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FOREWORD

Northeastern India experiences a unique natural phenomenon that the bamboos, which are deeply embedded in the cultures of the NE people, when blooms with beautiful flowers and paints the hills and valleys of the region in various shades, a sense of doom descends on the local people. The gregarious flowering of bamboos means only one thing for the people of the region, "that the inevitable famine is not far behind". In this region where bamboos constitute more than three fourths of National bamboos stock, it is some satisfaction that among many bamboo species occurring only a few species, when flower en masse result in rodent related famines. I am told that sporadic flowering in certain bamboo species has started already in many tracts in NEH region. Arunachal Pradesh and Manipur has suffered greatly in last 2 years.

Based on our reports and feed back received from the states, Department of Agriculture and Cooperation (Government of India) in collaboration with AINP on Rodent Control (ICAR) and NE states provided Strategy and Management Planning for survey, human resource development, awareness camps and rodent pest management. AINP on Rodent Control through Assam Agricultural University, Jorhat and ICAR Research Complex for NEH Region, Barapani have generated lot of information on this particular aspect. The Regional Meeting on Rodent Pest Management for NEH region organized by ICAR at Aizawl during April 21-22, 2006 formulated Action Plan for managing the native as well as invasive rodents during bamboo flowering periods in the region. Capacity building of local population on rodent control is the most important component in the planning for community based rodent control campaigns.

I am happy that AINP on Rodent Control is bringing out a Technology Bulletin specific to the NEH region, which covers many aspects on the subject like surveillance issues and safer management options. I congratulate the authors for their timely endevour. I hope this bulletin will be helpful to the extension officials and farmers alike in meeting the challenges being posed by outbreak of rodents during gregarious bamboo flowering periods.

(K.P.R. Vittal)

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INTRODUCTION

The north eastern region comprising the states of Arunachal Pradesh Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is located between 21.50° and 29.50° North latitudes and 85.50°-97.50° East longitudes and has a total geographical areas of 2,72,315 sq. km. This region is situated on the eastern border of India. The land is between Chin Hills (Burma) in the east and south, and Chittagong hill tracts (Bangladesh) in the west. This region accounts for7.7 percent of area and 4.04 per cent of country's population. It is interesting to note that each state has over 50 per cent of forest cover except Assam, which is also much above the national average. All the states of northeast region are hill states except Assam having only two hill districts namely Karbi Anglong and North Cachar. The economy of the northeastern hill (NEH) region is primarily agriculture with majority of the people still practising *"Jhum"* or shifting cultivation in hill slopes along with Wet Rice Cultivation (WRC) in lower altitude and plains. Natural vegetation primarily of bamboo forests normally surrounds the crop fields. Crop fields being ideal rodent habitats along with the surrounding bamboo forests provide a most favourable habitat for rodents 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.

RODENT SPECIES DIVERSITY

In northeastern region rice, maize and sugarcane are the major crops during *kharif*; mustard, cole crops and vegetables during *rabi* and summer. Among the vegetables, pea, potato, broad bean and brinjal are major ones. Damage estimates are available for rice, maize and pineapple. Lowland paddy was damaged at 4.6 to 16.8% and damage to upland paddy was 3.9 to 12.9%. In normal situation, the rodent species causing damage were *Bandicota bengalensis bengalensis, Rattus rattus* and *Mus booduga*. The range of damage to maize was 3.5-22.2% and the species involved were *B. b. bengalensis* and *R. rattus*. The rodent damage to pineapple ranged from 2.6% to 20.3%. Rodent problem in poultry farms and home steads are also realised by the farmers of this region (Fig. 1). Studies conducted by AINP Rodent Control, Jorhat Centre during 2004-05 revealed that rodent caused 30-40% damage in Jhum paddy during bamboo flowering in West Kameng and Papumpare district of Arunachal Pradesh and the species involved were *R. nitidus, R. sikkimensis, Niviventer niviventer* and *N. fulvescens*

The region is very rich as far as rodent diversity is considered. The rodent species recorded from North Eastern Hill region mainly belong to the genus *Bandicota, Rattus, Niviventer, Mus, Berylmys, Vandeleuria, Cannomys, Callsciurus* and *Dremomys* etc.

Among these, *B. bengalensis bengalensis* is the most predominant species followed by *R. nitidus, R. sikkimensis, R. rattus* and *Mus musculus castaneus.* A survey conducted by, ICAR Research Complex for NEH Region under AICRP on Rodent Control in all the NEH states revealed that rodent activity was highest in the areas where livestock and poultry are raised. This may be due to the presence of large quantity of nutritious feed round the year. Highest numbers of active burrows were recorded in upland cultivated areas and *Jhum* fields; lowest density was seen in lowland cropped area and wastelands.

Fig. 1. Rodent Problem in NEH Region

The rodent activities started increasing from March onward and reached the peak during September-October. Density of the rodents was low between December and February. Majotity of the species were recorded at all the altitudes varying from 0.0 to 5000 m above mean sea level (m.s.l.), whereas *Canomys badius badius* was limited to lower altitude i.e. 0-500m m.s.l. Five species viz. *R.r.tistae, B.indica nemorivaga*, *M. cervicolor* and *C. pygerithrus* were seen at 501-1000m m.s.l. Seven species namely *R.r.khyensis, R.norvegicus, R.nitidus, R.niviventer, R.bowersi*, *M.booduga* and *V.oleracia* were found from 501 to 5000m m.s.l. The relative distribution of rodent species in North Eastern region is shown in the Table 1.

Table 1. Distribution of rodent species in North Eastern Region

Rodent Species	Aruna-chal Pradesh	Assam	Man-ipur	Megh-alaya	Mizo-ram	Naga-land	Sik-kim	Tripura
Bandicota bengalensis bengalensis	+	+	+	+	+	+	+	+
B. indica nemorivaga		+	+	+				
Rattus sikkimensis	+	+	+	+		+	+	
R. rattus	+	+	+	+	+	+	+	+
R. nitidis	+	+	+	+	+	+		+
R.r. tistae	+		+	+	+		+	+
R. r. brunneusculus	+	+	+	+		+	+	
R. norvegicus		+		+	+			
Niviventer niviventer	+	+	+	+		+	+	
N. fulvescens	+	+	+	+			+	
Mus musculus castaneus	+	+	+	+	+	+	+	+
M. booduga	+	+		+	+			+
M. cervicolor			+	+				
Berylmys bowersi	+		+	+	+	+		
B. mackenzie			+	+	+	+		
B. manipulus		+	+		+			
Vandeleuria oleracea	+							
Cannomys badius	+	+	+	+	+	+		
Callosciurus pygerythrus	+	+	+	+	+	+		+
Dremomys lokriah macmillani	+	+	+	+	+	+	+	+

BIOLOGY AND GENERAL BEHAVIOUR OF RODENTS

Rodents are equipped with a pair of ever-growing incisor teeth in each jaw, which is the real weapon of rodents. These incisors grow at a rate of about 0.4 mm per day (Approximately 12 cm/year). To keep these chisel shaped incisors in proper shape, size and sharpness the rodents have developed the habit of gnawing and nibbling any hard or soft objects. This causes lots of destruction to mankind. Secondly, they are prolific breeders with annual breeding potential of 800-1200 per pair per year. The breeding biology of rodents is detailed below:

Life span	-	1-2 years
Age at puberty	-	6-16 weeks
Oestrous cycle	-	3-7 days
Duration of heat	-	9-24 hours

Mating habit	-	promiscuous
Gestation period	-	18-30 days
Breeding season	-	year round
Litter size	-	1-22
Post partum heat	-	4-96 hours

They are one of the most successful groups of animals on the earth today due to their vast breeding potential and easy adaptability to a wide variety of habitats and have acquired cosmopolitan distribution. Rodents have adapted different modes of life, from arboreal to subterranean. Some of them are found from snowy heights of about 5790 m to the extremes arid tracts of the world. Some behavioural characteristics of rodents are listed in Table 2.

