RODENT PEST MANAGEMENT

PRINCIPLES AND PRACTICES

By

ISHWAR PRAKASH

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JODHPUR

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FOREWORD

Rodents are unwelcome associates of mankind. They are scious pests of food, fodder and plantation crops and are carriers of a nuiber of diseases. Unlike swarms of devastating locusts, rodents hav not attracted public attention to the extent which is desired. Fortunzely, however, the Central Arid Zone Research Institute has been inv\ved in this problem since its inception and has assumed a leading rce in rodent research in India. The scientists at this Institute have alays based their ideology of controlling rodents on ecological principlesand have tackled the problem as a management practice rather than s an 'eradication' or control operation. In pursuance of this thinking, hey have studied the habits, behaviour, habitat selection and popultion and breeding cycles; side by side with investigations on poison baing, bait preferences and related aspects and thus have been able to evlve and standardise effective procedures of rodent pest management uder various ecological situations. The Institute is also deeply involvd in extending the results of these researches to the rural areas for the bne-fit of the masses. It has also arranged several training cours to educate plant protection personnel from all over the country in reent advances in the field.

Now that the National Programme for Rodent Pest Managerent has been launched, there is need for training a large number of peple at all levels and to involve the community as a whole in the efrt. Dr. Ishwar Prakash has prepared this monograph and it is hoped hat it will not only be of value to plant protection agencies but also tothe trainers, trainees and farmers who may be involved in the programme.

Central Arid Zone Research Institute,
Jodhpur.
May 1, 1976

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PREFACE

Rodents have always been with us, ever since primitive man became an agriculturist and are the most destructive of the vertebrate pests, probably only next to man. Rodents inflict incalculable losses to standing crops, to stored foodgrains and other commodities and to crops in the threshing yards. The farmers and, in fact, the people in general in this country have been tolerating these losses for rather too long. It is, therefore, in the fitness of things that the Indian Council of Agricultural Research has recently formulated the National Plan for Rodent Pest Management which should provide us the necessary impetus to fight a "war" against rodents systematically.

Rodent control is a tricky job as the operator has to tackle a variety of rodents living together in the rural as well as the urban environment. All species of rodents do not have similar habits and they occupy different micro-habitats apparently to minimise inter-specific competition. It is, therefore, necessary to evolve a strategy which should effectively control all the resident species of a particular area. This is a rather difficult preposition and to fulfil this requirement, a great deal of basic information pertaining to the behaviour, food and breeding habits, habitat selection, range of movements etc. of the species involved should be available with the control planner. Clearly, we need to know a good deal more than what we do now in order to achieve a reasonable degree of success.

In this monograph, an attempt has been made to briefly present the current status of our knowledge with regard to the habits of the rodents of economic importance and to discuss the principles and practices of rodent pest management under various situations. The precautions needed to be observed, and the antidotes to be used in case of accidents, have also been discussed in detail.

It is hoped that this monograph will be useful to rodent control operators at all levels in the country.

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May 1, 1976

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Animal Ecologist

RODENT PEST MANAGEMENT—PRINCIPLES AND PRACTICES

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INTRODUCTION

Since Vedic times, the Indian people realised the role played by the rodents as agricultural pests and as carriers of diseases. But inspite of this knowledge nothing substantial was done till recently to control this menace in our country. It is well known that in the tropical regions the turnover rate of rodents is much faster than in other biomes. The rodents are, therefore, able to maintain here a fairly high level of density in every habitat. Their superiority in adapting to almost all habitat conditions have made them man's enemy number one. Man has also inadvertently, or carelessly, been providing adequate shelter and nourishment to these creatures in crop fields, residential premises and in godowns, thereby helping them in their survival and multiplication. Our religious and social taboos have also assisted in the maintenance of rodent numbers at a high level. As a result, various rodent species have become serious pests at almost all stages of food production. They inflict losses to the standing crops and to foodgrains in the threshing yards, godowns and residential premises. The total loss to the nation due to rodent activity must be of great magnitude and it is obvious that we can ill afford to continue incurring this loss. Several field studies have clearly shown that the cost benefit ratio in rodent control operations ranges from 1:75 to 1:100.

It is gratifying that a National Plan for Rodent Pest Management has recently been launched. The programme has been formulated to be carried out in four stages, viz., : preparation of the community, training of personnel, the actual control operation and prophylactic strategy. In this monograph an attempt has been made to provide information on all these aspects of rodent pest management. It is expected to serve the Apex level trainers, the district and village level organisers, and the student and farmer squads with guidelines and operational instructions for rodent pest management both in rural and urban habitats.

RODENT DAMAGE

Foodgrains and other farm crops

Rodents damage standing crops, both kharif and rabi, almost at every stage of their vegetative growth. In the paddy fields in Uttar Pradesh (U.P.) and Madras, 7.1 to 21.5 per cent and 5.2 to 65.3 per cent of plant tillers were destroyed by rodents. This damage reduced the yield of paddy by upto 59.5 per cent and yield of straw by upto 45.7 per cent (Jotwani and Beri, 1968).

Damage to the groundnut crop recorded in Andhra Pradesh was 6 to 9 per cent at seeding stage, from 18.2 to 25.8 per cent at growth stage and from 4.1 to 7.6 per cent at maturity (Jotwani and Beri, 1968).

Rodent damage to wheat and barley crops at Kanpur during rabi season was found to be 11 per cent in both seeding and growth stages (Jotwani and Beri, 1968).

