# Crop Losses to Rodent Pests in Kerala: A Pre-harvest Survey in Selected Crop Fields and Survey on Grain Storage Losses

**Punnen Kurian**

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## Crop Losses to Rodent Pests in Kerala: A pre-harvest survey in selected crop fields and a survey on grain storage losses

Punnen Kurian *

### 1. Introduction

With the rising need for world food supplies to meet the demands of the burgeoning population, interest in augmenting agricultural production has increased rapidly in recent years. About half the world population is actively engaged in agriculture. Yet, and despite many advances in agricultural technology, millions of people in scores of nations suffer hunger, malnutrition, and starvation. The reasons for this pathetic situation are several and complex; one important factor is food loss to crop-pests. Vertebrate pests, especially rodents, are responsible for much of this loss. In developing countries, which are predominantly agrarian, rodent infestation poses a serious threat of not only reduced income but widespread food shortage as well (Milan, 1990).

Rodent pests play a significant role in limiting agricultural production. Information available on the extent of damage caused by rodents is meagre. However, it is estimated that in India, on an average about 70 per cent of cocoa and 20 per cent of coconut are lost due to rodent attack. In islands like Minicoy (Lakshadweep) and Car Nicobar, the damage by rodents to coconut crop reaches even up to 55 per cent. Rat damage to coconut in Kerala is calculated to be in the range of 21 to 28 per cent. Srivastava (1970) reported that, on an average 4.6 to 54.0 per cent of rice, 11.9 per cent of wheat, and 2.2 per cent of sugar-cane are lost due to rodent damage in India. Pre-harvest damage surveys conducted in nearly 1,600 paddy-fields distributed throughout Philippines revealed that rat damage is about 90 per cent in the fields (Sanchez, *et al,* 1971). Wood (1971) estimated that rats were responsible for yield reductions of more than 60 per cent in rice. Rodent species may cause damage, either directly or indirectly during the entire crop development period or at the post-harvest stage. Forest pastures, grain crops, stored products, orchards, equipment, and live stock are all liable to damage by rodents (Elias, 1988). The extent of actual loss in post-harvest situations is unknown because no practical methods for obtaining loss estimates are available (Harris and Linblad, 1978), though there are a number of rough estimates available in this regard. In 1966, the post-harvest losses to the grain storages in India were estimated as 9.33 per cent. Of this, 2.5 per cent was caused by rodents. The overall losses to wheat in provincial grain storage centres of Pakistan caused by vertebrate pests was estimated to be 0.2 to 0.5 per cent

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of all stocks. The major vertebrate pest that causes damage and losses of stored grains is rodent.

Historically speaking, rodents have not received the degree of attention given to other agricultural pests. With few exceptions, little reliable information on the species involved, the extent of damage caused by them, and its economic impact is available. The common inability to express rodent damage in economic terms is probably one of the principal reasons why control of rat damage has been given much less attention than that caused by insects and plant diseases (Fall, 1977). Further, damage by rodents is often accepted as part of the normal scheme of things in agriculture. It is considered unavoidable and only minor attempts are made to evaluate damages, identify species or attempt control (Elias, 1988).

The situation in Kerala is not different from the rest of the world; may be it is even worse. Annual crops such as rice, tubers, and banana are affected adversely by rodents. Production of tuber crops such as cassava in the State has gone down steeply during the past decade. The fall is mainly due to the rat problem, specifically of Bandicoots. In perennial crops such as coconut and cocoa where the damage is cumulative, the problem is even more serious. But little information on actual losses by rodents is available in the State, except the results of a few studies and surveys done during the early seventies (Koya, 1975). Studies on pests of agriculture in the State were mainly centered on insect pests. In fact, no extensive study on rodent pests and their damages has taken place in the State. There are more than 6,000 different kinds of rodents. Nearly 600 of them belong to the genus, *Rattus* and are called 'rats', though many other rodent species are commonly referred to as rats. The term 'mouse' is applied to smaller rodents. The present study is undertaken to conduct a survey of the damages caused by rodents, principally rats, to the different crops in the central Travancore area. The study is conducted in multicrop mixed farming systems, and monoculture crop, fields which come under small holder ecosystems.

Loss of stored grain to rodents is a serious problem, experienced throughout the world. In Kerala, no scientific studies are undertaken that provide reliable data. The extent of stored grain losses depends upon the distribution, abundance, and species composition of the rodent populations involved. Techniques for estimating rodent populations and the loss to grain storages are well established (Mian *et al*, 1987). The present study includes analysis of the grain storage losses in houses and shops of Kerala.

## 2. Objectives, Methodology, and Study Area

### Objectives

The major objectives of the study are the following:

(i) assessment of the extent of damage caused by rodents to various crops in the central Travancore area;

(ii) assessment of the crop damage caused by rodents to different crops in a multicrop, mixed farming ecosystem;

(iii) identification of the pest species of rodents associated with crops in the area;

(iv) enquiry into the extent of damage in houses, small-scale storages, shops and farm-granaries caused by rats; and

(v) comparison of the value of loss with the standard cost of different control measures, and suggestion of efficient control strategies.

The study is expected to come up with the following items of information.

(i) crop damage caused by rodents to crops such as rice, cocoa, coconut, and cassava;

(ii) pest species of rodents associated with various agricultural crops, by numbers and types;

(iii) loss in houses, granaries, and shops caused by rats; and

(iv) the present state of rodent control programmes.

It should be possible, on the basis of the findings of the study to make suggestions for improved agricultural practices to reduce crop damage by rodents. A cost-effective pest management programme, based on the comparative studies on expenses involved in control measures and the value of loss, would be drawn up. Suggestions for rodent-proof storage techniques and better management programme in houses and shops would also be attempted.

We envisage publication of

(i) a series of manuals on rodent pest management for principal crops of central Travancore such as cocoa, paddy, coconut, and cassava;

(ii) a guide to common rodent pests of central Travancore area with a section on improved rodent management programme in the houses and shops as well as documentation on traditional rodent control techniques (which may be included in the 'manual series').

### Methods and study area

The field investigations were conducted in selected crop fields and shops of three wards of the Vijayapuram panchayat in Kottayam district.

Vijayapuram is one of the largest panchayats in the district and comprises 15 wards covering an area of 29.7 sq. km (Map 2.1). The panchayat headquarters is six km away from the district capital, Kottayam, and is situated alongside the Kottayam-Kumili road. The area has an undulating terrain of medium-sized hills, paddy-fields and in-between, cultivated low-lands. The panchayat is thickly populated with a density of 1697.5 persons per sq. km and has 10,114 residential buildings, according to the Census of 1991. The majority of the people is engaged in agriculture and the cropping pattern is determined by the monsoon. The principal crops and their cultivated area and productivity are given in Table 2.1.

**Table 2.1 Principal crops in Vijayapuram panchayat, 1996**

| Sl. No. | Crop | Area under cultivation (in hectares) | Productivity per hectare |
|---|---|---|---|
| 1. | Coconut | 475 | 4300 nos. |
| 2. | Rubber | 925 | 750 kg. |
| 3. | Pepper | 135 | 1800 kg. |
| 4. | Cocoa | 10 | 1800 kg. |
| 5. | Rice | 332 | 2800 kg. |
| 6. | Pineapple | 50 | 12500 nos. |
| 7. | Banana | 30 | 7700 nos. |
| 8. | Cassava | 15 | - |
| 9. | Ginger | 10 | - |
| 10. | Vegetables | 8 | - |
| | Total | 1990 | - |

Source: Agricultural Office, Vijayapuram, Manarcaud

More than 90 per cent of the farms is of less than five hectares in size, the majority averaging between one and two hectares. Fields consist of small plots with a variety of crops on them, a few animals, a few fruit trees, and on-farm storage facilities of produce (with houses). In several cases, groups of farmers plant rice or other field crops in large monoculture blocks separated from dwellings, gardens or other areas.

Richards and Buckle (1987) termed these complexes of fields and dwellings the 'small holder ecosystem'. Typically such farms maintain many small plots containing a variety of crops with planting and harvesting occurring through much of the year. The present study is conducted in selected 'small holder ecosystems', each consisting of complex fields of a number of crops and interspersed with house plots.

The selection of the crop-fields as well as the shops and houses, is done taking into consideration the geographical and ecological characteristics of the area (Table 2.2).

The study was conducted from December 1996 to November 1998. The agro-climatic features of the study area and their seasonal variations are given in Table 2.3.

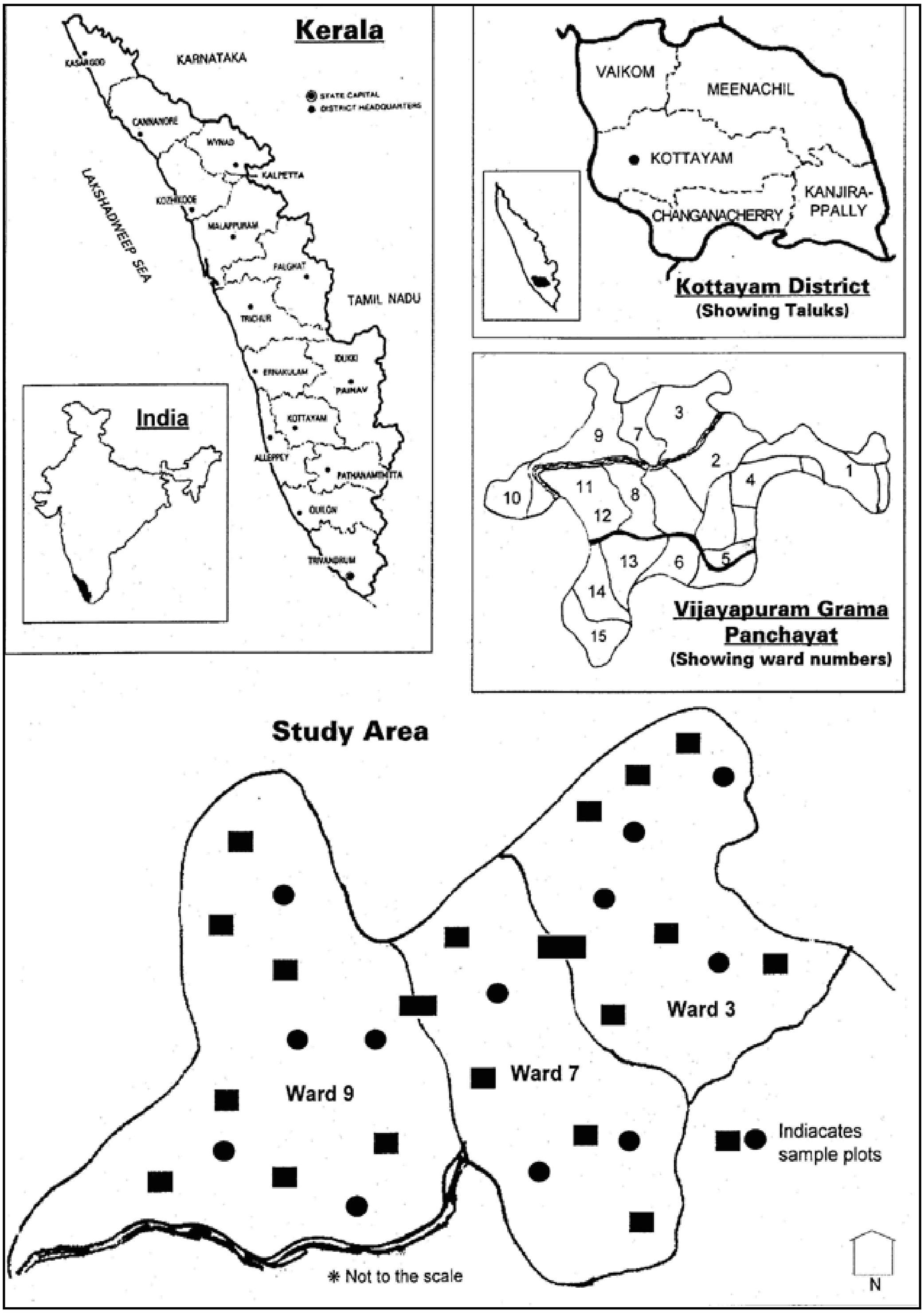
**Table 2.2 Baseline data of study plots**

| Sl. No | Crop | No. of sample plots | Total area (in acres) | Average area of a plot (in acres) | Description |
|---|---|---|---|---|---|
| 1 | Rice | 10 | 11.95 | 1.195 | Three plots are in the middle of a vast stretch of paddy-field and each is separated by a minimum area of 5 hectares; 2 plots are close to house plots; 3 plots are adjacent to upland cultivated with cas sava and coconut; 2 are close to house plots. |
| 2 | Coconut Total number of trees - 631 | 10 | 11.77 | 1.177 | Four plots have only coconut; 3 are mixed with cocoa and plantain; 3 plots have cassava in addition to coconut; 4 plots are near to houses and buildings; 6 plots are surrounded by paddy-fields. |
| 3 | Cassava Total number of plants-5448 | 10 | 4.23 | 0.423 | Five plots have monoculture of cassava; 2 plots have coconut trees and plantains intermixed; 3 plots have cassava with coconut. |
| 4 | Sugar-cane Total number of canes - 800 | 1 | 22.5 | 22.5 | A large area sampled through line transect method |
| 5 | Cocoa | 4 | 2.0 | 0.5 | Two plots are intermixed with coconut; 2 plots have cocoa and other fruit trees. |

**Table 2.3 Agro-climatic features of the study area**

| Season | January-March | April-June | July-September | October-December |
|---|---|---|---|---|
| Climate | Mid-summer | Late summer; onset of monsoon | South West monsoon; rainy season | North-east monsoon; partly rainy period |
| Crops | **Crops available in the study area/productivity or growth stage** | | | |
| a. Rice | Plants 60-90 days old | Post-harvest period | Fields partly or fully submerged in flood water | Plants at the seedling stage 1-2 months old |
| b.Coconut | Lowest productivity period | Average productivity period | Real productivity periods | Average productivity period |
| c.Vegetables | Period of maximum production | Harvesting completed | Lands remain uncultivated | Plants at the seedling stage |
| d. Cassava | Plants at the seedling stage | Plants at the tuber -developing stage (3-4 months old) | Plants 5-8 monthsold; tubers formed | Uprooting period |
| e.Sugar-cane | Replanting stage after harvest | Stem–forming stage (3-4 months old) | 5-6 months old; period of sugar content formation in stems | Harvest period |

**Map 2.1 The study area and the sample wards**



## 3. Rodent Damages to Cassava

### Introduction

Cassava (Tapiocca) is one of the staple items of food of the Keralites. It is cultivated in most parts of the State since the mid-nineteenth century. But today this crop is in a crisis, which compels farmers to switch over to other economically viable crops. The crisis has arisen mainly due to the rat-problem, which the farmers find impossible to control.