Table 2: Behavioural characteristics of rodents

Sl.No.	Targets	Characteristics
1	Sight	Colour blind, but can distinguish between shades. Can discriminate between pattern and size and have good depth perception.
2	Taste	Wide food range and prefer fresh food but can thrive on garbage and decaying or spoiled food also.
3	Hearing smell and touch	Well developed senses; readily distinguish unusual noises and the long whiskers on their muzzle and guard hairs on the body serve as sensitive feelers.
4	Balance	Excellent balancing sense enables them to run on pipes, narrow ledges or wires. Long tails act as balancing organ.
5	Gnawing	Gnaw to gain entrance to food and to wear down their incisors to keep them in sharpened condition which grow @ 12 cm/year.
6	Climbing and swimming	Can climb almost anything they can get their claws to hold. Roof rat is the better climber. Norway rats living in sewers are excellent swimmers.
7	Temperament	Bandicoots and Norway rats are much more aggressive than house rats and mouse. Cannibalism is quite common.
8	Travel routes	Use fixed pathways, usually moves along the walls, under floors or through thick grass or litter.

COMMON RODENT PESTS OF NEH REGION

(i) Lesser bandicoot rat, *Bandicota bengalensis* : This Indian mole rat is a major vertebrate pest of the country. It 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 length(HB), and dorsum with dark brown colour and coarse hair (Fig. 2). It has been transported through human agencies and established in various parts of the country in the field as well as in houses. *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. It is a nocturnal and fossorial rodent lives in self constructed burrows. It hoards the grain. The burrows are characterized 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. The oestrus period varies from 3 to 5 days and gestation period is 22 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 with a post partum period of 30 days. It is also a vector for leptospirosis. The larger bandicoot, *Bandicota indica* is not reported in the state, ahthough they may exist in deep water rice cultivated areas.

Fig. 2. *Bandicota bengalensis*

(ii) Himalayan rat, *Rattus nitidus* : In appearance it is like a commensal form of *Rattus rattus*. Fur is soft, naked, dark and longer tail (110% of Head and body length). Hind foot with 5 toes, all clawed, dark brown in colour with dark mid dorsal patch or line. The feet are usually yellowish or whitish, rarely dark. Ventral side is gray (silvery) or brownish (Fig. 3). Distributed in all NE states. Crop fields including jhum fields and homesteads are its preferred habitat. It is noticed to damage rice, pineapple, maize, ragi etc. Not much information is available for this species.

Fig. 3. *Rattus nitidus*

(iii) Brunneusculus rat, *Rattus rattus brunneusculus* : It is reported from Sikkim, Assam, Meghalaya, Manipur and Nagaland. It is the only Asiatic white bellied wild *R. rattus*, but those occurring in tribal settlements have yellowish or buffy belly. Occurs in hilly slopes, paddy and other fields in jhums, forests and also near tribal settlements. Nocturnal and fossorial. Females are sexually active from March to December. Litter size 1-10 but 6-8 is most common.

(iv) Bowers' rat, *Rattus (Berylmys) bowersi* : Recorded from Assam, Nagaland and Indo China. It is larger in size with white belly. This rat is renamed as *Berylmys bowersi*. Medium sized to large rats, fur moderately soft, ear more than 1/10 HB, tail longer than HB and is of two colours. Back is dark brown or gray and white below (Fig.4). It makes the burrows on slopes of hills deep and has 2-4 outlets. They mainly feed on tender shoots of various crop plants preferably underground vegetables.

Fig. 4. *Berylmys bowersi*

(v) White bellied rat, *Niviventer niviventer* : Not much is known about this species. Tail larger than HB. Dorsal side is gray in colour. Toes usually white. Under parts sharply contrast white. Tail quite clearly bicolor, dark above and whitish below (Fig. 5). Another species viz., *N.fluvescens* also occurs in the region. Both the species were observed in large numbers during recent out break in Arunachal Pradesh. They prefer to live in evergreen rain forests and were reported to cause damage in rice fields at grain formation stage. It is reported that they cut the rice ear heads, drop in the fields and carry to their hiding places.

Fig. 5. *Niviventer niviventer*

(vi) Bamboo rat, *Canomys badius* : It is widely distributed in NEH region in bamboo forests. It is a moderately large, stockily built rodent with lush brown-orange fur (Fig. 6). It has massively broadened head, a plump body with short limbs, strong claws and a short sparsely haired tail, which lacks scales. It has massive incisors and small eyes and ears. It makes simple burrows consisting of a single tunnel running at a depth of 60 cm or so and ending in a large chamber. When the burrows are occupied the entrance is closed with freshly piled earth.

Fig. 6. *Canomys badius*

(vii) House rat, *Rattus rattus* : Medium sized (80-120 g) rodent with ringed tail that is longer than head and body length (HB). It is also called as Black rat or Roof rat. This is the most prevalent house dwelling rodent living with *Mus musculus* in the residential

premises and storage units. This rat is partially social and lives in inter connected burrow system dug in the floor and walls. 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 (Fig. 7). It is one of the most important pests of stored grains and fruits in the state. It is also a vector of plague and leptospirosis diseases.

Fig. 7. *Rattus rattus*

(viii) House mouse, *Mus musculus* : Dark house mouse, *Mus musculus homourus* with whitish under surface is found in the fields as well as 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 (~15 g body weight) with tail longer than head and body (Fig. 8). The dorsum is dark brown to sandy. They are nocturnal, fossorial and highly active and have nibbling habit, which result in damage to sacks 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.

Fig. 8. *Mus musculus*

(ix) Norwey rat, *Rattus norvegicus* : This is an Europian rodent but reached India through ships while transport. Earlier it was reported from port cities only but now it has spread in many other regions including NEH states through goods transport. It is a short tailed brown rat with blunt nose and small eyes. It is nocturnal in habit and digs extensive burrow systems along foundation of buildings, under concrete or near rubbish piles in soil. They are omnivorous and breed all through the year. Gestation period is 24 days with 3-7 litters per year. Litter size range from 6-10 young ones. Sexual maturity is attained in 3 months. Its pest status is not known. It is seen all through India due to accidental transportation by human agencies (Fig. 9).

Fig. 9. *Rattus norvegicus*

(x) Sikkim rat, *Rattus sikkimensis* : It was previously grouped as a sub species of *Rattus rattus*, but now it has got the status of separate species because of longer maxillary tooth row and mid dorsal black hairs (Fig. 10). Earlier it was reported from Sikkim, but has now spread in many states of NEH region. This species was one of the important constituents in the catches during recent rodent out break in Arunachal Pradesh.

Fig. 10. *Rattus sikkimensis*

BAMBOO FLOWERING AND RODENT OUTBREAKS IN NEH REGION

Bamboo habitats in north east region

Bamboo is a group of plants that belongs to the family Poaceae, subfamily Bambusoidae and accounts for 75 genera and 1250 species in the world. Our country is very rich as far as species diversity in bamboos are concerned, because as many as 126 species beloging to 23 genera are found in India. Besides the species diversity, India has the largest bamboo resource also. It occupies about 10.8 m ha area constituting 12.8% of total forest cover of the country. In northeast region alone 58 species (46%) of 16 genera (87%) are harboured by forests and degraded land in northeastern region. The state like Arunachal Pradesh alone harbours 88% generic and 59% species diversity that is highest in the entire north eastern hill region (Table 3).