The sugarcane fields in U.P. suffer an average loss of Rs. 66.55 per hectare due to rodents; total damage exceeds Rs. 7.8 crores (Gupta *et al.*, 1968). In Punjab, Bindra and Sagar (1968) found that loss in yield of *gur* (molases, brown sugar) due to rodent damage averages about 200 kg/ha and in the lodged sugarcane crop at Rupar rat damage reached 575 kg/ha.

Rodents also attack coconut trees. More than 11 per cent of coconut palms were destroyed by rats in Andhra Pradesh (Krishnamurthy, 1967); the loss of nuts and the number of attacked trees was maximum (17.1 per cent) during the rainy and winter seasons. Kidavu Koya (1955) reported that the coconut yield in Laccadive islands was reduced by 50 per cent due to rodent damage.

In Rajasthan in 1970, *Gerbillus gleadowi* was a major pest of bajra crop and the intensity of destruction to sown seeds was so high that the crop in four districts had to be re-sown 3 or 4 times. In *rabi* crop, wheat and *sarson (Brassica campestris)* are likewise destroyed by rats to a great extent.

At harvest, the bajra *(Pennisetum typhoides)* cobs from the field are heaped in the backyards of huts in villages of the desert region. The

gerbils follow the cobs, dig tunnels unde them and feed upon the bajra grains leaving the cob near the burow openings. In one such village, some 40 gerbils were observed in 15 m×40 m area — a very high density of gerbil population.

Orchards and vegetable gardens arenot exempted from rodent attack. Rodents eat or spoil the fruits o gnaw at vegetable stems. Squirrels are a major pest of grapes, guva, blackberry, etc. *Tatera indica* also damages the vegetables. In Himachal Pradesh, serious damage to apple plantations by rodents as recently reported. The porcupine, *Hystrix indica* damages partiularly the tuberous crops, chiefly sweet-potato, potato, turnip, carrot antichoke etc.

Afforestation trees

Rodent damage to tree species, paticularly to saplings, is of two types : a) debarking, and b) compleely slicing the stem. The former type of damage has been observeon *Albizzia lebbek*, *Prosopis cineraria*, and *Acacia tortilis*. This activity s restricted to about half a metre above the ground surface but may ab extend to lateral branches. Usually the cortical cells of the stem are dbarked with a detrimental effect on tree growth but at times even th xylem vessels are injured causing the eventual death of the tree. Debarking activity has been observed in trees 3 to 4 years of age (Praksh, 1974).

Stems of *Prosopis juliflora* and *A. tortis* are also known to have been completely cut by rodents resulting inthe death of the trees, even when the latter were a few metres tall. Inthe sand dune fixation area of Udayramsar, 20 trees were damaged i about one month. This cutting activity by rodents occurs unde the soil surface. Similar damage was observed at Gadra Road in ar *A. tortilis* plantation and on *P. juliflora* in the Great Rann of Cutch

Grasses and Fodder crops

Whenever seeds of *Cenchrus setigerus*, *C. ciliaris* and *L. sindicus* are sown in grasslands to improve the foder quality for better animal production, rodents dig them up and feed n them almost to the roots of the fodder. The intake of grass seeds by*M. hurrianae* is much greater than that of the other desert rodents (rakash *et al.*, 1967). In the monsoon season, the rodents prefer to feed pon the unripe inflorescence

of grasses; unable to reach them, they gnaw the base of the plant. Recently, field rodents devastated some 40 acres of *L. sindicus* and 27 acres of *C. ciliaris*, *C. setigerus* and *L. sindicus* in an experimental pasture at Bikaner. At Maulasar, one of the range management and soil conservation paddocks of the Central Arid Zone Research Institute, during rainy season in 1965, the desert gerbil population was estimated at 477 per hectare. They fed upon fodder species which are grown for livestock causing immense loss in productivity. The palatability indices based on unconsumed plants found lying near gerbil burrow openings were 4.0, *C. ciliaris;* 3.7, *Aristida adscensionis*; 3.0, *E. ciliaris*; 2.7, *D. adscendens*; and 2.6 each for *Brachiaria ramosa* and *Tragus biflorus* (Prakash, 1969).

Gerbils thus clearly prefer grasses which are also relished by sheep and other livestock. The annual forage feed requirement of gerbils at the above density level is about 1,040 kg/ha compared with an annual forage production of this rangeland of only 1,210 kg/ha. At this rate, gerbils leave little, if any forage, for the livestock (Prakash, 1969).

During winter rodents feed chiefly on grass seeds but in summer they eat the rhizomes of the same grasses, partly because the seeds are in short supply and partly for the high water content of the rhizomes. In the rainy season the rodents feed upon leaves and flowers. This rotational feeding habit of rodents poses a real threat to natural pastures.

Soil conservation

The desert gerbil by its burrowing habit threatens conservation work. Its burrows are extensive and have no fixed pattern (Prakash, 1962; Fitzwater & Prakash, 1969; Barnett & Prakash, 1975). The burrow openings are scattered everywhere and as many as 14,000 have been counted in a plot of 100 m × 100 m. By tunnelling, it excavates fixed soil forming small mounds (about 1 kg.) near each burrow opening. At this rate, gerbils unearth about 17,000 kg. soil per hectare; the loose soil is blown away by strong winds increasing the areas of sandy wastes and barren land. In Shekhawati region, *Meriones hurrianae* excavated 61,500 kg/day/km^2 soil in cultivated field and 10,43,800 kg/day/km^2 in uncultivated field (Sharma & Joshi, 1975). This study further highlights the severity of soil erosion caused by rodents.

