased to about 0.2 kg per plot by the eighth week and was kept at that level or less for the remainder of the growing season (Figure 4, Table 6). Total bait additions for the three treated plots averaged 4.7 kg, was highest in Plot I (5.1 kg), and lowest in Plot III (4.3 kg).

Table 6. Average numbers of bait stations and amounts of bait added in three two-hectare corn fields employing sustained baiting with chronic toxicants, near Nauhan, Mindoro.

Week After Planting	Average No. of Stations/Plot	Bait Added (Weekly) Total (kg/plot)	Mean (g/station)
0	0	0	0
1	8	0.32	40
2	12	0.48	40
3	12	0.48	40
4	22	0.88	40
5	22	0.88	40
6	9.3	0.37	40
7	6.7	0.27	40
8	4.7	0.19	39
9	5.3	0.19	36
10	5.3	0.21	40
11	4	0.16	40
12	4	0.16	40
13	4	0.16	40
14	4	0	0
15	4	0	0
16	4	0	0
Total Bait Use	-	4.75	-

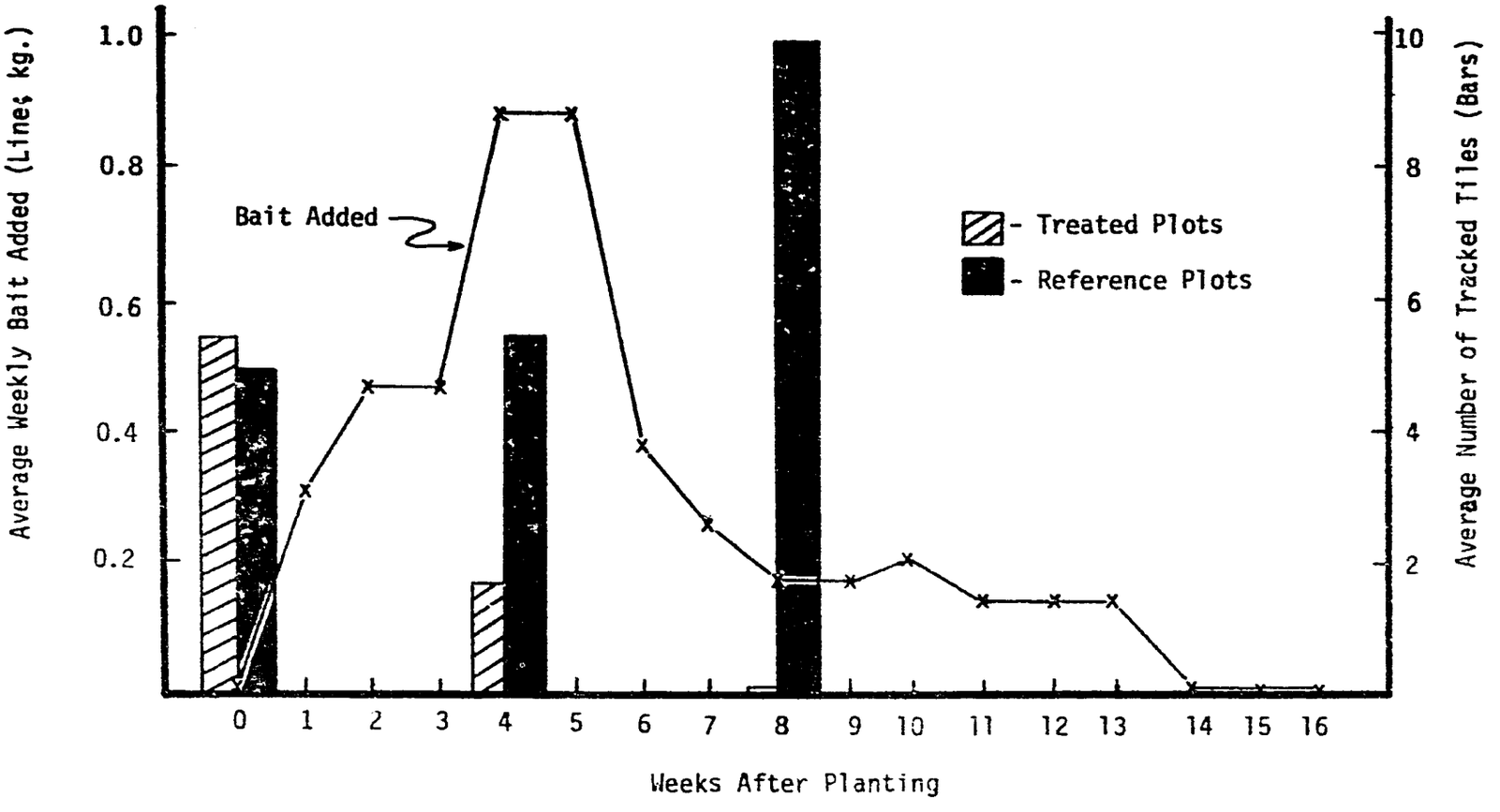


Figure 4 . Rat activity and bait use on three two-hectare corn field plots employing sustained baiting and three two-hectare reference plots near Nauhan, Mindoro. Activity estimates are based on the numbers of positive tracking tiles during each period, average per night per treatment; bait use was estimated by the total bait added weekly to all stations.

Based on tracking tile data, treated and reference plots had similar levels of rat activity before baiting (Figure 4). In reference plots, activity increased as the cropping season progressed, while it decreased rapidly in the treated plots. By the 4th week after planting, rat activity in the treated plots was considerably lower than in the reference plots (average 5.7% vs 18%, respectively); the difference was even more pronounced by the 8th week after planting (average 0% vs 33%, respectively).

About one-third of each plot was randomly sampled for rat damage within 1 week of harvest. Damage, both on a hill and an ear basis, was significantly lower in the treated than in the reference plots ($P<0.05$, ANOVA, Table 7). Assuming that our samples were typical for each of the plots, about 53 ears per plot were damaged in the treated areas compared to an average of 899 in the untreated plots, a difference of about 846 ear per two-hectare plot, or a damage reduction of about 94%.

Production investments of the farmers are summarized in Table 8. Farmers in treated and reference plots invested about the same amounts for seeds, land preparation, and planting, but farmers in the treated areas invested more heavily than reference area farmers in fertilizers, insecticides and weed control. Thus their total investments, exluding costs for rat control, were greater (₱364 per hectare vs ₱309 per hectare, treated vs reference areas, respectively).

We estimate that the cost for rat control in the treated plot ranged from ₱2.90-₱3.40 per hectare and averaged ₱3.12. These estimates are based on the cost for preparation and use of from 2.2-2.6 kg of bait per hectare at ₱1.30 per kg (Sanchez et al., 1972). Costs for preparation of bait stations and labor were negligible.

Farmers in the treated plots averaged 23.3 cavans per hectare of shelled corn, while those in reference plots averaged 15.8 cavans. The corn was sold at ₱50 per cavan, so farmers in the treated areas made an average profit of ₱798 per hectare, while those in the reference areas averaged ₱481 profit per hectare.

Discussion

Bait consumption and rat activity followed closely the patterns that we have observed when sustained baiting is used in ricefields; i.e., bait consumption increased rapidly during the first few weeks of treatment, presumably as more rats found and used the bait stations. Then consumption dropped rapidly and remained low during the rest of the growing season, probably caused by decreasing numbers of rats feeding at the stations as

Table 7. Average damage level for three two-hectare cornfield plots employing sustained baiting and three two-hectare reference plots near Nauhan, Mindoro. Hills and ears with damage were counted in sixteen randomly selected rows per plot.

	Treated Plots (Avg.)	Reference Plots (Avg.)
Total No. Hills:	18207	19482
Estimated Total No. Ears*:	54621	58446
Damage Sample:		
Total		
Hills	5712	6112
Ears	17136	18336
Damaged		
Hills	14.7	219
Ears	16.7	282
Percent Damaged		
Hills	0.26	3.58**
Ears	0.10	1.54**
Estimated Total Loss:		
Hills	47	698
Ears	53	899

*Estimates involving ears are based on an average of three ears (damaged or undamaged) per hill.

**Highly significant differences ($P < 0.05$)

Table 6. A comparison of production costs (pesos) for three corn field plots employing sustained baiting and three reference plots, all located near Nauhan, Mindoro. Data are presented as average per hectare costs for each treatment, although plot sizes were two hectares each.

Factor	Treated Plots	Reference Plots
Seeds	21	21
Land preparation	142	142
Planting	28	26
Fertilizer	81	51
Insecticides	47	34
Weed Control	45	35
Subtotal Production Cost	364	309
Rat Control	3 (estimate)	-
Total Production Cost	367	309
Gross Value of Crop	1165	790
Net Profit	798	481
Yield (cavans/ha)	23.3	15.8

mortalities due to the toxicant exceeded the rate of influx of new animals. As in our previous trials in ricefields, rat activity in the reference cornfields increased at least during the first half of the growing season, and, although measurements were not taken after the 8th week, it is likely that activity remained high in these plots for the remainder of the cropping period.

Although the reported differences in yields between treated and reference areas averaged 7.5 cavans per hectare, it is unlikely that most of these differences were due to the effects of rat control. Rat damage levels, trap success, and bait consumption records all indicate a relatively low population in both treated and reference plots. Except for Plot VI, where the farmer's entire crop was stunted for unknown reasons, yield correlated with total production investments ($r = 0.96$), excluding rat control (Figure 5). In particular, the use of fertilizer appears to have made a most significant contribution to the farmers' yields.

Despite the generally low rat damage levels, control with the sustained baiting method appears to have been economically beneficial. Since rat populations were low so was the cost for treatment (average ₱3.12 per hectare for treated plots, or about 0.82% of the total production investment). To break even, the farmer would have had to protect only 0.06 cavans of corn per hectare from damage. Based on the average difference in rat damage between reference and treated plots, and assuming that damaged ears were completely lost (an assumption warranted from our field observations), the farmers in treated plots actually saved about 0.34 cavans for a net gain of about ₱14 per hectare (₱17 minus ₱3 for control).

Based on the differences in rat activity and damage between reference and treated plots, we conclude that sustained baiting with anticoagulants effectively reduced damage in the treated corn plots. Since three major rodent pests were present, we also conclude that this method worked effectively against the damage potential of all three. Because levels of rat infestation were low in this study, additional work is needed to determine the effectiveness of the baiting program in areas where rat damage limits corn production. If effective, the method holds promise for incorporation as a general cultural practice, because cost of protection is largely dependent on bait consumption and should vary closely with the potential intensity of rat damage.

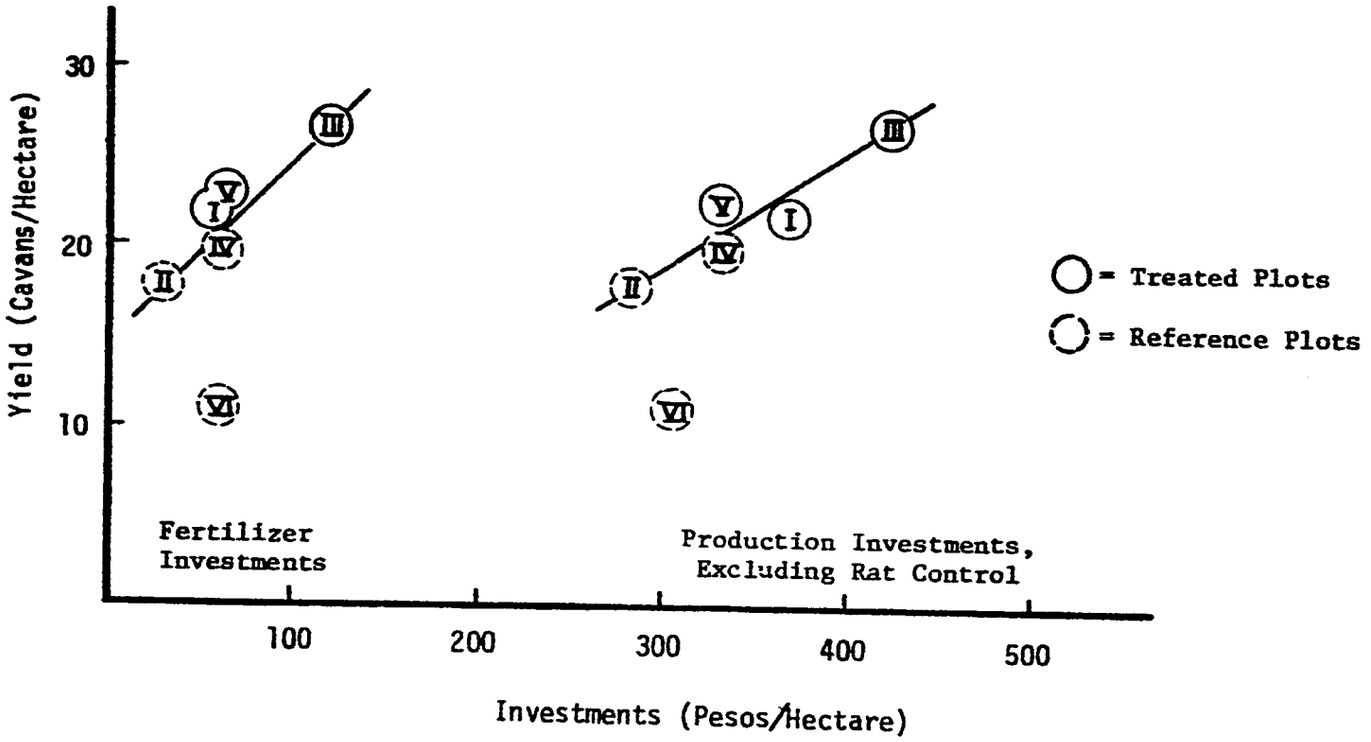


Figure 5 . Relationship between production investments and yield in six two-hectare plots near Nauhan, Mindoro. Although sustained baiting was effective and economically beneficial, rat damage was low in all plots and major yield benefits appear related to other production factors.