The majority of the small farmers have already withdrawn from cassava cultivation solely due to this problem. The data given by the State Farm Bureau show a sharp decline in the cultivated area in Kerala, i.e., from 169.48 thousand hectares in 1988-'89 to 113.60 thousand hectares in 1995-'96. Only persistent and labour-intensive control measures are of some success, but at the present juncture of high wages such methods are not economic.

Cassava cultivation in the study area is confined to certain pockets of the panchayat. Discussions with farmers, agricultural officers, and others who are engaged in cassava production and marketing in the panchayat, revealed that the major reason for withdrawal from cassava cultivation, is rodent damage. The present sample study makes an attempt to assess the extent of damage and economic loss, as well as control measures adopted by farmers and to analyse the possibilities of an integrated approach in rodent control.

### Method

Ten cassava plots in the study area were selected for the sample study, each bearing approximately 500-600 plants and of an average area of 1.5 acres. 'Small-holder crop lands' is a typical feature of Kerala's agriculture. Among the selected plots, five have monocultured cassava crop and the rest are mixed farms with cassava, plantain, and coconut. Three plots are near to houses, two near to bitumen-surfaced road, and the rest adjacent to fields, cultivated with rice, sugar-cane, and rubber.

The following local varieties of cassava are planted here: Malabar (M-4), *Vella* Mixture, *Karutha* Mixture, Kottayam *chulli*, *Pathinettu*, *Vella* block, and *Eatha*. About 7-10 months are needed on an average for these varieties to attain the harvesting stage. All the fields except two have more than one variety in one and the same plot. In the study area, in most of the fields, planting is done in April-May immediately prior to the south-west monsoon. In some of the fields where there are chances of flooding, planting is done in September-October, before the onset of the north-east monsoon.

Every morning and evening, a field assistant of the project visited each plot and checked every plant for any signs of damage, (signs of attack, damage / uprooting etc.,), number of tubers lost in each plant, quantity of tubers lost, and other signs of rodent activity. All agricultural activities including pest control measures employed were also recorded daily. One-way ANOVA was performed to compare the seasonal differences and the differences in damage under the farming systems.

**Observations**

Some of the general observations regarding rodent damage and the control measures taken are given below.

***Damage pattern***

Rats attack cassava, from the very first day of planting itself. Field rats uprooted the stumps and sometimes carved them into pieces. The attack becomes severe when the tubers start to develop on roots; if proper and persistent care is not given, the attack becomes widespread.

Four species of rats were identified as principal rodent pests to cassava in the study area: Large bandicoot (*Bandicota indica*), Lesser bandicoot (*Bandicota bengalensis*), House rat (*Rattus rattus*), and the field mouse (*Mus booduga*).

**Control measures**

The control measures employed in the past and at present by the farmers were collected and categorised into three groups.

***Cultural practices (Traditional control measures)***

(i) Removal of the harbourage from the cropfield and its adjacent fields, especially around stone or mud walls.

(ii) Rodents show a slight preference to feed on certain varieties of cassava such as Malabar *mutta* and Kottayam *chulli*. The practice is therefore to cultivate such varieties mingled with non-preferred varieties such as *Vella* mixture and *Chuvappu* mixture, so that rats would stray away.

(iii) Planting of Ginger (*Zingiber officinale*) and Turmeric (*Curcuma domestica*) in between and around the cassava keeps away rats. Plants such as *Chethikkoduveli* (*Plumbago rosea*) are good rat repellents.

(iv) Smoking rat-holes is an effective control measure. Capturing and killing practised by tribesfolk (eg. *Malavedans*) also helps control rat population.

***Chemical control measures***

Zinc Phosphide and Bromadialon are the commonly used rodenticides in the area, which are commercially available. Some of the effective baiting methods developed through the present study is mentioned below.

(i) The bait should be a food material other than cassava, preferably raw or baked coconut, dried fish, bread, and sweet maize-flour cake (*Bonda* - a local teashop item). Fire-cooked onions are the favorite food for Bandicoots.

(ii) Unpoisoned baits (plain bait) scattered together with poisoned baits will make the programme more effective.

(iii) Placing poisoned bait in bait stations made out of banana husk, coconut shell, cone-tile etc., would protect domestic animals and guard the bait from rain.

**Mechanical control measures**

Mechanical traps are widely used by farmers, but the majority of them belong to the traditional type (folk traps).

The commercial traps, which are available in the market, such as live trap, snap-trap, and spring-trap are used rarely, and they are found to be the least effective. The following precautions would make the traps more effective.

(i) Place the traps adjacent to the shoots, where the rats had attacked the previous night. Placing the traps on rat-paths is also effective. (Rat-path can be identified, by observing the field between 6 pm and 8 pm, consecutively for one to three days.)

(ii) Traps should be placed with suitable bait in the field for two to three days, and the trap-stick should be tied so as to avoid the trapping. This would attract the rats and help them to avoid neophobia (pre-baiting technique).

(iii) Remove the trapped rats or carcass at the earliest to avoid any type of communication with those roaming freely (pheromonal communication).

The traditional traps (folk traps) constructed and used by farmers in the area are the following.

**Bamboo pole trap (Pipe trap)**

This indigenous trap (Plate 3.1) is specifically intended to capture the lesser bandicoot rat. This trap is unique in the sense that there is no bait. One bamboo pole, 20-25 cm-long (both ends open), three umbrella strings, 50-60 cm-long, one metre-long steel wire, and 1/2 metre-long jute string are the materials required for the trap.

The trap can be fitted on the mouth of rat-hole, covered with wet soil, to merge it with the surroundings. A rat entering into the bamboo pole has to cut the jute string to move forward by which a steel wire get tightened on the neck suddenly, and kills the rat.

**Plank trap** (*Palakakkeni*)

This is an effective trap (Plate 3.2) to capture larger and lesser bandicoots and other field rats. Plank trap is a simple device of which all the components are locally available, from the surroundings. A plank of 4x60x45 cm size; a 'stump' of 18 cm height; a trapstick of 24 cm length; and a third piece 'bait stick' of 45 cm length (all sticks are of arecanut wood) and a stone of approximately 25 kg weight are the materials required. Even a small touch on the bait stick, by the rat would cause the plank to fall down together with the stone on it.

**Plate 3.1 Bamboo pole trap on the mouth of a rat hole**

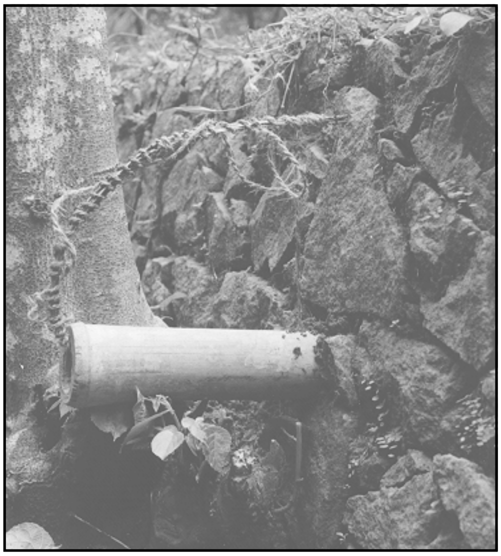
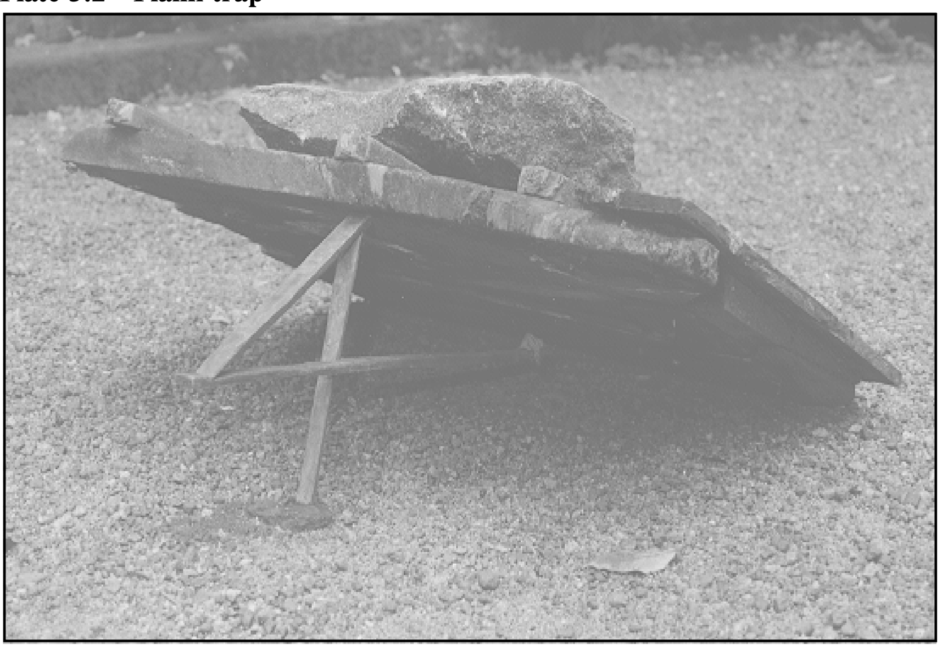


**Plate 3.2 Plank trap**



**Fencing trap**

Fencing trap (Plate 3.3) is the most common indigenous trap still used in cassava fields. This is also a habitat-compatible design.

About 15-20 numbers of stumps of trees like *Hibiscus tiliaceus L.* (*Velipparuthi*) of 70 cm in height; a 25 cm-long arecanut lath; a plank of 30x70x3 cm in size; a stone weighing 20-25 kg

**Plate 3.3 Fencing trap**

and 4-5 metre of coir are needed for constructing this trap. Two rows of stumps were piled as a fence (so the name) and the plank with stone hanged in between them. The rats that enter for taking the bait under the plank will be killed by the downfall of the plank together with the stone.

**Earthen pot trap**

Earthen pot trap (Plate 3.4) is a folk model of a pit-fall trap. An earthen pot having an average mid-circumference of 100 cm and neck diameter of 11 cm is buried in the earth with its mouth ring at the surface level. About 5-10 ml of toddy (local liquor tapped from fishtail palm fruits) or 10 ml of gruel water is taken in the pot. Now the trap is ready.

The rats attracted by the smell of the bait will easily fall into the pot. But they will not escape, as the inner wall is too smooth, preventing upward climbing. Attacking them with a pointed iron bar may kill captured rats, while they are within the pot itself.

**Results and discussion**

The analysed data are given in Table 3.1 and Table 3.2 and are illustrated in Fig. 3.1.

**Plate 3.4 Earthen pot trap**

**Table 3.1 Mean loss of cassava during different stages of growth, in first year**

| **Sl No.** | **Stage of growth of cassava** | **Mean** (No. of tubers/acre) |
|---|---|---|
| 1. | 3-4 months | 1.57 |
| 2. | 5-6 months | 1.53 |
| 3. | 7-8 months | 2.64 |

VR - 8.85** CD - 0.62.
** significant for $P<0.01$.

**Table 3.2 Mean loss of cassava during different stages of growth, in second year**

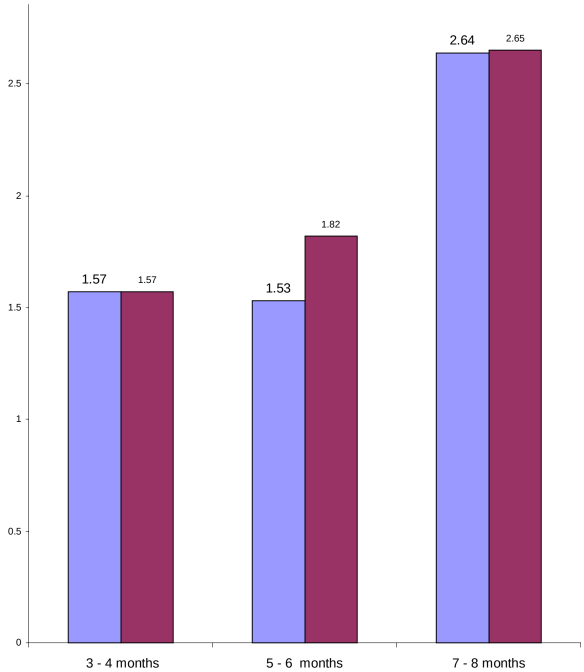
| **Sl No.** | **Stage of growth of cassava** | **Mean** (No. of tubers/acre) |
|---|---|---|
| 1. | 3-4 months | 1.57 |
| 2. | 5-6 months | 1.82 |
| 3. | 7-8 months | 2.65 |

VR - 13.82** CD - 0.44
** significant for $P<0.01$.

