

Rodent management in arid regions

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More than 2,000 species of the rodents are reported from across the globe, however, only 103 species belonging to 46 genera are reported from India and of that only a dozen species are regarded as pests of agriculture. Rodents cause immense losses to the crops, fodder grasses and forestry plantations in arid regions. In hot arid regions, only 7 to 8 species may be considered as pests with a species complex of 3 to 4 species reported to inflict economic damage in any particular cropping system/habitat. Non-chemical control methods such as trapping, sanitation, physical exclusion of rodents, use of natural enemies etc. can not achieve acceptable long-term results, therefore, the uses of rodenticides is found to be the cheapest and the most feasible and humane method to control pest rodents. Zinc phosphide is most widely used rodenticide in India and is recommended at 2 to 2.5% concentration in cereal baits. Major limitation in its frequent use is its high toxicity to non-target species and development of bait shyness/poison aversion in the target species after sub-lethal consumption. For controlling the residual rodents surviving after zinc phosphide treatment, another rodenticide viz., aluminium phosphide (a fumigant) or second-generation anticoagulant rodenticide (bromadiolone 0.005%) was advocated.

Key words: Arid regions, Management, Pests, Rodenticides, Rodent

RODENTS belong to the largest order Rodentia of class Mammalia and globally constitute about 43% of the total mammalia. The order includes animals commonly referred as porcupines, squirrels, voles, marmots, gerbils, mole rats, rats, mice etc. Many of rodent species are regarded as vectors of several zoonotic diseases to human beings and livestock. As long as the history goes back, rodents had a bad reputation as human beings enemy. Old Indian scriptures, dating back to 5 millennia, mentioned of rodents. One of the *shloka* in Atharveda (60.50.1, 3000 BC) reads as, “O Ashwin, kill the burrowing rodents which devastate our food grains. Cut their heads, break their necks, plug their mouth so that they can never destroy our food. Rid mankind of them”. Such a long association of human beings with rodents made these small mammals a serious problem in our food production, storage and public

health.

Ecologically, the deserts are considered as scarcity biomes, however, the Indian arid region is one of the most diverse deserts with rich floral and faunal diversity. To meet the food and fodder requirements, arid farmers adopted rainfed farming, development of range/*gochar* lands, arid horticulture and tree plantations providing sustainability to the region that forms the back bone of rural economy. Large-scale canalization of river waters and exploitation of ground water in recent years helped in increasing irrigated cropping and therefore introduction of several new and remunerative crops is transforming the arid agriculture in a big way.

Despite experiencing several abiotic challenges from low and erratic rainfall, temperatures extremes, poor soils, high wind velocity etc. the agriculture in arid

zones has suffered a lot by several biotic constraints like pest and diseases. Rodents primarily being herbivores, take a heavy toll (up to 15%) of the crops at every stage of production and storage, because of their sheer numbers. The forestry or horticultural plantations and range grasses too experience rodent depredations in a big way.

Management of rodent pests, especially in arid regions is intricated. Unlike insects, rodents are secretive and not easily observed because many of them are nocturnal. They infest an area throughout the year than 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 single night by residing at some other place.

Despite knowledge about their biology and control techniques, the fact however, remains that the rodent continued to damage standing crops and stored food grains.

Rodent diversity in Indian arid zone

In hot arid regions of western Rajasthan both the gerbils, viz., Indian desert gerbil, *Meriones hurrianae* and Indian gerbil, *Tatera indica* are regarded as most predominant rodent pests in rainfed as well as irrigated arable cropping systems and grasslands. Besides, Soft furred field rat, *Millardia meltada* and Little Indian field mice, *Mus booduga* prefer to inhabit irrigated croplands and hairy footed gerbil, *Gerbillus gleadowi* damages rainfed crops grown on dunes/interdunal spaces. The squirrels, *Funambulus pennanti*, occupy the trees scattered in the crop fields and fruit crops. Short tailed mole rat, *Nesokia indica* though sporadic in occurrence was reported from arid forestry and horticultural fields in Nagaur, Bikaner and Sri Ganganagar districts. Likewise the lesser bandicoot rat, *Bandicota bengalensis* was reported to cause extensive damage to irrigated crops in Indira Gandhi Canal Command areas. Besides these field rodents two commensal species viz., the house rat, *Rattus rattus* and house mouse, *Mus musculus* are predominant rodent pests in houses, godowns, storage, warehouse etc.