MAJOR RODENT PST SPECIES

According to the information avilable on the damage inflicted by rodents on food and fodder crops in hdia, about 10 rodent species are of major importance. A brief eological account of each is now presented :

1. Striped squirrel, *Funambulus pennanti* nd *F. palmarum*

The former species occurs in nrth and north-eastern India whereas the latter one inhabits souther region of the sub-continent. *F. pennanti* occurs usually in association ith man but also in wild populations throughout the range of its distrɔution. In towns squirrels are especially abundant in gardens and orhards. Squirrels are diurnal and arboreal in habit. In the desert rgion *F. pennanti* breeds from March to September (Purohit *et al.*, 196ł but most frequently during the March-April and July-September ɔeriods. Banerji (1955, 1957) reported that it breeds throughout the yar at Saharanpur. Litter size varies from 1 to 5 (Prakash, 1960; Puroit *et al.*, 1966, Seth & Prasad, 1969).

2. Indian Crested Porcupine, *Hystrix inica*

It is found throughout India and mostly in rocky habitats and surrounding regions. It is nocturnal ad lives in long tunnels which are dug in between broad crevices filled with soil. Nocturnal movements are wide ranging, and severe damge may be inflicted on crop fields, orchards and reforestation plɑntatɔns. The porcupine breeds all the year round and the litter size varies from 1-3, average being 1.45 (Prakash, 1971).

3. Indian Gerbil, *Tatera indica*

This gerbil is distributed throughot India. The subspecies *T. i. indica* is spread from the Rajasthan desert ɔ Bengal, Nepal terai, Madhya Pradesh and parts of Maharashtra. *T. i. cvieri* occurs in Nilgiris, Mysore, Madras and Bellary. *T. i. hardwickei* i found in Western Bombay, Coorg and parts of Mysore. The gerbils very adaptable and is found in most Indian habitats. A detailed stuy of its habitat selection has been made in the desert biome (Prakash*et al.*, 1971; Prakash & Rana, 1970). It is nocturnal and inhabits burɔws of comparatively simple

pattern. Its food consists of grasses, parts of standing crops and insects, (Prakash, 1962). Intensive work has been done on the ecology and behaviour of this rodent in this laboratory. It breeds throughout the year (Prakash, 1962; Jain, 1970; Prakash *et al.*, 1971) and the litter size varies from 1-9 (average 4.78). In South India, *T. i. hardwickei* shows a bimodal pattern of reproduction (Chandrahas, *pers. comm.*) and *T. i. cuvieri* is a seasonal breeder (from September to early March) with litter size varying from 1-10 (Prasad, 1954, 1961). Gestation period is 28-30 days (Prakash *et al.*, 1971). The young are weaned after 30 days and attain maturity in about 16 weeks.

4. Indian Desert Gerbil, *Meriones hurrianae*

This gerbil inhabits the arid and semi-arid regions of the Punjab, Haryana, Delhi, Rajasthan and Gujarat States. In the Rajasthan desert it is the most common species. It inhabits a variety of habitats but prefers the hummocky terrain over sandy plains (Prakash *et al.*, 1971; Prakash & Rana, 1973). It is diurnal and digs extensive burrows (Fitzwater and Prakash, 1969). The population of the desert gerbil varies markedly from place to place and year to year; the average annual numbers vary from 24 to 510 (Prakash *et al.*, 1971). Although *Meriones* occurs largely in grasslands, it is also found in the *kharif* crop fields. Its debarking activity is a menace to the re-forestation programme. No grassland improvement programme can be successful without gerbil control. Merion gerbil breeds all the year round (Prakash, 1964; Kaul and Ramaswamy, 1969) but the incidence of pregnancy increases during February-March and July-September. Litter size varies from 1-9 (av. 4.4). The gestation period averages to 30 days.

5. House Rat, *Rattus rattus*

About 16 sub-species have been recognised from the Indian sub-continent but probably *R. r. rufescens* is the most important one from an economic point of view. It is essentially a house rat but populations are also found in fields particularly in coconut plantations where it causes severe damage. It is nocturnal but at high densities some rats may be active during the day. Populations of house rats are usually more dense in the villages than in towns because of the greater availability of harbourage and the poor sanitation. Krishnamurthy *et al* (1967) estimated rat density in U.P. villages at 9.8 per house or 1.29 per person. In Gujarat State, the commensal rat population was 3.9

per house and 1.07 per person (Chaturved *pers. comm*) The house rat breeds throughout the year; litter varies fron 1 to 10 (av. 5.41).

6. Soft-furred field-rat, *Rattus meltada*

The sub-species *R. m. pallidior* occui in northern and eastern India, from Rajasthan to Nepal and froi the Punjab to Gujarat, whereas *R. m. meltada* inhabits Bihar, Madya Pradesh and southern India. This field rat usually occurs in irrigted fields but is also found in pastures (Prakash *et al.*, 1971; Prakash *etil.*, 1971; Prakash & Rana, 1972). It is nocturnal and lives in simple burrows. In the Rajasthan desert, it breeds only from March to Septerber (Prakash, 1971) but in South India it litters throughout the yea (Chandrahas, *pers. comm.*). Litter size varies from 2-10.

7. House Mouse, *Mus musculus*

In India, three sub-species of this speies are of economic importance. *M. m. bactrianus* is distributed in ie north-east India, *M. m. homourus* is spread from Kashmir, Kumaon, Madhya Pradesh to West Bengal, Assam, Sikkim and Nepal. In Sout it has been reported from Nilgiris and Eastern Ghats. *M. m. tytleri* i found in Punjab, Gujarat, Maharashtra, Himachal and parts of northeastern India. It inhabits two types of habitats, indoor and in th crop fields. It is fairly common in sugarcane fields along with oier species of *Mus*. It is nocturnal and fossorial in habit. Litterize is 4-8 (av. 5.4) (Mann, 1969). In certain parts of India, the nmber of field mice, *Mus platythrix* and *Mus cervicolor* is fairly dense nd they damage standing crops.

