Plant Archives Vol. 25, Supplement 1, 2025 pp.2408-2413 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.329

MANAGING VERTEBRATE PESTS IN AGRICULTURE: CHALLENGES AND STRATEGIES FOR SUSTAINABLE FOOD STORAGE IN DEVELOPING COUNTRIES

Kishore S. M.[1*], Chaitanya B. Police Patil[1], P. Dyamanagouda[1], A. Krishnaveni[2], Lavanya S.[1], Harideep[3] and Manideep K. S. N.[4]

[1]Department of Entomology, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences-Shivamogga-577204, Karnataka, India.
[2]Department of Entomology, College of Agriculture, Rajendranagar, PJTAU-500030, Hyderabad, India.
[3]Department of Entomology, College of Agriculture, Vijayapura-586101, UAS Dharwad, India.
[4]Department of Plant Pathology, Indian Institute of Horticultural Research, India.
*Corresponding author E-mail: kp464751@gmail.com;
ORCID ID: 0009-0007-0033-9310
(Date of Receiving : 09-10-2024; Date of Acceptance :16-12-2024)

ABSTRACT

Stored food losses due to vertebrate pests, particularly rodents and birds, pose a significant challenge in developing countries, exacerbating food insecurity for vulnerable farming communities. These pests not only cause direct consumption, contamination, and spoilage of stored grains but also affect the quality of seeds, which impacts future crop production. Rodents, including house mice (*Mus musculus*), roof rats (*Rattus rattus*) and Norway rats (*Rattus norvegicus*), along with pest birds, such as sparrows and crows, are among the primary culprits responsible for substantial post-harvest losses. In India, these pests damage various crops, including cereals, pulses, oilseeds and fruits, resulting in significant economic losses. A historical lack of accurate data and research on the scale of rodent damage has hindered effective management efforts. However, strategies such as habitat modification, trapping and the judicious use of rodenticides, as well as non-lethal bird control methods, have been suggested to mitigate these losses. Understanding the biology, behaviour and ecology of these pests is crucial for developing targeted and sustainable pest management approaches. Integrated pest management (IPM) strategies that incorporate both lethal and non-lethal methods, along with a focus on public awareness and community-based solutions, hold promise for controlling vertebrate pest populations and reducing food losses in rural settings.

***Keywords*:** Vertebrate pests, Rodents, Food losses, Pest management, Integrated pest management and Crop damage.

Introduction

Stored food losses at the farm and village level in the developing countries represent a significant but often poorly recorded issue, with many farm families, already facing poverty and food insecurity. While field crops are vulnerable to pests during the growing season, stored food remains at risk for 6-12 months post-harvest. In tropical and subtropical areas, household storage structures often harbour rodents and birds, leading to contamination, wastage and spoilage. The most severe loss occurs when seeds intended for the next crop are destroyed.

In developing countries, crop and food losses due to vertebrate pests, such as rats, mice and pest birds, are substantial, though often underreported. Farmers face double losses from these pests, both during the growing season and post-harvest (Tobin *et al*., 2004; Kumar *et al*., 2017). While crops are vulnerable to pest damage during their growth, stored food remains at risk while it is being kept for future use (Bhattarai *et al*., 2004; Gadi, 2017). Specialized storage structures

are commonly infested with rodents and birds, exacerbating the problem. Losses from these pests occur through consumption, contamination and spoilage, which can severely impact seed quality and hinder future planting (Cerda *et al*., 2017; Sridhara, 2016). Rodent and bird damage varies based on geography and season, with farmers employing methods like rodenticides, avicides, trapping and aversion techniques to mitigate these losses (Sexton *et al*., 2007). While much of the research has focused on individual pest species or crop-specific damage, there is a gap in studies addressing multiple pest species affecting different crops (Cummings *et al*., 2005; NASS, 2002).

In India, competition between humans and wild herbivores, especially in natural or cultivated fields, has become reason to increased crop damage. Species that were once not known for raiding crops, including elephants, wild pigs, bison's, monkeys, langurs, bears, bats, porcupines and various seed-eating and omnivorous birds, have now become significant pests in recent years. These animals have caused extensive losses to subsistence farmers and created conflicts with government conservation policies, as many of these species are endangered or threatened. This has resulted in a complex situation, with conservationists advocating for the protection of these species at all costs, while farmers, suffering from economic losses and demands compensation and action from the government. Effective management strategies, however, can only be developed by identifying the pest species causing damage, understanding their biology and evaluating pest control methods, while considering the local laws regarding wildlife protection (Rao & Dubey, 2006).