Table 3: Bamboo diversity in NE India

Region	Genera	Species
Arunachal Pradesh	14	34
NE India	16	58
India	23	126
World	75	1250

Source: Proceedings of Expert Consultation on Bamboo Flowering (2002), RFRI, Jorhat

In northeast India bamboo forests are seen from tropical to alipine zones. In most of the states particularly Arunachal Pradesh, Mizoram, Meghalaya, Nagaland and Tripura, bamboos grow as secondary vegetation after jhum cultivation or in forest cleared areas (Fig. 11). The most common species that comes up in such fallows are *Dendrocalamus hamiltonii* found in plains, lower and mid hill slopes. *Bambusa pallida* is another

Fig. 11. Bamboo forest in NEH Region

species in this respect. These bamboo species are more abundant in Meghalaya and Arunachal Pradesh. They are sympodial in nature and are clump forming. In contrast, bamboos like *Melocanna baccifera* (Muli bamboo), *Schizostachyum polymorphum* are non-clump forming type and prevalent in the plains and lower hills. They appear gregarious in localized patches. *Melocanna* sp is widely distributed in Mizoram, west Meghalaya, southern Tripura and parts of Assam. *S. polymorphum* is more abundant in Arunachal Pradesh. Another bamboo, *Chimonobambusa sp*. is grown with a sizeable population in Nagaland and Arunachal Pradesh. *Arundinaria maling* in west Kameng district of Arunachal Pradesh form extensive stands sometimes interspersed with other trees. Different species of *Arundinaria* grow extensively in temperate conifer forest belt in Arunachal Pradesh. Other than *Arundinaria*, species of *Phyllostachys* are important high altitude bamboos. These high altitude bamboos are seen largely cultivated in Ziro, Tawang, Shillong, Kohima and other places.

Fig. 12. ***Bambusa balcooa***

Fig. 13. ***Melocanna bambusoides***

Most of the domestically used bamboos come from cultivated source. They are cultivated in homesteads, community lands, crop fields, steam banks, etc. Almost all the rural houses in Assam are having bamboo clums. Size of such plantations may vary from

Fig. 14. ***Bambusa pallida***

Fig. 15. ***Dendrocalamus hamiltonii***

a single clump to five-six clumps in homesteads. While in garden/farms the clump number may vary from 20-100. Such bamboo garden can be seen in Assam, Meghalaya and Arunachal Pradesh. The common species under cultivation are few and belong to *Bambusa tulda, B. nutans, B. balcooa, B. pallida, B. longispiculata, D. gigaenteus, Oxytenanthera abyssinica, O. albociliata* etc (Fig. 12-17). The high altitudes in NEH region particularly Arunachal Pradesh has bamboo plantation in village gardens. The local people, the *Apatanis* cultivate bamboos particularly *Phyllostachys* sp. in hill slopes along with blue pine in Ziro/Hapoli valley in Lower Subansiri district and is model for the entire region. In Tawang of Arunachal Pradesh bamboos like *Phyllostachys* are cultivated along fences.

Thus bamboos are grown in a variety of habitats in north east India and they can tolerate extremes of climatic conditions depending upon the species. Natural bamboo forests and other natural vegetation surrounding the crop fields provide favourable habitats for rodents in northeastern region.

State wise availability of bamboo resources in NE India is detailed in Table 4. It indicates that out of 3.05 m ha, maximum area is occupied in Mizoram (0.92 m ha) followed by Assam (0.82 m ha),Arunachal Pradesh (0.46 m ha), Manipur (0.37mha) and Meghalaya(0.31 m ha). Among various bamboo species, *M. baccifera*, believed to be responsible for famine is expected to flower in 1.76 m ha.

Table 4. Status of Bamboo resources in northeastern India

Sl. No.	State	Bamboo growing area (mha)		Bamboo growing stock (m tons)	
		Total	*M. baccifera*	Total	*M. baccifera*
1	Arunachal Pradesh	0.46	-	9.84	-
2	Assam	0.82	0.33	13.41	0.57
3	Manipur	0.37	0.35	11.47	10.66
4	Meghalaya	0.31	0.14	4.41	3.40
5	Mizoram	0.92	0.85	10.89	10.51
6	Nagaland	0.08	-	3.66	-
7	Tripura	0.09	0.09	0.86	0.81
	Total	3.05	1.76	54.53	25.95

Source: Prasad,, K.G and Patnaik, S., RFRI, Jorhat, 2002.

A peculiar phenomenon observed in the north eastern hilly areas of India, namely Mizoram, parts of Meghalaya, Arunachal Pradesh, Nagaland and Manipur, is the periodic

gregarious flowering and seeding of certain bamboo species, which is accompanied by a tremendous increase in populations of certain rodent species. This eco-biological phenomenon results in severe famine conditions due to extensive devastations of agricultural crops and granaries by rodents.

Fig. 16. *Bambusa tulda*

Fig. 17. *Dendrocalamus* sp.

In Mizoram, the famines associated with the flowering of *Melocanna baccifera* (Fig. 18) (local name 'Mautak') and *Bambusa tulda* (local name 'Rawthing') are locally known as 'Mautam' and 'Thingtam' respectively. These famines occurred in 1864,1910-12, 1958-59 (associated with Mautam) and in 1880-84, 1928-29, 1976-78 (associated with Thingtam). Reports of next Mautak (*M. baccifera)* flowering as forecasted for 2005-07 has started pouring in. Other minor bamboo species found to be associated with *Mautam* are *Dendrocalamus longispathus (Rawnal), Melocalamus campactiflorus (Sairil)* and *D. sikkimensis (Rawni)* and with *Thingtam* are *Melocalamus campatiflorus, D. sikkimensis, D. longispathus, Bambusa spinosa (Phar)* and *Pseudostachyum polymorphum (Chal)*. Mautam is associated with a famine of much greater magnitude than Thingtam. The gap between two Mautams and Thingtams are 46-48 years; Mautam to Thingtam is 18 years and Thingtam to Mautam is 30 years (Table 5).

Fig. 18. *Melocanna baccifera*

Table 5. Incidence of bamboo flowering and rodent related famines in Mizoram

S. No.	Bamboos in flower	Period	Year
1.	*M. baccifera*	Mautam	1864
2.	*B.tulda; D.longispathus*	Thingtam	1880-84
3.	*M. baccifera*	Mautam	1910-12
4.	*B.tulda; D.longispathus*	Thingtam	1928-29
5.	*M. baccifera*	Mautam	1958-59
6.	*B.tulda; D.longispathus*	Thingtam	1976-78
7..	*M. baccifera*	Mautam	2006-07

Two rodent outbreaks in Garo Hills of Meghalaya were recorded due to flowering of wild bamboos in 1920-21 and 1929-30. During 1975-76 also an outbreak was reported in the region, when about 2.5 million rats were reported to be killed indicating the magnitude of rodent problem in the next 2-3 years. During the last five years minor out breaks have been noticed in various pockets of Arunachal Pradesh, Mizoram, Manipur and Assam.

Bamboo flowering, a natural phenomenon as in other plants, assumes special significance because of their monocarpic nature, i.e. they flower and seed gregariously only once in their lifetime and die thereafter. Flowering in bamboo is a botanical enigma and the factors that switch a bamboo plant from vegetative to flowering state are not fully understood. The culms that flower often die after the fruit has developed but other culms and rhizomes survive and perpetuate the stand after growing from rhizomes and branch production for a species specific period (3-120 years), most species flower gregariously, set a large quantities of seed and die. These seeds germinate after first rains. According to their flowering habits there are three types of bamboo (Table 6).