8. Short-tailed "Mole Rat", *Nesokia indica*

It occurs in the Punjab, Haryana, ajasthan, Delhi and Uttar Pradesh. It inhabits cultivated fields but my also occur in areas under natural vegetation near crop fields. In the rigated fields, it prefers to burrow in the bunds. It is specially abundnt in sugarcane fields. It is a nocturnal rodent and lives in burrows. The characteristic features of its burrow are the small "mole hills" f excavated soil. Little is known about this rodent.

9. Lesser Bandicoot Rat, *Bandicota bengalens*

It is found throughout India, excepi the western desert. It is nocturnal and fossorial. It occupies two typ of habitats, crop fields

and the godowns. In the fields, it moves by distinct runways amidst dense vegetation. It prefers wheat and rice crops. It hoards large amount of food in its burrows; upto 450 kg per hectare has been reported. It is also a serious pest of stored foodgrains in Uttar Pradesh, Bengal and parts of South India. Spillet (1968) estimated that in one godown in Calcutta, the foodgrain losses due to bandicoot rats annually exceeded 4000 kg. It breeds all the year round and a maximum of 15 young ones have been reported from a single litter.

10. Large Bandicoot Rat, *Bandicota indica*

It occurs in whole of India, except the arid region. It lives near human habitation and is also found in cultivated tracts but is most common in the outskirts of houses, backyards and gardens. It is not as common as *Rattus rattus*. In addition to food crops and foodgrains, it damages *kuchcha* houses by its nocturnal tunnelling. Litter size is 10-12. Little is known about this rodent. A field key to common rodents is appended (Appendix 1).

SOME BASICS OF RODENT CONTROL

For an effective and sustained control system, merely knowing the "pest" and the "poison" is not at all sufficient. Certain principles must be strictly followed. One of the most important factors in any control operation is its cost-worthiness; which method will be the cheapest and most effective in a given area for a given species. The answer depends largely on an accurate estimate of losses, on the size of the rodent population and on the magnitude of reduction in their population after a control operation. The assessment of the number of persons employed for rodent control in relation to economical return must also be considered. In outbreak of severe devastation of crops caused by rodents it might be justified to engage a large labour force, for a short period on an assumption that later, when pests had been greatly reduced fewer men could be employed for maintenance work. In any massive control measure manpower to be used should be properly assessed.

The other important principle is the knowledge about the biology of pest species, an essential for efficient control. Simple observations

of the daily activity and authentic knowledgeof their feeding rhythm can explicitly enhance the control efficieny. The diurnal rodents usually observe peak feeding time early in he morning whereas the nocturnal ones have it soon after dusk. Wis this information we can time our baiting schedule accordingly. Similarly the knowledge of breeding periodicity of a species will help to me the control operation during the year. We can greatly reduce te cost of labour, baiting material and poison if we know the range of iovements of the rodents. Such examples can be multiplied and some c them are explained elsewhere in the manual. It is, important to :cognise rodent control as an ecological operation since it is the regulatin of populations and not the destruction of individuals.

It is also important to time the contro operation to achieve the most fruitful results. I shall explain this rinciple of rodent control by citing an example. Studies on the habi and behaviour of field rodents have helped in arriving at a decisn about this important aspect of rodent control which has not been itherto considered in our country. The breeding rate of most field rodents is at a minimum during the summer months and in the month of December. Studies on their population dynamics indicate that lowest numbers occur during May and June. Analysis of their food habitspoints out that acceptability of baits is maximum during summer monhs when there is paucity of natural food. These results led us to pctulate that summer is the most appropriate season when large scalerodent control should be taken up effectively. Incidentally, the farmr is also comparatively free during the hot months to take up thiswork. If the job is done precisely, the need for follow up programmewill arise only during the next summer; studies at the Institute hav shown that the rate of reinfestation by rodents is slow. But it willalways depend upon the area in which the rodent control operatin has been taken up. If rodents are controlled on a district level, .e. in a large area, the reinfestation will be slow but if it is carried ut only in one hectare or so, immigration of rodents from surrounding ireas will result in rapid reinfestation.

THE CONTROL OPERATION

The rodent control operation should be planned to cover as large an area as possible. If the operation is carried out in a few hectares of crop fields or in a small group of houses, rodents from the infested surrounding region will re-infest the cleared area very quickly; in a large area, however, the problem of reinfestation will be delayed and the time until follow-up action is needed will also be increased.

Having arrived at a decision about the control operation timing (incidentally, if there is an outbreak of rodent population or in case of a restricted necessity one should not wait for the proper time to conduct the operation), one should plan the operation carefully; an estimate should be prepared of the requirements, baits, additives, poison(s), bait containers, traps, the man power required and the supervisory staff. All the items should be acquired before initiating the operation.

Another very important factor, often over-looked, is to secure close co-operation of the people of the area. The inhabitants should be fully informed by talks, films, posters about the need and advantages of the rodent control operations. This will result in benefits in two ways. People will co-operate fully and they will be aware of the happenings; the chances of any accident with poisons will thus be reduced. Help should always be taken from V.L.W.'s and Panchayats of the region. After a useful training, they should be made organisers of the control operation.

If the control operation is in a village or a town, a map of the area will be of great use. The workers should be divided in parties and each should be designated a particular area and day to day work should be fully explained to them. Even for field operation, the work should be assigned to every party and explained fully with the aid of a map. If the workers know their work of the day before they start, it will result in much more efficient control work.