It is evident that in both the years of the study, the highest damage occurred during the seventh and the eighth months of growth of cassava. These data include the damage to *B. bengalensis*, which is not visible and found only at the time of uprooting. However, from the planting stage itself the damage begins and persists till the time of uprooting.

The damage that occurred during the growth period of up to three months is not included in the analysis. The uprooting of the sprouting stumps was the common nature of damage during this stage; the farmers replanted all the uprooted stumps.

**Fig. 3.1 Mean loss of tapioca during different stages of growth of cassava**




The mean percentage differences in rodent damage to cassava in various farming systems are summarised in Table 3.3 and Table 3.4.

**Table 3.3 Mean percentage damage to cassava in different farming systems during the first year of study**

| Sl No. | Type of farming system | Percentage mean damage |
|---|---|---|
| 1. | Cassava - monoculture | 12.05 |
| 2. | Cassava mixed with coconut and plantain crop | 17.59 |
| 3. | Cassava mixed with coconut palm | 28.47 |

VR - 6.09 *; * significant for $P<0.05$

**Table 3.4 Mean percentage damage to cassava in different farming systems during the second year of study**

| Sl No. | Type of farming system | percentage mean damage |
|---|---|---|
| 1. | cassava - monoculture | 12.62 |
| 2. | cassava mixed with coconut and plantain crop | 15.68 |
| 3. | cassava mixed with coconut palm | 22.22 |

VR - 1.50 NS

The analysis of data shows that the damages occurring at various growth stages vary significantly. If the damages observed at the time of uprooting (by *B.bengalensis*) were subtracted from the total, it is found that the role of damages at all the stages is almost the same. Statistical analysis shows that there is no difference in rodent damage with regard to farming systems. During the first year in intermixed farms of cassava and coconut, a high degree of damage was observed (Table 3.3). During the second year also, a high degree of damage is observed but does not reach any significant level, compared to other farming systems such as cassava monoculture and cassava with coconut and plantain. This may be due to the lack of other food sources for ground rodents, which are non-climbers, in coconut-mixed cassava farms.

The damage caused by rats to cassava is very serious. The present study has revealed that if persistent and effective control measures are not implemented the damage will reach up to 80 to 90 per cent. The data of the sample plots compared with the data collected from two ill-cared plots in the study area reveal this fact. On the other hand, proper control measures introduced at the right time (e.g., from the very beginning of crop planting itself) will reduce the damage to below five per cent.

Among the control measures, it is evident that indigenous traps are the most effective in the field. The author's previous study on comparison of folk traps and commercial traps also shows similar results (Kurian *et al*, 1997). The success of folk traps, compared to that of commercial traps and poisoning, is due to their environment-friendly design and simple appearance. Though they are labour-intensive and need technical expertise to set up, folk traps are the most successful and sustainable control measures in the field.

Besides, the control measures should be implemented in an integrated manner. The various control measures have varied effectiveness in different seasons. Rodents show differences in their preference to various baits in each season. Bait preference of rodents has been studied and reported elsewhere (Kurian *and* Oommen, 1996).

It is observed that during the summer season only chemical control measures are effective. In the rainy season, poisons will become detoxified before consumption (e.g., Zinc Phosphide). During rainy season, commercial traps performed better than in other seasons. Indigenous traps performed very well, irrespective of seasons or fields.

# 4. Rodent Damages to Coconut and Cocoa

## Introduction

The coconut palm is one of the most important and traditional crops of Kerala. It is widely cultivated in the State, even in the backyard of every house. Each and every part of the tree has some role to play in the life of Keralites. So coconut palm is considered *Kalpavriksha* (tree which grants all wishes) in the State.

This palm is botanically known as *Cocos nucifera L.* and belongs to the natural order *Arecaceae* (*palmae*). A number of indigenous, exotic, and hybrid varieties are now under cultivation in Kerala. The commonly cultivated indigenous varieties are West Coast Tall (WCT), East Coast Tall (ECT), Lakshadweep ordinary and Lakshadweep micro, dwarf varieties such as Chowghat Green Dwarf (CGD) and Chowghat Orange Dwarf (COD), and hybrid varieties such as WCTxCOD, WCTxCGD (Thampan, 1981). Preliminary enquiries revealed that differences in varieties do not make any changes in the preference pattern for rats, irrespective of variations in quality and thickness of copra, percentage of oil in copra, size of nut girth, thickness of kernel, and volume of water inside.

In most of the tropical countries, rodents are identified as one of the principal pests of the coconut. A number of studies exist on rodent problems done in many parts of the world; minor attempts at rodent control too have taken place. In Kerala also, several studies have been conducted (Kurian, 1970, Koya *et al*, 1975). The present exercise is aimed at identifying the pest species involved and the actual intensity of damage caused, through a sample study.

Cocoa is a recently introduced cash crop in the State that gained wide acceptance during the seventies. The cocoa plant, scientifically called *Theobroma cacao*, is cultivated in several parts of Kerala as an inter-crop with coconut and arecanut. There are two varieties of this species cultivated in the State, the crayola, which produces large violet-coloured pods and the forestero, the pods of which are greenish and comparatively small.

Of the two, forestero is the more widely cultivated. Cocoa is one of the few crops which failed to thrive in the State, due exclusively to the problem of rodent attack - of rats and squirrels. The majority of the smallholder cocoa farms have been replaced by other cash crops. There exist a few studies in rodent damages to cocoa in Kerala (Koshy and Philip 1995; Advani, 1990).

Rodents irrespective of their variety, size, and position on trees, damage cocoa pods. The present study analyses the extent of damage and the resultant economic loss.

## Method

### *Coconut*

Ten plots of 60-70 trees each were selected. The area of the plots ranged between 1 to 1.5 acres. Among the selected plots two had coconut alone, two had cocoa and plantain crops intermixed, two had cassava intermixed, and the rest had plantain crop intermixed. All the plots are surrounded by paddies except four that are adjacent to houses.

The agricultural activities, including the data on harvest of coconut were collected and recorded regularly. A field assistant visited each plot, everyday in the morning and the evening and collected the number and nature of damaged coconuts. ANOVA was done for the data.

***Cocoa***

Only four plots were in the study area. All the four plots, averaging an area of 50 cents (0.5 acres) with 70-75 plants, were selected for the study. Everyday the number and the nature of the damaged pods were recorded through direct observation. Analysis of variance (ANOVA) was used to compare the seasonal variations in damage as well as the plot-wise differences.

**Observations**

***Damage pattern***

**Coconut**

There are two types of damage occurring to coconuts: (i) Damage to the nursery-level plants (seedlings). Rats pick-out coconut seedlings from the sand and cause them damage. Rats also cause serious damage to young plants by boring through the crown to eat the cabbage. (ii) Damage at the crown of the trees. Nuts from the age of two to three weeks up to the fully ripened stage are damaged. Rats enter the crown of the palms and burrow into the immature nuts to drink the nutritive water in them and to eat the soft meat.

Nuts from the size of a grape fruit to the nearly mature green nut stage are susceptible; however, rats prefer nuts with softer and less fibrous husk. Typically, the damage consists of a single ragged-edged hole in the husk of green nuts made between the fourth and eighth month of development at the base, side, and in rare cases, at the distal end of the nut. The attacked nuts get damaged and eventually shed within two-six days.

The damage is severe in closely planted gardens where the rats can jump from one palm to another and remain on the crown for days together. In the study area, the average density of palms is 200-300 trees per hectare, which is lower than in Lakshadweep and other main coconut-growing States. But in mixed farms with other trees, especially rubber, damage is even higher.

Another interesting observation is that the damage is usually confined to 1-5 trees in a 60-100 tree plot. The rate was the same in all the plots. But it could not be found out why this type of preference remains. The damage is very irregular too.

The following are the principal rodent species identified as pest to coconut: Indian tree rat (*Rattus rattus wroughtoni*), coconut rat (*Rattus rattus rufescens*), Indian long-tailed tree mouse (*Vandeleuria oleracea*), large bandicoot rat (*Bandicota indica*), lesser bandicoot rat (*Bandicota bengalensis*), and field mouse (*Mus booduga*).

***Cocoa***

Rats and squirrels damage the cocoa pods from very young stage at an average 50 days of growth. But fully-ripened pods are the mostly attacked. Rodents gnaw the outer carp of the pods and make a hole through which they take out the seeds. After eating the juicy, sweet coating, the seeds are discarded.

In mixed farms, depending on the main crop of the farm, the extent of damage varies. In coconut farms, where cocoa is an intercrop, damage is found principally to coconut, then only to cocoa. But in arecanut, pepper, and rubber plantations, the damage to cocoa is the most severe.

Squirrels mainly attack during the daytime and rats at night, the latter being nocturnal. Rats usually damage the pod at the part near to the fruit stalk; squirrels, on the other hand, damage the mid-part. Squirrels are more active in the morning and the evening.

The following are the principal rodents that attack cocoa in the study area: Indian tree rat (*Rattus rattus wroughtoni*), house rat (*Rattus rattus*), Indian long-tailed tree mouse (*Vandeluria oleracea*), Indian coconut rat (*Rattus rattus rufescens*), and the common Indian striped palm squirrel (*Funambulus palmarum*).

**Control measures**

Control measures practised are mostly common to coconut and cocoa.

***Cultural practices***

Removal of harbourage in the coconut and cocoa farms and their adjacent areas is found to be effective to reduce the rat population.

Smoking burrows is very effective, but needs a little skill and is slightly labour-intensive.

Neem oil or powdered neem cake poured through the crown of the coconut palm would scare away the rats.

Observations made in two plots suggest that producing noise during mornings and evenings between 6 and 10, (periods of high rodent activity) by drumming with discarded tins or lashing with palm strands, regularly for a period of six months, reduces the damage by about 50 per cent.

In coconut trees, which stand alone, without their leaftips touching other trees, tin sheet or plastic sheet of one metre width covering the trunk at a height of 5-6 metre from the ground, will prevent the entry of rats to the crown.

Covering the palm trunk with twigs of *Ziziphus horrida*, a bushy, thorny plant, as suggested above, also prevents rat-entry to the crown.

Cocoa pods covered with red-ants will prevent the rodent attack; plants harboured with red-ants are usually discarded by rodents.

Spraying 1.5 percentage fish-oil soap on pods will scare away rodents.

Spraying 0.4 percentage neem-seed solution in cocoa plantation, six weeks intermittently and then onwards regularly reduces rodent attack.

Polythene bags, coated with fishoil soap or diluted tar (in kerosene) prevent the contact of rodents with cocoa pods. This method is very effective in small-holder farms.

Harvest of ripened pods every day and removal of the remnants of damaged pods regularly, is helpful in reducing rodent attack.

Isolating trees by cutting off twigs and leaves of cocoa and coconut that are in contact with neighbouring trees is an effective technique to prevent rat-entry.

Creating a fear in the minds of squirrels by pelting stones at them while they are on cocoa plants, will discourage their revisit for a minimum period of one week, according to the farmers in the study area.

**Chemical control measures**

Poison-baiting of the crowns as well as the ground is an effective control measure. Baits should be placed at the crown of the coconut palm and in the junctions of cocoa-branches. Zinc Phosphide mixed with suitable bait such as sweet maize-flour cake, bread, ripe banana, dried fish or the Bromadialone cakes will give moderate results. In the case of Zinc Phosphide, it is advisable to place 3 gm of poison in a 4-8 gm piece of the bait. Some helpful hints for effective baiting are given below.

Place the baits in selected positions before 6 pm and check the same spot before 6 am, the next day.

Poison should be covered completely with the bait material and not a trace of it should be exposed. Poisons are more effective during summer than during rainy seasons.

Freshly caught dragon flies and grasshoppers may be used as effective bait. Divide the abdomen of the insects with a blade and place 1-2 gm Zinc Phosphide and place the poisoned bait on coconut crowns and trunk top of the cocoa.

Ripe jackfruit, ripe banana, and ripe fruits of *Anjili* (*Artocarpus hirustus*) are favourite food for squirrels. The use of these fruits as bait gives better results.

**Mechanical control measures**

Among the 'commercial traps', the spring trap and live trap are the ones commonly used. Place such traps at the crowns of the coconut tree or the tree tops of cocoa, in a firmly tied position. All other types of commercial traps and folk traps such as plank traps may be set on the ground.

**Bamboo-pole trap**

A unique folk trap, specifically for the use at the coconut crowns, known as the 'bamboo pole' (Plate 4.1) is very effective to capture all arboreal rats.

A 20 cm-long bamboo pole, with a diameter of 4-5 cm; a rubber band 10 cm-long and 1 cm-wide cut out from a cycle tube; a 5 m-long 'food stick', made out of bamboo and a 4 cm-long trapstick, made out of arecanut stem; and 1-2 meters of steel wire are the requisites for the trap.

**Plate 4.1 Bamboo pole trap: set on a coconut crown**

The trap is fitted at the crown of the coconut by tying it with a coir-rope to leaf stalk or inflorescence stalk. Rats entering through the trap mouth will be hanged on the steel wire knot, which will get tensioned when the rubber band retracts to its original position when the rat touching the bait.

**Results and discussion**

The mean loss of coconuts in each plot is given in Table 4.1 and Table 4.2 and shown in Fig. 4.1. The frequency of damage in different seasons of the year varies.

