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Abstract.--The results of about 12 years' study deals with rodent damage to several annual and perennial crops of India including cereal, vegetable, fruit, plantation and other cash crops. The rodent species composition in order of predominance infesting different crops and cropping patterns percent damages and cost effectiveness of rodent control operations in each crop and status of rodent management by predators are analysed.

INTRODUCTION

Rodents, as one of the major important vertebrate pests (Advani, 1982a) are directly related to the production, storage and processing of the agricultural crops and their eventual utilisation by man and its livestock for food, fibre and protection. In India, where malnutrition and starvation are best known to exist due to disparity between human population and available food, the rodents eat about 10 percent of agricultural production. Moreover, as India is situated in tropical and subtropical regions of the world with green vegetation available throughout the year, the turn over rate of rodents is much faster than other biomes of the world. In the world, rodents are responsible for the annual loss of about 33 million tones of stored cereals and rice alone (WHO, 1974).

In some of the crop fields with important crops in North India, reduction in rodent populations through integrated pest management techniques yielded cost return ratios to the extent of 1:900 (vegetables, Advani and Mathur, 1982), 1:247 (wheat, Advani, *et al* 1982) 1:220 (stored grains, Prakash *et al* 1981). To bring down the rodent populations at low level, control operations for six continuous crop seasons (two/year) are necessary (Advani, *et al* 1987) in cereal and vegetable crops. However, hitherto no authentic and quantified information exists for other crops like maize, rice, barley, sugarcane, all tuberous and fruit crops, arecanut, oil palm, etc. Whereas, some

attempts and preliminary investigations in cocoa and coconut crops yielded information that pods and nuts worth of rupees 500 and 650 respectively can be saved when one rupee is spent on trapping of rodents in the plantations (Advani, 1982b).

The damage magnitude and association of various rodent species with their respective crops studied so far, are presented.

METHODS

The results presented in this communication mostly pertain to the studies conducted in twelve villages near Jodhpur (Rajasthan, North India) and eight villages in Kasaragod (Kerala) and Mangalore (Karnataka, South India). The population ecology and dynamics of rodents were studied after Prakash (1975), whereas, the assessment of damages by rodents to different annual crops were evaluated after Greaves *et al* (1977). For damage assessment in the coconut and cocoa crops (perennial), methodology of Williams (1971, 1974) was followed. Control operations were carried out after Prakash (1977).

RESULTS AND DISCUSSION

Vegetable crops

In Rajasthan, studies in twelve vegetable crops in twelve villages, showed predominance of Indian desert gerbil, *Meriones hurrianae*; Indian gerbil, *Tatera indica* and Soft-furred field rat, *Rattus meltda* in the infested crop fields. The small field mouse, *Mus booduga* and a gerbil, *Gerbillus gleadowi* were also damaging the vegetables mainly tomato and brinjal. The rodent damage to various crops ranged from 4.1 to 19.9 percent, the average being 8.7 percent (Advani and Mathur, 1982). As a result of trapping, control and other management practices, rodent populations reduced by 92.5%. The rodent damage also declined by 91.9 percent and the production of crops increased (on an average) by 7 percent per hectare. The cost benefit ratio of rodent control work was 1:900 (in rupees).

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Chilly

Chilly is a main crop of the farmers of Rajasthan and is exported to neighbouring states in India and to middle-east Arab countries. The average rodent damage to this crop was 18.8, 11.48, 27.85 and 25.74 percent at sowing vegetative growth, maturity and threshing stages respectively (manuscript). As a result of continuous management practices, the relative rodent damage reduced by 89.89, 77.60, 85.79 and 83.5 percent respectively to these four stages of growth. This increased the production by about 16.1 quintals/ha, the cost benefit ratio being 1:571 (in rupees). Along with three predominant rodents, M. hurrianae, T. indica and R. melta; the Bust rat, Golunda ellioti gujerati, and Indian palm squirrel, Funambulus pennanti were also captured in higher numbers from the crop fields. In several cases, the M. hurrianae were found to thrive upon chilly in storage as exhibited by their stomach contents.