In residential houses in rural or urban surroundings one man (or two if required) should enter the house and survey it for obvious signs of rodents, find the places frequently visited by them, and then place sufficient bait in suitable containers at these points. On the

second day, a quick look will give an indication of bait consumed and it should be replenished in quantities which should be sufficient for 3-4 days. Then there is no need to revisit the house for further baiting until the sixth day. The inhabitants should be asked to deposit dead rats or mice at one place in the village. Arrangements should be made to bury them deep so that dogs and other wild animals cannot dig them out. All necessary precautions should be taken, as explained later, particularly in livestock sheds.

In the fields as well, distribution of work among the parties increases efficiency and minimises the amount of confusion when a large number of workers are assembled together. The number of persons required per day should be judged well in advance. The workers should stand in a line at an interval of one metre or so at one side of the field and should proceed towards the opposite side putting baits in the freshly opened burrows. If, however, baits are placed in containers at a regular interval of 10 or 15 m fewer people may be employed as the baiting continues.

Whether the rodent control is undertaken in the field, residential buildings, livestock pens, godowns or ware-houses and by any of the methods described, a residual population of rodents survive either by not taking lethal dosages of the poison, by refusing the poison-bait altogether, or as a result of the unavailability of poison-bait. This is the population about which we should be most concerned as the reinfestation will depend on this and on immigration. If the control operation is precisely done, the residual population will be of low density; after a haphazard operation, however, many rodents may still be present.

When the control operation is finally over, it is essential that a follow-up programme continues. With the present information available about the Indian species of rodents, it is difficult to state the interval at which control operation should be repeated. But it would be worthwhile to keep a watch and to repeat it *at least* at six monthly intervals. It is imperative to emphasize, however, that the success of control operation will depend solely on improvement in sanitation condition and rat proofing in houses, godowns and warehouses. Clearance of rodent harbourages and improvements in storage facilities must be given equal importance with the control programme itself.

Crop fields and threshing floors

An important aspect in the control of rodents that is often overlooked is the fact that, in the field one encounters mixed population of rodent species. Therefore, control programmes have to be of a broad spectrum to cover all known rodent species. Seldom is a population of a single species found in fields. Control operations on a mixed population of several species often eliminate the dominant and mobile rodents with poison bait but the smaller rodents with restricted range of movement generally survive in appreciable numbers. The less mobile species then reproduce unchecked and soon become predominant. Poison-baiting, therefore, requires a thorough knowledge of the habits of all rodent species.

For a mixed population of rodents, the selection of bait is also a very important factor for effective control. The medium for poisoning should be selected to be acceptable to all rodent species. This should be pre-tested. Field rodents possess individual tastes and unless we take this characteristic into account, poison baits may be ineffective. The proportion of rodenticides should be carefully determined for various rodent species. The mixing of baits can be effectively carried out with the help of a seed dresser; thorough mixing is essential. A rough calculation of rodenticide requirement is shown in Table 1.

Table 1. Calculation of rodenticide requirement for crop fields.

Approximate No. of rodents	20/hectare
Approximate No. of burrows baited	30/hectare
Zinc phosphide required	0.12 g/burrow opening × 30 = 3.6 g/hectare
Out of 20 rodents 70% are killed	30% remain = 6 left
Requirements Zinc phosphide	360 g/100 hectare
Aluminium phosphide	900 g/100 hectare
Antidote	According to the need

As far as possible, rodent control operations should be taken up before the sowing of the crops. The active burrows are to be surveyed and pre-baiting (cereal flour or cracked grains 97 parts and vegetable oil 3 parts in the form of 1 gram ball or lump, 6 g. per active burrow opening) done on the first and third day. On the fifth day,

2 per cent zinc phosphide is added and he baits distributed. This operation will take care of 70 to 80 per ent population of the field rodents. The residual population cannot e tackled by zinc phosphide poisoning as most of the rodent species develop poison and bait shyness after a single exposure to this toic chemical. The residual population should be controlled by the fmigation of burrows. On the sixth or seventh day all burrow oenings are closed. On the eighth day, in those burrows reopened aiminium phosphide tablets are put, @ 1.5 g per active burrow opaing. This will control the residual population of rodents (Appendi 2). This operation must be taken up at the beginning of Kharif ad Rabi seasons.

Residential premises and Godowns

On the first day the volunteers will cllect 1 kg food material from each household representing the bait reqirement for field as well as households which cannot contribute it. They will visit individual houses in village and predetermine the laces where baits are to be placed. An assessment of total and dai/ requirement of bait, the poison (Table 2) and the manpower reqired should also be made. In order to prepare the bait material, te collected cereals will be crushed and 5 per cent master mix (0.5%) oncentrate of anti-coagulant (Warfarin) will be mixed and kept reay for distribution. On the second day the bait will be distributec in suitable containers like broken pitcher, mud channel, coconut shlls, bamboo etc. In each house, baits will be placed at 2-4 point with about 300 g bait per house and baiting should continue for thre weeks (Appendix 3). The dead rats will be collected and buried This operation must be repeated once each six months to keep villge comparatively rodent free.

Table 2. Calculation of rodenticide requirment for rural households.

Anticoagulant poison required	1 g/house
One village	33 houses × 17 g = 5950 g = 6 kg
One CD Block	at 110 villages × 6 kg = 660 kg
Antidote	Acording to the need

This method will bring down the hose rat, *Rattus rattus*, population to a very low level but some hous mouse, *Mus musculus* will

survive for which regular trapping should be carried out by the villagers.

Placement of Baits

Placement of baits involves several basic principles. It should be in a manner that largest numbers of the rodents if possible all, should have within their reach one or two baiting centres. It does not, however, suggest that if in an area, there are 100 rats, hundred or one hundred fifty baiting stations should be placed. The number of baiting centres and the quantity of baits required at each should be adequately assessed by the operator based on the knowledge of the habits and behaviour of the test species.