In cold arid regions five rodent species were reported from different altitudes and habitats in and around Leh, viz. *Mus booduga* (crop fields and rural storage), *Rattus turkestanicus* (godowns and kitchen gardens), *Pitymys leucurus* (grasslands), and *Marmota himalayana* (grasslands and barren lands) and *Rattus* sp. (outskirts of Leh city). Of these, *M. booduga* is widely distributed in crop fields and *R. turkestanicus* in stores and godowns. Major rodent species of arid regions (Fig. 1), their distribution, habitats and breeding biology are depicted in Table 1.

The rodent problem

Rodents are highly adapted to a variety of habitats and the crop fields



Fig. 1. Major rodent economically important species a. *Tatera indica*, b. *Meriones hurrianae*, c. *Bandicota bengalensis* and d. *Millardia meltada*

and food grain stores provide most conducive environments for field and commensal rodents, respectively. The gnawing habit of rodents owing to their ever-growing incisors, and their vast breeding potential make them one of the most destructive organisms. Besides, rodents possess a great feeding potential as they generally consume 5 to 10% of their body weight on a daily basis. Agricultural fields serve as a highly productive rodent habitat. Similarly, threshing yards located near crop fields also act as an excellent abode for food and shelter of rodents. In hot arid regions 18 rodent species belonging to three families' viz., Hystricidae, Sciuridae, and Muridae were reported. Among these a species complex of 3 to 4 species were generally reported to inflict economic damage in any particular cropping system/habitat (Table 2).

Losses due to rodents

Rodents cause immense losses to the crops, fodder grasses and forestry plantations in arid regions. The monsoon is very conducive for breeding of desert rodents, thus these pests maintain a very high population at the ripening/maturity stage of *kharif* crops. During *rabi*, the area under cropping is drastically reduced due to limited availability of irrigation facilities, therefore the pest rodents migrate to the crop fields *enmass* and

cause extensive damage to *rabi* crops (Table 3). Rodent damage to various crops in the last 7 to 8 years revealed that *isabgol* and cumin the two most important cash crops of the region suffers heavily (up to 50% plant damage) in peripheral regions of crop fields. Other crops viz. wheat, mustard and pulses experience rodent damage to the tune of 3 to 20%, 10 to 12% and 2.0 to 8.5%, respectively in arid region of Rajasthan. In Kachchh region of Gujarat, sugarcane and cotton suffer 13.1 and 3.4% damage to canes and bolls, respectively. Young saplings of date palm were observed to be damaged to the tune of 2.0 to 10.4%. In Indira Gandhi Canal Command areas of western Rajasthan, groundnut crop experienced damage of 12 to 17.5%. Likewise cotton crop suffers up to 6.7% plant damage in Sri Ganganagar district. Moong registered 4.2 to 9.3% rodent damage (Fig. 2).

RODENT HUBANDRY

Knowledge about the rodent bio-ecology, behavior, extent of damage and the situations vulnerable to attack by rodents in different crops and regions are important components in planning management strategies. Various common methods employed for rodent control are discussed here, which may be integrated as a package of rodent management strategy.

