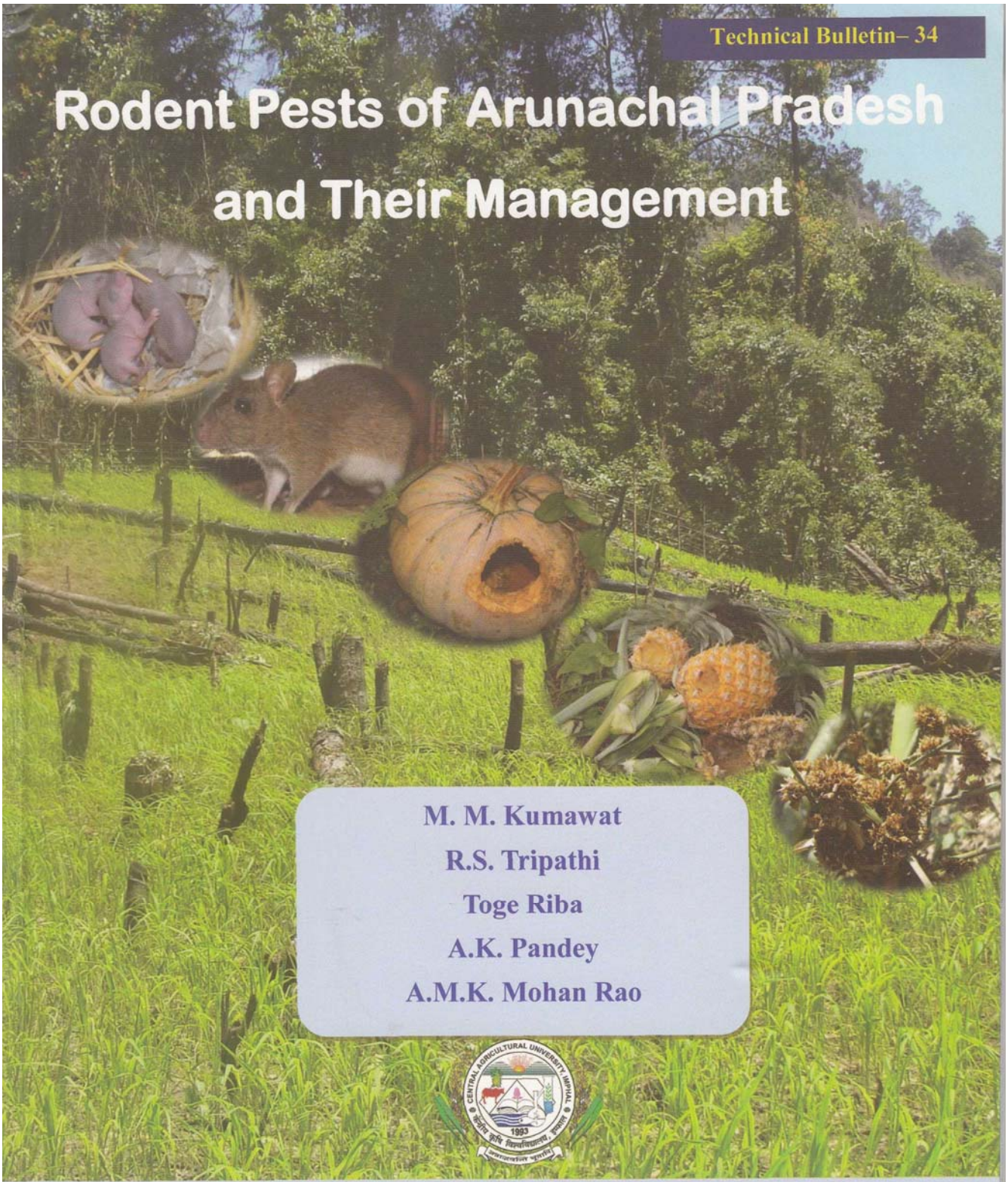

Technical Bulletin– 34

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All India Network Project on Vertebrate Pest Management

College of Horticulture and Forestry

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Pasighat- 791102 Arunachal Pradesh

Extension activities on rodent control by "AINP on Vertebrate Pest Management" Pasighat center

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FOREWORD

Rodents are important link in food chain between plants and the carnivorous predators, hence, they play an important role in different ecosystems. They are important sources of prey for a vast array of predators like owl, hawk, eagle, cat, etc. Rodents share almost 40% of the mammals species and represent the largest order of the mammals. Arunachal Pradesh is the largest state among all the North eastern states of India located in the Eastern Himalaya and has various topographical zones which favours the increasing diversity of rodents. The gregarious flowering of bamboo and the outbreak of rodents has been observed in North eastern states since many years. A peculiar problem of sudden outbreak in the rodent population coinciding with the bamboo flowering has been observed in Arunachal Pradesh. This type of rodent outbreaks at a periodic interval has also been reported from the neighbouring states like Mizoram and Manipur. It is a common belief that the bamboo flowering gives a big boost to the rat's population, though a proper scientific explanation is meager. It is essential to initiate the steps for management of irruptive rodent pests by focusing the strategy on prediction and monitoring of rodent population, tactical and prophylactic use of rodenticides to suppress the likely rodent outbreak. Rodents are serious agricultural, storage and household pests throughout the country. The extent of rodent damage in India ranges from 1 to 20% of tiller damage in rice, although, this amount increases at the time of bamboo flowering. Beside agriculture, they consume and contaminate food, damage structures and property, and transmit parasites and diseases to other animals and humans.

Keeping above facts in view the University opted and intensively participated in All India Network Project on Vertebrate Pests Management since 2008. Present bulletin "Rodent Pests of Arunachal Pradesh and Their Management" has been compiled on the basis of very practical information generated on various points of their management. Information compiled in the form of technical bulletin will be of immense help to the farmers, trainers and state functionaries for better management of rodents.

Dated 02nd January, 2016
Imphal

(M. Premjit Singh)

PREFACE

Rodents are one of the most important non-insects pests of agricultural crops, particularly rice, wheat, coconut and potato. They consume and contaminate food, damage structures and property, and transmit parasites and diseases to other animals and humans. Rats live and thrive under a wide variety of climates and conditions; they are often found in and around homes and other buildings, farms, gardens, and open fields. Fifteen species of the rats and mice were recorded from North-Eastern Hill Region, belonging to the genus *Rattus, Bandicota, Mus, Cannomys, Vandeleuria* and *Callosciurus. Rattus rattus* is the predominant species followed by, *Rattus sikkimensis, Bandicota bengalensis, Rattus nitidis, Mus musculus* and these were recorded at all the altitude varying from 130 to 5000m MSL. Out of 15 rodent species identified from Arunachal Pradesh, 6 species of squirrels and 2 species of porcupines are also reported to cause damage in various agricultural crops. All India Network Project on Vertebrate Pest Management (Indian Council of Agricultural Research) has developed technologies for rodent pest management, which need to be transferred to the end users.

Vigorous flowering and seeding in certain species of bamboos are believed to cause severe rodent outbreaks in the region in certain years, resulting in famine. The greatest damage recorded in rice ranged from 12.9% to 15.4% during bamboo flowering 2008-09, whereas it was 5.3% to 5.8% in the non-flowering year 2010. It is not clear that bamboo flowering, rainfall and nutritional factor of bamboo seeds are linked with rodent outbreak. It is very necessary to develop trained personnel in all the north eastern states.

The authors are highly grateful to Indian Council of Agricultural Research, New Delhi and Central Agricultural University, Imphal rendering the financial assistance and continuous support. Authors are well confident that the present technical bulletin will prove to guide the extension officials and farmers in managing the rodent pest problems in agricultural crops very effectively.

Pasighat
February, 2016

Authors

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Chapter- 1: Introductory Consideration

1. Introduction

Rodent pests are a serious problem of agricultural production in India. They are responsible for 5-10% loss of food grains annually during production, processing, storage and transport accounting a loss of about 10-25 MT annually. Generally, they are omnivorous, feeding mainly on plant materials, animal tissue, insects, snails and other invertebrates. Rodents occupy a wide range of natural habitats including forests, grassland, agricultural landscape and townships. Management of rodent pests in agricultural regions is therefore a high priority for reducing poverty. In north eastern states, they are highly significant pests of agricultural commodities especially during the bamboo flowering. Their population increases tremendously resulting in heavy loss, sometimes go up to famine.

Arunachal Pradesh, the land of rising sun, is situated in the North-East extremity of India. The state is the largest among all the North- East States considering its vast area comprising of 83743 Sq. kms. It is endowed with wide topographical variations, vegetation and wild life. There are 25 major tribes and 100 sub-tribes speaking over 50 main dialects. Repeated surveys were carried out during the year 2009 and 2015 in East Siang, West Siang, Upper Siang, Papumpare and Lower Subansiri Districts of Arunachal Pradesh for assessment of losses due to rodents and development of the rodent management strategies. Despite diversity in ethnicity, they practice a common but unique farming system locally called jhum around which their culture and tradition revolves. Natural vegetation, primarily bamboo forests, surrounds the crop fields and provides the most favourable habitat for rodents in the NEH region of India. Rodents are a serious threat in residential premises and stores. Vigorous flowering and seeding in certain species of bamboos are believed to cause severe rodent outbreaks in the region in certain years, resulting in famine. Bamboo flowering interval is genetically triggered and ranges from less than 10 years to more than 120 years. The present publication is an attempt to collate the available information on rodents of Arunachal Pradesh and their management, and compilation of indigenous techniques of rodent control which have great cultural significance among tribes of Arunachal Pradesh.

2. Diversity of rodents in India

Rodents make up almost 40% of the mammals species and represent the largest order of the mammals comprising some 1700 species in 35 families that include 389 genera in the world. Further 12 families and 300 genera are known only from fossils. Out of these, four families namely Sciuridae, Muridae, Dipodidae and Hystricidae occur in India. Family Muridae, which is the largest family, represents 28 genera and 68 species; family Sciuridae represents 12 genera and 29 species; family Dipodidae represents one genus and one species while family Hystricidae represents 2 genera and 3 species. Zoological Survey of India published faunal document including rodents from Arunachal Pradesh. Their principal nonflying feature is the possession of one pair of incisors, which are used for gnawing. The name of the order rodentia is derived from the Latin '*rodere*' meaning to gnaw. The rodents' incisors are remarkable in their length, the open roots of the lower pair reaching back to the articulation of the jaw and their front surface is coated with enamel. This enamel enables the dentine for producing a self-sharpening blade.

2.1. Family Sciuridae: The family Sciuridae has five sub-families and includes tree squirrels, ground squirrels and flying squirrels which are a diverse group consisting of approximately 51 genera and 279 species. Tree squirrels have long, bushy tails, sharp claws and large ears. Some have well-developed ear tufts. Flying squirrels have a furred membrane '*patagium*' extending between the wrist and ankle that allows them to glide between trees. Ground squirrels are generally more robust than tree squirrels and often have short, sturdy forelimbs those are used for digging. Their tails, while fully furred, generally are not as bushy as those of tree squirrels.

2.2. Family Hystricidae: The family Hystricidae includes 11 species of porcupines found in Africa and Asia. These Old World rodents are large, weighing up to 25 kg. Members of this family are nocturnal and fossorial possess specialized pelage or hairs those are modified into sharp spikes or quills. These quills act as a deterrent defense against larger predators. Three species of porcupines are found in India out of which two are threatened.

2.3. Family Cricetidae: Cricetidae is an extremely diverse large family of muroid rodents represented by 6 subfamilies, 130 genera and 681 species. About 21% of the species in this family are included on the IUCN's Red List of Threatened Species. Of these, 58 are of lower risk, 2 are near threatened, 27 are vulnerable, 27 are endangered, 11 are critically endangered and 10 are lacking sufficient data. Another 6 have gone extinct in recent years. Many cricetids have restricted geographic ranges,

making them even more vulnerable to extinction. As research animals, cricetids have contributed greatly to the fields of ecology, physiology, and genetics. Some species are used for food or for their valuable fur. Also, cricetids play an important role in controlling populations of insect pests. Cricetids have a large impact on forest succession by preying on tree seedlings, and are sometimes considered keystone species when they play such roles. Cricetids represent five species in India of which two species are threatened (including *Alticola roylei* from Arunachal Pradesh) and one is vulnerable.

2.4. Spalacidae: This family contains species of fossorial and subterranean muroids characterized by extreme morphological, physiological, and behavioral specializations associated with subterranean life in tubular burrows. This family represented 6 genera and 36 families in the world. Only two species of spalacid rodents are found in India belong to genus *Cannomys* and *Rhizomys*. Both the species are restricted in Northeastern region.

2.5. Muridae: The Muridae, or murids, are the largest family of rodents containing over 700 species found naturally throughout the world. They are fossorial, arboreal, and semi-aquatic, though most are terrestrial. Murids generally have excellent senses of hearing and smell. They live in a wide range of habitats from forest to grassland, and mountain ranges except Antarctica or many Oceanic Islands. A number of species, especially the gerbils, are adapted to desert conditions, and can survive for a long time with minimal water. A few species, notably the house mouse and house rat have been introduced worldwide. In India, 55 species of murids are found belong to 20 genera mainly represent by gerbils, rats, bandicoots and mice.