Wheat

In three varieties of wheat, Desi (local), Kharchia (salt tolerant) and Kalyansona (hybrid) the average rodent damage was quantified to be 18.66, 21.28 and 16.29 percent respectively (Advani et al 1982). The cost benefit ratio obtained after two years' work on rodent pest management practices was, 1:247. T. indica predominated the Kalyansona and Kharchia varieties of crops, whereas, M. hurrianae infested the Desi variety, in more relative abundance. Third species, R. melta which has shown its preference for wheat crop in field as well as storage (Rana and Advani 1981) also occurred in moderate densities. Along with rodents shrew, Suncus murinus sindensis, hitherto known as insectivorous, was also found to feed upon wheat (Advani and Rana, 1981).

Millet

About 90 percent farmers of the Rajasthan state depend upon millet (summer-rainfed crop) for their family needs. Out of seven species infesting millet, M. hurrianae, T. indica, R. melta and G. ellioti were four major rodents infesting this crop (Advani 1982b). The damage inflicted was about 15.0, 7.6 and 20.1 at sowing, vegetative, growth and harvesting stage. Management of about 90 percent of rodent populations resulted into cost: return ratio of 1:267 (Advani et al 1981).

Oil seeds

About 8 percent of rodent fauna captured during five years' studies (1977 to 1981) in twelve villages in Rajasthan, was found to infest oil seed crops, mainly Sarson (Advani, 1982a). R. melta, F. pennanti, G. ellioti were three main pests besides two predominant gerbils, infesting this crop. The percent damage was 5.5, 6.09, 10.8 at sowing, growth and harvesting stages respectively. In Gujarat, about 50 percent of ground nut was being damaged by the field rodents (B.D. Rana personal communication).

Coconut

Rodent damage at a level of 28.5 percent was evaluated in West coast variety of the coconut (Advani, 1982b) in Western Ghat biome of South India. IN the hybrids DXT, TXD) and Laccadive variety it was ranging from 10.2 to 20.5 percent. The House rat, Rattus rattus was the predominant rodent species occurring in about 70 percent of relative abundance. This species is a major pest of stored grains in houses and godowns in Rajasthan (Prakash et al, 1981), with the highest average litter size (6.60±0.10) among all rodents and the 27.03/young ones/Female annual productivity rate (Rana et al 1982). Among other species, the Field mouse, Mus booduga and the Bandicoot rats, Bandicota bengalensis, Bandicota indica and Indian gerbil, Tatera indica cuvieri were also captured from nurseries of coconut. To the inflorescence of coconut, the Western ghat squirrels, Funambulus tristriatus also damages in higher magnitudes. In a single instance about 250 male flowers and capsules were plucked by a single animal in one hour. Regular trapping of rodents with local traps for four months reduced the damage by over 76 percent, resulting into return of Rs. 650 when only one rupee was spent on labor and cost of trap. In Lakshadweep, as much as 6 million coconuts worth of 35 lakhs rupees are damaged per year (Whitaker and Bhasker, 1978 Shah & Subiah 1978). The estimated loss to coconut crop is about 55 percent in Minicoy island (Advani, 1984b) and 35 percent in Car Nicobar groups of islands in Bay of Bengal (Advani, Unpublished data).

Cocoa

A heavy damage (75 percent) can be seen by rodents in any of the farmers' fields having cocoa plantations (Advani, 1982b). With predominance of Rattus rattus and Western ghat squirrel, Funambulus tristriatus, three mammalian species, like Long-tailed tree mouse Vandeleuria oleracea; a fruit bat, Cynopterus sphinx and House shrew, Suncus murinus were also collected in rodent traps. The Indian flying fox, Pteropus giganteus also damages cocoa pods besides coconut, banana guava, grapes etc. Regular trapping of rodents and bats in cocoa plots resulted in cost benefit ratio of about 1:500 in plantations near Kasaragod, increasing the productivity by more than ten times per ha.

Forest plantations

In Rajasthan (North India), due to debarking of stems and roots of important trees like Albizia lebbek, Prosopis cineraria and Acacia tortilis by rodents (mainly Cutch rock rat, Rattus c. cutchicus), heavy mortality among plants is observed (Prakash, 1975). Similar damages were also observed in A. tortalis plantations in Jaisalmer and in P. juliflora in Great Renn of Cutch (Prakash, 1977) in Gujarat state. Treatment with Zinc Phosphide (2%) could reduce rodent population by about 88 percent in two years.