Table 6. Types of bamboo flowering

Sl. No.	Types	Example
1.	Continuous flowering (Those that flower annually or nearly so)	*Arundinaria* *Bambusa lineata* *Ochlandra stridula, etc*
2.	Periodical flowering *(Those that flower gregariously)*	*Dendrocalamus hamiltonii* *Melocanna baccifera* *M. bambusoides* *B. tulda*
3.	Irregular flowering *(Those that flower sporadically)*	*B. bambos* *B. balcooa* *B. nutans and Phyllostachys edulis*

Gregarious flowering 1occurs in cycles, the cycles are more or less constant for a species in a given locality (Table 7)

Table 7. Flowering cycles of some bamboo species of North East Region

Flowering Cycle (Years)	Species
16-17	*Dendrocalamus longispat hus*
25-65	*Dendrocalamus strictus*
30-40	*D. hamiltonii*
30-60	*Bambusa tulda*
35-60	*B. polymorpha*
40-45	*Melocanna baccifera, B. bambusoides*
48	*Pseudostachyum polymorphum*
60	*Phyllostachys bambusoides*

RECENT RECORD OF BAMBOO FLOWERING RELATED RODENT PROBLEM

During the last 10 years, minor rodent outbreaks have been noticed in various parts of the northeastern region. During 2002-03, in Karbi Anglong and Haflong of Assam, there was gregarious flowering of *Melocanna baccifera* and *Dendrocalamus hamiltonii* resulting severe rodent outbreaks. Recently, there was gregarious flowering of *D. hamiltonii* in West Kameng and Papumpare district of Arunachal Pradesh during 2004-05 resulting a loss of 30-40% in Jhum paddy due to rodent outbreak. During this period nine circles of East Kameng Distt, Thirizino subdivision of West Kameng Distt and Sagalee subdivision of Papumpare Distt suffered due to rodents. The bamboo species, *D. hamiltonii* (locally called as Hubbi/Ayee) *S. fuchsium* and *S. polymorphum* (locally called as Talem) and *P. bambusoides* were in flower during October-November 2004. The rodent problem in jhums and WRC fields was experienced during August 2005, which reached to devastating propensities by October 2005 when the crops were at harvesting stage. As per the reports of a Central team of Experts, the crop damage in the region was done by forest dwelling rodents and not by burrowing ones. The experts estimated a rodent damage of 43-47.3% in rice crop alone. The WRC fields experienced total damage in Rallo-a local rice variety. Here mainly *B.bengalensis* did the damage. Occurrence of *B.bengalensis* to the tune of about 130 active burrows/ha in the region itself is quite worrying.

Earlier some minor out break was also noticed in the state in 1999-2000 covering an area of about 7000 ha (rice and maize). Manipur and Nagaland too suffered severe

rodent problem in an area of 2264 and 100 ha, respectively during 1999-2000. Similarly in Manipur, Tamenglong (20526 ha), Churachandpur (5406 ha) and Chandel Districts (947 ha) and Jiribam sub division (400 ha) experienced 53.9-83% crop damage due to rodents after flowerings in *D. hamiltonii*.

According to a report of Diretorate of Agriculture, Mizoram, 85 villages have recorded sporadic flowering in the Muli bamboo, *M.baccifera* affecting about 34 villages in 2002-03 and another 16 villages in 2004. Low to moderate increase in rodent population was noticed in most of the villages except in 3 villages, where severe rodent problem was reported during 2002-03. However in coming years, when gregarious flowering occurs the problem may aggravate leading to mautam.

The valid scientific reasons for sudden outbreak of rodents during flowering of bamboos 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 forests which results in mass migration of native rodents to the surrounding jhum or WRC crop fields causing large scale devastation of standing crops. A recent record of bamboo flowering in northeast region is given in Table 8.

Table 8. Recent record of Bamboo flowering in NE Region

Name of Species	Nature of flowering	Year of flowering	Area of flowering
Bambusa bambos	Sporadic	1997-1998	Nalbari (Assam)
B. nutans	Sporadic	1997-1998	Lakhimpur (Assam)
B. balcooa	Sporadic	1996-1997	
		1998-1999	Jorhat (Assam)
Dendrocalamus hamiltonii	Sporadic	1997-1998	Golaghat (Assam)
D. hamiltonii	Gregarious	1996-1997	Assam/Arunachal Pradesh border
D. Hamiltoni	Gregarious	1994-1995	Nagaland/Assam border
D. hamiltonii	Gregarious	1997-1998	N.C. Hills (Assam) Meghalaya
D. hamiltonii	Gregarious	2000-2001	Deopahar (Numaligarh) Assam
D. hamiltonii	Gregarious	2003-2004	Tamenglong,Chura Chandpur, Chandel, Jiribam

M. baccifera	Sporadic	2000-2001	Jorhat (Assam)
M. baccifera	Gregarious	2000-2001	Tripura
M. baccifera	Sporadic	2001-2002	Manipur
M. baccifera	Gregarious	2002-2003	Karbi Anglong and Haflong (Assam)
M. baccifera	Sporadic	2003-2004	Mizoram *Bambusa tulda* *B. nutans*
B. balcooa	Sporadic	2004-2005	Hojai (Assam)
D. hamiltonii, *S. fuchsium* and *S. polymorphum*	Gregarious	2004-2005	Arunachal Pradesh

MONITORING AND SURVEILLANCE OF RODENT PROBLEM

Assessment of rodent population

Knowledge of rodent population is necessary on three accounts (i) it provides information on gravity of the problem and helps in assessment of raw materials and manpower requirements for undertaking rodent control operation (ii) it helps to some extent in identification of rodent species infesting the area and (iii) it also helps in assessment of control success and further monitoring of the pest after any control operation. Although accurate population census is not possible due to migratory habits, changing species composition, diversified habitats and different body sizes of native rodents, however use of signs, tracks, surplus baiting techniques, burrow counts and trappings are some of the methods generally adopted for population estimation. Following two methods are commonly recommended for field level estimations.

***(i) Live burrow count methods*:** Generally live burrow count gives idea of living rodents in an area. Live burrow or active burrow generally look fresh, marks of rodent are there, fresh excavated soil and cut parts of various plants etc. may also be there. Since a rodent may use more than one opening for activity this may give false picture of rodent population. Therefore, all the burrows may be plugged in the evening and next early morning all reopened burrows would reveal correct picture of rodent numbers. By this, we may compute number of live burrows/ha. If we know the mean number of rodents residing in a burrow, a correct population of rodents can be estimated by multiplying this with number of live burrows. This situation generally arises during breeding season when more rodents live in a burrow, otherwise adult rodents occupy single burrow. A comparison of pre and post control census will give control success of the operation. For this method an area of 10 acres is randomly selected at two places in village covering

crop fields, roads, canal bunds, forests etc (if present) and total number of active burrows are counted and then converted on per ha basis to arrive at level of rodent infestation. In case of hilly tracts where terrace cropping is practiced, 0.5 ha area may be sufficient for this evaluation. A burrow density <25/ha is considered as low infestation, between 25-50/ha is moderate and more than 50 /ha is in the high infestation category. This criterion is more appropriate where burrowing rodents like *B.bengalensis, canomys badius or mus booduga etc.* are the predominant rodent species.

***(ii) Trap index* :** In situations like North-eastern States the rodent species like Himalayan rat, white-bellied rat, etc are not burrowing rodents. They hide in the densely populated bamboo thickets and make damage to the crops in jhum and wet rice cultivation areas. Under such a situation the monitoring the rodent situation could be done using Trapping index method. The following methodology could be followed: Select field at random, Set 2 trap lines of 10 snap/kill traps, Observe for trapped rodents next day, Repeat the same practice for 3 nights, and calculate the trap index as:

$$\text{Trap index} = \frac{\text{Number of rodents caught}}{\text{Total number of traps set x No. of nights}}$$

Although threshold limits for trapping index do not exist as of now, the index reflects the changes in the populations of the area under study. The trap index could also be used for evaluation purpose after rodent control campaigns by working out index before and after any control operation.

