The Philippines Recommends for Rodent Control

PCARRD Technical Bulletin Series No. 57

PHILIPPINE COUNCIL FOR AGRICULTURE AND RESOURCES RESEARCH AND DEVELOPMENT
National Science and Technology Authority
Los Baños, Laguna
1985

1st printing, 1985

Published through the Philippine Agriculture and Resources Research Foundation, Inc.

Foreword

Rodents are notorious agricultural pests. Their presence always causes concern since they are capable of destruction and big losses. They can damage crops from nursery to storage, largely contributing to low yields and huge post-harvest losses. Estimated crop loss due to rat damage can run into millions of pesos.

Significant findings of rodent research prompted the publication of the *Philippines Recommends for Rodent Control*. This volume summarizes basic information on rodent biology and ecology. It also recommends measures to reduce losses in major crops due to rodent attack.

The estimated net returns per hectare of rodent control is also included to give the farmers of various crops an idea of the benefits they can derive from the practice for each unit cost that they are willing to incur.

The *Philippines Recommends for Rodent Control* is published as an attempt to contain the perennial rodent problem in rice, coconut, corn, sugar, coffee and other economically vital crops.

RAMON V. VALMAYOR
Executive Director
PCARRD

Acknowledgment

The Philippine Council for Agriculture and Resources Research and Development (PCARRD) is grateful to Chancellor Emil Q. Javier of the University of the Philippines at Los Baños, Director Domingo F. Panganiban of the Bureau of Plant Industry, and Dr. Dante B. de Padua of the National Post-Harvest Institute for Research and Extension for allowing their respective staff to serve as members of the committee which drafted the *Philippines Recommends for Rodent Control.*

Acknowledgment is also due Mr. Reynaldo G. abad and Mr. Emmanuel Aterrado for providing valuable information and pictures on rodent control in coconuts, Dr. Dolores F. Hernandez of UP, the Science Education Center and Dr. Dioscoro Rabor of UP College of Forestry for allowing the reproduction of rat illustrations, Mr. Joselito A. Payot and Ms. Concepcion E. Magboo of PCARRD for their help in preparing the manuscript.

The Rodent Control Committee 1984

Pablo J. Alfonso
Asst. Professor
Department of Zoology
University of the Philippines
Los Baños, Laguna

Edwin A. Benigno
Researcher
National Crop Protection Center (NCPC)
University of the Philippines
Los Baños, Laguna

Filipinas M. Caliboso
National Postharvest Institute for Research and Extension
Taguig, Metro Manila

Lynwood Fiedler
Visiting Asst. Professor
NCPC
University of the Philippines
Los Baños, Laguna

Deiy P. Gapasin
Director, Crops Research Dept.
Philippine Council for Agriculture and Resources Research and Development (PCARRD)
Los Baños, Laguna

Melanda M. Hoque
Researcher
NCPC
University of the Philippines
Los Baños, Laguna

Priscilla P. Rubio
Senior Science Research Specialist
Crops Research Department
PCARRD
Los Baños, Laguna

Fernando F. Sanchez
Director
NCPC
University of the Philippines
Los Baños, Laguna

Jesus P. Sumangil
Chief, Plant Pest Control Division
Bureau of Plant Industry
San Andres, Metro Manila

Madeline B. Quiamco
Senior Science Research Specialist
Applied Communication Department
PCARRD
Los Baños, Laguna

Contents

List of Tables

List of Figures

Introduction

Rodents are real pests in agriculture and residential communities. They cause considerable damage to standing crops and stored products, and contaminate food and feedstuff. They damage building structures, transmit infectious diseases, and annoy people.

Losses that rodents have inflicted on agriculture has been a major concern. Rat damage in crops range from 2-50% of production. Ricefields suffered 2-6% rodent damage nationally in 1971-1975. Yield loss of 6.16% recorded in a 2-season rice farm in 1975 was estimated to value ₱721.5 M. Surveys in Negros farms also showed rat damage on 30-50% of the canes, resulting in sugar loss of 8% in 1967 or an estimated loss of about ₱13 M. Few coconut plantations are free from rats, and estimates of crop loss traceable to them vary from 14-40% from region to region.

Although nationwide estimates of rat damage are not available as yet except in rice, farmers and government field technicians are fully aware of the sizable loss rats cause on other agricultural crops. Many corn farmers realize that loss of germinating seeds and developing corn ears to rats can often be severe. Girdling, cut branches, and severe defoliation due to rat results in decreased coffee berry production. Tell-tale signs of rat damage on pineapple are gnawed tops or crowns at early fruiting stage and gnawing off of the succulent flesh from mature fruits. Cacao, cucurbits, sweet potato, cassava, papaya and other important economic plants have also been observed to sustain rat damage.

Rats attack warehouses as well. Few modern and conventional warehouses are free from rat infestation. About 12-25 cavans of stored grain are lost to rats per warehouse annually. This excludes the reduction of quality of contaminated and spilled stocks and structural damage on building structures and facilities due to continuous rat presence.

Rats are also potential carriers of human and animal diseases. A survey in Manila and suburbs in 1967-1968 showed that about 53% of the rodent species collected carried helminthic parasites and microbial pathogens. They are infested with fleas, ticks, soil mites, and biting lice which can transmit dangerous diseases such as bubonic plague, pneumonic plague, tularemia, scrub typhus, leptospirosis, salmonellosis, rickettsial pox, rabies, and capillariasis.

Rats annoy people. Infested places reek of their waste and urine. A dead rat in an unreachable or undetected area will certainly send people hunting for it. They steal or contaminate food. The noise that gnawing and active rats make at night can be annoying to home owners.

The damage, danger to health, and annoyance rodents inflict on mankind are more than enough reason to control them. Improved technology and extension of control methods to rice farmers have reduced

annual loss to rodents to less than 1% of total production. A massive and sustained control program with maximum community involvement like the "Rat Control Operation, Palagad '75" initiated in 1975 at Candaba, Pampanga can keep rodents from inflicting uncontrollable damage on crops and people.

Rodent Forms

Rats, mice, and other rodents are characterized by two pairs of sharp front teeth or incisors and a conspicuous gap between the incisors and the molars. The incisors are efficient cutting tools that enable rodents to damage man's crops and property.

At least 46 rodent forms or species have been identified in the Philippines. Rats are distinguishable by size, weight, tail length and color, fur color and texture, and number of nipples. The last characteristic is expressed in terms of a mammary formula. A 3 + 3 mammary formula means that the rodent has 3 pairs of nipples at the breast and another 3 pairs at the lower abdomen (Fig. 1).

Each form has different habits and behaviors. Their common names describe their native habitat, hence names like tree rat, house rat, ricefield rat, ship rat and others. A tree or mountain rat cannot normally thrive in cities because it is not adapted to conditions in the cities.

Only 4 of some 26 known species of *Rattus* are considered major agricultural pests (Fig. 2). The following descriptions, which include the highly commensal and annoying house mouse, are largely based on the work of Barbehenn *et al.* (1973).

Common Ricefield Rat [*Rattus rattus mindanensis* (Mearns)]
The common ricefield rat is medium-sized, with adults averaging 180 g in weight (weight range: 100-250 g). General color is cinnamon-buff with darker streaks on upper parts, light color on underparts although some individuals have darker undersides. Tail is uniformly black or dark brown and usually longer than the combined head and body length. Fur is coarse in adults (Fig. 3a).

Mammary formula: 2 + 3 = 10.

This is the species with the widest range of distribution. It is also the most destructive considering its association to all major crops. The common ricefield rat is strongly commensal in habit and is the most common species affecting grain warehouses.

Asian Ricefield Rat [*Rattus argentiventer* (Robinson & Kloss)]
The Asian ricefield rat is medium-sized but slightly smaller than *R. r. mindanensis* with adults weighing about 130 g. The general color of its upperparts are similar to *mindanensis*, but this species has a salt and pepper appearance. Underparts are usually light gray to whitish and the tail is slightly shorter than head and body length. The fur is less coarse with small orange tufts at the base of the ear. The pads on hind foot soles

are generally small and slightly raised.

Mammary formula: 3 + 3 = 12.

The species is a notorious pest of rice in Southeast Asia. Presently, its presence is restricted to Mindanao and Mindoro islands where it is the major pest of rice, being the species that constituted the major Mindanao rat outbreaks of the 1950's. Essentially a grassland form, it is not popularly associated to tree crop losses as it is a poor climber.

Polynesian Rat (*Rattus exulans* Peale)

Also known as bush rat, the Polynesian rat is markedly smaller than the ricefield rat. It weighs about 30 g. Its upper body parts are generally dark smoky gray with some off-color streaks; underparts are of a lighter color. The tail is nearly as long as head and body length. The fur is soft.

Mammary formula: 3 + 3 = 12.

The species has an island-wide distribution being closely associated to underbrushes and second-growth forests. It tends to cluster in small communities and often becomes the dominant species affecting upland rice, corn, coconut, and vegetable crops. It is a major granary pest.

Norway Rat [*Rattus norvegicus* (Berkenhout)]

The Norway rat is variously called brown rat, ship rat, or warehouse rat. It is the largest of the common rats, with adults weighing about 200-500 g. Upper parts are usually brownish while underparts are grayish. Norway rats have two color phases: brown and black. A Norway rat in the latter phase is easily mistaken for the black rat (*Rattus rattus* Linn). It is distinct from *mindanensis* by its bulk and small ears and by a shorter, heavier tail. The underpart of the tail is pale, especially at the base. The feet are large and usually all white. The fur is short, with long, thick grooved hairs. Its vibrissae (stiff hairs growing around the nostrils) are relatively long (Fig. 3b).

Mammary formula: 3 + 3 = 12.

The species is of world-wide distribution. It is considered as an urban pest, since it causes problems related to food and grain storage, health, and sanitation. The Norway rat is highly commensal in habit. It is known to have recently displaced *mindanensis* as the dominant pest of rice in several Iloilo towns. They may be found where increased commerce is established at barangay level. Norway rats are known for their fierceness and pugnacity.

House Mouse [*Mus musculus castaneus* (Warehouse)]

These are very small, weighing about 12 g. The upperparts are generally brownish and the underparts are light drab. The tail is about as long or slightly longer than head and body length. The fur is short and soft. Eyes and ears are prominent (Fig. 3c).

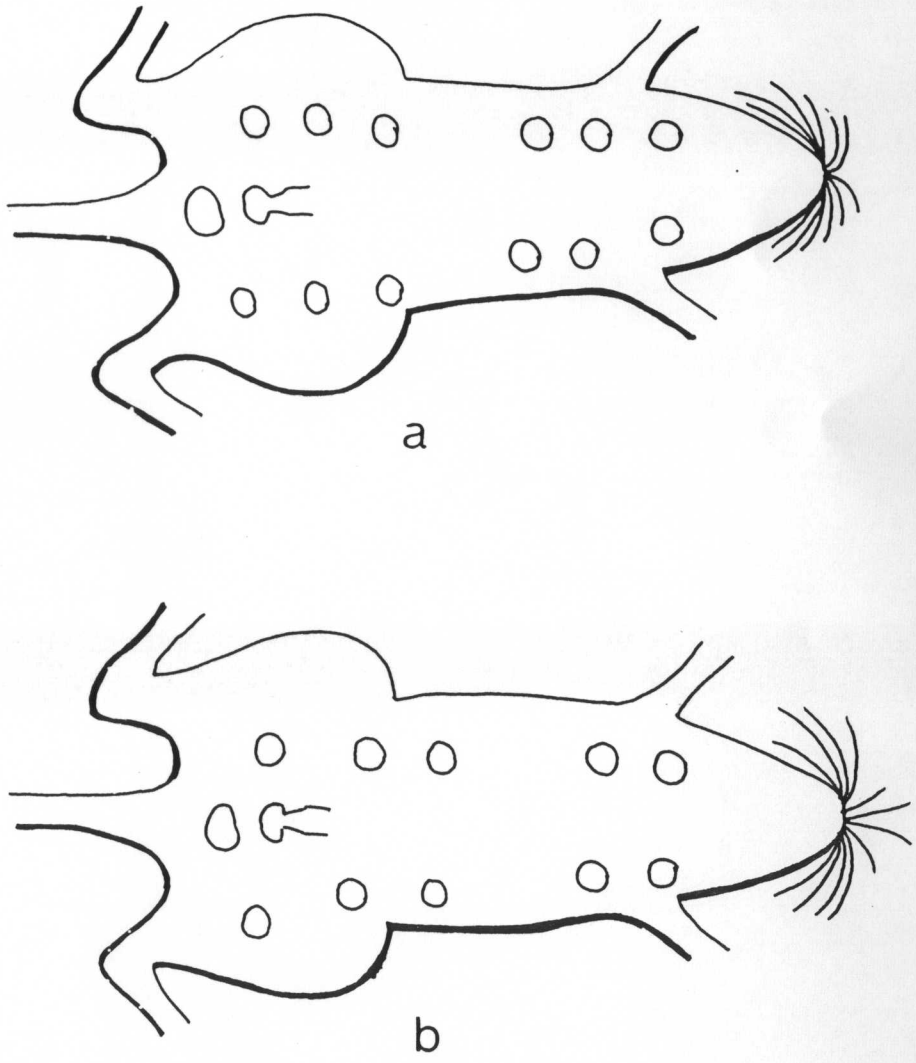

Figure 1. Illustration of mammary formula (a) 3 + 3 = 12; (b) 2 + 3 = 10

Mammary formula: 2 + 3 = 10.

