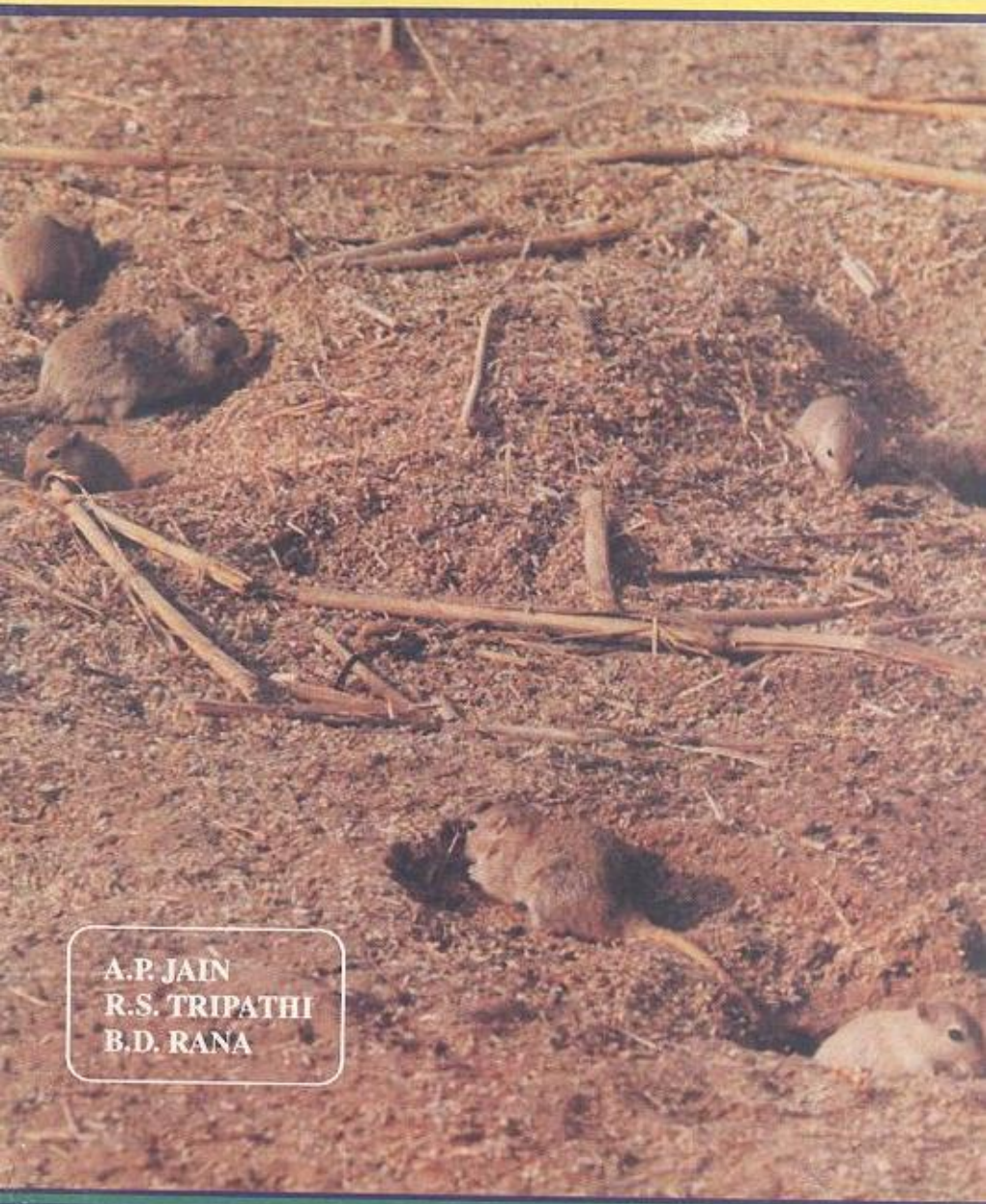
RODENT MANAGEMENT THE STATE OF ART



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Technical Bulletin—1

RODENT MANAGEMENT THE STATE OF ART

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI-110001

PROJECT COORDINATING UNIT
ALL INDIA COORDINATED RESEARCH PROJECT
ON RODENT CONTROL
CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR-342 003

Technical Bulletin

No. 1
Project Coordinating Unit
AICRP on Rodent Control
March, 1993

Published by

Director CAZRI, Jodhpur
For Indian Council of
Agricultural Research
Krishi Bhawan
New Delhi-110001

Cover page photo

A group of desert gerbils
foraging at a threshing yard

Printed by

M/s Cheenu Enterprises at
Rajasthan Law Weekly Press
High Court Road,
Jodhpur-342 001

FOREWORD

Any attempt to increase the food production to meet the growing needs of the nation is a matter of pleasure. Due to unique geographical position of India, several pests and diseases take a heavy toll of country's food production. Among these pests, rodents have been identified to devour the human food at all the stages of its production, processing and storage. Besides these, they incur unbelievable losses to fodder and afforestation sites. To match with the seriousness of the problem Indian Council of Agricultural Research thought it worth to launch a National Programme of Rodent Research and Control with an active collaboration of Government of India in 1975. Realising the gaps in knowledge for appropriate technologies, the ICAR went a step ahead by launching an All India Co-ordinated Research Project on Rodent Control during 1977. A considerable wealth of knowledge has since been generated. One of the unique features of the Project has been the "Social Engineering Activity on Rodent Control" wherein farmers fields were the real testing laboratorier in various agro-ecological regions of the country.

A timely attempt has been made to collate the information from all the ten co-operating centres of the AICRP in the form of present publication. I appreciate the sincere efforts of the Project Co-ordinator (Rodent control) and the team of the scientists working at the Co-operating Centre, Central Arid Zone Research Institute, Jodhpur and congratulate them for bringing out such a publication which would be of great help to rodent researchers, planners and field extension functioneries.

P.N. Bahl
10.3.93

(P.N. BAHL)

Dy. Director General (C.S.)
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ACKNOWLEDGEMENTS

The present bulletin is the first attempt of the Project in the series of Technology bulletins for rodent control. Attempts have been made to present the State of the art of "Rodent Management". We Sincerely express our deep sense of gratitude to the Indian Council of Agricultural Research, New Delhi, for liberally financing the publication of the Series. We are grateful to Dr. J. Venkateswarlu, Director, Central Arid Zone Research Institute, Jodhpur, for his constant encouragement and for providing necessary facilities for this publication.

Our special thanks are also due to Dr. P.N. Bahl, Dy. Director General (Crop Sciences), ICAR for his valuable Foreword. We are deeply indebted to Dr. A.K. Raheja, Asstt. Director General (Ent.) and Drs. O.P. Dubey and G.C. Tewari of Plant Protection Section, ICAR for their inspiration and constant encouragement in this endeavour.

It is pleasure to record our gratitude to the scientists and staff of all the Cooperating Centres of AICRP on Rodent Control for their incessant research efforts in the field of rodent management and for providing necessary inputs in terms of valuable informations and photographs which has helped us in bringing out the publication in its present shape. Thanks are also due to our colleagues at CAZRI, Jodhpur centre for their help in bringing out this publication. Last but not the least, we extend our thanks to Shri Harish Kumar for prompt secretarial assistance.

INTRODUCTION

Since vedic period, the Indian farmers recognised significant role played by both field as well as the domestic rodents as pests and as carriers of a number of diseases. But surprisingly nothing concrete was done to get rid of menace inspite of the very alarming situation in tropical regions where the turn over rate of rodents is much faster than that of any other region. Rodents are, capable to maintain a fairly high level of density in any type of altered environment by virtue of their superior adaptive mechanisms. They have been assigned man's enemy number one. Unfortunately, due to religious taboos and man's mismanagement by way of providing adequate harbourage and nourishment in one or the other way to these animals in crop fields, threshing floors, residential premises and in godowns, their numbers have been on an increase. As a result, the rodents survive conducively and multiply at faster rate. Consequently various rodent species have become serious agricultural pests at almost all stages of food production.

Besides, the losses to cereals, oil yielding crops, plantations, rangelands and household articles, rodents are also responsible for transmission of number of diseases among human beings. In this regard, ICAR has launched an All India Coordinated Research Project on Rodent Control with 10 co-operating centres located in different agroclimatic zones, at PAU Ludhiana, UAS Bangalore, IISR Lucknow (U.P.), JNKVV, Jabalpur (M.P.), GAU, Junagarh, (Gujarat), CPCRI Kasaragod (Kerala), APAU Agril. Res. Station Maruteru (A.P.), ICAR Research Complex for NEH Region, Barapani (Meghalaya) and Dr. Y.S. Parmar university of Horticulture & Forestry, Solan (H.P.) with Coordinating and Cooperating Centre located at CAZRI, Jodhpur (Rajasthan).

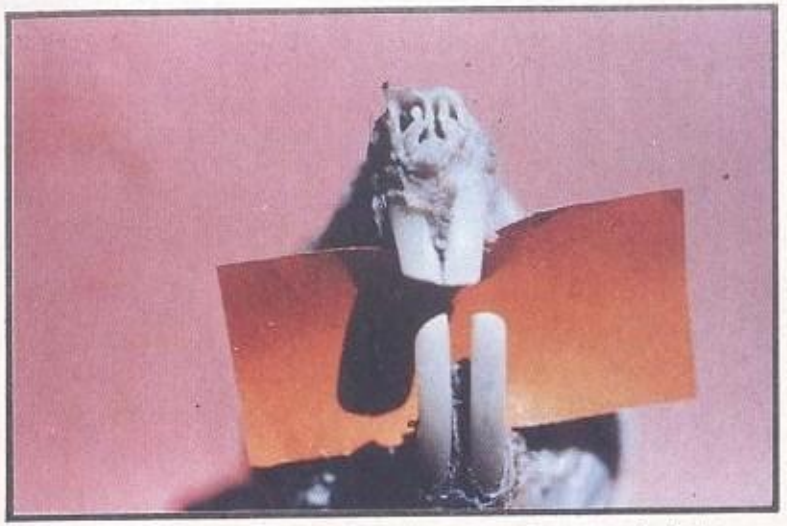
Characters and Distributional Patterns of Rodents in India

Rodents come under order Rodentia of Class Mammalia. These small mammals are characterised by their "chiesel" shaped incisors. The canine teeth are absent leaving a wide gap called diastema. These incisors grow throughout the life span of rodents and if this is allowed, the growing incisors will ultimately pierce the skull causing death of the rodent. Hence, in order to arrest the growth of these incisors, rodents nibble whatever hard substance they find in the surrounding environment. This is the main reason for lot of devastation caused by rodents to the crops, household articles and food grains, telephone cables, wooden fixtures clothings, dams, electronic goods and other wirings in machineries including cars, tractors, helicopters, airoplanes and other electronic equipments.

In India, Order Rodentia is represented mainly by three families—Fam. Hystricidae, Sciuridae and Muridae. Some biological characteristics of rodents are detailed in Table 1. The taxonomic classification of Rodentia is more complicated. Hence, a simple identification key based on their morphological characters is presented in chart-1. Since the basic information such as the exact species involved is essential for rodent pest management, this chart will be useful for the field level plant protection workers to indentify the predominant rodent species. The distributional patterns of major rodent pest species of India are detailed in Tables 2 and 3.