**Table 4.1 Mean loss of coconuts due to rats in different seasons: first year**

| Sl No. | Season | Mean (No. of coconuts/acre) |
|---|---|---|
| 1. | January-March | 15.30 |
| 2. | April-June | 53.00 |
| 3. | July-September | 123.80 |
| 4. | October-December | 88.30 |

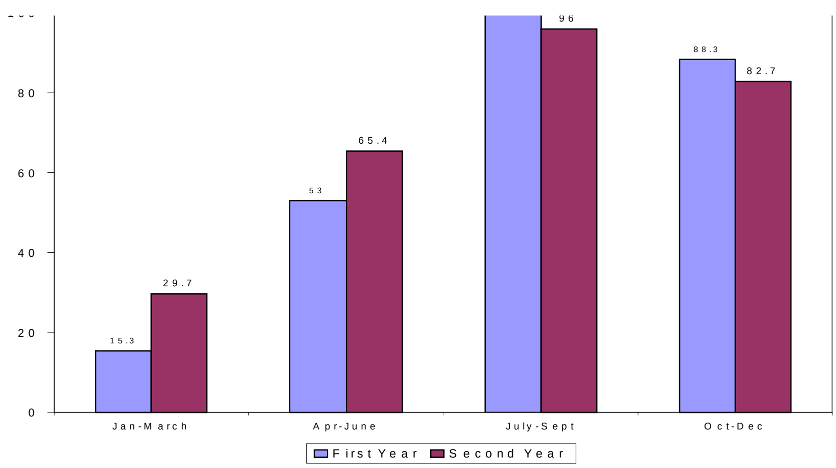
VR - 8.88 ** CD - 44.66
** significant for $P<0.01$

**Table 4.2 Mean loss of coconuts due to rats in various seasons: second year**

| Sl No. | Season | Mean (No. of coconuts/acre) |
|---|---|---|
| 1. | January-March | 29.70 |
| 2. | April-June | 65.40 |
| 3. | July-September | 96.00 |
| 4. | October-December | 82.70 |

VR - 3.89 ** CD - 41.58
**significant for $P<0.01$

**Fig. 4.1 Mean loss of coconuts due to rats in different seasons**




Statistical analysis of the data reveals that there is significant difference between seasons with regard to the mean loss of coconut. The mean percentage of damage to coconut in different farming systems is given in Table 4.3. It is evident from the data that there is significant difference only between monoculture coconut plots and plots having cassava and plantains along with coconuts.

The mean loss of cocoa due to rodents in the first and the second years of study is given in Table 4.4 and Table 4.5, respectively and is shown in Fig. 4.2.

**Table 4.3 Mean precentage damage to coconut in different farming system**

| Sl No. | Type of farming system | percentage mean damage |
|---|---|---|
| 1. | Coconut - monoculture | 8.87 |
| 2. | Coconut inter mixed with cocoa | 7.15 |
| 3. | Coconut mixed with coconut cassava and plantain tree | 3.07 |

VR - 1.50 NS

**Table 4.4 The mean loss of cocoa pods due to rodents in different seasons: first year**

| Sl.No. | Season | Mean |
|---|---|---|
| 1. | January-March | 31.25 |
| 2. | April-June | 69.50 |
| 3. | July-September | 199.75 |
| 4. | October–November | 256.50 |

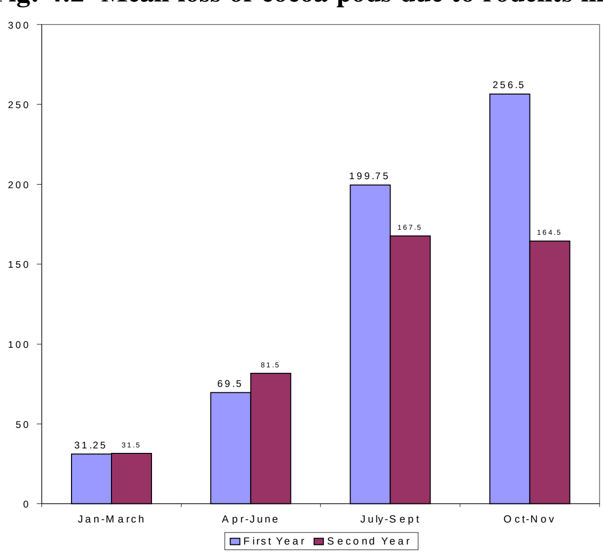
VR - 10.80 **
** significant for $P < 0.01$

**Table 4.5 The mean loss of cocoa pods due to rodents in different season: second year**

| Sl.No. | Season | Mean |
|---|---|---|
| 1. | January-March | 31.50 |
| 2. | April-June | 81.50 |
| 3. | July-September | 167.50 |
| 4. | October-November | 164.50 |

VR - 6.52**
** significant for $P<0.01$

**Fig. 4.2 Mean loss of cocoa pods due to rodents in different seasons**



The damage was the highest during July-September and October-November in both the years of study. While considering the period from January to December in a year, damage is found increasing month after month and reaching the maximum in November. The rodent damage to coconut in the study area is lower than in the prominent coconut-growing areas of the world. In Lakshadweep, the damage to coconut is 32 per cent and in Andhra Pradesh, it is 8.7 per cent (Vidyasagar, 1993; Mathew, 1996). But considering the low productivity in Kerala, the loss is significant.

In all coconut farms damage is confined to two to four trees. This fact provides a better chance for success of control programmes. The control measure could be confined to the affected trees only.

The highest loss due to damage was observed during July-September and the lowest during January-March. April-June loss is also at par with that during January-March. The high damage during July-September was mainly due to climatic reasons and the crop pattern of the area. Monsoon rains result in flooding in the area, and paddies and most of the low-lands remain under water till the end of September. During this period, the rodent population is forced to remain confined to upland crops; and the damage to coconut naturally becomes the maximum. Paddy-fields and low lands lie uncultivated till the end of May. The damage becomes the minimum in the upland during this period. The pest control managers should consider this aspect of seasonal migration of rodents, in designing control measures.

The statistical analysis shows that rodent damages to coconut do not significantly vary with the different farming systems. The highest damage was found in coconut farms with cocoa than in the monocultured farms and farms with cassava and plantains. This may be due to the concentration of arboreal rats such as *R. r. rufescens* and *R. r. wroughtoni* in the fields in which both coconuts and cocoa stand.

The highest damage was observed during October-November and July-September seasons. These are the months, which come close to or fall within the peak seasons of cocoa production i.e., November-January and May-August (John, 1979). But persistent and regular control programmes will save the crop (Vidyasagar, 1993). The control techniques may be used sequentially or simultaneously. The combined application of the various control measures would produce good results.

This may be also due to the confinement of rodents to terrestrial crops when low-lands lie submerged during the entire period of monsoon. Besides, for cocoa, November-January and May-August are the peak seasons of fruiting. It has been reported earlier by researchers that rain fall (here, monsoon) results in increased vegetation which provides rodents with increased food and shelter (Poulet, 1980). In these favourable conditions, reproduction and survival increase, eventually leading to high population densities and high damage to crops (Fiedler, 1988).

## 5. Rodent Damage to Rice and Sugar-cane

### Introduction

The rice crop has the distinction of being the most extensively cultivated in the world. Rice is known to have been cultivated in India since ancient times. The varietal diversity of cultivated rice in India is considered the richest in the world with the total number of varieties estimated to be around 2,00,000. (Krishnan and Ghosal, 1995). Rice, scientifically called *Oryza sp.*, belongs to the family *graminae*. In Kerala, rice and rice products are part of the Malayalee culture. Un-husked rice and spike bunches have been in use for centuries in rituals and festivals. Cooked, boiled rice is the staple item of the typical Kerala lunch. Besides, rice is traditionally cultivated in the State.

Kerala's rice possesses a wide diversity in morphological and physiological characters. Indigenous varieties such as *Thottaryan*, *Chempavu*, *Vellathil Kulappala*, *Peruvazha*, *Kochuvithu*, and *Edavaka* are nowadays not in common use. At present, hybrid varieties like 1285, IR-8 or TN-1, Culture, *Jaya*, *Thriveni*, *Jyothi*, and *Pavizham* are the common varieties. These varieties take between 90-135 days to attain maturity. In the study area there is only single cropping of rice from November-December to March-April.

Recently, in Kerala, rice cultivation is in a crisis due to the rising cost of chemical fertilisers and insecticides and also due to the lack of enough manpower supply for agricultural activities. The area under rice cultivation decreases rapidly from year to year. Though the damages caused by rats and the resultant economic loss is comparatively negligible, in the event of the present crisis, it becomes significant (Sanchez, *et al*, 1971). Moreover, rarely, but not so irregularly, rodent damages reach huge magnitudes. The damage of rice by field rodents is well documented (Barnett and Prakash, 1975; Jackson, 1977).

Sugar-cane is also one of the important crops widely cultivated in many parts of the State. It is scientifically known as *Saccharum officinanum* and belongs to the family of grasses, *graminae*. Indigenous varieties such as *Vellakkarimpu* were once the commonest here. But nowadays hybrids such as *Aluva*; *Java,* and Nursery (co.419; co.997 etc.) are the commonly cultivated varieties. Sugar-cane is an annual crop and the cropping season in the study area starts from February-March and ends up by November-December. During the past decade, the cultivated area of sugar-cane drastically declined to a meagre 0.18 percentage of the total cultivated land in the State (Gangadharan, 1998). The switchover of farmers from this crop to others is not only due to economic factors, but because of the uncontrollable damages caused by rodents as well.

### Method

Ten plots of rice in the study area were selected as the sample. Each plot is approximately of 1-1.5 acres in area but all of them lie surrounded by a minimum area of five hectares of rice crop. Among the selected fields, four were surrounded by the rice crop on all sides; two were close to house plots; another two were adjacent to upland cultivated with coconut and cassava and the last two were in the centre of a raised land, appearing like a pit.

A field assistant searched all sample plots every morning for heaps of cut-tillers or single tillers and recorded all damages including rodent activity signs. The number of cut tillers at each damage spot was counted and the remains measured. ANOVA was done with the collected data to find out the seasonal differences in damage.

In the case of sugar-cane, sampling was conducted through line transect method in a large 10-hectare single plot. The programme was conducted twice a year, first at an age of 4-5 months of growth (when the sugar-cane stems got the sweet taste and the crop became a thick growth) and the second, at the age of 9-10 months of growth (just before the harvest). While sampling, the number of canes with damaged roots, with damage to one or two internodes, and with damage up to half the total length, was recorded separately for the analysis.

## Observations

### *Damage pattern*

#### Rice

The rodent attack starts from the time of sowing of seed itself. Rats take away the sprouted seeds from the field and eat them. In upland cultivation, such damage is more, especially at the nursery stage. The damaged areas will appear as ploughed ground. The damage is more in areas near to the dikes and adjacent to raised lands. It reaches the highest level by about 30-45 days of growth after sowing. In the case of transplanted wet rice, this period will extend up to 40-65 days of growth. Again, at the growth stage of 50-80 days, the damage increases, when the rats eat the sweet tender spikes (milky stage). Besides, damage occurs irregularly at every stage of growth.

The following are the important rodent species that attack rice in the study area: large bandicoot rat (*Bandicota indica*), lesser bandicoot rat (*Bandicota bengalensis*), house rat (*Rattus rattus*), field mouse (*Mus booduga*) and the water rat (*Rattus rattus norvegicus*).

#### Sugar-cane

There are two types of damages found in sugar-cane caused by rodents: first, uprooting of canes by damaging the root system, which eventually leads to the complete loss of the cane; second, the more common type, in which rats gnaw the internodes for eating the sweet flesh. The damage to the stems may reach up to 1-5 internodes of a stem. Sometimes the damage may be only in one internode at a height of half the length of the cane. In that case, the stem bends down at the damaged spot causing loss of the complete cane.

The following rodents are identified as pest to sugar-cane in the study area. Large bandicoot rat (*Bandicota indica*), lesser bandicoot rat (*Bandicota bengalensis*), house rat (*Rattus rattus*), and field mouse (*Mus booduga*).

## Control measures

Most of the control measures in the study area are the same for both rice and sugar-cane such as the following.

***Cultural practices (Indigenous control techniques)***

(i) Field sanitation of the cropfield and adjacent plots, dikes, and stone walls, reduces rat menace;

(ii) Closing and filling of burrows on dikes, just before the sowing is an effective measure;

(iii) Flooding of burrows by artificial means will kill the rats, especially the young ones;

(iv) Growing repellent plants like *Echites malabaricus*, *Plumbago rosea*, and *Vetiveria zizanioides*, on dikes of rice will keep away the rats to some extent;

(v) Mixing the rice seed with 50 kg of powdered neem cake per acre, at the time of sowing reduces rodent damage;

(vi) Pouring kerosene on the dikes once a week would reduce rodent attack;

(vii) In paddies tying worn-out video tape films or audio cassette films across the field and just above the leaf canopy is an effective trick to scare away rats. The noise produced from such tapes, fluttering in the wind, is the reason for the scare;

(viii) Drumming discarded tins or coconut shells from 6 pm to 10 pm is also a good device to keep away rats. This is effective in sugar-cane fields also;

(ix) Plastic flags made out of used carry bags, (preferably, of white colour) placed in the field also produce noise frightening for rats. Hanging strips of banana stem husk and tender coconut leaves is another effective technique;

(x) Closing of burrow mouth with twigs of the plant, *Zizyphus horrida* is helpful to stop the entry of rats into the field; and

(xi) Predation is the best form of biological control. Place small stumps or coconut leaf stalk intermittently in the field to provide a sitting place for the owls, the best known predator of rats.

***Chemical control measures***

Zinc Phosphide is not an effective rodenticide in paddies and sugar-cane fields. The water-clogged condition is not favourable for proper action of Zinc Phosphide. But Bromadialon cakes are effective. Some techniques employed by farmers for better poisoning are given below.