The house mouse is widely distributed and highly commensal to man. It is a major pest of urban and rural homes. It often causes serious damage to structures, garments, stored foods, and grains.

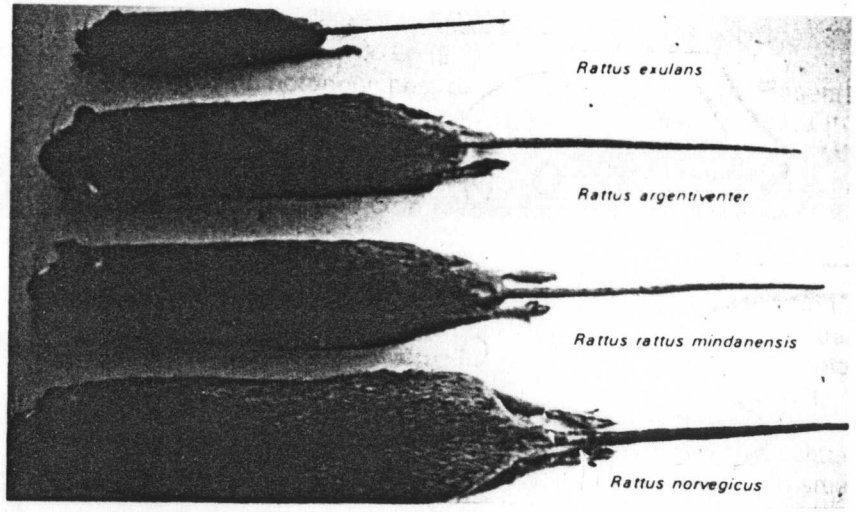

Figure 2. Some common rodent pests of agricultural crops in the Philippines

Figure 3. (a) *Rattus rattus mindanensis*

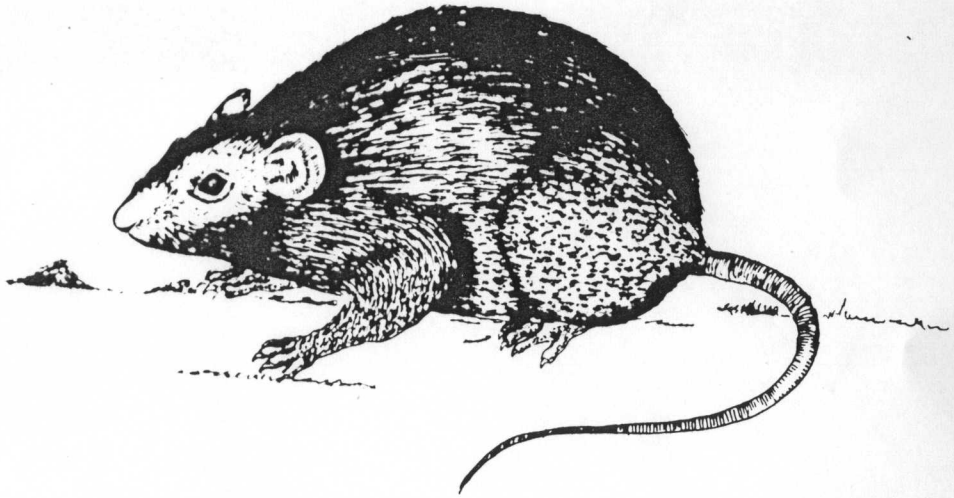

Figure 3. (b) *R. norvegicus*

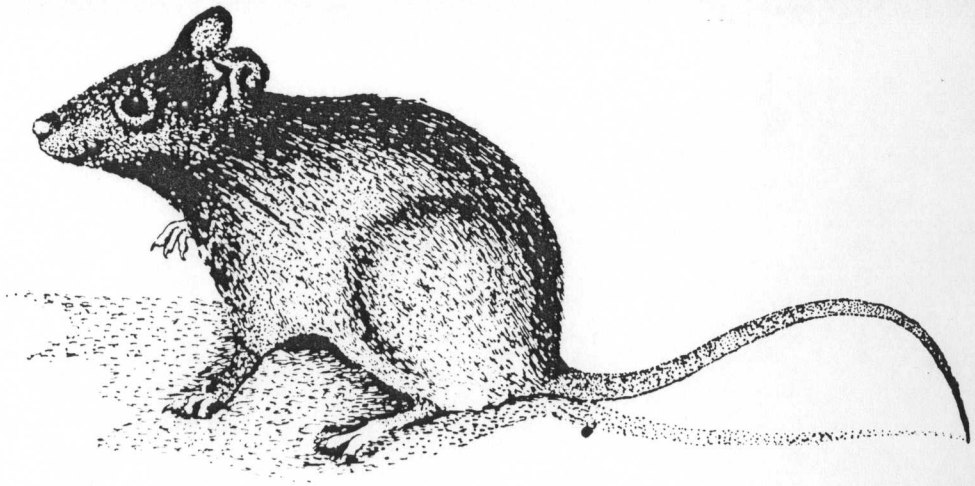

Figure 3. (c) *Mus musculus castaneus*

Population Characteristics

Many of the important problems in rat control are due to lack of correct information about the animal. One cannot effectively implement rodent control measures without knowing their natural habits and behaviors.

Life History

Rats in laboratories can live up to 3-4 years. Field rats hardly live beyond one year because of different conditions in the field. They are subjected to various mortality factors from the embryonic to the adult stage. Young rats or pups can die due to cannibalism and trampling by the parent rats. Predation and lack of available food and shelter often kill older rats.

Female rats become sexually mature at the age of 1.5-5 months. Males mature sexually in 2 months. Gestation takes 21 days, and litter size averages 8 per delivery, depending on the species. Litter size of *R. r. mindanensis* ranges from 2-11, with an average of 7. During the whole year, a female rat reproduces about 4 times, and can wean 15-32 pups per year. It is estimated that if one pair of mature rats is left undisturbed to continue normal reproduction, along with their offspring, they can produce 1,270 rats in a year. This occurrence may be very rare in nature, but it shows the potential of rats for rapid multiplication.

The pups are born blind and helpless. They depend on their mother for nutrition up to 21 days, after which they fend for themselves.

Reproduction

Rat reproduction depends on climate and food availability. In areas with evenly distributed rainfall and available food year-round, rats can reproduce any time of the year. House rats and some field rats produce a uniform population density throughout the year. In areas with distinct rainy and dry seasons and therefore a seasonal food abundance, the annual reproductive cycle of rodents reflects the local cropping pattern. In rainfed one-season crop areas, rats have a single peak of reproductive activity during the year; in irrigated two-season crop areas, 2 peaks are indicated. During these peaks, population markedly increases.

Early maturation of both sexes causes population explosion. This was observed among ricefield rat populations in Cotabato during the 1955 breeding season when rats became sexually mature at 1.5 months.

Rats in lowland irrigated areas have been found to breed more frequently, have more young per litter, and grow larger than rats in rainfed areas. Since rat populations are able to adapt to prevailing environmental conditions, it is difficult to control them. Rodent reproduction can be controlled by limiting the factors that favor it such as available food, harborage, and space. These factors are difficult to limit in the tropics. However, with increased population, social stresses occur and can result in reduced births and increased deaths or dispersal of individuals, consequently reducing the population in the area.

Social Structure and Communities

Rats form limited social structures or communities based on a hierarchy. Power and security, mainly on priority for satisfying food and sexual needs, depend on physical strength. Inspite of this inequality, individual rats have a strong instinct for "territorialism"; each member of a social group moves about in the group's small territory. The territory of a rat community may cover an area about the size of a small rice paddy or even a larger one, depending on the group size. Group members move only within this bounded area or "home range" that averages 100 m in diameter. Rats guard their territories jealously and prevent the entrance of other animals. Separate communities occupy different areas. Rats distinctly display "territorialism" during the planting season or where the environment is stable due to abundant food and shelter.

Movement and Migration

Rats tend to move only within their territorial boundaries when food and shelter are abundant. However, they may migrate to as far as 400-700 m away when food becomes scarce at harvest, or when their area is disturbed by floods, fire, or field plowing.

Immigration is the fastest way by which rodents populate crop lands. In some areas, sustained trapping and poisoning that killed 50-70% of the population failed to control rat infestation because of constant rat migration from untrapped or non-poisoned infested areas nearby (mainly wasteland). In small ricefields, the population can recover from physical removal of rats completely within 2 weeks if a rat harborage is nearby. Therefore, control measures should consider the effect of rat movement on population.

Rat migrations are erratic and non-directional. Individuals migrate until they find the right habitat. Since field rats tend to roam widely in search of food, continuous baiting may be done even when rats are not in the feeding area.

Feeding Behavior

Rats eat almost anything. Stomach examinations showed that field rats can take in dried bamboo, resins, soil, and pieces of glass. Norway rats are known to eat cereals, nuts, fruits, vegetables, invertebrate animals, fish, meat and even manure.

When food is plenty, rats become choosy and prefer grains. Thus, they concentrate where rice and corn are planted. They prefer booting and ripen-

ing rice plants and green corn. Cassava, coconut, sugarcane, and other crops are comparatively inferior items.

Rats also eat large insects, fresh-water snails, and dead fish and fowls when these are available. Occasionally, they also consume the weaker members of their group. They do not continuously take in oily foods such as coconut and shrimps. They drink water if it is available.

Young, newly weaned rats eat about 6 g of food per day; older ones consume 12.5-25 g daily.

Rats are nocturnal, doing 90% of their feeding at night. They nibble their food until they are satisfied. This feeding habit presents a problem when fast-acting poison is used on inferior baits because the rats do not eat enough amounts to kill them.

Shelter Preference

Rats prefer shelters that provide adequate food access and space and protect them from predators and heat. Thus, ricefields and succulent grasses are preferred shelters. If these are not available, rats seek shelter in adjacent grassy covers such as cogon (*Imperata cylindrica*) and talahib (*Saccharum spontaneum*) where they have access to nearby food.

Ricefield rats can live in either watery or dry areas. Thus, flooding the fields will only displace rats temporarily; it will not keep them from thriving in the area.

Burrowing Habits

Rats are excellent diggers. Burrows are constructed mainly for the delivery, shelter, and protection of the young. The pregnant rats close the main entrance of the burrow with loose soil and hide inside during the breeding season.

A typical burrow has a principal entrance with one or two well-camouflaged exits. It may vary from 0.45-1.5 m in length with curves and loops up to 0.6 m deep. The burrow is divided into food storage and delivery sections.

Abandoned burrows are not generally used by other rats, except for protection and shelter.

Control Methods

Local rodents are widespread, adaptable, and opportunistic. Since different food sources and habitats are available, complete eradication of the pest is not possible. The aim of rodent pest management is to regulate troublesome populations to a tolerable level and lessen the damage they cause.

Crop fields vary greatly and rodent populations behave differently. Thus, it may be necessary to use several methods of control to prevent or reduce crop damage. Although current rat control strategies rely heavily on rodenticides, supplementary methods will help.

Effective rat control can be done by the cooperative efforts of the community. Farmers should organize into working groups or cooperatives to fully benefit from the control measures.

