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Short Article

Advancements in Rodent Vector Management for Food and Health Security

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A B S T R A C T

Rodent vector management has undergone substantial development in today's world which has helped to save the damage to agriculture and human health. It is a known fact that rodents are mammal species which are characterised by peculiar upper and lower pairs of ever-growing rootless incisor teeth. Moreover, rodents are the largest group of mammals with approximately 4,660 species. The impact of these species on human populations leads to big threats to the national economy and health. Crops are damaged before harvest, stored food is contaminated by rodent wastes, and burrowing buildings and pieces of furniture are damaged by the gnawing nature of rodents. From the point of view of human health, certain species are reservoirs for diseases such as plague, murine typhus, scrub typhus, tularaemia, rat-bite fever, Rocky Mountain spotted fever, and Lassa fever, among others. In the present manuscript, an attempt is made to highlight the recent advances in rodent vector management for food and human health.

Keywords: Rodents, Environment, Agriculture, Mammals, Bio-Diversity

South Asia including India, has ecologically rich, natural and crop-related biodiversity due to its unique geographic location and diversified climatic conditions. India is one of the 12 mega-biodiversity centres with three out of 34 biodiversity hotspots in the world. In addition, recent changes in climatic patterns owing to increasing industrialisation and over-exploitation of natural resources for various developmental activities, are affecting many species of plants, animals and insects resulting in a decrease in their populations.[1] Such accelerating loss of biological diversity reduces the ecosystem's resilience. Small mammals including rodents play a vital role in providing various ecosystem services and their demographic variations impact both agricultural productivity and human health.

Rodent-borne Zoonotic Diseases

Health security is the primary need for any country. Environment-led changes such as floods and temperature variations increase the chances of rodent-borne bacterial diseases like leptospirosis, salmonellosis and scrub typhus thus impacting human health.

- Leptospirosis became endemic in Andaman and Nicobar, Kerala, parts of Karnataka, Tamil Nadu, Gujarat and Orissa.[2] In addition, Mumbai city is known to experience

incidences of leptospirosis every year linked to water stagnation due to the South-West monsoon. The city has recorded 29 leptospirosis cases since January 2023 with a fatality rate of 46%. As humans and livestock are in regular contact with rodents, the potential for transmission of this disease is very high. The 2022 October floods resulted in 123 suspected cases with 71 confirmed cases of leptospirosis in different parts of Kerala. Similarly, sporadic cases of the disease have been reported by the Municipal Corporation of Chennai also.[3] Since this disease remained undiagnosed, its prevalence elsewhere is not known in the country.