Grasslands and Fodder crops

Nine rodent species with preponderance of gerbils, infest grasslands in the Western Rajasthan

biome (Advani 1982c). In monsoon season, rodents damage inflorescence. They feed upon stems, seeds and roots of the predominant grasses (*Cenchrus* spp., *Lasiurus indicus*) grown for livestock, causing great loss in the productivity of grasslands and in turn affect the milk production of region, which is source of income for **about 50 percent of the inhabitants of arid zone**. The annual forage feed requirements of gerbils at the density of 400 to 470/hectare, is about 1,040 kg/ha compared with an annual forage production of this range land of only 1,210 kg/ha. (Prakash, 1977).

Soil erosion and desertification

The extensive burrow systems of the desert gerbils and murids as well as their high numbers (14,000/100x100m plot), is a great danger for soil conservation in Rajasthan. By tunnelling the gerbils excavate 61,500 kg soil in a day per km² in crop fields and 10,43,800 kg soil/day/km² in uncultivated lands (Sharma and Joshi, 1975). Thus they uproot seeds of almost all cereal and vegetable crops.

Destruction to other crops and storage

The results of some studies conducted in a small area for a short term period are tabulated in the Table (1). Under storage conditions in rural complexes in Rajasthan, regular six monthly rodent trapping and control work resulted in saving of grains worth of Rs. 220 when only one rupee was spent (Prakash et al 1981).

Table 1.--Rodent damage to various crops: results compiled on the basis of short term studies in India

Crop	Damage propensity	Source
Cotton	57%	Panchabhavi and Thimmiah 1975
Groundnut	1-4% 12-31 kg/acre	Srivastava, 1966 Bindra & Sagar, 1968
Coconut	3-17%	Srivastava, 1966
Betel nut	20%	Valsala, 1958
Sugarcane	65-97 kg/ha loss 66.50 Rs/ha	Bindra and Sagar, 1968 Gupta et al 1971.
Tea bushes	upto 50% (roots)	Veeraraghavan, 1966
Barley	3-12%	Srivastava, 1968
Paddy	6-9% 1,400 kg (Storage)	Srivastava, 1968 Spillet, 1968
Sorghum	6%	Srivastava, 1966

Rodent pest management by predators

In regulating the rodent numbers predators play an important decisive role. However, parallel annual breeding cycles and reproduction capability of predators decide their effectiveness in controlling rodents. Reptiles, birds and mammals are some of the major vertebrates preying upon rodents in India. In North India, two species of lizards, *Varanus bengalensis* and *V. griseus konieczyni* are bigger and powerful as well as fast running reptiles to manage the rodent populations on the ground as well as trees. However, due to their diurnal activity patterns, they can only predate upon diurnal rodents like Indian desert gerbil, *Meriones hurrianae*, Bush rat, *Golunda ellioti gujerati* and the Indian palm squirrel, *Funambulus pennanti*. *F. pennanti* remains were collected in the stomach contents along with birds, lizards, fishes, beetles, crabs and snakes (Minton, 1966).

Snakes have been found to be promising agents in regulating the rodent numbers to a certain extent (Whitaker and Advani, 1983). Prakash (1962) listed some snake predators as the Rat snake, *Ptyas mucosus*; the Earth snake, *Lytorhynchus paradoxus*; five species of Coluber; the Sand snakes, *Eryx johani*, *E. conicus*; the Kraits, *Bungarus caeruleus*, *B. sindanum*, the Cobra, *Naja naja* and the Viper, *Echis carinata*. In addition to these, Minton (1966) reported that *Sphalerosphis archarius* also feeds upon the rodents. Whereas, Whitaker and Bhaskar (1978) found that Pythons regulate rat populations effectively.

Among birds, recently Jain and Advani (1982) found that about 66 percent of the fecal contents of owl, *Athene brama* had remains (bones, skulls, hairs etc) of *Mus* spp. on a yearly basis. Shikra, *Accipitar badius*; Tawny eagle, *Aquila rapax*, Merlin, *Falco chicquera* and Kestrel *Falco tinnunculus* are some of other bird species feeding upon rodents (Prakash 1975).

Predation by mammals like Long-eared hedge hog, *Hemiechinus auritus collaris* (krishna and Prakash 1960), the Indian false vampire bat, *Megaderma lyra lyra* (Advani, 1981; Advani and Makwana 1981). Asiatic jackal, *canis aureus*; foxes, *Vulpes bengalensis* and *V. vulpus pusilla*; Jungle cats, *Felis libyca* and *F. chaus* prateri and mongoose, *Herpestes edwaraii* are known to regulate rodent populations to some extent (Prakash, 1975).

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