Physical Methods

Physical control methods involve direct killing or exclusion by manual or mechanical means. These methods are oftentimes used, but they are costly, laborious, and may not be reliable.

DESTROYING BURROWS

Burrow systems can be dug up, flooded or flamed to force rats to come out. However, many animals remain among the plants during the day, reducing their chance of being caught in the burrows.

TRAPPING

Trapping is recommended if the area being damaged or to be protected is small and valuable such as seedbeds, and where the use of poisons pose a safety hazard such as in homes. Trap several times since the animals from surrounding areas can immigrate. The disadvantages of trapping are: (1) rats may develop an aversion to traps (trap shyness) if these are continually used; and (2) trapping is costly and laborious for larger areas.

The snap or spring trap may be used (Fig. 4). Test the strength of the spring and sensitivity of the release mechanism. The size of the trap depends on the target rats; a large trap is used for large rats and a small trap for small ones.

During the pre-trapping period, try different baits on unset traps to determine the most acceptable bait. In setting the traps, fasten baits securely to the trigger with light string, thread or fine wire to ensure that in attempting to remove the bait, the rat will spring the trap. Set the traps so that the spring will be released with slightest pressure.

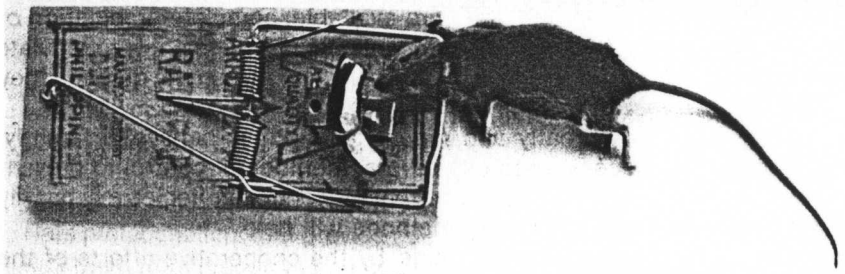

Figure 4. Trapping rat with snap trap

Place traps in protected areas where the rats are likely to wander and out of reach of children and pets. Good trapping areas are where rodent droppings, gnawings, and damage are found or where they are most likely to pass over the trigger. Change trap locations every few days.

Use one trap for every suspected rodent infesting the area. Have enough traps for the trapping period to be short and effective, and prevent other rodents from becoming trap-shy.

Keep traps clean and in good working order. Clean them with a brush, soap, and water. Check the traps everyday and dispose of dead rats immediately.

HERDING OR BLANKETING

Herding or blanketing is useful in areas where a good amount of cover is available like cogon, talahib, and also the inside areas of succulent and mixed grasses. Herding is impractical to use in growing crops but it is helpful in reducing reservoir populations between croppings, before planting or in waste areas adjacent to the crop field.

Several people are involved in herding rodents. An area of 20 x 20 m would require 12-20 people. A group armed with sharp, long-handled bolos cuts and strips around the outer edge of vegetation to isolate the animals. Another group collects all the cut grasses or branches from the side and piles them in the middle of the plot. The first group continues cutting towards the center to force the animals to seek shelter in the blanket of

grasses or branches. When the blanket is about 2 sq m in diameter, only one man is assigned to clear it. The other workers encircle the area to stop any escaping rat.

Hand tractors or other farm machineries may be used to cover larger areas in one operation. The grass blanket should be at least 4 sq m in diameter and should be thick enough to afford maximum cover. Plowing of field or cutting of tall vegetation is done in a circular manner towards the general direction of the blanket.

If there are not enough people, fences or nylon fish netting (1.3 cm sieve) may be used. Rats are driven towards a U-shaped section of the netting or fence by cutting or disturbing vegetation. Then the area is enclosed and rats are captured.

BARRIERS

Electric fences and metal sheets are some barriers used to isolate crops from rodent pests. The International Rice Research Institute (IRRI) at Los Baños, Laguna uses electric fences run by heavy duty 6-12 V battery. A well-maintained electric fence with base in water or flooded soil may be an effective rat barrier. However, on dry soil, animals readily burrow under the base. Continuous patrolling is needed to remove hanging electrocuted rats that may allow other rats to climb over, unharmed. Metal sheets for rice fields should be inserted deeply in the soil and the edges securely fastened together to prevent climbing over.

For individual coconut trees, metal or plastic band around the trunks 3 m from the ground is an effective barrier.

Chemical Method

Poison baiting is the most acceptable chemical rodent control method. Details are presented in another section (Poison Baiting).

Cultural Methods

Cultural methods including sanitation have long been recommended. Reduction of rat harborage by clearing waste areas adjacent to the field, reducing dike size and number, reducing grain wastage at harvest, and disposing of straw piles inside ricefields before planting anew can supplement other control methods effectively.

Synchronized crop planting within the same general area reduces the time that favorable food and shelter are available, distributing rats and damage evenly. A single farm planted earlier or later than the others offers food and shelter when surrounding crop fields are unattractive, and is more susceptible to severe damage. If a corn crop reaches its susceptible dough stage when adjacent rice fields are harvested, the rat population from the ricefields moves to the cornfield. Burning sugarcane fields also

abruptly moves rodent populations to adjacent crop areas. Planting time should be scheduled so that the susceptible crop stage will not coincide with the harvest of other crops nearby and the crop will not be vulnerable to potentially severe rat damage.

Other Methods

BOUNTY SYSTEM

People are given rewards or cash payments for carcasses or tails of rodents turned in. The bounty system had become so popular that beauty contests rode on this campaign. This has generally resulted in failure as pest problems continue unabated. Rat-catching activities are usually greatest after harvest when rats are still numerous and are easier to catch. Reduction of rat numbers becomes meaningless when there is no crop to protect. The rat-catching activities would be more useful if it were implemented during the period when the plants are most susceptible to damage.

ORGANIZATION

Rat infestation is a problem that can be solved with strategic organization among government agencies and farmers. The "Rat Control Operation, Palagad '75" initiated on January 3, 1975 in Candaba, Pampanga is an example of a successful managerial type of field rat control. This was a massive and sustained rat control program managed by the Ministry of Agriculture, Ministry of Local Government and Community Development, the municipal and barangay governments. Its funding came from a fee of ₱50 paid by the rice farmer for every hectare of riceland he tills.

The strategy called for a coordinated program implementation on the municipal level. The working committees were the technical, financial, and audit committees with members from the Ministry of Agriculture, Ministry of Local Government and Community Development, barangay and municipal government. Details of the operation are included in Appendix C.

Although only 1,200 ha of ricefield was planted out of the targeted area of 4,000 ha, it was estimated that the program saved ₱1 M and reduced rat damage from 22% to 2.2%. Community-wide cooperation of the farmers with the government agencies contributed to its success.

Poison Baiting

Rats are very cautious when approaching food. However, after a few safe feedings for about 5 days, they overcome their fears. Thus, pre-baiting with a non-poisonous bait before exposing an acute poison is an important step in rat control. The most acceptable bait is the regular food of the rat. A conscientious pre-baiting schedule will determine rat preferences.

Bait Containers

The bait container/station/holder is used to protect the bait from the rain, to provide a place for rats to feed, and to keep the poison from people and domestic animals. No bait holder can do all the functions at the same time for a reasonable price. Cost and rat acceptance are primary factors to consider; protection from weather, people and animals are secondary considerations.

The choice of a bait container depends on the existing conditions and availability of materials in the locality. Sections of bamboo (7.6 cm in diameter x 30 cm in length or more) with nodes at the middle or ends, tin cans, or coconut husks supported by a bamboo stick make good containers (Fig. 5). In rainy weather, use holders that afford maximum protection of bait from the weather.

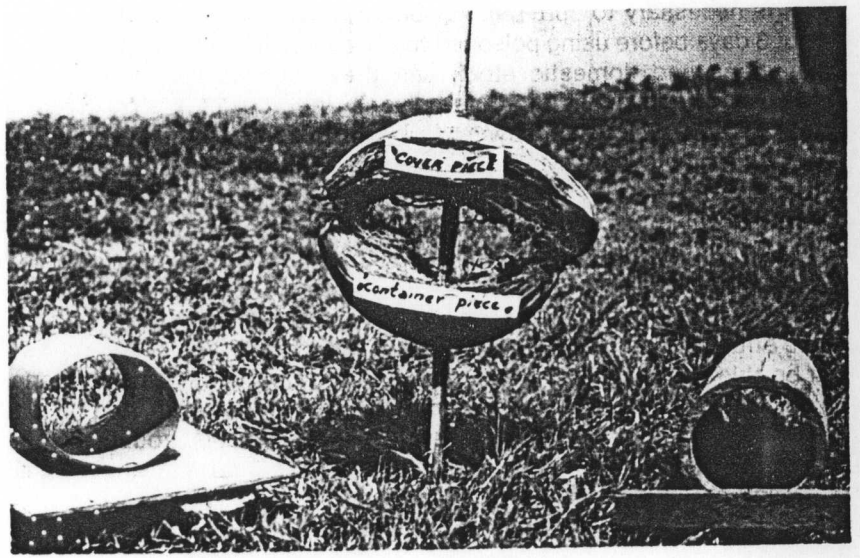

Figure 5. Types of bait holders

The size of containers depends on the condition in the area. As bait consumption decreases, use more small bait containers to make the bait available to a greater percentage of rat population within a shorter time.

Baits

Rats will eat almost anything. However, they have slight preferences for some food materials over others. Bait material must be more palatable to the rat than the protected crop. The bait should mix well with the poison, must be readily available and inexpensive, and should not easily spoil. Rice shorts, fine bran and/or corn grits meet these requirements and have been effectively used in many different field situations.

Rodenticides

Rat poisons are classified into acute or fast-acting and chronic or slow-acting poisons.

ACUTE POISONS. These rodenticides require only a single dose to be lethal. It is used when: 1) widespread infestations and rat populations should be reduced immediately; 2) there is a lack of sufficient bait and manpower; 3) adequate superior palatable food such as sprouted corn and rice is used as bait; 4) stored food is being contaminated; and 5) rat infestation poses a great disease hazard.

Some of the acute poisons are arsenous oxide, thallium sulphate, sodium fluoroacetamide, and zinc phosphide. Use of these materials except zinc phosphide is restricted in the Philippines due to toxicity hazard (Appendix D).

It is necessary to "pre-bait" or bait rats with untreated material for about 3 days before using poisoned bait. Acute poisons pose great danger to humans and domestic stock and they have no known antidotes. Moreover, effectiveness of acute poisons often declines after repeated use. The rats develop 'bait shyness' wherein more and more animals learn to associate poisoning symptoms with the bait material while eating sub-lethal doses.

CHRONIC POISONS. The available chronic rodenticides today are collectively known as 'anti-coagulants' because they prevent blood clotting. Animals develop toxic symptoms more slowly, usually over several days. The rats die of internal bleeding. The poison does not require pre-baiting to be effective and bait shyness does not become a problem as rats will not be able to associate any symptoms of poisoning with the bait material. With the first generation anti-coagulant typified by warfarin, rats have to feed for about a week on the bait before a lethal effect is produced (Table 1). Newer anti-coagulants (e.g., biodifacoum) are effective in single doses.

Many chronic toxicants are marketed in the Philippines as concentrates. Ratoxin, Racumin, Tomorin, Diphacine, and Liphadione are forms of commercial anti-coagulants (Table 1). Prices, concentrations, and package size vary considerably, but all concentrates have similar action.

Table 1. Relative cost of mixed baits using 5 commercially available anti-coagulant rodenticides and rice shorts

Brand name	Percent Active Ingredient[a]	Percent in Prepared Bait	Toxicant (g)/kg Bait	Toxicant Cost/kg Bait (₱)[b]	Rice Shorts (g)/kg Bait	Cost of Rice Shorts (₱)[c]	Total Cost/ kg Mixed Bait (₱)	Mean Bait Consumption till Death of Rat (g)	Mean Cost of Bait/ Mortality (₱)
Ratoxin	1.00	0.025 (1:39)[d]	25	0.25	975	1.95	2.20	40.8	0.10
Racumin	0.75	0.025 (1:19)	50	1.60	950	1.90	3.50	32.8	0.10
Tomorin 1.19	1.00	0.025 (1:19)	50	0.90	950	1.90	2.80	34.7	0.08
Liphadione	0.25	0.004 (1:50)	19.60 (ml)	2.30	980.4	1.96	4.26	35.6	0.17
Diphacine 110	0.10	0.0025 (1:19)	50	1.50	950	1.90	3.40	46.2	0.12

a Commonly used rates
b Based on 1981-82 Masagana 99 pricelist
c Broken rice at ₱2.00/kg
d Toxicant to rice shorts ratio

When comparing prices, choose concentrates that can be used to prepare more bait materials than others. To determine the actual cost of chemical in a finished bait, divide the retail cost of the concentrate by the quantity of bait (kg) to be treated. Read the label carefully and follow the manufacturer's instructions. All rodenticides should be colored to warn people of the poisonous content.