Table 1. SOME BIOLOGICAL CHARACTERISTICS OF RODENTS

1. Very good swimmers
2. Well developed sense of smell, hear and touch
3. Colour blind but distinguish shades
4. Use run ways
5. Can not vomit
6. Transmit several diseases
7. Mostly nocturnal
8. Omnivorous/Cannibalistic
9. Highly adaptive
10. Neophobic & Neophilic
11. Life span — 1-2 years
12. Incisor growth — 0.4 mm/day or 12 cm/year
13. Age at puberty — 6-16 weeks
14. Oestrous cycle — 3-7 days
15. Duration of heat — 9-24 hours
16. Mating habit — promiscous
17. Gestation period — 18-30 days
18. Breeding season — year round
19. Litter size — 1-22
20. Post-partum heat — 4-96 hours
21. One pair may become 800-1200 rodents in a year.



Plat 1 Chisal shaped evergrowing incisors – A nofail weapon of rodents.

Plat 2 A Lesser bandicoot rat mother, *Bandicota bengalensis* with young ones.

Table 2. Predominant rodent species of the country and their major habitats of occurrence.

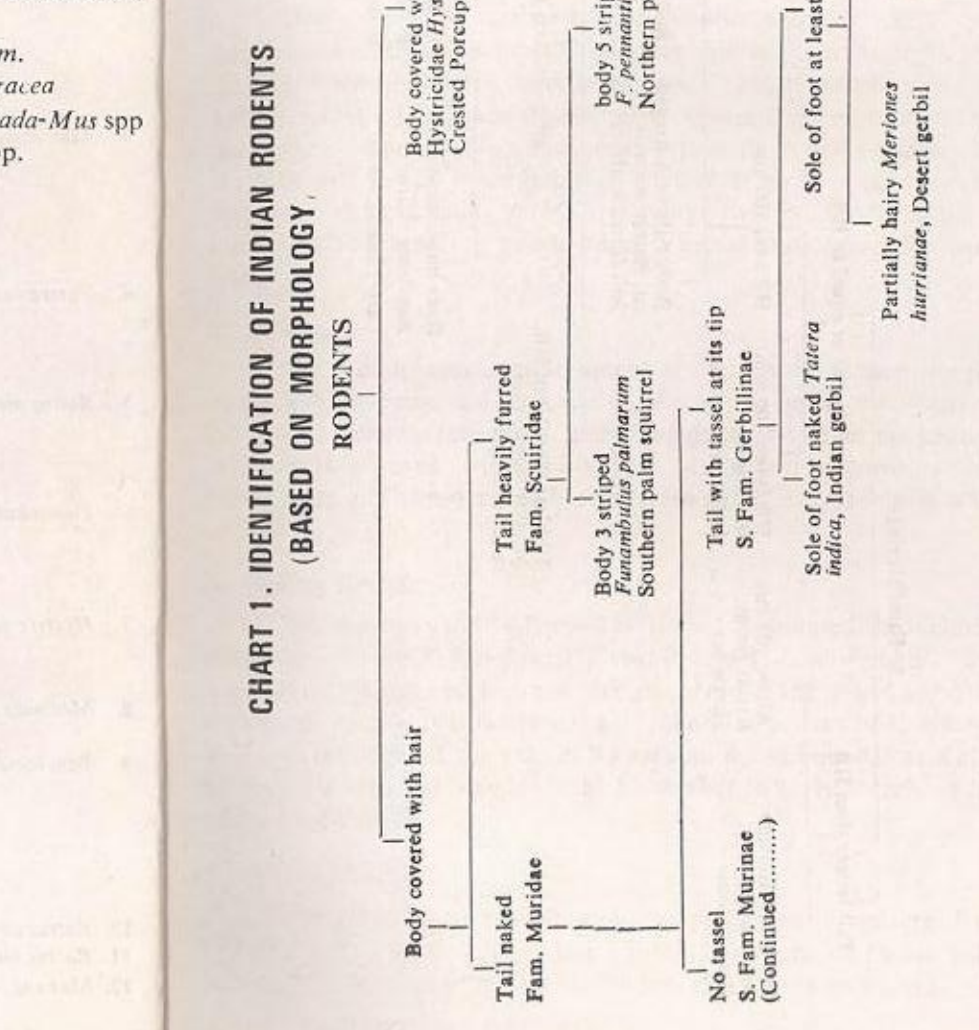
Rodent species	Habitat	Place of occurrence
1. *Bandicota bengalensis*	a. Crop fields	All over India except extreme arid zone
	b. Godowns, ware houses and stores, poultry farms	Eastern and Central India and some parts of Southern India.
2. *Rattus rattus*	a. Plantation crops	Throughout the tract of plantation crops mainly Southern India and coastal zones.
	b. Rural and urban residential premises, stores, godowns and poultry farms.	All over the country.
3. *Mus musculus*	a. Crop lands	Punjab, Haryana, Rajasthan,
	b. Rural and urban residential premises including stores and poultry farms.	All over the country.
4. *Tatera indica*	a. Crop fields and grass lands	All over the country.
	b. In poultry farms	Punjab, Rajasthan etc. (In rural areas)
5. *Rattus meltada*	a. Crop field and grass lands	Rajasthan, Gujarat, Punjab, Haryana, Central and Southern India
6. *Funambulus sp.*	a. Plantation crops	Southern India and coastal zones
	b. Horticultural and other crops	All over India
7. *Hystrix indica*	a. Tuberous crops and orchards near hilly tracts	All over India
8. *Meriones hurrianae*	a. Crop fields & grass lands	Rajasthan, Haryana, Gujarat
9. *Bandicota indica*	a. Near human habitation	Common in Southern India and some eastern states Kerala, Andhra Pradesh and West-Bengal
	b. in fields	
10. *Rattus norvegicus*	a. Sewers	Major ports
11. *Rattus nitidus*	a. Hilly tracts	North Eastern states
12. *Mus spp.*	All over India and in most of the crops.	

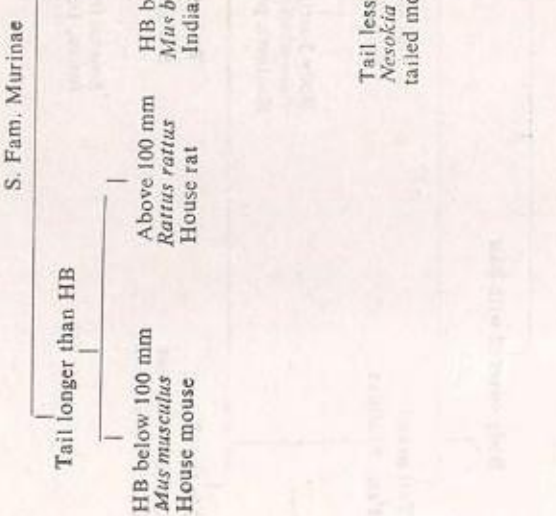
Table 3. MAJOR RODENT SPECIES ASSOCIATED WITH CROPS

Bajra, Sorghum	— *M. hurrianae-T. indica*
Maize, Barley	*R. meltada-B. bengalensis-Mus* spp.
Paddy	— *B. bengalensis—M. booduga*
	R. meltada
Ragi	— *R. meltada-T. indica-Mus* spp.
Groundnut	— *M. booduga-R. meltada-T. indica*
Cotton	— *R. meltada – B. bengalensis*
Oil seeds & Pulses	— *Mus* spp-*R.meltada-T. indica*
Chillies	— *R. rattus, R. meltada, M. hurrianae*
Tuber crops	— *Hystrix indica*
Coconut, Cocoa	— *R. rattus—F. palmarum.*
	F. triastriatus—V. oleracea
Wheat	— *B. bengalensis-R. meltada-Mus* spp
Sugarcane	— **B.** *bengalensis-Mus* spp.

Mus spp = *M. booduga* and *M. platythrix*

CHART 1. IDENTIFICATION OF INDIAN RODENTS (BASED ON MORPHOLOGY)





ECOLOGICAL FEATURES OF RODENTS

Rodents can adapt to any environment. They are distributed from extreme desert conditions to green forests, deep coal mines to mountains, jungles to houses. The chief ecological characters of predominant Indian rodent species are detailed below:

1. **Squirrel:**

Two species of squirrels, *Funambulus pennanti* and *F. palmarum* are economically important. The former species occurs in north and north-eastern India, whereas, the later one inhabits southern region of the subcontinent. They are found near villages, living commensally with man, but wild populations also occur, especially in rockey habitats. In wild state as well as in other habitats, it inhabits holes of the trunks of trees, but near villages and cities it mainly lives in crevices in the walls of buildings. The breeding female builds a brood nest. Litter size varies from 1 to 5.

2. **Porcupine:**

The Indian crested porcupine, *Hystrix indica* is seen frequently in rocky habitats and is destructive to the nearby crops especially tuberous crops and tree plantations. It also damages forest trees by girdling them. Its body is covered with quills with alternate deep brownish black and white bands. The porcupine breeds throughout the year with a litter size of 1 to 3.

3. **Indian Gerbil:**

The Indian gerbil, *Tatera indica* is distributed throughout India with 3 sub species *T. i. indica. T.i. cuvieri* and *T. i. hardwickei*. This gerbil is highly adaptable and hence is able to spread in the desert as well as high regions of Assam. It is nocturnal and inhabits burrows of simple patterns. It breeds throughout the year in Rajasthan, but is bimodal at Kolar. *T. i. cuvieri* is a seasonal breeder from September to early March. Litter Size varies fron 1 to 10.

4. **Desert Gerbil:**

Distributed in parts of Punjab, Haryana, northewestern Rajasthan and northern Gujarat. The desert gerbil, *Meriones hurrianae* inhabits a variety of habitats but prefers the hummocky terrain over sandy plains. Its

debarking activity is a menace to the afforestation programmes. It breeds all through the year with a litter size of 1 to 9.

5. House rat:

The house rat, *Rattus rattus* is most predominant and cosmopolitan commensal rodent. However, it is a serious pest of coconut grooves in coastal belt and Andmans & Nicobar and Laccadive Islands. It breeds throughout the year with a litter size of 1 to 10. Commensal populations are usually more dense in the villages than in towns because of the greater availability of harbourage and the poor sanitation. 16 subspecies occur in India of which *Rattus rattus rufescens* is very common.

6. Soft-furred field rat:

Rattus (*Millardia*) *meltada* is mostly found in irrigated crop fields, in bunds, in hedges and grasslands of the country. It lives in the burrows vacated by the bandicoot rats or in crevices in irrigated crop fields formed by the drying of moist clay. It breeds throughout the year. The litter size varies from 2 to 10.

7. Brown or Norway rat:

The brown rat, *Rattus norvegicus* is universal in the cities and farm lands of the temperate countries but it is restricted only to major sea ports in the Indian subcontinent. Recently it is spreading in other parts of India through navigable routes.

8. House mouse:

Distributed throughout the world, the house mouse (*Mus musculus*) is a commensal, small rodent occurring in the houses, shops, flourmills, backyards, gardens, cattle sheds, godowns, grain warehouses and poultry farms. These are also reported from the crop fields showing 'atavism' i.e. becoming wild. It breeds throughout the year with litter size varying from 4 to 8.