Assessment of Rodent damage

Rodent damage to crops also is equally important in monitoring and surveillance of rodent pests. 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. The methodology involved in collecting the damage index for rice crops is given below:

Rodents damage rice crop in all the stages of growth. They may cut/uproot newly transplanted seedlings. They cut diagonally (45^0) the developing tillers 5-10 cm above the water level (Fig 19). The damage can be easily recognized when the tillers are thickened and possess hollow tubular cross section. Damage in nursery is not much important since even if a nursery is devastated, resowing is usually carried out. Significant damage starts from the time of active tillering and it will be higher during early

Fig. 19. Typical diagonal cut by rodents in rice tillers

growth stages and decreases after heading, when feeding switches over from vegetative tissue to the more nutritive panicles. The extent of rodent damage reported in India ranges from 0.44 to 60.8% of tiller damage.

Minor or moderate rodent damage on standing rice crop is not readily visible unless the plants are examined closely. The distribution of damage is highly variable. Some times, patches of severe damage are visible within the fields, while some fields may appear undamaged but possess evenly distributed damage. In the entire case boarder rows sustain little or no damage, which might be a protective instinct. The damage patch distance varies from the size of the field. A direct relationship between the number of live burrows and damage exists in rice. The protocol for damage assessment is given below:

Philippine Method :

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.
   Tabulate for 100 (10 rows x 10 hills) observations.

   Calculate damage incidence (P) as

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

Where A = No. of damaged hills in the sample.

B = No. of undamaged tillers in the hills with damage.

C = No. of damaged tillers.

***Diagonal method* :**

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 x 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* :**

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 ten samples are taken.

A sample frame of 30 x 30 cm open at one end is required for taking the observations. Data can be tabulated as below:

Sample No.	No. of tillers	
	Cut	Uncut
Total		

% Damage= Cut tillers x 100/ Total tillers

RODENT MANAGEMENT TECHNIQUES

Management of rodent pests is a very intricate as well as a ticklish problem. Unlike insects rodent are very secretive and not easily observed because many of them are nocturnal. They infest an area throughout the year as compared to insects which may appear sporadically only for short periods in certain seasons. Often, the farmers must rely on various signs like damaged plants, tooth marks, burrows and traps to identify them. Moreover the rodents are highly mobile and a single individual may typically cause damage to several plants in one night by residing at some other place. There are several methods of rodent control, which needs to be integrated for successful rodent control operation. Various rodent control techniques are detailed below.

Mechanical/Physical control

Rodent control by mechanical or physical methods includes trapping, killing, blocking and entry of rodents and hunting by driving, herding and others.

(i) Trapping **:** Trapping is one of the oldest of rodent control practices from time immemorial. There are various types of traps in use today under two major categories viz. snap trap and live trap. Traps that catch live rats are called live-traps and traps that kill rats are called snap traps (Fig. 20-22). Live traps are of two types viz. single catch and multiple or mass catch. Some commonly used live traps are Sherman traps, wonder traps, box type traps etc. Snap traps, sickle traps, bamboo traps, Tanjore Kitty, Palmyra type traps, butta traps, urang or arrow traps, etc. are kill type traps. The live traps can capture more animals than kill traps but to cover a larger area kill traps are more convenient, because of easy handling and low-cost. Sticky traps (pieces of cardboard of wood are coated with very sticky resinous materials and placed in strategic positions) may be considered for commensal rodent control in indoors. In NEH region, the locally available bamboo traps are quite effective and more suited to the area as tribal people are quite aware about the rodent pathways in the field (Fig. 23).

Fig. 20. Snap trap

Fig. 21. Wonder trap for multiple catch

Fig. 22. Butta traps

Trapping method is more advisable for small areas with populations consisting of mostly adult rodents. It can be an effective mean for control of small population of

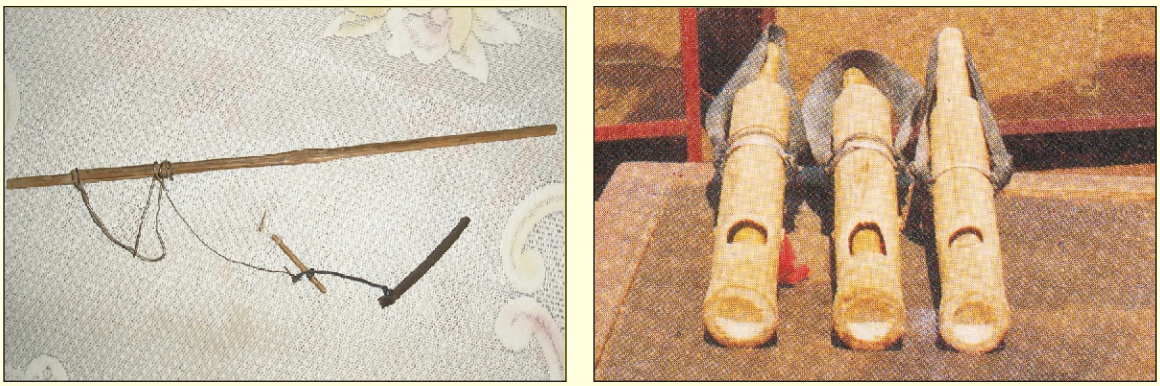


Fig. 23. Local bamboo traps : commonly used by NEH people

commensal rodents in houses, stores, homesteads, etc. It can also be used as follow up action after chemical control operation. Traps need to be placed on rodent runways, near droppings, near/under bushes (in fields) and near walls (in houses). Besides placement, proper attractant bait is also important for enhanced trappbility. Common baits are biscuit, bread, dried fish, meat, rice (wrapped by cloth), bananas, etc. In fields with more than 20 cm of water, traps placed on some kind of float also attract rats. Live traps placed on raft made of bamboo trunk in flooded fields are very effective for controlling rats in deep water rice fields.

***(ii) Smoking and watering* :** Rodents can be driven out of their burrows by blowing smokes (may be created by burning dry chillies also) or pouring water into the burrows. A net needs to be placed on the top of the burrow system to prevent the escape of rats. Fields that is heavily infested by rats can be flooded and ploughed after crop harvest to kill rats that try to escape from underground tunnels.Recently, the Maruteru center of AINP on Rodent Control has developed a small and compact device called as 'burrow fumigator' for smoking the rodent burrows (Fig. 24). The device utilizes rice straw, grasses and other farm wastes, which is burnt for generation of smoke and the smoke is pushed inside the active burrows with the help of attached blower.

Fig. 24. Burrow fumigator in operation

***(iii) Digging burrows* :** In some areas, after harvest of rice, farmers or poor people dig rat burrows to collect stored rice and kill rats. Some tribal people do rodent hunting by digging the live burrows.

Biological control

Biological control is suppression of a pest population either by introducing diseases or increasing predation. In case of rodents, some scant information on salmonella disease caused by bacteria, *Salmonella typhimurium* and *S. enteritidis* on Indian rodents are available but these have not been found effective. Moreover use of such pathogens have negligible practical value in rodent management because it may pose serious health hazard to man. As far as predators are concerned, some animals like, cats, owls, snakes, hedgehog, fox, mongoose, monitor lizards and kites are known to feed on rodents. Cats have been seen to affect the rat density in villages. These predators are useful in maintaining the natural ecological balance to some extent but do not prove to be an effective tool for rodent management,

Fig. 25. Barnowl, *Tyto alba*

because rodents as such do not form their main diet and these predators being opportunist prey on whatever is easily available. In recent years barn owls have been reported as an effective predator of rodents in Cauvery delta region in Tamil Nadu (Fig. 25). Perches for attracting predatory birds like owls in the night to facilitate hunting of the colonial rats may be used at tillering stage of crops to tackle the immigrating rodents.