Table 1. Major rodent pests of arid zone in India

Family	Common/Scientific name	Distribution	Habit/habitat	Reproduction
Scuridae	Northern palm squirrel, <i>Funambulus pennanti</i>	In India it is found between south of Sikkim and northern district of Dharwad in Karnataka, from Baluchistan (Pakistan) to West Bengal (India) and also from Andaman Islands. In Rajasthan it is found near human habitations throughout Rajasthan.	It is diurnal and peaks of activity occur in the morning and early evenings. It generally lives close to human habitation, orchards, gardens, and parks and in areas with fairly good number of trees. The squirrel nests in holes in tree trunks and crevices in the walls of buildings, window sills, compounds etc.	It breeds throughout the year. In Rajasthan breeding is generally seasonal from March to September with peaks between March–April and July–September with a litter size varying from 1 to 5.
Muridae Sub-family: Murinae	Lesser Bandicoot rat, <i>Bandicota bengalensis</i> these were seen in urban	In India it is found in all regions except extreme arid zone, however, in recently different ecologic locals of Jodhpur and Bikaner.	The lesser bandicoot rat is well adapted to various habitats and lives in seasons across the country. conditions which include cultivated fields, pastures, forests, mountains, inter-tidal mangrove zones, semi-arid zones and of late as a commensal in towns and cities across India. The rat is nocturnal and completely a fossorial rodent.	Breeding occurs throughout the year. Definite peaks occur during different Litter size up to 14.
	Soft furred field rat, <i>Millardia meltdada</i>	It is distributed throughout India except the north–east mountainous areas. It is distributed throughout Rajasthan in irrigated crop fields, scrub grassland, sandy plains and is therefore regarded as sub-mesic rodent fauna.	It is Nocturnal and occupies the cracks and crevices in the dried up crop fields after harvest as well as the deserted burrows of other rodents. Makes simple and shallow burrows, which are slightly slanted.	In Rajasthan this species breeds throughout the year with peak reproduction occurring in monsoon and spring. Annual productivity of the metad in Rajasthan is quite high i.e., 52.5 young ones/female/year.
	House/roof/ black rat, <i>Rattus rattus</i>	In Rajasthan it is the most common rodent species sharing human inhabitations in houses, stores, godowns etc.	Mostly commensal living in houses, godowns, stores, poultry farms, crop fields, adjacent to villages, plantation crops, especially coconut, open country, forests and in the hills. It is nocturnal and colonial.	House rats breed throughout the year, reportedly with two peaks of reproduction viz. March-April and August-September.
	Indian field mouse, <i>Mus booduga</i>	It is a ruderal species and occurs in and around crop fields throughout India, including hot and cold arid regions.	The mouse is a fossorial and nocturnal, and found in crop fields especially irrigated ones.	Breeds throughout the year except during bating days in winter. Litter size 2 to 11.
	House mouse, <i>Mus musculus</i>	Cosmopolitan in distribution.	Commensal, nesting in rafts, crevices in walls, amidst staked undisturbed bags of food grains in godowns, table draws; often lives in fields digging burrows. Nocturnal.	It breeds round the year. In Rajasthan it shows a bimodal pattern of breeding season. Litter size up to 8. Population peak during March and.
	Short tailed mole rat, <i>Nesokia indica</i>	In India it is a north Indian rodent reported from Punjab, Rajasthan, Haryana, Uttar Pradesh, Himachal Pradesh and Union Territory of Delhi. It is reported from Sri Ganga nagar, Bikaner, Churu and Nagaur districts in Rajasthan.	It prefers bunds in cultivated fields along water channels but also occurs in natural vegetation and garden lawns. Prefers soft soil with high moisture content and good vegetation cover. It is a very shy rodent with nocturnal and fossorial habits. In orchards and afforestation areas in Rajasthan its burrow openings plugged	Although it breeds throughout the year in captivity but in nature breeding occurs mainly during winter with a litter of 1-6.

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Table 1. Major rodent pests of arid zone

Family	Common/Scientific name	Distribution	Habit/habitat	Reproduction
Muridae Sub-family: Gerbillinae	Indian gerbil, <i>Tatera indica</i>	The species is ubiquitous occurring throughout India from the Himalayas to Mainly a wild fauna preferring sandy and ruderal habitats in Rajasthan, this species is frequently seen in streets of Bikaner city.	with excavated soil mole hills WAS seen near base of fruit or forestry trees and all the openings are interlinked under ground. Indian gerbils are nocturnal. At the slightest alarm, they move in leaps and bounds, sometimes clearing 1.2 to 1.5 m distance in a single leap. It inhabits open plains, loose sandy soils of the desert, and is usually found at the edges of cultivation. Burrows are dug near hedges, thickets or under bushes, sometimes inside the field also when conditions are dry.	Breeds throughout the year in arid Rajasthan with maximum littering in the month of August and a minor peak in February. Gestation period is 3 to 4 weeks. Litter size varies from 1 to 10.
	Indian desert gerbil, <i>Meriones hurrianae</i>	Its distribution in India is restricted to arid tracts of Rajasthan and adjoining regions of Haryana, Punjab and north-west Gujarat. In Rajasthan it is widely distributed in sandy areas.	Prefers sandy habitat the most lives of Thar desert, Burrows are elaborate, criss-crossing like a honeycomb. Desert gerbils are diurnal. They are far more gregarious than Indian gerbils but live in smaller colonies. They are most active during early morning. When alarmed the desert gerbil makes a drumming sound by stamping its hind legs on the ground and raising its tail.	Breed throughout the year with two peaks in February and July but a third peak was observed between September and November. Litter size varies from 1 to 9.