The Importance of Farmer Attitudes for Successful Implementation of the Sustained Baiting Program

Introduction

Since 1972, we have performed field trials on the effectiveness of sustained baiting with anticoagulants in reducing rat damage in Philippine ricefields, all with encouraging and some with spectacular results (Sanchez et al., 1972-1974). During the course of these studies, we have also provided some information on requirements for successful implementation of the procedure. Although initial trials were conducted with completely external inputs of materials, supplies, labor, and technology, in later trials we involved and observed the assistance of the farmers. In field trials conducted in Pangasinan in 1973, for example, BPI and we provided complete technical and commodity assistance but farmers implemented the procedure (Sanchez et al., 1973). The same approach was used in the 1974 trials in Lumban, Laguna, and in Mindoro Oriental (Sanchez et al., 1974).

With the recent incorporation of the sustained baiting procedure into the Philippine national rice production program, Masagana-99, and into the national rat control programs for non-Masagana-99 areas, we have begun to look more carefully at some of the factors which may be associated with successful implementation of the procedure. Since all national control programs currently involve some form of loan or commodity assistance to the farmer, we questioned the effect of giving technical assistance as required without loan or commodity support.

Materials and Methods

Two adjacent barrios with histories of severe chronic rat infestation near Santa Cruz, Laguna, were chosen for the trial. Both areas are adjacent to marshland habitat. In one barrio, San Pablo Norte, we called an organizational meeting of the farmers through the local farmer's association and the barrio captain. At this meeting, the farmers described their past problems with rats and requested technical assistance. We described deficiencies of their current methods and the advantages of using the sustained baiting approach. We offered to provide full technical assistance if the farmers chose to implement the sustained baiting program and enough toxicant and bait to demonstrate methods for mixing and to begin the program (mixed bait for the first 2-4 weeks). Thereafter, we explained that technical assistance would be provided as required and as requested, but that the farmers would have to provide their own sources of bait materials. We estimated that, at current costs, their total investment should not exceed 30 pesos ($4) per hectare per growing season and would probably be considerably less. The farmers voted unanimously to

implement the procedure and agreed that they had sufficient funds to carry out the baiting program if they were provided adequate technical assistance.

In the second barrio, San Pablo Sur, we offered no technical or commodity assistance, but asked for and received permission to make periodic observations and measurements in the fields.

Technical assistance was provided to San Pablo Norte at 1-2 week intervals by two Center staff. During these visits, current problems were reviewed, solutions recommended, and, at times, help was given in implementing solutions. In addition, the technicians took notes on the conditions of the ricefields, bait stations and looked for signs of rat infestations in both San Pablo Norte and San Pablo Sur. Fifty tracking tiles were placed at about 50-meter intervals in five transects separated by 50-75 meters (10 tiles per transect) in both areas for 3 consecutive nights during the vegetative, early booting and maturing rice stages. In addition, damage appraisal was conducted in 10 randomly selected plots at San Pablo Norte and in 10 randomly selected plots at San Pablo Sur. Appraisal was by the tiller cutting index in which 100 hills, randomly selected, were examined in each of the plots, and damaged and undamaged tillers were counted.

Results and Discussion

During the first 3-4 weeks after transplant, when both technical and commodity assistance were provided, bait station arrangements and attendance in the fields of San Pablo Norte followed closely the Masagana-99 interagency recommendations. But after commodity assistance was discontinued, implementation of the baiting system degenerated quickly. Within 1 week, bait stations were left unrefilled. Upon visits and questioning by the technicians, farm leaders provided a variety of excuses, most commonly a local unavailability of bait or toxicant. Our own checks at commercial outlets and warehouses indicated that most of these statements were unfounded. This was the general pattern for the rest of the growing season, so that from the 4th week after transplant to harvest, only sporadic and token amounts of baits were placed in the stations. In additional discussions with farmers, we noted apathy toward rat control and a general feeling that the 1st month of baiting was adequate to have solved the problem, despite our persistent warnings to the contrary.

By 6-8 weeks after transplant, we noted the first major signs of rat infestation in the fields of San Pablo Norte. Fresh rat burrows were abundant along dikes at 5-10 meter intervals, rat tracks were

common in paddies and we could occasionally flush rats from paddies in the daytime by walking along the dikes. We also observed nests with young along some of the larger dikes. Cut tillers were common. At this time, the farmers took renewed interest in rat control, but decided to do it their own way. Bait stations were moved from paddies and concentrated along major dikes and irrigation ditches. Most were still only supplied with token amounts of bait, however, and acute toxicants were used by a few farmers. There were sporadic attempts to blanket and club rats, and occasionally farmers flooded and plugged burrows. Some farmers tried superstitious practices, such as placing altar flowers along paddy dikes.

In San Pablo Sur, traditional methods (as described above) were used during the entire growing season with farmers relying most heavily on acute toxicants such as zinc phosphide. A major difference between the two areas was that rats and their signs were seen more commonly in San Pablo Sur during the earlier growth stages.

Rat activity, as measured by tracking tiles, was considerably lower in San Pablo Norte than San Pablo Sur during the early vegetative stages, but increased steadily until rat activity was about the same in both areas by booting to milk stages (Table 9). Since the areas are close to each other and are surrounded by similar habitats, we suggest from this data that the sustained baiting procedure worked effectively during its brief period of implementation in the treated barrio, but that rats quickly reinvaded the area when farmers received no additional commodity support and switched to traditional control methods. As shown in Table 9, damage in San Pablo Norte was slightly, but not significantly ($P = 0.6-0.7$) lower than in San Pablo Sur. It, thus, appears that the sustained baiting procedure was not implemented for a long enough period to significantly reduce rice losses to the rats.

We have noted in previous studies (Sanchez et al., 1973) that farmers sometimes appear to follow a recommended control procedure, not because they think it will work, but because they respect the technician who has worked hard to help them. From this study, it appeared that the farmers in San Pablo Norte required loan or commodity support in addition to technical assistance for successful implementation of the sustained baiting procedure. In a national rat control program, it is unlikely that government technicians will be able to visit the areas and provide assistance as frequently as we did. Additional studies are required, of course, to determine the importance of loan or commodity assistance for successful implementation of the sustained baiting procedure on a national basis.

Table 9. Rat activity and extent of rat damage in two ricefield areas near Santa Cruz, Laguna. In barrio San Pablo Norte, farmers were given technical assistance in damage reduction but only limited commodity support. In barrio San Pablo Sur, farmers were provided neither technical nor commodity assistance.

Rice Stage	Rat Activity (Mean No. Positive of 50 Tracking Tiles, 3 Days Each Period ± s.e.)	
	San Pablo Norte	San Pablo Sur
Vegetative	5.3 ± 1.5	27.3 ± 5.5
Early booting-booting	26.7 ± 4.9	44.7 ± 5.8
Milk-maturing	42.0 ± 2.6	42.0 ± 2.0
	Rat Damage (Mean Percentage of Cut Tillers ± s.e.)	
Near harvest	23.8 ± 4.3*	29.8 ± 3.4**

* N = 19 randomly selected paddies, 100 randomly selected hills each paddy.

** N = 10 randomly selected paddies, 100 randomly selected hills each paddy.

Rat damage to sugarcane is usually most abundant near the base of the stalk. Actual sugar losses are compounded when the wound allows access of disease organisms which infect the rest of the stalk.

Preliminary Observations of Rat Damage to Sugarcane in the Philippines*

Introduction

Sugarcane production and processing in the Philippines is an extremely diverse agro-industry. Practices range from small grower-owned fields and carabao-powered mills to highly progressive plantations and sugar refineries. The 10-12 month crop is labor intensive when compared to other major sugar producing regions of the world. All harvesting and many of the cultural operations are conducted by contractual or grower-related hand labor. The number of ratoon crops from a planting varies from zero with smut susceptible varieties up to six for resistant varieties.

About 23,000 farms encompassing 440,000 hectares and employing 360,000 farm workers are planted to sugarcane. The majority of farms are 10 hectares or less in size with the largest percentage being less than 5 hectares (Table 10). The crop is grown in 18 provinces on 6 islands. The majority of cane is milled at 38 privately-owned mill centrals and processed at 5 refineries. Total sugar production was estimated at 2.5 million short tons during the 1973-1974 crop year. Fifty-six percent of the production was allocated for export and the remaining was retained for local consumption and reserve. Annual dollar earnings from sugar exports constitute 20% of the country's foreign exchange income. The industry assumes a major role in determining the nation's economy as well as supporting a significant portion of its labor force. Considerable growth of the industry is expected with the planting of new lands and addition of mill centrals in Mindanao and the Visayas.

Because rat damage is a common complaint of sugarcane farmers, we made preliminary qualitative observations on the extent and nature of rat damage to sugarcane in the Philippines during November, 1975. The observations were made to provide a basis for determining the extent of future Center commitment to research on this problem. They were conducted with the expert assistance of a consultant from the Wildlife Damage Research Station, Hilo, Hawaii, which specializes in the development of systems for the reduction of vertebrate damage to sugarcane. The approaches for solving sugarcane-rat problems in the Philippines, which will serve as the basis for our future work in this area. This report summarizes our major field observations and the findings of the expert which were given in a trip report.

---

*Based on a trip report entitled "Rat Damage to Philippine Sugarcane" by Larry F. Pank, USFWS, Wildlife Biologist, Wildlife Damage Research Station, Hilo, Hawaii.

Table 10. The sizes of sugarcane farms in the Philippines

Farm Size (ha)	Percentage
0-5	45.5
5-10	10.7
10-25	18.7
25-50	9.7
50-100	6.0
100 +	3.5

Materials and Methods

Data were collected by interviews with sugarcane farmers and plantation owners and research personnel, discussions with research staff of the Philippine Sugar Institute, review of the current literature, and by many cursory field inspections over most of the major sugarcane growing regions in the Philippines.

Results and Discussion

Although a large number of factors influence sugarcane production yearly, average yields on a national basis have remained largely unchanged for the past 30 crop years (Table 11). Rat damage, one factor adversely affecting yields, has never been quantitatively assessed on a national scale. Without a reliable measure of the economic impact of rat damage at the national level, it is impossible to assign meaningful funding and manpower priorities to the problem on an industry-wide basis. Based on conversations with growers, managers and researchers, it appears that rat-related losses are of less immediate importance than: (1) the storage, reprocessing and export-related marketing problems, (2) problems associated with milling allocations and capacities, (3) development and implementation of improved cultural practices, and (4) the development and distribution of high yielding varieties.

These priorities, however, do not preclude incorporating pest problems of which rats are generally ranked at or near the top, into a well-rounded research program. There is sufficient damage information from individual farmers and plantations to justify rat-related research on a localized basis. Researchers at Victorias Milling Company (VMC) in the Visayas, for example, estimate that rats damage an average of 15% of stalks and reduce yields by approximately 5% (Porquez and Ledesma, 1970; Panol et al., 1975). Based on an average production of 114 picules sugar per hectare and a price of 46 pesos per picule, VMC estimates the monetary loss to rats at 265 pesos per hectare. Overall levels of damage that we observed were generally lower than those reported by VMC; however, damage in localized areas equalled or exceeded the VMC levels (Table 12). These observations were made during the beginning of the harvesting period and may underestimate actual losses because there was a general concensus that damage becomes greater toward the end of the harvesting period. It also appeared that damage was related to cane tonnage and lodging. If true, the absence of typhoon-caused lodging because of an unusually mild typhoon season may have resulted in abnormally low damage levels. Similarly, damage may increase in the future with the implementation of higher yield varieties, if a cause-effect relationship exists between tonnage and damage. Expansion of multiple cropping and intercropping is also likely to increase damage levels in both sugarcane and the adjacent crops.

