Review Article

RODENT DAMAGES AND APPROACHES FOR THEIR MANAGEMENT

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ABSTRACT

Rodents are major vertebrate pests belongs to order Rodentia and class Mammalia. About 40% of all mammal species are rodents (2,277 species).They have emerged as a major pest due to their high damage potential and tendency to damage major crops at field level and in storage in India. Analysis of the reviews on pre-harvest losses indicates a range of 5–15% damage to major cereal crops and higher damages are noticed in endemic areas. Also about 2.5% damage is caused by rodents in post- harvest system. Rodents also gained importance due to their outbreaks in endemic areas and potential vector to cause and transmit zoonotic diseases such as plague and leptospirosis. The lesser bandicoot, *Bandicota bengalensis*, is predominant in irrigated crops throughout the country. The Indiang erbil, *Tetara indica*, soft-furred field rat, *Millardia meltada*, and field mouse, *Mus booduga*, are widespread in both irrigated dryland and dryland crops in the country, except in the north-eastern states. Farmers are facing huge problems due to rodent damage to their agricultural and horticultural crops for food and hoarding. The use of rodenticides is the common approach to manage rodent menace, but rodenticide coupled with many cultural practices like clean cultivation, proper soil tillage and crop scheduling, had given long-lasting results. Currently, problems occur due to increased intensive cropping with expansion of irrigated areas, changing agricultural practices resulting in higher breeding and damages by lesser bandicoot rats, increased coconut cultivation without proper spacing, cultivation of oilpalm in rodent-endemic areas, and natural calamities like flash floods and drought spells followed by heavy rains etc. Integrated rodent management is the available option to manage rodent damages.

INTRODUCTION

Indian food production has touched a greater height of 277.74 million metric tonnes in the year 2017-18. Indian agriculture has progressed a long way from an era of insufficiency due to various reasons to become a significant exporter of different agricultural commodities. This can be attributed to harnessing a larger portion of the land to agricultural purposes and induction of new varieties and agricultural technologies. A remarkable increase in food grain production took place from about 55 million tons (m.t) during 1949-50 to a level of 277.74 million tonnes during 2017-18. The thrust on intensive cropping coupled increased fertilizer use resulted in increase in pest problems with a crop loss of 10 to 20 percent annually amounting to ` 60,000/- million in field and storage situations (Rajak, 1993).

Rats and mice have adapted well to the diversity of agricultural habitats created by humans. Some 42% of all mammal species are classified as rodents (animals that have continually growing incisor teeth and no canine teeth). Although fewer than 10% are significant agricultural pests, this still leaves over 200 species to manage. Rodents are an enigma in that they are the ultimate mammalian weed, living in almost every habitat on earth, yet they also play a pivotal role in nutrient cycling and water flows in many ecosystems and therefore the non-pest species need to be protected (Singleton, 2010)

Rodents have three major impacts. The first is the substantial damage they can cause at any stage of the growing crop. The second is the losses they cause post-harvest to stored grain and vegetables. The third, and often overlooked, impact is on the health of smallholder farmers – rodents are carriers of at least 20 severely debilitating human diseases (Meerburg *et al.*, 2009).

ECONOMIC IMPORTANCE OF RODENTS

AGRICULTURE

Rodents cause direct damage to various crops/commodities by gnawing and feeding and indirect damage by contamination and hoarding during on-farm and post-harvest stages (Parshad, 1999, Rao and Joshi, 1986). The pattern, extent of damage and their level of infestation vary in different crops and geographical regions (Table-1). The Indian gerbil, *T. indica*, soft-furred field rat, *M. meltada*, and field mouse, *Mus booduga*, are wide spread in both irrigated dryland and dryland crops in the country except in the north-eastern states. The Indian crested porcupine, *Hystrix indica*, is widely distributed in hillock or arid habitats, occasionally inflicting severe damage to crops, orchards and reforestation plantations.