Poison must be rotated after one or two seasons of use to prevent build-up of resistance in rats.

When a farmer uses chronic poisons, the protective effects of baiting usually extend outside his farm up to 200 m in each direction. During the first few weeks, rats from peripheral areas will be attracted to baiting points. If neighboring fields also practice rat control, results will improve and costs are reduced.

Bait Placement

Place baiting stations in strategic spots to attract rats. Choose undisturbed spots to encourage rat feeding. Bait consumption will usually increase rapidly during the first few weeks after baiting begins. Do not be alarmed by this rapid increase. Continue to replenish the bait and consumption will generally level off or decline. If neighboring fields are also practising rat control, the increase will not be as great. When bait consumption drops sharply, this means that only a few rats remain in the field.

In areas with many rats, use enough containers to allow easy access to bait and to have bait material available to all rats occupying the field during the vulnerable crop stages. Place the containers 1 m from each other to allow a rat to feed from a container without interference from another rat.

Protect the baits from getting wet or being eaten by ants. Bait holders in rice paddies will need flotation or support with sticks to keep the bait above water. In dry land, supporting the bait holder over water keeps out the ants.

For greater bait consumption, place poison baits following an afternoon rain or shower after a series of rainless days.

Do not place baits in the field when heavy rains are expected during the night following a dry or rainless day. Where rains occur every night or day, bait daily to ensure bait consumption.

Cost and Benefits

Based on 1983 prices, it is beneficial to bait rats with poison. Table 2 summarizes the cost and benefits of sustained poison baiting in different crops. Cost includes bait, rodenticide, bait holders, accessories, tools, labor, and interest on capital (12%). With baiting, additional yield and income ranging from 5-10% can be expected. An additional per hectare income ranging from ₱147.52 to ₱3,967.52 can be derived on the crop.

Details of the cost/benefit analysis are presented in the section on Crop Specific Measures for Controlling Rat Damage.

Table 2. Summary of cost and benefits of sustained poison baiting per ha of different crops, based on 1983 prices [1]

Crop	Cost (₱)	Additional Revenue Due to Baiting			
		Harvest	Unit Cost (₱)	Total Revenue (₱)	Net Revenue (₱)
Rice	43.50	4 cav	80	320	276.50
Coconut	114.58	900 kg	1.50	1,350	1,235.42
Corn	79.46	4.4 cav	80	352	272.54
Sugarcane	124.54	5.5 picul	167	918.50	793.96
Coffee	88.17	40 kg	10	400	311.83
Sweet Potato	38.78	500 kg	1	500	461.22
Cassava	126.43	285 kg	1	285	158.57
Pineapple	99.42	1,125 pc	3.5	3,937.50	3,838.08
Ipil-ipil	218.79			375	156.21
animal feed		125 kg	1	(125)	
wood fuel		250 bunches	1	(250)	

[1] At US $1 = ₱14

Crop-Specific Measures for Controlling Rat Damage

This section provides details on the damage, rodent species, and control methods for specific crops. Cost/benefit analysis of poison baiting to protect some crops are estimated from limited experiments.

Rice

DAMAGE

Rats may cause crop damage at any stage, from seedbed to post-harvest storage. They may cut or uproot newly transplanted seedlings. They cut developing (6-12 weeks after transplanting) tillers near the base usually in a 45° angle (Fig. 6). After the panicles mature, feeding shifts to the grains.

Minor or moderate rat damage on a standing rice crop is not readily visible unless the plants are examined closely. Heavy damage of more than 15-20% cut tillers can be readily seen from a distance, often as a central eaten-out area of the paddy. Damage to the wet-season crop is generally higher.

Figure 6. Rat damage to rice

SPECIES INVOLVED

R. r. mindanensis causes heavy damage to rice. However, *R. exulans, R. argentiventer,* and *R. norvegicus* have also been observed, the latter in ricefields near structures or urban dwellings.

CONTROL METHODS

PHYSICAL. Digging up or flooding burrows, trapping, "blanketing" or herding, scare devices, and barriers such as fences may be effective against small-scale infestation.

CULTURAL. Synchronize planting with adjacent fields so that rice crops in an area will be of approximately the same age and will be harvested at the same time. Rice areas with crops at varying stages provide rats with continuous shelter and food, leading to rapid reproduction and increased rodent populations.

Remove weeds within or adjacent to ricefields.

DESTROYING BURROWS. Fumigating, burning/flaming or flooding burrows is effective if the rats are in the burrows. Evidence on the effectiveness of this method is not available.

POISON BAITING. The sustained baiting method given below has been extensively tested and is recommended:

1. Prepare poisoned bait using shorts (*binlid*) or whole rice. Mix the bait material with available anti-coagulant rodenticide such as Ratoxin, Racumin, etc. following the instructions on the label.
2. Select 5 baiting locations for every hectare of riceland to be protected. For fields less than 1 ha in area, choose at least 4 sites. Locate the sites at least 50 m apart on or along dikes, dike intersections, canal banks or old threshing mounds.
3. Start baiting as soon as rice seedlings are transplanted into the field. Do not delay for more than 1 month. In each location, place 1 bait holder containing 30-50 g bait material.
4. After 3 days, check all bait holders. If all the baits were eaten up at one location, add two more bait holders with 30-50 g bait material.
5. Check all bait holders again in 3-4 days. If all the baits were taken, place 3 more in the same location, maintaining the 30-50 g bait material in each.
6. Continue checking the bait holders twice a week. Increase the amount of bait in each holder (Fig. 7) where rats continue to consume most of the baits. Anticipate increases in bait consumption and see to it that some left-over remains in the holder. It is important that bait is provided when necessary. If bait is not available when rats come to the bait holders, they may feed on plants nearby.
7. Replace bait material that is moldy or excessively wet.
8. When bait consumption begins to decline in some locations,

Figure 7. Baiting in ricefields

remove some bait holders. Leave at least one bait holder in each of the 5 locations until consumption stops during the mature crop stage. However, if consumption remains high, maintain sufficient bait up to harvest time.

COST/BENEFITS

Baiting is an efficient rat control method. Sustained baiting has no fixed costs, since inputs are based totally on consumption of bait materials. Baiting high rat populations will cost more, but will result in much higher grain yields than if no rat control or less efficient methods are used.

Two levels of rat population and damage are compared in Table 3. Without the rat control, a high rat population has potential for 25% yield loss, while a low rat population can potentially cause a 5% loss. Both assumptions are conservatively based on actual field data. An additional net income of ₱276.50-₱1,449.00/ha can be derived from baiting.

Coconut

DAMAGE

Rodent damage in coconut plantations readily appears as gnawed holes on fallen green immature nuts (Fig. 8). Five-month-old nuts are most often damaged, although all 3-8 month-old nuts or those between the button- and shell-hardening stages are susceptible. Rats often gnaw holes near the point of attachment. This indicates the rats' easy access to the basal end of the nuts as they climb on or close to the bunches.

Table 3. Cost and return of sustained baiting in a 1 ha ricefield

Item	Unit cost (₱)	High Population[1]		Low Population[1]	
		Quantity	Total Cost (₱)	Quantity	Total Cost (₱)
Materials					
Bait holders	0.20	45 pc	9.00	15 pc	3.00
Bait	2.00	32 kg	64.00	6 kg	12.00
Rodenticide	15.00	2 kg	30.00	0.3 kg	4.50
Labor	2.00	24 hr	48.00	12 hr	24.00
Total			151.00		43.50
Normal harvest without baiting	80.00	80 cav	6,400.00	80 cav	6,400.00
Additional harvest with baiting	80.00	20 cav	1,600.00	4 cav	320.00
Net income			1,449.00		276.50

[1]High rat population means 25% yield loss, low rat population means 5% yield loss.

Figure 8. Rat damage to coconuts

Estimates of rat damage to coconut have ranged from 2-23% and few plantations are without any damage. Applying the lower estimate at 6 nuts/tree per year to 270 M nut-bearing palms in the Philippines, we derive a total nut loss of 1.62 billion per year. At a value of 30 centavos per nut, annual loss would be ₱486 M.

Rats can also damage young coconut plantings. They gnaw at the fronds and base when the pseudostem is still soft. This usually results in death of the seedling.

Tall coconut palms tend to have less rat damage than short palms. Closeness to the ground probably increases the rat damage potential, so that dwarf varieties may be more susceptible unless they prove to be less preferred by rats. Rats in the Philippines tend to visit the crown nocturnally to feed on developing nuts, then return to the ground during the day. Some are crown dwellers.

SPECIES INVOLVED

Although many rat species have been caught by traps in and around coconut plantations, *R. r. mindanensis* is the primary coconut pest. It is a good climber and is capable of inflicting severe damage. *R. exulans* is not as frequently present nor as widely distributed in coconut plantations as *R. r. mindanensis*. *R. argentiventer* is a poor climber and if present in the plantation, it probably does not climb coconut palms.

CONTROL METHODS

Three methods of controlling rats in coconut plantations have been field tested: crown baiting, ground baiting, and banding. The easiest and most cost-effective method is crown baiting. However, coconut growers still use the more traditional methods: banding and ground baiting.

Each method has disadvantages. Crown baiting and banding may not protect other crops in the coconut grove. Ground baiting costs more time and money since most other rats feed on the bait material along with the few that are damaging the coconut. Ground baiting also takes longer time to reduce the damage to low levels. Banding requires a high initial cost, and does not appeal to most farmers.

Bait at crowns in pure coconut stands. Combine crown and ground baiting in intercropped coconut; crown-bait once a month and ground-bait when the second crop becomes vulnerable. Use the specific recommendations for baiting in the second crop if these are presented in other sections of this bulletin.

Procedures

CROWN BAITING

1. Mark or identify one palm for every 10 palms in a plantation. The marked palms should be evenly distributed.
2. Assign one small plastic bag per marked palm. Place 150 g of anti-coagulant rodenticide bait in each bag. Tie each bag shut and poke a small hole in it near the top.
3. Place a bag in the center of the crown of each marked palm. Using a climber, a plain bamboo pole (Fig. 9) or a modified harvesting pole (*halabas*), position the bag in the basal groove of a middle frond, usually the third from the bottom.
4. Repeat the procedure every month.

Figure 9. A packet of bait is placed in the coconut crown with the aid of a bamboo pole.

GROUND BAITING

1. Distribute evenly 20 bait holders per ha to include border areas harboring rats.
2. Place up to 100 g of bait material in each bait holder (Fig. 10).
3. Check and replenish consumed bait material as frequently as possible.
4. Do not bait when Japanese snails (*Achatina fulica*) abound. They consume the baits without being affected by the poison.

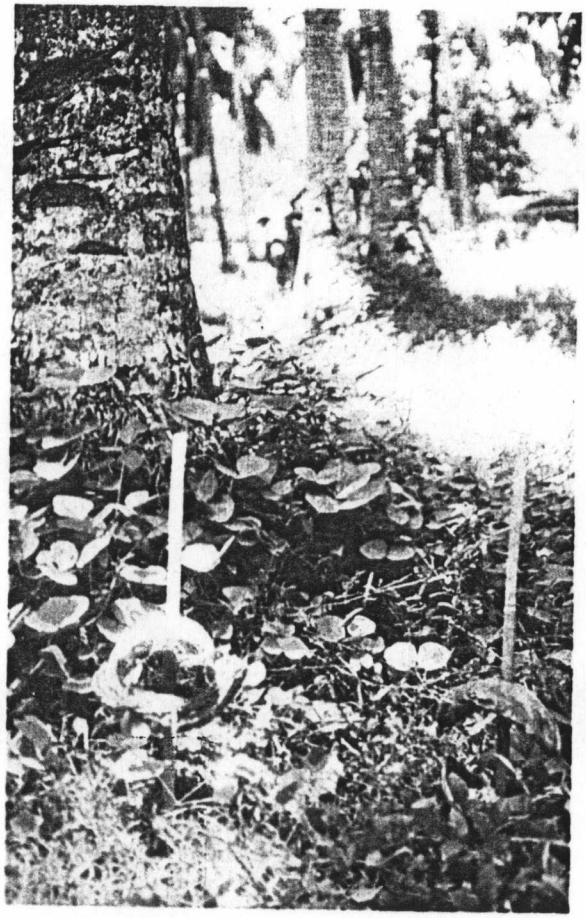

Figure 10. Ground baiting in coconut.