Table 11. Past production records for Philippine sugarcane fields (from Covar, 1972).

Crop Year	Yield (Tons/Ha)	Yield (Picules Sugar/Ha)
1945-46	43.06	77.50
46-47	43.75	79.62
47-48	43.75	76.70
48-49	47.47	88.93
49-50	43.01	76.77
50-51	47.98	86.77
51-52	47.90	81.92
52-53	45.29	77.72
53-54	53.62	93.27
54-55	51.98	90.07
55-56	52.45	92.96
56-57	50.66	92.12
57-58	57.84	107.62
58-59	63.03	111.93
59-60	62.04	106.09
60-61	65.91	99.10
61-62	60.46	107.18
62-63	57.76	99.80
63-64	58.22	94.26
64-65	49.75	75.18
65-66	44.64	74.50
66-67	53.06	85.66
67-68	50.73	82.54
68-69	51.49	79.06
69-70	61.89	87.96
70-71	58.56	87.84

Table 12. A summary of observations on the extent of rat damage to sugarcane during visits to representative sugar producing areas of the Philippines from 6-19 November, 1975.

Area	Damage*	Comments
1. Laguna	Negligible to low	Low damage was confined to a few fields with lodging and heavy tonnage. One exception was in upright cane adjacent Laguna de Bay (marshy area). Damage confined to ground level.
2. Cavite	Negligible	Limited observations, damage restricted to ground level.
3. Batangas	Negligible	Limited observations, damage restricted to ground level.
4. Davao del Sur	Negligible to high	High damage was observed in cane-coconut interplanting but not predictable. Damage occurred 3-5 feet off ground in fields interspersed with coconut.
5. Occ. Negros	Negligible to high	Victorias area. High damage in fields without control. Damage may be higher because of high tonnage and continuous harvesting. La Granje area had light damage. Damage was generally confined to ground level.
6. Pampanga	Negligible	Limited observations, damage was confined to ground level.
7. Tarlac	Negligible to high	Damage was generally restricted to high yielding varieties with high tonnage and lodging. Potentially associated with wetter areas. Damage was confined to ground level.
8. Pangasinan	Negligible	Low yielding varieties were prevalent. Damage observed was confined to ground level.

* Qualitative estimates of percent stalks damaged Negligible = <5%, Low = 5-15%, High = >15%.

Rat control methods practiced by growers are as diverse as the industry itself. Chemical control practices include the use of 1080, 1081, thallium, zinc phosphide and anticoagulant baits distributed in bait stations, torpedoes, banana leaf packets, or small plastic bags. Treatment is generally initiated when the cane is 8-9 months old and ranges from daily to bi-monthly applications until harvest. Non-chemical control measures include: 1) burning the cane at harvest to prevent migration of rats to adjacent fields, 2) collection of rats for food at harvest and, 3) planting hard-rind varieties. Users of each method generally feel that they are achieving some control; however, none (with the possible exception of staff at VMC) have actually assessed the efficacy of their treatment.

Based on these observations, control-oriented research on a minor scale is probably economically justified. Based on observations of the current status of control programs and discussions with sugarcane farmers and researchers, a research program at this level should include the following steps: 1) selection and development of techniques to index rat populations, assess damage levels and measure yields, 2) selection of effective toxicants and baits, 3) selection of appropriate bait forms and distribution patterns, 4) evaluations of efficacy of management programs, 5) determination of frequency of applications, 6) evaluation of efficacy (damage reduction and yield increase) of the resulting control programs and, 7) evaluation of hazards associated with the control program. This approach is based on chemical control which currently has the greatest probability of success. The benefit of background information on chemical control should minimize developmental time and requirements. To overcome problems of short-term effect and hazard, however, research plans should eventually include work on non-chemical approaches (e.g., identification and selection of varieties resistant to souring or less preferred by rats) -- approaches that may be economically justified when development and control costs are prorated over a number of years.

A field technician points to a rat nest that was constructed high above the water level in a marshland sedge community. Active nests have been observed in marshes with rat populations as dense as a rat per square meter.

Preliminary Observations of Rats in Marshland Habitat

Introduction

Plant communities associated with marsh habitats along Laguna de Bay have already been described and separated into five types (Pancho et al., 1969, Pancho, 1972, 1976). The Scirpus grossus community is usually found in the shallow areas of the lake shore. The dominant species, S. grossus, is a coarse, erect, triangular-stemmed sedge which can grow up to 2 meters high. Although it occurs in almost pure stands, it is usually mixed with water hyacinth, Eichornia crassipes, as well as less common water plants, including Polygonum tomentosum, Ludwigia adscendens, Ipomea aquatica, Sacciolepis indica, and Panicum paludusum.

The sesbania community is dominated by the yellow-flowered, shrubby legume, Sesbania cannabina. It usually begins in shallow areas and can extend fingers into deeper waters. In some areas, the shrubs are almost tree size and provide good harborage for many forms of wildlife. Common community associates: Ipomea triloba, I. aquatica, E. crassipes, P. tomentosum, some S. grossus, S. indica, Echinochloa crusgalli, and Echinochloa cruspavonis.

The lotus community is usually found in the deeper portions of the lake, dominated by the sacred lotus, Nelumbo nucifera, water plants with big orbicular leaves and long-peduncled flowers or fruits. The seeds are edible, can be eaten raw when green, boiled or roasted when ripe, and are commonly taken by rats and other wildlife. Since the lotus does not cover the water surface entirely, underwater plants, Hydrilla verticellata and Ceratophyllum demersum, are common community associates along with occasional green and brown bryophytes. S. grossus and E. crassipes are sometimes also mixed with this community.

The reed community is usually found in shallow water and is dominated by the common reed, Phragmites australis, which can grow up to 4 meters high. Other associates: P. paludusum, E. cruspanovis, E. crusgalli, Bracharia mutica, and sometimes Ludwigia adscendens. The fifth community is actually a mixed one dominated by E. crassipes and S. grossus. Other associates: P. tomentosum, I. aquatica, I. triloba, L. adscendens, L. perennis, P. paludusum, small patches of S. cannabina, B. mutica, Leersia hexandra, Panicum repens, Sacciolepis indica, Commelina benghalensis, E. crusgalli, E. cruspavonis, and P. australis. Of all the marsh species, the water hyacinth, E. crassipes, is by far most common and widely distributed.

Many of the historical rat "outbreaks" in the Philippines, such as those described by Villadolid (1956) and Crucillo et al. (1954), have occurred adjacent to wide marshlands. We have repeatedly encountered reports of sporadically heavy rat infestations in areas bordering the Liguasan and Libungen marshes on the island of Mindanao, in agricultural areas bordering the Candaba Swamp, Chico River and Laguna de Bay on Luzon, and in the areas bordering Lake Naujan on Mindoro. We have observed heavy rat infestations in marshlands on many occasions and measured densities as high as 1 rat/m^2 (Sanchez et al., 1974).

In national damage surveys conducted from 1970-1972, ricefield areas adjacent to uncultivated or marshland habitat generally had more rat damage than areas adjacent to other ricefield or water transport dikes (Sanchez et al., 1973). Damage appears augmented when flooding forces the rats out of marshy areas and into adjacent agricultural lands.

We have also received reports from fishermen along Laguna de Bay that rats damage their nets. At times, the rats chew holes through netting used for fish pens. When the holes are cut near or below the water surface, the cultured fish escape and the owners suffer severe economic losses.

It, thus, appears that a better understanding of rats in marshland habitat could lead to effective means of reducing high chronic levels of damage in many adjacent croplands and, perhaps, to means of predicting and preventing major rat "outbreaks". We have, therefore, begun a preliminary study in marshy areas along Laguna de Bay to obtain some basic information on rat-marshland-agroecosystem interrelations. The study was initiated in September, 1975, and will continue for one year. We report here the results from September through December, 1975.

Materials and Methods

A marshy area between the ricefields in Barrio San Pablo Norte, Santa Cruz, and Laguna de Bay was chosen for initial trials. Two trap lines were established: one, about 1.5 km long, was placed in marsh dominated by the triangular-stemmed sedge, S. grossus, and located between 25 and 150 meters from adjacent ricefields. The other, about 300 meters long, was placed in deep-water marsh dominated by the lotus, N. nucifera, about 0.5 km from the ricefields. Access, particularly to the transect located in the sedge, was difficult. This trail was initially made with the help of a large number of farmers who cut through the dense vegetation with long knives. We opened it further with the use of an airboat which has since also provided a means of reaching and maintaining both transects.

Both lines were trapped for three nights each month. Snap traps with fresh coconut bait were placed at about 25-meter intervals--40-50 along the transect in the sedge community, 10 along the transect in the lotus community. Trap locations were marked and approximately the same location was used for each trapping period. Wher necessary, traps were placed on small platforms of cut vegetation to assure buoyancy. Data were recorded on the numbers and locations of rats caught and traps sprung, the dominant vegetation within one square meter of every trap for each trapping period, water depth along each transect, and the condition of adjacent ricefields. Rats caught were brought to the laboratory and autopsied.

Results and Discussion

Only R. r. mindanensis (93%) and S. murinus (7%) were caught in the sedge community, and only R. r. mindanensis in the lotus community. No R. exulans were collected at either site. Adult male R. r. mindanensis averaged 234 ± 8.3 g. Adult females weighed 220 ± 8.8 g, slightly, but not significantly, less than the males (Student's t, $P<0.95$). These rats were slightly heavier than those collected in irrigated areas near Siniloan, Laguna, in 1971 (where males averaged 216 g and females averaged 207 g), although it is unlikely that this difference is statistically significant. They were considerably heavier than those collected in rainfed areas near Cuyapo, Nueva Ecieja, in 1971 (153 g and 150 g, males and females respectively; Sanchez et al., 1971).

Total tail and body lengths of male and females from the marshland were similar to those collected in Siniloan. However, rats in rainfed areas near Cuyapo had considerably shorter total lengths. The physiological or nutritional reasons for these differences have not been studied in the Philippines and should be the subject of future research.

All adult male R. r. mindanensis that we collected had testicles in the scrotal position during the period of this study. Gravid females were collected only in October and November (Table 13), juveniles only in November and December (Figure 6). This corresponded with the harvest and preplanting periods of adjacent ricefields (Figure 6).

Overall trap success for the period reported was about 14%. As shown in Figure 6, trap success was lowest in October, when adjacent ricefields were booting, then increased sharply as adjacent fields were harvested and prepared for the next cropping season. Farmers first began complaining about rat damage in their fields during the booting periods, and it may be that large numbers of rats were moving from the marshes into the rice at that time. However, water level in the