Historically, the magnitude of stored food losses due to rodents has been poorly documented. Early efforts to estimate these losses were based on speculative data that reveals a significant lack of precise information on the scale of rodent damage and the control measures needed. A survey was conducted by Hopf *et al*. (1976) found that most estimates of food losses were based on speculation, highlighting the widespread ignorance surrounding the scale of the problem and the methods of control. Jackson (1977) conducted a review of global food losses due to rodents but encountered similar data limitations. The US National Academy of Sciences (1978) acknowledged significant food losses in developing countries, though the data was often rough and unreliable. Despite efforts to gather more precise information, little new data emerged over the following two decades. Notable works by researchers like Dubock (1984), Meehan (1984), and Buckle and Smith (1994) offered brief mentions of rodent damage but failed to provide latest, updated and comprehensive data on the subject.

Major Vertebrate Pests of Stored Foods:

Rodents

The main rodent pests are the roof rat (*Rattus rattus*), house mouse (*Mus musculus*) and Norway rat (*Rattus norvegicus*). These species vary by region, but all contribute to food loss in agricultural settings. While the house mouse typically consumes less food than rats, its high population make it a considerable problem. The Norway rat, though less widespread than the roof rat, remains a major issue in many temperate regions. These rodents infest food storage structures, leading to food consumption, spoilage and contamination.

Rodents consume large amounts of food, and even a small number can cause significant losses. For example, a single adult Norway rat eats between 5 to 9 kg of grain per year. Although this seems minimal compared to the total grain stored in food warehouses, the losses add up when many rodents are involved. For instance, a group of five roof rats, three bandicoot rats, and ten house mice can collectively consume 43-57 kg of rice per year, representing a 4-6% loss of 1,000 kg of rice.

In India, rodents like *Rattus rattus*, *Mus musculus* and *Bandicota bengalensis* are widespread pests affecting various crops. These rodents are found in agricultural fields, warehouses and livestock facilities, where they cause more considerable damage to crops. The damage to cereals such as wheat, rice, maize and sorghum can range from 1.9% to 80%, with rodents particularly damaging crops during the seedling and maturation stages. In pulses, the damage can reach up to 100% at the seedling stage for crops like pigeon pea and 7% during pod maturation stages (Parshad, 1999; Sridhara and Tripathi, 2005). Oilseeds like groundnut and sunflower also suffer significant losses, ranging from 30% to 85% during seedling stages (Parshad, 1999). Rodents also damage fruits, vegetables and plantation crops, such as coconut and cocoa, with losses ranging from 5% to 60% (Sridhara and Tripathi, 2005).

Rodent Species and Behaviour

1. **House Mouse (*Mus musculus*)**
   - **Description**: Small, weighing around 15-20 grams, with a slender body and prominent ears.

- **Habitat**: Found worldwide, including rural and urban areas. They are common in food stores, fields, garbage dumps, and even cold stores.
- **Behaviour**: Nocturnal and territorial, house mice typically create burrows in fields and nest in the upper parts of buildings. They only need about 2-3 grams of food daily, often nibbling on food and discarding parts. They can breed year-round, with up to 6 young per litter. They reach sexual maturity in just 42 days.

2. **Roof Rat (*Rattus rattus*)**

- **Description**: Larger than the house mouse, with a body weight of 120-260 grams. They are slender with a sharp muzzle and prominent, hairless ears.
- **Habitat**: Roof rats are found in buildings, grain stores, markets, and even in trees and shrubs. They prefer living in the upper parts of buildings due to their excellent climbing abilities.
- **Behaviour**: They are nocturnal and mostly feed on grains, seeds, and fruits, eating around 8-12 grams of cereal grains daily. They breed throughout the year, especially in spring and fall. A single colony can have a dominant male and several females. Gestation lasts 20-22 days, with litters of about 6 young.

3. **Norway Rat (*Rattus norvegicus*)**

- **Description**: Larger than the roof rat, weighing 250-600 grams, with a bare tail and smaller ears.
- **Habitat**: Mostly found near water sources, they prefer living in basements, sewers, or between walls and floors in buildings. They infest coastal areas and food storage centres but are less common inland in tropical regions.
- **Behaviour**: Norway rats are excellent swimmers but poor climbers. They eat a variety of foods, including cereals and meat, consuming around 30 grams of food daily. They are more common in temperate regions, where they are often replaced by roof rats in the tropics. They can breed year-round with a gestation period of 21-23 days.