Habitat manipulations or environmental management

In any habitat food, shelter and water are major governing factors in rodent environment. Manipulation or removal of any of these factors can reduce the carrying capacity of the habitat holding the rodents. The reduced food and shelter will increases intra and inter specific competition and aggressiveness among rodents, which may result in decrease in population either through mortality or migration. These methods are very easy, effective and require no extra expenditure hence can be easily adopted.

Indoor habitats :

i. Rodent proofing and sanitation : Construction of rodent proof buildings, warehouses, and repairs of old houses, help in reducing the entry of rodents. Poorly maintained warehouses, kucha floors, ill cared garbage, storage and poor sanitation adds in building up dense population of rodents. Lakhimi bhoral, an indigenous outdoor storage structures with rat guard of GI sheet fitted in the pillars has been found successful in protecting the stored rice grain from rodents in Assam.

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

In fields :

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

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

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

Chemical control

In this method, toxicants (rodenticides) anti fertility agents, attractants etc are utilized for rodent control. Among these only rodenticides have proved their effectiveness in practical sense and are widely used.

COMMON RODENTICIDES

The rodenticides registered under the Insecticides Act, 1978, broadly belong to two categories based on their ingestion: (i) oral poisons and (ii) respiratory poisons. The oral rodenticides are further grouped into two types; (a) Acute or fast acting and (b) chronic or slow acting. In the former type the death of target animals occur with in 24 hours of lethal ingestion, whereas in case of chronic poisons the animal dies at least after 3-5 days of intake depending upon the toxicant. In the oral toxicant group six rodenticides are registered, while only one respiratory poison i.e., aluminium phosphide is registered under the Act. Among oral category only two chemicals, viz., zinc phosphide and barium carbonate are acute rodenticides. The chronic poisons, which are primarily anticoagulant in action are further classified as first generation or multi dose anticoagulant rodenticides and second generation or single dose anticoagulant rodenticides. The first generation anticoagulant rodenticides include three toxicants viz., warfarin, coumafuryl and coumatetralyl whereas only one second generation anticoagulant i.e., bromadiolone is registered for common use. Of these, the most commonly used rodenticides viz., zinc phosphide, aluminium phosphide, coumatetralyl and bromadiolone are briefly described as under.

Zinc phosphide

It is grayish black garlic like smelling powder and is most commonly used acute rodenticide world over. When ingested, it reacts with water and acidic medium of gastric juices with the result lethal phosphine gas is produced, which kills the animals. It is extremely toxic to all mammals. The acute oral toxicity of zinc phosphide to rodents are: *Tatera indica* (35 mg/kg); *Rattus rattus* (40. 1 mg/ kg); *B. bengalensis* (25 mg/kg) and *Mus musculus* (250 mg/kg). It is recommended to be used as baits at 2.0% (w/w basis) concentration for rodent control.

Coumatetralyl

It is an improved first generation anticoagulant rodenticide and is bluish amorphous powder. In market it is available in 0.75% a.i. concentration. The acute oral toxicity is 16.5 mg/kg, while the chronic toxicityfor rats is 0.3 mg/kg daily for 5 days. Therefore it is recommended in saturated baiting technique with alternate day bait replenishment. It is recommended as baits at 0.0375% concentration (w/w) for rodent management in commensal and storage situations. It is formulated as tracking powder (0.75%) and ready to use bait (0.0375%).

Bromadiolone

It is the only second-generation anticoagulant rodenticide registered in India. it is very effective against a variety of rodent species. The acute oral toxicity is 3-5 mg/kg. Single feeding in baits leads to mortality of rodent population (40-60%) within a week or so. In fact mortality in rodents starts after 3 days of poison bait ingestion. It recommended at 0.005% conc (w/w) in baits for control of rodents in commensal as well as field situations. It is available as ready to use wax blocks and loose bait (0.005%). This rodenticide is also formulated as bait concentrate containing 0.25% a.i. from which the end user can prepare poison bait afresh (0.005%) at his doorstep.

Aluminium phosphide

It is a respiratory poison and is advocated for fumigation of rodent burrows. It has been formulated as pellets of 0.6 g size exclusively for rodent control and is recommended @ two pellets /burrow. The tablet formulation(3g size) of this compound must not be used for rodent burrow fumigation. This is a restricted rodenticide and can only be used under the supervision of technically competent persons. It is an extremely toxic chemical, hence due care is required to use it. In no case it should be used for commensal or storage rodent control. In fields two pellets are to be inserted deep in side the burrows and the treated burrow be plugged immediately to prevent leakage of lethal gas from the burrows.

TECHNIQUES OF BAIT PREPARATION AND BAITING

Rodenticides have a greater scope in large-scale rodent control programmes. It is the most common, expedient and humane method to control rodent depredations. Since mixed populations of several rodent species are associated in the crop fields, rodent poison should be broad spectrum to cover all the known species. Among acute rodenticides, zinc phosphide is the most widely used rodent poison in India. It is highly toxic to a variety of rodent species. However, sub-lethal consumption of this acute poison leads to problem of bait shyness/aversion which may persist for 2-3 months depending upon the dose ingested and the species involved. This phenomenon leads to non-acceptance of zinc phosphide on subsequent exposures. With the introduction of second generation anticoagulant rodenticides, like bromadiolone, the concept of rodent control has witnessed a revolution. These compounds are single dose anticoagulants and are required in very small concentrations in baits.

Bait preparations

It is an important aspect of rodenticide application technique, which is often overlooked. The proportion of toxicant to bait should be maintained properly. The recommended dosage for zinc phosphide is 2.0-2.5% and that of bromadiolone is 0.005% in baits and coumatetralyl is 0.0375%. The zinc phosphide is marketed in India as >98%

pure powder and Bromadiolone comes as bait concentrate (BC) at 0.25%, and coumatetraly at 0.075% cone. Bromadiolone is available as ready to use wax block baits also at 0.005% cone. The poison baits of these chemicals are to be prepared by end users himself. Too heavy dosages may repel the pest and with too light dosages rodents may stop eating before consuming the lethal dose resulting into development of bait shyness, as in case of zinc phosphide. It is, therefore, important that the toxicant is uniformly distributed through the bait mixture in desired concentrations rather than left as distasteful clumps. Since most of the rodenticides are available in powder from, the oil component of the bait is most important. In India, several methods of bait preparation arc in vogue, which are cumbersome, risky and uneconomic. The Coordinating Unit of AINP on Rodent Control Jodhpur has developed a very effective, easy and economic technique of bait preparation. By this technique farmer himself can prepare baits within 5 to 10 minutes and require no equipments like masks and gloves, etc. The technique has been evaluated in different agro-climatic conditions in the country and has been found very effective and is widely accepted by the farming community. The technique is as follows:

a*) Pre-bait material* (If zinc phosphide baiting is to be done): for one Kg of bait.

i) Take 960 g of locally grown food grains (broken rice/broken maize/ millets).

ii) Mix 20 g vegetable oil in food grain with bare hands.

b) *Poison bait material*: for one kg bait.

i) Mix oil in food grains as suggested above in pre-bait preparation.

ii) Sprinkle 20 g of zinc phoshpide or 20 g of bromadiolone BC and stir with wooden stick till uniform mixing is achieved. (no house hold utensil be used for this purpose).