BANDING

1. Cut metal (preferably aluminum) or plastic sheets into 30-40 cm wide strips.
2. Wrap the strip around the trunk of each tree in the plantation about 3 m from the ground (Fig. 11).
3. Trim overlapping fronds of adjacent palms and older fronds that bridge the banded area regularly. Remove vines or other plant growth that may be used as ladders or bridges by rats attempting to enter the coconut crown.
4. Repair any detached or loose band immediately. Replace missing or rusty bands.
5. Do not band short palms. For good banding, the palms should be 10 m or more.

Figure 11. wide metal strip (30-40 cm) is wrapped and nailed around the tree 3 m from the ground.

COST/BENEFITS

The costs of the three control methods are compared in Table 4. Although actual benefits may vary, the net revenues are considered the same for this example so that costs over a 5-year period can be compared. Table 5 shows that crown baiting is the least expensive method and has consistently resulted in the doubling of harvested nuts in field trials.

Banding costs will depend on materials used. In the example given, galvanized iron is considered since it is the material most often used. Aluminum would last longer but is initially more expensive. Plastic may be cheaper to use depending on the source; it will last a very long time with little maintenance.

The cost/benefit ratio of ground baiting improves when a second crop such as pineapple is included in the computation since the benefits would come from two crops. However, an even better cost/benefit ratio would result if a combination of crown and ground baiting is used in a suitable intercropped situation involving a second crop that is vulnerable to rat damage.

Table 4. Annual cost and return comparison of three rodent control methods used in 1 ha coconut plantation with 100 trees

Item	Quantity	Unit Cost (₱)	Total Cost Per Crown Baiting (₱)	Control Method Ground Baiting	Banding[1]
Materials					
Galvanized iron					
3 m x 0.9 m sheets	14 pc	32	—	—	89.60
Nails, 3.8 cm	2 kg	7.5	—	—	3.00
Bait	71 kg	2	36.00	106.00	—
Rodenticide	3.55 kg	15	13.50	39.75	—
Bait holders	100 pc	0.20	—	20.00	—
Plastic bag	120 pc	0.02	2.40	—	—
Bamboo pole[1]	1 pc	12.00	2.40	—	—
Sub-Total			54.30	165.75	92.60
Labor					
Installation of materials		2.00/hr	—	16.00	11.20
Removing vegetation		2.00/hr	—	—	48.00
Maintenance		2.00/hr	48.00	224.00	68.80
Sub-Total			48.00	240.00	128.00
Interest on loan (12%)			12.28	48.69	26.47
Total Cost			114.58	454.44	247.07
Gross Income[2]	900 kg	1.50	1,350.00	1,350.00	1,350.00
Net Income[3]			1,235.42	895.56	1,102.93

[1]Costs are pro-rated for five years
[2]Theoretical income based on increased harvest of 3 nuts/palm/month where 4 nuts equal 1 kg copra
[3]Gross income — Total cost

Corn

DAMAGE

Rats begin to feed on corn when ears are formed and continue the damage until the corn matures. They chew through the ear husk and feed on the developing kernels (Fig. 12). Damage on individual ears may extend from

Figure 12. Rat damage to corn ears.

the tip toward the base, and may be of the circular or strip type. The circular type has missing kernels around the cob whereas the strip type has missing kerneis along one side of the cob.

Damage patterns in cornfields tend to be peripheral and clumped; that is, more damaged ears are found in the outer corn rows than in the inner ones. Occasionally, large rat damage may be found in the middle of the field.

Rats may be a problem at seeding time when they feed on germinating seeds. Subsequently, bacteria and fungi may invade rat-damaged ears and result in additional yield loss.

SPECIES INVOLVED

Damage to corn ears is inflicted by *R. r. mindanensis, R. argentiventer,* and *R. exulans.*

CONTROL METHODS

Baiting has been the only field tested method that has been successful in controlling rats on cornfields. A baiting schedule in corn areas is a modification of the sustained baiting method used in rice areas. Unlike rice, corn is not susceptible to rat damage until the later crop stages — during ear formation and maturation. For this reason, baiting need not begin until a few weeks before ear formation, which is about 40 days after seeding. Weedy fields tend to have more rat-damaged ears than those without weeds. Good weed control decreases rat damage potential.

Practical pathways have to be provided in wide corn field areas for ease of baiting and other pest control operations.

Where baiting around the periphery of the corn field is useful, the following baiting schedule is recommended:

1. Forty days after seeding, place 8 bait holders around the periphery of the corn field within the first 5 rows (Fig. 13).
2. Place 50 g of bait per holder. Prepare poisoned bait using rice shorts, whole rice, corn grits or other suitable baits. Follow directions on the label of rodenticide to be used, e.g., Ratoxin, Racumin, Tomorin.
3. Check bait holders at least once per week to replace missing or moldy bait.
4. If bait consumption is high at any one point, increase the number of bait holders following the procedure given for sustained baiting in rice areas.

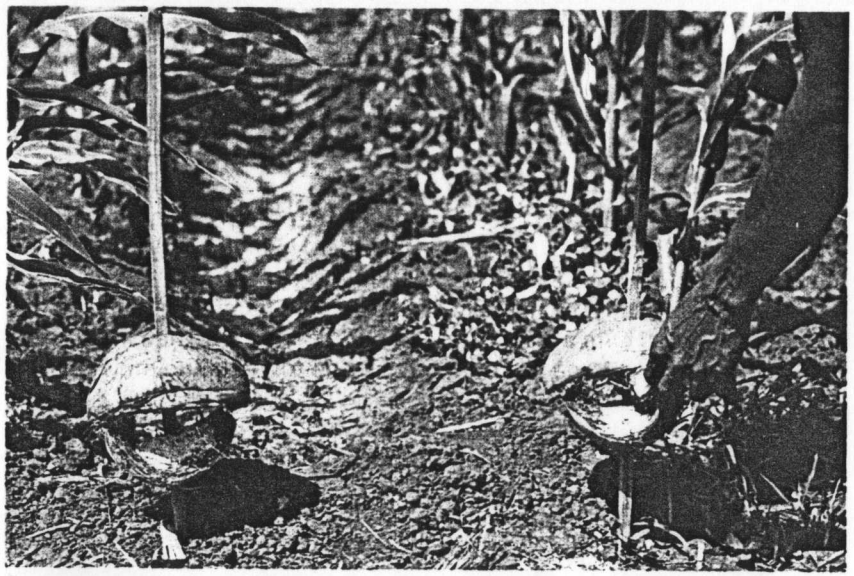

Figure 13. Baiting in cornfields

COST/BENEFITS

Baiting involves expenses for baits, containers, rodenticide, labor, and loan interest. Benefits will vary depending on the rat damage potential of the area. In the example in Table 5, damage in untreated plots average 5.5%. Thus, rodent control would result in an additional yield of 4.4 cav (220 kg)/ha of corn.

Table 5. Cost and return of rodent control per ha of cornfield

Item	Quantity	Unit Cost (₱)	Amount (₱)
Materials			
Bait	10.75 kg	2.00	21.50
Bait containers	40 pc	0.20	8.00
Rodenticide	0.43 kg	15.00	6.45
Sub-Total			35.95
Labor	17.5 hr	2.00	35.00
Interest on loan (12%)			8.51
Sub Total			43.51
Total			79.46
Gross additional income	4.4 cav	80.00	352.00
Net income			272.54

Sugarcane

DAMAGE

Rats damage sugarcane by gnawing portions of the stalk internodes (Fig. 14). This direct damage may result in secondary losses like fallen cane stalks, fermentation from microbial invasions, and evaporation. These lead to gradual decay and finally, total sugar loss at the mill site.

Rat damage may be minor, or may be responsible for a total loss. Rodents have been observed to prefer sugarcane varieties that have a softer rind, higher sucrose content, greater lodging, and a lower fiber content.

Rodents damage cane as far as 100 m into a canefield, with the lowest damage occurring within the first 10 m. Damaged stalks can be as high as 30% in some fields. However, the average is much less, about 7%, which is equivalent to more than 2% total sugar loss.

SPECIES INVOLVED

The primary rodent pests in sugarcane fields are *R. r. mindanensis, R. exulans, R. norvegicus,* and *R. argentiventer.*

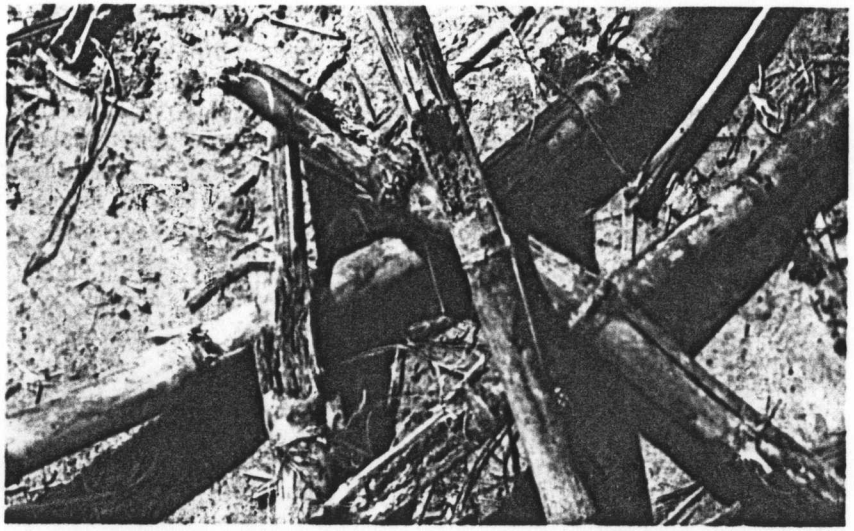

Figure 14. Sugarcane damaged by rats at about seven months after planting

CONTROL METHODS

SANITATION. Clear the field to prevent early and frequent rat migration as well as to reduce their number. A weed-free environment offers limited food sources and cover and thus reduces attractiveness as habitat to rats.

PHYSICAL METHOD. Dig up and excavate burrows to deprive rats of breeding places and prevent their re-use.

Snap traps may also be used. Use as many traps as possible. Attach baits securely to the trigger.

RESISTANT VARIETIES. When offered a choice, rats least prefer some sugarcane varieties such as Phil. 6559, Phil. 6553, Phil. 6421, Phil. 6019, and Phil. 6111. It may be possible to plant these rodent-resistant varieties in areas subjected to annual severe rat damage. Avoid lodging varieties since they are more susceptible to rat damage.

UNIFORM PLANTING DATES. Schedule planting dates close together within an area. Rats move from harvested canefields to standing crops, so it is advisable to have simultaneous planting dates so that harvesting will be about the same time.

POISON BAITING. In planning a baiting program, consider the fact that rat damage occurs well within the field and that damage is not seen unless frequent field inspection for damage is done. Perimeter baiting or placing baits along the field borders before any damage occurs may deter rats from entering the fields and reduce rat damage.

Aerial broadcast may be feasible if an appropriate poisoned bait material can be developed for interior baiting. However, this is doubtful, because poison compounds for this purpose are fast-acting.

Baiting programs are unnecessary during harvest. The natural biological factors of reduced shelter, water (during dry season harvest), food (provided other susceptible crops are not available), and predation for the rats may be more cost-effective than baiting.

The effectiveness of any baiting program has not been evaluated yet. Thus, the recommendations made here are considered preliminary and subject to field testing.

Recommendations are given for baiting in a 1 ha field since about 55% of farms are less than 6 ha in area.