The visceral mass (flesh) of apple snail (*Pila globosa*) is a favourite food of water-rodents. It can be used as bait for poisoning. Divide the flesh into two halves (not completely separated) and place 2 gm of Zinc Phosphide, and press the halves into one piece, and place it in the field.

Nymphae fruit is a good bait, being a favourite food for rats.

Take an empty molluscan shell and put 2 gm of rodenticide into it. Pour 2 ml of egg white over it. Place the shell in the field. Rats will gulp it down greedily.

Poisons should be placed in bait-stations made out of coconut shell/husk, or banana stalk.

***Mechanical control measures***

Among the commercial traps, live traps and spring traps are the most effective, in paddies and sugar-cane fields. A few suggestions for better results are given below.

(i) Place the traps on the dike and in the field in the rat-paths. If burrows or heaps of burrowed soil are seen, place the traps near to them.

(ii) Tie the traps to a stalk piled into the earth, so as to avoid dragging the traps by rats, after trapping.

(iii) Nymphae fruit, flesh of apple snail; molluscan flesh, sweet-maize flour cake, and dried fish are the best baits for traps.

(iv) Cover the entrance of the traps with mud, while placing the traps in the field.

(v) There are a few indigenous traps, invented by local farmers, in common use. Such traps that can be effectively used in paddies are described below.

**Earthen pan trap**

This is a novel trap (Plate 5.1) that can be set in water or swamps and is very effective to trap water-rats. This trap is set on a plank, which is supported on four stumps piled into the bottom of the field.

A plank of size 45x35x3 cm, an earthen pan of flattened bottom, having a minimum diameter of 30 cm; a ramified plant twig of an average length of 20 cm, a tin-sheet 2 mm thick and 25x1cm in size; one or two metres of jute string and five to ten 1'' nails are the materials required for this trap.

The earthen pan is placed in a slanting position on the jute string that makes a contact between the ramified twig and the tin sheet. Tin sheet strip bears the bait. The rat trying to touch the food gets trapped under the pan; it can be killed by immersing the whole trap with plank, under water.

**Results and discussion**

The mean loss of rice, at different stages of growth, during the first and second year, are given in Table 5.1 and Table 5.2 respectively and shown in Fig. 5.1.

**Plate 5.1 Earthen pan trap**

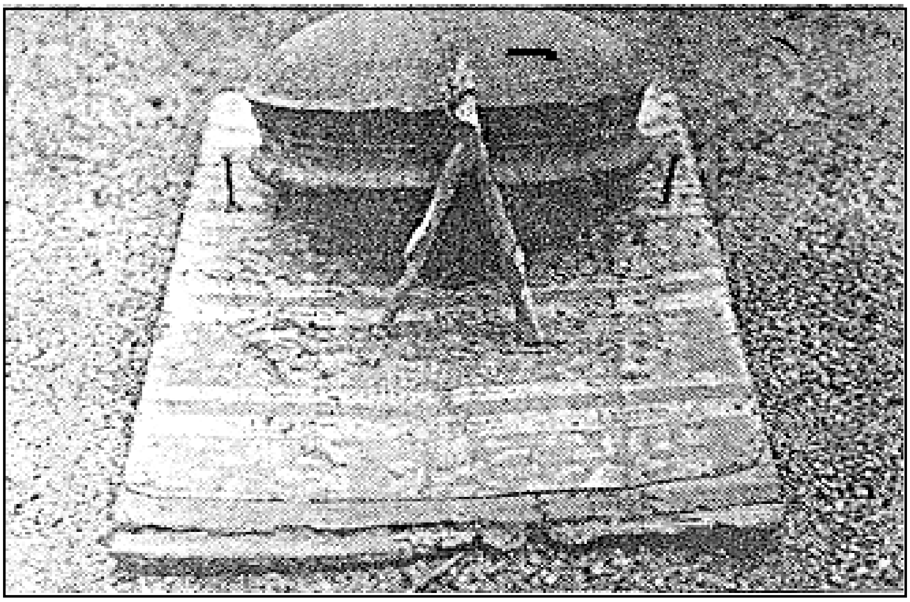


**Table 5.1 Mean loss of rice, at different stages of growth: first year**

| Sl No. | Stage of growth of the rice | Mean (No of tillers/acre) |
|---|---|---|
| 1. | 1-30 days | 1.72 |
| 2. | 31-60 days | 2.90 |
| 3. | 61-90 days | 2.12 |
| 4. | 91-120 days | 0.47 |

VR - 5.03 **

** significant for $P < 0.01$

**Table 5.2 Mean loss of rice at different stages of growth: second year**

| Sl. No. | Stage of growth of the rice | Mean (No of tillers/acre) |
|---|---|---|
| 1. | 1-30 days | 1.47 |
| 2. | 31-60 days | 3.25 |
| 3. | 61-90 days | 2.30 |
| 4. | 91-120 days | 0.62 |

VR - 9.17 **

** significant for $P < 0.01$

The percentage mean damage to rice in different locations characterised by varied circumstances is given in Table 5.3 and Table 5.4.

**Fig. 5.1 Mean loss of rice at different stages of growth**

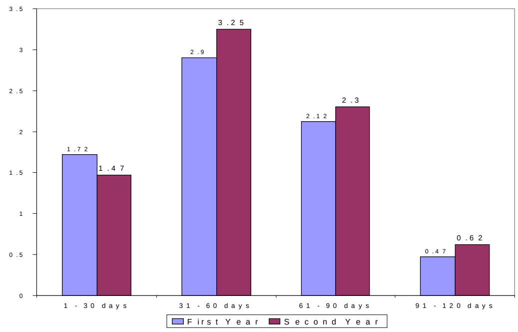



**Table 5.3 Percentage mean damage to rice in different field environments: Ist year**

| Sl No. | Field environment of the paddy | Percentage mean damage |
|---|---|---|
| 1. | Near to coconut farm (upland) | 0.19 |
| 2. | In the midst of a vast stretch of paddy | 0.44 |
| 3. | Close to road with transport | 0.18 |
| 4. | Near to housing plots | 1.03 |

VR - 2.97**
** significant for $P<0.01$

**Table 5.4 Percentage mean damage to rice in different field enviornments: IInd year**

| Sl No. | Field environment of the paddy | Percentage mean damage |
|---|---|---|
| 1. | Near to coconut farm (upland) | 0.04 |
| 2. | In the midst of a vast stretch of paddy | 0.18 |
| 3. | Close to road with transport | 0.29 |
| 4. | Near to housing plots | 0.69 |

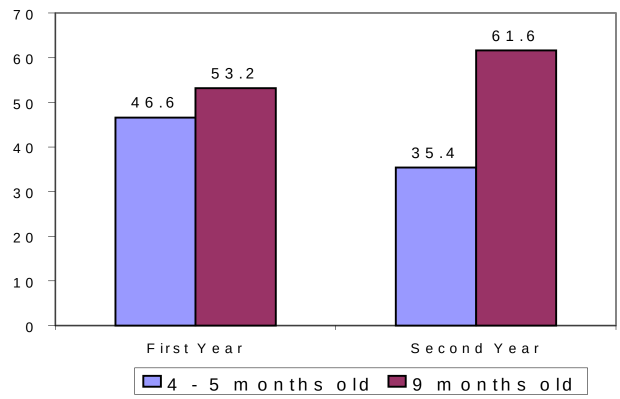
VR - 3.65**
** significant for $P<0.01$

The data on damages to sugar-cane are given in Table 5.5 and shown in Fig 5.2.

**Table 5.5 Mean loss of canes due to damaged internodes**

| | | Ist year | IInd year |
|---|---|---|---|
| 1 | Sample I (at 4.5 month old stage of growth) | 46.6 | 35.4 |
| 2 | Sample II (at a month old stage of growth) | 53.2 | 61.6 |

**Fig. 5.2 Mean loss of canes due to damaged intermodes by rats during difeeerent stages of growth**




It is observed that the damage to sugar-cane is severe in the fields where annual floods occur, during and just after flooding. The overall cane loss due to the damage to internodes is 80 per cent.

Rodent damage to both rice and sugar-cane is very serious and causes considerable economic loss. During the study period, the highest damage to rice was observed in the growth period of 31-60 days. Damage occurred during the seedling stage (1-30 days) is about equal to damage at the milky ear-head stage (61-90 days). The lowest level of damage was observed during the grain stage (91-120 days).

These data are in conformity with earlier statistics on pre-harvest damage in Philippines and other Asian countries (Fall, 1977). Though the percentage of damage seems to be small, it is significant because much of the rice is grown on small farms. Heavy damage in a few fields can be a serious economic problem for the individual farmers concerned.

Variations in the field environments have also significant impact on damage rate. However, the highest damage was observed in the first year on farms surrounded by paddies; but in the second year it was in the farms near to roads with vehicular transportation. Fall (1977) observed that crops in fields near to unfarmed areas and those bordering roads or irrigation canals are often more heavily damaged than others, presumably because of the additional rat harbourage provided by them. During both the first and the second years, the least damage was observed in paddies near to upland coconut farms.

The damage in paddies near to house plots was equal to that of the fields near to the coconut farms. The low damage in these fields may be due to the availability of alternative food sources. In the first case, rodents have no other choice of food. Most of the rodents have a very limited range and territorial movement. Elias (1988) and Quick (1991) reported that most of the rodent species are capable of feeding on a wide variety of native plants, but they cause economic damage primarily in monocultures of concentrated agricultural crops such as rice. This is the case in the present study also.

It is found out that the control measures currently being used, do not yield good results, due to lack of integration of the techniques used and absence of a proper scientific programme. It is important that the different types of control measures are well-integrated taking into various physiological, economical, and ecological factors. Besides, the damage in the paddies is not regular; it varies in its intensity too, from year to year.

In the case of sugar-cane, a very high percentage of damage was observed (Table 5.6). It is clear that the damage to sugar-cane, mainly to the internodes, starts at the time of cane formation and persists at significant levels till the harvest. During flooding, the extent of damage suddenly rises. This is because of the evacuation of rats from the burrows and their resulting confinement to the exposed canes. Damage of sugar-cane is very high, but it does not correlate directly with a drop in sugar yield, because many plants, though partially damaged, do retain some sugar content at harvest. But rodent gnawing on the internodes of growing plants kills stalks and increases the incidence of secondary infection. The resulting damage diminishes juice quality and reduces yields.

**Table 5.6 Percentage of damage to sugar-cane caused by rodents**

| | | **First year** | | **Second year** | |
|---|---|---|---|---|---|
| | | **At 4.5 months old stage** | **At 9 months old stage** | **At 4.5 months old stage** | **At 9 months old stage** |
| 1 | Total no of canes examined | 400 | 420 | 400 | 410 |
| 2 | Percentage of canes with damaged roots | 1.0 | 0.72 | 1.5 | 0.73 |
| 3 | Percentage of canes with damaged intemodes | 58.25 | 63.34 | 44.25 | 75.12 |
| 4 | Percentage of canes with damage to 2 internodes up to half of the stalk | 28.25 | 25.47 | 22.50 | 36.58 |
| 5 | Percentage of canes with more than half the stalk damage | 30.00 | 37.85 | 21.75 | 38.53 |

The implementation of control measures in sugar-cane fields is comparatively difficult due to the high density crop pattern and other environmental factors.

It is clear that a persistent and integrated control programme is needed for a successful control programme of rats in rice and sugar-cane.

# 6. Rodent Damage in Houses and Shops

## Introduction

Among the household pests, rats have been found to occupy a significant position from very ancient times onwards. Rats actually evolved with human cultural and social evolution. When man lived as a nomad, rats enjoyed shifting from place to place, harbouring on his luggage and eating upon his food and other holdings. The evolution of man from hunter to cultivator (agriculture) must have had an effect on the rodent world nearly as profound and far reaching as it had on his own. In many areas, some species - especially seed eaters - no longer had to search for wild plants, since cultivated crops ensured a regular and plentiful food supply.

Today, with the sole exception of man, the most successful and abundant mammals on earth are the house rats and mice. They would have never enjoyed this success without man's inadvertent help. After acquiring this adaptation to live with man, rats have taken advantage of human transport and trade routes and in this way spread from their ancestral houses in Asia to all the continents of the world.

At present, wherever human beings are, rats also abound. Rat species usually found in houses and shops (in close association with man) are referred to as 'commensal rodents' due to the fact that these animals live at man's expense, invading his house, eating his food, and damaging his commodities. They are capable of transmitting diseases to man, who thus derives no benefit from the relationship (Brooks, 1990).

The commensal rats and mice have had a profound effect upon man. They spread a number of diseases such as Plague and Leptospirosis, and contaminate food stuffs with bacteria that produce salmonellosis, a form of food-poisoning. They cause losses of stored foods throughout the world. In India, the commensal rodents cause a loss of 2.5 per cent of stored foodgrains in governmental grain storages (Panse Committee report, 1990). It is estimated that about 20 times the grains fed by rats are destroyed due to contamination with rat's excreta, urine, hair, and carcass.

Besides the loss of stored foods, is the damage to man's structures, fiber, and fabrics. The commensal rodents gnaw their way through barriers to obtain food and shelter, damaging doors, windows, walls, and floors. Even as the damages and dangers posed by the rats are on such a high scale, very little organised efforts by man have gone into controlling them. It is almost accepted that rat damages are part of life, due to persistent failure of control measures.

The present study has made an attempt to assess the actual loss due to commensal rodents in houses and shops of the study area.

## Methodology

Ten shops were selected as the sample units. Details of the selected shops are given in Table 6.1.