4. **Lesser Bandicoot Rat (*Bandicota bengalensis*)**

- **Description**: Similar in size to the Norway rat, weighing 250-600 grams with a coarse fur coat.
- **Habitat**: Found in parts of Asia, including India, Bangladesh, and Myanmar, they live in fields and urban areas, where they are known to infest homes and food stores.
- **Behaviour**: These rats are burrowers and hoard food, storing 3-4 times the amount they consume. They breed year-round, with a gestation period of 21-23 days. They can be aggressive when trapped but are susceptible to poisons similar to Norway rats.

5. **Gerbils (*Tatera* species)**

- **Description**: Small, weighing 50-220 grams, with a strong, rat-like build and soft to medium fur.
- **Habitat**: Found mainly in Africa and parts of Asia, gerbils live in grasslands, savannahs, and cultivated areas.
- **Behaviour**: These nocturnal rodents are great burrowers and hoarders. They primarily eat grains but will also consume fruits and insects. They have a gestation period of 22-30 days, with litter sizes ranging from 1-13 young. They breed during different seasons depending on the species.

1) Pest Birds

Unlike rodents, birds are not typically found inside farm or village structures, which limits their opportunity to damage stored foods. However, birds primarily cause harm in outdoor settings, especially during grain drying and threshing when grains are exposed. In these situations, pest birds such as house and tree sparrows (*Passer domesticus*, *P. montanus*), common pigeons (*Columba livia*), doves (*Streptopelia* species), Asiatic house crows (*Corvus splendens*) and common mynas (*Acridotheres tristis*) are attracted to the grains (Garg *et al*., 1966; Libay *et al*., 1983). Although the losses caused by birds are typically smaller than those caused by rodents, they still result in significant damage, especially when birds feed in large flocks.

Birds generally feed on waste or spilled grain found at threshing yards, drying fields and storage centres. In India, bird activity led to a loss of about 7.3 kg of grain over a 30-day threshing period (Garg *et al*., 1966). Similarly, in the Philippines, European tree sparrows caused losses of 4.5-5.0 kg per day of rice at duck farms (Libay *et al*., 1983). While these losses are smaller in comparison to those from rodents, they can still have an economic impact, particularly for smallholder farmers with limited resources.

To control bird damage, it is essential to prevent access to stored foods. One effective method is to use wire mesh or netting in open storage structures, which helps to keep birds from accessing the grains. At threshing or drying sites, bird-scaring devices, such as loud noises or visual deterrents like scarecrows, can be used to minimize losses. Additionally, removing

sparrow nests from farm structures can help reduce the presence of these birds (Garg *et al*., 1966).

In India, around 1,200 bird species, has 63 species from 19 families known to damage various crops, particularly grain and fruit-bearing crops. Granivorous birds, including the common peafowl (*Pavo cristatus*), rose-ringed parakeet (*Psittacula krameri*), blue rock pigeon (*Columba livia*) and rosy pastor (*Sturnus roseus*), cause damage to crops such as millet, wheat, paddy, and maize, (Qamar, *et al*., 2019). The damage from birds can range from 0.1% to 60%, with smaller grains being more vulnerable to bird damage than larger grains like maize (Rao & Dubey, 2006). Sunflower and groundnut crops are particularly prone to bird damage, with losses ranging from 10% to 90% in sunflower and 3% to 33% in groundnut (Rao & Dubey, 2006).

Non-lethal management strategies are commonly employed to control bird pests. These methods include altering crop patterns to deter birds, using chemical repellents, treating seeds with chemicals like Thiram, and employing scarecrows and pyrotechnic devices (Feare *et al*., 1988; Rao & Dubey, 2006). These approaches, when applied effectively, can significantly reduce bird-related losses while balancing the need to protect both crops and bird populations.

2) Bats

Bats also pose a challenge to agriculture, especially in orchards, (Marimuthu, 2004). Among the 12 species of fruit bats in India, three are commonly found throughout the country: *Cynopterus sphinx*, *Rousettus leschenaultia* and *Pteropus giganteus*. These species have been known to cause significant damage to crops like grapes, guava and areca nut, with damage reaching up to 100% in some cases (Srinivasalu & Srinivasalu, 2001; Verghese, 1998). Eco-friendly methods such as netting trees with fine-mesh nets, using mist nests to capture bats, and growing trap crops like Singapore cherry have been suggested as effective control measures (Chakravarthy & Girish, 2003).