3. Rodent diversity in Arunachal Pradesh

3.1. Family Muridae

1. Bower's rat, *Berylmys bowersi*
2. Common Indian rat, *Rattus rattus*
3. Cook's mouse, *Mus cookii*
4. Himalayan rat, *Rattus nitidus*
5. House mouse, *Mus musculus*
6. Indian field mouse, *Mus booduga*
7. Indian rat, *Rattus rattus brunneusculus*
8. Indian rat, *Rattus rattus tistae*

9. Lesser bandicoot rat, *Bandicota bengalensis*
10. Sikkim rat, *Rattus sikkimensis*
11. White bellied rat, *Niviventer niviventer*
12. Chestnut rat, *Niviventer fulvescens*
13. Indian long-tailed tree mouse, *Vandeleuria oleracea*

3.2. Family Spalacidae

14. Lesser bamboo rat, *Cannomys badius*
15. Hoary Bamboo rat, *Rhizomys pruinosus*

3.3. Family Cricetidae

16. Royle's Mountain Vole, *Alticola roylei*

3.4. Family Sciuridae

17. Giant Flying Squirrel, *Petaurista petaurista*
18. Hoarybellied Himalayan Squirrel, *Callosciurus pygerythrus*
19. Malayan Giant Squirrel, *Ratufa bicolour*
20. Orange bellied Himayayan Squirrel, *Dremomys lokriah*
21. Particolored Flying Squirrel, *Hylopetes alboniger*
22. Red bellied Squirrel, *Callosciurus erythraeus*

3.5. Family Hystricidae

23. Bush-tailed Porcupine, *Atherurus macrourus*
24. Chinese Porcupine, *Hystrix brachyuran*

Red bellied Squirrel
Callosciurus erythraeus

Hoarybellied Himalayan Squirrel
Callosciurus pygerythrus

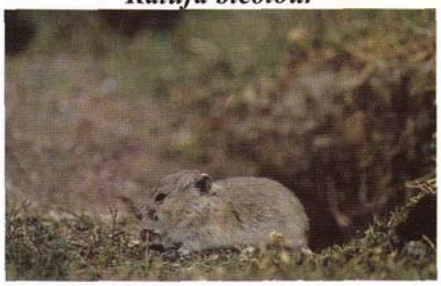
Orange bellied Himayayan Squirrel
Dremomys lokriah

Particolored Flying Squirrel
Hylopetes alboniger

Giant Flying Squirrel
Petaurista petaurista

Malayan Giant Squirrel
Ratufa bicolour

Hoary Bamboo rat
Rhizomys pruinosus



Royle's Mountain Vole
Alticola roylei

Bush-tailed Porcupine
Atherurus macrourus

Chinese Porcupine
Hystrix brachyuran

4. Common rodent pests of Arunachal Pradesh

The major groups of rodents, which have economic importance in Arunachal Pradesh are porcupines, rats, squirrels and mice. The major pest species of rodent group are discussed below:

4.1. Lesser bandicoot rat, *Bandicota bengalensis*

Lesser bandicoot rat, *B. bengalensis*

B. bengalensis is a major agricultural and urban pest across much of south East Asia. It occupies communal burrows and can reach very high local population densities. The habitual hoarding of large quantities of cereal grains is also noteworthy. This Indian mole rat is a robust rodent (around 200 to 300 g body weight) with a rounded head and a broad muzzle. Tail is shorter than head+body, and dorsum with dark brown colour and coarse hair.

Distribution: Widely found in South East Asia. It is transported through human agencies and established in the field as well as in houses.

Habitat: *B. bengalensis* although found in various ecological conditions is a wet rodent and hence depends on mesic conditions. As a result it is seen on the embankments around rice cultivation and irrigated fields.

Habits: It is a nocturnal and fossorial, lives in self constructed burrows. It hoards the grain. The burrows are characterised by the presence of scooped soil before the entrance. Sometimes these openings are closed with soil plugs for regulating temperature and relative humidity inside the burrows. They breed throughout the year with peak activity coinciding with the maturity of *kharif* and *rabi* crops. However, males are reportedly fecund all through the year. The oestrus period varies from 3 to 5 days and gestation period is 21-25 days. Litter size range from 1 to 11 (mean 6.2). It litters 9 to 11 times a year producing about 70 young ones per annum per female with a post partum period of 30 days.

Pest status: *B. bengalensis* damages all kinds of field crops and also attacks stored grains. It is a major pest in the state. Losses due to consumption and hoarding were estimated at 261kg/ha in rice crop and 260-388kg/ha in wheat crop in some areas of the country. It is also a vector for leptospirosis.

4.2. Common Indian rat, *Rattus rattus* Complex

This group or 'complex' includes a number of closely related species that presumably found in discrete geographical areas. This has probably resulted in some local interbreeding and gene flow, and resulted in much confusion over the true number of species in the group. It is medium sized (80-120 g.) rodent with bicolour and ringed tail that is longer than head +body length. It is also called as black rat or roof rat. It has bicolor tail and nocturnal in habit.

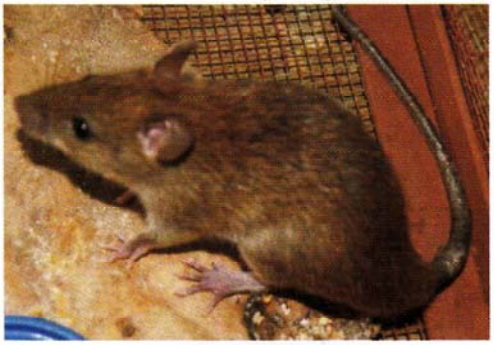
Common Indian rat, *R. rattus*

Distribution: This is the most prevalent house dwelling rodent living with *Mus musculus* in the residential premises and storage units. They also live in colonies on the crown of coconut trees in the state.

Habitat: This rat is partially social and lives inside residential premises and storage areas.

Habits: It is generally nocturnal. It is a good climber with longer tail to balance and lives on roofs of residential premises. It breeds throughout the year producing 5 to 7 litters a year. Gestation period is 22 days with a litter size of 6-14 young ones.

Pest status: It causes extensive damage to a wide variety of cereals, vegetables and fruit crops, including coconut. The rats cut whole tillers at all stages of growth but are also sufficiently agile to climb and directly attack the panicles of mature plants. It is one of the most important pests of stored grains and fruits in the state. It is also a vector plague and leptospirosis diseases.



Himalayan rat, *R. nitidus*

4.3. Himalayan rat, *Rattus nitidus*

R. nitidus is a major agricultural pest species in rice and wheat growing areas. It is medium sized (length 160 mm and weight 110-120g), snout is long and ears are large. The tail is approximately equal in length to the head+body length. It is paler below and weakly bicoloured.

Distribution: Mountain and hilly region of northern India and Nepal through Myanmar.

Habitat: It is found abundant in all cropping systems including rice, wheat, maize, potato and orchards. The individuals regularly shift their exploitative focus between habitats following the availability of foods.

Habits: It nest in or around houses, but may dig burrows where it occurs as a field pest. It breeds throughout the year and litter size ranges from 4-15 with overall average of 8.25. Captive females can produces four litters per year with an interval between births of 35±10 days.

Pest status: It is comparatively a minor pest in Arunachal Pradesh. However, it is associated with damage to rice and maize at grain formation stage.

Sikkim rat, *R. sikkimensis*

4.4. Sikkim rat, *Rattus sikkimensis*

R. sikkimensis is widespread in upland forest habitats of mainland Southeast Asia. It is a highly arboreal species and closely resembles *R. rattus* in appearance. It has proportionally longer tail commonly 20-30 mm longer than the head+body. The belly fur is either pure white or cream in colour sometimes with a reddish brown chest patch. The eras are relatively larger than the other *Rattus* sp. The average weight is 100-125g with

150-180mm head+body length.

Distribution: It is widely distributed across the upland regions of Southeast Asia from Nepal to Myanmar through Sikkim and Arunachal Pradesh.

Habitat: It is common in evergreen forest of mountains. The species is also found in upland gardens adjacent to forest and in clumps of bamboo belt along with river flowing and villages.

Habits: It is rarely found near the human settlements and in houses. It is often trapped in agricultural fields adjacent to the forest areas. The breeding biology is unknown.

Pest status: It is found to cause damage in various vegetable crops, jhum rice, and other crops grown in shifting cultivation in forest areas of Arunachal Pradesh.

4.5. Bower's rat, *Berylmys bowersi*

This species is confined to the forest habitats. It can be recognized by their pale cream or white incisor enamel and their short grey or brownish-grey dorsal fur. The tail is slightly longer than the head+body and usually slightly darker above than below. The average head+body length is 240-285mm with 292-420g weight.

Bower's rat, *B. bowersi*

Distribution: This species is found from North-eastern India to southern China through Thailand, Laos, Sumatra, Indonasia and Vietnam.

Habitat: It is most commonly encountered in upland regions and live in burrows, although it is a good climber.

Habits: *B. bowersi* appears to be more strictly forest dwelling, although it is occasionally trapped in cropping areas. It spends most of the time foraging on the ground. Its diet consists of fruits and vegetables. The nests of this species are located in fallen logs and in burrows situated in drier, more elevated sites. The female have been found with 2-5 live embryos. Maturation of both sexes is very slow, with males developing scrotal testes.

Pest status: It causes the damage to most of the fruits, vegetables and tuber crops but it is stayed in or nearby the forest.

4.6. Bay bamboo rat, *Cannomys badius*

C. badius is widespread across the upland regions of North-eastern India. It is a moderately large well built with lush orange brown fur and well adapted for fossorial life. It has massively broadened head, a plump body with short limbs, strong claws, short haired tail and small ears. The average head+body length is 147-259mm with 0.5-0.8kg weight.

Bay bamboo rat, *C. badius*

Distribution: Its presence ranges from Nepal, Northeast India to Thailand through Myanmar. It is found in bamboo based forest areas.

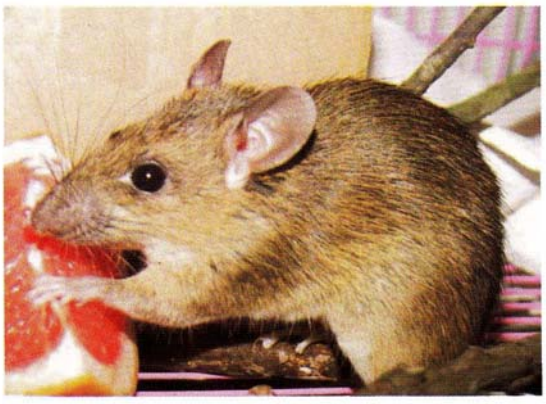
Habitat: The bamboo rats are probably most abundant in the natural bamboo forests. Their presence in such areas is always obvious from their large, poorly concealed burrow systems in which they shelter through the day. Their burrows are often located within or around the margins of gardens.

Habits: In North eastern India, the burrows consist of a single tunnel running at a depth of 60cm or so below the ground and ending in a large chamber. A second tunnel usually partway to the surface, perhaps as an incomplete emergency exit. When the burrow is occupied the active entrance is closed with freshly piled earth. Litter size consists of 3-5 young ones.

Pest status: It causes damage to rice crop, sugarcane, cassava and orchard trees. Some farmers also claim that *C. badius* tunnels below rice plants and consume the plants from below.

4.7. White bellied rat, *Niviventer niviventer*

This is one of the common rats in Arunachal Pradesh. Tail is longer than the head+body length. Dorsal side is grey in colour and toes usually white. Under parts are sharply contrast whitish. Tail is quite clearly bicolour, dark above



White bellied rat, *N. niviventer*

and whitish below.

Distribution: This species is widely distributed in Arunachal Pradesh, Meghalaya, Nagaland and Assam.

Habitat: It is found in evergreen forest areas and sometimes caused damage to agricultural crops which are adjacent to the forest.

Habits: It is found to make damage in rice fields at grain formation stage. This species cut the rice ears and drag into their burrows.

Pest status: This species is confined to the forest but sometimes causes the damage to rice fields. Its population rises at the time of mass bamboo flowering in the region.

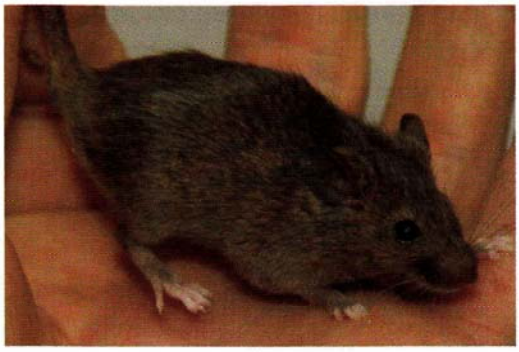
4.8. House mouse, *Mus musculus*

House mouse is found in the houses, living in burrows, below rocks and in crevices. It is omnivorous and causes lot of damage to grains and stored food material. They are small rodents with 26-95mm head+body length and 13-26g weight. It has bicolour tail longer than head + body. The dorsum is dark brown to sandy.

Distribution: It is widely distributed throughout the region and its most population is found in towns and small villages.

Habitat: It is usually confined to the houses and human habitations and rarely found in cropping areas.

Habits: They are nocturnal, fossorial and highly active and have nibbling habit, which result in damage to snacks and foods. Breeds throughout the year with a litter size of 1-8 (Mean 5.6) young ones, oestrous period of 5.7 days, and has a gestation period of 18 days. Young ones reach maturity in 45 days. This species uses a variety of nesting sites, including burrows excavated in the walls and floor of buildings or under piles of straw. Nests are sometimes also constructed in piles of grain bags or stored cloths. Burrows usually have 1-3 entrance with 1-2 brood chambers.