1. Five months before harvest, place 16 bait holders 25 m apart close to the field edge.
2. Place 50 g of bait into each container. Victorias Milling Company (VMC) in Negros uses 25-g plastic packets filled with an anti-coagulant rodenticide mixed with corn bran moistened with vegetable oil and sweetened with 0.5 g sugar. The sausage-like packets are distributed at the rate of 50-100 packets/ha. They are laid on the ground 5 m from field edges. Permanent baiting points are established a few days later where packets are found consumed. Unconsumed baits and new packets are then placed on these points to maintain an excess of bait.
3. Check and replenish bait twice a week. If consumption is very low, reduce the number of holders to 8. If consumption is high at any location, place more bait holders.
4. Once every two weeks, check the interior of the field for rat damage. If such damage has occurred, add 2-4 bait holders, each with 50 g of bait (Fig. 15).
5. Continue checking bait holders once a week until consumption ceases or harvest time draws near.

Burning or harvesting adjacent cane fields will drive rats very quickly into a baited field. Any baiting program may be overwhelmed by this temporary surge of rats. To avoid potential control problems, encourage operators of adjacent farms to control rats. When such rat invasion does occur, anticipate increased bait consumption and the need for more bait holders. Be ready with bait material and extra bait holders for quick replenishment.

COST/BENEFIT

Table 6 compares the estimated cost/benefit of the present recommendation and the VMC rat control method. Since neither method has been evaluated, each method is assumed to reduce losses equal to 5% of the yield. The figure is twice the mean total sugar loss of sampled fields in Negros and approximates the material input levels for an above-normal rodent population.

Figure 15. Start baiting seven months after planting sugarcane. Continue baiting until harvest

Table 6. Comparison between cost and return of preliminary recommendation and VMC rat control methods used on 1 ha heavily infested canefield, assuming a 4-month baiting program

Item	Quantity	Unit Cost (₱)	Preliminary Recommendation	VMC Practice
Material				
Bait	12.8 kg	2.00	25.60	—
Rodenticide	0.64 kg	15.00	9.60	—
Bait packets (with rodenticide bait mixture)	400 pc	0.15	—	60.00
Bait holders	40 pc	0.20	8.00	—
Sub-Total			43.20	60.00
Labor				
Initial		2.00	8.00	12.00
Maintenance	30	2.00	60.00	60.00
Sub-Total			68.00	72.00
Interest on loan (12%)			13.34	15.84
Total Cost			124.54	147.84
Gross additional income	5.5 piculs	167.00	918.50	918.50
Net Income			793.96	770.66

Coffee

DAMAGE

Rodent damage to coffee plants begins at the flowering stage when new growth also appears. Flowering and new growth occur any time between October and February, depending on climate and geography. The rats cut, strip or hollow out terminal branches, resulting in severe defoliation after a few weeks. Consequent losses in berry or bean yields are incurred at harvest the following year. Robusta coffee growers in Northern Luzon, Mindoro, Mindanao, and in Cavite have reported rodent damage in their plantations. Little or no rat damage has been reported from arabica coffee areas.

SPECIES INVOLVED

R. r. mindanensis, R. exulans, and *R. everetti* attack coffee.

CONTROL

In a limited field trial, rat damage to coffee was minimized by baiting with anti-coagulant rodenticides in rice shorts or whole rice. Damaged branches were reduced and bean yields increased.

The procedure used is outlined below:

1. In each hectare of plantation, select coffee trees to be protected.
2. Place two bait holders on each selected tree prior to the emergence of new growth. Coconut husk bait holders may be tied to the upper trunk of the coffee plant and/or to its major branches (Fig. 16).

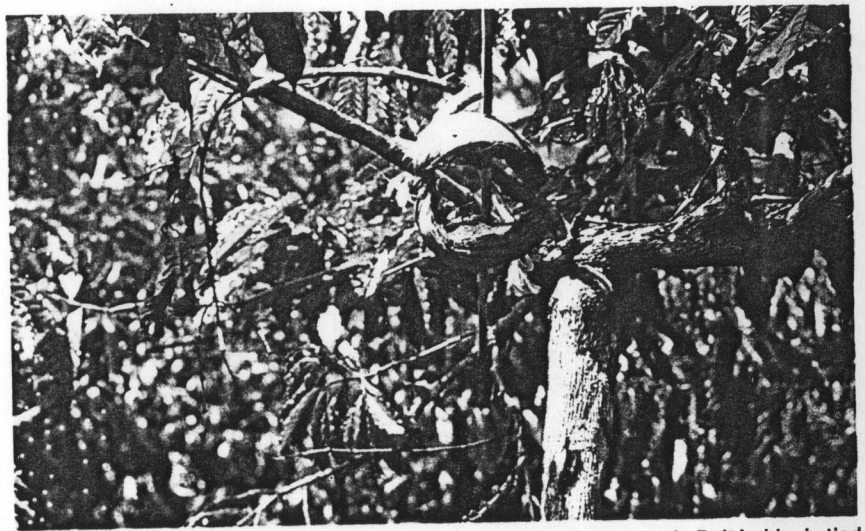

Figure 16. Baiting in coffee starts before the emergence of new growth. Bait holder is tied to the trunk of the tree

3. Pour about 50 g mixed bait into each bait holder, and check weekly to replace consumed or spoiled bait.
4. Continue this baiting schedule until bait consumption ceases and new growth has matured. Baiting may last 3 months or more.

Ground baiting may be possible in coffee plantations. Wait until damage occurs before baiting to lower cost and improve the cost/benefit ratio.

COST/BENEFIT

Labor is the most costly input for rat control in coffee (Table 7). Three months of baiting (October-December) can double the harvest.

Controlling rat damage in a hectare of coffee plantation may result in an additional net income of ₱311.83.

Table 7. Cost and return of rodent control on 1 ha (600 trees) coffee plantation in Kiangan, Ifugao

Item	Quantity	Unit Cost (₱)	Amount (₱)
Materials			
Bait	9.6 kg	2.00	₱ 19.20
Rodenticide	0.48 kg	15.00	7.20
Bait holders	16 pc	0.20	3.20
Sub-Total			₱ 29.60
Labor			
Bait holder	4 hr	2.00	8.00
Maintenance	24 hr	2.00	48.00
Sub-Total			56.00
Interest on loan (3%)			2.57
Total			88.17
Gross additional income	40 kg	10.00	400.00
Net Income			₱ 311.83

Root Crops (Sweet Potato, Cassava, White Potato)

DAMAGE

Root crops like cassava, white potato and sweet potato are vulnerable to rodent damage when the tubers start to develop. Rats dig the soil around the stems to reach the tubers. Growers may not easily notice the digging activity inside the field especially when plant cover is thick, as in sweet potato.

SPECIES INVOLVED

Since root crops are grown in upland areas, it is possible that not only *R. r. mindanensis, R. exulans,* or *R. argentiventer* may be involved. Other unusual rodents that are only occasionally encountered as pests may also damage root crops.

CONTROL METHODS

1. When tubers begin to form, choose 5 baiting points per ha about 50 m apart. If it is difficult to maintain baiting points in the middle of the field; baiting points may be set up near the field corners and along the sides.
2. Place 50 g of bait in each bait holder at the selected baiting locations.
3. Inspect the bait location as frequently as possible and replenish or replace bait when needed.
4. If bait consumption is high, increase the number of bait holders at that location so that surplus bait is present at each weekly check (Fig. 17).

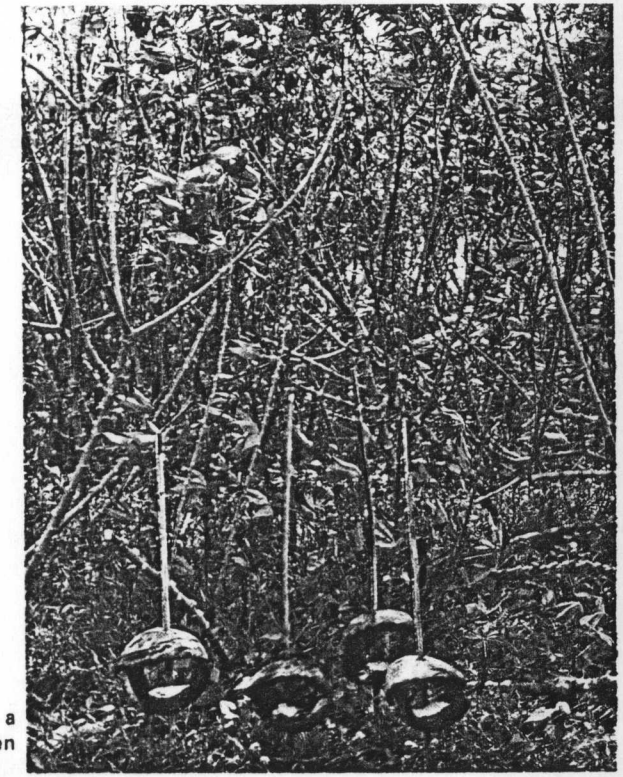

Figure 17. Baiting on a cassava field when tubers are mature

5. Bait consumption may increase during the first 4-6 weeks of baiting. When consumption begins to decline, remove some of the extra bait holders at each station. Increased consumption of bait will mean that new rats have entered the area and increased bait and/or bait holders may again be necessary.
6. Continue adjusting the number of bait holders and bait depending on consumption until tubers are harvested.

COST/BENEFIT

Rodent control in two root crops are compared in Table 8. Cost of controlling rodent damage in cassava is more than three times that of sweet potato because the period when cassava is vulnerable to rat damage is 28 weeks, while sweet potato is vulnerable for only 7 weeks. The per hectare yield difference between the crops also contributes greatly to cost/benefit differences. Sweet potato is very attractive to rats and up to 40% damage to some fields has been reported. Thus, to use these rat control methods appears to be very desirable.

Table 8. Cost and return of rodent control per hectare of sweet potato and cassava fields

Item	Unit Cost (₱)	Sweet Potato Quantity	Sweet Potato Total Cost (₱)	Cassava Quantity	Cassava Total Cost (₱)
Materials					
Bait	2.00	5.3 kg	10.60	21 kg	42.00
Rodenticide	15.00	0.27 kg	4.05	1.05 kg	15.75
Bait holders	0.20	15 pc	3.00	15 pc	3.00
Sub-Total			17.65		60.75
Labor (₱2/hr)					
Placement	2.00	4 hr	8.00	4 hr	8.00
Maintenance	2.00	6 hr	12.00	27 hr	54.00
Sub-Total			20.00		62.00
Interest on loan (3%)			1.13		3.68
Total			38.78		126.43
Benefits					
Gross additional income	1.00	500 kg	500.00	285 kg	285.00
Net income			461.22		158.57

Pineapple

DAMAGE

Rat damage of pineapple begins during the flowering stage and continues up to maturity in the absence of control methods. Rats gnaw the tops of the crown at the early fruiting stage and consume any part of the fruit (Fig. 18). Fruits that sustain even superficial cuts may not grow to full size.

Figure 18. Rat damage to pineapple fruit

SPECIES INVOLVED

R. r. mindanensis and *R. exulans* are the common species observed in pineapple plantations in Luzon. *R. argentiventer* or other less common species may also cause damage when present.

BAITING METHOD

1. Place two bait holders at each corner of a 0.5-1 ha pineapple field 18 months after planting or just after the flower has emerged (Fig. 19).
2. Place 50 g of bait in each bait holder.
3. Check bait holders weekly for bait consumption. It is advisable to check bait holders twice a week during the first 2 weeks of baiting, then once per week thereafter to insure a continuous supply of bait for the rats. If at one baiting point, all the baits are consumed, add two more bait holders 1 m apart. Maintain 25 g of bait in each bait holder.
4. Increase the number of bait holders at each location each time the bait is almost consumed. During 4 months of baiting, as many as 56 bait holders or more and 1 kg bait per week may be required per hectare.

COST/BENEFIT

A field study in Luzon showed the cost for protecting 1 ha of pineapple for 4 months is about ₱99.42 (Table 9). At a price of ₱3.50 per fruit, an additional net income of ₱3,838.08 can be expected.