Table 1: Extent crop loss due to rodent pests, pest species and their distribution in India

S. No.	Name of the crop	Extent of loss (%)	*Rodent pest species*	Habitat/distribution of species
1	Rice	1.1 to 44.5	*Bandicota bengalensis*	Irrigated fields
			Millardia meltada	Semi irrigated fields
			Mus booduga	Irrigated fields
			Rattus nitidus	Jhum fields in North east
			Rattus rattus brunneusculus	Jhum fields in Mizoram
2	Wheat	2.7 to 21.3	*Bandicota bengalensis*	Irrigated fields
			Millardia meltada	Irrigated dry fields
			Tatera indica	Rain fed fields
			Meriones hurrianae	Desertic soils in Indian desert
3	Sugarcane	2.1 to 31.0	*Bandicota bengalensis*	Irrigated fields
			Nesokia indica	Irrigated fields in Punjab
			Millardia meltada	Irrigated fields
4	Groundnut	2.9 to 7.3	*Tatera indica*	Irrigated dry fields
			Millardia meltada	Irrigated dry fields
			Bandicota bengalensis	Irrigated fields
5	Coconut	4.5 to 55.00	*Rattus rattus*	Throughout India
6	Cocoa	30 to 50	*Rattus rattus wroughtoni*	South India
			Funambulus palmarum	Andhra Pradesh and Tamil Nadu
			Funambulustristriatus	Kerala & Karnataka
7	Oilpalm	11.2 to 57.3	*Bandicota bengalensis*	Fruits in South India &
			Hystrix indica	Andaman
			Tatera indica	Seedlings in nurseries
8	Vegetables	1.4 to 30.6	*Bandicota bengalensis*	Irrigated fields
			Millardia meltada	Irrigated dry fields
			Tatera indica	Dry fields
			Meriones hurrianae	In Indian desert soils
			Funam buluspennanti	Northern India
9	Fruits	Varied	*Funam buluspennati*	Northern India
			Funambulus palmarum	Southern India
10	Storage	2.5	*Rattus rattus*	Residential premises and farm level storage
			Mus musculus	
			Bandicota bengalensis	

Other rodent species have restricted distributionnamely: the desert gerbil, *Meriones hurrianae*, in desert Rats, Mice and People: Rodent Biology and Managementareas; the Himalayan rat, *Rattus nitidus*, in the north-eastern region; the short-tail mole rat, *Nesokia indica*, inthe north-western plains; the three-striped squirrel, *Funambulus palmarum*, on the southern peninsula; the five-striped squirrel, *F. pennanti*, on the northern peninsula; the western Ghat squirrel, *F. tristriatus*, on the west coast of the southern peninsula; and the Norway rat, *R. norvegicus*, in port areas.

The house rat, *R. rattus*, and the house mouse, *Mus musculus*, are the major commensal pests (Prasad and Rao, 2000). At least 14 subspecies of *R. rattus* have been reported from India (Biswas and Tiwari 1969). Of these, *R. r. Rufescens* Gray occurs in premises throughout thecountry, *R. r. wroughtoni*, Hinton and *R. r. Blanfordi* Thomas are restricted to plantation crops like coconut, oilpalm and cashew on the southern peninsula (Bhat 1992), *R. r. andamanensis* Blyth occurs on Andaman and Nicobar Island (Subiah and Mathur, 1992) and *R. r. Brunneusculus* occurs in Mizoram (Chauhan and Saxena, 1985).

In Asia, pre-harvest rice losses are estimated to be between 5 and 10%. A loss of 6% of SE Asia rice production amounts to approximately 36 million t, i.e. enough to feed the population of Indonesia (215 million people) for 12 months (Singleton, 2003). Farmers often use inappropriate methods to reduce the impacts of rodents, and rely heavily on chemicals, causing risks to non-target species and to the environment, and generally providing poor return on investment (Singleton, 2003).