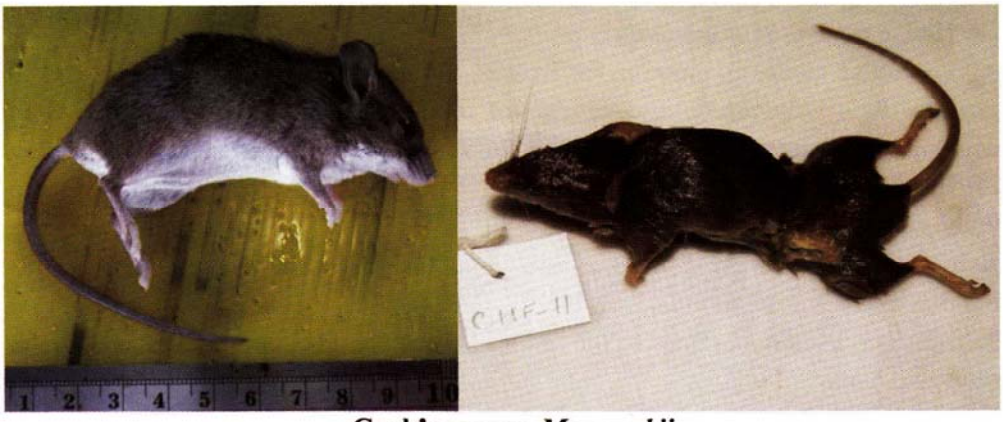


House mouse, *M. musculus*

Pest status: House mice presumably cause significant damage to stored grain and other foods items. They are also said to damage household items such as clothes and furniture.

4.9. Cook's mouse, *Mus cookie*

This species is found in jhum rice fields. *M. cookii* is a moderately large species of mouse with a long narrow snout, large, broad ears and weakly bicoloured tail. The belly fur is cream with dark grey bases. The tail may be slightly shorter or slightly longer than the head+body length. It has 16-23g of weight with 77-96mm length.



Cook's mouse, *Mus cookii*

Distribution: Widespread across North eastern India, Myanmar to Vietnam.

Habitat: It is reported from forest under leaf litters and sometimes in jhum rice fields.

Habits: This species is flushed from straw piles in jhum rice fields. However, it is unclear whether the animals are nesting among the straw or in small burrows observed below the straw piles.

Pest status: It is found to cause damage in rice fields of Arunachal Pradesh, however, the extent of damage is very less.

4.10. Orange bellied Himalayan Squirrel, *Dremomys lokriah*

This is medium sized forest squirrel with a head to body length of 200 mm and tail length of 220 mm. The dorsal coat is dark rufous brown speckled with

yellowish brown, while the ventral side is orange, varying from pale to rusty red. This species is hunted in Arunachal Pradesh for medicinal and religious purposes.

Dremomys lokriah

Distribution: This species is distributed in northeastern South Asia, southern China and western Southeast Asia including Bangladesh, Bhutan, India and Nepal with elevations of 200 to 3,000 m MSL.

Habitat: It is diurnal and arboreal species that also forages on the forest floor. It occurs in subtropical evergreen and broadleaved forests (including moist semideciduous forest).

Habits: It has been found to occupy tree hollows in mid high canopy of dense oak, bamboo, fir, conifer and pine forest patches. The species litters of two to five young.

Pest status: The species is reported to feed on fruits, coconuts and aracanuts in the region.

4.11. Hoarybellied Himalayan Squirrel, *Callosciurus pygerythrus*

This species is listed in the Schedule II of the Indian Wildlife (Protection) Act, 1972. It is known from the protected areas in India *viz.* Namdapha National Park and Pakhui Wildlife Sanctuary in Arunachal Pradesh.

Callosciurus pygerythrus

Distribution: Hoarybellied Himalayan Squirrel is a widely distributed species at present in northeastern South Asia, southern China and western Southeast Asia. In South Asia, this species is widely distributed in Bangladesh, Bhutan, India and Nepal at elevations up to 1,560 m MSL. It is largely confined to western and central Myanmar.

Habitat: In general, this is a diurnal

and arboreal species that occupies mid canopy temperate, tropical and subtropical moist forest with thick to moderate evergreen forest patches.

Habits: The species has been recorded from gardens, plantations including bananas and cane shrubs. The species reproduces once each year, with a litter size averaging three to four offspring.

Pest status: Hoarybellied Himalayan squirrels were observed to prefer a rich and varied habitat consisting predominantly of Bamboo, *Ficus* spp., *Azadirachta indica*, *Bombax ceiba*, *Olea europaea*, *Bambusa* spp., *Dendrocalamus* spp. and various other fruit plants and wild shrubs and trees. In north east India, it is a major pest of coconut.

Chapter- 2: Rodents in relation to public health

In addition to the depredations caused to the agricultural crops and commodities in storage, rodents also transmit various diseases to humans as well as livestock. They serve either as vectors of diseases to man through the direct transfer of disease causing organisms or as reservoirs of diseases which are transmitted to man by arthropod vectors. The frequency of disease transmission is facilitated by the close association, which rodents have with man, living in the houses and consuming and contaminating human food. A proper understanding of their role in transmitting diseases provides means of the prevention of the public health diseases. The rodents transmit bacterial, viral and protozoan diseases.

2.1. Bacterial diseases

2.1.1. Leptospirosis: Leptospirosis is a bacterial disease affecting human beings as well as livestock. It is caused by *Leptospira interrogans*, which are parasitic in rodents and other animals. There are 26 serogroups with about 140 serovars within the species of *L. interrogans.* This infection is carried by wild vertebrate animals, especially, rodents and transmitted to man. Without laboratory diagnosis of leptospiral infection, this disease cannot be diagnosed with certainty. Therefore, *Leptospirosis* is a *hidden disease officially not documented in number of states since scanty diagnostic facilities are available*. It is reported as endemic in the States of Kerala, Karnataka, Gujarat, Tamil Nadu, Maharashtra and Andamans and Nicobar islands. However, reports exist from several other states, viz., Orissa, Madhra Pradesh, Delhi, Andhra Pradesh etc. The clinical features may resemble those of fever, influenza, typhoid fever, dengue hemorrhagic fever, viral hepatitis, bacterial meningitis or acute renal failure. Illness lasts from few days to 3 weeks with low human mortality

Pathogenic leptospires survive for long periods in the convoluted tubules of the kidney in natural hosts, multiply and are shed in the urine up to 100 million leptospires per 1 ml. of urine. They survive in moist warm soil and stagnant waters, particularly if the pH is on the alkaline side. Wild and domestic rodents, carnivores (jackals, dogs), herbivores (cattle, sheep, goats), pigs, hares, frogs and humans are infected by contact with soil or water contaminated with these organisms. Therefore, the disease is common among rice and sugarcane field workers/farmers, fishermen and sewer workers and is considered as occupational hazard.

The limited work in India so far indicated only three rodent species i.e., *Rattus norvegicus, Rattus rattus* and *Bandicota bengalensis*, as important shedders or vectors of the leptospirosis. The disease is more common than ordinarily diagnosed and many so-called fevers of unknown origin are due to it. Further, denser the rodent populations, greater will be the risk of infection to man. As leptospirosis results from contact of skin or mucosa with urine contaminated water, general measures of prevention such as rodent control, disinfection of water and the wearing of protective clothing contribute to its prevention.

2.1.2. Plague: Recently in late 2004 incidence of plague in Uttaranchal was noticed by NICD. Definite records of plague incidence in India exist from 1896 onwards with rodents as vectors/reservoirs for this bacterial disease. Rodents are primary hosts of the causative bacteria, *Yersinia pestis*, for the plague disease through oriental flea, *Xenopsylla cheopis.* In India the sylvatic plague foci are recognized in the foothills of the Himalayas (Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Uttar Pradesh, and Bihar), in the watersheds of the Vindhyas (Madhya Pradesh) and in the Deccan Plateau (Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu). Recent report is from Uttaranchal during 2004.

Among rodents, some species are susceptible to the disease leading to high mortality, while others are relatively tolerant to the disease. The Indian gerbil, *Tatera indica* is resistant to the disease and as such act as permanent reservoir host in many foci in India. The *T. indica* lives in wild and away from human habitations. However, summer periods or prolonged dry spells compel them to go near the fields around human habitations. During this period the commensal rodent species like the lesser bandicoot, *Bandicota bengalensis* in these fields will get infested with the plague-infected flea, *Xenopsylla cheopis.* When this species

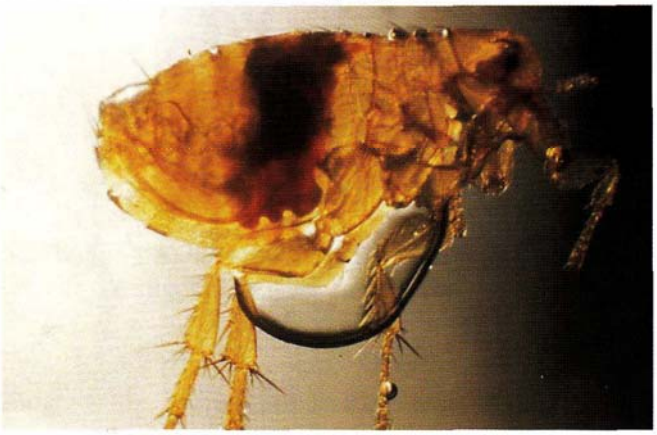
Rat flea under rat furs

interacts in the domestic areas the infected flea will reach the house rat, *Rattus rattus*. Both *R. rattus* and *B. bengalensis* are susceptible to infection, disease, and rapid mortality; they act as links between wild rodent infection and human plague. Sick and dying rodents may fall of from roofs or on the ground. As the body temperature of these carcasses fall, fleas escape and find other warm-blooded hosts such as dogs and humans around the vicinity.

2.1.3. Salmonellosis: Salmonellosis caused by *Salmonella bacillus* is characterised by acute gastroenteritis in man. Contaminated water and foodstuffs do the transmission by faeces of an infected person or animal, and rodents are very frequently a source of such infection. Although rats are not the only animal source of salmonellosis infection, worldwide information on this disease indicated them as one of the major sources.

2.2. Viral infections: Although viral infections are reported to be highly prevalent in Asian countries, India has no reported vectors for transmitting the hemorrhagic fevers caused by *arbo* and *arena* virus. The virus of Kyasanur forest disease is widely distributed in India with human infections only in Karnataka State. Transmission is by *Haemaphysalis* ticks and the disease is maintained in small mammals, such as *Suncus murinus* and *Rattus* species, while monkeys in forest areas serve as amplifying hosts.

2.3. Rickettsial infections: There are five diseases in this group of zoonoses caused by *rickettsia* and all have rodents implicated, at least in part, as reservoir hosts. Among them, Murine typhus is a very widespread, acute, febrile rickettsial disease caused by *Rickettsia typhi*. The reservoir hosts of the disease are primarily *Rattus* spp., *Rattus norvegicus* and *R. rattus*. Through fleas, which are vectors from rat to rat or from rat to man. The most important flea vector is *Xenopsylla cheopis*. This disease is most common in cities with high rat populations and a relatively high incidence of the vector flea. Due



Flea vector, *Xenopsylla cheopis*

to the difficulty in its diagnosis the disease is under reported in tropical areas where it may be confused with a number of other febrile diseases.

2.4. Helminth and Protozoan diseases: Leishmaniasis is caused by protozoan parasites belonging to the genus *Leishmania*. Cutaneous leishmaniasis caused by *Leishmania tropica* is very widespread. The cutaneous ulcers of varying degrees of severity are common in areas where sand fly vector, *Phlebotomus* species are not controlled. Visceral leishmaniasis is caused by *Leishmania donovani* and widely known as kala azar. The vector is *Phlebotomus* sandflies. The reservoirs include man himself as well as dogs, other canines and a number of wild rodent species. The exact role that rodents play as reservoirs of the disease is not clear.

Chapter- 3: Damage caused by rodents in agricultural crops

3.1 Rice crop

Rodents are one of the most important non-insects pests of agricultural crops, particularly rice and maize in the state. Under irrigated conditions in plain regions of Arunachal Pradesh, *Bandicota bengalensis, Rattus sikkimensis* and *Rattus rattus* are the predominant rodent pests associated with rice crop.

3.1. Damage at different stages

In India, rodents have been estimated to cause 5 to 10% losses in rice. Severity varies with season, location and ecosystem. Among the field crops, rice is the most vulnerable crop to rodents. In Arunachal Pradesh the losses are estimated as 2 - 20%. Rodents do not spare any variety and they attack all stages of the crop during all seasons. In addition to tiller cutting, they also hoard ripened panicles inside their burrows. Hoarding of grains by *Bandicota bengalensis* was observed in the farm at the time of harvest.

Typical rodent damage in rice tillers

12.1.1. Nursery: Maximum damage to nurseries takes place when the seeds are just germinated. At this stage, the nurseries are drained out and the rodents run freely inside the bed spoiling all germinated seed. Later, they also cut the seedlings 1-2 inches above the water level.

12.1.1. Main field: Sometimes the rodents pull out the transplanted seedlings and create gaps in the main field. They start cutting the seedlings. Generally, their activity is confined to inside field leaving 2-4 meters on all sides of the field. In the initial stage, damage appears in patches and after some time, all these small patches become into one big patch. Damage increases with the onset of panicle initiation and continues upto panicle emergence.

Wet land rice cultivation

3.2. Oil palm: The damage most commonly associated with rodents in oil palms is that related to their attacks on fruit bunches. Palms bear fruit throughout the year and these develop in large bunches, containing hundreds of individual fruitlets, in the axils of fronds. The palm trunks are easily climbed.