**Table 6.1 Baseline data of the sample shops**

| Shop No./ Sampling Spot No. | Area (in sq.ft) | Age of the Structure (in years) | Type and Rodent-proofing Status | Major Items handled(quantity/week) (only 'vulnerable' items shown) |
|---|---|---|---|---|
| 1 | 8 x 5 | 25 | Street shop Poor | Toffees in plastic bottle– 500 gm each (3-5 items) Chips and mixture in packets –100 gm each; 15 packets. Plantain Fruit – 20 kg; Arecanut – 25 Nos.; Soaps and detergent cakes –10; Biscuits – 200 gm.; Battery - 12–15 Nos.; Lemon - 25 |
| 2 | 20 x 10 | 9 | Grocery shops Medium | Grains 75 kg. Chips etc. -10 packets; Vegetables 25 kg.; Pulse - 10kg; Sugar - 30 kg; Soaps-15; Bread, Biscuits -10 packets; Plantainfruit - 20 kg. ; Dried fish – 5 kg. |
| 3 | 10 x 8 | 10 | Grocery shop Poor | Rice–30 kg; Wheat flour–25 kg; Soaps-15, Maize flour-25 kg; Mixture/chips-10 packets, 100 gm each;Vegetable 20 kg; Rubber chappal-2 pairs Cattle feed–30 kg;Bread-10packets |
| 4 | 8 x 8 | 6 | Street shop Very poor | Toffees in plastic bottle-500 gm each (3-5 item) Chips and mixture in packets-100 gm each, 15 packets;Plantain fruit-20 kg; Arecanut 25 Nos. Soaps and detergent cakes -10 No.s Biscuits - 200 gm; Battery-1-15 Nos.; Lemon - 25 |
| 5 | 20 x 10 | 15 | Grocery shop Very poor | Rice - 30 kg, wheat flour - 25 kg, Soaps -15, Maize flour-25 kg; Mixture/chips -10 packets,100 gm each; Vegetable - 20 kg, Rubber chappal - 2 pairs; Cattle feed - 30 kg; Bread - 10 packets |
| 6 | 15 x 10 | 24 | Grocery shop Medium | Grains - 75 kg.; Chips etc. -10 packets; Vegetable - 25 kg; Pulse -10 kg, Sugar - 30 kg; Soaps -15, Bread, Biscuits -10 packets, Plantain fruit - 20 kg, Dried fish - 5 kg. |
| 7 | 15 x 10 | 18 | Grocery shop Poor | Rice - 30 kg; wheat flour - 25 kg, Soaps -15, Maize flour -15 kg; Mixture/chips-10 packets, 100gm each; Vegetable-20 kg, Rubber chappal-2 pairs, Cattle feed-30 kg;Bread-10 packets |
| 8 | 15 x 10 | 12 | Grocery shop Medium | Grains – 75 kg; Chips etc – 10 packets; Vegetable – 25 kg; Pulse –10 kg, Sugar – 30 kg, Soaps – 15, Bread, Biscuits – 10 packets, Plantain fruit – 20 kg, Dried fish – 5 kg. |
| 9 | 10 x 10 | 25 | Ration shop Poor | Rice – 900 kg, Wheat – 450 kg, Sugar – 150 kg, Kerosene – 500 Litre |
| 10 | 20 x 10 | 15 | Ration shop Medium | Rice – 900 kg, Wheat –450 kg, Sugar – 150 kg, Kerosene – 500 litre |

A field assistant visited all the shops daily and recorded the items, quantity lost, and nature of damages caused by rats during the previous night. The indirect losses, such as loss due to contamination of rat exereta, hair and urine, were recorded separately.

## Observations

### ***Commensal rodent species***

The most common commensal rodents are house rats (*Rattus rattus*) and house mouse (*Mus musculus*). Besides these animals, brown rat (*Rattus rattus norvegicus*) and some other subspecies are also found in Kerala, according to earlier reports.

## Damages

The damages in shops and houses may be categorised into two: direct and indirect.

Damages such as contamination of food items due to the excreta, hair, and urine of rats and secondary damages due to rodent attack are referred to as indirect damages. It is estimated that rodents contaminate 20 times more than what they consume, with their faeces, urine, hair, and sometimes even with their own dead bodies (Brooks and Lavoie, 1990). However, there is practically no way to quantify and measure most of the indirect damages. The indirect damages observed are listed below.

(i) Gnawing on electrical wires, causing short circuits that lead to fire inside walls.

(ii) Contamination of open sacs containing sugar, rice, wheat-flour, etc., in shops, with excreta, urine, hair, and carcass. Shop-owners are reluctant to report such damages fearing loss and reduced sales.

(iii) Contamination of foodstuff results in common food-poisoning, Salmonellosis, caused by the bacteria *Salmonella*.

(iii) Rodents gnaw holes in bags causing grains to be spilled on to the floor or the ground. The grain often swept up with dirt, mould, and faeces is rebagged and sent on for milling. Commensal rodents together with field rodents cause or spread several diseases. Among them, Leptospirosis (rat-fever) is the most common and widespread in Kerala. During the study period, this disease affected about twenty persons and took two lives in the Vijayapuram panchayat. The fatal stage of the disease is known as 'Weils disease' and the pathogen is a bacterium called *Leptospira icterohemorrhagiae*. The disease has recently become very common in the central Travancore area and the death toll in the past one year was more than 300 lives (unofficial statistics).

Other common rat-mediated diseases such as Plague, Leishmaniasis, and Rat-Bite fever are not reported in the study area.

## Control measures

Control measures are rarely employed by shop-keepers; a few used, however, to conduct mechanical or chemical treatment during peak periods of rodent damage. The commonly employed measures in the study area are the following.

**Cultural practices**

Sanitation of shops once in a week and removal of all types of waste from the shops and adjacent area is a measure commonly used. Domesticating cats in the shops is an effective control measure. The comparatively low damage in one of the shops in the sample was the result of the predatory nature of a cat that visited the shop every night.

Covering the top of plantain bunch and other hanging objects with plastic sheets or newspaper prevents the entry of rats to them through the rope.

***Chemical control measures***

In the midst of a number of food items, this method is not advisable for preventing contamination of food with poison and carcass. If the method is used, strict care should be taken. Some of the precautions to be taken in employing poisons are given below.

(i) Close the open sacks and other exposed food products with polythene sheet before placing the poisoned bait.

(ii) Prepare safe bait stations with bamboo-pole or discarded powder tin with (both ends open) and place the poisoned bait, in places not reachable by children and other domestic animals.

(iii) Place the bait stations in the regular rat-paths.

(iv) Place the poisoned bait before 6 pm and check it before 6 am. Thorough checking should be conducted for any balance of the bait.

***Mechanical control measures***

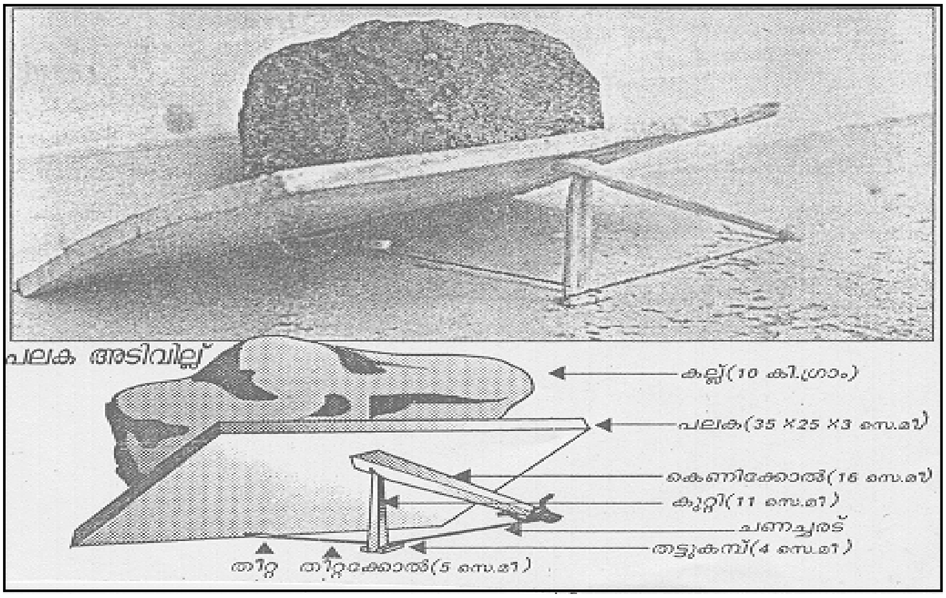
Among the commercial traps, live traps are found to be more effective. Special care should be taken to place the traps one metre away from sacks and food items, to avoid chances of the urine of the trapped rats spilling over to them. Two types of folk traps are in use: little plank trap and withered-coconut trap.

**Little plank trap**

This trap (Plate 6.1) is very efficient to capture all species of commensal rodents. It also avoids accidental trapping of domestic animals.

It consists of a wooden plank of 3 cm thickness and a size of 35x25 cm; two arecanut laths of 11 cm and 16 cm length; a coconut leaf-midrib of 25 cm and a strong jute string of 18 cm length. A large stone weighing about 10 kg, placed on the plank will ensure the trapping.

**Plate 6.1 Little plank trap**

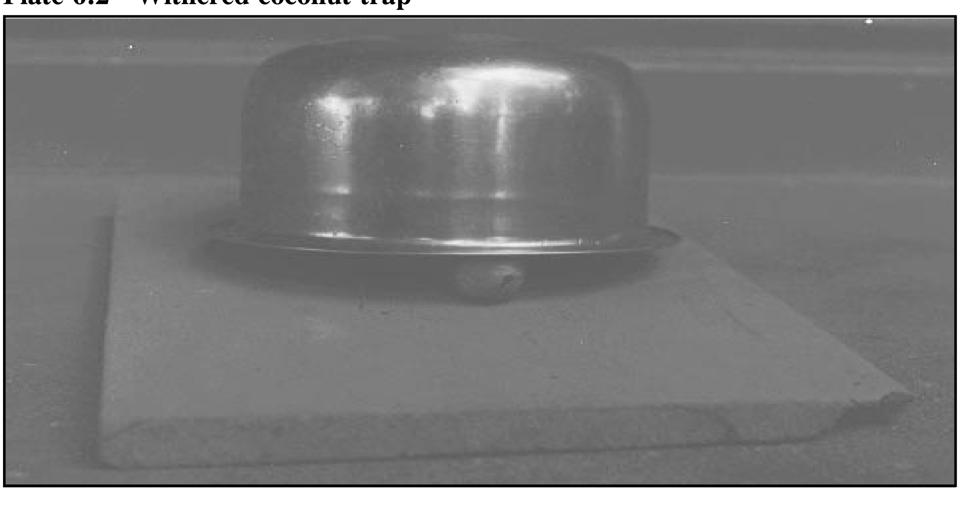



**Withered-coconut trap (*Machingakkeni*)**

This is an indigenous simple trap (Fig. 6.2) made with a tender, withered coconut and a 15 cm-long coconut leaf mid-rib. A steel vessel of 25 cm diameter and 10 cm height with a flat mouth edge and a wooden plank of 40x30x2 cm size are the other materials required.

The coconut leaf mid-rib, pitted into the withered coconut, bears bait on the other end. The vessel is placed on the tender coconut in a slanting position so as to let it fall on to the plank when the rat touches the bait. Trapped rats may be killed by dipping the whole set-up, in water.

**Plate 6.2 Withered coconut trap**



**Results and discussion**

The damage caused by rats in shops is significant, though it is lower than in the fields. The wide range of items attacked by rodents, irregularity of their attack, and the very serious indirect effects are remarkable.

We were able to measure only direct damages. The items, which are regularly damaged and the quantity lost, are given in Table 6.2. The data show that the extent of damages caused to plantain fruits, vegetables, and grains come to 1.41 per cent, 2.85 per cent, and 0.42 per cent respectively in the first year; the corresponding figures for the second year were 0.83, 2.21 and 2.10 respectively. A number of other items are also damaged by rodents such as grain bags, rice flour, wheat flour, and maida bags; food items packed in polythene covers (chips, fried food, etc.), dried fish, tubers, coconut, toilet soaps, coir bundles, rubber chappals, plastic buckets, wooden furniture, and even currency bundles. But such damages happen only once in a while; they are not of measurable magnitude either.

The percentage of damage observed in our sample is in agreement with that reported in earlier studies. Grain consumption by rodents in storages of Food Corporation of Bhutan was estimated at about 2.6 per cent and an additional 25 per cent to 50 per cent of the stored grain was contaminated with faeces, urine, and hair (Brooks and Lavoie, 1990). The estimate of about 2.5 per cent loss of grains in Indian grain storages given by Panse Committee (1990), also agrees with the present findings.

The high level of rodent infestation in shops was due to poor rodent-proofing measures and good harbourage facilities. Moreover, the control measures employed by shop-keepers were confined to trapping during two or three days when peak damage was caused. Chemical treatment using poisons was employed rarely. It is considered too dangerous for use in the midst of numerous substances. All the factors provided ample facilities for rats to multiply in large numbers and infest the nook and corner of buildings.

The biological adaptations of commensal rodents are also a factor that helps them to occupy any type of building (Ahmad *et al.*, 1990). The capacity to breed all the year, low mortality, ability to acquire a nutritionally-balanced food under any circumstances, special sensory and physical abilities concerning vision, smell, hearing and touch, and physical abilities such as for climbing, jumping, diving, swimming, and gnawing are the important adaptations of rats which enable them to live with man.