For preparing poison bait of Coumatetralyl of desired conc. of 0.0375 % the bait composition should be 930g food grain + 20g vegetable oil + 50g coumatetralyl (0.75%)

(Rate of application of these baits/burrow are 8-l0 g for zinc phosphide, 15-20g for bromadiolone. In residential areas and homesteads, bromadiotone and/or coumatetralyl *can be used as baits in bait stations. In no case zinc phosphide be used in residential areas and homesteads.)*

Presently zinc phosphide is the only acute rodenticide registered for public use. For this poison, pre-baiting for at least 1-2 day is essential to achieve higher kill of the pest. Pre-baiting material consists of any cereal bait and oil. Similar cereal bait and oil should be used in pre and poison baiting. This helps in acclimatizing the field rodents to feed on new food at a specified place. Small amount of pre-bait (8-10 g per burrow or 50-100 g per bait station) is applied in the infested area. After the pre-baiting, the poison bait is placed (8-10 g per burrow). At the end of treatment the unconsumed poison bait and dead rodents should be collected and buried deep.

Bait placement

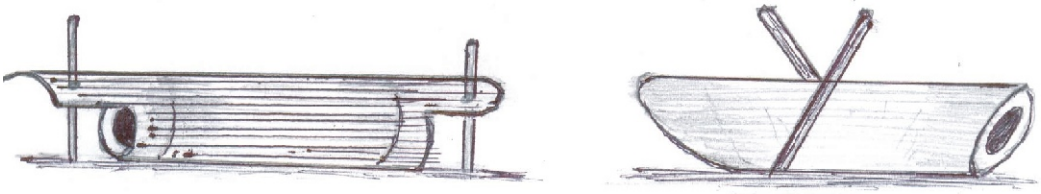
Placement of bait is one of the most important aspects for an effective chemical rodent control strategy. It involves several basic principles. It should be tried to cover largest possible area in one go. It should however, be ascertained that the rodent population consists of adults only who can consume bait material. The bait may be placed either in the burrows or in the bait containers/bait stations

***Burrow baiting* :** This method is advisable in field conditions where clear rodent burrows are visible. For this, all the existing burrow openings should invariably be plugged in the evening and next morning re-opened/active/ live burrows be treated with pre/poison baits. The treatment of only the active burrows saves the poison bait material, labour cost and time and is highly effective. In this method 8-10 g of poison bait (zinc phosphide) is rolled deep inside the active burrows to avoid any secondary hazards. To assess the control success the burrows are plugged again after 1-2 days of treatment with zinc phosphide or 10-15 days after bromadiolone baiting and reopened burrows are examined on the next day. The reduction in the number of active burrows in post treatment period indicates control success. In case of lesser bandicoot rats, *Bandicota bengalensis*, which normally keeps its burrows plugged from outside, the identification of live/active burrows is done by deplugging the burrows first and examining the re-plugged burrows next day.

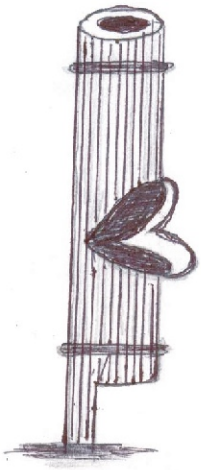
Use of bait stations

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

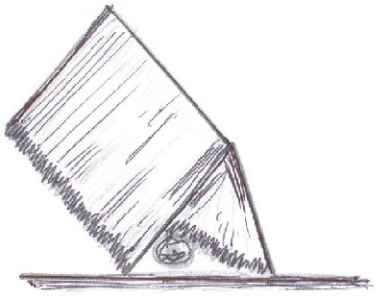
***(b) In field conditions* :** Several types of indigenous bait stations have been used in India for keeping the baits. The basic idea of selecting bait stations is that the bait should be easily accessible to the target species and should reduce the hazard to other animals and man. This will also protect the baits from rain and other weathering. Indigenously, procured items like mud channels, hollow bamboo pieces, broken pitchers, coconut shells etc. have been effectively utilized for this purpose. In North eastern hill regions bamboos are available in plenty and bait stations made from such indigenous materials can be effectively utilized (Fig. 26).



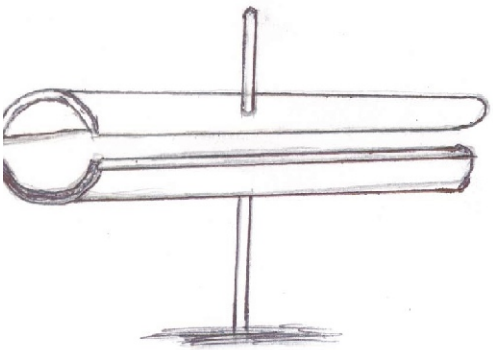
Bamboo Bait Stations (Horizontal Type)



Bamboo Bait Station (Vertical Type)



Hut Type



Banana Sheath Bait Station

PVC Pipe

Fig. 26. Bait stations

BURROW FUMIGATION

Aluminium phosphide, the most common fumigant is available in tablet and pellet forms however only pellet formulation is recommended for fumigation of rodent burrows. For fumigation, all the existing burrow openings are plugged with wet mud and two pellets of aluminium phosphide is to be inserted in the active burrows, which should also be plugged with mud to check the escape of lethal gas. All the nearby burrow openings need to be plugged invariably. The dead rodents, if observed outside are to be collected next day and disposed off. This fumigant is recommended only in case of severe rodent upsurge or out break. **It is never recommended for residential premises/indoor use**.

SAFETY PRECAUTIONS IN HANDLING RODENTICIDES

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

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

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

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

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

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

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

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

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

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

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

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

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

ANTIDOTES OF RODENTICIDES

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

Acute poisons (Zinc phosphide and Aluminum phosphide)

When ingested accidentally, severe gastroenteritis with nausea, and severe abdominal pain may result followed by cough and pulmonary oedema. Severe poisoning may result in failure of liver and kidney also. In case of poisoning through consumption of poison baits vomiting should immediately be induced by giving mustard emetic. When vomiting stops, give 6 gm of potassium permanganate dissolved in a glass of warm water. This oxidizes the phosphide to phosphates. After 10 minutes half a teaspoon full of copper sulphate dissolved in 250 ml of water should be administered. This will produce insoluble copper sulphide. After this, any purgative can be given and doctor be called immediately.

Anticoagulant poisons

In case of accidental consumption of such poisons, call the physician immediately. Vitamin K_1 administration and blood transfusion are recommended.

PLANNING PROCESS FOR RODENT MANAGEMENT IN FIELDS

The planning process for rodent pest management involves four component activities viz., situation analysis, control design, actual control operation and follow up evaluation. Depending on the situation analysis, appropriate action plan for control design is to be made. After its implementation periodic monitoring should follow it. The various steps involved are indicated below :

Step I: Situation Analysis

- Species of the area
- Position of infestation
- Condition of surrounding areas
- General layout and situation of cropping season
- Decision on control

While making situation analysis the available resources, control technology and human attitudes are to be precisely judged. Very often this situation analysis is not done. As a result most of the rodent control efforts are resulting in failure.

Step II: Control Design

- Type of control viz., trapping, baiting, biological etc.
- Hygiene & Proofing
- Rodenticide to be used
- Area to be controlled
- Time of control
- Staff requirement, farming community etc.