9. Short tailed mole rat:

The distribution of the short tailed mole rot, *Nesokia indica* in India is restricted to Punjab, Haryana, Rajasthan, Delhi and Uttar Pradesh. It inhabits cultivated crop fields and canal bunds. It is specially abundant in the sugarcane fields. Little is known about this rodent and is

usually confused with the *B. bengalensis*. Actually its tail is very short as compared to its body length.

10. Lesser-bandicoot rat :

The lesser bandicoot rat, *Bandicota bengalensis* is distributed throughout India. It was absent in the Western Rajasthan, but is now seen in the Bikaner city and some south-eastern parts of Indian desert. It occupies two types of habitats in the country-crop fields and the godowns. It is seen abundant in wheat, rice and barley crops. It is a serious pest of stored food grains and hoards upto 450 kg grain per hectare, whereas, in fields, it hoards upto a quintal of food grains per hectare. It litters throughout the year with litter size of 18.

11. Large-bandicoot rat :

The larger bandicoot rat, *Bandicota indica* is also found throughout India except in Thar desert. It lives near human habitation and is also found in cultivated tracts but is most common in the outskirts of houses, backyards and gardens. By its nocturnal tunnelling, it damages kuchcha houses also. Litter size is 10 to 12. Little is known about this rodent.

12. The Himalayan rat

The Himalayan rat, *Rattus nitidus nitidus* is predominant in north eastern parts of the country. It causes serious damage to paddy, maize and pineapple crops. This inhabits bunds, crop fields and the thickets of bamboo jungles. Not much is known about its ecology.

13. The Brunneusculus rat

The brunneusculus rat, *Rattus rattus brunneusculus* is a major pest of paddy, maize etc. in north-eastern parts of the country and is associated with bamboo flowering in Mizoram. It constitutes 92 per cent of the rodent population and breeds from March to December. Peak in breeding activity is observed from June to August. The litter size varies from 1 to 10.

THE RODENT DAMAGE

Nature of damage :

Rodents cause immense losses to the standing crops and to stored produce. They also cause losses to the forest plantations, plantation crops, orchards and other commodities of various human importance. The nature of rodent damage is as follows :

a) By feeding on the crops, stored products.

b) By gnawing with their ever-growing incisors to any hard and soft surface to maintain their optimum size.

c) By picking the sown seeds before germination.

d) By hoarding the food material in their vast burrow systems.

e) By cutting the field crops at base and causing crop lodging.

f) By spoilage through their excreta, urine and hair etc.

g) By extensive burrowing, they cause soil conservation problems in fields and damage to Kuchha house and dams etc.

h) By consuming poultry feed, eggs and chicks.

i) By transmitting rodent borne diseases to man and his pet animals.

Extent of damage :

a) *Cereals :* Various estimates of rodent losses to field crops have been reported which range from 10 to 20 per cent for different crops. In case of paddy rodents have been reported to cause 7.0-21.5 and 5.2-65.3 per cent loss in Uttar Pradesh and Tamil Nadu, respectively. FAO estimated that every year about 120 lakh tonnes of paddy is damaged at the field and storage level due to rodent pests. Similarly, in West Bengal and Karnataka, a total loss of 261 kg/ha and 72/kg/ha respectively have been reported. Bandicoot rats have been seen to hoard as high as 1 q of wheat earheads in their burrows in one hectare area. Jhum paddy during the out breaks of rodents associated with bamboo flowering were reported to suffer from 40 to 80 per cent damage.

Rodent damage to wheat and barley crops in UP was found to be 11 per cent at both seedling and growth stages. In desert village complex near Jodhpur, rodents viz. *M. hurrianae, T. indica* and *R. meltada* were

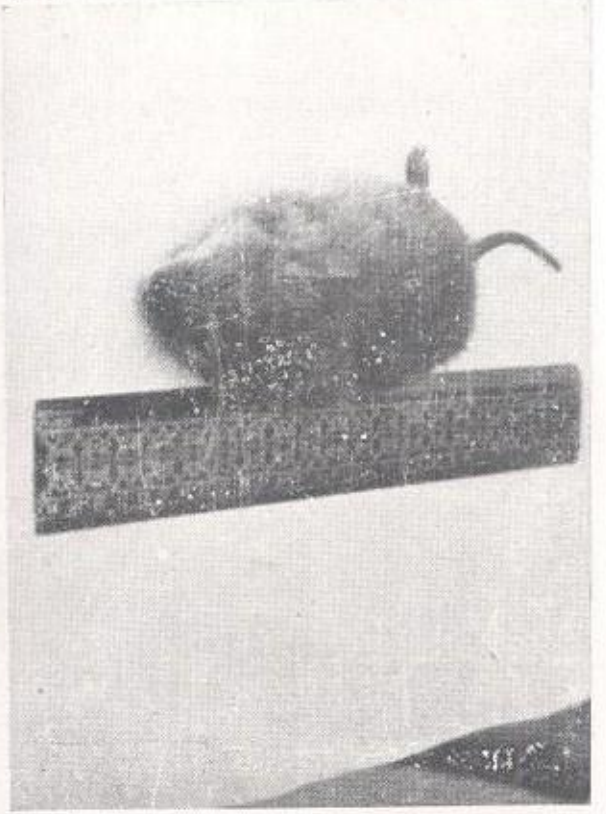


Fig. 7. The larger bandicoot (*Bandicota indica*)

Fig. 8. The short tailed mole rat (*Nesokia indica*)

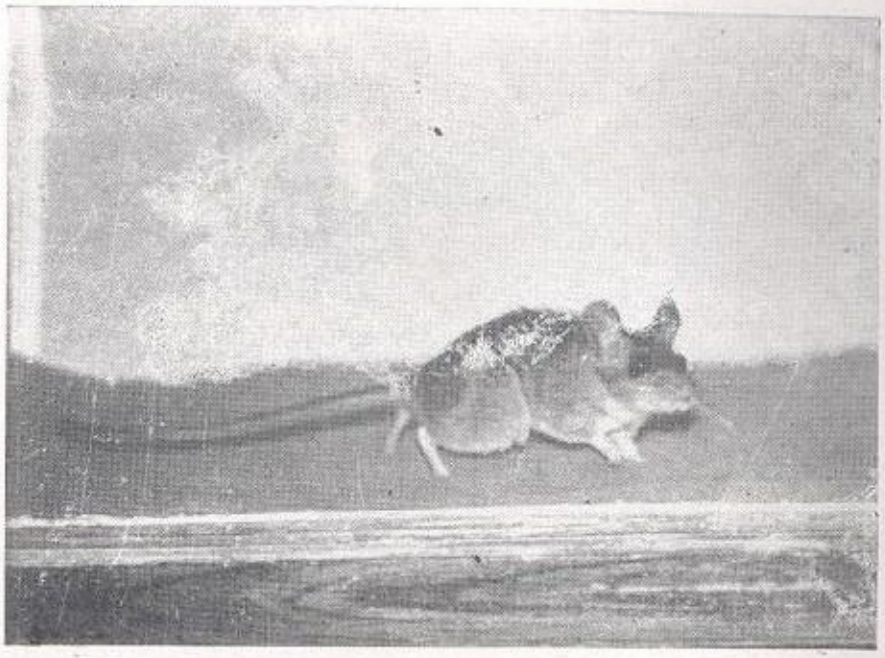


Fig. 3. The house rat (*Rattus rattus rufescens*)

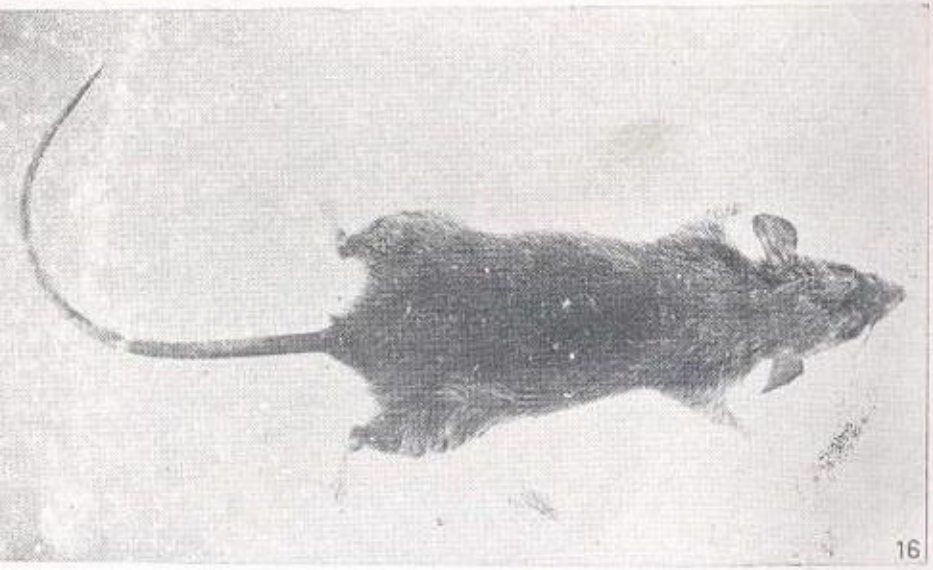


Fig. 4. The Sikkim rat (*Rattus rattus brunneusculus*)

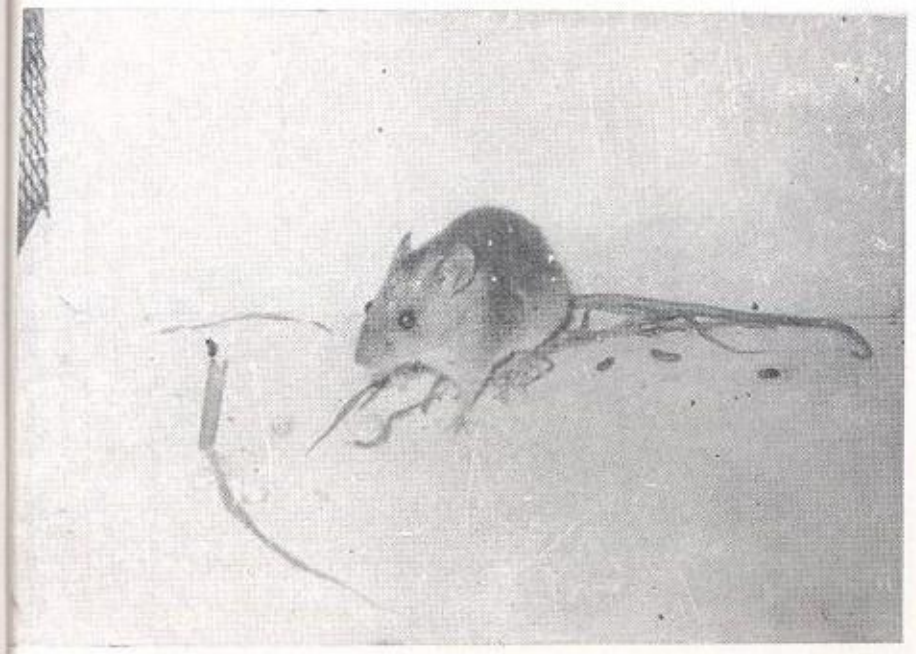


Fig. 5. The Himalayan rat (*Rattus nitidus*)