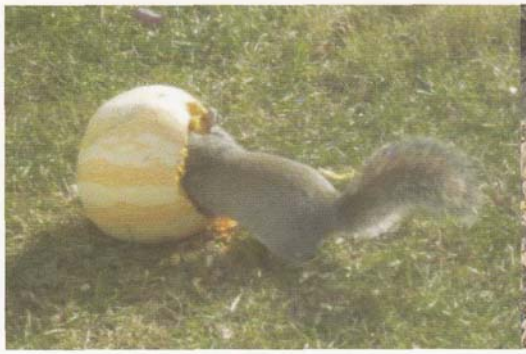
3.3. Coconut: Rats climb the boles of palms to reach the crowns and, perhaps because of some difficulty in doing so, attack short palms more readily than taller ones. Developing nuts are attacked close to the point of attachment to the inflorescence and a hole is made, typically about 65 by 40 mm. Rats seem unable to penetrate nearly mature and mature nuts and the majority of damage is therefore inflicted on those aged between three and six months. Damaged nuts remain in the palm crowns for only three to five days before falling to the ground.

Damaged coconut

Felled coconuts after damage

Damaged fruit bunch of oil palm

Damage in maize cobs

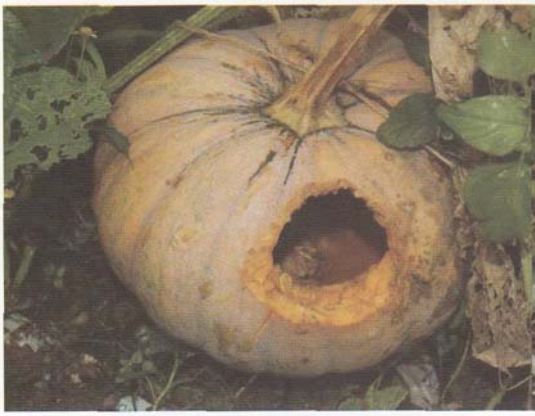


Squirrels damage

Damaged tomato fruit by rats

Rat in rice crop

Rodent damage in rice field



Damaged pumpkin fruit by rats

Damaged pineapple fruits

Farmer showing damaged pineapple fruit

Damaged sucker of pineapple

Damage in paddy grains

Damaged pea pods

Damaged tapioca roots

Damage in sugarcane

Damage in electric items

Damage in clothing

Chapter- 4: Ecology and behaviour of rodents

Understanding of rodent behaviour is a vital for planning eradication of long-established rat populations in agricultural as well urban ecosystem. They have many ecological and behavioural adaptations which are given below:

4.1. Habitat: Rodents are adapted to a wide range of habitats. Bandicoots are fossorial i.e. live inside the burrows. They are good diggers. Borrows are occurred only in irrigated croplands having a scooped soil at the entrance with pebbles. Major channels and around village gardens are prime habitats during fallow. The squirrels are arboreal. They live in tree trunks and make nest. House rat in urban areas are found around warehouses, residential buildings and other human settlements. In cities, preferred habitats are upper levels of buildings, and are commonly found in hollow places in wall cavities and false ceilings. In the wild conditions they live in cliffs, rocks, ground and trees. *R. rattus* are excellent climbers and found in trees, such as pines and palm trees. Their nests are typically spherical and made of shredded material, including sticks, leaves, other vegetations and cloths. The Norway rat lives in the underground. It is strong burrowing animal sometime the burrowing activity may lead to collapse the building. Porcupines make shelters in caves, rock crevices, dark holes, or dens / burrows, excavated by the species along the side of a hill / hillock or in the plains. The burrows are usually self constructed and extensive with a long entrance tunnel, multiple exits and large inner chamber. It is essential to understand the spatial distribution of rats and their burrows for management of rodent population. For example, in Indonesia, monthly trapping of rodents in 5 different habitats indicated that village gardens and the banks of main canals were important breeding habitats (source habitats) for rats. They aggregate into these habitats following the disturbance of cropping lands during land preparation and planting of the rice crop before resume the breeding. In such areas, rat campaigns are advised after a week of rice transplanting.

4.2. Food Habit: Rodents like to live near water of any sort, and prefer foods rich in carbohydrates and protein. They are omnivorous and can eat a wide range of plants and animal foods. Fruits, seeds and invertebrates are also included in the diet as a major source of portion. Main food items of larger bandicoot are invertebrates particularly insect larva, arthropods, reptiles, hatchlings of bird and cockroaches.

Unlike mice, rats cannot survive without water, they required about an ounce of water daily. The physical capabilities of rats are extremely alarming, they can climb stairways, pipes, wires and even bare walls with a rough surface. Most of the rats are nocturnal in habit; they will adjust, however, to feed during times in which food is freshest and most available.

4.3. Fossoriality: Generally rodents live in fossorial and live under the ground by making burrows. In indoor situation, rats prefer to nest on ground levels, though they will move to upper levels and attics when the population is increased. Squirrels prefer arboreal habitats, live in tree holes and crevices. Rats have also been found nesting within furniture in rooms which are placed since long time. In outdoor conditions, nests are often burrows located around the foundation of the structure. These burrows will become expanded and enlarged as the rat population grows. Many burrows may interconnect with one another forming a complex network of underground tunnels. These burrows will contain one main entrance, as well as two bolt holes which are used for escape purposes. Constant environmental conditions will be maintained inside the burrows, facilitated by soil. The depth normally depends on the atmospheric temperature

- Porcupines – make crevices between rocky areas; the crevices are normally tapering; complex of crevices due to gregarious living.
- Bandicoots – scooped soil exists before the burrows with soil pebbles.
- Soft furred field rat – vertical burrow, which extends laterally
- Gerbils –burrow is complex in nature

4.4. Nocturnality: They are crepuscular (active mostly after dark), but are adaptable if warranted by circumstances; indoor mice are generally nocturnal but less predictable than rats. The spontaneous activity starts at evening hours after sunset and have exploration, feeding and feeding rhythms; the activity will be minimize by 9.30 pm. Again they become active in early morning having exploratory and feeding activities.

4.5. Exploration: Rodents have a habit of checking the environment during the spontaneous activity period. This is to guard the area where they live to check any incursions or change in the environment. This is an inborn instinct of all rodents.

4.6. Theigmotaxis: Prefer to travel along, and in contact with vertical surfaces rather than in the open; wary of crossing open spaces that provide no cover. They prepare to move side of the bund in field conditions. Hence, the baits placed on the bund are not accepted. Territories of most of the rodents ranging from 50 to 150 feet from the burrow, however, rats will travel up to 300 feet to a food source. As rat populations grow, competition, conflict, and fighting begin to increase. Large males will become dominant and any given territory can be divided up into several social orders where subordinate males also maintain an smaller area. Many rats will often be seen during the day, as they must feed when larger dominant rats are inactive.

4.7. Agonistic behavior: Agonistic behavior refers to the complex of aggression, appeasement and avoidance behavior that occurs between members of the same species. Agonistic behavior is a much broader term than "aggression," which refers to behavior patterns which serve to intimidate or damage another.

4.8. Social agonistic behavior: Agonistic behavior involves several actions, or motor patterns, including chasing, sidling, boxing, biting, and kicking, as well as audible and ultrasonic vocalizations. Agonistic behavior can occur between rats in a colony, and between resident rats and intruders.

4.9. Urine Marking: Urine marking in rats refers to the deposit of drops or smears of urine in the environment, sometimes accompanied by secretions from preputial sebaceous glands. Urine marking is a type of scent marking, a form of *chemical communication*, in which one rat, the *sender*, generates a chemical signal (the drop of urine) and transmits the signal by depositing the drop in the environment. Another rat, the *receiver*, identifies, integrates and responds either behaviorally or physiologically to the signal. It is assumed that the sender-receiver relationship is the result of natural selection, such that the sender's signal produces a response in the receiver that benefits the sender in some way (e.g. the signal attracts a mate for the sender etc.), while the receiver assesses the signal and responds in a way that most benefits the receiver. Urine marking is very common in mammals, and it has become adapted for use in a variety of contexts and may have more than one function in any given species. In addition, it may have different functions in different species. Chemical secretions contain an enormous amount of information. A rat who smells a urine mark can determine all sorts of things about the rat that produced it: its species, sex, age (juvenile vs. adult), reproductive status, familiarity, social status, individual

identity, and current stress level. In addition, rats can tell how long in the past a urine mark was deposited.

4.10. Neophobia: Rats constantly explore their territories and are very suspicious of new foods, new objects, or any new changes in their environment. This behavior is known as neophobia and can last up to several weeks. *Neophobia defined as the avoidance of an unfamiliar object in a familiar place.* This has definite impacts on the control of norway rats. They exhibit *bait shyness,* often not returning to food which makes them sick after taking little nibbles in initial tasting. These are extreme neophobic rats which avoid all baits and traps. The neophobic response can be one of the most pertinent obstacles to efficient rat control. It causes problems in poisoning programmes because neophobic animals will avoid new foods and even foods previously eaten if they are placed on or in a novel object. The response varies not only between species but also between populations of the same species and between individual animals.

Table: Neophobic period of some rodent species

Species	Period
Rattus rattus	3 days
B. bengalensis	1 day
Millardia meltada	5 days
Taterai indica	3 days

4.11. Bait Shyness or poison aversion (cognition): Aversion towards the poison bait is called bait shyness. A number of researchers, especially in India, have looked at the role of various food characteristics in the development of conditioned food aversions, and aversions to different poisons. Micro-encapsulation of poisons as a way of reducing the formation of learned aversions, by delaying the symptoms of poisoning. Sub lethal doses of acute rodenticide will not kill the rodents, but the minute quantities of phosphine generated in stomach will give stomach disturbance. Rodents will associate this confusion with bait material ate. Consequently they avoid eating the food item, and this reaction is called *Bait Shyness*. It is temporary phenomenon. Thus, Rodents have advanced cognitive abilities. They can quickly learn to avoid poisoned baits. *Cognition is the set of all mental abilities and processes related to knowledge, attention, memory and judgment.*

Table: Persistent period of some rodent species

Species	Period
Rattus rattus	75 days
B. bengalensis	21 days
Millardia meltada	135 days
Taterai indica	75 days

4.12. Resistance to rodenticides: Rats can also be physiologically resistant to poisons. This is a genetic trait that has been selected for over generations of exposure to certain rodenticides. Warfarin-resistant mice, Norway rats and ship rats have been found in England and Europe. Warfarin resistant rats can be also resistant to difenacoum. The issues of bait avoidance and the efficacy of poisons against warfarin and difenacoum resistant rats were studied and found that there is no evidence of resistance to brodifacoum in mice. Chronic rodenticides are reported to result in development of resistance over a period of time. Bromadiolone has so far not shown proven anticoagulant resistance.

4.13. Migration: Rodents inherently have migratory behavior and their movement continues in search of food sources. There are two types of migration occur in rodents:

1. Emigration – outward movement after the harvest in search of food available areas.
2. Immigration – inward movement of rodents to the crops under establishment.

The range of movements depends largely on location between food resources and suitable harborage. Under stable conditions their movement is limited. Home range of bandicoot is between 50 meter to 55 meter. A Norway rat will move within a diameter of 100 to 150 ft., a roof rat, 45 to 150 ft., and a house mouse, 10 to 30 ft. This range may expand when conditions are unstable or changes, such as a construction site. They may also expand their range in protected areas such as in sewers, in passages between buildings, and under groundcovers and during seasonal or climatic change.

4.14. Reproductive behavior:

Reproduction plays a major role in the buildup of population densities since under normal conditions; it is the basic and most important source for recruitment. Changes in reproductive performance of a population will be reflected in density changes.

4.14.1. *k-pattern*: Rodents in a stable or seasonally predictable environment will have limited population due to the limited availability of food and other resources. In these circumstances, supply and demand will be in balance. The only way to prosper to utilize the available resources to the optimum and the emphasis is on quality and not quantity. The parents will have more offspring in the long run with smaller litter size. Such species are said to be *k-selected.*

Foetus development in uterus

k refers to the *carrying capacity* of the environment in *logistic equation. k-selection* promotes individual success under conditions where *individuals* are living in population at the *carrying capacity* of its environment. In these circumstances, the growth is *logistic* due to continuous favourable conditions i.e., adequate food, water, and harbourage. The populations reach maximum level determined by intraspecific density dependent factors such as competition for food or nesting sites.

Management of *k-strategists*: Where logistic growth occurs, i.e., situations of *k-strategists*, control measures must be sustained over the life of the crop that is protected. This is because the very existence of this type of growth indicates that conditions are continually favourable for the pest and must be regularly modified to make them unfavourable. Ideally, management aims to modify the carrying capacity of the environment for the rodent population to such a low level that the damage caused is economically insignificant. Biological control by introduced natural enemies is not likely to be successful since the densities of *k-strategists* are often too low to sustain a reliable predator population. This sort of pre-emptive intervention is less economically viable making it imperative to depend on chemical rodenticides.

Even rodenticides are unlikely to be cost effective. This is because the shape of logistic growth curve with more than above 10% of their maximum numbers will quickly rebound to pest status. Indeed the steepest part of the curve occurs at 50% of the asymptote and consequently, this is the target for reduction. Inappropriate rodent pest management can, therefore, produce more rodents, in total than no control effort at all.

4.14.2. *r-pattern*: Contrary to the above, some environments are unstable and have discontinuous favourable conditions making rodent species to breed explosively. As conditions improve, the supply of resources exceeds the demand for their survival, as the survivors find themselves in a land of plenty. Under these situations rodents produce lot of young as fast as possible before the going gets bad. This sort of environment is called *r-selecting*. Environmental events such as flash floods, above average rainfall after a prolonged dry spell might increase the period and area over which high quality food and harbourage are available. This leads to an increase in both length of the breeding season and survival of the individuals into the next season. The rodent population irrupts and the surplus rodents emigrate to newer habitats into previously unfavourable areas.