In a grain store, or in houses in villages, baits should be placed at places most frequented by the rodents. This is especially important when two or more rodent species occur together. In the villages, the range of movements of *Mus musculus* and *Rattus rattus* do not usually overlap. Under such circumstance bait placement should be done in a manner that both the species can feed upon it. Usually, in control operations in rural as well as urban areas, the majority of *R. rattus* are eliminated leaving behind populations of *M. musculus* almost untouched. These reproduce quickly in an environment of surplus food and without competition from *R. rattus*. *Mus musculus* usually live under boxes, almirahs, in fuel wood stacks and often under clothes. If baiting is carried out keeping *Mus musculus* movement in mind, there is no reason why both the species cannot be knocked out in a single operation. What usually happens is that due to apparently visible signs left by *R. rattus* bait placement is carried out only in its movement ranges.

Similar situations are found in field as well. In the Punjab, *Rattus meltada pallidior*, *Tatera indica* and *Bandicota* live together. In western Rajasthan *Meriones hurrianae*, *Gerbillus gleadowi* and *Tatera indica* live side by side. In southern parts of Rajasthan, *Rattus meltada* is found along with *Tatera indica* and *Golunda ellioti* (Table 3 & 4). Although they could be trapped in a single trap line in a single habitat, yet they occupy slightly different microhabitats. *Tatera indica* is found in open sandy patches, *Rattus meltada* in crop fields and in vegetated parts of the land, whereas *Golunda ellioti* moves on set paths under grass and bush cover. By giving these

examples, we want to stress on the point iat even in a single habitat, the rodent baiting should be planned in acordance with the habits of the various rodent species. Certain rodent respond to slight habitat changes; a newly cleared patch of land wi arouse their interest. Thus if a 6 cm x 6 cm earth is scraped and bits placed there, this may attract many rodents. As has been discused previously, the study of rodent movements may not only increas the efficiency in uptake of baits but may also reduce the cost of baitig.

Table 3. Predominant rodent species in croplands in various States in India.

States	Predominnt rodent species
Andhra Pradesh	*Bandicota bengalensis—Tatera indica—Rattus meltada—Mus* spp.
Assam	Bamboo rats ?
Bihar	*Bandicota bengalensis—Tatera indica*
Gujarat	*Meriones hurrianae—Tatera indica—Rattus meltada*
Haryana	*Rattus meltada—Nesokia indica—Tatera indica*
Himachal Pradesh	*Rattus rattus—Rattus ratides*
Jammu & Kashmir	? ?
Karnataka	*Tatera indica—Bandicota bengalensis—Rattus meltada—Mus platythrix*
Kerala	? ?
Madhya Pradesh	*Tatera indica—Bandicota bengalensis—Rattus meltada*
Maharashtra	*Bandicota bengalensis—Mus* spp.
Manipur, Meghalaya, Nagaland	*Bandicota bengalensis—Rttus r. bullocki*
Orissa	*Bandicota bengalensis—Rttus meltada—Mus* spp.
Punjab	*Tatera indica—Rattus meltada—Nesokia indica—Mus* spp.
Rajasthan	*Meriones hurrianae—Tatera indica—Rattus meltada*
Sikkim	? ?
Tamil Nadu	*Tatera indica—Rattus meltada—Mus* spp.
Tripura	? ?
Uttar Pradesh	*Rattus meltada—Tatera indica—Bandicota bengalensis—Mus* spp.
West Bengal	*Bandicota bengalensis—Mus* spp.

TABLE 4. Predominant rodent pests associated with the major agricultural crops in India.

Important crops	Predominant rodent pests
A. KHARIF CROPS	
Pearl Millet, Sorghum, Maize	*Meriones hurrianae, Tatera indica*
Rice	*Bandicota bengalensis, Rattus meltada*
Ragi	*R. meltada, T. indica, M.* spp.*
Groundnut	*Mus musculus, Mus booduga, Rattus meltada*
Cotton	*Meriones hurrianae, Rattus meltada*
Oilseeds	*Tatera indica, R. meltada, M. hurrianae*
Pulses	*Mus* spp., *R. meltada, T. indica*
B. RABI CROPS	
Wheat, Barley, Gram & Mustard	*Tatera indica, Rattus meltada, Bandicota bengalensis, Nesokia indica, Mus booduga*
C. MISCELLANEOUS CROPS	
Tuber crops	*Hystrix indica, M. musculus*
Vegetables	*Tatera indica, R. meltada, Mus* spp., *Funambulus pennanti, F. palmarum, Hystrix indica*
Orchards	*Funambulus pennanti, F. palmarum, T. indica, Nesokia indica, Hystrix indica*
Coconut	*Rattus rattus, Tatera indica*

**Mus musculus, Mus booduga, Mus platythrix* and *Mus cervicolor*

Several types of indigenous bait containers have been used in India and elsewhere for keeping the baits. The basic idea in selecting bait containers should be that the bait should be freely accessible to target species, and they should reduce hazards to other animals and man. Simple improvisations can protect the baits from other animals and from rain water and other weatherings. We are, therefore, not recommending any particular types of bait boxes. Indigenously procured items like mud channels, hollow bamboo pieces, broken pitchers, coconut shells can be well utilised for the purpose.

In the fields, however, baiting should be done nearer the active burrow openings, near the rodent runways, on the bunds and in mud-thorn clad fencings. In heavily infested fields baits can be scattered in small heaps or even be broadcasted. This should depend on the judgement of the local operator in a way to make them accessible to the majority of rodent population, side by side minimising hazards for non-target species.