Table 2. Pest species composition indifferent cropping systems in arid zone

Habitats	Rodent pest species
Rainfed crops	<i>Meriones hurrianae</i> – <i>Tatera indica</i> – <i>Gerbillus gleadowi</i>
Irrigated crops (sprinkler)	<i>tatera indica</i> – <i>Meriones hurrianae</i> – <i>Millardia meltada</i>
IGNP areas	<i>Bandicota bengalensis</i> <i>Tatera indica</i> – <i>Millardia meltada</i> – <i>Nesokia indica</i> – <i>Mus</i> sp.
Grass/ range lands	<i>Meriones hurrianae</i> – <i>Gerbillus gleadowi</i> – <i>Tatera indica</i>
Horticultural crops	<i>Funambulus pennanti</i> – <i>Mmeriones hurrianae</i> – <i>Tatera indica</i>
Forest/Silva fields	
(a) Sandy areas	<i>Meriones hurrianae</i> – <i>Tatera indica</i> – <i>Millardia meltada</i> – <i>Nesokia indica</i>
(b) Rocky area	<i>Meriones hurrianae</i> – <i>R cutchicus</i> – <i>Nesokia indica</i>
(c) Forest and fruit nurseries	<i>Funambulus pennanti</i> – <i>Ttatera indica</i> – <i>Millardia hurrianae</i> – <i>Rattus rattus</i>

Cultural control

This technique is primarily based on ecological concepts wherein the rodents' habitat is manipulated in such a way that created stress among native rodent pests. The methods were low cost treatments and involved little modification in crop husbandry practices, like deep ploughing, removal of wild vegetation and refuge of previous crops, reduction in bund size etc. It

helped in migration of pest rodents from crop fields. Moreover, the habitat stress created by these practices enhanced the chances of rodents falling prey to predators.

Mechanical control

Mechanical removal of rodent population from any habitat is mainly done by use of different types of traps. This method is very effective for indoor situations, like stores,

godowns, houses etc but may not be effective for field rodent control. However, it may be used as a follow up measure after bringing down the rodent pest population by poison baiting. Trapping on the other hand is used as a diagnostic tool in understanding the pest species composition and infestation levels. The traps may be of single (Sherman/ Snap traps) or multiple catch (Wonder traps) type. In snap traps the rodents were killed whereas others catch live rodents. Rodents use visual and olfactory cues towards traps, therefore camouflaging the traps with bushes, grasses etc. in fields enhanced the trap success considerably.

Chemical control

Use of rodenticides is most common, expedient and humane method to control pest rodents. They have greater scope in large-scale control operations, since mixed population of several species are encountered in fields. Zinc phosphide