Fig. 6. The soft furred field rat (*Rattus meltada*)

Fig. 1. The Indian crested porcupine (*Hystrix indica*)

Fig. 2. The five striped squirrel (*Funambulus pennanti*)

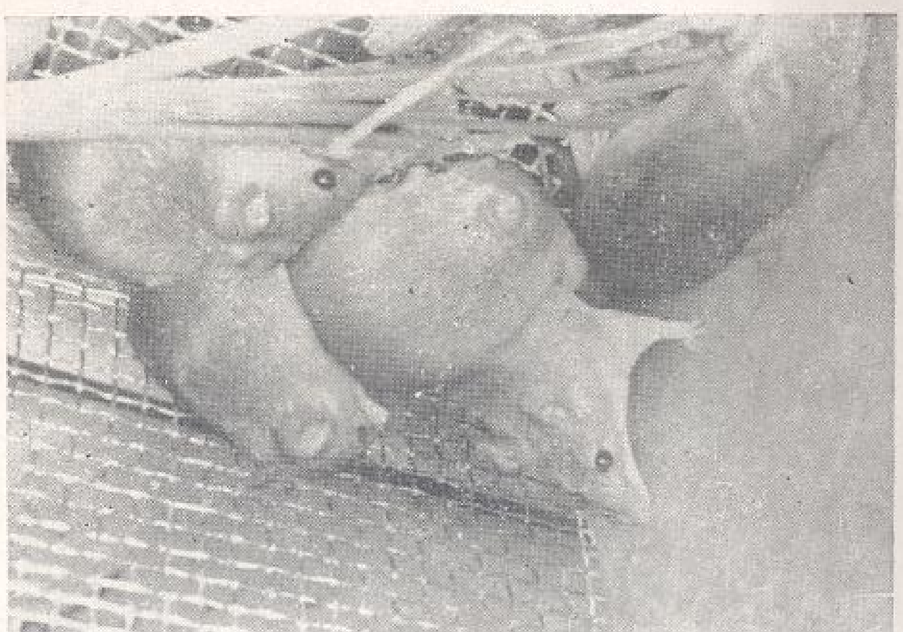


Fig. 9. The brown spiny mouse (*Mus platythrix*)

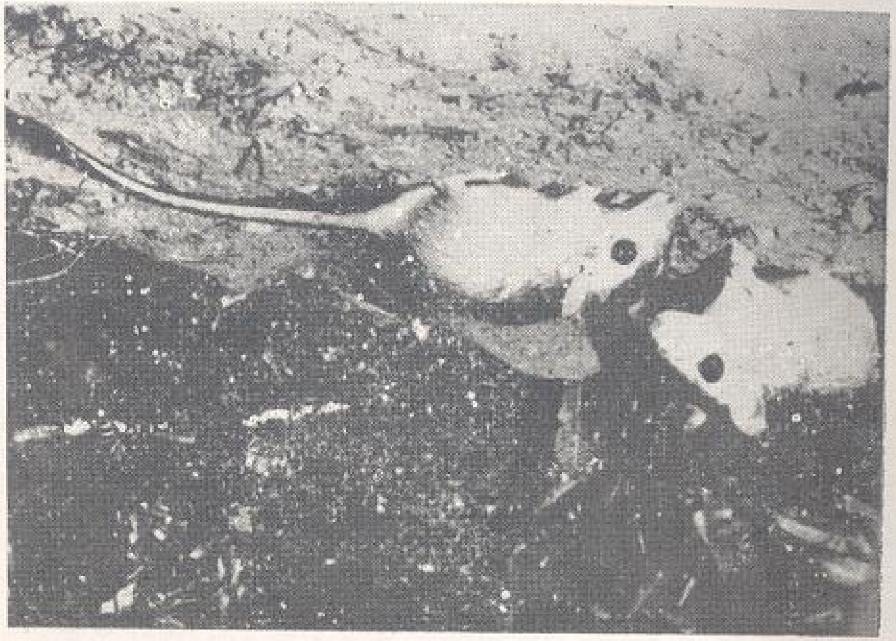


Fig. 10. The Indian gerbil (*Tatera indica*)

Fig. 11. Rodent problem in wheat crop

Fig. 12. Rodent damage in mustard crop

observed to cause 19.3, 21.3 and 18.7 per cent damage to Kalyana sona, Kharchia and desi varieties of wheat crop respectively. Similarly during kharif season (in 1970) sown seeds of pearl millet were so severely attacked by *Gerbillus gleadowi* that crops in 4 districts of Rajasthan had to be re-sown 3-4 times. After harvest the cobs of pearl millet are kept in the threshing yards. Field rodents follow them. In one such threshing yard, some 40 gerbils were observed in a 15 x 40 sqm., a very high density of gerbil population.

b) *Sugarcone* : Sugarcane crop serves as an ideal habitat for rodents. This crop is also extensively damaged all the year around but their peak damaging activity is observed from August to February. It has been reported that in U.P. alone this crop sufferes an average loss of Rs. 66.55 per hectare due to rodents which exceeds Rs. 7.8 crores per year. In Punjab, the reduction in cane yields reaches to the tune of 40.8 q/ha due to rodent depredations. The average loss in sugar recovery has been reported to be 0.08 per cent, resulting a significant decrease in gur yield.

c) *Oil seeds :* Rodent damage to groundnut has been estimated to be 6-9 per cent at seedling stage, 18.2-25.8 per cent at growth stage and 4.1-7.6 per cent at maturity stage in Andhra Pradesh. Another study from the same state recorded 14.3 per cent loss in total kernel yield. Similarly, in Punjab this crop has been observed to suffer to the tune of 7.1% due to field rodents. In M.P. about 4.62-57% damage has been observed to the groundnut pods. During 1976, Saurastra region of Gujarat experienced a serious rodent population explosion in groundnut crop.

Mustard crops have been reported to suffer more at vegetative growth stage when 33.2-45.2 per cent plants were observed to be removed by rodents in desert villages of Rajasthan. This crop suffers less rodent depredations (2.66%), when taken as a mixed crop with wheat, as practiced in Eastern U.P. and Bihar, because wheat is more preferred by rodents over to mustard.

(d) *Vegetable and fruits* : Rodents inflict considerable damage to vegetable crops. It is estimated to be 8.7 and 10 per cent in Rajasthan and Gujarat, respectively. In water melon crops, the damage sometimes reaches from 70 to 80 per cent. Similarly, ber orchards are also severely attacked by gerbils. Squirrels are major rodent species attacking the kitchen gardens and fruit orchards.

Table 4. Different estimates of losses caused by rodents

Crop	Losses (per cent)
Paddy	4.6-54.0
	59.5
	261 kg/ha
	72 kg/ha/year
Jhum paddy	70-90
	25-30
Paddy hoarding in burrows	5.7 kg/burrow
	3.2 kg/burrow
	1.75 kg/burrow
Wheat	11.1-11.9
	18.7-21.3
Wheat hoarding in burrows	1 q/ha
Sorghum	.85-6 28
Pearlmillets	107.7 kg/ha
Groundnut	4.1-25.8
	4.1-7.6
	4.6-50.2 kg/ha
Sugarcane	40.8 q/ha
Sugar recovery	0.08
Coconut	11.0
	50.0
	1.0-8.0
Cacao	8.0-5.13
Vegetables	8.7-10.0
Grasses	1040 kg/ha

(e) *Plantation crops :* Rodents also attack plantation crops like coconut and cocoa in Andhra Pradesh, Karnataka, Kerala and other coastal parts of the country. A sub-species of house rat, i.e. *Rattus rattus wroughtoni* is the major pest of coconut accounting for 10-50 per cent losses to the immature nuts. This species is arboreal in habit and remains on the coconut crowns. It migrates from one tree to other without coming down to the earth, which creates serious management problems. In Karnataka and Andhra Pradesh, damage in coconut amounted to 8 and 11 per cent respectively. Cocoa plantations in Kerala, Tamil Nadu and Karnataka are damaged to the tune of 8.0 to 51.3 per cent. Similarly, casava tubers are also attacked by various rodents.

(f) *Afforestation plantations* : Rodent, mainly gerbils, bandicoots and short tailed mole rats are major threat to forest plants and nurseries. These rodents either debark the stem (gerbils) or cut the roots (bandicoots and *N. indica*) which affects the plant growth (upto 50%) as a result.

plants die. In arid areas, planting of tree species, like *Albizzia lebbek*, *Prosopis cineraria*, *P. juliflora* and *Acacia tortalis* is being undertaken on large scale. Debarking activity has been observed on *A. lebbek*, *A. tortalis* and *Parkinsonia aculeata* which are restricted to about 0.5 m above the ground. Mainly corticalt issues are debarked. The root cutting activity has been observed in case of *P. juliflora*, *A. tortalis*, and *A. nilotica* at Udayramsar, Gadra Road, Shekhawati region and Kuchaman City in Rajasthan, and some parts of Haryana, where 5-10 year old trees have been seen to be cut by subterranean rodent species under the soil surface. Similar devastative propensities have also been observed in Great Run of Kutch (Gujarat). The porcupine, *H. indica*, damages afforestation trees and orchards to an alarming extent.

g) *Rangelands :* For developing *gochar* lands and under sand dune stabilisation programmes in arid areas, planting of grasses has been taken up. Rodents being herbivorous and primary consumers are serious competitors of our livestocks also as these prefer to feed on the grasses which livestock prefer, i.e., *Lasiurus sindicus*, *Cenchrus ciliaris*, and *C. setigerus* etc. Whenever seed of *C. setigerus*, *C. ciliaris* and *L. sindicus* are sown in grassland to improve the fodder quality for better animal production, rodents dig them up and feed on them almost to the roots of the fodder. In monsoon season, they feed on inflorescence of grasses by cutting and gnawing the stem from the base. Field rodents have been reported to devastate some 40 acres of *L. sindicus* and 27 acres of *C. ciliaris* and *C. setigerus* in an experimental pasture at Bikaner. Duriug winter season they feed on seeds and in summer they eat the rhizomes. This rotational feeding of desert rodents cause a real threat to the natural pastures. At one of the range management areas of CAZRI, Jodhpur during rainy season, 477 gerbils per hectares were reported. At this population level they require about 1040 kg/ha of feed and the estimated production of the rangeland was 1210 kg/ha.

h) *Soil conservation* : Soil conservation programmes are greatly threatened by desert rodents, mainly gerbils due to their habit of extensive burrowing. Their burrows have no fixed patterns. The burrow openings are scattered everywhere and as many as 14,000 have been counted in one hectare area. By tunneling, the rodents excavate about 17,000 kg soil per hectare. This loose soil is blown away by high velocity winds, which is very common in arid zones, thus increasing the areas of sandy wastes and barren lands. In Shekhawati region, *M. hurrianae* excavated 61,500 and

10,43,800 kg soil/day/km^2 from cultivated and uncultivated fields, respectively. This way rodents cause severe soil erosions.

i) *Stored food grains:* Rodents, mainly *R. rattus* and *M. musculus* inflict serious losses to different foodgrains at farmers level or godowns and ware houses. The post harvest losses due to rodents may amount to 25-30 per cent. Other sources quote losses upto 1-12.5 million tonnes. In a 100 x 100 m^2 space in godown at Howrah, the loss of grains due to rodents was reported to be 4,200 kg.