PRECAUTIONS

Rodenticides are dangerous for men, livestock and the natural fauna. It is of utmost importance that scrupulous care is taken in storing them, handling them and while laying poison-baits in residential surroundings as well as in the field.

The poisons should be stored in a steel cupboard and its key should be kept in safe custody. After use, the rodenticides should not be left carelessly. While taking out rodenticides from cans, it should be ensured that its fine dust is not filtered and inhaled. After weighing, the pan of the balance should be thoroughly cleaned. If a can is emptied, it should be smashed and buried deep in the ground.

Mixing of poisons should be done in well ventilated rooms so that question of gas being released by some poisons (Zinc phosphide, Aluminium phosphide) does not accumulate in lethal concentration for the operator and others. It is probably best to mix the poison with the bait in mixing drums if large quantities of the poison-baits are to be prepared. While mixing the baits and handling poisons, one should always wear gloves and mask.

While distributing poison-baits in the houses and fields, ensure that all the inhabitants are aware of the dangers and the parents should especially take care that children do not touch the baits. The baits should also be protected from cats, dogs and livestock, particularly the goat which is very exploratory in behaviour. Attempts should be done to conceal the poison baits as far as possible in cheaply made bait boxes, in earthen channels. Bait not used at the end of a control campaign should be collected up and incinerated or deeply buried.

In the fields, the poison baits can be protected from birds, livestock and other non-target species by putting them 6-8 cm inside the burrows. Moreover, the rodents find the poisoned bait before they

reach their natural food supply or the baits placed near the burrow openings.

It is of great importance that no worker distributing poison baits should have cuts on his fingers or hands. The poison can enter the body quickly through these bruises. After handling the poison and the baits, the hands should be scrupulously washed with soap or detergent. The nails should be cleaned with a brush.

Fumigation should not be, as a rule, tried in residential buildings. In the fields if cyanogas powder is used, one should face towards the wind direction, not opposite it. This will keep away the leaking gas from the operator. If aluminium phosphide is used, keep it away from fire or lit cigarettes as it is highly inflammable. Do not handle the tablets; use an applicator or a long tube to insert them in the burrow openings.

After a control operation, dead rodents lying on the surface should be picked and disposed off adequately in an incinerator or by burying them deep into the soil. This will safeguard the predatory birds and animals from secondary poisoning.

In residential buildings, the fleas, flying off from the dead rodents should be tackled by either dusting or spraying an insecticide.

RODENTICIDES, FIRST AID AND ANTIDOTES

Zinc Phosphide and Aluminium Phosphide

Zinc phosphide is the most widely used rodenticide in India, and probably throughout the world. It is a greyish black powder, slightly soluble in alkalis and oils but is insoluble in alcohol and water. The toxic action of the compound is due to the evolution of phosphine gas and not from the zinc molecule. It emits an odour of phosphine. The compound readily breaks down in the presence of dilute acids but is fairly stable in air, water and food materials which are not acidic in character. When it is ingested by animals the acidic medium of the stomach activates the release of phosphine gas causing injury to kidneys and liver and paralysing the heart. The heart failure is probably caused due to pulmonary hyperemia and oedema under ordinarily dry

conditions. Zinc phosphide baits can retain effective toxicity for 20-25 days but in moist environment, the poison baits deteriorate quickly. Exposure of the baits to heavy rains will reduce the toxicity considerably. It is fairly hazardous to human beings and to domestic animals, particularly poultry. It should not be freely distributed to inexperienced villagers and should be, as far as possible, handled by trained personnel. While mixing the poison with the bait, phosphine, being emitted from the toxicant, can be inhaled. The phosphine inhaled into the lungs has also been found to be very dangerous. It is, therefore, essential that poison should be handled in well ventilated room with utmost care. The active ingredient in Aluminium phosphide, available in tablets and used for fumigation of burrows in field is also the phosphine gas.

In case of poisoning through inhalation or accidental consumption of poison-baits, swift action should be taken. Mustard emetic should be immediately administered to induce vomiting. When the vomiting stops, give 6 gm potassium permanganate dissolved in glass of warm water. This oxidises the phosphide to phosphate. After ten minutes half a teaspoonful of copper sulphate dissolved in about 250 cc of water should be administered. This will produce insoluble copper sulphide. After that give a purgative—one tablespoonful of epsom salt in water. Call the doctor immediately.

Anti-Coagulant Rodenticides

These are the multi-dose poisons. Some of them are derived from coumarinic acid which occurs in many plants and others are indandiones. These differ from the inorganic poisons in that a given quantity of the chemical is much more potent if taken over a few days than as an individual dose. The action of anticoagulants affects two of the body mechanisms, (a) causes haemorrhage in the body and (b) prevents blood clotting by inhibiting of pro-thrombin formation. Thus the animals suffer a total internal haemorrhage and show increasing weakness due to loss of blood.

In case of accidental consumption of this poison, call the physician immediately. Vitamin K administration and blood transfusion are recommended.

HABITAT ALTERATION AND RODENT PROOFING

In the fields, the number of rodents can be effectively reduced by habitat alteration. Keith *et al* (1959) and Cumings (1962) found that upto 90 per cent field rodents were removed due to weed control in the fields. The rodents major food was dependent upon forbs and other weeds and when these were removed, the rodent populations were automatically controlled due to reduction of the carrying capacity of the land.

In our agricultural fields, a large number of rodents inhabit the bunds and the mud fences covered with thorns. If the height of bunds is reduced and the fences replaced by *Opuntia* plantings, rodent numbers may be reduced due to lack of sites for shelter. Field experiments on such suitable habitat alteration practices should be carried out to study this aspect of rodent control.