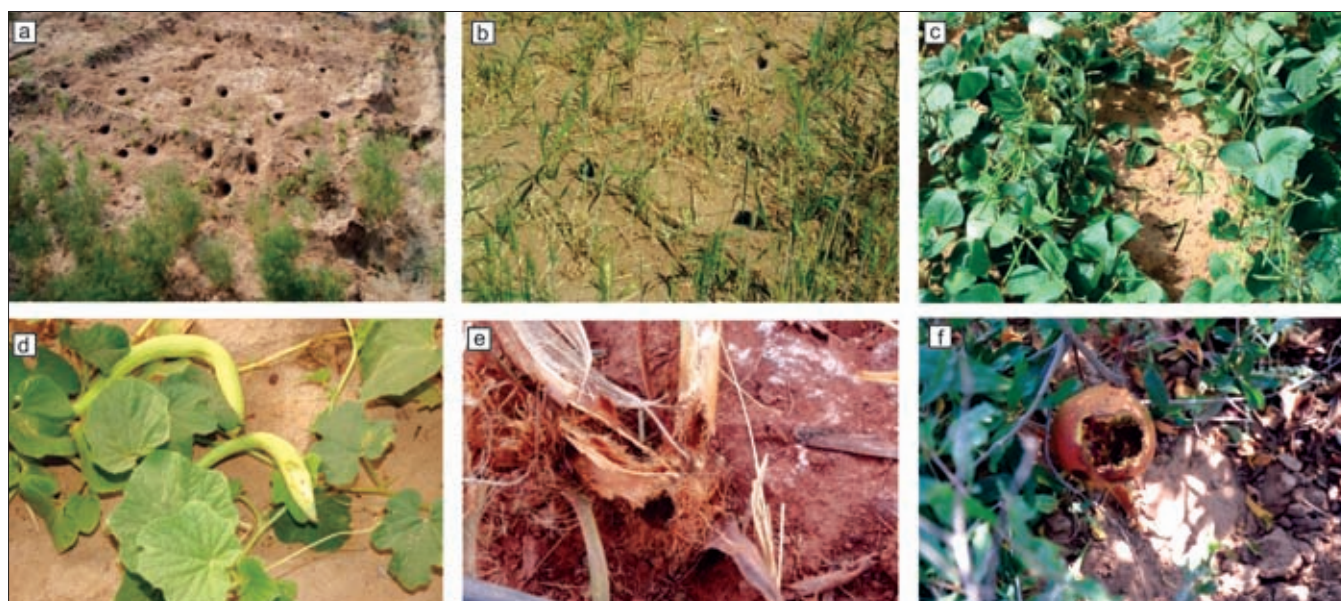


Fig. 2. Rodent damage: a. Cumin, b. Wheat, c. Moong, d. Cucumber, e. Date palm, f. Pomegranate

Table 3. Estimates of damage caused by rodents in arid ecosystems

Crops	Rodent damage (%)
Wheat	3.0-20.0
Sugarcane	13.1
Mustard	10.0-12.0
Cotton	3.40
Cumin	1.2-12.4
Arid pulses	2.0-8.5
Date palm	2.0-10.4
Bajra and Sorghum	2.0-4.0
Vegetables	6.0-8.5

is a most widely used rodenticide in India and is recommended between 2 and 2.5% concentration in cereal baits. It is highly toxic to a variety of rodent species. Major limitation in its frequent use is its high toxicity to non-target species and therefore it is recommended for rodent control in fields only (not in indoor habitats). Secondly, sub-lethal intake of zinc phosphide baits also leads to development of bait shyness/poison aversion in the target species in the surviving (residual) populations that may persist for more than 2 to 3 months in different rodent species. For managing the residual rodents (surviving after zinc phosphide treatment), one has to resort to other alternative rodenticide like, burrow fumigation with aluminium phosphide (a fumigant) or baiting with anticoagulant rodenticide.

Among anticoagulants only bromadiolone, a second generation anticoagulant rodenticide is registered

with Central Insecticide Board for rodent control in fields and also in commensal situations. This anticoagulant rodenticide is effective as single dose and is highly effective at a very small concentration (0.005%). In cereal loose or wax-cake baits. They are recommended for management of rodents both in fields and domestic situations, stores, godowns, poultry farm etc alike.

Bait preparation: It is an important aspect of rodenticide application technique, which is often overlooked. The proportion of toxicant to the bait should be maintained properly. The recommended dosage for zinc phosphide is between 2.0 and 2.5% and that of bromadiolone is 0.005% in baits. The zinc phosphide is marketed in India as >80% pure powder and Bromadiolone comes as bait concentrate (BC) at 0.25%. (Bromadiolone is also available as ready to use wax block baits at 0.005% conc). The poison baits of these chemicals were prepared by end users himself. The Bait preparation technique developed by CAZRI, Jodhpur is easy and simple, effective and is widely accepted by the farming community. The technique is as follows (Fig. 3):

Pre-bait material: (If zinc phosphide baiting is to be done) for 1 kg of bait.

- Take 980 g of locally grown food grains (wheat/bajra/jowar).
- Mix 20 g vegetable oil in food grain

with bare hands.

Poison bait material: for 1 kg bait:

- Mix oil (20 g) in food grains (960 g) as suggested above in pre-bait preparation.
- Sprinkle 20 to 25 g of zinc phosphide 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).

Use any plant leaf as applicator for bait placement inside burrows (Fig. 3).