These are some of the estimates of losses caused by rodents in one way or the other. Magnitude of rodent damage are presented in Table 4. Considering their severe damaging propensities it becomes imperative to undertake rodent management operations on a large scale compaign basis as discussed in following pages of this Manual.

RODENT PROBLEM IN NORTH-EASTERN HILL REGION

The North-eastern hill region includes Arunachal Pradesh, Manipur, Tripura, Nagaland, Meghalaya, Assam and Mizoram. This region is characterised by having thick forests with unreachable terrains with heavy rainfall throughout the year. People are localised very far in the jungle and follow jhum cultivation (shifting cultivation) on the hills except Assam, a portion of Meghalaya and Manipur where settled cultivation is done. Rodents being universally distributed, form part of the pest population even in these areas. However, their presence as pests in these States has been brought out by periodic recurrence of damage in the crop fields, both in jhum and settled cultivations.

In settled cultivation, more or less same species are associated throughout India. However, in the hilly regions, the damage propensity is recorded with periodic intervals. In Mizoram, the flowering of certain bamboos and subsequent famine due to outbreak of rodents was recognised. In hilly terrain of Mizoram, there are sixteen major varieties of bamboos of which only seven species flower in different times. The local names of these species are Mautam, Rawthing, Rawangal, Rawni and Rawthla. The two major bamboo species flowering coincide with out break of rodents are Mautam and Rawthing. The flowering of these two species takes place at 18 and 30 years interval. In between these two, a bamboo 'Ramangal' also flowers. But it does not encourage rodent outbreak and the common people believe it to be a year of prosperity. The rodents migrate to the surrounding crop fields in search of food in large numbers causing severe damage to the crops resulting in famine.

Rodent species.

In NEH region, *Rattus* spp. forms about 45% of the total rodent population (specially, *R. nitidus*) followed by *Mus* spp. (34% *M. musculus*) and *Bandicota bengalensis* about 8%. Interestingly, *R. norvegicus* has also been trapped in appreciable numbers from Shillong town. The presence of insectivores (*Suncus murinus* and *Annoxora* sp.) in appreciable numbers in residential premises may have some chek on commensal rodents- Occurrence of Burmes ferret badger in forests indicates possibility of its exploration, as natural predator of rodents.

In Arunachal Pradesh, rodent species responsible for famine in the local language are: Bumpy, Kabung, Bangli, Kabung Libo, Kitty and Boongo. Of these, first three are economically important. In addition to these other species found in the NEH region are *R. rattus* (house rat) *R. nitidus nitidus* (Himalayan rat), *R. niviventer* (white bellied rat), *Cannomys badius badius* (bamboo rat), *R. bowersi*, *R. khyensis*, *R. tistae*, *R. r. bullocki* (Manipur rat), *Mus musculus* (house mouse), *B. bengalensis*, (lesser bandicoot rat) *M. booduga* (field mouse) and *B. indica* (larger bandicoot rat). Rats responsible for famine in the years of bamboo flowering are *R. rattus*, *R. nitidus nitidus*, *R. niviventer* and *R. brunneusculus*.

Rodent management.

Rodent control in the fields should be taken up in and around the fields before sowing. Baits should be placed at least one meter a part @ 6-10g per point. The control operation may be adopted as follows: a) Zinc phosphide baiting followed by b) Bromadiolone baiting or fumigation of burrows with Aluminium phosphide and c) Trapping by locally available traps.

Rodent outbreak.

Two out breaks of rodents in Garo hill of Meghalaya were recorded due to flowering of wild bamboos in 1920-21 and 1929-30. During 1975 some varieties of bamboos flowered in Arunachal Pradesh which resulted in rodent outbreak in 624 ha area having paddy, maize and jowar. About 80-100% of the crop was damaged by rodents. Earlier in Mizoram, the rodents caused 90% (in 1911), 70.3% (in 1929) and 70% (in 1956) damage to the crops. During 1977, the government took mass scale control measures in the area, which provided some relief to the farmers. The damage to pineapple is generally 10 per cent but it may go up to 60% if uncheked. Similar outbreaks of rodents are said to have occurred in Nagaland also (Table 5)

Table 5. The years of bamboo flowering in two varieties and estimated loss.

Bamboo variety	Year of flowering	Estimated loss (%) due to rodents
Mautam	1864	—
Thingtam	1881	—
Mautam	1911	90.0
Thingtam	1929	70.00
Mautam	1956	75.0
Thingtam	1977	Control measures adopted.
Mautam	2007	Expected to flower

Possible reason for the outbreak.

The bamboo flower and seeds are known to have more proteins. It is believed that the flowers and seeds increase the estrogen level in the rodents which enhances the reproduction rate and their number increases in an epidemic proportion, thus sudden availability of nutritious food increases the potentiality of local rodent population.

ASSESSMENT OF RODENT POPULATION

Knowledge of rodent number is important from two point of views. (1) it provides an idea for assessing man power and raw material required, and (2) it also gives control success of operation. Accurate population estimation is not possible due to migratory habits, changing species composition, diversified habitats, and different body sizes of mixed population of rodent species. However, use of signs, use of tracks, surplus baiting technique burrow counts, tracking signs and trap catches are some of the methods generally adopted for population estimation studies. Moreover, burrow count is most handy, quick result giving and easily applicable method for all practical purposes under field cond itions. But use of tracks is also easy for domestic rodent population estimation.

(a) *Burrow count method*: Generally live burrow count gives rough idea of living rodents in an area. Live burrow or active burrow generally look fresh, marks of rodent are there, fresh excavated soil and cut parts of various plants etc may also be there. Since a rodent may use more than one opening for activity—this may give false picture of rodent population. Therefore, all the burrows may be plugged in the evening and next early morning all reopened burrows would reveal correct picture of rodent numbers. By this, we may compute number of live burrows/ha. If we know the mean number of rodents residing in a burrow, a correct population of rodents can be estimated by multiplying this with number of live burrows. This situation generally arises during breeding season when more rodents live in a burrow, otherwise adult rodents occupy single burrow. A ccmparison of pre and post control census will give control success of the operation.

(b) *Tracking signs :* This is useful for population estimation of house hold rodents. Cues to the presence of rodents may be foot prints of rodents on dusty floor, fresh loose earth, shiny and fresh droppings, greasy marks on wooden beams due to regular movement of rodents, gnawed doors and windows. It is not always necessary that rodents are apparently visible but by above mentioned cues we may have an idea of the presence of rodents in godowns, houses, stores and poultry farms etc.

This method is easiest for population estimation. Before control operation known number of smears of any flour or powder are spread near

infested area. Next day smears having foot prints or tail marks of rodents or with tracking of rodents are counted. Comparison of pre-control and post control track census will indicate control success. For example one operator has used 100 smears before control operation of which 80 smears were tracked. After control operations again 100 smears were laid down of which 5 smears showed tracks of rodents. This revealed that the control success is 96 per cent i.e. out of 100 smears 80 are tracked pre-control,

so out of 1 smear $\frac{80}{100}$ are tracked

so out of 5 smear $\frac{80}{100} \times \frac{5}{1}$ are tracked-post control = 4 are tracked

or live.

Hence control success is 100 - 4 = 96 per cent.

(c) *Trap index :* The method is based on direct trapping of live rodents. There are two ways of determining the trap index.

(i) *Lincoln index* : It is based on capture, marking, releasing and recapture of marked rodents. Traps are set, as far as possible in a grid pattern at an interval of 15 meters. The traps are set for 24-48 hours. In the morning, all the trapped rodents are marked by too dipping and released at the point of capture. The second trapping could be done after one week or so. The exact interval depends upon the species involved. The second trapping will include some marked rodents from first trapping and some unmarked rodents also. The population size at the first trapping can now be worked out as :

$$N = \frac{M \times n,}{m}$$

where N = Population size

M = No. trapped in first trapping

n = Total no. of trapped rodents in second trapping

m = No. of retrapped (marked) animals in second trapping.

(ii) *Removal method :* This method is based on removing (kill trapping) the rodents from the study area. Fifty four kill type traps should be set in a checker board fashion at a distance of 10 m apart. The relative

density of rodents per hectare will be the number of rodents collected. The trap index (I) can be calculated as :

$$I = \frac{M}{n \times t} \text{ rodents/day/trap.}$$

where n = No. of traps used in a trapline

t = No. of days during which traps were set.

M = Total no. of rodents trapped.

RODENT MANAGEMENT TECHNIQUES

There are several methods of rodent control which are needed to be integrated in a manner to manage the rodent population to 5-10 per cent of its original level, because a single method may not achieve this level of success. The common rodent management techniques are detailed below :

(1) **Trapping** : It is one of the oldest practice of rodent control reported from earliest civilisation. There are many types of traps in use today which can capture rodents live or dead. Some commonly used traps are sherman traps, and the snap traps, urang or arrow trap, bow, pit fall traps (for dead trapping). The live traps can capture more animals than kill traps and hence these can also be used on small scale, but to cover a longer area snap traps are more convenient, because of easy handling and low cost. Trapping method is more advisable for small areas with populations consisting of mostly adult rodents. It can be an effective mean for control of small population of squirrels, house rat and house mouse etc. It can also be used as follow up action after chemical control operation. About 54 sherman or 60 snap traps per hectare are to be placed. Peanut-butter or any other locally prepared bait may be used for these traps. These traps should be placed on rodent runways near droppings nearoundar bushes (in fields) and near walls (in houses) to enhance the trappability.

Recently, glue traps have been introduced which have been found very effective in managing commensal rodents, specially house mouse and house rat.

(2) **Biological control** : Biological control is suppression of a pest population either by increasing predation or by introducing diseases.

(a) *Predation :* Cats, owls, snakes, hedghog, fox, mongoose, monitor lizards and kites are the major predators of rodents. Cats have been seen to affect the rat density in villages. These predators are useful in maintaining the natural ecological balance but do not prove to be an effective tool for rodent management, because these predators are opportunist animals and prey on whatever is easily available, e.g., when Indian mongoose were introduced in West Indies to kill rats in sugarcane fields, they cleared all ground birds causing serious ecological disturbances. Moreover, the rate of predation was also reported to be very low.

Diseases : The intensive use of disease agents for the control of wild animals was successful through introduction of myxomytosis in rabbits in Australia. After 10 years or so the rabbits developed genetic resistance to the disease. In case of rodents, Salmonella diseases (caused by *Salmonella typhimurium*, S. *enteritidis)* were successfully used against mice, voles and rats in foreign countries. In India, 16-18 per cent kill in house rats and bandicoots were reported with this bacterium. The use of pathogens in rodent control has very little practical value on one side and great potential for public health hazards on other side. That is why WHO and FAO have stated its least usefulness in rodent management.

(3) Habitat manipulation or environmental management :

In any habitat food, shelter and water are major governing factors in rodent environment. By removing any of these factors can reduce the carrying capacity of the habitat holding the rodents. The reduced food and shelter will increase intra and inter specific competition and aggressiveness among rodents which may result decrease in population either through mortality or migration.