The study clearly points out that most of the losses are directly associated with poor and inadequate storage conditions, lack of sanitation and good house-keeping, and improper food handling practices. Brooks and Lavoie (1990) reported that this is a worldwide situation, based on their studies in grain storages of Pakistan, Bangladesh, Bhutan, Kenya, and Yemen. A typical example in our study was that of a shop which had medium grade rodent-proof building, where the damage was very high. The reason was the rolling shutter of the concrete building that had a single hole in it; 40-50 house rats were found residing in it. The killing of rats followed by the closure of the hole in the shutter reduced the damage to zero, there being

Table 6.2 Principal items damaged by rodents in shops

| Shop No. | First Year | | | | | | Second Year | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plantain Fruit | | Vegetables | | Grains | | Plantain Fruit | | Vegetables | | Grains | |
| | A mount handled /year | Loss% | Amount handled year | Loss% | Amount handled /year | Loss% | Amount handled year | Loss% | Amount handled year | Loss% | Amount handled year | Loss% |
| 1 | 1000 kg | 1.428 | 1300 kg | 4 | - | - | 1000 kg | 0.79 | 1500 kg | 2 | - | - |
| 2 | 1040 kg | 0.57 | 1000 kg | 6 | - | - | 1040 kg | Nil | 1300 kg | Nil | - | - |
| 3 | 1000 kg | 1.785 | - | - | 1500kg | 0.8 | 1000 kg | 1.23 | - | - | - | - |
| 4 | 800 kg | 0.125 | 1000 kg | 0.5 | - | - | 1200 kg | 0.98 | - | - | - | - |
| 5 | 1000 kg | 4.285 | 1000 kg | 1.5 | - | — | 100 kg | 0.74 | 1300 kg | 1.30 | - | - |
| 6 | 1040 kg | 1.16 | 1300 kg | 1.23 | - | - | 1000 kg | 0.38 | 1500 kg | 3.67 | - | - |
| 7 | 1000 kg | - | 1000 kg | 1.25 | - | - | 1000 kg | 0.71 | 1000 kg | 1.95 | 1800 kg | 2.1 |
| 8 | 1000 kg | 0.28 | 1300 kg | 1.0 | - | - | 1000 kg | 0.46 | 1000 kg | 2.11 | - | - |
| 9 | - | - | - | - | Rice 46800 kg | 0.032 | - | - | - | - | - | - |
| 10 | - | - | - | - | 46800 kg | Nil | - | - | - | 2.206 | - | - |
| Ave rage Loss | | 1.409 | - | 2.85 | - | 0.416 | - | 0.83 | - | 2.206 | - | 2.1 |

no other entrance to the shop for the rats. The construction of rodent-proof structures, well maintained storage facilities, and properly designed control programmes will reduce the rodent damage to a negligible level (Ahmad *et al*, 1988). It is, therefore, very important to construct fully rodent-proofed buildings for shops. It is also advisable to employ different types of control measures on a regular basis to keep away rats.

# 7. Rodent Population Estimate

## Introduction

Rodent population estimates are important to assess the economic loss due to them and to evaluate the success of control measures. Population estimates are helpful in calculating the extent of grain loss to rodents or in following the seasonal changes that occur in field crops during the several growing cycles. Rodent population is mostly related to the ecological conditions in rural dwellings (Yashoda *et al,* 1979). Each dwelling has its own ecosystem. Population size depends mainly on the varied habitats, food sources, and status of sanitation existing in the premises. The population estimates not only give the number, but also the species involved, population cycle, habitual preference, and factors such as inter-crop migration.

There are a number of standard methods and techniques to assess the rodent population density. The known methods include surplus baiting (Chitty, 1942), live trapping (Davis, 1964), and rodent activity survey. Some methods give information on the distribution, size, and species composition of the population while others give only indirect information such as on activity measures. Hence for the present programme, considering the small sample size and the limited period of study, a combination of direct and indirect survey techniques has been used.

## Method

The population estimation has been done using removal trapping technique coupled with tile tracking method. The removal trapping method is based on the standard minimum method of Grodzinski Pucek and Ryszkowski (1966), modified by Pelikan (1971).

In this case, a large number of traps were dispersed in a 4x4 grid inside the shops and 8x8 grid in the field. About five traps were set in 8x5 sq. ft shop building and 30 traps were set in a one-acre cropfield. Trapped animals were removed twice every night, first at 10 pm and second the next morning at 6 to minimise the effect of immigration and emigration. The programme continued for 21 days uninterrupted, and was conducted once in a year during the July-August season. The study was conducted in the field for the crops of coconut, rice, cassava, and sugar-cane in each one hectare plot.

Tile marking has been used here only to check the residual rodent population, if any, and not as a measure of population density. Hence the data are not referred to here. Vinyl-chloride-coated tiles were placed with suitable baits to attract rats and analysing footprints to determine the presence of rats.

## Results and discussion

### *Population density*

Population density (number per hectare) of rats in the crop fields is given in Table 7.1. The highest population density was observed in the cassava plot, i.e., 68.5 per cent per hectare, and the next in the sugar-cane field i.e., 61.0 per cent per hectare, due probably to the good harbouring facilities in these fields.

**Table 7.1 Population density of rats in various crop fields**

| Crop | Cassava | | Coconut | | Rice | | Sugar-cane | |
|---|---|---|---|---|---|---|---|---|
| Period of Study | 1st year | 2nd year | 1st year | 2nd year | Ist year | 2nd year | 1st year | 2nd year |
| Total Number of rats captured in one hectare | 65 | 72 | 42 | 38 | 34 | 41 | 58 | 64 |
| | **Species composition** | | | | | | | |
| *B. Indica* | 18 | 26 | 8 | 5 | 14 | 14 | 26 | 29 |
| *B. bengalenis* | 10 | 7 | 5 | 4 | 3 | 4 | 4 | 3 |
| *R.rattus rattus* | 16 | 21 | - | 3 | 9 | 11 | 14 | 16 |
| *R.r wroughtoni* | 2 | - | 9 | 8 | - | - | - | - |
| *R.r rufescens* | - | 1 | 10 | 6 | - | - | - | 1 |
| *M.booduga* | 19 | 17 | 10 | 12 | 8 | 12 | 12 | 15 |

Note: These values are based on a single programme every year, so it is not scientifically correct to make any further conclusions. A large number of musk shrews (*Suncus murinus*) were in the catch, but their number is discarded being an insectivore.

**Table 7.2 Rodent pest species of the study area**

| No. | Common Name | Scientific Name | Preferable Crops/Food |
|---|---|---|---|
| 1 | House rat | *Rattus rattus rattus* | Rice; coconut; cassava; cocoa; stored grains; vegetables; sugar-cane |
| 2 | Tree rat | *Rattus rattus wroughtoni* | Cocoa, coconut, sugar-cane |
| 3 | Coconut rat (Roof rat) | *Rattus rattus rufescens* | Coconut, cocoa, household items |
| 4 | Water rat (Brown rat) | *Rattus rattus norvegicus* | Rice, cocoa, cassava |
| 5 | House mouse | *Mus musculus* | Stored grains;fruits; vegetables |
| 6 | Field mouse | *Mus booduga* | Cassava;sugar-cane; vegetables |
| 7 | Large bandicoot | *Bandicota indica* | Cassava;sugar-cane;coconut(secondary) |
| 8 | Lesser bandicoot | *Bandicota bengalensis* | Cassava,sugar-cane;coconut(secondary) |
| 9 | Three-striped palm squirrel | *Funambulus palmarum* | Cocoa; plantain fruit |
| 10 | Indian long-tailed tree mouse | *Vandeleuria oleracea* | Cocoa; coconut; plantain fruit |

Among the rodent species, the large bandicoots (*B.indica*) have the highest density in all crops on an average and the field mouse (*M.booduga*) holds the second highest position.

It is estimated that in shops there are 1.5 rats per sq.ft. Among the principal commensal species, 48 per cent of total catch consists of house rats (*R.rattus rattus*) and another 42 per cent of house mouse (*M.musculus*). Roof rat (*R.r.rufescens*) accounts for about 8 per cent, and the rest are visiting bandicoots (large bandicoot only).

The results show a high infestation rate of rodents in all the fields and in the shops. Among the catches, *B.indica* takes the major toll in the field and *R.rattus rattus* in shops. In all the fields bandicoots account for the principal portion of the damage except in coconut fields, as they are not good climbers.

The high population density of rodents in the field and in the shops, is due to the outstanding characteristics of rodents such as short gestation period, large litter, production of several litters in a short period and having rapid sexual maturation (Azhar and Hussain, 1990). Among the other important attributes of the pest species, is their ability to live under varied conditions of environment and utilise a wide variety of foods.

Population estimation in this study was conducted only once in a year, for two years. Hence we do not draw any strong conclusion on the seasonal variation in density, population cycle, breeding behaviour, and crop preference of rodents. Knowledge of the seasonal variation and a basic understanding of reproduction in rodents are important and useful in planning control procedures. Hence, before designing proper integrated control programmes, extensive studies should be conducted in the State in order to understand these aspects.

## 8. Folk Techniques of Rodent Control in Kerala

### Introduction

Each folklore has its own world view about the universe, animals, and plants around and about the human race itself. It carries the traditions of a people that originated in the primordial past and have survived to the living present. Agricultural folklores are innately linked with the culture, art forms, and definitely the livelihood of the rural folk which is intimately linked with soil and seeds - both representing a mother status - in their culture, as propagated through generations in the forms of tables, proverbs, and puzzles. Folklores may look unscientific, but recent research has shown that they are thoroughly scientific and systematic. They involve thorough observation of natural phenomena, classification of objects, and scientific analysis of events.

Many folklores exist on pest control and related agricultural activities. Tolerance has been, perhaps, the overriding strategy used traditionally by farmers in dealing with rodent problems. In the past, this was practiced by increasing the area cultivated to compensate for pest damage. In Kerala, many tribal folks engaged in agriculture, set aside a corner of their crops for ‘ants and rats’, traditionally considered incarnations or vehicles of gods, to be venerated. Such rituals may be an indication of the approach of tolerance followed towards pests.

Nonetheless, rural people worldwide are highly aware of rodents and rodent damage; folklore is replete with stories about how to contend with rodent problems (Fall, 1991). In general, when rodent control activities are undertaken by farmers, they are simple, low-cost, often applied ineffectively, techniques such as constructing rodent guards for houses or storage structures, keeping cats or dogs, organising rat drives in fallow fields or nearly rough areas, token baiting with small amounts of rodenticide, or trapping, often with a single trap. The focus is nearly always on visible rodents than on crop damage that is often hard to detect during the period of plant growth.

Kerala may feel justly proud of its rich agrarian folklores, of their volume and variety, and of the technology that blends with that of nature. Such know-how, especially regarding rodent control has acquired little new dimensions and evolution during the past century.

The folklores of rodent pest management in Kerala may be catogorised into two broad groups: diverse folk tricks propagated through ‘farmer stories’ from generation to generation, and ‘folk mechanisms and folk procedures’ for rodent control, that involve several indigenous traps and trapping procedures. These traps and mechanisms are extremely localised in practice and are the inventions of single individuals, a farmer or a tribe as a whole. The knowledge gets transmitted from one folk to another through local agricultural fairs such as *Samkranthi mela* (a local annual fair held on the spring Equinox) and temple festivals where farmers from different villages come together.

### Method

We collected information on folk rat-control measures through surveys, discussions, and interviews with tribesfolk and farmers in various parts of the State. Transect walks, interviews, and surveys were conducted. Advertisements were made in agricultural magazines and local newspapers, inviting people to provide details regarding rat-control measures.

**Observations**

The indigenous rodent-control tricks are categorised into three groups: first, the folk knowledge of tribesfolk and villagers which are truly localised in technique and practice, second tricks using prey-predator relationships in nature; and third, 'farmers' knowledge' which promotes the efficiency of chemical and mechanical control measures, including that of the modern traps.

**Folk knowledge of tribesfolk and villagers**

Sprinkling of cut pieces of hair around the cassava shoot and vegetable bed, will prevent the attack of rats. Small pieces of hair will enter into the nose of rats, while they sniff at the roots. Hair pieces could be collected from local barber shops.

Tying-up white polythene bags, plantain stem sheath, and tender palm leaf on a rope across the paddy-fields will keep away the rats from the fields. Placing flags of white polythene sheets, here and there in the field, is also effective.

Use discarded plastic sacks (usually of cement bags) to protect vegetables from rodent attack.

Make small balls of seed powder of *cassia marginata* with *saccharum* (sugar-candy) and scatter them in the crop field. The combination is effective bait because of the poisonous alkaloid present in the Cassia seed and *Saccharum* is a favourite for rats. This is very effective, even in water-clogged paddy-field.

Dried prawn powdered and mixed with a pinch of cement is an effective rodenticide. The intestine of the rats that consume it gets blocked, when the cement sets, on coming into contact with the mucus of alimentary tract.

A small bunch of surgical cotton also can be used as an effective rodenticide. Make a small ball of cotton in melted *saccharum*. Make it into little balls (of the size of a coffee-bean) by rolling it with any of the favourite rat foods such as wheat flour, dried fish or sweet-maize flour cake. The rats, which eat the balls, die within 10-15 days, due to the clogging in the intestine.

Pour powdered neem-cake in the vegetable bed and the basin of banana pleats to stray away rats. Pouring of neem oil is also effective.

The small-sized common commensal rodent, the house-mouse (*Mus musculus*) very rarely gets trapped in mechanical traps. Here is a very simple technique to capture it: Pour 10-15 ml of toddy (local liquor) or gruel water, in a large bucket or an earthen-pot and place it in a room, and close to the wall, leaving provision for mice to enter into the pot. The smell of the bait solution will attract mice to the bucket and the trapped ones will not escape since the side walls of the bucket are highly smooth.

This is a little crueller trick. Capture a live rat with a live trap and release it into a paper carton filled with wastepaper or cloth. Stab with a pointed stick continuously, into the carton so as to make the rat scream with pain. The tortured rat defecates and urinates on the waste paper. Kill the rat and remove the carcass. Take the wet-waste, containing rats' pheromones, and place it wherever the rat attack is severe. Rats will not come to such spots.