3) Blue bull

The blue bull (*Boselaphus tragocamelus*) which is indigenous to India, has become a major pest in agricultural areas, particularly in states like Rajasthan, Haryana and Punjab. Its population has increased due to protection laws, lack of natural predators and deforestation (Chauhan & Sawarkar, 1989). The blue bull causes damage to crops such as gram, wheat, mustard and sugarcane, with losses ranging from 10% to over 50% in some areas (Chauhan & Singh, 1990). While some farmers rely on human and dog guards to protect fields, more sustainable solutions like fencing, sterilization, and translocation remain impractical due to high costs and opposition from local communities.

4) Elephants

Elephants, particularly the Asian elephant (*Elephas maximus*), have long been associated with crop raiding in India, a problem that has worsened due to habitat loss and fragmentation. Elephants are known to cause substantial damage to crops such as paddy, sugarcane and millet, with studies showing damage to up to 9% of cultivated fields (Balasubramanyam *et al*., 1995). The challenge lies in balancing conservation efforts for elephants with the need to protect agricultural livelihoods.

5) Monkeys

Monkeys, specifically *rhesus macaques* (*Macaca mulatta*), *bonnet macaques* (*M. radiata*), and Hanuman langurs (*Semnopithecus entellus*), have also become pests in agricultural areas, especially in urban fringes, (Malik, 2001). These primates consume a wide variety of crops, leading to significant losses for farmers (Chhangani & Mohnot, 2004). However, religious reverence for these animals complicates management efforts. Measures such as translocation and fertility control have been suggested, but their implementation faces cultural and logistical challenges (Southwick & Siddiqi, 2001).

6) Other Sporadic pests

Other sporadic pests like langurs, sloth bears (*Melurus ursinus*), wild boar (*Sus scrofa*), golden jackals (*Canis aureus*), hares and peacocks cause varying degrees of crop damage in specific regions. While traditional methods like trapping and hunting are still used, these methods are often criticized for being inhumane. A more effective approach is the Integrated Vertebrate Pest Management (IVPM), which seeks to combine various strategies, reducing reliance on lethal methods and considering social and ethical concerns.

1) Managing Rodent Populations on Farms

Effective rodent management is crucial for reducing these losses. A combination of methods, including habitat modification, rodenticide application and trapping, is often used to control rodent populations. Habitat modification involves removing food and shelter sources to make areas less conducive to rodent infestations. Trapping and the strategic application of rodenticides can help reduce rodent numbers, though these measures should be implemented cautiously to avoid environmental damage and non-target species harm.

Farmers can reduce rodent damage to stored food using simple, cost-effective methods that are easy to implement. These methods focus on three key strategies: maintaining cleanliness, preventing rodents from accessing food and reducing rodent populations.

1. Sanitation and Good Housekeeping

Keeping farm areas clean is essential to prevent rodents from finding food. Farmers should sweep up any spilled grains daily and avoid leaving food scraps around. Cooking areas and utensils should be cleaned regularly. Grains, vegetables, and spices should be stored in tightly sealed containers when not in use. It's important to trim vegetation near farm structures, especially fruit trees and vines, as they attract rodents. When drying grains outside, the area should be swept afterward to remove leftover debris.

2. Denying Rodents Access to Food

Storing large quantities of grain can be difficult, but it's important to protect it from rodents. Jute bags and woven baskets do not effectively keep rodents out. Instead, metal, ceramic containers or concrete bins should be used. For cost-saving, farmers can collaborate and store grains collectively in a shared structure. This may require cooperation to ensure fair storage and withdrawals. In homes with chickens or other birds, their food should be kept in rodent-proof areas, and any uneaten food should be cleaned up daily.

3. Reducing or Eliminating Rodent Populations

Rodent nests in roofs and beams should be destroyed, and burrows around the farm should be dug up and eliminated. Trapping can help reduce rodent populations. One method is using glue boards, though these can be ineffective in poor conditions. If affordable, poison baits can also be used carefully, ensuring they are out of reach of children and animals. Anticoagulant poisons like warfarin or zinc phosphide can be effective, but they must be handled with caution. Baits should be placed in secure containers to prevent accidental exposure to humans or pests.