New born pups of house rat

Table- Breeding pattern in rodents

Normal Breeding (*k-pattern*)	Abnormal breeding (*r-pattern*)
▸ Sex ratio (M:F)- 1:1 ▸ Average litter size – 6 ▸ Post partum oestrous- 90 days. ▸ Maturity period- 90 days ▸ This is seen in normal un-disturbed agrarian ecosystems	▸ Sex ratio (M:F)- 1:2 ▸ Average litter size -20 ▸ Post partum oestrous- 2 days. ▸ Maturity period- 75 days ▸ This is seen during unexpected favourable climatic situations

Management of *r-strategists*: The management of irruptive or *r-selecting* rodent population requires a different strategy. Since damage is confined to times of outbreaks, sustained prophylactic control would be wasteful unless it cheaply forestalled irruptions viz., habitat manipulation. Therefore, the management of irruptive rodent pests focuses on prediction and monitoring of outbreaks, with the tactical and prophylactic use of rodenticides to nip the outbreak in the bud thereby preventing an outbreak.

In some cases, cultivation timing can be altered so that the vulnerable crop stages coincide with periods when the possibilities for outbreaks of *r-selecting* pests are minimal. Predators also react too slowly to prevent outbreaks of *r-selecting* pests. Normally it is thought that mortality is the most critical population process to interfere within any control action. However, it is also a fact that increased mortality is often rapidly compensated by increased recruitment. Neglecting this fact leads to sustained yield. Many individuals are killed initially giving first impression of an apparent success. In reality however, the obtained reduction in population size is virtually absent. This is very commonly felt in most of the rodent control campaigns, which are not planned systematically looking at the situation of the pests, habitat and environmental interactions.

Chapter- 5: Bamboo flowering and rodent outbreak

The rodent outbreaks have been recorded in north-eastern hill region of India since time immemorial. The rodent outbreaks associated with bamboo flowering and subsequent mass seeding at cycle of 30-60 years has appeared in the literature since the 18th century. Natural vegetation primarily bamboo forests surrounds the crop fields. Crop fields surround the bamboo forests provide a most favourable habitat for rodent in NEH region. Apart from this, rodents are also a problem in the residential premises and storage. Moreover, gregarious flowering and seeding in certain species of bamboos are believed to cause severe rodent outbreaks in the region in certain years, resulting in famine like situation. Bamboo flowering intervals are genetically triggered and range from less than 10 years to more than 120 years.

Mass bamboo flowering

In Mizoram, periodic famines were associated with the flowering and fruiting cycle of *Melocana baccifera* (local name mautak) and *Bambusa tulda* (local name rawthing). The flowering, fruiting and dying of mautak is called mautam whereas that of rawthing is called thingtam. The gap between mautam and thingtam is found to be almost regular, being 30 years from thingtam to mautam and 18 years from mautam to thingtam. Famines which occurred in 1864, 1910-12, 1958-59 were associated with mautam and those in 1880-84, 1928-29, 1976-77 were associated with thingtam. The recent famine in Mizoram during 2007-08 was associated with

Seed collection of bamboo

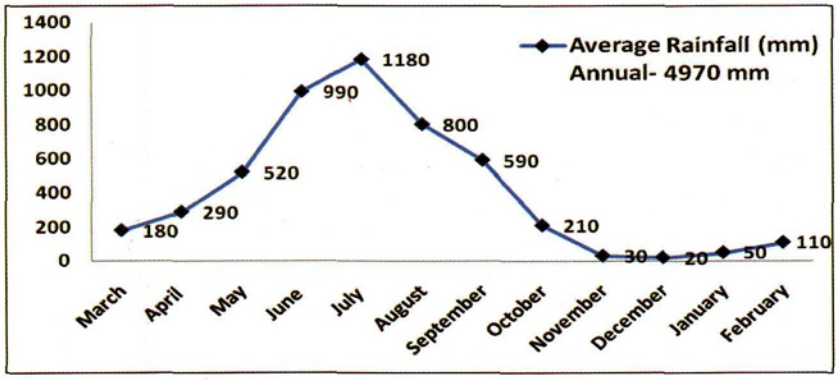
mautam. The next expected thingtam and mautam will be in 2025-26 and 2055-56, respectively. As a conservative estimate, the forest area with bamboos in India is about 9.57 Mha (12.8%) of the total forest area of 75 Mha. Major bamboo growing states of the country are Arunachal Pradesh (19790 km^2), Assam (10000 km^2), Manipur (2500 km^2), Tripura (750 km^2) and West Bengal (164 km^2). There are 124 indigenous and exotic species under 23 genera found naturally. Clump forming bamboo constitutes over 67% of the total growing stock, of which *Dendrocalamus strictus, Bambusa bambos*, *D. hamiltonii*, *B. tulda* and *B. pallid* occupy 45, 13, 7, 5 and 4%, respectively. All other species put together are 6%. *Melocanna baccifera*, a non-clump forming bamboo, accounts for 20% of the growing stock and is found in the north-eastern states.

Bamboo flowers

The valid scientific reasons for the sudden outbreak of rodent during flowering of bamboo are still not understood. It might be due to sudden changes in entire ecosystem of the bamboo forest, which helps rodents in switching over to *r-pattern* of faster breeding, higher than the carrying capacity of forest which results in mass migration of native rodents to the surrounding jhum and WRC crop fields causing large scale devastation of standing crop. Linkage between bamboo

Seeds of bamboo, *D. hamiltonii*

flowering and rodent outbreak have not been proven and the causes of rat floods were mere speculation. But, we observed that the rodent outbreak is closely related to bamboo flowering. The sporadic bamboo flowering occurring at frequent interval in Arunachal Pradesh and at the same time the rodent population increased in the bloomed area as compared to other area. This hypothesis is supported by many studies can link rodent population outbreak to variation in rainfall, with unusually high rainfall leading to rat floods due to increased vegetative matter on which rodent feeds. We observed that there was no rainfall peak during the year 2009 in Arunachal Pradesh but rodent flood observed in same year whereas high peak was recorded during the year 2007 but no rodent outbreak noticed. The indiscriminate hunting of predatory animals like, cat, fox, wolf and predatory birds is second factor. The local tribes used to hunt the wild animals as a hobby; they also celebrate hunting festival in first week of March. The geographical barriers are another cause for irruption. This area is totally under hills which are geographically isolated with other hills by water streams as the region has high rainfall. In this situation the increasing rodent population cannot migrate to another area, ultimately the population reaches to carrying capacity. This environmental condition may create favourable habitat for rodents to change their *k- breeding pattern* into *r- pattern.* This hypothesis can explain why all flowering seasons do not give rodent outbreaks of the same severity.



Monthly average rainfall in East Siang district of Arunachal Pradesh since 20 years

Chapter- 6: Rodent management techniques

1. Surveillance of rodent pests

Major cereal crops are quite often affected with rodent damage in jhum as well as in wet rice cultivation situations in NE region. Invasive rodents from the adjoining forest areas would mostly cause more damage synchronizing with gregarious bamboo flowering. In addition, burrowing rodent species like *Bandicota bengalensis* colonized in the region in WRC and terrace cultivation situations. Hence, the methods that could be adopted for their surveillance are damage index, burrow count and trapping index for this purpose.

1.1. Damage index: Limited work undertaken on monitoring indicated that damage index of 15% of rodent affected hills or 2% tiller damage in rice may be taken as threshold value. Rodents cause damage cereal crops in all the stages of growth. They may cut/uproot newly transplanted seedlings. They cut diagonally (45°) the developing tillers generally 5-10 cm above the water level.

Rice crop: Three methods for damage assessment in rice crop are given below:

Philippine method: This method is applicable for transplanted rice and suitable for precise loss estimations in transplanted fields.

1. Select a field at random.
2. Select a plot at random.
3. Select 10 rows for observation. (Count total rows. Divide the number by 10 and round the figure to next higher. Select based on this)
4. In each row, select randomly 10 hills at equal distance.
5. In each hill count rat cut tillers and other healthy tillers.
6. Tabulate for 100 (10 rows x 10 hills) observations.
7. Calculate damage incidence (P) as:

$$P = (AxC) / (B+C)$$

Where A = Number of damaged hills in the sample.
B = Number of undamaged tillers in the hills containing damage.
C = Number of damaged tillers.

Diagonal method: This method is suitable for extension purposes in transplanted fields.

1. Select a field at random.
2. Select a plot at random.
3. Select a diagonal.
4. Start with first hill.
5. Count cut and uncut tillers.
6. Select next position on the diagonal.
7. Repeat step 5 and 6 until 25 samples at equidistance are taken.
8. Calculate damage incidence (P).

$$P=(A \times 100)/(A+B)$$

Where A = Total number of damaged tillers in the 25 hill sample.
B = Total number of healthy tillers in 25 hill sample.

Quadrate Method: This method is to be used for directly sown rice and in jhum field situations.

1. Select field at random.
2. Select plot at random.
3. Select first position of sample frame on one of the diagonals.
4. Place sample frame on the ground without looking.
5. Count cut and uncut tillers and note on record sheet.
6. Select next position of sample frame by walking 3-5 steps.
7. Repeat steps 4-6 till 10 samples are taken.

A sample frame of 30 x 30 cm size open at the end is required for taking the observations.

Damage (%) = (number of cut tillers x 100) / total number of tillers

Oil palm: The damage most commonly associated with rodents in oil palms is that related to their attacks on fruit bunches. Palms bear fruit throughout the year and these develop in large bunches, containing hundreds of individual fruitlets, in the axils of fronds. The palm trunks are easily climbed. The damage percent is calculated as given below.

Percent fresh fruit damage= 100 (a/b)

Where, a= number of palms with fresh fruit damage
b= number of palms assessed

Coconut: Rats climb the boles of palms to reach the crowns and, perhaps because of some difficulty in doing so, attack short palms more readily than taller ones. Developing nuts are attacked close to the point of attachment to the inflorescence and a hole is made, typically about 65 by 40 mm. Rats seem unable to penetrate nearly mature and mature nuts and the majority of damage is therefore inflicted on those aged between three and six months. Damaged nuts remain in the palm crowns for only three to five days before falling to the ground. The damage percent is calculated as given below.

Percent rat damage nuts= 100 (a/b)

Where, a= number of rat damaged nuts

b= Total number of harvested and rat damaged nuts

1.2. Burrow count method: Number of live burrows gives the general estimates of active rodents in an area or field. Fresh excavated soil and cut parts of various plants etc is the general sign of live burrows or active burrows. Most of the rodents may use more than one opening of the burrows; therefore, they may give wrong estimates of rodent population. For actual live burrow count, all the burrows should be plugged by soil in the evening and next morning all reopened burrows would give the correct estimates of rodent population. With the help of this method, we can compute number of live burrows per hectare area. Generally adult rodents occupy single burrow except the breeding season when more rodents live in a single burrow. A comparative numbers of pre and post control census will give control success of the operation. The area of 10 acres is selected from a village covering crop fields, canal bunds, road sides, animal sheds, forests etc and total number of active burrows are counted and then converted on per hectare basis. This area may be reduced in hilly tracts. The following scale may be used for categorization of rodent infestation.

1. Low infestation: Number of burrows < 25/ha
2. Moderate infestation: Number of burrows between 25-50/ha
3. High infestation: Number of burrows > 50/ha

This method is more appropriate when burrowing rodent like *B. bengalensis, Canomys badius* and *Mus booduga* etc are predominantly present.

1.3. Trap index method: This method is more suitable for hilly regions like north eastern states where rodents are live in forest and do not burrows. Generally they live under the dense forests, bamboo patches and under the leaf litters. Under such situation the monitoring of rodents can be done using Trapping Index method as given below:

1. Select field at random and set 2 trap line of 10 traps.
2. Observe the trapped rodents in next day morning.
3. Repeat the same practice for 3 nights and calculate the trap index as:

Trap Index= A/ (B x C)

or

Trap Index (trapped animals/100 traps/night) = [A/ (B x C)]x 100

Where,

A- Number of rodents cought

B- Total number of traps set

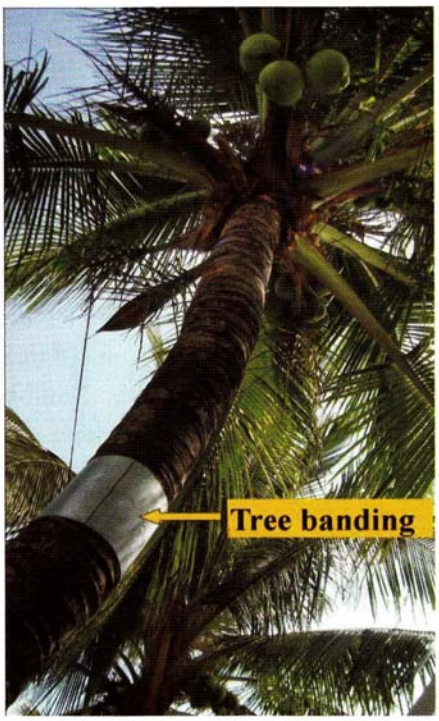
C- Number of nights

The threshold level for trapping index does not exist as of now. The trap index could be used for evaluation purpose after rodent control campaigns by working out index before and after the control operation.