Rate of application of these baits/burrow are 10 g for zinc phosphide, 10 to 15 g for bromadiolone.

For baiting with zinc phosphide, pre-baiting (plain bait without poison) is essential at least 1 to 2 days prior to poison baiting to achieve higher control success. However, bromadiolone baits can be used directly without any pre-baiting.

Bait placement: Placement of bait is one of the most important aspects for an effective chemical rodent control strategy. The bait may be placed either deep inside the burrows or in the bait containers/bait stations (Fig. 3 a.)

Burrow baiting: All the existing burrow openings should invariably be plugged in the evening and next morning only re-opened/active burrows will be treated with baits (Fig 3b). In this method 10 g of poison bait (zinc phosphide) after 1

to 2 days pre-baiting is rolled deep inside the active burrows to avoid any secondary hazards. To assess the control success the burrows are plugged again after 3-4 days of treatment and reopened burrows are examined on the next day.

Use of bait containers or bait stations: Several types of indigenous bait containers (like mud channels, hollow bamboo pieces, broken pitchers, coconut shells etc.) were used for keeping the baits. The basic idea of selecting bait containers is that the bait should be easily accessible to the target species and should reduce the hazard to other animals and human being. This will also protect the baits from rain and other weathering.

Burrow fumigation: Aluminium phosphide (3 g) tablet, was earlier recommended for burrow fumigation, however, because of being extremely toxic, this formulation was put under restricted ban by the Government of India and therefore, it must be used by trained plant-protection personnel and not by general public. Recently its new formulation (12 g tablet) with 6% a.i was registered as burrow fumigant. For fumigation, all the existing burrow openings were plugged with wet mud and one tablet (12 g) 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. This fumigant is recommended only in severe rodent upsurge or outbreak. It is never recommended for residential premises/indoor use.

Safety precautions in handling rodenticides

Rodenticides, if handled carefully and sensibly, should present no risk to other animals or human being including the operator himself.

Following precautions should be followed to avoid any risk.

- No eating, drinking or smoking should take place when live or dead rodents or poison baits are handled.
- Poison baits should be prepared in well ventilated room and care should be taken not to breathe in



Fig. 3. Rodents management technique a. Demonstration Bait preparation technique, b. Bait administration in active burrows

or absorb any poison.

- After poison bait preparation and field application, hands should be washed with soap properly.
- All poisons (pure chemicals, baits, etc.) should be clearly labelled 'POISON' and held in a locked almirah and should be away from the reach of children.
- The poison bait should not be touched by bare hands. Any broad leaf or spoon or gloves should be used.
- 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.
- 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.
- If aluminium phosphide is being used for burrow fumigation in the fields, the fumigant should be kept away from fire as it is highly inflammable. Do not touch the tablets. Use an applicator or a long tube to insert them into the burrows.
- After the control operation, the left-over baits, should be picked up and dead rodents be collected and buried deep in the soil.

Safety precautions in handling rodenticides

If any poison is absorbed or illness is suspected medical advice be sought immediately following antidotes should be administrated in case of accidental poisoning due to rodenticides.

Acute poison (Zinc phosphide and Aluminium phosphide): 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 permagnate dissolved in a glass of warm water. This oxidizes the phosphide to phosphates. After 10 minutes, half a tea spoon full of copper sulphate dissolved in 250 ml of water should be administered. This will produce insoluble copper sulphide. After this, any purgative can be given and doctor be called immediately.

Anticoagulant poisons (Bromadiolone): In case of accidental consumption of such poison, call the physician immediately. Vitamin K1 administration and blood tranfusion are recommended.

SUMMARY

Rodents are serious pest of agriculture, causing 2 to 15% losses to crops at pre-harvest stage and up to 5% losses in storage. In hot arid regions, only 7 to 8 species may be considered as pests which cause immense losses to the crops, fodder grasses and forestry plantations in arid regions. Besides non-chemical control like trapping, sanitation, physical exclusion of rodents, chemical control through rodenticide is cheapest and the most feasible. Application of 2 to 2.5% zinc phosphide in cereal bait is recommended for rodent management in fields. It should be followed by bromodiolone (0.005%) baiting for managing residual rodent populations surviving after zinc phosphide baiting. For indoor condition only bromodiolone (0.005%) bait is recommended.

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