- Rodents, especially mice, exude pheromones for their various body functions, particularly home range maintenance. However, some of them incite adverse and allergic reactions in humans in residential premises, schools, hospitals, stores, restaurants, animal laboratories and other public facilities.[4] The health impact of rodent exposure starts with sensitisation, which leads to allergy and then to morbidity if the exposure continues. Exposure to rodent allergens, particularly to levels above 1.6 µg/g of dust, is associated with an increased risk of developing rodent-specific IgE. For that reason, it is recommended to reduce rodent allergen exposure as much as possible. A more linear or even sigmoidal type of relationship exists between exposure and morbidity, which could mean that any amount of exposure might potentially be harmful. Once sensitisation has occurred, continued exposure is associated with a risk of developing disease. With further exposure to rodent allergens, sensitised individuals tend to develop symptoms, such as wheezing and rhinorrhoea. To minimise this risk, exposure reduction is recommended for sensitised individuals. Immunotherapy for rodent allergy has not been adequately studied, so no recommendations have been provided regarding the administration of rodent-specific immunotherapy. The problem with obtaining high-level evidence to demonstrate the efficacy of rodent avoidance measures is that most interventions are non-specific.
- Scrub typhus is a re-emerging zoonotic disease and its distribution is linked to temperature, rainfall and disturbed environment. Originally scrub typhus outbreaks were in areas located in the sub-Himalayan belt, from Jammu to Nagaland, due to low temperatures. Reports of scrub typhus outbreaks in Himachal Pradesh, Sikkim and Darjeeling (West Bengal) during 2003-2004 and 2007, more frequently during the rainy season, have been found. However, in southern India, outbreaks are being reported during the cooler months of the year. In a rarely organised systematic survey in Tamil Nadu, several districts were reported to have this zoonosis.[5]
- *Salmonella* - Since 1990, a multi-drug resistant variety of typhoid fever, caused by *Salmonella typhi* and resistant to most of the existing antibiotics, had been prevalent in many parts of India.[6] Human infections of the virus of Kyasanur forest disease, transmitted by *Haemaphysalis* ticks, were reported in Karnataka state. This disease is maintained in small mammals, such as *Suncus murinus* and *Rattus* species, while monkeys in forest areas serve as amplifying hosts.[7] In recent times, this disease has been reported in parts of Kerala, Tamil Nadu, Goa, and Maharashtra also. The symptoms of this disease include diarrhoea, lower abdominal pain, fever, and meningo-encephalitilis.
- Rat Bite Fever (RBF) received its name due to how the disease spreads. The disease causes common symptoms such as a fever or vomiting, but it can also lead to joint pain, swelling, or a rash. Streptobacillary RBF can cause infections in the liver, lungs, brain, and heart. Spirillary RBF comes with fever, swelling, swollen lymph nodes, and a rash.
- Tularaemia is a bacterial disease associated with rodents which can cause various symptoms including ulcero-glandular, glandular, oculo-glandular, oropharyngeal, pneumonic, and typhoidal symptoms.
- Viral zoonoses include diseases caused by (1) Hantavirus - pulmonary syndrome, haemorrhagic fever with renal syndrome, Lassa Fever, and (2) the Arenavirus - Argentine, Bolivian, Sabiá-associated, and Venezuelan haemorrhagic fevers. Cases of monkeypox, a viral zoonosis, are on the rise at the global level. Simultaneously, the world is still facing a COVID-19 pandemic with its variants, despite the number of cases tapering off. The world body warned that such issues are becoming increasingly common as factors such as the destruction of animal habitats and human expansion into previously uninhabited areas intensify. Rat-bitten coconut films filled with rainwater often become the main breeding place for *Aedes* mosquitoes. This caused the outbreak of Chikungunya in the Lakshadweep Islands.

Impact of Fluctuating Rodent Vector Populations on Food and Nutritional Security

The aggravating pest problems under changing climate regimes are expected to intensify the yield losses, threatening the food security of countries with high dependency on agriculture.[8,9] This has major implications for food and nutritional security.[10] Population irruptions sometimes lead to rodent outbreaks[11] which may create famine-like conditions. Reasons attributed are (i) prolonged

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drought/ dry spell followed by heavy rains increasing the reproductive propensity of the rodent pests as happened in Saurashtra Region of Gujarat state, (ii) failure of monsoon in the preceding year resulting in a favourable environment for rodent breeding as in Cauvery delta area of Pondicherry (Karaikal Region) and Tamil Nadu (Tanjore & Nagapattinam districts) states, (iii) flash floods leading to an unusual increase in the subsequent carrying capacity of the environment for rodent pest breeding and absence of predators, and (iv) flowering of *Melocanna baccifera* and *Bambusa tulda* species of bamboo leading to increased carrying capacity in the *jhum* cultivated fields in Arunachal Pradesh, Manipur, Mizoram and Nagaland States.

Impact of Flash Floods on Rodent Outbreaks in Andhra Pradesh

Andhra Pradesh has a history of periodic rodent outbreaks in the rice belt of the Godavari and Krishna basins.[11] Major outbreaks are reported every ten years, while minor outbreaks occur in the delta districts every four years. During 1997-98, a major rodent outbreak occurred as a result of the increased reproductive potentiality of rodent pests caused by a favourable environment created by flash floods during 1996. A potential loss of 17,497 MT of rice was saved in Kharif 1997 by the Federal Government due to the implementation of rodent control campaigns spending Rs. 1,399.76 lakhs.[11] Another climate-induced rodent outbreak during 2001 in the East Godavari and adjoining West Godavari districts affected by flash floods made the rodent pest sex ratio 1:4.7 favouring females instead of 1:1 with all adult females in pregnant/ lactating situations having 10.5 young ones/female[12] instead of 6-7 per female. This led to a rodent vector outbreak situation affecting the livelihood of the villagers in these affected areas as their survival is directly linked to outcomes from food production systems.