RODENT DAMAGES IN OILSEED CROPS

Although other pest rodent specie like *M. musculus, A. somalicus, M. natalensis* and *T. robusta* were abundant in groundnut fields and major damage caused on it was by *X. rutilus* (Parshad, 1999). Rodents may damage the whole or the branches of the plant during burrowing. They damage and removal of the pods at the maturity and harvesting stages and take them in to their burrows

The extent of rodent damage in Soybean and ground nit in India is listed in Table 2. Awasthi and Agarwal (1991) reported a yield loss of 16.5Kg/ha at green pod stage in soybean crop in Madhya Pradesh. Groundnut serves as an ideal rodent habitat where rodents registered 4-7% pod damage besides hoarding 320g/burrow (Mittal and Vyas, 1992). During outbreaks (1976 and 1988-89) ground nut suffered upto 85.42% damage in Saurashtra region of Gujarat (Shah, 1989; Vyas *et al.*, 2000).

Rodents like rats, squirrels pose major threat and cause huge damages in plantation crops like coconut and oil palm. R. Rattus along with squirrels *Funambulus palmarum* and *F. tristriatus* are serious pests of plantation crops such as coconut and oil palm in the southern peninsula (Parshad, 1999). Rodent causes economic damages in coconut up to 28% in peninsular India and upto 45% in Andaman & Nicobar Islands and Lakshadweep. In case of oil palm, it causes damages up to 57% in Andaman and Nicobar Islands.

Table 2: Rodent damages and species infesting Soybean and Groundnut in India

Crop	Stage	Damage (%) Yield loss Kg/ha	Species	State
Soybean	Green pods	27.27	*Bb, Mm, Rr*	Madhya Pradesh
	Pod formation	0.60-3.00	*Mm, Ti*	Karnataka
Ground nut	Plant and Pods	3.90 -19.00	*Ti, Rn*	Punjab
	Pod setting	4.50	*Bb, Mb, Mm*	Gujarat
	Pod maturity	6.90	*Bb, Ti*	Gujarat
	Harvesting	7.30	*Mm*	Gujarat
	Peg formation	30 – 40	*Bb, Ti*	Karnataka
	Hoarding	2.00	*Bb, Mb*	Karnataka

(Sridhara and Tripathi, 2005)

(*Bb – Bandicoota bengalensis, Mm – Mus musculus, Rr – Rattus rattus, Ti – Tatera indica, Mb – Millardia meltada, Rn – Rattus nitidus*)

ENVIRONMENTAL AND CULTURAL MANAGEMENT

Several agronomic measures used in raising crops in the country contribute indirectly to reduction of rodent populations. Deep ploughing, bund trimming and other land preparation measures reduce the carrying capacity of the habitat for rodents. Routine weed removal by farmers in crops also deprives rodents of shelter and alternative food sources. Sharma and Rao (1989) reported a decline in rodent infestation in rice fields with reduction in bund dimensions. Sabhlok and Pasahan (1985) also reported migration of gerbils from about 65–78 m away after removal of wild vegetation from the fields. Christopher *et al*. (1984) reported that periodic removal of garbage and nesting material in animal/human dwellings, stores and god owns discourages rodent habitation. Alley planting of rice also reduces rodent damage (Anon. 1959–69).

Physical elimination of field rats is in vogue with communities in Irulas of Tamil Nadu and Erukulas of Andhra Pradesh where rats are used for food. Rodents, especially *T. Indica* and *B. bengalensis*, are caught physically by digging the burrows. Sometimes, fumigation of burrow sussing smoking straw is employed. However, this physical killing is done often around the time of ripening of the crop after maximum rat damage has already occurred. There is an improved smoke generator for effective control of burrowing rodents. Paddy straw is burned, leading to the generation of smoke, which is pushed into the burrow tunnel with the help of a blower (Rana and Tripathi, 1999).