2. Rodent management

2.1. Immigration reduction and exclusion

Exclusion of rodents from a commodity or structure at risk can take many forms, and could be very local to the item to be protected (e.g. a tree guard) or a barrier to entry to a large area (e.g. an electric fence). The essential feature of exclusion is that it must take account of both the physical ability and the biology of the potential pest species. Thus, the roof rat *Rattus rattus* is a better climber and, is therefore, less easily excluded from buildings with high-level apertures. However, the Norway rat regularly burrows 30 cm below ground but may go deeper and so building foundations or other below ground barriers must take account of this and go down at least 45 cm. The Norway rat is also sufficiently powerful to jump 75 cm vertically and to scramble higher if it can achieve any purchase. In general, rodents can



Rodent exclusion in coconut

squeeze through any aperture that their head will go through since their bodies are very flexible.

2.2. Rodent-proofing premises

The most successful and long lasting form of rat control in buildings is to "build them out." Seal cracks and openings in building foundations, and any openings for water pipes, electric wires, sewer pipes, drain spouts, and vents. No hole larger than 1/4 inch should be left unsealed to exclude both rats and house mice. Make sure doors, windows, and screens fit tightly. The following points should be kept in mind for rat proofing the home and warehouses.

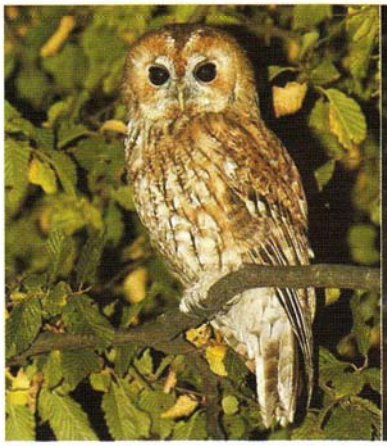
- Materials must be proof against gnawing, e.g. brick, concrete blocks, sheet metal (preferably galvanized steel), fine-mesh metal.
- Repair or replace damaged ventilation screen around the foundation and under eaves.
- Provide a tight fitting cover for the crawl space.
- Seal all openings around pipes, cables, and wires that enter through walls or the foundation.
- Be sure all windows that can be opened are screened and that the screens are in good condition.
- Cover all chimneys with a spark arrester.
- Make sure internal screens on roof and attic air vents are in good repair.
- Cover rooftop plumbing vent pipes in excess of 2 inches in diameter with screens over their tops.
- Make sure all exterior doors are tight fitting and weatherproofed at the bottom.
- Seal gaps beneath garage doors with a gasket or weather stripping.
- Install self-closing exits or screening to clothes dryer vents to the outside.
- Remember that pet doors into the house or garage provide an easy entrance for rodents.
- Keep side doors to the garage closed, especially at night.
- Doors should be equipped with automatic door closer.

2.3. Role of predators

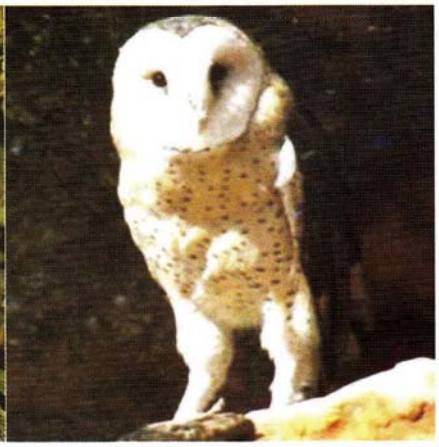
Snakes and owls have been the natural predators for field rodents. Bird perches of 3 meter height with a 2 ft cross bar are employed for attracting owl perching in the nights to facilitate hunting the colonising rats. The perches should be used at tillering stage of the crops to tackling immigrating rodents. However, if these perches are

continued in later stages, granivorous birds will cause damage to the panicles. Since most of the predators of rodents are general feeders, they often tend to feed on food other than rodents. It was further noted that during day time insectivorous birds perched on these perches and shown significant consumption of insect pests. Declined rodent population after harvest of the crops makes these predators to leave the area on emigration. There is also sometimes a possibility of predation triggering increase in rodent populations after partial removal of the rodents. Attempts were also made with parasites and pathogens to bring successful rodent control. However, the efforts are so far not fruitful since they also equally affect human populations. Attempts are in progress to use "immuno-contraception through viral vectors" (VVIC) among rodents. However, the trials are at infancy stage only.

Spotted Owlet, *Athene brama*



Tawny Owl, *Strix aluco*

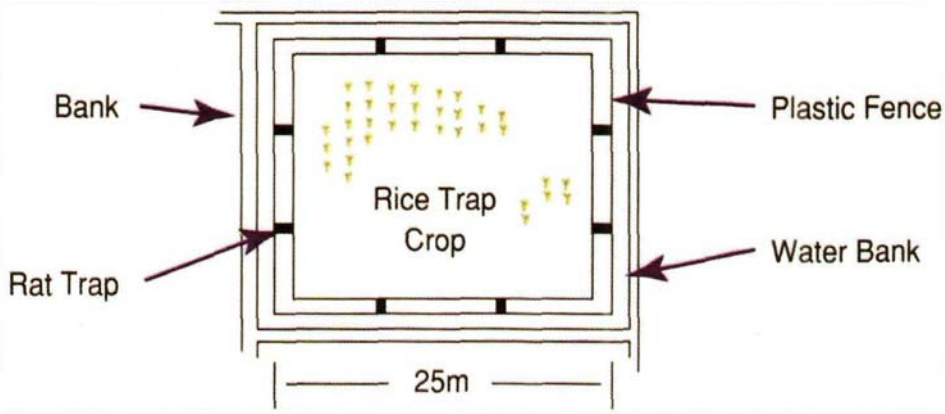


Grass Owl, *Tyto capensis*

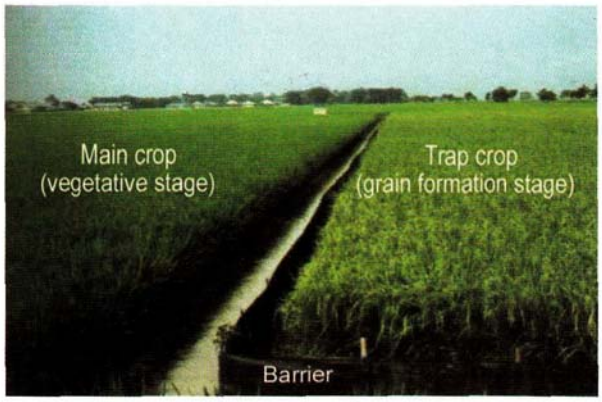
2.4. Barrier methods

Barriers on individual crop plants are only viable for large, long-lived plants such as coconut or oil palms where damage may affect the long-term as well as the immediate yield. Sheet metal to an appropriate height (90 cm) can prevent rats

gaining access, but exposed edges may provide a means of climbing, especially for the agile roof rat. Trap Barrier System (TBS) is being tried in different countries employing fences to the rice farming and fixing traps at different intervals. Trap crop is also is added to attract rats to immigrate by growing a small patch of the crop on the periphery. However, looking at the cost of fencing and land holdings, it may not be appropriate in Indian conditions to use this method, although the preliminary studies yielded significant results. However, in North-eastern States this method can be followed in jhum cultivation. Non-lethal electric fencing as a barrier method was found to be cost effective and has limited extension value. The detail procedure of TBS is given in chapter-13 "Management of rodents in rice crop".



Modal of trap barrier system



Trap barrier system in rice

Trap installation in TBS

2.5. Ultrasound and electromagnetic devices

The sense of hearing of rodents extends well into the ultrasonic range i.e. above 20 kHz, for example in Norway rats up to 100 kHz with most response around 40 kHz and in house mice up to 90 kHz. In consequence, a number of ultrasound devices have been marketed, mostly for use in buildings. Ultrasound devices are being used as deterrents to rodent immigration. However no convincing evidence was found them as effective against rodents. Similarly little scientific support was found for use of electromagnetic devices.

2.6. Chemical repellents

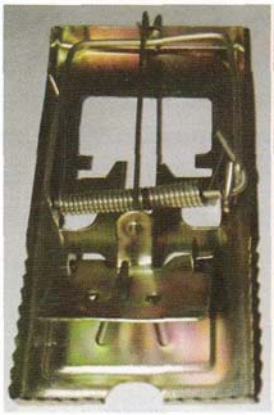
There is no effective chemical repellent available that is not also toxic. Although pheromones appear to be promising, lot of scientific work is required to identify, isolate and bring out the pheromones for extension purpose. Recently, a castor based repellent (trade name- Ecodon), exhibited significant repellent effect on *B. Bengalensis* in rice fields, when applied as granules or sprayed on the boundaries of rice crop. Rice tiller damage is less than 5% in treated fields, while untreated had more than 25% loss.

2.7. Trapping and hunting

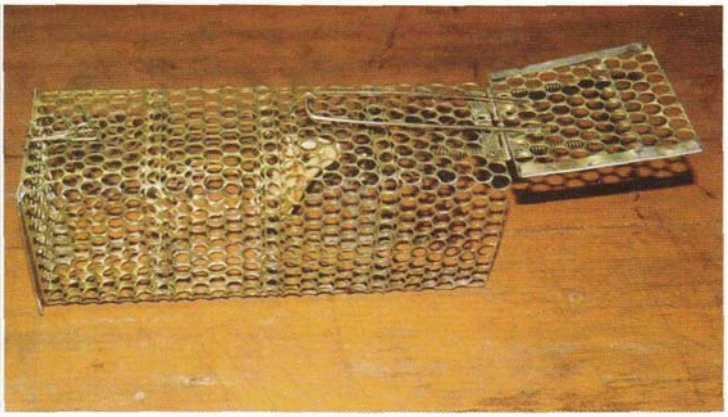
The main practical problem with trapping and hunting methods is that they are labour-intensive and therefore unlikely to be cost-effective in countries where labour costs are relatively high compared with the cost of chemical rodenticides. However, there are circumstances where trapping usefully supports conventional chemical control, or can replace chemical control in areas of high risk or environmental sensitivity.

Wonder trap (multiple catching)

Killed rat in snap trap



Snap trap (kill type)



Cage trap

Glue trap

Trapped rat in glue

Trapping is one of the oldest methods of rodent control in Arunachal Pradesh. A variety of traps can be used against rodents in fields and buildings. The traps are various types based on their function viz. live traps (wonder traps, cage traps, Sherman traps), snap trap or kill type and glue traps. The efficacy of trapping, whether live or snap trap, depends on operational conditions of the trap, number of traps set, type of bait, place and time of placement.

Scientific literature has seldom proved trapping as effective method against rodents as a measure of reducing their numbers. However, they can be employed in controlling localized infestations effectively. *Etku* (bamboo traps) are highly effective for localized infestations. They help in maintaining rodent numbers at a low level once they have been reduced by other methods.

3. Indigenous methods for rodent pests control

Rodents are one of the most important non-insects pests of agricultural crops, particularly rice. They consume and contaminate food, damage structures and property, and transmit parasites and diseases to other animals and humans. Rats live and thrive under a wide variety of climates and conditions; they are often found in and around homes and other buildings, farms, gardens, and open fields. Sixteen species of the rodents were recorded from North-Eastern Hill Region, belonging to the genus *Rattus, Bandicota, Mus, Cannomys, Vandeleuria* and *Callosciurus.* In Arunachal Pradesh the losses are estimated up to 2-25% in rice. Rodents do not spare any variety and they attack all stages of the crop during all seasons.

4. Local traps for rodent control

In Arunachal Pradesh various techniques of rodent control are used by different tribes. These techniques includes in physical methods using locally available material for the control of rodent in fields. Now a days the farmers incorporated the iron or steel wire in its traditional equipments. In indigenous traps, the pre assessment and arrangement of rodent passage about 15 days prior to installation is required. Once a rodent is trapped in a passage with *uju* and *gorha* traps, the same passage is avoided by the other rodent when trapped rodent is left for a long time. Despite this, these rodent traps are much effective and popular in Arunachal Pradesh. The rodent meat is considered as a precious dish among most of the tribes of Arunachal Pradesh for which the use of rodenticide is not preferred. The following traps and methods are used by the tribal of Arunachal Pradesh to catch the rodents:

4.1. *Etku*

Material required: Green bamboo, cane stripe or strong thread or iron binding wire
Type of trap: Kill type
Site of trap placement: Equipment is mostly placed on passage of rodents in border of the field and along with irrigation channels, bunds and in front of burrows opening.
Principle: This trap made up of fresh bamboo split and a cane stripe. In this equipment the end point of fresh bamboo split is molded into a triangular shape. The triangular shape act as a gate or entry point which is facilitate with a trigger obtaining tension from another end of bamboo split through a rope or fine strong thread or iron wire, thus the bamboo split act as a bow. The triangular shape of the trap is placed at the passage and pathway of rat; when rat runs from inside the triangular gate the

trigger get dislodge (free) due to slight disturbance and the same time rat is trapped by the tense thread or wire inside the triangular area and killed. For increasing the efficiency, some grains can be put near the triangular gate.

Etku

Trapping of rats using *Etku*

Trapped rat in *Etku*

4.2. *Odey*

Material required: bamboo sticks, flat stones

Type of trap: Kill type

Site of trap placement: This apparatus is installed at field bunds, near burrow or passage etc.

Principle: It is rat crash equipments using of flat stone. In this technique a flat stone is flap up from one side on a peg or stick in such a way that the rats will get crash/hit under the stone when the stick is dislodged when the rat attempts to take away the bait.

Odey

4.3. *Uju*

Material required: Bamboo, iron wire (3mm), fine rope or thread.