These methods are very easy, effective and require no extra expenditure hence can be easily adopted.

(a) Indoor habitats :

(i) *Rodent proofing and sanitation :* Construction of rodent proof buildings, ware houses, and repair of old houses, help in reducing the entry of rodents. Poorly maintained ware-houses, kucha floors, ill cared garbage, storage and poor sanitation adds in building up dense population of rodents.

(ii) *Removal of garbage etc :* Rodents inhabit dirty and undisturbed areas. Near residential areas in urban and rural human inhabitations, good hygienic conditions should be maintained by following strict sanitation practices.

(b) In fields :

Deep ploughing : Deep ploughing of the fields at the time of land preparation helps in destruction of rodent burrows which exposes the newly borns to the predators and adults migrate to other areas.

(ii) *Reduction in bund size* : Rodents inhabit high bunds present around the crop fields, which remain undisturbed. Such bunds should be kept at minimum possible level to reduce rodent infestation.

(iii) *Planting of non-preferred crops* : It is suggested that if Opuntia plantings are done on the bunds, rodent populations decrease considerably. Similarly, a band of low preferred crop (castor) or cluster bean crop (which is difficult for rodents to dehusk) may be grown in 6-10 m strip around main crop, can also reduce the entry of rodents. In Mizoram, Arunachal Pradesh and other North-Eastern States of the country, where rodents invade rice fields from nearby bamboo forests, planting of ginger crop around the main crop may prove to be very effective.

(iv) *Weed management* : Weeds serve as a food of rodents during lean period. They also act as hiding places. Regular weed management practices have been reported to reduce the rodent infestation significantly.

(4) Chemical Control :

Rodent management, as a rule should be prerequisite for the successful crop production. The active as well as freshly opened rodent burrows should be checked and prebaiting (one kg bajra grain and 20 g groundnut or sesame oil) is suggested for two days only. On the fourth day 2.00 per cent zinc phosphide should be added to the bait (i.e. 1 kg bajra + 20 g vegetable oil + 20 g zinc phosphide) and rolled deep into the active burrows at the rate of 6.0 g per burrow. After 8-10 days of operation, Bromadiolone (0.005 per cent) ready to use loose bait or wax cakes should be rolled deep in the freshly opened burrows for managing the residual population of rodents. 0.075% Cholecalciferol in bait is also found to be effective against a wide variety of rodents.

In India, there is a great paucity of rodenticides, as only 5-6 rodenticides are registered for common use. Of them only three viz., zinc phosphide, aluminium phosphide and bromadiolone are in demand. But during last decade, common use of aluminium phosphide has also been kept under restricted use. Single use of zinc phosphide kills 60 to 70% of rodent population. The residual population (30-40%) become bait shy and is the real problem for pest control operators and the end users, because zinc phosphide becomes ineffective for them. Secondly, use of zinc phosphide for commensal rodent control is not advocated due to its very high toxicity to non-target species also. In such circumstances use of bromadiolone and cholecalciferol can very well be integrated in the management scheme against field as well as commensal rodents.

(5) Other methods :

(a) *Tribal rodent catchers* : In India certain tribes, like *Irulas* and *Kuruvas* of Tamil Nadu and *Nats* of Bihar, *Yenadis* of Andhra Pradesh are

professional rat catchers. These people catch the field and commensal rodents using nets and catapults, scare and lure them or dig their burrows and catch them by hand. They consume the field rodents only. The only problem with these catchers is that they do not catch pregnant females.

(b) *Electrical fencing*: It has been used in developed countries, but not feasible in our country due to poor economic conditions of the farmers and low rate of literacy, although it has been tried in rice fields in India.

(c) *Ultra sound waves* : It is comparatively new development in field of rodent control. It has been tried in U.S.A. and other countries including India, but could not prove successful because of great power of adoption in rodents to any situation. Rodents can habituate this noise (utlra sound) produced by electro magnetic waves and make this method ineffective. This connot be used alone but may be integrated with other methods.

RODENTICIDE APPLICATION TECHNIQUES

Bait preparations :

This is an important aspect of baiting which is often overlooked. The proportion of toxicant to bait should be maintained too heavy dosage may repel the pest and too light dosage may stop eating before consuming lethal dosage resulting into development of bait shyness. It is, therefore, important that the toxicant is uniformally distributed through the bait mixture rather than left is distasteful clumps. Since most of the rodenticides are available in powder form, the oil component of the bait is most important. In India, several methods of bait preparation are in vogue which are cumbersome, risky and uneconomic. The Coordinating Unit of AICRP, on Rodent Control Jodhpur has developed a very effective, easy and economic technique of bait preparation. By this technique farmer himself can prepare baits within 5 to 10 minutes and require no equipments like masks and gloves, etc. The technique has been evaluated in different agroclimatic conditions in the country and has been found very effective and is widely accepted by the farming community. The technique is as follows (for zinc phosphide 2%).

a) *Pre-bait material :* for one kg of bait.

i. Take one kg of locally grown foodgrains (wheat/bajra/rice/ragi/jowar)

ii. Mix 20 g. vegetable oil in foodgrain with bare hands.

iii. Sprinkle 20 g of zinc phosphide and stir with wooden stick till uniform mixing is achieved.

iv. Use any plant leaf such as (Ak and bargad) as applicator for bait placement inside the burrows.

Bait placement:

Placement of bait is one of the most important aspect for an effective chemical rodent control technology. It involves several basic principles. It should be tried to cover largest possible area. It should however, be ascertained that the rodent population consists of adults only who can consume bait material.

The bait may be placed either in the burrows or bait containers/bait stations may be used.

i. *Burrow placement* : This method is advisable in field condition where clear rodent burrows are visible. For this, all the existing burrow openings should invariably be plugged in the evening and next morning reopened/active burrows are treated with pre/poison baits. The treatment of only active burrows saves the poison bait material, labour cost and time and is very effective. In this method 6-10 g of poison bait (zinc phosphide) is rolled deep inside the active burrows to avoid any secondary hazards. To assess the control success the burrows are plugged again after 3-4 days of treatment and reopened burrows are examined on the next day. In case of *B. bengalensis*, which normally keeps its burrows plugged from outside, the identification of live/active burrows is done by deplugging the burrows first and examining the re-plugged burrows next day.

ii. **Use of bait containers or bait stations :**

In houses, stores and other indoor situations : The baits should be kept at places most frequented by rodents. This is more important when two or more rodent species occur together. In the houses, *R. rattus* and *M. musculus* occur together. Under such situations, baits should be placed in such a manner that both the species can feed upon it. Usually in control operations, the majority of *R. rattus* is eliminated leaving behind *M. musculus* untouched. These reproduce quickly in the absence of *R. rattus* without any inter-specific competitions. These mice live under boxes, almirahs, in fuel wood stacks and under cloth. So, if baiting is carried out keeping *M. musculus* movement in mind, there is every likelihood of control of these commensal rodents in a single baiting schedule.

In field conditions : In the fields also, similar inter-specific associations are observed among rodents. In Punjab, *R. meltada*, *T. indica* and *B. bengalensis* live together. In Western Rajasthan, *M. hurrianae*, *T. indica* and *G. gleadowi* live side by side. They have different micro habitats in similar habitats. Hence, the micro habitat and movement of rodents are to be kept in mind before placing the baits. This will not only increase the efficiency in uptake of baits but may also reduce the cost of baiting.

Several types of indigenous bait containers have been used in India for keeping the baits. The basic idea of selecting bait containers is that the bait should be easily accessible to the target species and should reduce the hazard to other animals and man. This will also protect the baits from rain and other weatherings. Indigenously procured items like mud channels, hollow bamboo pieces, broken pitchers, coconut shells etc. have been effectively utilised for this purpose.

Plate 3 Rodent management technology – Preparation of prebait material by farmers.

Plate 4 Rodent management technology – Farm women laying the poison baits in actual burrows.

Treatment with anti-coagulants

Treatment with anti-coagulant poisons need no pre-baiting. The poison baits of first generation anti-coagulants e.g., warfarin and fumarin are to be placed for 14-21 days. The bait containers are to be placed 4-10 days before poison to allow their thorough investigation by rodents. For such anti-coagulants, surplus baiting (bait should not exhaust completely after 24 h exposure) is to be done throughout the poisoning operation. About 200-400 g of bait is required for per bait station and regularly replenished. The dead rodents are to be collected and buried deep in the soil. The second generation anti-coagulants e.g. bromadiolone have proved lethal on single feeding with the result "pulsed" or "minimal" baiting is required, where only a small amount of bait is required at large number of stations for every five to seven days baiting interval. The advantages of pulsed baiting is to save labour and bait costs for effective management in comparison to that with surplus baiting. Laying of least amount of bait would naturally provide safety to non-target species. The second generation anti-coagulant rodenticide registered for commercial use is bromadiolone, which comes as ready to use loose bait and in wax cake formulation and is effective at 0.005% concentration.

Baiting with acute poisons: Presently zinc phosphide and barium carbonate are the only two acute rodenticides which are registered for public use. Of these, the former is more effective and is in use since long. For this poison, prebaiting for at least a day is essential to achieve higher kill of the pest. Pre-baiting material consists of any cereal bait and oil. Similar cereal bait and oil should be used in pre-baiting and poison bait. This helps in acclimatising the field and commensal rodent to feed on a new food at a specified place. Small amount of pre-bait (8-10 g per burrow or 50-100 g per bait station) is applied in the infested area. After the pre-baiting the poison bait, is placed (6-8 g per burrow). The simplified bait preparation technique has been described earlier. At the end of treatment the unconsumed poison bait and dead rodents should be collected and buried deep. For evaluating the control success, the burrows are plugged three days after treatment and reopened burrows are examined on the next day. The reduction in the numbers of active burrows in post treatment period indicates control success.

Fumigation technique

Aluminium phosphide, most common fumigant rodenticide is available in tablet and pellet form. Because of being extremely toxic, it must

be used by trained plant protection personnel and there should be restriction for its use in general public. This fumigant is a very effective and popular poison. For fumigation, all the existing burrow openings are plugged with wet mud and 1.5 g aluminium phosphide is to be inserted in the active burrows, which should also be plugged with mud to check the escape of lethal gas. All the nearby burrow openings need to be plugged invariably. The dead rodents are to be collected next day and disposed off. In the management technology the fumigant is recommended to be used after zinc phosphide baiting to control the residual rodent population. The fumigant is more effective in humid zone and irrigated fields with heavy soil. It is never recommended for residential premises/indoor use.

SAFETY PRECAUTIONS AND ANTIDOTES OF RODENTICIDES

The main hazards to persons either directly or indirectly concerned with rodents and their control are the contraction of rodent borne diseases and the risk of accidental poisoning. The need to maintain high standards of personal hygiene at all times should be stressed upon. Rodenticides, if handled carefully and sensibly, should present no risk to other animals or people including the operator himself. Following precautions should be followed to avoid any risk.

(a) No eating, drinking or smoking should take place when live or dead rodents or poison baits are handled.

(b) All cuts and abrasions on the hands and arms should be covered before starting the work.

(c) Any rodent bites should be reported and sought medical advice.