TRAPPING

Although trapping is one of the oldest methods, there is little proof in the scientific literature that it is an effective method of reducing rodent numbers (Reddy 1999) *Tanjore kitties* (bamboo palmyra traps) are effective in maintaining rodent numbers at a low level once they have been reduced by other methods. Indigenous bamboo snap traps are laid on the periphery of *jhum* cultivated fields in the north-eastern states to trap rodents immigrating from adjoining forest areas and resemble the trap–barrier system of rodent management (Singleton *et al.,* 1999).

ROLE OF PREDATORS

Biological control existed in the country before the1970s due to the presence of natural predators. Cats in domestic situations, and snakes and owls in field situations are the predominant vertebrate predators. Whitaker and Dattatri (1986) reported that rodents constitute prey items for the cobra (75%), Russels viper (75%), krait (29%) and scaled viper (22%). However, the feeding rate of captive snakes is one rodent every three days. This predatory pressure on rodents is very low compared to the faster breeding propensity of rodents. Hence, snakes alone may not be able to control rodent populations in nature.

Kumar (1985) reported that 61% of the total estimated biomass of the pellets of spotted owlet was *R. rattus* and *M. musculus*. Neelanarayanan (1997) reported the consumption of 1–6 rodents/night by the barn owl, with an average of 1.58 rodents/day. *B. bengalensis* (40%) and *M. musculus* (33%) constituted the major prey items in the pellet analysis. In view of this he reported that nest box (36x18x21") and T-shaped owl perches provided alternative sites for barn owls for predatory activity (Neelanarayanan, 1997). However, declining rodent populations post-harvest resulted in predators leaving the area. The T-shaped owl perches are currently popular in cereal crops as one of the integrated Est management (IPM) practices. However, their use is not desirable after the flowering stage of crops because granivorous birds use the perches during their feeding activity in the grain crops.

USE OF MICROBES

Salmonella and murine typhus bacteria were found tobe ineffective against *R. rattus* and *B. bengalensis* in India (Deoras, 1964). Bindra and Mann (1975) reported that the murine typhus bacterium cause <40% mortality of *M. musculus* and *T. indica*. Studies with the trichostrongloid nematode, *Hepatojarakus bandicoti*, are yet to explore the potential for rodent control. Studies on viral vector induced Immuno-contraception (VVIC) is yet to be taken up in the country.

ULTRASOUND DEVICES

The sense of hearing among rodents is above 20 kHz, thus extending well into the ultrasonic range. Ultrasound devices are being used as deterrents to rodent immigration. However, so far, no convincing evidence was found them as effective against rodents.

CHEMICAL REPELLENTS

There is no effective chemical repellent to rodents available that is not also toxic to humans. Field rodents often damage the imported rodent-repellent cables installed in telecommunication networks. Although pheromones appear to be promising, scientific work is lacking to identify, isolate and introduce pheromones for extension purposes.

RODENTICIDES

The use of rodenticides is the most common approach to tackle the rodent problem in the country. Zinc phosphide is the most commonly used acute rodenticide. Used at 2% in cereal baits, it detoxifies rapidly in carcasses and baits, and thus is relatively safe and economical (Prakash and Mathur, 1992). Development of bait shyness and the lack of an effective antidote are limitations to its use. The control success that can be achieved is usually around 60% (Rao *et al.,* 1998). ICAR recommends use of zinc phosphide to control rats in rice, wheat, jowar, millets, sugarcane, pulses, oilseeds and vegetable crops. However, due to toxicity problems in non-target species, its use is advocated primarily in situations where rodent infestations are at high levels, *i.e.* 50 active burrows per hectare. Efforts are in progress to develop a ready-to-use formulation of this rodenticide for effective application indifferent situations.