Type of trap: Kill type

Site of trap placement: This trap is generally placed on a bridge of bamboo or bamboo log over irrigation channel and water streams from where the rodents are entered in the field.

Principle: The trap is made up of a triangular wire in which a rope is fasten for strangle and triggering. Strangle force is driven from a plant or bamboo sticks through a fine rope which is connected to strangle thread. From the base of triangular structure a fine thread attached to trigger and then tension rope. This trap is placed upon the bridges of irrigation channel on a bamboo or tree log. Generally rats have a habit to cross the irrigation or water channel through tree or bamboo log as a bridge. When a rat passes through the triangular structure the fine thread dislodges the trigger and the strangle rope pull up and rat is strangled at same time.

Uju

Trapped rat in *Uju*

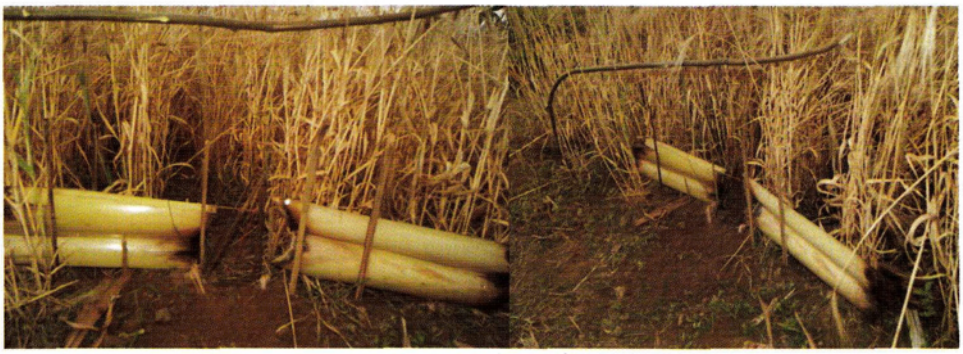
4.4. *Gorha*

Material required: Green bamboo sticks, thread or binding wire (1mm)

Type of trap: Kill type

Site of trap placement: This apparatus is installed at field bunds, near burrow or pathway etc.

Principle: The all tribes of Arunachal Pradesh grow rice in jhum agriculture. The rodents cause more damage in jhum cultivation of rice because of they live in the jungle nearby the jhum area in day time and they come out from the forest during the night and cause damage. To avoid the damage the local people install *gorha* traps in periphery of the fields. The crop area is marked by putting the waste plant material and grasses around the field leaving some small entry points for rodents. At the entry point a trap is installed known as *gorha*, this trap has the same principle as *uju* in which a strong thread is attached with a trigger and a tense stick. When the rodent try to pass the entry point the trigger is released and the rodent is trapped by stretching the wire.



Gorha ***Gorha*, work as trap barrier**

4.5. *Pak*

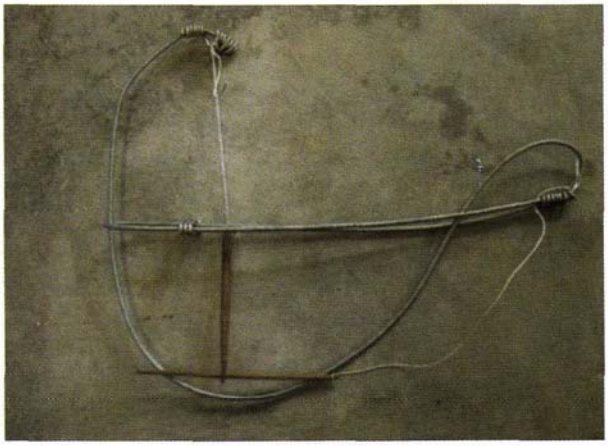
This trap is usually installed on a bamboo placed over irrigation channel and water streams from where the rodents are entered in the field.

Material required: iron wire (3mm), thread

Type of trap: Kill type

Site of trap placement: This trap is mostly placed on passage of rodents in border of the field and along with irrigation channels, bunds and in front of burrows opening.

Principle: This trap is installed at field bunds, near burrow or rodent pathways etc. This equipment is made up of a steel wire. Actually in new era of steel the tribal people also start using the iron wire instead of traditional bamboo. The iron wire is molded in such a way that it becomes straighten when the rodent disturb the trigger. The trigger is connected through a thread with end part of tense wire. This trap can be used for long time.



Pak

4.6. *Middu*

Material required: Green bamboo

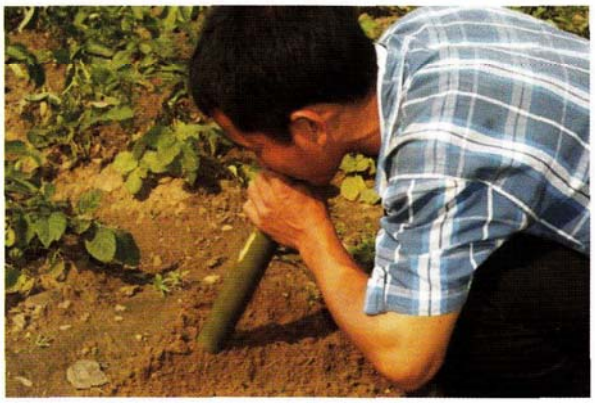
Type of trap: Burrow fumigator or smoking

Site of placement: This equipment creates smoke which is pushed inside the active burrows with the help of blowing.

Principle: This equipment is used for smoking in rodent burrows. It is made up of fresh bamboo piece which is opened from one side and blocked from other end through internode of the stem. A pencil size narrow hole is made in the internode end. Dried paddy husk is filled in the bamboo and ignite it by using charcoal. From open end the air is blown through mouth thereby smoke produced which is released from narrow hole of internode end. This smoke is blown inside the burrow resulting in the rats get suffocated and killed. Precaution should be taken before blowing smoke into burrow. Rat always makes an emergency exit hole for running away as their predators enter in the burrow. This emergency exit burrow hole must be located and closed before smoking to avoid running away the rat.

Open end of *middu* for propel

Small hole for smoke release



Smoking in burrow with middu

4.7. *Buroo*

Material required: A group of people having all type of traps and burrow fumigator.

Type of trap: Kill type

Site of trap placement: various types of traps can be used for trapping by this method. Each trap is placed in suitable place, so that, there is more possibility of trapping.

Principle: This is the method of rodent hunting in a mass scale in which all the farmers of an area gathered at the site of rodent breeding and burrowing. Generally in off season of crop the rodents are lived in a group by making burrows away from the fields. At the time of grain formation in rice they start to immigrate near the cropped area. Therefore, in off season the group of farmer starts hunting of rodent at breeding and burrowing site. In this practice *middu* are also used for smoking of rodent burrows. The other traps like *etku* and *pak* are also installed at the opening of the burrows. Some group of farmers also kills the rodents by beating. They also dig the burrows for the destruction of small new borne rodents. In this practice they not only

kill the rodents but also they get the meat because many of the tribal people of Arunachal Pradesh eat the rodents.

Team of buroo trapping

Dead rodents during buroo method

4.8. Trapping strategies by using local traps:

1. Installation of *uju*, *etku*, over irrigation channels @ 1 *uju*/5 meters distance starting from panicle initiation stage till harvest.
2. Installation of *odey* at bunds of the fields.
3. Installation of *gorha* at around the crop area and opening of live burros in the field and nearby the fields.

4.9. Some other indigenous practices for rodent control in this region

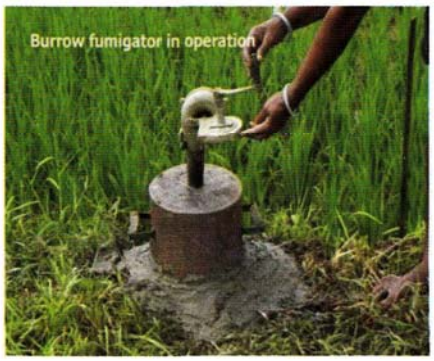
1. Rodents cause heavy loss to paddy in jhum fields. To control this menace burrows of rats are stuffed with smoke by burning paddy husk and dry chillies variety. Complete control over rodents depends on the number of burrows plugged by smokes. The suffocating pungent smokes promptly affect the respiration systems of rats and become lethal.
2. Rats are also controlled by employing the bird perches in field. Branches, preferably of bamboo, are put in terraces. They act as a resting place for owls at night, which will keep the rat population in check. This practice is used by some tribal people of the region.
3. Cleaning bunds and borders of fields. This practice eliminates the shelter of the rodent near fields.
4. Maintain good water level in fields for avoid burrow formation.

5. Management of rodents in rice crop

Rodent control is an age old practice and various methods are in vogue. However, there are very few methods which are practicable and feasible in situation like this. In Arunachal Pradesh, local traps called '*etku*' are extensively used for the control of rodents in rice. These traps provide fairly good results when applied after chemical control operation. However when directly used, trapping will be costly affair and one cannot manage entire population over large areas. Moreover, at certain crop stages, like primordial formation, rodents are not attracted towards traps.

5.1. Natural Smoke

1. Control of rodents living in burrows with natural smoke is one of the old practices in Arunachal Pradesh. The main principle involved in this operation is simply filling the burrows with smoke, which causes suffocation to rodents ultimately leading to their death.
2. The smoke liberated by burning rice straw mainly contains carbon dioxide. Now, the burrow fumigator is being used very extensively by the farmers of the country.



Burrow fumigator

5.2. Preventive measures

1. Keep rice bunds (banks) less than 30 cm wide to prevent rats from burrowing.
2. Keep the edges of the field, bunds and surrounding areas clean and free of tall weeds and hiding areas for rats.
3. Plant at the same time as your neighbours.
4. Keep area around fields, homes, and villages clean- no piles of wood or brush, no garbage heaps, no weedy areas.

5. Keep grain stores and surrounding area clean.
6. Strategic use of Trap Barrier System (TBS).

5.3. Trap Barrier System (TBS)

A Trap Barrier System (TBS) will have an effect over an area of 200m radius from the TBS (10 ha). A TBS is simple to construct, but to work properly, the following procedure should be taken.

Trap Barrier System

5.3.1. Requirements for TBS

1. Plastic for barrier fence (stronger material will resist damage, withstand high winds and be reusable for several seasons).
2. Bamboo stakes to support the barrier and traps; string or wire to erect barrier.
3. Stapler and staples to fix plastic to string or wire.
4. Multiple capture live-traps and kill traps for use within the 'lure' crop.

5.3.2. How to build a TBS

1. Select an existing 20 to 50 meter square plot within the rice field;
2. Use stakes and string to erect fence, bury plastic 10cm into ground and have fence 60 cm above ground.
3. Dig or widen existing channels to construct an encircling water trench (bank) at least half a meter wide.

4. Install two multiple capture traps along each side (total 8). These must be held tightly against the fence, with no holes or gaps that might allow rats to bypass the traps.
5. Construct earth mounds pathway across the trench, reaching to traps.
6. Place kill traps along the inside of the fence to catch any rats that climb the barrier.
7. Transplant the lure crop (trap crop) 2-3 weeks before the surrounding crop (main crop) so that the lure crop will come early in grain stage for attracting the rats.

5.3.3. TBS maintenance

1. Empty the traps early each morning (dead rats left in the traps will discourage other rats from entering).
2. Check the plastic barrier for holes each day and either repair these or install extra traps.
3. Keep the trench free of grass, cover traps with straw and provide food in traps for trapped rats.
4. If unable to check the TBS for a few days, place the straw in the entrance of the traps for blocking.

6. Use of rodenticides

Generally rodenticides are used for mass scale rodent control campaigns. Application of rodenticides and environmental manipulation should be considered as complimentary to each other rather than alternative approaches. Amalgamation of various methods, as above, results in reduction in rodent damage in different situations.

The majority of rodenticides are administered as poisoned baits, although some compounds are available in forms used as liquids, contact, dusts and poisonous gases. No matter how they are applied, rodenticide active ingredients are considered to fall into two categories: the acute or fast-acting compounds and the chronic rodenticides exclusively anticoagulants with a relatively slow mode of action.

6.1. Types of rodenticides

6.1.1. Acute Rodenticides

As the name of the group implies, the onset of toxicosis is rapid after an effective dose has been ingested. Generally, symptoms appear in less than 24 hours

and with some compounds in only minutes. Examples of this category are Zinc phosphide, Red squill, Sodium fluoroacetate, Fluoroacetamide, Alphachloralose, Thallium sulphate.

6.1.2. Sub-acute Rodenticides

Three compounds, bromethalin, calciferol and flupropadme are sometimes termed as sub-acute rodenticides. They have many of the characteristics of acute but differ from them in certain respects. Although rodents may take a lethal dose of these materials during the first 24 hours, repeated feeding may occur and death is normally delayed for several days.

6.1.3. Anticoagulants or slow acting or chronic rodenticides

The chronic mode of action of the anticoagulants is the key to their success. They act by interrupting the vitamin K cycle in liver microsomes. Anticoagulants inhibit the epoxide reductase enzymes and block the recycling of the active hydroquinone form of the vitamin. With this process of recycling blocked, only dietary vitamin K is available and this is insufficient to maintain clotting factor synthesis in blood, resulting in fatal haemorrhage. This generally takes 4-10 days. Delaying the symptoms of toxicosis with the anticoagulants may prevent the development of bait shyness. Common examples of this category are warfarin and bromadiolone.