Table 1 : Strategies for rodent pest management suitable for Indian agriculture.

Sl. No.	Strategy	Steps/Technology to be Adapted
1	Preventing access to crop fields.	➢ Tillage ➢ Bund reduction ➢ Agro-forestry ➢ Barriers
2	Discouraging infestation	➢ Clean cultivation ➢ Resistant varieties ➢ Synchronized Planting
3	Density reduction	**Physical control** ➢ Hunting and killing ➢ Trapping ➢ Trap barrier system **Chemical control** ➢ Acute rodenticides ➢ Chronic rodenticides ➢ Fumigants ➢ Timing of control ❖ Prophylactic control ❖ Symptomatic control **Biological control** ➢ Predators ➢ Pathogens and diseases. **Fertility control** ➢ Steroids. ➢ Immunocontraception vaccines. ➢ Predator odours.
4	Integrated pest management of rodents	➢ Understanding pest species. ➢ Action threshold. ➢ Population dynamics. ➢ Management. (a) Prevention of infestation (b) Non-lethal or weak chemical use. (c) Pesticide application.

Over the past three decades, significant efforts have been made in India to control vertebrate pests, including research on pest biology, rodenticides and non-chemical management techniques. Despite these efforts, rodent damage remains a persistent issue, with occasional outbreaks. This ongoing problem can be attributed to two main factors: the biological adaptability of rodents and socio-economic conditions. Rodents, being prolific breeders with high reproductive rates, and their ability to adapt quickly to changing environments, evade control methods. In addition, genetic resistance to anticoagulant poisons and behavioural traits like neophobia and bait shyness further complicate control measures (Parshad, 1999). Farmers, particularly those with small land holdings, often neglect pest control due to a lack of awareness, education, and resources. Many see rodent damage as an unavoidable problem that cannot be effectively managed.

Conclusion

Rodent and bird damage to stored food in developing countries, particularly in rural areas, is a persistent and often underreported issue. Effective management strategies are essential to reduce these losses and improve food security. Integrating non-lethal methods, habitat modification, and environmentally safe pest control measures can help mitigate damage. However, challenges remain due to

the adaptability of pests, socio-economic factors, and limited resources for farmers. Collaborative efforts, education, and appropriate pest management strategies are key to addressing this complex problem, ensuring sustainable agricultural practices and minimizing food waste.

References

Balasubramanyam, M. N., Baskaran, S., Swaminathan. and Desai, A.A. (1995). Crop raiding by Asian elephant (*Elephas maximus*) in the Nilgiri Biosphere reservoir of south India. Pp. 350-367 in: J. C. Daniel and H. Datye (Eds.), A Week with Elephants. Bombay Natural History Society and Oxford University Press, Bombay, India.

Bhattarai, B.P and Basnet, K. (2004). Assessment of crop damage by wild ungulates in the eastern side of Barandabhar corridor forest, Chitwan. Proceedings of IV National Conference on Science and Technology, 1976 1980.

Buckle, A. P. and Smith, R.H. (1994). Rodent Pests and Their Control. pp. **405**. CAB International, Wallingford, UK.

Cerda, R., Avelino, J., Gary, C., Tixier, P., Lechevallier, E. and Allinne C. (2017). Primary and secondary yield losses caused by pests and diseases: assessment and modeling in Coffee. *PLOS ONE*, 12(1): e0169133.

Chakravarthy, A. K. and Girish, A.C. (2003). Crop protection and conservation of frugivorous bats in orchards of hill and coastal regions of Karnataka. *Zoo's Print J.* **18**(8):1169-1171.

Changani, A. K. and Mohnot, S. M. (2004). Crop raid by Hanuman langur, *Semnopithecus entellus*, in and around Aravalli hills (India) and its management. *Primate Report.* **69**:1-18.

Chauhan, N. P. S. and Singh, R. (1990). Crop damage by overabundant populations of Nilgai and black buck in Haryana (India) and its management. *Proc. Vertebr. Pest Conf.* **14**:218-220.

Chauhan, N. P. S. and V. B. Sawarkar. (1989). Problems of over abundant populations of Nilgai and black buck in Haryana and Madhya Pradesh. *Indian Forester.* **115**(7):488 493.

Cummings, J. L., Shwiff, S. A. and Tupper, S K. (2005). Economic impacts of blackbird damage to the rice industry. *Pro. Wildl. Damage Manag. Conf*, **11**, 317e322.