In 2010, another rodent outbreak was reported in the West Godavari district with an estimated rice tiller damage of 49.24%. The rice crop was truncated in Rabi 2009-10 and in its place, black gram was planted in an area of 23,345 hectares.[13] Due to the higher palatability of black gram, the immigration of rodents happened from all neighbouring uncultivated rice growing areas. In addition to this, black gram cultivation favoured rodent breeding leading to some farmers abandoning the harvest of the crop due to poor yields. These environmentally induced favourable conditions further made rodent pests breed at an exponential rate.

Impact of Drought on Irruption of Rodent Populations

Environmental events such as flash floods and above-average rainfall after a prolonged dry spell/ drought also increase the availability of high-quality food and harbourage and induce a faster mode of breeding pattern. The Saurashtra region of Gujarat state experienced this in 1990 when the state got copious rainfall preceded by a 3-year-long drought period.[14] Similarly, the rodent outbreaks in Tamil Nadu and Pondicherry in 1994 need a mention. In normal years, a natural equilibrium of rodent populations was achieved in the tail-end areas of these two southern states due to the flooding of rice fields by the Cauvery River water during the September-November months. However, in 1993, the Cauvery water was insufficient to flood the fields resulting in irruptive populations with a higher average litter size of 18 per female as well as an abnormal sex ratio of 3:4 in favour of females[15] compensating for the mortality rate. This makes it imperative to plan rodent management measures systematically considering environmental interactions and pest situations.

Climate and Bamboo Flowering

It is believed that climatic factors induce sporadic bamboo flowering, which extends to gregarious flowering in Northeast India. The bamboo, *Melocanna baccifera,* flowers once in 48 years triggered by the environment, further resulting in favourable conditions for them. During the initial sporadic flowering period, the supply of resources like food and shelter exceeds the demand for rodent survival leading to unrestrained breeding. Under these situations, rodents produce many young ones in shorter intervals due to the onset of a faster mode or 'r' pattern of breeding which leads to an increase in the length of the breeding season as well as the survival of the individuals into the next season. The rodent population irrupts and the surplus rodents migrate and establish themselves in newer habitats. This process is repeated in a 3 to 4-year period with the gregarious flowering phase. With the death of the bamboo after the gregarious flowering phase, the irrupted rodent populations face deprivation of food as well as shelter, which leads to mass migration of rodent populations to adjoining areas and even residences of the local population. Even the agricultural/ horticultural crops around would be devoured by these irrupted populations resulting in famine-like conditions for locals. As per the past record, gregarious bamboo flowering by *Bambusa tulda* is expected during 2023-25 (and hence systematic planning is needed to prevent rodent irruptions in the initial stages itself.[11]

Mitigating Environmental Impacts on Rodent-related Issues

In all such situations, farmers initiate the practice of rodent control campaigns under the farmers' participatory adoption to combat the rodent problem in crop fields and often they ignore treating residential premises/ structures, although they were listed in the standard operational procedure. It is imperative to mitigate rodent-related issues viz., commodity/ storage losses and zoonotic diseases,

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that may emanate from environmentally induced climate changes. Initiating only community rodent control measures at a faster mode of breeding would not be sufficient due to compensatory breeding by residual populations. Hence, it is imperative to plan rodent management measures systematically looking at the situation of the pests, habitat, and environmental interactions.

Sensitisation of Stakeholders

Considering the impacts of future environmental changes on the sustainability and productivity of agriculture, there is a need to sensitise the farmers, extension workers and other stakeholders involved in supply chain management about the likely changes in the incidence of rodent pests and diseases and desired strategies to cope with the situation through awareness campaigns, training and capacity enhancement programmes, and by the development of learning material, support guides etc. for different risk scenarios.

Farmer Field Schools

The farmer field schools could be utilised for farmer-to-farmer-led extension with respect to rodent pests. In addition to increasing the decision-making ability, this approach provides farmers with an adaptive capacity and helps them to be considered as equal partners to improve the dissemination of knowledge at the farm level. A decision support system (DSS) involving mechanisms for the collection and dissemination of information on rodent pest surveillance needs to be developed for preventive actions on both crop loss and zoonotic disease prevention at the national level.

Promotion of Resource Conservation Technologies

Proven scientific and indigenous technical knowledge (ITK) in trapping, burrow smoking etc. is helpful to mitigate the adverse effects of even chemical rodenticides besides moderating soil temperatures and conservation of soil microbes. However, more studies are required towards integrating indigenous adaptation measures and scientific research.