Yet another cruel trick! Capture a live rat and anesthetise it with chloroform. Stitch the anus of the anesthetised rat, in order to seal it tightly. Release the rat into the field when it wakes. The 'stitched' rat will get 'mad' within hours and kill all its relatives by biting them and gradually meet with death.

Intercropping cassava with ginger or turmeric is found to be effective to keep away the rats to a great extent. Tuber crops such as colocasia and yam can be protected employing this trick. It is found that certain plants are repellent to rats and planting of such plants intermixed with desired crops will reduce rodent damage. *Plumbago rosea*, *Echites malabaricus,* and *Ichocarpius* fruits are examples for such repellent plants.

Disposing carcass of trapped rodents in the field, openly but not exposed to birds, is an effective measure to keep away rats.

Sprinkling kerosene through the dikes is good to keep away rodents. Scattering small pieces of white cloth on the surface of the pot in which vegetables are grown, will also keep away rats.

Cassava fields can be totally protected through a simple technique, but it is a little expensive. Construct cement thatched wall around the field at a height of half a metre, without any gap. Place fencing stumps close to the inner wall, at a distance of one metre interval, firmly. A polythene roll sheet of one metre width should be tied closely with the fencing stumps without any gap at the joint with cement wall surface. The rats will not enter through the plastic.

Five ml of crude plant extract of *Bauhinia Sp.* mixed with 90 gm. of wheat flour, 2 ml of mustard seed oil, 2 gm of *saccharum* and a little water, made into small balls, may be placed at the mouth of the rat hole and in the rat-path. The rats, which consume the balls die within minutes. Rat-holes sealed with twings of *Zizyphus Horrida* will prevent harbourage by rodents. The openings at the open ends of rolled carpets (especially made out of *pandanus* leaves, for agricultural purposes) may also be closed with such thorned-twigs.

The dispersal of bits of jackfruit and fruits of *Artocarpus*, in pineapple crop fields, will reduce the attack on pineapple fruits.

Planting local varieties of pea like *Kappappayar* intermixed with cassava is found effective, in reducing rodent damage.

To kill the large bandicoot rat, first of all, find out its usual path of travelling, by observing between 6 pm and 8 pm for two to four days. While the rat is coming along, flash a powerful torchlight upon it and keep it scared by the dazzling light for sometime. Stunned by the powerful light the rat will not move; suddenly we may beat it to death with a strong stick.

**Using prey-predator relations**

Barn owl (*Tyto alba*) is the most important predator of rats. It is estimated that a single owl can devour 40 rats in a single night. Place the boughs of palm leaf, intermittently in the paddy-field, to provide a seat for owls.

Domesticated cats are bitter enemies of rats. Pussy cats should be trained to catch rats from very early age, so that commensal rodent population would be controlled by them.

Do not kill rat snakes (*Ptyas sp*.). This non-poisonous snake is specially adapted to prey upon rats.

Wild animals such as Indian fox (*Vulpes bengalensis*) and small Indian mongoose (*Herpestes auropunctatus*) are also efficient predators of rats. Conserve such animals and their habitats.

**Folk knowledge of farmers to improve the efficiency of traps and chemical control measures**

Select the locally available and most favourite bait for chemical treatment (poisoning). Bandicoots are much fond of onions, especially of semi-cooked onions. Divide an onion into two halves and place a pinch of Zinc Phosphide and re-unite the halves with a coconut leaf mid-rib.

During rainy season, traps, especially the live traps are more effective than chemical control measures. If the rats get a chance to drink water just after consuming the poison, toxins such as Zinc Phosphide would get neutralised. During summer, all types of control measures are effective.

Take 2 gm of the rodenticide in a molluscan shell. Pour 2 ml of egg-white over it. Place the shell in the field. Even in the rainy season, this is an effective baiting method.

Place the bait in bait stations made out of coconut shell or plantain stem sheath. This will prevent the poisoning of non-target animals and also protect it from rain water.

*Nymphae* lotus fruit is a favourite food for rats. Divide the fruit into pieces and place a pinch of Zinc Phosphide in them and reunite the pieces to make the fruit.

The food preference of rats varies seasonally depending upon climate, environmental features, and the crop pattern of the area. When cassava tubers are available in the field richly, never use cassava as bait. During the rainy reason, dry food and baits rich in oil, are quite effective. In summer, wet food such as raw coconut and salt-dried fish may be used.

To kill the trapped rodents in mechanical live traps, immerse the trap in a large bucket fully for 10-15 minutes or keep the trap in direct sunlight for one to two hours, focussing the light on the rat. Take care to wash hands and other parts that come into contact with the water in the bucket and the trap.

Conduct pre-baiting with suitable bait for three to four days before every trapping. Give one to two days interval after every trapping. Repeat pre-baiting on every trapping.

Live traps and snap-traps could be painted with brown or black colour so as to mimic the surroundings. This will help to avoid the necrophobia of rats to some extent.

Traps as well as poisoned baits should be placed in rat-paths or at the mouths of rat holes for good results.

**Folk traps**

The present study has brought to light a number of indigenous trapping techniques and traps to capture rats. A brief list of the mechanisms is given below: bamboo pole trap, plank trap, fencing trap, earthen-pot trap, earthen-pan trap, bamboo pole trap (for coconut), little plank trap, and tender-coconut trap.

**Discussion**

The study reveals that most of the folk control techniques are very effective, though their real scientific basis is not yet known. Some of the techniques like making noise through *Elimooli* (a folk instrument that makes loud noise) are of no use at present, in the midst of the noisy environment.

All the folk traps identified are found more effective than the commercial traps. The success of these traps is mainly due to their natural and habitat-compatible design (Kurian and Oommen, 1996). This quality enables the trap to mimic the environment and so to lure rats to them without hesitation. The use of locally available materials for traps is proven to be better than artificial materials in earlier experiments too (Prakash and Mathur, 1987).

Moreover, the materials used as well as the preparation of each trap, are of lower cost than of all other commercially available ones. Disposal of the dead rats and cleaning of the trap are also easier. The only drawback of folktraps is their labour-intensive aspect and the need for skills required for setting them. These can be rectified through scientific modification of trap mechanism to minimise labour requirements as well as to make the technique of assembling simple, so that any unskilled person would be able to learn it. Such a modification has been done in the case of the plank trap and the little plank trap (Kurian and Oommen, 1996). The modification and use of folk traps is definitely a promising area of the rodent pest control programme in Kerala, especially in integrated pest management (IPM) strategies.

# 9. Conclusions and Suggestions

## Introduction

The present research is based on a small sample confined to three wards of a village panchayat. It is can not therefore make generalisations for the entire State, though the agro-physical characteristics and socio-economic features of the study area are somewhat representative of the State. The smallness of the sample and the shortness of the period of study account for its observed differences from studies made in other regions of the world. Nevertheless, it provides some indicators of the magnitude of damage in the State and thus makes a significant contribution since studies on or data regarding the damage caused and the diseases spread by rodents in the State are almost non-existent.

In this section, the major conclusions of the study and the future course of action needed to implement them are presented in some detail.

## Conclusions

The damage caused by rodents in all the crops surveyed was found to be serious. However, it is found to be lower than in the other regions of the world. This fact does not give any cause for complacence because of the typical small holder nature of the Kerala farms and the low productivity of most of its crops.

The direct measurable damages in the shops due to rodents are negligible. But the indirect damages caused by rats, such as contamination of food items and spreading of pathogens, which are difficult to measure, should be considered seriously. In many shops, the spilled out grains and even the grain flour are found to be repacked and sold by the shop-keepers. The spread of diseases such as Leptospirosis in the State is definitely a result of such faulty and dangerous practices.

The annual chronic losses due to rodents in pre-harvest and post-harvest situations probably account for greater cumulative losses than the more visible and dramatic outbreak situations that occur periodically.

The population density of the rodents is very high in all the fields and shows seasonal variations or variations with crop pattern changes due to intercrop migration. About six species of rodents were identified as the common pest of the crops and as the commensal rodents.

Currently, farmers as well as villagers mainly use commercial traps and chemical poisons. Among the commercial traps, the box-type live traps and spring traps are the most common. Chemical poisons are Zinc Phosphide and rarely Bromadialone cakes, which are available in the market.

Most of the farmers employ control measures only when the damage becomes severe; and they stop the programme immediately after a slight decrease in damage is observed. Persistent and systematic programmes were not in practice.

A number of indigenous control techniques and trapping mechanisms were in practice in earlier times. But at present, only a few of them are in use. This is mainly because of the lack of knowledge about such mechanisms, which need a little skill and expertise. Most of them are labour-intensive. So the farmers have turned to modern 'instant', or 'ready made', control measures that are far less effective than the folk tricks and traps. The collection, scientific modification, and proper awareness creation of such traditional mechanisms, is an immediate need. Folk control devices are cheaper and more eco-friendly than modern contraptions in components as well as in killing methods. They are non-polluting devices as well.

Rodent control has received less attention than control of other agricultural pests such as weeds, insects, and plant diseases. This is a worldwide situation, but the negligence towards rodent menace or the practice of considering rats as part of life, is more deep-rooted in Kerala. This is evident from a comparison of the actions taken by the Government of Kerala and the community at large in fighting the Eriophid attack on coconuts and, the fatal Leptospirosis epidemic, which broke out in recent years.

During the last two years more than 500 lives were lost by this disease (statistics from media reports). But not a single programme has been implemented to control the rats, which is the only possible way to curb the Leptospira menace. The situation is similar in the case of the agricultural crop damage, and the attitude of even the Agriculture Department is disheartening. Proper scientific and efficient programmes for rodent control need to be designed and implemented on a long-term basis.

Rodent populations, and the damage they cause, will need to be managed successfully if the human population is to live in health and its standards of living maintained and improved. The continued efforts of the research community, both in the public and the private sectors, national and international agencies, and the panchayat, State and Central governments are required to meet the challenge.

## Suggestions

### *Integrated Pest Management Programme (IPM)*

Even through Integrated Pest Management (IPM), is widely discussed in relation to the management of rodent damage problems, only minimal field research on the integration of methods and evaluation of programmes has taken place. A few practical IPM programmes are in routine use for rodent damage problems in field crops. Smith and Calvert (1978) defined IPM as broad, ecologically-based control systems that use and manipulate plant protection tactics in an effective and co-ordinated way.

More complex definitions have come up, but they remain broadly the most applicable to all plant pest situations, including those involving rodents. Smith (1970) recognised two decades ago that chemical pesticides would continue to provide powerful tools in IPM programmes and that the hope for 'revolutionary' approaches to pest control should not be a basis for rejecting effective chemical techniques. Although IPM is increasingly promoted as an ‘alternative’ to the use of chemical pesticides, in fact and in practice, pesticides, effectively and selectively used, remain an important component of most successful IPM programmes. This will most certainly be the case for the foreseeable future for programmes to manage rodent damage to field crops. Nonetheless, in every pest situation there are many opportunities to improve the effectiveness, selectivity, and environmental compatibility of rodent damage control programmes by developing, evaluating, and using IPM approaches.

Development of IPM approaches to reduce or prevent crop damage by rodents presents some special problems that require consideration (Marsh, 1981; Fall, 1991). The species are all highly responsive to changes in environmental conditions, making it essential to develop a thorough understanding of the specific ecological, phenological, and climatic factors that influence rodent population behaviour in particular crop situations. Such rodents enjoy longer periods of life than crop cycles, have the capability for relatively long range movements across different habitats, and can reproduce rapidly whenever adequate food and cover are available.

Most rodent damage problems must be studied and evaluated in fields owned by farmers rather than on small plots or experiment stations. The same rodents often damage a variety of crops in the same area, shifting from one field to another as crop fields near to dwellings or storage structures are common for a number of problem species. In some cases, more broad-based integrated programmes addressing community problems may be more practical and sustainable than specific crop-oriented approaches.

Many of the techniques, materials, and practices available for rodent damage control programmes have the potential for affecting other wildlife adversely and reducing biotic diversity. Although farmers cannot be expected to divert agricultural lands or suffer crop damage to maintain wildlife populations, one need only consider the impact of such desperate rodent control practices as burning or destroying habitat adjacent to croplands or poisoning of irrigation water, to recognise that the utility and impacts of rodent control operations need careful evaluation.

If other wildlife species are determined to have a measurable role in predatory mammals or birds around crop fields, then they may be a useful part of an IPM programme. Even if ‘natural controls’ are not demonstrated as practical components of crop damage prevention, IPM programmes should be developed with the dual objectives of minimising crop damage and environmental effects (Fiedler, 1994).

Developing integrated rodent pest management programmes is more complex for small holders than for plantation crops. The major problem is organising large number of farmers; and developing simple methods  (Richards and Buckle, 1986).

In the Kerala context, IPM is the only promising way of pest control. Pollution due to the excessive use of insecticides and rodenticides has reached a disastrous level in the State. Besides, the present rodent control measures - chiefly mechanical and chemical - are found to be a total failure due to the unscientific implementation. Proper integration of the various control measures giving thrust to indigenous techniques and minimising the use of chemical control measures, is needed. Factors such as rodent population dynamics, seasonal variation, crop diversity, inter-crop migration of rodents and the social and ecological dimensions should be considered. Extensive research programme for a minimum period of five years, covering the whole State should be conducted before or as part of designing the IPM for rodents, in Kerala. Only the implementation of IPM and the sustaining efforts for developing IPM strategy can become effective to curb the rat menace. Further research to chalk out an IPM programme for the State is needed since Kerala is a conglomeration of 'small holder ecosystems'.

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