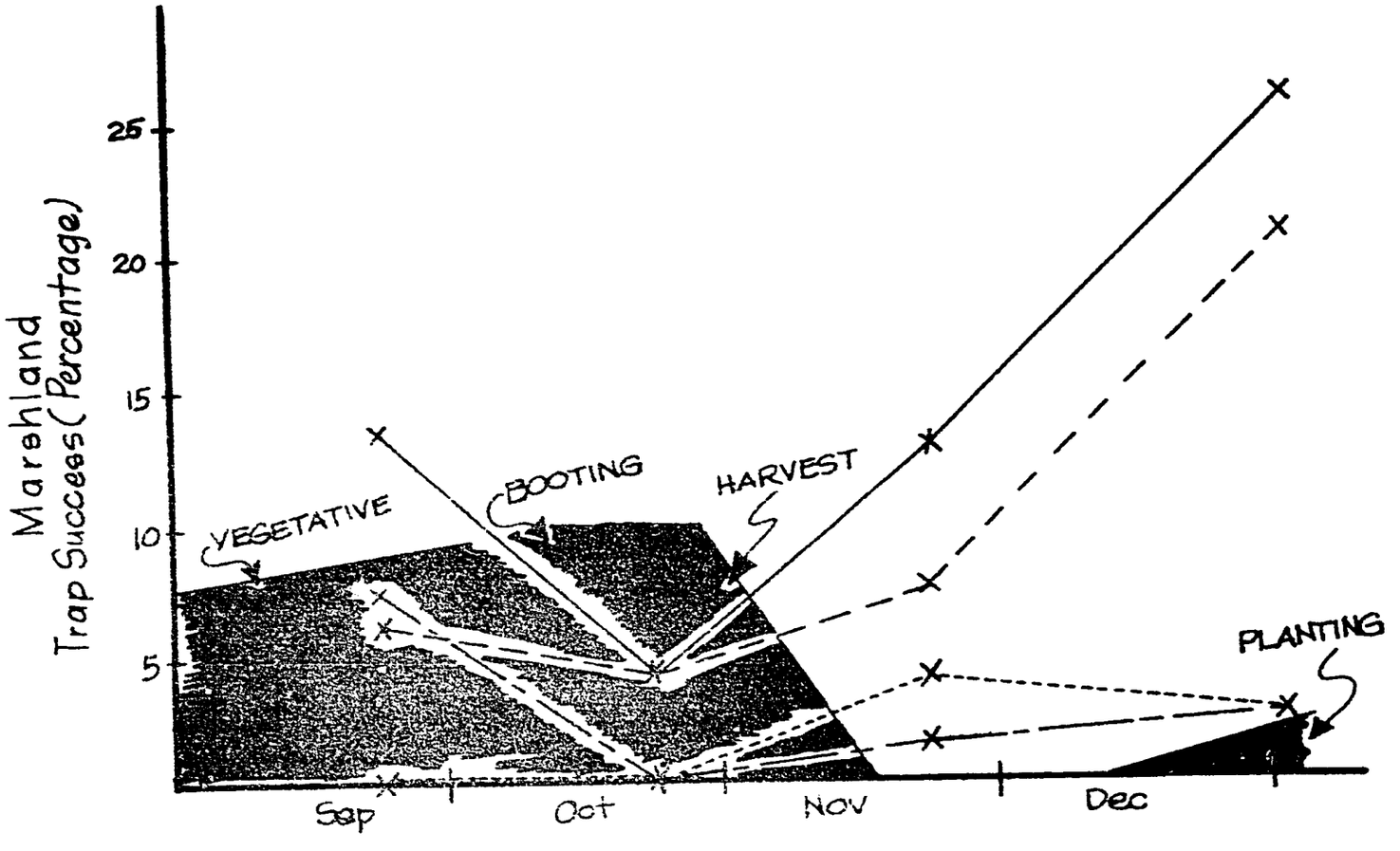


Figure 6. Relationship between trap success in a sedge-type marshland community and stages of rice development in adjacent fields.

marshland also rose dramatically during the December trapping period (from about 0.4 m to over 1 m), and might have concentrated the rats that were in the marshland and resulted in a higher trap success. Additional studies, possibly with marking agents and biotelemetry, are needed to determine the specific movement patterns of rats between marshes and adjacent ricefields as a function of the growing season.

Marshlands are commonly viewed by ecologists as pulsating ecosystems and the microhabitat changes which have occurred in the Scirpus marshland between September and December have been quite impressive. Water level on the near-shore transect was about 0.3 m during the initial month, increased gradually to about 0.5 m for 2 months, then rose rapidly to 1 m following a sustained rainy period in December. During this time, adjacent ricefields were also flooded and preparations for the next growing season followed the gradual recession of the water. In September, the sedges were tall, brilliant green and the apparent dominant plants of the community. Water hyacinth was common, appeared to fill disturbed or open areas quickly and served as a patchy "undergrowth" for the sedge. By December, the sedge was clearly a less prominent community plant, in part because it was partially submerged by the deeper waters but also because large portions of it were turning brown and dying. Water hyacinth, on the other hand, was green and prominent. The net result was a marshy stand which appeared considerably shorter but thicker than during the initial few months of the study.

Figure 7 presents the microhabitat changes at trap sites and, to an extent, quantifies these observations. Most notably, hyacinth increased as a common prominent plant while sedge and sedge-hyacinth wavered or decreased in importance. Since our preliminary data shows a greater trap success in the hyacinth than in the sedge-type microhabitat, this may also be a contributing factor to the increased trap success during November and December. Additional discussions and interpretations of the results will be made following completion of this preliminary study.

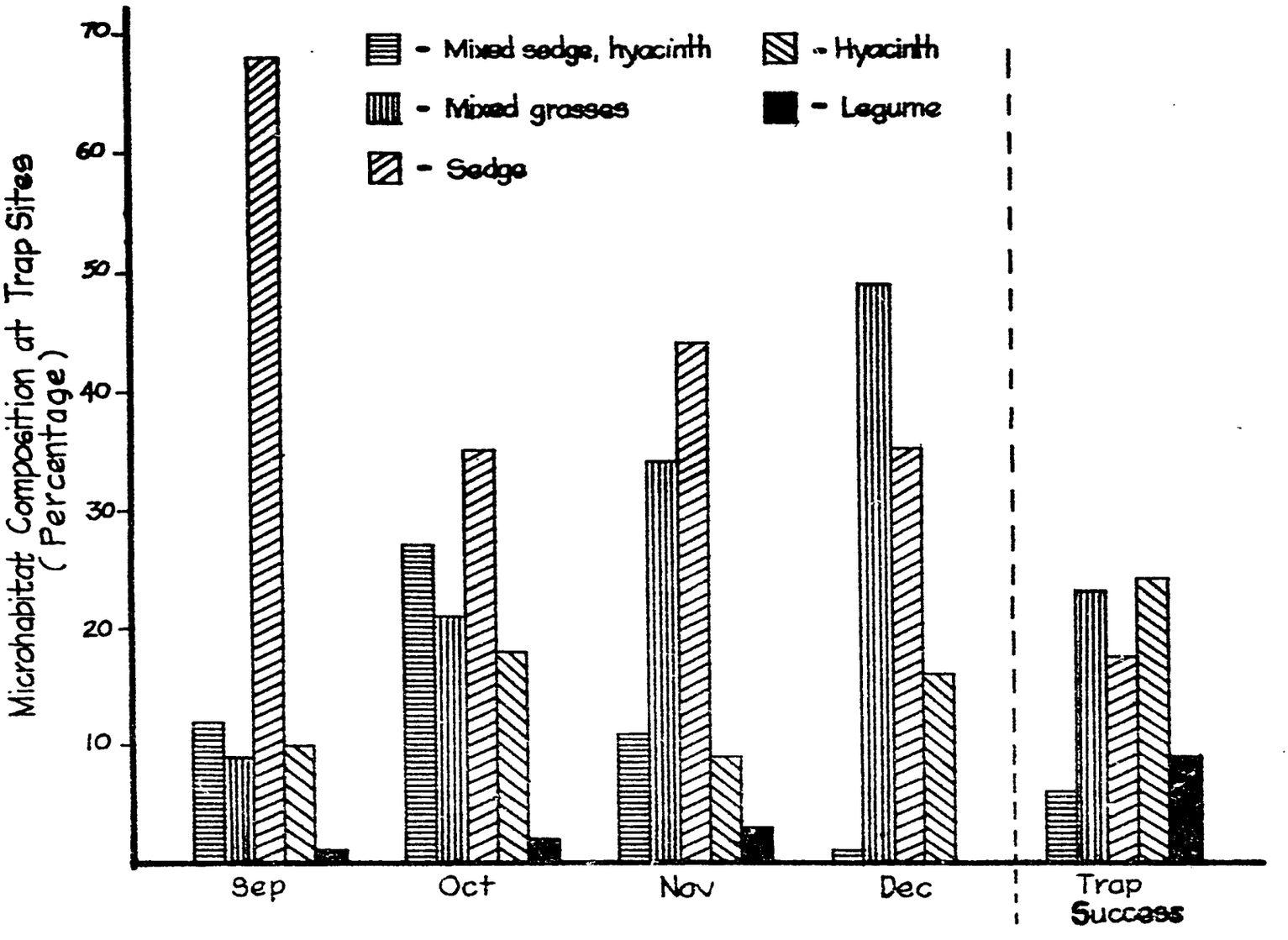
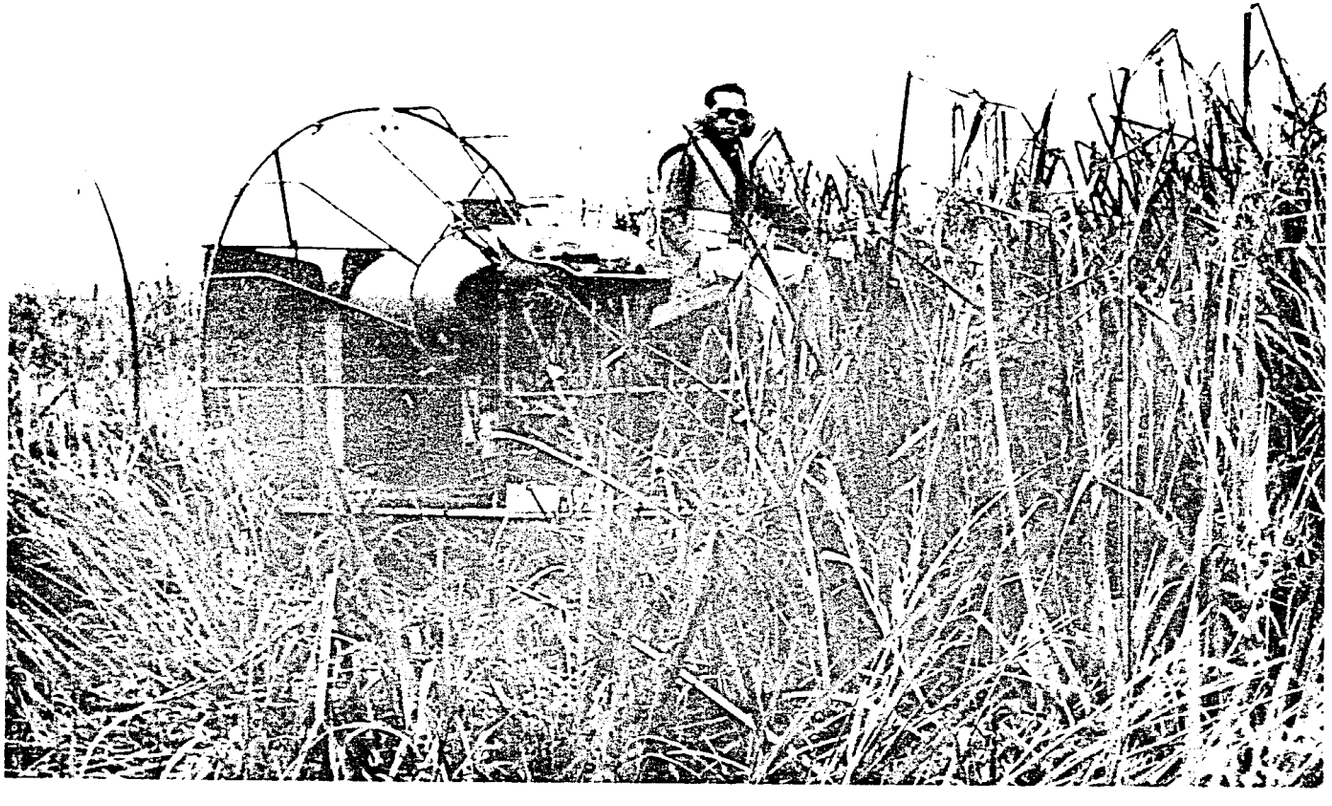


Figure 7. A summary of microhabitat floral composition in a sedge-type marshland community adjacent to the ricefields of Barrio San Pablo Norte, Sta. Cruz, Laguna. Dominant vegetation in the one-square meter surrounding each trap was used to determine the percentages of trap locations dominated by each major vegetation type for every trapping period.



An airboat provides transportation into a marshland community dominated by sedges. A heavy undergrowth of water hyacinth makes penetration almost impossible by normal watercraft.

Preliminary Trial of a Sublethal Electric Barrier Designed to Reduce Rat Damage to Agricultural Crops

Introduction

In the Philippines, farmers and agricultural researchers have tried a myriad of fence designs to exclude rats from their fields. We have observed nylon fish-net surrounding seed beds, galvanized steel roofing placed around hectares of growing rice, and a variety of electrified fences which range from a simple array of paralled wires charged from high power lines to elaborate combinations of chicken fencing and wires with complex, self-contained power units.

The International Rice Research Institute (IRRI) operates what is probably the most sophisticated electrified fence system in the Philippines in an attempt to minimize rat damage to their experimental plots. Chicken wire fencing (1.2 cm mesh, 36 cm tall), supported by bamboo stakes at 1-meter intervals, is placed in the paddy, about 0.1 to 0.5 meters from the dikes. Plastic insulators are fastened to the bamboo poles near the top of the fence, and two strands of 18-20 gauge galvanized steel or copper wires are stretched between the insulators. Power is supplied by 6- or 12-volt car batteries, but first passes through a vibrator and a transformer, so that 125 volts alternating current (AC) is supplied on the lines. Fences are electrified from sunset to sunrise, and encompass up to 65 hectares of experimental plots. A crew of at least 30 staff maintain the fences at night, and remove electrocuted animals which short the fences and render them inoperative. Removal of the animals involves a complicated and frequently time consuming procedure. When a fence becomes inoperative, an electric bulb lights to alert a crewman. The crewman knows only that the fence has short-circuited, not the location of the electrocuted animal. He patrols the fence until he locates the cause, then removes the animal with a dry stick. If the short-circuit was caused by more than one animal, he continues the search until he has located and alleviated the problem. Since IRRI fences kill up to 20,000 rats per year, a fair proportion of which cling to the fence and cause short-circuits, and since frogs and toads frequently cause the same problem, the fences are inoperative for a considerable time each evening.