The second-generation anticoagulant bromadiolone has been available commercially in ready-to-use formulation since 1988 for use in crops and storage/domestic situations. It is recommended as a component of the IPM packages for rodent control in crops with moderate levels of rodent infestation. It is used in cereal bait at 0.005% and applied inside burrows at 15 g per burrow. It is advocated for use in bamboo bait stations in *jhum* fields of the north-eastern states. Bait shyness does not exist with this chemical; hence a second application is recommended after 15 days to address the residual rodent infestation (Rana and Tripathi, 1999). It is recommended in ready-to-use formulation to tackle rodent infestations in plantation crops and in storage. Application of aluminium phosphide pellets at two per active burrow is recommended for effective field rodent control. Due to easy handling, application and immediate kill of rats inside burrows, the farming community prefers this fumigant rodenticide. However, because of the higher toxicity of the chemical to non-target species and the absence of an antidote, the Government of India has restricted the use of this rodenticide for use.

TIMING OF RODENT CONTROL

Farmers normally resort to symptomatic treatments. controlling rodents after damage is seen in their crop. Mostly, these measures lead to partial success due to poor bait intake in the presence of food crops in the fields. Most of the states of the country adopt prophylactic or lean period rodent control. It is assumed that bait intake will be high during the interval between two crop seasons and farmers will have free time to participate in the control operations on a community basis. However, analysis of implementation of this approach showed that farmers were not keen on rat control in this period due to the absence of rodent infestation in their fields (Rao *et al.*, 1998). Cereal crops exhibit compensatory growth if pest inflict damage in the initial stages, but not if damage occurs after the vegetative stage (Rao, 1992). Hence, rodent control is advocated during the vegetative stage of cereal crops when rodents immigrate to and try to establish in the crop. Treatment during this stage resulted ineffective rat control (Rao *et al.*, 1998).

INTEGRATED ACTIONS TO MANAGE THE RICE FIELD RAT IN LOWLAND IRRIGATED RICE

- Synchronize planting of rice crops within 2 weeks of one another; otherwise the breeding season of the rice field rat is extended, leading to exponential population growth;
- Conduct community campaigns before the rice field rat breeding season using local methods, such as trapping and fumigation, to control rats within 3 weeks of planting the crop; these community actions usually focus on village gardens, main irrigation channels, and roadsides;
- Keep irrigation channel bunds less than 30 cm wide to make it difficult for rats to build nests;
- Clean up any grain spills at harvest and practice good hygiene around houses and gardens.

CHALLENGES FOR INTEGRATED RODENT MANAGEMENT

Identification of emerging rodent problem in the changing cropping systems

Intensive cropping due to increased irrigation will be making rodent pests to invade these new terrains and may cause increased problems. These changing agricultural practices also influence the density of rodent populations. The Indira Gandhi Canal in desert tracts brought more cultivable land under irrigation, but also increased rodent problems due to replacement of desert rodents with the lesser bandicoot rat, a dominant rodent pest. Similarly, failure to follow proper spacing in increased coconut cultivation has led to significant rodent damage to the nuts. Cultivation of oil palms in rodent endemic areas also naturally decreases the productivity of oil palms due to their vulnerability to these pests in the initial bearing years. Natural calamities like flash floods and drought spells followed by heavy rains etc. also foster irruption of rodent populations in these areas, contributing to significant crop losses. However, monitoring the rodent situation in the regular pest monitoring systems of the states is lacking in the country.

Infrastructure for rodent incidence monitoring

There are endemic areas for rodent pests due to continuous availability of food and shelter in irrigated crops. Rodent surveillance may be done based on the burrow intensity in the crop fields with the working index as 25 active burrows per hectare. Intensifying monitoring efforts does not exist after prolonged drought/dry spells and floods thereby ignoring early symptoms of the rodent populations for taking up timely actions.

Zoonosis diseases

Reports on increased incidence of leptospirosis are a matter of concern since this is considered as an occupational hazard to rice/sugarcane field working farm labourers. Similarly resurfacing of plague also is a major concern in public health. Epidemiological surveys and studies on the biology of ectoparasite populations in different areas are lacking. Such studies will indicate actual reservoir/vector species responsible for disease transmission and indicate factors responsible for arthropods propagation in the rodent burrow systems and may lead to proper management of vectors transmitting diseases.

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