(d) Poison baits should be prepared in well ventilated room and care should be taken not to breath in or absorb any poison.

(e) After poison bait preparation and field application, hands should be washed with soap properly.

(f) All poisons (pure chemicals, baits etc.) should be clearly labelled 'POISON' and held in a locked almirah and should be away from the reach of children.

(g) The poison bait should not be touched by bare hands. Any broad leaf or spoon or gloves, if available, should be used.

(h) When poison baits are laid, the residents/owner of the area should be cautioned about the treatment so that children, livestock and pets can be kept away for a day or two.

(i) Poison bait should not be laid where the excess bait can not be picked up in order to prevent any later danger. A record should be kept of the number and location of baiting points.

(j) While placing the baits in the burrow, the poison baits should be rolled deep in the burrows to protect birds, livestock and other non-target species.

(k) Fumigation as a rule should not be tried in residential buildings. If aluminium phosphide is being used for fumigation in the fields, the fumigant should be kept away from fire or lit cigarette, as it is highly inflammable. Do not handle the tablets, use an applicator or a long tube to insert them into the burrows.

(l) After the control operations, the left-over baits, should be picked up and dead rodents be collected and buried deep in the soil.

ANTIDOTES

If any poison is absorbed or illness is suspected in relation to rodent control work, medical advice be sought immediately. Following antidotes should be administered in case of accidental poisoning due to rodenticides.

(*i*) *Acute poisons* (Zn_3P_2,AlP) : In case of poisoning through consumption of poison or baits vomitting should immediately be induced by giving mustard emetic. When the vomiting stops, give 6 gm of potassium permagnate dissolved in a glass of warm water. This oxidises the phosphide to phosphates. After 10 minutes half a tea spoon full of copper sulphate dissolved in 250 ml of water should be administered. This will produce insoluble copper sulphide. After this, any purgative can be given and doctor be called immediately.

(*ii*) *Anticoagulant poisons :* In case of accidental consumption of such poison, call the physician immediately. Vitamin K administration and blood transfusion are recommended.

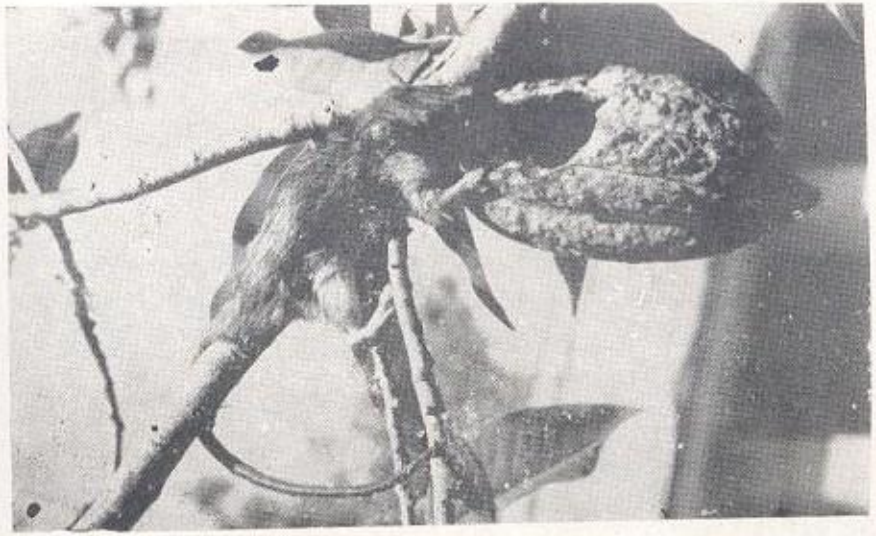


Fig. 13. A rat attacking a cocoa fruit

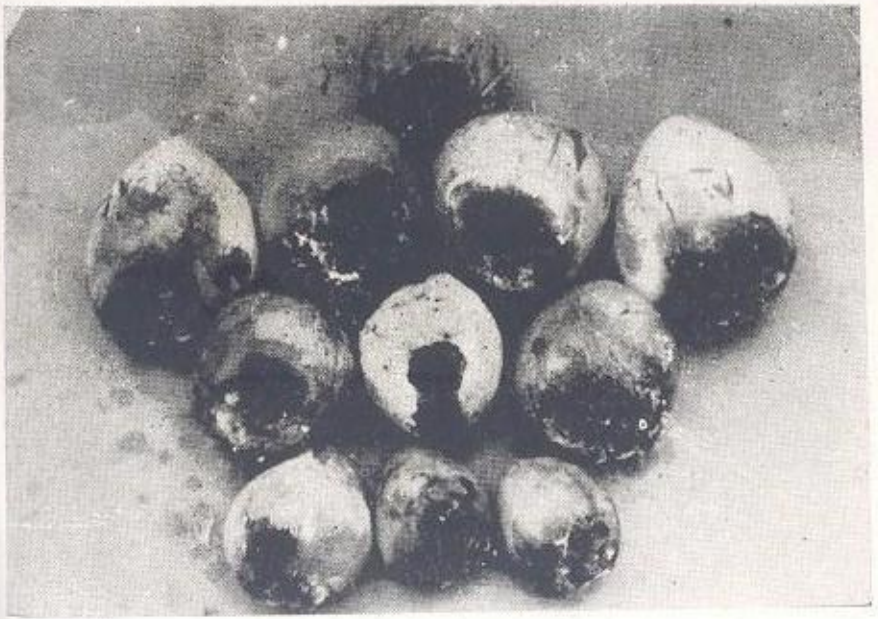


Fig. 14. Fallen coconuts due to rodent depredation

Fig. 15. Rodent problem in sugarcane

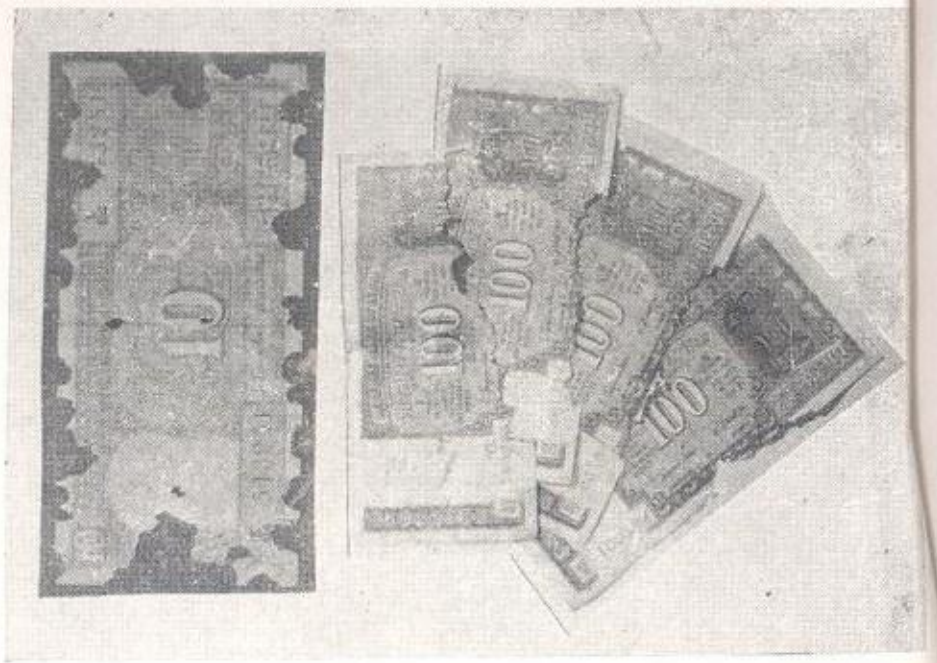


Fig 16. Damage incurred by domestic rodents

TIMING THE CONTROL OPERATION

The basic principle behind any control operation lies in its economic viability, ecological soundness and sociological acceptability. Besides these the knowledge of habits, habitat, breeding season, activity pattern and burrow structure of pest complex would also add to the success of the control operation. However, cost worthiness of the total operation in terms of material and manpower should also be properly assessed in advance.

Studies conducted on population and breeding cycles of rodents in different agro climatological parts of the country indicated that control operation is to be taken up before sowing/planting of crops in the fields. Studies on the population dynamics further indicated that lowest number of rodents occur during May and June. The population, therefore, comprises of adults only, which can ingest cereal baits. Analysis of their food habits revealed that acceptability of baits is maximum during summer months when there is paucity of natural food. These results evidently reflected that summer is the most appropriate season when large scale rodent control operations should be taken up. The farmer is also comparatively free during summer months. Studies conducted at this Institute have clearly shown that the control operations are to be taken up in large areas Hence, next treatment is required to be taken up before sowing of rabi crops.

Studies under social engineering activity on rodent control at CAZRI, Jodhpur indicated that if control operations are taken up twice a year (i.e. May-June and November-December) regularly for 4 years, rodent population is reduced to 5% the initial level corresponding to 90% reduction in losses to agricultural production and cost benefit ratio achieved was upto 1 : 247 (wheat crop), 1:900 (vegetable crops) and 1 : 220 (in houses). It is, therefore, generally recommended to undertake control operation twice, i.e. during extreme summer (i.e. before kharif season) and winter (before rabi sowing). This schedule is applicable only in the crop fields. Orchards, plantation crops, houses, godowns, poultry farms and other indoor rodent habitats, the basic approach for rodent control is based on the population of rodents present in the area and extent of damage observed. However, in these habitats, trapping and use of anti-coagulant poisons (Bromadiolone) is more effective. In such situations, control operation may be undertaken more than two times in a year.

MANAGEMENT TECHNOLOGIES FOR MAJOR CROPS

Based on the information gathered on the basis of studies on rodent management following calendar of operations are suggested for the major crops.

i. Wheat : (Punjab, Haryana) (a) Pre-sowing treatment with zinc phosphide (2%).

b) Second treatment in Feb-March (70-80 days after sowing with bromadiolone (0.005%) baiting. Baiting should be done at 10 X 10 m^2 distance or at burrow/damage site with 8-10 g bait per point. Burrow baiting is comparatively more effective.

ii. Paddy : (Punjab) (a) Pre-sowing/planting treatment with zinc phosphide (2 %).

b) Second treatment with aluminium phosphide fumigation (if available) or bromadiolone (0.005%) baiting after 6 weeks after transplantation. OR,

2 Treatment with zinc phosphide first followed by bromadiolone baiting between 10-13 week after transplantation.

3. Poisoning should be done in the burrows present on the bunds and nearby areas also. For baiting inside the fields, the baits can be placed in bait containers made of broken earthen ware/or bamboo stems or coconut shells. Such 10-12 bait stations are sufficient for one hectare area.

iii. Millets : Pre-sowing treatment with 2% zinc phosphide in the burrows. Follow it up with bromadiolone baiting.

iv. Sugarcane : Sugarcane is generally damaged by rodents throughout the year (mostly from Aug.-Feb.) because they get very favourable micro-climate in the field.