6.1.4. Respiratory Poisons

Aluminium phosphide 0.6g pellets are recommended for rodent burrow fumigation @ 2 pellets per burrow. This is a restricted rodenticide to be used under the supervision of technically competent persons. The pellets can be procured by the Government Departments directly from the manufacturers. One pellet per burrow is effective to control field mice. The pellets release phosphine gas in the atmospheric conditions, which is lethal to the rodents inside the burrows. Due to this, care is required to be taken to insert the pellets deep inside the rodent burrows and burrows are to be plugged to prevent leakage of the toxicant gas from the rodent burrows.

6.2. Implementation of Chemical Control

1. The fumigants like Aluminum phosphide 0.6g pellets are effective and widely used for the control of field rodents living in burrows. It was evaluated against *Bandicota bengalensis* in rice fields in Punjab, providing 66.6 % kill.
2. The control of rodents using rodenticides is the more common way. There are two groups of rodenticides registered and available in our country. They are

    - Acute rodenticides (Single dose and quick acting), Eg: Zinc phosphide.
    - Chronic rodenticides (Multi dose and slow acting), Eg: Warfarin, Bromodiolone.

3. Among the acute rodenticides, Zinc phosphide and Barium carbonate are registered for use. Zinc phosphide is the only acute rodenticide available to control rodents.

6.2.1. Bait Stations

Sub lethal doses of acute rodenticide will not kill the rodents, but the minute quantities of phosphine generated in stomach will give stomach disturbance. Rodents will associate this confusion with bait material ate. Consequently they avoid eating the food item, and this reaction is called *Bait Shyness*. This habit is overcome by use of pre baiting. Bait stations provide a protected place for rodent to feed, allowing them to feel more secure and consume more bait. These stations protect bait from moisture and dust. It keeps non-target species including poultry birds, dogs, livestock, wild animals and children away from the poisoned bait.

Bait station (PVC made)

Improved bait station (steel made)

6.2.2. Action plan for acute rodenticides (Zinc phosphide)

Proportion of zinc phosphide poison bait:

Broken rice/wheat - 96 parts
Edible oil - 2 parts
Zinc phosphide - 2 parts

Ingredients for bait preparation

Day wise plan

Day 1- Identify live burrows through the presence of soil plugs and faecal pellets and place 20 g of pre-bait material inside the burrow. Pre-bait consists of approximately 20g broken grain of staple food with little amount of vegetable oil (0.5ml).

Day 4- Place 10g zinc phosphide poison bait inside the burrow. Keep the bait packets deep inside the burrows to avoid accidental toxicity to other animals with the help of wooden stick.

Day 5- Close all the rodent burrows, collect dead rats and burry them, then again close all the burrows with soil and treat the residual burrows or live burrows with the anticoagulant Bromadiolone (0.005% a.i).

Day 6- Treat the opened burrows with aluminum phosphide 0.6g @ 2 pellets per burrow.

Day 13- Apply Bromodiolone 1 cake per burrow. Repeat Bromodiolone baiting.

Advantages of Zinc Phosphide

1. Quick killing
2. Small quantity of chemical is required
3. Single feeding
4. Population can be brought down immediately

Disadvantages of Zinc Phosphide

1. Necessity of prebaiting
2. Low killing around 40 – 50 %,
3. Induce bait shyness.
4. Toxic to non target species,
5. Chances of secondary poisoning are more.

6.2.3. Action plan for Chronic Rodenticides

Proportion of bromadiolone poison bait:

Bromadiolone powder	- 2 parts
Crushed rice/wheat	- 93 parts
Edible oil	- 3 parts
Jaggery	- 2 parts

- In order to overcome limitations and hazardous nature of acute rodenticides, lengthy baiting programme and possibility of resistance, new series of rodenticides have been developed and known as single dose anti-coagulants or second generation anti-coagulants. These rodenticides (bromodiolone) combine better qualities of acute and chronic rodenticides.
- For effective and successful rodent control, the anticoagulants should be adopted on large areas at a time on community approach.
- Chronic or multi-dose rodenticides (at present only anti-coagulants) are much safer than acute rodenticides because they are less toxic to the non-target species. But they have to be fed for 5 – 7 days to obtain desired results, which increases the cost of operation.

Keeping in view the cost involved, simplicity and feasibility in field application, safety to human beings and non target species, weather and soil types, the following action plan is more pertinent or suitable for the control of rodents with bromodiolone concentration in rice fields in Arunachal Pradesh.

Day wise plan

Day 1 - Identify live burrows and place 15g bromodiolone concentrate bait (0.005%) inside the burrows. Bait stations should be used in jhum situations to avoid accidental toxicity to non target animals.

Day 15- Repeat Bromodiolone baiting in active or live burrows.

Day 16- Eliminate residual population through trapping or fumigation with burrow fumigator.

6.3. Important points for effective management

- Grow same maturity group cultivars on large areas to restrict the availability of the vulnerable stage (reproductive) of the crop.
- Reduce the number and size of the bunds, keep them clean to locate burrows and avoid harborage.
- Rodent control operations should be taken up on large area at a time.
- It checks cross infestation or migration of rodents from untreated fields to treated fields.
- All the control operations should be completed before the crop attains primordial initiation stage since at this stage the rodents are invariably attracted to the rice crop.
- Rodenticides should be made available before beginning of the season.

7. Indigenous storage methods for rodent management

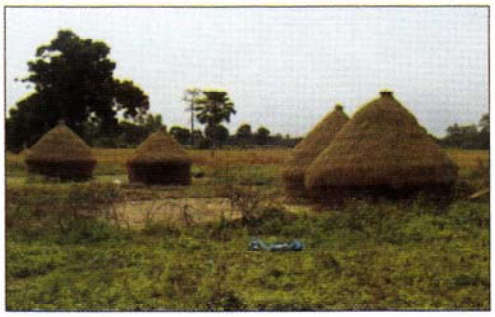
7.1. Hanging type: This structure is used for storing of maize, foxtail millet, finger millet, soybean which is used for seed purpose. The whole maize cobs are hanged in the roof of the bamboo house. According to farmers less damage is caused by the rodents. Seeds of maize and leguminous crops are often kept intact along with their outer husk and hang over the kitchen/ furnace. Here, maize cobs are tied up in bunches of 10 - 12 cobs by folding their next to outermost husk and hang over the

wooden beams of kitchen and sometimes roof beam in the periphery of the house. Open air mixed with smoke seemed to inhibit the attack of pests and pathogens.

Hanging of maize cobs

***Gumpir*- unmanaged storage structure**

***Gumpir*-plastered with clay**

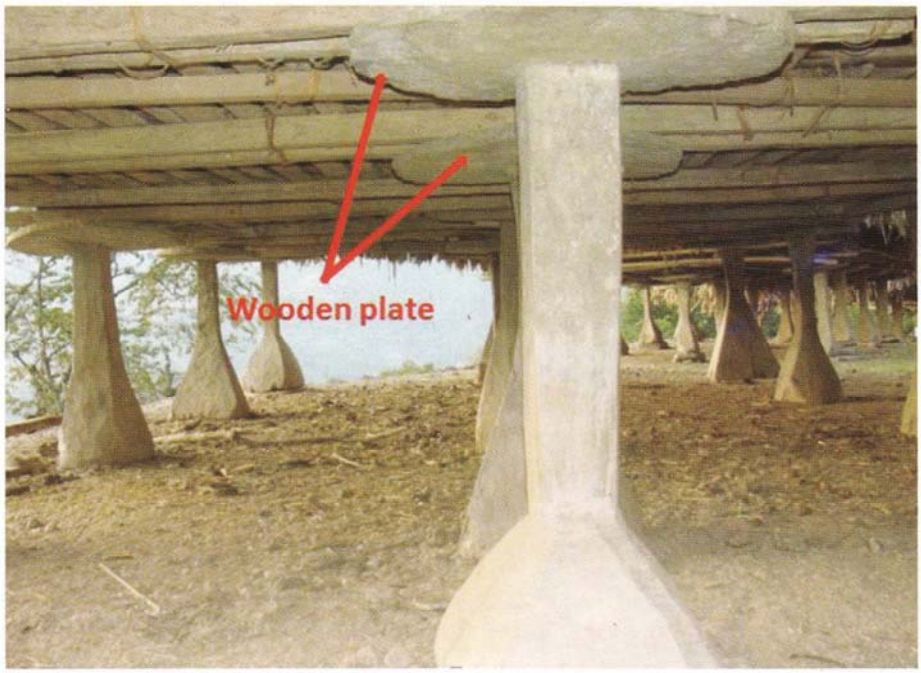


***Ampom* (*Guchibhoral*)- open storage method prone to rodent attack**

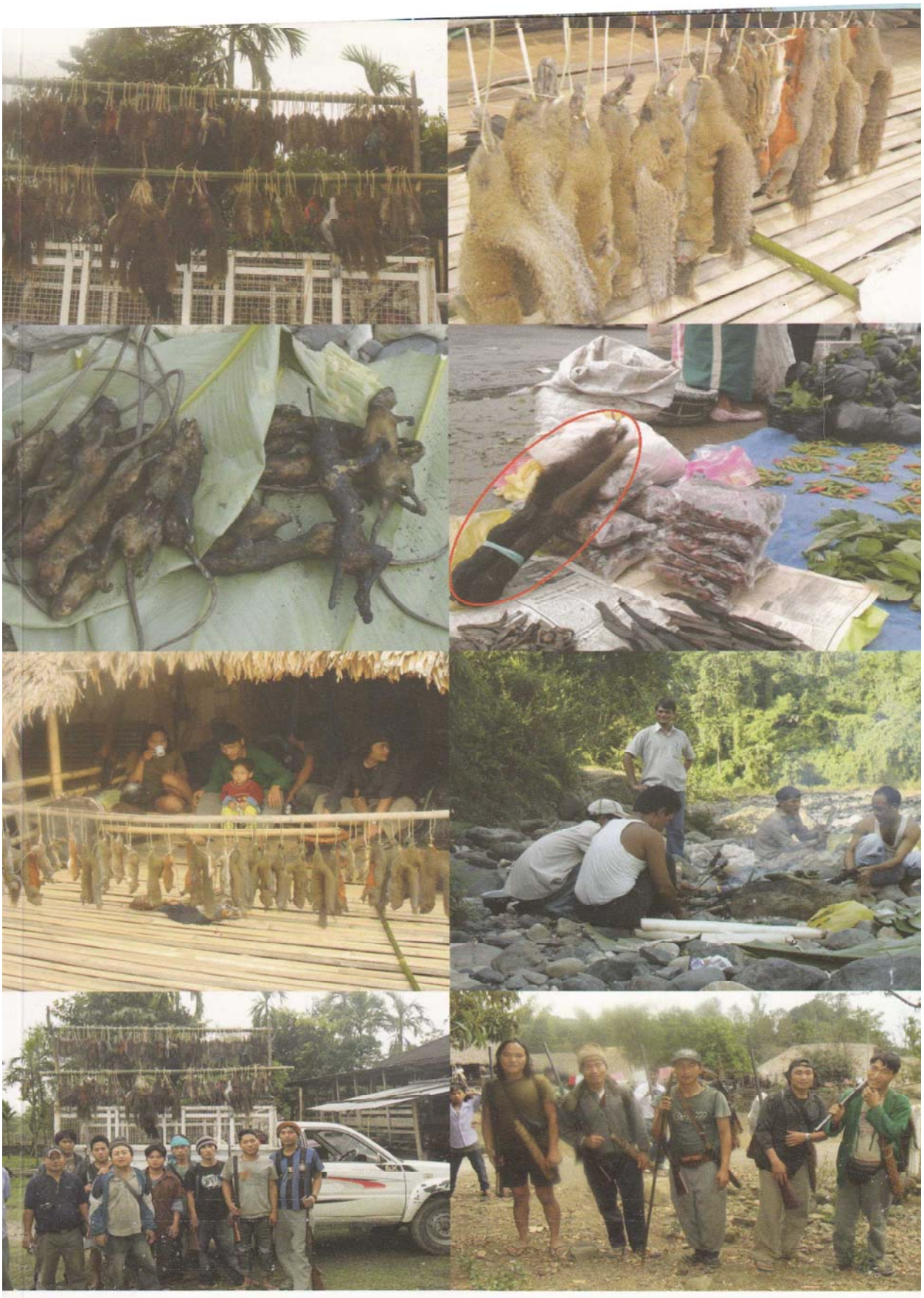
7.2. *Kumsung*: It is also known as *Nahu* and *Noshu* in Arunachal Pradesh. In this storage structure the commodity are kept in hut in the field. The hut is made up of wood, cane, palm leaves or *toko patta* (Himalayan fan palm, *Livistona jenkinsiana* Griff.) and bamboo. The size is varied according to availability of commodity to be stored generally 5-10 tonnes. The storage structure constructed near the village, however enough away to escape at the time of fire accident. It is mainly used for store of paddy, maize, millet and seeds etc. This storage structure is rectangle in shape. The granary is build at height of 4-9 feet above the ground leve. The structure is based on the wooden pillars to avoid the contact of moist soil and rain water as the state has high rainfall. The wall of *kumsung* made-up of bamboo and the roof is made-up of *toko patta*. To avoid the climbing of rodents, a disc shaped wooden plate

of radius 1.2-1.5ft is fixed on the top of the pole in such a way that disc is at right angle (horizontal position) with the pillar, this plank prevent upward movement of rodent to store thereby avoid rodent entry in store. In recent time, these wooden pillars are wrapped by the metal sheet to make it more slippery. Thus, the wooden plates act as a barrier for rodent climbing on *kumsung*.

***Kumsung* having wooden plates for avoiding rat attack**



Wooden plate act as a barrier



Glimpse of rodent hunting festival (*Aran*) in Arunachal Pradesh