GIS-based Risk Mapping of Crop Pests

Geographic Information System (GIS) is an enabling technology for agriculture extension professionals, which helps in relating rodent outbreaks to biographic and physiographic features of the landscape that can best be utilised in large-scale rodent pest management campaigns. Trends of climatic changes affecting the development, incidence, and population dynamics of rodent pests can be studied through GIS by predicting and mapping trends to delineate the agroecological hotspots and future areas of pest risk. This is particularly important at this time since *Dendrocalamus* flowering-led rodent outbreak is likely to occur in 2020-23.[11]

Problematic Issues and Suggested Actions

1. Resurgence: Several pathogens which caused pandemics in the past ages are showing a resurgence, with outbreaks highlighting ageing or decaying infrastructure systems, such as sewage or water treatment, and the failure of consumers to know, understand or heed the common-sense warnings related to rodents.
2. Understanding the pathogens and route of transmission: A careful study of the associated epidemiology of emerging diseases, and their routes of infection and natural reservoirs, is the only way to gain insights for planning appropriate measures to prevent epidemic zoonoses outbreaks. Research in these directions needs to be accelerated by qualified competent scientists (both medical and non-medical personnel).
3. Pest/ Vector surveillance: Pest and vector surveillance are needed to be implemented by local governments for analysis and planning of pathogen management.[16] The methodology to be followed is shown in Table 1.
4. Awareness creation programmes: Vector orientation/ awareness creation programmes need to be increased.
5. Studies on risk exposures in poor infrastructure areas: There is a need to identify the source of contamination and risk exposures, which normally are highly prevalent in slum areas or with high-density urban populations so that effective community-based preventive measures can be implemented.
6. Development of qualifications for employable skills in pest/ vector management: There exists a lack of qualified pest/ vector personnel and often personnel with flimsy knowledge are employed for pest and vector management tasks by local bodies and public undertakings. Identifying this, the National Institute of Rural Development, Government of India developed standards for pest and vector control.[17]
7. Involving ICAR scientists and pest management professionals: So far ICAR–AINP on Vertebrate Pest Management has been dealing with field pests; now this project may initiate some research work on vertebrate pest management, especially commensal rodents. The governments and public undertakings including food and manufacturing industries may associate with qualified pest/ vector control professionals for a long-term impact.

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Table 1.Residents' Questionnaire to Screen the Impact of Rodent Vectors in Premises on Allergic Reactions

1. Details of premises

Name of the ward and municipality:

Name of the locality:

Name of the apartment with details:

2. Details of residents

No. of residents: age, profession/ workplace and educational qualifications to be provided individually

Adult:

Males:

Females:

Children:

Males:

Females:

Toddlers:

3. Details of symptoms of the disease

No. of residents having symptoms with details

i. Rat/ mouse bites
ii. Rashes
iii. Blisters
iv. Fever
v. Diarrhoea/ motions
vi. Vomiting or symptoms
vii. Other allergic symptoms
viii. Any other disease

4. Type of building premises

Presence of trees with no. of branches around the premise: if so, no. of branches touching the building/ roof

Presence of compound wall around the premises: Yes No

Gate having steel rods/ metal sheet 6 inches from the ground:

No. of drain openings at the compound wall: Wide open/ mesh fixed:

Type of gates – With cattle traps:

Without cattle traps:

No. of holes present on the compound wall/ s with the height from the plinth:

No. of holes with wire mesh:

No. of windows with wire mesh/ without wire mesh:

No. of electric or other cables entering the building:

Drainage situation/ condition of drainage in the locality: Open/ closed

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Drain pipes from the ground to the building:

Drain pipes having mesh at the drainage canal:

No. of wires entering the premise:

5. Within the premises

Rat/ mouse damage recorded with place:

Faecal pellets observed:

Type of cleanliness: Regularly done

Sometimes done

Weekly done

Premise storage: Present

Absent

Placement of storage items:

i. Adjoining walls
ii. 4-6 feet away
iii. Storage done in tins
iv. Stored in paper packets

6. Rodent species spotted

No. of rodent footprint tracks observed

Rodent faecal pellets spotted in areas -

i. Corners
ii. Trains
iii. Ventilators
iv. Rat holes
v. Other places … Please specify

Rodent smears observed on wires and pipes at places:

i. On overhanging leaves of adjoining trees
ii. On the electric and cable wiring
iii. At other places… Please specify

7. Efficacy of rodent management

S. No.	Particulars	Before Management (A)	After Management (B)	Control (%) A-B/A X 100

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