The effectiveness of fence designs in reducing rat damage to crops varies greatly, but is usually less than desired. During observations of a galvanized roofing fence which surrounded 13 hectares of ricefields in Central Luzon last dry season, we noted abundant rat burrows along the perimeter and underneath the fence, and rice within the fence was

almost completely damaged. A farmer in Barrio Wawa, Lumban, Laguna, however, harvested over 700 cavans of rice from 12 hectares enclosed by an electrified fence during the 1974 dry season crop, and only 15 cavans from an adjacent 6 hectares that was unprotected. Damage in the fenced area averaged 13.2% cut tillers, while it was almost 100% in the unprotected area. Based on the production inputs, including costs for investment and operation of the electric fence, and profits, we concluded that the farmer received economic protection by using the barrier and made a modest profit (Sanchez et al., 1974). Although the fences at IRRI probably afford the highest level of protection using current designs, rats still pass the barriers and damage rice, sometimes causing the loss of valued experimental information.

Despite the interest in using barriers to protect crops, and despite their obvious potential in tropical situations where damage is frequently caused by rat invasions from surrounding areas, we have found few barrier designs which are based on an understanding of rat population dynamics and behavioral characteristics. Present designs have implicit difficulties, including high initial costs, high maintenance and operational costs, limited periods of electrical operation, questionable safety margins, and at best, limited effectiveness. Most of these problems stem from attempts to kill the rats rather than simply exclude them from an area. Since considerable current is required to kill a rat, the fences pose a potential safety hazard to non-target species, including toads, frogs, carabao and humans. Electrocuted animals cause short-circuits and further increase current drain. The removal of rats adjacent to the barriers probably causes a "sink effect" which would induce movement of additional rats toward the barrier, sustain rat pressure on the fence, and increase current drain. Heavy current drain and the need for a crew to minimize periods of inoperation constitute major operational costs. Because of high operational costs, the fences can usually be electrified only during the period when most, but not all, rats are active. This leaves the areas open to invaders who are not active during the typical nocturnal period, and limits the effectiveness of the barrier (already limited by periods of inoperation due to short-circuits).

This report summarizes the first preliminary field trial of a non-lethal electric fence in the Philippines. The fence was designed and tested in laboratories at the Denver Wildlife Research Center (DWRC) with encouraging results. Because the fence is non-lethal, it has the potential of continuous operation for extended periods of time with a minimum use of electricity, without the need for an operational crew. The shocker used in the system meets Underwriters Laboratory's criteria for human safety, and presumably will not kill a wide variety of other non-target organisms. We hypothesize that upon repeated contact this barrier will condition rats in surrounding areas to avoid the fence,

and that the trained rats will serve as a biological buffer to reduce fence contacts by more distant rats. If the hypothesis is correct, rat contacts on the fence should diminish during the period of the growing season, and further reduce operational costs. Fencing for this study was supplied by IRRI.

Materials and Methods

Four plots, about one-quarter hectare each, were selected near Santa Cruz, Laguna. Rice, IR-26, was about 10 weeks after transplant and was receiving noticeable damage. The fields were adjacent to a barrio and planted under coconut trees. On one side was a wide area of rice, somewhat older; thus, the test plots would likely receive increasing rat pressure as the test proceeded. Two of the areas were fenced, two were left for survey at harvest.

The fence design followed closely the prototype model proposed by DWRC. We used 1.2 cm mesh chicken wire fence, 36 (instead of 46) cm high. This was set around the perimeter of each fenced plot, about 0.1 m from the dikes and about 5 cm into the paddy mud. Two rows of wires were installed on double sets of insulators along the outside of the fence; one row was about 13 cm above the ground, the second row was about 28 cm. The top 2.5 cm of the chicken fence was curled outward. The charge on the fence itself and outer rows of wire was negative, while the central wires were positive. For test purposes, we installed two shockers, one which operated from an alternating current (AC) source, and one which required a DC source, to deliver high voltage pulses (0.3 second) at 0.7-second intervals. A 220 volt (reduced to 110 volts with a transformer) house socket was used as the AC power source and two, 12-volt car batteries (one operating while the other was recharged) served as the DC power sources. Except for a few brief periods of short-circuit problems, the fence was operated continuously from the 10th week after transplant until harvest.

Records were kept on battery performance, line voltages from both power sources and under wet and dry conditions, and maintenance problems associated with the fence. Observations were made on rat activity for the first few days following electrification of the fence, and for several additional nights during the rest of the growing season. At harvest, damage appraisals were conducted in each of the plots and yields recorded.

Results

Battery life varied considerably because we had some initial problems with defective batteries. With new batteries, we operated the fence for

up to 10 days without recharge. Voltages on the fence were between 1000 and 7500 on dry days, and between 1000 and 4000 on wet days. On a few occasions, wet leaves in contact with the lines and the ground caused the fence to short-circuit. This became a more serious problem as the rice began to mature and touch the fence. In all cases, the short-circuit was easily corrected during daytime by walking fence and removing blades that touched it. In general, higher voltages were obtained from the AC than from the DC power sources.

During the first evening following electrification of the fence, there was considerable noise and activity by animals contacting it. Most of the animals seemed to be getting shocked on the lower set of wires, but some were seen to reach the upper wires before tumbling. Three of the eight sides were watched closely; on this segment, more than 30 rat contacts were seen. Based on the size and location of animals, this probably represented multiple tries by about seven individual rats. No successful crossings were seen. Additional observations were made early the next morning. Only three attempts (apparently by different rats) were seen. By the third evening, no activity was observed along the fence, and burrows located near the fence appeared to be unoccupied. Some rats that were observed coming from older rice nearby, changed direction within several meters of the fenced area and went toward the unfenced plots. Intermittent short-night observations were made during the rest of the growing season, but no activity was observed near the fence.

Damage appraisal, based on percentage of cut tillers, was conducted in each of the plots within 2 weeks of harvest. Fenced areas had 0.60% and 0.78% cut tillers, while unfenced areas had 13.6% and 13.4%. Much of the damage in the fenced areas was old and may have occurred prior to the initiation of the study. It, thus, appears that the sublethal electric barrier did provide effective protection for the fenced plots.

Discussion

Based on the results of this preliminary trial, we suggest that the sublethal electrical barrier holds the potential of reducing crop losses to rat damage. Additional studies are, of course, required and they should include measures of rat activity between fenced and unfenced plots, damage appraisal, field observation on the behavioral effect on rats, and additional data on the mechanical performance and operation of the fence.

The observation that rat activity occurred during the initial hours of operation of the fences, with virtually no pressure observed on the fence during the latter weeks of rice growth, is consistent with our

hypothesized theoretical operation of the barrier. Additional studies are needed to confirm this hypothesis, perhaps with the use of marked or radio-monitored animals. If it continues to perform well in additional trials, the present design could serve as a safer, more economical and more effective barrier than those in current use. Even more important, if additional studies verify the theoretical basis for operation of the fence, the concept might be applied to other approaches which will bring effective and economic protection into the price range affordable to the small farmer.

A prototype sublethal electric barrier designed to exclude rats from agricultural crops. In a preliminary field trial, fenced plots had much lower levels of rat damage than those left unfenced.

Preliminary Evaluations of Coulometric Field Event Recorders for Measuring Rat Activity at Bait Stations in the Philippines

Introduction

A detailed understanding of rat behavior at or near baiting points could result in new bait station designs or arrangements which improve the effectiveness of current damage reduction methods and will also assist in the development of new control systems. In previous studies, for example, we found that bait consumption could be improved considerably by simple modifications of station designs to increase available feeding surface at baiting points (Sanchez et al, 1973). In the past, our major methods for the study of rat activity at or near bait stations have included night observations with red or infrared lights, use of television monitors equipped to sense infrared, and measurement of food consumption through weigh-back methods or estimates through amounts of bait added. Although we have obtained useful information by using these methods, they have logistic constraints which limit sample sizes or sensitivity of the results.

Recent advances in electronic sensing have provided tools which may allow us to overcome some of the limitations of the current methods. One of the more promising devices which has been developed recently is the coulometric field event recorder, designed by DWRC cooperators specifically to obtain more information on rat behavior at bait stations. In preliminary trials at Denver, these recorders provided reliable measurement of the activity of penned *R. r. mindanensis* when compared with conventional laboratory methods (Kolz and Johnson, 1975). Based on these encouraging results, we began a series of laboratory and field evaluations to determine the reliability and applications of the recorders for field use in the Philippines.

Materials and Methods

A description of the coulometric event recorder has already been provided (Kolz and Johnson, 1975). It consists of a data recorder and data readout instrument. The data recorder consists of a coulometer with a silver and a gold electrode. Recording current is used to electroplate silver ions onto the gold electrode. The rate of ion migration can be made a direct function of time by using resistors to control ion flow, or directly proportional to the number of times the circuit is opened and closed by using a capacitor which stores a constant amount of current each time the circuit is closed, and causes deposition of a single quantum of silver for each closure. The cells are portable and plug into

a tube socket mounted to a bait station platform, recording current is provided by a small battery under the platform, and the circuits are opened and closed by treadles on either side of a can-shaped bait station. With this arrangement, the coulometer can be made to record the total number of visits to a bait station for a given time period and the total length of time spent at the station, although the recorder might be used in other designs for a wide range of other applications.

Field recorders are unplugged, returned to the laboratory and read with an AC-operated data readout system. This system operates by driving known amounts current at a constant rate through the time and counting circuits of the cell until the electroplated silver is depleted. Time and count are read directly from an elapsed time indicator with electrical components selected so that visits are read directly and time in tenths of minutes.

We obtained five two-treadled feeding activity monitors and twelve coulometric cells. To determine the initial condition of these units and to learn how well they would perform under Philippine conditions of high temperature and humidity, we performed a series of laboratory and field evaluations. For the trials, ten of the cells were randomly selected and randomly assigned to activity monitors. For the first laboratory test, a cell was placed in an activity monitor and each treadle was depressed fifty times (total count of one hundred for each test); the cell was then removed and read out to determine the count that was registered by the instrument. This test was repeated ten times for each cell in a completely randomized sequence. In the second test, treadles were depressed with 100-200 gram weights for five minutes each (total ten minutes per test per cell). This test was also repeated ten times for each cell in the same sequence as for the first test.

In a third laboratory test, a cell was placed in an activity monitor, then each treadle depressed either 5, 25, 50, 150, or 250 times; the cell was then removed and read out. This test was repeated twice at each count level for eight cells and four counters, again in a completely randomized design. In the fourth laboratory test, a cell was placed in an activity monitor and the treadles were depressed with 100-200 gram weights for 0.5, 2.5, 5.0, 15 and 25 minutes, then removed and read out. This test was also repeated twice at each time level for eight cells and four counters in completely randomized designs. All of the laboratory tests were conducted in a room at ambient (unairconditioned) temperature and humidity.

To gain some initial data and field experience with the monitors, we chose to use them to measure rat activity at bait stations in one of our field evaluations of sustained baiting using chronic toxicants. In this

trial, four, 1.5 hectare plots were treated with chronic toxicants following closely Masagana-99 interagency recommendations for rat control in ricefields (see Sanchez et al, 1973), while four other plots received a modified treatment in which bait stations were not adjusted according to levels of rat activity. Activity monitors were used as replacements for some of the bait stations in the plots. During the first two weeks, cells were changed daily, brought to the laboratory and read out. During the rest of the cropping season, cells were returned and read out biweekly. In addition, monitors were rotated between plots, so that weekly information was obtained on all eight plots by using four monitors and eight recording cells. Data was also collected on bait consumption at the monitors by using conventional weigh-backs. This approach was similar to that used by Kolz and Johnson (1975) in their evaluation of the counters with caged rats, only ours was carried out in the field and over a longer period of time, and contained no alternative measures of rat activity at the bait stations.

In one other field trial, two cleared cells were placed in activity monitors and observed for two nights for five hours each. Records were kept of numbers of visits to the stations and the length of time spent by rats as determined by visual observations using red lights. Cells were then returned to the laboratory and read out.