Step III: Control Preparation

- Make a plan of action
- Inform people involved
- Obtain equipment required
- Fix dates for various phases of control action
- Prepare rodenticide baits if necessary

Step IV: Rodent control

- Carry out control activity

Step V: Monitoring

- Check signs of activity
- Note areas which require further action
- Decide on further action and type of action
- Continue monitoring

In most cases, monitoring of rodent situation is not done after the application of poison baiting or using traps. This leads sometimes to transformation of rodent breeding from k-pattern to r-pattern, which ultimately results in increase in rodent problem than its reduction.

Step VI: Maintaining low rodent population density

- During cropping season control rodents at tillering stage
- Do not wait until the grain matures. By then rodent population will be very high and difficult to control
- Use acute poison like zinc phosphide, aluminium phosphide in case of serious rodent infestations only.
- Use anticoagulants such as bromadiolone, coumatetralyl etc. during low rodent density or normal situations.
- Integrate the application of acute poison baiting always with either fumigation or chronic poison baiting for maximum reduction of rodent population.
- Use bait stations in all the situations.

PREPARATION OF COMMUNITY FOR RODENT MANAGEMENT

This is the field where we are lacking the most. By education and training one can increase the knowledge and awareness of end users and also change the attitude of the local people for rodent management. Although, it is not so easy especially for older people, because of several socio-religious taboos attached with the rodents. In NEH region rodents are considered as delicacy and form a major component in the diet of local people. Therefore, we have to infuse in students and youths, the idea, that rodents are one of our greatest enemies and need to be dealt tactfully. For preparation of the community for rodent management work various media may be approached for their education, however, farmers trainings, field demonstrations etc. may also be arranged by Government departments, NGOs and/or voluntary agencies.

Two pronged strategy is urgently required for involving the common man to undertake rodent management practices on a larger scale viz., whole village/ community basis. First strategy should be to create a nucleus of trained personnel engaged in extension activities. This is most important, because there is paucity of trained manpower in this field. The trained official would then act as trainers for farmers and other end users. Rodent management technology is easy to operate, quick~ result oriented and cost effective. All the strata dealing with extension and education need to be invariably trained. This training may be divided into different levels:

Apex Level Trainings

It is a master trainers training programme, which should be imparted to key officials like of Departments of Agriculture, Horticulture, Health, Forests etc. Besides the rodent management techniques this training should emphasizes on management of transfer of technology, training required for the lower strata, man management and other human factor aspects for moulding the attitude of common people towards rodent control. The training should also cover the aspects on procurement of inputs like poisons, baits, traps etc. Attention of senior officials of concerned states/departments may also be brought to their notice for coverage of government lands, common property resources, railway tracks, roadsides etc. These lands are real breeding sites of rodents, hence, highest priority must be given to these sites for rodent management.

Middle Level Trainings

Those who have undergone training under the Apex Level Training should in turn organize training for supervisors and field level workers in their respective states and Departments and may take the help of the Directorate of Agriculture, State Agricultural Universities, ICAR Institutes, Krishi Vigyan Kendras, Save Grain Campaign officers and Pest Control Organisations.

Field Level Trainings

The trained nucleus units in the state would in turn impart training to voluntary agencies like Nehru Yuvak Kendras, Farmers Clubs, Yuvak Dal, Mahila Mandals etc. and to the students. This operational training may consist of the techniques on rodent management in crop fields, threshing floors, rural/urban residential premises, stores, godowns, etc., preparation and laying of poison baits handling and precautions to be taken and the first aid measures to be adopted.

Farmers education, training and demonstration

Education : If the enormous losses caused by rodents to our food and health in general and during mass bamboo flowering in particular, are brought to the notice of farmers and common man, at least thinking against rodents can be generated. This can be achieved if Radio and T.V. and print media are utilized on a larger scale through advertisements, interviews, talks etc. Once thinking against rodents is created, the programmes incorporating management technology may be popularized.

Training/demonstrations : Different government agencies like KVKs, ATCs, States Extension Departments, State Agril. Universities, ICAR Institutes organize regular training programmes for farmers. These training programmes must include rodent management as a major input. There are several other agencies working among farmers. These organizations may prove highly beneficial in creating awareness among farmers, if trainings are organized at their doorsteps. Rural youths and students may be trained and **"Rodent Control Squads"** should be formed at village levels. When these squads are trained rigorously, the media may be utilized to popularize the rodent control campaign on a whole village/ community basis.

TECHNICAL APPROACH FOR NEH REGION

The Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India worked out the technical approach for various action points for rodent management in the region in consultation with concerned technical officers of the Department of Agriculture of NE States. The approach as finalized is as under:

Survey of sporadic bamboo flowering areas

Joint survey teams drawn from the respective State Agriculture and Forest Departments may conduct surveys of bamboo flowering areas, especially of bamboos with a record of associated rodent outbreaks. One district survey may be completed in 15 days time by the local forest and Agriculture Department officials. Two such surveys may be undertaken during one year. Each district-wise survey team may have 4 officials for this additional specialized activity. The concerned District Agriculture Officer may monitor these operations. Chief Principal Conservator of Forests of each State may be associated for identifying the bamboo flowering pockets.

Surveillance of rodent incidence

Rodent pest monitoring and forewarning system assumes significance as the farmers are not familiar with the changing pest scenario in their fields and they remain ignorant until serious damages are caused. Fore warning would help farmers to take timely corrective measures. Once the pockets of bamboo flowering areas are identified in different districts, surveillance teams may be constituted with trained technical personnel. Nontechnical persons may not be assigned the surveillance work.

Awareness campaigns

All the members of the surveillance teams arc required to be trained in monitoring as well as control of rodents in jhum fields and homesteads in the bamboo flowering zones. Hence human resource development for monitoring rodent incidence may be undertaken to develop core group of master trainers. For field level lower extension functionaries at Block/Sub-Divisional Levels, peri-patric training by the Master Trainers of the respective States may be organized.

Programmes for farmers' training

It may be included at village and Block levels on rodent pest management of one-day duration by the trained officers of the State Department of Agriculture. Farmwomen may also be provided such training. Leaflets and video films on rodent pest management as per local situation may be produced for giving wide publicity.

Rodent pest management measures

a. Local traps are highly effective to kill the migrating rodents from forest areas to jhum fields. Hence they may be popularized. Twenty-five bamboo traps per hectare in jhum and WRC areas may be advocated to control emigrating rodents from forest

areas. The traps may be advocated for use in the boundaries of jhum/WRC areas to tackle effectively the immigrating rodents.

b. Rodenticide treatment may be planned with a provision of using safer anticoagulant rodenticide on unit hectare/homestead basis. These safer rodenticides include bromadiolone 'c' for jhum/WRC fields and coumatetralyl in homesteads for treating the infested areas. All precautions for avoiding any accidental or secondary poisoning are required to be taken. During severe infestations, zinc phosphide baiting may be resorted in fields with utmost caution.

c. Bounty payment system should be minimized as far as possible. Globally it is experienced that this system does not give tangible results on long range.

d. Evaluating the rodent control operations should be done at District and State level. At field level comparing the rodent infestation levels before control operation and after control operations will give the control success.

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Rodents are known to cause immense losses to various production systems world over. On an average, 5-10% losses are estimated in agriculture sector alone. The populations of certain species are reported to outbreak during gregarious flowering in bamboos,having a very long flowering cycle in North Eastern Hill regions of the country. All India Network Project on Rodent Control (Indian Council of Agricultural Research) has developed technologies for rodent pest management, which needs to be transferred to the end users. There is acute shortage of trained technical manpower in the country in general and that of Northeastern regions in particular. Since the NEH states are expected to face the rodent problem due to bamboo flowering within next two years, it was felt necessary to develop a nucleus of trained personnel in all the states. Keeping it in mind this technology bulletin has been brought out by AINP on Rodent Control, as a guide to the extension officials of State Departments.

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Authors