1. Ratooning should be avoided.
2. Multiple baiting schedules are to be followed.

a First treatment at pre-planting stage during Aug.-Sept. with zinc phosphide followed by bromadiolone baiting.

b Second treatment in Oct-November with zinc phosphide or bromadiolone baiting alone.

v. Coconut, cocoa etc. : Regular monitoring of the rodent attack is done and control measures should be adapted depending upon the intensity of damage. Coconut is mainly attacked by different subspecies of *Rattus* (House rat) which remain on the top of the trees in the crown of the leaves. For this, wax cakes of bromadiolone may be placed in the crown of the leaves. The baits may be replenished at regular intervals. For rodents in cocoa, wax cakes may be fixed on the branches. This may be coupled with trapping.

vi. Vegetable crops : Treatment with 2% zinc phosphide before sowing/planting in nurseries/fields. For residual rodent population, aluminium phosphide fumigation (if available) or bromadiolone baiting may be resorted to.

Wherever porcupines are a problem, zinc phosphide bait at higher concentration (3-5%) should be put in their tunnels or at the activity sites in the evening.

For a proper rodent management :

1. Control operation should be a pre-requisite before sowing/planting.
2. Surrounding fields should also be treated to avoid rapid rebuild of rodent population by migration.
3. Rodent management may be included as regular agronomic practice by farmers.
4. Pre-baiting is necessary before zinc phosphide baiting.

CALENDAR OF OPERATIONS

1. **Dry land and rainfed agriculture**

Time of operation : Before sowing/transplanting

Day 1 : Plugging of burrows/de-plugging of bandicoot burrows and estimation of bait and poison etc, removal of weeds, harbourage etc.

Day 2 : Identification of live burrows/pre-baiting

Day 4 : Zinc phosphide baiting

Day 5 : Collection and burying of dead rodents

Day 7 : Plugging of burrows/de-plugging of bandicoot burrows

Day 8 : AlP fumigation (if available) for heavy soils or bromadiolone baiting (loose bait/wax cake)

In case of bromadiolone baiting-after 7-10 days remaining burrows may be plugged/de-plugged (bandicoot burrows) to assess the control success.

2. **Wet land (irrigated) agriculture**

Time of Operation : Before sowing/transplanting

Day 1 : Plugging of burrows/de-plugging of bandicoot burrows, estimation of bait, poison, removal of weeds, harbourage etc.

Day 2 : Identification of live burrows/ALP fumigation (if available) or pre-baiting.

Day 4 : Zinc phosphide baiting (if fumigation is not done)

Day 5 : Collection and disposal of dead rodents.

Day 7 : Plugging of burrows/de-plugging of bandicoot burrows.

Day 8 : Bromadiolone baiting (loose or wax cake)

(After 10 days, all burrows to be plugged/bandicoot burrows to be de-plugged for assessing the success of control operations).

EDUCATION AND TRAINING

Sufficient cost effective technologies have been evolved over a period to contain the rodent menace, but these have not yielded satisfactory dividends. The reason being that the end users i.e. farmers are ignorent about the technologies. There could be several reasons for this. However, the most important reason is lack of education and training leading to unawareness among farmers. Through education and training we can increase the knowledge of end users. Besides this their attitudes can also be molded accordingly. We all agree that religious taboos are one of the major constraints in our society which hinder even initiation of rodent pest management programmes. This problem can only be overcome through proper education and training.

The rodent pest management programmes can only be successfully launched with the close cooperation and understanding of the public. In Rajasthan, at the time of sowing of crops, farmers usually put 2-3 handfuls of seeds in the name of rodents and birds. This is not because they are not aware of the problems, but because of lack of knowledge about management technologies. On the other hand some people do not want to kill the pest at any cost. Therefore, their attitudes need to be changed. It is generally said, "You can teach a young parakeet but not the adult one". Similarly, to change the attitude of adults, who play a key role in decision making process, is a herculean task. Therefore, if we infuse the idea of rodent pests and their managements in the minds of school-going children, we may succed in building a solid base of social consciousness which will encourage people to hate the damaging rodents and to take measures to eliminate them.

Role of media : Radio and Television are two strong media which can be utilised for mass education of farmers about rodent pest management technologies. If the enormous losses caused by rodents are brought to the notice of all, atleast a thinking against rodents can be generated. Once such a thinking is developed, programmes incorporating management technologies may be broadcasted/televised. Besides this, education of extension workers needs to be intensified on a priority basis. In every block one village should be made "rodent free" for demonstration purposes. Public can also be educated by short pamphlets, which should be profusely illustrated showing damages, and spread of diseases through rodents.

Training : It is the most important component in popularisation of any technology on a mass scale. Since rodent management technologies are easy to operate and are quick result oriented and cost effective, these can be translated into practice at farmers fields. But, for proper dissemination of knowledge on this aspect, all the states dealing with extension and education need to be invariably trained. This training may be divided into:

(a) *Apex Level Training :* This training is to be imparted to the Directors/Jt. Directors of Agriculture. The contents of the course or methodology may emphasise on management of transfer of technology, the type of training required for lower strata, human resource management, molding the attitudes and behaviour of the people towards rodent control, and on effective communincation. Further, procurement of inputs like rodenticides and baits etc. should also be dealt in this training. The coverage of Government Lands, Common Property Resources, Railway tracks, road sides etc. should receive the highest priority for rodent control work, because these are the real breeding grounds of rodents.

(b) *Field Level Training :* The present Training and Visit (T & V) system is quite effective. Therefore, all the training programmes for Subject Matter Specialist to farmers may invariably include a package of rodent management technology. Since rodent management is a skill oriented training more emphasis is to be laid on practicals.

(c) *Training among farmers* : Several voluntary organisations like, Nehru Yuvak Kendras, Farmer's Club, Yuvak Dals and Mahila Mandals are working among farmers. Within these organisations "Rodent Control Squads" should be formed. The squads may be given vigorous training in rodent management techniques and on the availability of rodenticides and baits etc. When the squads are formed, the media may be utilized to popularise the rodent management campaigns on community basis. Like '*Van Mahotsav*", a "Rodent Control Week" may also be celebrated before sowing of the crops i.e., in May-June and in October-November.

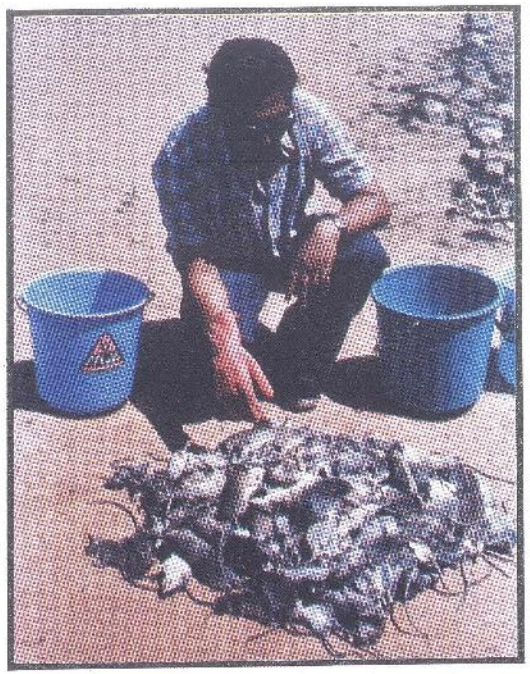


Plate 5 Result of a successful rodent control operation.

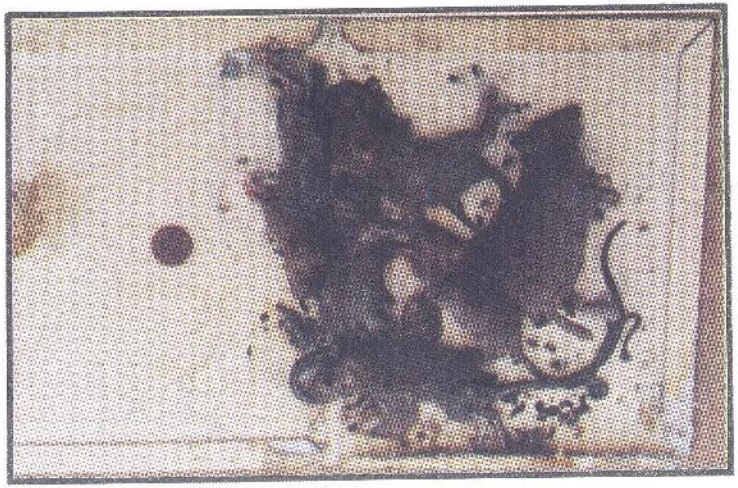


Plate 6 Glue traps – an effective non lethal tool for rodent management.

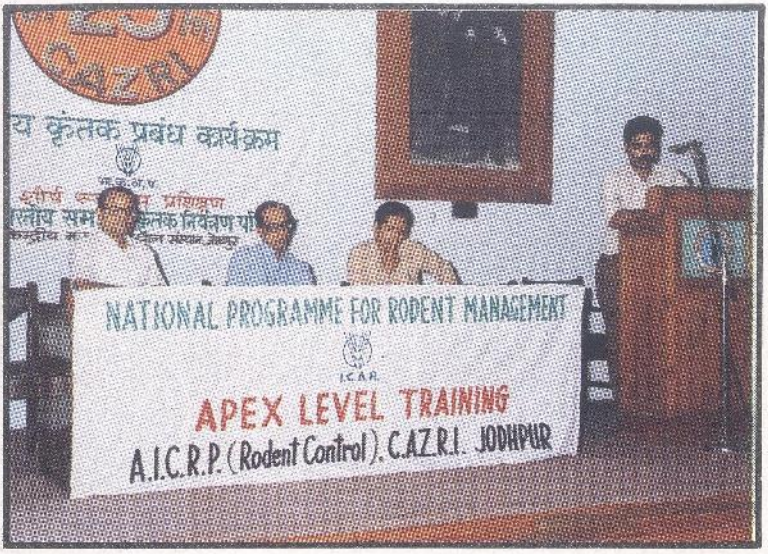


Plate 7 Apex Level Training for creating nucleus of trained personnels.

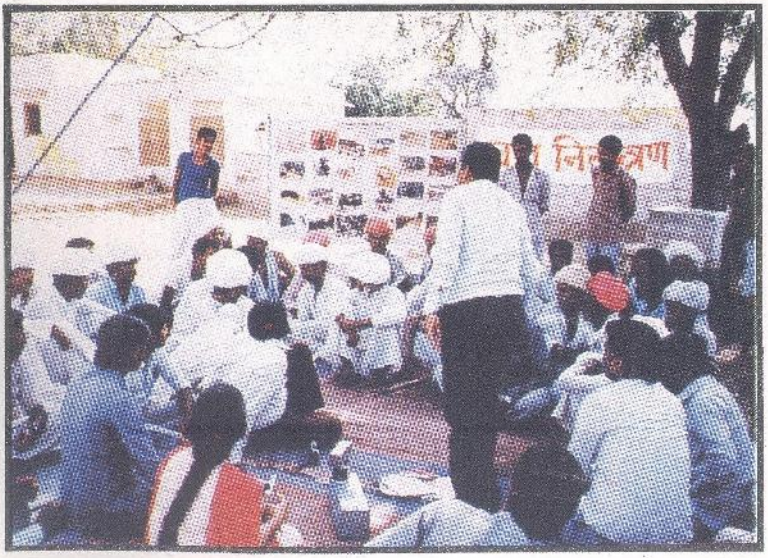


Plate 8 Scientists in dialogues with farmers in a village panchayat.