Dubock, A.C. (editor). (1984). Proceedings of a Conference on the Organisation and Practice of Vertebrate Pest Control. Elvetham Hall, UK. 30 August-3 September 1982.

Feare, C. J., P. W., Greig-Smith. and Inglis, I.R. (1988). Current status and potential of non-lethal means of reducing bird damage in agriculture. *Proc. Int. Ornithol. Cong*. **19**: 493-506.

Gadi, V.P.R. (2017). Integrated management of insect pests on canola and other brassica oilseed crops. Centre for Agriculture and Bioscience International, Wallingford, Oxford shire, United Kingdom, 240-255.

Garg, S.S.L., Singh, J. and Prakash, V. (1966). Losses of wheat in thrashing yards due to birds and rodents. *Bull. Grain Tech*. **4**(2): 94-96.

Hopf, H.S., Morley, G.E. and Humphries, J.E. (1976). Rodent damage to growing crops and to farm and village storage in tropical and subtropical regions. pp. 115. Cent. Overseas Pest Res., London, UK.

Jackson, W. B. (1977). Evaluation of rodent depredations to crops and stored products. *EPPO Bull*. **7**: 439-458.

Kumar, D. and Kalita P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods*, **6**(1): 8.

Libay, J. L., Fiedler, L.A. and Bruggers, R.L. (1983). Feed losses to European tree sparrows (*Passer montanus*) at duck farms in the Philippines. Proceedings of the Ninth Bird Control Seminar. Bowling Green State University, Bowling Green, OH, 4-6 October 1983. pp. 135-142.

Malik, I. (2001). Monkey menace – who is responsible. In: A. K. Gupta (Ed.), Non-Human Primates of India. Wildlife Institute of India, Dehradun, India.

Marimuthu, G. (2004). A non-commercial fruit attracts bats and saves commercial fruits - a boon to orchardists. BAT NET **5**(1).

Meehan, A.P. (1984). Rats and Mice, Their Biology and Control. pp. 383. Rentokil Ltd. East. Grinstead, UK.

National Academy of Sciences. (1978). Post-harvest Food Losses in Developing Countries. pp. 206. National Academy of Sciences. Washington, D.C., USA.

National Agricultural Statistics Service (NASS), (2002). U.S. Wildlife Damage. Agricultural Statistics Board. U.S. Department of Agriculture.

Parshad, V. R. (1999). Rodent control in India. *Integr. Pest Manage. Rev*. 4:97-126.

Qamar, S.U.R., Khan, W.A., Wasti, S.M.A., Majeed, W., Naveed, M., Samad, A. and Khan A.U. (2019). Damage impact of vertebrate pests on different crops and stored food items. *GSC Biological and Pharmaceutical Sciences*. **6**(1), 16-20.

Rao, V. and Dubey, O.P. (2006). Granivorous bird pests and their management. Pp. 29-61 in: S. Sridhara (Ed.), Vertebrate Pests in Agriculture -The Indian Scenario. Scientific Publishers, Jodhpur, India.

Sexton, S.E, Lei, Z. and Zilberman, D. (2007). The economics of pesticides and pest control. *International Review of Environmental and Resource Economics*, **1**(3): 271-326.

Southwick, C. H. and Siddiqi, M.F. (2001). Status, conservation and management of primates in India. In: A. K. Gupta (Ed.), Non-Human Primates of India. Wildlife Institute of India, Dehradun, India.

Sridhara, S. (2016). Vertebrate pests in agriculture. Scientific Publisher, Jodhpur, India, 378.

Sridhara, S. and Tripathi, R.S. (2005). Distribution of rodents in Indian agriculture. Indian Council of Agricultural Research, Technical Bulletin No. 13. Central Arid Zone Research Institute, Jodhpur, India. 136 pp.

Srinivasulu, B. and Srinivasulu, C. (2001). Magnitude of depredation on grapes by short nosed fruit bats, *Cynopterus sphinx* Vahl, 1997 in Secunderabad. *Curr. Sci.* **80**(1):14-15.

Tobin, M.E. and Michael, W.F. (2004). Pest control: Rodents. USDA, National Wildlife Research Centre - Staff Publications, 67.

Verghese, A. (1998). Non-destructive control of the bat, *Cynopterus sphinx* Vahl (Chiroptera: Pteropodidae) in grapes (*Vitis vinifera* Linn) in India. *Int. J. Pest Manage*. **44**:81-85.