Often growing a crop which is left vulnerable to field rodents, around the main cash crop, pays dividends. For example, if 20-30 metres strip of an unpalatable crop like *guar (Cyamopsis tetragonoloba)* or that of an unpalatable grass sown around the wheat crop, may act as an impenetrable barrier to the immigrating rodents, and the main cash crop will be saved from rodent pests. Fitzwater and Prakash (1973) suggested planting of varieties of grains difficult to husk, changing harvesting practices so that grains are not left piled in the fields to dry, and abandonment of cropping in areas that are most susceptible to rodent damage, as means to cut down the losses.

One of the most important aspects of rodent control, particularly in the rural and urban areas, is reduction of harbourage spots for rodents. It is not uncommon to see refuse dumps permanently stationed without a routine programme for their removal and quick disposal. Such habitats are ideal for the maintenance and propagation of rodent populations. If these are removed and sanitary conditions improved, the rodent numbers will be invariably reduced.

Rodent proofing is one of the most important factors of their management. This is probably a permanent form of excluding them out of residential premises, shops, hotels, warehouses and foodgrain godowns. If rodents can be kept away from food, it will be difficult

for them to survive. Rodent exclusion can be easily achieved in residential buildings without incurring lot of expenditure. All the cracks in the walls should be properly sealed. The drains opening outside should be fitted with a wire mesh so that rodents cannot enter through them. 15 cm broad metal strip should be fixed at the bottom of wooden doors so that rodents are unable to gnaw through them. Besides, food material should be kept in rodent proof containers and grains should be stored in metal or cement bins. Details of the methods of rodent proofing have been further explained by Fitzwater and Prakash (1973) and Barnett and Prakash (1975).

PUBLIC UNDERSTANDING AND EDUCATION

The control of rodents can only be successfully done with the close cooperation and understanding of the public. The organisers of this work should initially spend much time in organising lectures (in local language) supplemented by films on the advantages of rodent-free living and on actual rodent control work. Such education through good films leave a better impression on the public than only lectures or talks. Public can also be educated by short pamphlets which should be profusely illustrated, showing damages, and spread of diseases through rodents. Television and radio are also very suitable media for this work and fullest cooperation from the organisations should be sought by the control organisers. In every state and in every block, one village should be made "rat-free" for demonstration purposes. By a multichannel propaganda against the rodents, the people will become aware of the problem and will be able to overcome their religious and sentimental taboos and the public will extend full cooperation after a good understanding of the advantages of the rodent control (Appendix 4).

Success cannot be expected unless there is a good administrative set up for undertaking this work in a block or in a state as a whole. It is of great importance to have a proper and permanent staff for Rodent Control at every level.

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FIELD KEY FOR THE IDENTIFICATION OF PREDOMINANT RODENTS OF ECONOMIC IMPORTANCE

1 (2) Quills present, almost on the entire body—*Hystrix indica*
2 (1) Quills absent
3 (4) Tail bushy throughout, heavily furred—*Funambulus pennanti*
4 (3) Tail not bushy throughout
5 (8) A hairy tassel present on the tip of the tail
6 (5) Dorsal colour buffish, large—*Tatera indica*
7 (5) Dorsal colour sandy, mixed with grey medium—*Meriones hurrianae*
8 (5) A hairy tassel on the tip of the tail absent
9 (12) Tail longer than head and body
10 (11) Head and body more than 100 mm—*Rattus rattus*
11 (10) Head and body less than 100 mm—*Mus musculus*
12 (9) Tail usually shorter than or equal to head and body
13 (14) Head and body usually more than 200 mm—*Bandicota indica*
14 (13) Head and body usually less than 200 mm
15 (14) Tail about 70% of head and body, mammae 10—*Nesokia indica*
16 (14) Tail about 75% of length of head and body—mammae 12-18—*Bandicota bengalensis*
17 (14) Tail about 90% of head and body—mammae 8—*Rattus meltada*
18 (13 & 14) Head and body less than 100 mm
19 (18) Size large, occipitonasal length 23 mm and above—*Mus platythrix*
20 (11) Size medium, occipitonasal length 20-23 mm—*Mus cervicolor*
21 (18) Size small, occipitonasal length less than 20 mm—*Mus booduga*

CONTROL OPERATION—1

CROP FIELDS AND THRESHING FLOORS

Day 0	Survey of rodent burrow openings
	Estimation of man power and other requirements
	Formation of Operational Squads
	Distribution of work
Day 1	Start pre-baiting
Day 3	Pre-baiting
Day 5	Mix poison, Poison-baiting
Day 7	Close burrow openings
Day 8	Fumigation of burrows
Day 9 & 10	Harbourage removal and sanitation

CONTROL OPERATION—2

RESIDENTIAL PREMISES AND GODOWNS

Day 0	Study of map of operational area
	Survey houses, back yards, etc.
	Estimation of man power and other requirements
	Formation of Operational Squads
	Distribution and allotment of work
Day 1	Mix poison in cracked foodgrains
	Distribution of bait stations, 2 to 3 per house
Day 2	Assess consumption, replenish for 5-6 days
Day 7,10,13,16,20	Collect and dispose dead rodents
	Replenish bait station for 5-6 days
	Skin larger rodents for by-product utilisation
Day 21-22	Harbourage removal, sanitation and rodent proofing, storing of foodgrains in rodent proof structures

Operational Plan for Rodent Pest Management

TRAINING

Films SITE All India Radio Extension Education

PREPARATION OF COMMUNITY

Trained student squads
and
Village youth groups

CONTROL OPERATION

RODENT PROOFING
and
SANITATION

SUSTENANCE STRATEGY