Results and Discussion

In general, cell counts and times were similar to those expected in the laboratory trials (Tables 14 and 15). Percent error for one hundred counts was always less than 5% for all of the operational cells, and was about 1% for cells in the ten-minute time trials, excluding tests with one defective cell and recorder. Even though the count errors of the monitors were quite low in our trials, they could be reduced even further by regression determinations between actual and recorded counts. As shown in Figure 8, the relationship can be expressed by a simple linear equation with high correlation ($r = +0.99$). If recorded counts were used as the independent variable and actual counts as the dependent variable, a predictive equation could be developed. Likewise, the relationship between actual and recorded time was linear and highly correlated (also $r = +0.99$).

In their caged rat studies, K[illegible] and Johnson found high correlations between time ($r = 0.84$), count [illegible] $= 0.81$), and time-count product ($r = 0.87$) and food consumption and even better correlation ($r = 0.92$) when they used multiple regression including both numbers of rat visits and total feeding time. These variables were poorly correlated, however, in our preliminary

Table 14. Expected and actual counts in laboratory evaluations of field event recorders. Fifty counts were placed on each treadle and the number recorded by the coulometric cell was determined. Cells were randomly assigned to activity monitors prior to the tests and tested in a random sequence.

Cell No.	Sample Size	Expected Counts	Mean Counts ± s.e.	Error (percentage)
1A	10	100	102.5 ± 0.4	2.5
1B	10	100	103.2 ± 0.2	3.2
2A	10	100	103.2 ± 0.2	3.2
2B*	10	100	103.3 ± 0.2	3.3
3A	9**	100	104.3 ± 0.4	4.3
3B	8**	100	102.6 ± 1.2	2.6
4A	10	100	103.9 ± 0.3	3.9
4B	10	100	104.1 ± 0.3	4.1
5A	10	100	103.3 ± 0.2	3.3
5B	10	100	102.9 ± 0.3	2.9
All Cells	87***	100	103.3 ± 0.2	3.3

* Results of a replacement cell; initial cell, used in the randomized tests, was defective.

** Results not completed because of failure of the activity monitor

*** Excludes results of the replacement cell.

Table 15. Expected and actual times in laboratory evaluations of field event recorders. Weights were placed on each treadle for five minutes and times recorded by coulometric cells were determined. Cells were randomly assigned to activity monitors prior to the tests and tested in a random sequence.

Cell No.	Sample Size	Expected Time (Min)	Mean Time (Min ± s.e.)	Error (Percentage)
IA	10	10	10.0 ± 0.01	0
IB	10	10	9.9 ± 0.01	1
2A	10	10	10.1 ± 0.03	1
2B*	10	10	10.1 ± 0.06	1
3A	9**	10	10.1 ± 0.03	1
3B	8**	10	10.1 ± 0.02	1
4A	10	10	10.1 ± 0.03	1
4B	10	10	10.0 ± 0.02	0
5A	10	10	10.1 ± 0.02	1
5B	10	10	10.1 ± 0.06	1
All cells	87***	10	10.07 ± 0.01	0.7

* Results of a replacement cell; initial one, used in randomized tests, was defective.

** Results not completed because of failure of the activity monitor.

*** Excludes results of replacement cell, 2B.

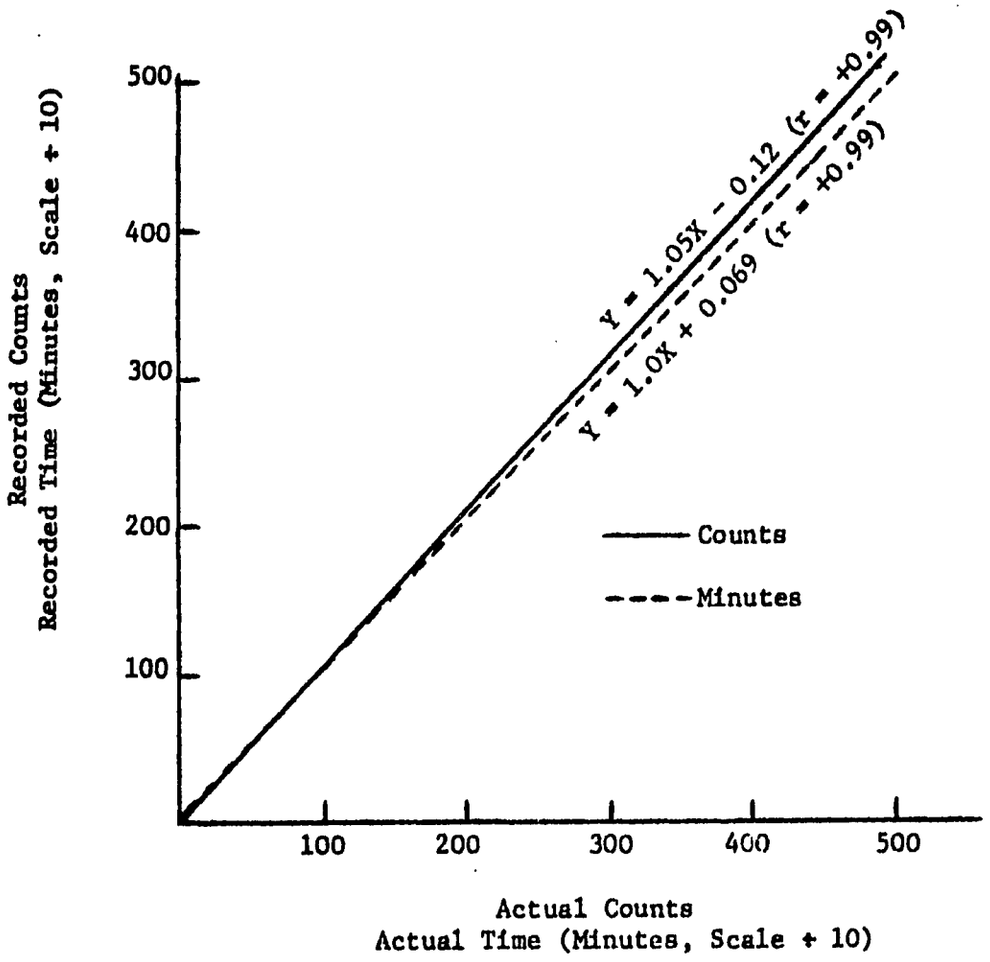


Figure 8. Laboratory evaluation of relationships between actual and recorded "time spent at" and "number of visits to" activity monitors. Times were simulated by placing weights on monitor treadles, visits by depressing treadles briefly. Five time and visit levels were used, two replicates each cell; figure summarizes data for eight cells and four activity monitors.

field studies (r = 0.44, 0.16, 0.23, time, count, time-count product versus consumption respectively) and additional work is planned to determine the most effective use of the recorders. Table 16 summarizes the results from one field plot, although data from the eight plots varied considerably.

Table 16. Results from field use of event recorders during evaluation of a sustained baiting program using chronic toxicants. In these trials, event recorders were alternated daily or twice weekly between two plots.

Week	Time in Field (Days)	Event Recordings (Mean/Day) Time (Minutes)	Counts	Time (Min) X Counts	Bait Consumption (g)
1	1	0.04	108	4.3	55
1	1	0.25	183	46	39
2	1	0.25	13	3.2	9
2	2	0.24	10	2.5	6.5
3	4	0.12	8	0.9	24
4	4	0.38	18	6.7	30
5	4	0.24	45	11	14
6	4	0.34	34	12	9
7	4	0.01	4	0.0	6

Biological and Toxicological Studies on Philippine Pest Bird Species

Introduction

Feeding behavior and damage potential of three Philippine bird pests have already been reported (Alviola et al, 1973; Benigno et al, 1975). During the past year, preliminary field evaluations on the use of methyl carbamate and fenthion as bird repellents in maturing rice were conducted, and additional toxicological studies were conducted on three weaver pest species (*Lonchura malacca*, *L. leucogaster*, and *L. punctulata*) and on *Passer montanus*. The latter species has been identified as another important pest in the ricefields and in warehouses. Studies were initiated on the reproductive and population characteristics of *L. malacca*.

Materials and Methods

Preliminary field evaluations on the effectiveness of methyl carbamate and fenthion in repelling *L. malacca* were conducted in Bongabon, Or. Mindoro in ricefields adjacent to a low-lying area of *Scirpus maritimus* which serves as an excellent roosting area for the birds. One percent sprays of each chemical were used to treat rice at the early dough stage in treated plots. No chemicals were used in reference plots. The experiment was designed as a randomized complete block with three replications, each plot measuring 10 m x 15 m. Shortly before harvest, damage appraisal was conducted by counting the missing grains on 12 randomly selected plants per plot. In addition, two random 1 m^2 areas were harvested from each plot for yield estimates.

Methyl carbamate, fenthion, and carbofuran were also tested in the laboratory for possible use as bird repellents or poisoned bait. Previous tests with these and other chemicals indicated that birds preferred to feed on definite spots in the cage. To overcome this strong position effect, a 4 x 4 latin square experiment was used with replication (trial) as row and position within the cage as column. In this way each of the chemicals and the control had equal exposure in the most preferred feeding spots. For each trial, one hundred *L. malacca* were kept in a 1.6 m x 2 m x 2 m bird cage and exposed to the treated grains for 24 hours. Seventy five grams of rice seeds were soaked overnight in solutions of 0.2% fenthion or carbofuran or in 0.5% methyl carbamate. Because of difficulties in obtaining birds, only two of the four trials required for the experimental design were actually conducted.

The acute oral toxicities of carbofuran to three Lonchura species and P. montanus were also determined as well as the toxicity of methyl carbamate and fenthion to P. montanus. Procedures for toxicity determinations have already been reported (Sanchez et al, 1974).

Population and reproductive studies on L. malacca were initiated. A representative nesting site consisting of fruit-bearing calamansi trees in Barcinaga, Or. Mindoro was visited at least once a month for observations of nest building, egg-laying, age composition, and other data. Monthly mark and recapture of birds were also started in Barcinaga and in Baco, Or. Mindoro.

Results and Discussion

In the field repellency trial, slightly more missing grains were observed in the control plots than in those treated with 1% methyl carbamate and fenthion. Yields in the treated plots (334 g/m^2 for methiocarb and 400 g/m^2 for fenthion) were slightly higher than the control (315 g/m^2). The levels of pest bird populations at the time of the study, however, were too low to permit meaningful conclusions.

Results of the repellency tests in the laboratory were very variable. In the first trial, the birds consumed 47 g of the carbofuran-treated seeds, 8 g for methyl carbamate, 6 g for fenthion and 3 g for control. In the second test, consumptions were 7 g for carbofuran, 4 g methyl carbamate, 5 g fenthion and 60 g control. In the first exposure, all birds died in less than 24 hours while in the second exposure 30 birds died after 24 hours and the rest survived. Additional studies are planned.

Monthly inspections of trees in Barcinaga Or. Mindoro revealed that L. malacca start building nests and lay eggs in early February. The species prefer to build nests in calamansi trees, especially those near cogon grasses which serve as nesting material. Both males and females aid in nest construction. Females incubate the small, whitish eggs while the males stand guard on nearby branches. No nests have been observed in the roosting area. Although 20 birds were tagged and released in Barcinaga and 78 in Baco, no recaptures have been made except within the same netting period.

Table 17. LD_{50} values (mg/kg) or methyl carbamate, fenthion and carbofuran on Philippine weavers. Figures in parenthesis are the 95% confidence limits.

Chemical	*Passer montanus*	*Lonchura punctulata*
Methyl carbamate	13.73 (8.52 - 22.12)	18.00 (4.78 - 67.89)
Fenthion	1.12 (0.80 - 1.56)	2.39 (0.14 - 3.93)
Carbofuran	0.38 (0.32 - 0.45)	0.49 (0.37 - 0.66)

TRAINING ACTIVITIES

TRAINING ACTIVITIES

Introduction

The Center has been increasingly active in training and extension within recent years. During this year, staff members provided resource lectures, laboratories or demonstrations on rodent control to over 3000 government extension personnel and key farmers from the Philippines and other countries. In addition, more than 300 visitors from many countries were briefed on the Center's activities, given technical assistance in the form of literature on rodent control, or advice in program planning. Numerous requests for technical information on rodent control were filled with Center publications or copies of appropriate material from our library.

Workshops and In-Service Training

In preparation for the launching of the Philippine Governments' intensified food production programs - Masagana 99, Masaganang Maisan, and Multiple Cropping, several short courses and specialist courses on rice and corn production were conducted at UPLB and IRRI. Two-week courses on multiple cropping were also conducted by the Department of Agronomy, UPLB. These courses were aimed at updating the knowledge of the technicians on the methods and skills in crop management practices and to present the principles of agricultural extension, farmer cooperatives, and supervised farm credit. The workshops offered opportunity for center staff members to present current information on rodent biology and control. During these lecture-discussions, emphasis was placed on mechanics and application of sustained baiting with anticoagulants. More than 1000 technicians from the Bureau of Plant Industry (BPI), Bureau of Agricultural Extension (BAEX), and other government agencies were involved.