Figure 19. Two bait holders are placed at each corner of a pineapple field

Table 9. Cost and return of rodent control per hectare of pineapple field[1]

Item	Quantity	Unit Cost (₱)	Cost (₱)
Materials			
Bait	19.2 kg	2.00	38.40
Rodenticide	0.96 kg	15.00	14.40
Bait holders	24 pc	0.20	4.80
Sub-Total			57.60
Labor			
Placement	5 hr	2.00	10.00
Maintenance	14 hr	2.00	28.00
Sub-Total			38.00
Interest on loan (4%)			3.82
Total			99.42
Benefits			
Gross additional income[1]	1,125 pc	3.50	3,937.50
Net additional income			3,838.08

[1]Subjected to a moderate rat damage potential (9%).

Cucurbits

DAMAGE

Cucurbits like ampalaya (*Momordica charantia* L.), upo (*Lagenaria siceraria*) (Mol) Standle, squash (*Cucurbita maxima* L.), patola (*Luffa cylindrica* L.) Roem and *L. acutangula* (L) (Roxb.), and watermelon (*Citrullus vulgaris* L.) are vulnerable to rat damage. In one area of Laguna, up to 30% rat damage to ampalaya, upo, patola, and squash has been observed (Fig. 20). Young ampalaya fruits of about 5 cm long have been found in some rat burrows. Rats pick and eat the maturing fruits. Mature upo is eaten out and the young fruits are clawed, scratched or nibbled, so its market value is reduced. Damage to squash is similar to damage to upo. Watermelons are usually damaged by rats when the fruit has reached its maximum sweetness, close to harvesting.

SPECIES INVOLVED

The primary pest is probably *R. r. mindanensis,* but other species are also capable of inflicting damage when present.

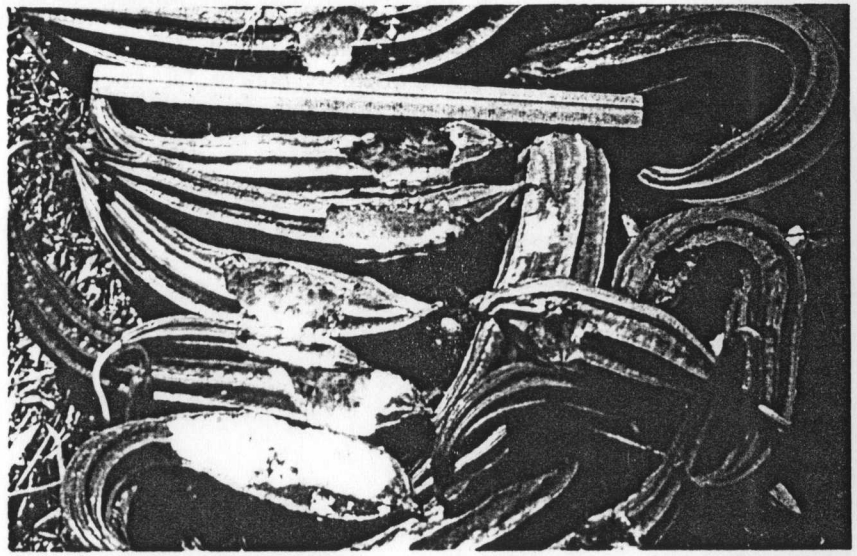

Figure 20. Rat damage to patola

BAITING METHOD

1. Baiting should begin according to the following schedule:

Crop	Days after flowering
Ampalaya	20 - 25
Squash	65 - 75
Upo	45 - 55
Patola	45 - 59
Watermelon	30 - 35

2. Select 5 baiting locations per ha. For smaller fields, maintain 4 locations of equal distance from each other.
3. Place bait holder at each location and pour in 50 g of bait.
4. Visit bait stations at least once a week to replenish consumed bait. If most of the bait at any location has been consumed, add more bait holders 1 m away from the other containers.
5. Continue to check weekly and maintain an excess bait between checks at each location. If too much bait remains in the holder, remove the extra bait holders. However, always maintain 1 bait holder at each of the 5 original locations until harvest.

Ipil-Ipil (*Leucaena* sp.)

DAMAGE

Young ipil-ipil plants are cut and barks of older trees are stripped or gnawed close to the ground. When the bark is completely ringed, the upper portion dies (Fig. 21). Regrowth starts where the bark is still intact, usually 5 cm above the collar but the damage delays growth or completely destroys the seedling. Rat damage to ipil-ipil may be heavier during the dry season than in the wet season.

SPECIES INVOLVED

R. r. mindanensis, R. argentiventer and *R. exulans* damage ipil-ipil.

CONTROL METHODS

Baiting has been the only method field tested and found effective.

1. Start baiting 2 weeks before planting the seedlings. Plowing the area planted or cutting grasses will reduce the rat damage potential.
2. Select 6 baiting locations approximately 50 m apart per ha. Place 1 bait container per location and pour in 50 g of bait material.
3. Check bait containers at least once a week. If most of the bait has been eaten at one location, place two containers more and maintain 50 g of bait in all three. Check again after 1 week.
4. Continue adding bait and bait containers if there is a noticeable increase in consumption during weekly visits.

5. If bait consumption decreases any time after baiting, remove some of the bait containers.

Figure 21. Girdling or gnawing of bark is a characteristic rat damage to ipil-ipil

COST/BENEFIT

Since ipil-ipil is most vulnerable to rat damage during the first year, cost and benefits are summarized for that period only. The resultant cost and return, however, would not probably change during the second year since less rat damage would require less baiting cost.

Benefits are difficult to evaluate because of the numerous uses of ipil-ipil. A combination of animal feed and roadside fuelwood are used in the following table.

Table 10. Cost and return of baiting 1 ha of ipil-ipil during the first year after planting

Item	Quantity	Unit Cost (₱)	Total Cost (₱)
Materials			
Bait	30.6 kg	2.00	61.20
Rodenticide	1.53 kg	15.00	22.95
Bait holders	36 pc	0.20	7.20
Sub-Total			91.35
Labor			
Placement	2 hr	2.00	4.00
Maintenance	50 hr	2.00	100.00
Sub-Total			104.00
Interest on loan (12%)			23.44
Total			218.79
Benefits			
Gross additional income			
Animal feed	125 kg	1.00	125
Wood fuel	250 bunches	1.00	250
Total			375
Net Revenue			156.21

Stored Products

Damage Patterns in Warehouses

Warehouses with concrete walls and floors sustain the same amount of rat damage as warehouses made of light materials. Rodents have no exits in "better" warehouses so they live and multiply inside. In loosely-constructed storage structures, rodents easily move in or out of the building.

Large-capacity warehouses have lower incidence of gnawed sacks while commercial establishments have more.

Species Involved

R. norvegicus and *R. mindanensis* are known to infest warehouses.

Control Methods

a. Proper warehouse management
   1) Do not keep stocks long in the warehouse to reduce food supply and make the warehouse unsuitable for rodents.
   2) Do not accumulate rubbish, idle machinery, empty sacks, and other materials in secluded parts of the warehouse.
   3) Keep surrounding areas free of weeds and accumulated sweeping or residues.
   4) Inspect the warehouse regularly to check presence of rodents and ensure high standards of hygiene and proofing.

b. Rodent proofing
   1) Close all unnecessary openings accessible to rodents with sheet metal and concrete. Figure 22 shows the points through which rodents can enter into the warehouse.
   2) Cover openings such as ventilators and windows with suitable screen wire or expanded metal. Use 6 mm mesh gauge expanded metal, and coat it with asphaltic paint.
   3) Cover all openings larger than 6 mm in diameter.
   4) Where practical, place barriers across rodent access routes. For example, when rodents enter a warehouse below the eaves and can only reach the top of the wall through a single overhead cable or downspout leading to a canal, it is simpler to attach a rodent guard to the cable or screen the spillway of the downspout than to fill in all the space under the eaves.
   5) Make the new buildings rodent-proof at the start. Design elevated floors (not less than 1 m from the ground) and provide movable stairs.

6) Fit a metal kicking plate onto the base of doors (Fig. 23). Use a 20-gauge galvanized iron sheet approximately 30 cm high. Fix it to the outer face of the door and finish within 6 mm of the step. For sliding doors, erect a 1 m high movable metal barrier inside the doors.

7) Fit metal baffles to all pipes, cables, etc. that lead to the roof or window level (Fig. 24). Project the baffle at least 25 cm from the wall, pipe or cable.

8) In rough walled structures, apply a band of glass paint outside the building, below the window level but at least 1 m above the ground. Apply a coat of primer before two undercoats, and a final top coat of hard gloss. Apply light colored paint to detect any rodent marks.

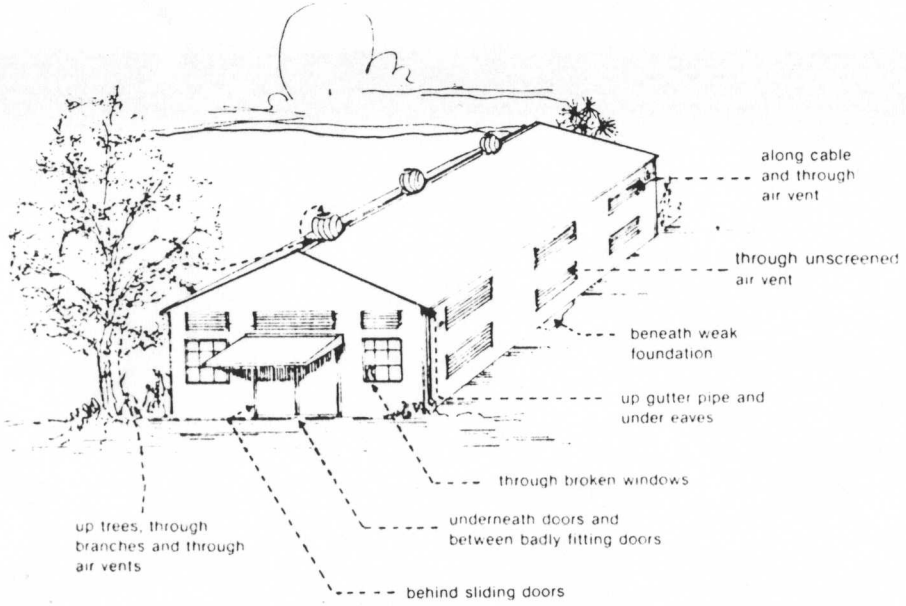

Figure 22. Entry points of rodents into warehouse

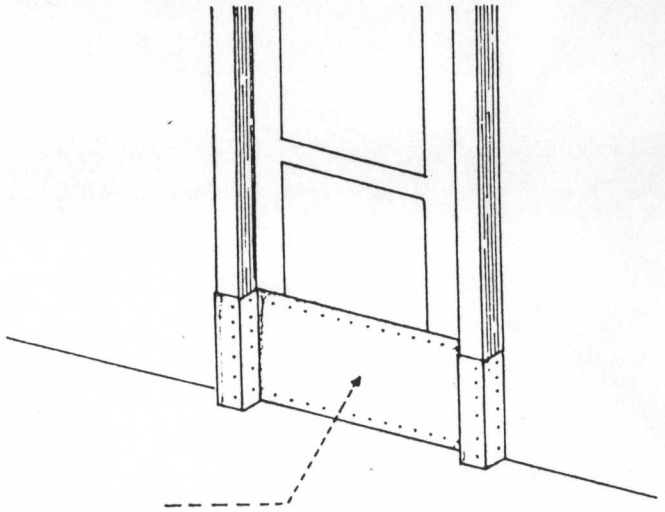

Figure 23. Proofing the bottom of a door

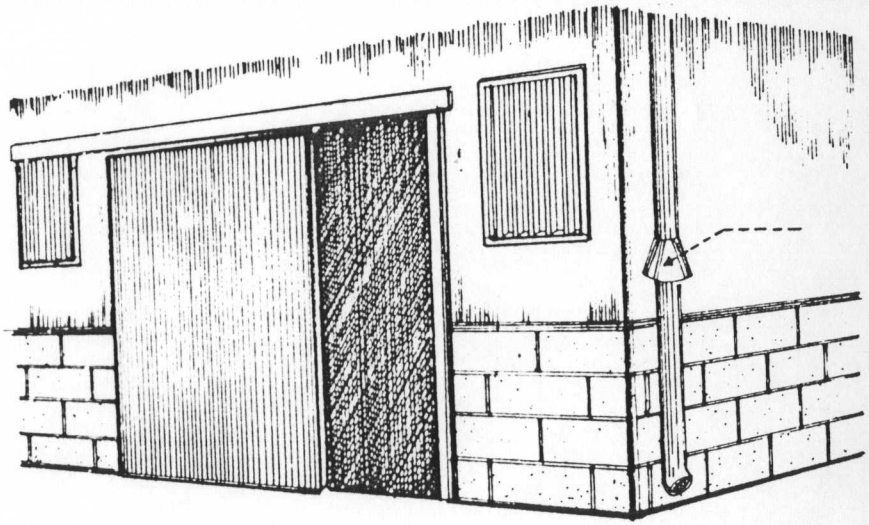

Figure 24. Rat guard on drain pipe

c. Trapping

1) Place traps along walls, runways and in places where rats will most likely wander as indicated by droppings, gnawings, smears and damage, and spilled grains.
2) Set the trap with its trigger end perpendicular to the wall or stock pile.
3) Use baits that are different from the stored products and are not attractive to other animals like cats in the warehouse.
4) Try several kinds of baits on unset traps to determine the most acceptable ones.
5) Traps may be set for three consecutive nights for one period. As trap-shyness develops, leave traps unset for some time before starting another trapping period.
6) Set more traps than the expected rat density. For a modern sized warehouse, use 50-100 snap traps laid about 10 m from each other.

d. Chemical control

1) Mix acute or slow-acting rodenticide (Tables 1 & 2) with solid baits or drinking water.
2) Maintain permanent stations for continuous baiting. Use discarded oil cans, 110 mm-diameter pipes, tin lid, and trays made of wood, metal, plastic or cardboard.
3) Bait inside and outside the warehouse.