Center staff members also presented lectures on vertebrate pest control in several one-month Supervised Farm Credit Courses involving more than 200 Philippine National Bank (PNB) and Agricultural Credit Administration (ACA) loans officers. These courses were conducted under the auspices of the Agricultural Credit and Cooperative Institute. Some staff members of the Center also presented lectures in Vertebrate Pest Management to trainers (instructors at UPLB) who teach Crop Protection Courses at UPLBCA. More than 100 students who took Crop Protection Courses visited the Center and were briefed on its current activities.

To ensure the successful launching of the National Rat Control Program for Masagana 99 and Non-Masagana 99-covered areas, one week workshops on Vertebrate Pest Management were conducted at the Rodent Research Center and in selected places in the different regions of the Philippines. Center staff members composed the main core of trainers during the workshops. More than two thousand Production Technicians of the BPI, BAEX, and Department of Agrarian Reform attended these workshops. Lectures on the principles and practices of rat control, population biology and ecology, sustained baiting program, massive rat control operations and data monitoring were presented to the participants.

International Training

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

Two trainees from Sri Lanka completed this program in 1974. Messrs. A. G. Senevirathne and Canagaratnam Wijeyaratnam arrived in July and remained at the Center for about two months, under the sponsorship of the German government.

Graduate Training

The opportunity for Master's degree work in vertebrate pest management is available through the University of the Philippines at Los Banos (UPLB). Scholarships, funded by the National Economic and Development Authority (NEDA) and developed through the cooperation of the Rodent Research Center Board are available, to provide support to qualified students. Additional support for book and research expenses is provided by the Bureau of Plant Industry. Graduate students have office space at the Center and make use of its facilities in conducting

their research; senior staff members or other university faculty members may serve as graduate advisors. Under this program, six students have completed the requirements for the M. S. degree and six others are currently involved. The three M. S. graduates who joined the research staff of the Center are currently pursuing Ph.D. degrees in pest management, one under a PCARR Graduate Fellowship, others with UPLB's reduced fee privilege. Mr. Bienvenido Estioko, another PCARR Graduate Fellow, from the Philippine Sugar Institute (PHILSUGIN), is also pursuing Ph.D. degree in pest management at the Center.

Staff Instruction at UPLB

Several Center staff members hold joint appointments with departments of the University of the Philippines at Los Banos and act as graduate advisors or instructors. During this year, staff members taught or helped teach courses in Vertebrate Pests, Mammalogy, and Wildlife Management. Some sessions were held in the classroom and laboratories at the Center, and students used equipment and facilities located at the Center to conduct individual research projects. Several classes from other Philippine colleges visited the Center for special lectures or demonstrations on vertebrate pest control.

RESEARCH UTILIZATION

In early 1975, sustained baiting with anticoagulants, a method of reducing rat damage to rice crops that includes procedures and innovations developed and tested at the Center, was included as a required practice for farmers participating in the Government of the Philippines' national rice production program, Masagana-99. This program provides non-collateral loans of up to ₱1200 (ca. US $170) per hectare for the purchase of modern farming materials, including seeds, fertilizers, and pesticides. Each farmer works under the supervision of an agricultural technician to insure that the recommended practices are followed. Loans are repaid at each harvest and new loans are made for the next crop. Under the program, participating farmers can borrow up to about ₱50 (ca. US $7) per hectare for purchase of chronic rodenticides and materials for sustained baiting. In previous years, the sustained baiting procedure was included as an optional method for participating farmers. The procedure has also been included as the major damage reduction method in the Philippine governments' national rat control program for non-Masagana-99 areas.

During 1975, implementation of the rat control aspects of these programs was initiated through massive in-service training programs of government technicians and rat control officers in current methodology, and through administrative reorganization of agencies involved with rodent control to facilitate implementation and on-going evaluation of the program. During 1976, it is anticipated that the national rat control program will be further implemented in three phases: education of farmers in current methods through technicians and extension agents; use of acute toxicants in severely infested areas to reduce population levels; and, implementation of the sustained baiting approach over wide areas to reduce rat damage to the crops.

INTERNATIONAL ACTIVITIES

Director Sanchez was named by the Food and Agriculture Organization (FAO) as an expert consultant on vertebrate pest management for Southeast Asia for a four year period. He attended a consultation held in Rome from April 7-11, 1975, entitled "Ad hoc Government Consultation on Pesticides in Agriculture and Public Health," and summarized the current status of vertebrate pest research and management in Southeast Asia. Director Sanchez was also invited to attend a rat control seminar sponsored by the Food and Fertilizer Technology Center, Asian and Pacific Council (Taipei) which was held in Tokyo, Japan, from October 20-26, 1975. At the seminar, he summarized current chemical methods for control of rats. Several staff members also attended and participated in a "Pesticide Management Seminar-Workshop" that was held in Manila from February 10-15, 1975, under the sponsorships of the University of California, USAID, and the Philippine Bureau of Plant Industry. Problems with the use of pesticides were discussed on both worldwide and national bases.

One staff member visited Nepal in March, 1975, to identify species of rodents and birds causing crop losses, to help initiate damage survey work in major crops, and to help initiate planning for a cooperative research program on vertebrate damage control.

In preliminary tests by personnel of the Nepal Department of Agriculture, it was found that methods used successfully in controlling rodent damage to field crops in Southeast Asia were not effective on the local species in Nepal. As shown in Table 18, preliminary damage surveys in mature wheat fields in the Kathmandu Valley and Terai regions showed an average damage index of 7.2% (cut stems). Since these surveys were made during the dry season and rodent populations can be expected to increase during the wet season, damage to rice and corn is probably greater. Three species of rodents (Table 19) and four species of birds (*Psittacula eupatria*, *P. krameri*, *Lonchura malacca* and *L. punctulata*) were identified as pests responsible for major agricultural losses, and preliminary observations were made on damage patterns caused by some of the species. Recommendations were presented for continuing applied and developmental research on vertebrate pest management in Nepal, and means for additional cooperative work were established.

A staff member also visited Indonesia to consult with individuals involved in a rodent control program proposed for the Luwu Integrated Development Area in South Sulawesi.

Table 18. Rodent damage in maturing wheat fields in Nepal in March, 1975.

Location	Date (1975)	Field No. and Notes	Size (m^2)	Total Stems (five m^2 quadrats)	Mean Percent Damage (field)	Mean (Percent Damage) (Location)
Godaveri (Midland Region)	5-20	1 inter-cropped with mustard	875	473	4.1	-
"	5-20	2 inter-cropped with mustard	690	598	0.9	-
"	5-20	3 inter-cropped with mustard	900	483	2.7	2.6
East edge of Bharatpur	5-25	4 plowed by tractor	1785	367	0.0	-
"	5-25	5 plowed by tractor	2400	836	59.8	-
"	5-25	6 plowed by tractor	1000	280	0.4	-
"	5-25	7	1350	449	0.5	-
"	5-25	8	900	246	1.7	12.5

Table 18 (Continued)

Location	Date (1975)	Field No. and Notes	Size (m^2)	Total Stems (five m^2 quadrats)	Mean Percent Damage (field)	Mean (Percent Damage) (Location)
Between Bharatpur and Rampur along airport road	5-25	9 Farmer has used zinc phosphide in past	1450	323	0.0	-
"	5-25	10 Farmer said sparse planting due to bird damage at sowing	1800	260	0.3	-
"	5-25	11	900	482	3.5	-
"	5-25	12	2064	733	2.4	-
"	5-25	13	1764	647	0.0	1.3
Between Bharatpur and Rampur along Narayani River Road	5-25	14	1750	648	7.6	-
"	5-25	15	2340	905	32.6	-
"	5-25	16	2320	594	10.8	-
"	5-25	17	1200	436	2.1	-
"	5-25	18 many mouse burrows observed	2800	408	0.0	10.6

Overall Mean Damage = 7.2%

Table 19. Autopsy data for rodent specimens collected in agriculture fields in Nepal.

No.	Taxonomic Designation	Sex	Weight (g)	Standard Measurements (mm)	Reproductive Condition	Date of Preparation	Location	Habitat
1	Rattus brunneus	F	140	405-215-35-20	-	31 Dec 74	Shreemahal (West Kathmandu)	Trapped in wheat field
2	Bandicota bengalensis	F	70	225-110-31-20	-	20 Jan 75	Khumultar Ag. Res. Stat.	found dead in wheat field burrow
3	Mus musculus homourus	F	15	155-73-14-14	-	2 Feb 75	Khumultar Ag. Res. Stat.	Trapped in wheat field
4	Bandicota bengalensis	NR	50	210-85-28-10?	-	1 Nov 73	Khumultar Ag. Res. Stat.	Trapped in wheat field
5	Rattus brunneus	F	NR	480-235-40-12?	Mammae: 3+3 = 12	NR	Pasapati (East Kathmandu)	Trapped in field
6	Rattus brunneus	M	228	440-232-42-26	Testes scrotal	23 Mar 75**	Khumaltar Ag. Res. Stat.	Trapped on bank near wheat field
7	Bandicota bengalensis	M	138	299-125-35-22	Testes abd; Lgth: 18 mm; Tubules vis;	23 Mar 75***	Khumultar Ag. Res. Stat.	Trapped on bank near wheat field

Table 19 (Continued)

No.	Taxonomic Designation	Sex	Weight (g)	Standard Measurements (mm)	Reproductive Condition	Date of Preparation	Location	Habitat
8	Bandicota bengalensis	M	178	306-127-34-24	Testes scrotal	25 Mar 75	Rampur Inst. (Terai Region)	Trapped in mature wheat field
9	Bandicota bengalensis	F	190	340-134-35-24	Mammae: 4+4 = 16	26 Mar 75	Bharatpur (Terai Region)	Trapped in mature wheat field

* Tentative identifications provided by Dr. J. T. Marshall, Jr., SEATO Medical Project, Bangkok, Thailand.
** Animal was livetrapped on 6 January 1975 and held in Khumaltar lab colony until preparation. Weight at capture was 250 g.
*** Animal was livetrapped on 7 March 1975 and held in Khumultar lab colony until preparation. Weight at capture was 125 g.

Based on information from previous visits and from the Government of Indonesia's (GOI's) Directorate of Agricultural Technique, it appears that rat populations fluctuate considerably throughout Indonesia; damage in South Sulawesi was higher during the 1972-1973 crop season. Two rat species, Rattus argentiventer and R. exulans, are major field pests. Both species occur in most Southeast Asian countries and have been the subject of the RRC's experimental studies. Since all of the rice had been harvested in the areas of Bone-Bone, Masamba, Mangkutana, and Wotu, field surveys for damage were not conducted. However, extensive discussions with farmers, agriculturalists, and local government officials sustained the reports that rat damage is one of the most important problems facing both established farmers and transmigrants in North Luwu. During periods of sporadic population highs (the last of which probably affected Luwu in the early 1970's) damage is reported to reach 80-100% in some areas. Based on field observations and detailed discussion with many of the persons involved in development of the proposed rat program, it was concluded that the proposed program was soundly based and would be in a situation where a small investment could significantly increase production in the area. It was recommended that the program include components for implementation, training, and on-going technicial evaluation, and that it should be carefully coordinated with and complement the GOI crop protection programs in the area. Channels for additional exchanges of information and technical assistance were also established.

THE CENTER LIBRARY

In May, 1974, the Rodent Research Center established a small, specialized library which emphasizes the acquisition of current materials on vertebrate biology, ecology, and management. The library is attended by a staff member. Permanent users are issued cards and loaned materials according to library policy. The library room is air-conditioned and has work space for persons who require only the brief use of its resources.

In its second year of operation, the library now contains 676 books and pamphlets, 59 center publications, 704 reprints, 55 periodicals with a total of 971 volumes, 76 maps and nearly 500 photographs and negatives on vertebrates and their control. In anticipation of continued growth and expanded services, the library room was renovated during 1975 to increase book and storage space and to install shelves for catalogue and cross-reference cards.

In addition to providing resource materials to local users, the library also fills request for reprints or other technical information and maintains a mailing list for the Annual Report. This year, about 102 articles and over 300 Annual Reports were mailed to scientists, extension personnel and other libraries in the Philippines and many other countries of the world.

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

SUMMARY OF ACCOMPLISHMENTS

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

2. A baiting program using anticoagulants to protect coconuts from rat damage was evaluated in Oriental Mindoro where R. r. mindanensis R. argentiventer, R. exulans, and S. murinus were found. Two, one hectare plots containing one hundred trees each received treatment while two were left untreated as reference plots. In the treated plots, a single packet of poisoned bait was placed in the fronds of twenty-five randomly selected trees each month. By the second month of treatment, rat activity and numbers of fallen nuts had dropped to negligible levels in the treated plots and remained low thereafter, while both remained high in the reference plots. Production in the treated plots increased by at least twofold from pretreatment levels while it remained about the same in the reference plots. We concluded that the procedure provided effective protection from rat damage with economically beneficial return, and that the effects of rat damage to coconut production were much treater than accounted for by dropped nuts alone.

3. A study was conducted to determine if current methods for quantifying bird damage to corn in the United States could be modified to provide a reliable means of predicting corn losses to rats in the Philippines. Ears of mature, field-dried corn were randomly selected from a cornfield in Oriental Mindoro. Ears were husked and total length and damage length measured; damage was simulated on healthy ears and the corn removed was weighed. Circular and strip type damage were defined. Regression equations for estimating weight loss from a known length of damage were highly correlated at all length categories and were similar to those developed to predict corn losses to birds in temperate countries.

4. A baiting program using anticoagulants was evaluated on six, two-hectare corn plots in an area where R. r. mindanensis, R. argentiventer, R. exulans, and S. murinus were found. Three plots were randomly selected for treatment, three as reference areas. For treatment, we employed the continuous use of chronic toxicants at four baiting points per hectare. Stations were refilled twice weekly and adjusted

according to levels of rat activity at each point. In reference plots, rat activity increased as the cropping season progressed, while it decreased rapidly in the treated plots. There was about a 94% reduction of damage in the treated plots, although damage was low (avg. 3.6% or less) in all plots. Based on these data, treatment was economically beneficial. Although yields were considerably higher in the treated than in the reference plots, we attribute major differences to factors other than rat control, particularly use of more fertilizer in the treated plots. Additional studies are needed to determine the effectiveness of this baiting procedure in situations where rat damage limits corn production.

5. In a study to determine the importance of farmer loan or commodity support for successful implementation of the sustained baiting procedure in rice, a barrio near Santa Cruz was given technical assistance as required for one growing season but only limited commodity support for the first few weeks of the season, while a reference barrio was given neither commodity nor technical assistance. Farmers in the assisted barrio followed the sustained baiting technical recommendations until commodity support was terminated, then rapidly abandoned the new technology for traditional methods. Rat activity in the assisted barrio remained lower than in the reference barrio while the sustained baiting procedure was followed, then gradually returned to reference areas levels of activity. Damage levels at harvest were similar between the two areas. From this study, it appeared that farmers of the assisted barrio required loan or commodity support in addition to technical assistance for successful implementation of the procedure. Additional studies would be required to determine the importance of these factors on a national basis.

6. Preliminary field surveys were conducted and discussions were held with sugarcane farmers and industry staff to determine the extent of rat damage to sugarcane in the Philippines. Based on conversations with growers, managers and researchers, rat-related losses are of less immediate importance than storage, reprocessing and export-related marketing problems, problems associated with milling allocations and capacities, development and implementation of improved cultural practices and the development and distribution of high-yielding varieties. Based on our own observations and the comments of some farmers, however, there is justification for rat-related research on localized bases, which should include developing means of indexing rat populations and assessing damage levels, selection of effective toxicants and delivery systems, and evaluation of hazards associated with promising control programs.

7. In the first four months of a preliminary trapping study in two marshland habitats along Laguna de Bay, only R. r. mindanensis and S. murinus were caught in the sedge community and only R. r. mindanesis in the lotus community. Adults weighed considerably more and were longer than those collected in rainfed areas in previous years. Overall trap success was about 14%, was lowest when adjacent ricefields were booting and increased sharply as adjacent fields were harvested and prepared for the next cropping season. Water levels and microhabitat composition of the sedge community also changed dramatically during the period of study and may have also contributed to changes in rat abundance and trap success.

8. In a preliminary trial of a sublethal electric barrier, four, one-quarter hectare plots containing IR-26 variety rice at about ten weeks after transplant and the likelihood of heavy rat pressure, were selected. Two plots were protected with electrified barriers, two were left unprotected. In the protected plots, most activity was observed the first few evenings after the fence was electrified, when more than thirty rat contacts were seen along three sides of the fences. Thereafter, no activity was observed during intermittent short-night observations. Fenced areas had 0.60% and 0.78% cut tillers, while unfenced areas had 13.6% and 13.4%.

9. In preliminary laboratory tests of coulometric field event recorders for measuring rat activity at bait stations, cell counts and times were similar to those expected. Percent error for one hundred counts was always less than 5% for all operational cells, and was about 1% for cell in ten-minute time trials. Count errors could be reduced even further by using regressions between actual and expected counts, which were highly correlated (r = +0.99). In preliminary field trials, however, there were no correlations between time, count, and time-count products and food consumption. Additional studies are planned.

10. Acute oral toxicities of three compounds, methyl carbamate, fenthion, and carbofuran were determined for P. montanus and L. punctulata. Fenthion was least toxic to P. montanus while methyl carbamate was least toxic to L. punctulata. Carbofuran was highly toxic to both species. Preliminary laboratory repellency results with these compounds were variable and additional trials are being planned.

11. Over 300 hundred visitors from many countries were briefed in Center activities, given technical assistance in the form of literature on rodent control, or advice on program planning. Over 250 requests for

technical information on rodent control were filled with Center publications, and others with copies of appropriate materials from bibliographic files.

12. Staff members participated in several two-week courses for more than 1000 extension workers and technicians from the Bureau of Plant Industry and Agricultural Extension as part of the Masagana-99. Masaganang Maisan, and Multiple Cropping programs at UPLB and IRRI. Center staff also presented lectures on vertebrate pest control in several, one-month courses for over 200 Philippine National Bank and Agricultural Credit loan officers. Center staff members gave lectures on rat biology and control to more than two thousand Production Technicians of BPI, BAEX, and Agrarian Reform in one week workshops for the National Rat Control Program.

13. Two research trainees from Sri Lanka spent a total of four months participating in a variety of on-going research and methods evaluation studies and worked independently on project proposals related to vertebrate pest problems in Sri Lanka.

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

15. Sustained baiting with anticoagulants was included as a required practice for farmers participating in the Government of the Philippines national rice production program, Masagana-99 and was included as the major damage reduction method in the government's national rat control program for non-Masagana-99 areas. Implementation of the rat control aspects of these programs was initiated through massive in-service training programs of government technicians and rat control officers in current methodology, and through reorganization of agencies involved with rodent control. We anticipate that implementation will proceed in three phases during 1976: education of farmers in current methods; use of acute toxicants to reduce population levels; and, implementation of the sustained baiting program for long-term damage reduction.

16. Director Sanchez was named an expert consultant on vertebrate pest problems of Southeast Asia by the FAO. He attended his first consultation in April and also summarized chemical methods of rat control at a rat control seminar in Tokyo in October.

17. In a short-term visit to Nepal in March, 1975, one staff member identified major bird and rodent pest species, initiated preliminary damage surveys, and assisted in the development of plans for continuing research programs on vertebrate damage control for the country.

18. In a short-term visit to Indonesia, one staff member assisted in determining the needs for rat control research and implementation programs for the Luwu Integrated Development Areas in South Sulawesi and evaluated currently proposed programs.

19. In its second year of operation, the library now contains 676 books and pamphlets, 59 center publications, 704 reprints, 55 periodicals with a total of 971 volumes, 76 maps and 500 photographs. The library room was renovated this year to increase book and storage space and to install shelves for catalogue and cross-reference cards.

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

Benigno, E. A. 1975. An introduction to sampling and field plot techniques for crop protection research. Rodent Research Center, College, Laguna. 37 pp. (mimeo).

Benigno, E. A., P. L. Alviola, F. F. Sanchez, M. M. Hoque and G. V. Llaguno. 1975. Damage potential of three species of the Philippine weavers (Lonchura). Kalikasan (Philippine J. Biol.) 4:141-144.

Fall, M. W. 1975. Rodents in tropical rice. Rodent Research Center, College, Laguna. 72 pp. (mimeo).

Fall, M. W. 1975. Vertebrate pests: problems and needs in Nepal. Rodent Research Center, College, Laguna. 18 pp. (mimeo).

Ferrer, L. S. 1975. Growth of Rattus rattus mindanensis Mearns. Philippine Agriculturalist. 59: (in press).

Reidinger, R. F. 1975. Biology and nutrition. Background paper in proceedings of forum entitled "Nutrition in National Development" held at the University of the Philippines at Los Banos, 6-7 January, 1975. (in press).

Reidinger, R. F. 1975. Organochlorine residues in free-tailed bats (Tadarida brasiliensis) at Eagle Creek Cave, Greenlee Co., Arizona. In Proceedings of the Fourth International Bat Research Conference, 22-30 September, 1975, Nairobi, Kenya (in press).

Sanchez, F. F. 1975. Rodents affecting food supplies in developing countries: problems and needs. FAO Plant Protection Bulletin 23(3/4): 96-102.

Sanchez, F. F. 1975. Chemical control of rodents. Presented at Rat Control Seminar, Tokyo, Japan, October 20-26, 1975, sponsored by the Food and Fertilizer Technology Center, Asian and Pacific Council, Taipei, Republic of China.

West, R. R., M. W. Fall and J. L. Libay. 1975. Reducing interactions among rats to improve bait acceptance. Philippine Agriculturalist. 59: (in press).

West, R. R., M. W. Fall and J. L. Libay. 1975. Tiller-cutting behavior of rats in growing rice. Philippine Agriculturalist. 59: (in press).

LITERATURE CITED

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

Benigno, E. A., P. L. Alviola III, F. F. Sanchez, M. M. Hoque and G. V. Llaguno. 1975. Damage potential of three species of Philippine weavers (Lonchura). Kalikasan 4:141-144.

Carangal, V. R. 1970. Corn production in the Philippines. In: National Food and Agricultural Council, 1970. The Philippines Recommends for Corn 1970-1971. pp. 4-5.

Covar, R. R. 1972. Significant findings on the fertilization of sugarcane. Philippine Sugar Institute Quarterly 18(1):3-13.

Crucillo, C. V., F. Q. Otanes and J. L. Morales. 1954. What we're doing to control rats in Cotabato, Philippine Islands. Pest Control 22(10): 9; 22(11):10.

De Grazio, J. W., J. F. Besser, J. L. Guarino, C. M. Loveless and J. L. Oldemeyer. 1969. A method for appraising blackbird damage to corn. J. Wildlife Manage. 33(4): 988-994.

Elias, D. J. and D. Valencia G. 1973. Control de roedores en el cocotero. In: ICA Informa No. 8. Instituto Colombiano Agropecuario. Bogota, Colombia. pp. 5-6, 13-14.

Everly, R. T. 1961. Effect of planting date on infestation and damage by the corn earworm. Proc. North Cent. Branch Entomol. Soc. Amer. 16:36.

Food and Agriculture Organization. 1970. Crop loss assessment methods. Food and Agriculture Organization of the United Nations. Rome. 84 pp.

Kolz, A. L. and R. E. Johnson. 1975. Coulometric field event recorder: predicting food consumption for rats. Unpublished manuscript. 16 pp.

Pancho, J. V. 1972. Aquatic angiosperms of Laguna de Bay, Luzon. Kalikasan 1:94-120.

Pancho, J. V. 1976. Philippine aquatic weeds. Kalikasan 5:37-91.

Pancho, J. V., M. R. Vega and D. L. Plucknelt. 1969. Some common weeds of the Philippines. Weed Sci. Sco. Philippines. 106 pp.

Panol, F. Y., C. N. Elevado and F. I. Ledesma. 1975. Estimating sugar loss due to rat damage on cane. Proc. Philippine Sugar Technologists, 23rd Annual Convention. (in press).

Porquez, P. H. and F. I. Ledesma. 1970. Sugar losses from cane damage by rats. Proc. Philippine Sugar Technologists, 18th Annual Convention. pp. 123-127.

Sanchez, F. F., et al. 1972. Rodent Research Center 1972 Annual Progress Report. 50 pp.

Sanchez, F. F., et al. 1973. Rodent Research Center 1973 Annual Progress Report. 94 pp.

Sanchez, F. F., et al. 1974. Rodent Research Center 1974 Annual Progress Report. 102 pp.

Stone, C. P., D. F. Mott, J. F. Besser and J. W. De Grazio. 1972. Bird damage to corn in the United States in 1970. The Wilson Bulletin 84(1): 101-105.

Stone, C. P., D. F. Mott, J. F. Besser and J. W. De Grazio. 1973. Bird damage to ripening field corn in the United States, 1971. Wildlife Leaflet 505. U. S. Dept. of Interior. 7 pp.

Villadolid, D. V. 1956. A study of Cotabato rats and their control. Araneta J. Agric. 3:1.

Woronecki, P. P., et al. 1973. Cali, Colombia Field Station 1973 Annual Progress Report. 42 pp.