References

Aganon, T.M. 1981. Survey of rat damage in Nueva Ecija ricemill warehouses. M.S. Thesis. UP at Los Baños. 40 pp.

Benigno, E.A. 1980. Rat damage distribution in rice and cornfields. *Philipp. Agri.* 63:239-250.

_____ 1982. Rodent Pest Control in Storage, *in*: NAPHIRE-NFA Seminar on Efficient Grain Handling for NFA Supervisory and Executive Personnel. p. 128-153.

Castro, F.B. 1978. Management of limiting factors in sustained anti-coagulant baiting of lowland ricefield rats. MS Thesis, UP at Los Baños. 43 pp.

Coslick, J.W. and D.J. Decker. (n.d.) Rat and mouse control. N.Y. State Coll. Agri. Life Sci. Info. Bull. No. 163. 22 pp.

Control of Rats and Mice (Reference Manual for Pest Control Personnel). 1978. Pest Infestation Control Laboratory, Surrey, England. 97 pp.

Crop Protection Division. 1977. Guidebook on Coconut Pests and Diseases. Agricultural Research Branch, Philipp. Coconut Authority. 85 pp.

Fall, M.W. 1977. Rodents in tropical rice. Rodent Research Center. UP at Los Baños. Tech. Bull. No. 36.

Ferrer, L.S. 1975. A laboratory study on juvenile growth of the common ricefield rat. M.S. Thesis. UP at Los Baños. 48 pp.

1975. Growth of *Rattus rattus mindanensis*. *Philipp. Agri.* 59:37-42.

Gallego, V.C., E.D. Aterrado and R.G. Abad. 1980. Rat damage assessment and control studies in coconut. I. The use of rat bands and anti-coagulant rodenticides. Annual Report 1980, PCA. Agricultural Research Branch, Bago Oshiro, Davao City.

Hoque, M.M. 1972. Notes on a rodent pest affecting coconut. *Philipp. Agri.* 56:280-289.

Iral, P.T. 1977. Development of rodent control as practiced by the Philippine German Crop Protection Programme. 2nd Regional Training Seminar on Field Rat Control and Research, Manila, 16-25 March, 1977. 9 pp.

Kapoor, I.F. and R.N. Khare. 1965. Studies on bird and rodent control in rice mills. Bull. Grain Tech. 3(2):51-55.

Krisnamurthy, K. 1972. Post harvest problems of wheat. Bull. Grain Tech. 10(4):291-296.

Lavoie, G.K., G.C. Atwell, F.N. Swink, J.P. Sumangil, and J. Libay. 1971. Movement of the ricefield rat, *Rattus rattus mindanensis*, in response to flooding and plowing as shown by fluorescent bone labelling. *Philipp. Agri.* 64(7 & 8):325-330.

Libay, J.L. and M.W. Fall. 1976. Observations of an exceptionally dense population of wild rats in marshlands. *Kalikasan, Philipp. Journ. Biol.* 5:207-212.

Magallona, E.D. 1980. Pesticide management. Fertilizer and Pesticide Authority. 193 pp.

Medina, F.I.S., C.L. Madriaga, B. de la Cruz, V. Paguirigan, E. Padrelana, S. Eslit, and J. Gregorio. 1973. A study on the adaptation and breeding of field rats (*Rattus rattus* sp.) in the laboratory. *Philipp. Agri.* 56 (7 & 8):274.

National Post Harvest Institute for Research and Extension. 1981. Rodent Pests and their Control in Storage. First Progress Report.

_____. 1982. Rodent Pests and their Control in Storage. Second Progress Report.

Pank, L.F. 1975. Rat damage to Philippine sugarcane. W.D.R.S. Hilo, Hawaii and D.W.R.C. Denver, Colorado.

Philippine Sugar Commission. 1980. A guide on rat control in sugarcane fields. Department of Crop Protection, Luzon Experiment Station, Paguiruan, Floridablanca, Pampanga.

Rubio, R.P. 1971. Survey of rat damage in Laguna ricemill warehouses. B. S. Thesis. UP at Los Baños.

Salazar, N.P. 1977. Commensal rodents and their parasites in Manila and suburbs. Lecture at Second Regional Training Seminar on Field Rat Control and Research, Manila. 16-25 March 1977. 32 pp.

Sanchez, D.C. 1978. Contemporary rat control methods: A review. Short Course on Integrated Pest Control for Irrigated Rice in South and Southeast Asia, 16 Oct. - 18 Nov. 1978. Philippines, 7 pp.

Sanchez, F.F. *et al.* 1973. Reducing inter-actions among rats at bait stations to improve bait acceptance. RRC Paper. p. 32-38.

Sanchez, F.F. 1980. Rodent pest management in the Philippines: The last 12 years. L.B. Uichanco Professorial Chair in Pest Management Lecture, 16 May 1980.

_____. **(Ed.)** 1980. Proc. Symposium on Small Mammals: Problems and Control. Biotrop Special Publication No. 12. 248 pp.

Sumangil, J.P. and N.C. Rosell. 1956. Blanketing as a method of estimating rat population density. Technical Report, Bureau of Plant Industry, Manila. 13 pp.

Sumangil, J.P. 1965. Handbook on the Ecology of Ricefield Rats and their Control by Chemical Methods. Pest Control Division, Bureau of Plant Industry. Mimeographed. 30 pp.

_____. 1978. The effect of rain and shower in the feeding activity of Cotabato field rats. *Philipp. Agri.* 56(7 & 8):267-273.

_____. 1978. Principles of rodent control in rice agroecosystem. Short Course on Integrated Pest Control for Irrigated Rice in South and Southeast Asia, 16 Oct. - 18 Nov. 1978, Philippines. 7 pp.

Taylor, K.D., D.C. Drummond and F.P. Rowe. (n.d.) Biology and Control of Rodents. Pest Infestation Control Laboratory, Surrey, England. pp. 136-768.

West, R.R., M.W. Fall and J.L. Libay. 1975. Reducing interactions among rats to improve bait acceptance. *Philipp. Agri.* 59(1-2):31-36.

_____. 1975. Tiller cutting behavior of rats in growing rice. *Philipp. Agri.* 59:27-30.

Appendix A

Safety Precautions in Handling Chemicals

1. Store pesticides in clearly labelled containers kept out of reach of children and pets and far from food storage.
2. Do not use mixing cans and spoons used to measure pesticides for any other purpose.
3. Read the instructions on the label carefully.
4. Mix chemicals outside your house. If possible, wear gloves, goggles, and mask or suitable protection while handling rodenticides. In case of contact, wash skin with plenty of soap and water; for eyes, flush with water for 15 minutes and get medical attention.
5. Do not breathe the dust or vapors.
6. Do not eat, drink or smoke while handling chemicals.
7. Wash your hands thoroughly each time you finish your work.
8. Do not throw cartons or containers into irrigation canals, rivers, and other bodies of water. Bury excess rodenticides and containers.
9. One advantage of anti-coagulants over most acute rodenticides is the availability of an antidote in case of accidental poisoning. If treated bait or concentrate is accidentally eaten, take the person to a doctor or clinic immediately. Treat poisoning with chronic toxicants with oral doses of Vitamin K or injections of aqueous Vitamin K (phytonadione). Inject either subcutaneously or intramuscularly at 10-25 mg doses, or intraveneously. In case of severe poisoning, blood transfusion is needed.

Appendix B

Symbols and Abbreviations

cav	cavan
cm	centimeter
Fig	figure
g	gram
ha	hectare
hr	hour

kg	kilogram
m	meter
mg	milligram
mm	millimeter
M	million
%	percent
₱	peso
pc	piece
spp.	species (plural)
sq. m.	square meter
tbsp	tablespoon
V	volts

Appendix C

Managerial Type of Field Rat Control

OBJECTIVES

General: To organize a massive and sustained rat control program with maximum community involvement.

Specific:

1. to harness the available resources of the community in the activity
2. to prepare the barangay group to be responsible for rodent control in their respective areas
3. to instill self-reliance in farmers through cooperative effort
4. to establish a coordinated effort of all the agencies and citizenry concerned
5. to monitor and evaluate control program and activities

STRATEGY

A. Organization and Program Management
   1. Coordinator per province — Provincial Crop Protection Coordinator
      Ministry of Agriculture and Food (MAF)
   2. Committees/municipality — MAF, Ministry of Local Government and Community Development, Barangay Government, Municipal Government

      a. Technical Committee
         1. formulates guidelines and regulations for the benefit and effectiveness of the program
         2. withdraws funds from the barrio rat control budget to purchase items needed for the operation
         3. distributes needed materials to the barrio Rat Control Committee

      b. Financial Committee
         1. oversees the fund and other resources of the operation

      c. Audit Committee
         1. checks the book after each cropping season

   3. Barrio Production Technician
      a. monitors the activities of the operation all year round
      b. includes ₱50.00 per hectare of riceland in the Farm Plan and Budget
      c. submits a list of farmer-borrower together with withdrawal slip to the serving bank
      d. reports the farmer who refuses to sign the withdrawal slip for the ₱50.00 in historically infested areas

   4. Barangay Worker trained by MAF in rat control
      a. allocates bait stations
      b. checks and refills the baiting stations with chronic poison at least once a week
      c. collects and stores baiting stations after every cropping season

B. Funding
   1. The amount of ₱50.00 per hectare of riceland must be included in the Farm Plan and Budget of the Farmer's Cooperative under Masagana 99 for every cropping season to cover expenses in the barrio's Rat Control Program. The amount shall be used to purchase needed rodenticides, baits, and baiting station materials.
   2. Non-borrowers must be required to pay ₱50.00 in cash. Collection must be the responsibility of the MLGCD, barangay council and Samahang Nayon.
   3. All funds collected in the serving bank shall accrue to a common fund for the barrio rat control program.

4. A complete and accurate financial statement shall be made after each cropping season.

Appendix D

FERTILIZER AND PESTICIDE AUTHORITY
PESTICIDE CIRCULAR NO. 5
SERIES OF 1982

Banned and Restricted Pesticides in the Philippines

1. Elemental phosphorus (White & Yellow)
2. Thalium sulfate
3. 1-Naphthylthiourea (ANTU)
4. Gophacide
5. Sodium Fluoroacetate (1080)
6. Sodium Fluoroacetamide (1081)
7. Strychnine

Fumigants and Other Chemicals for Use Only by Certified Fumigators

1. Methyl bromide
2. Ethylene dibromide
3. Carbon disulfide
4. Phosphine generating compounds
5. HCN-generating materials
6. Carbon tetrachloride
7. Chloroform
8. Ethylformate

Agenc

National I

Philip