

Role of rodents in poultry environs and their management

Abstract

Many poor and middle class farmers in developing countries are taking up poultry since the industry has become a major source of income. Poor quality sheds and their proximity to the crop fields and village habitats result in migration of premise pests like flies, cockroaches, rodents in to the poultry environment contributing to significant losses. Among them rodents take primary share due to their role as pests as well as vectors. They make both qualitative and quantitative losses by feed and egg consumption, losses to the structures, nuisance value causing loss of productivity in the farms. In addition, they transmit dreaded disease like Salmonellosis Pasteurellosis, Mycoplasmosis, Hemorrhagic enteritis, Hymenolepiasis, Capillariasis, and Ascariasis to the birds. A Global level review was made on different rodent species responsible for these losses, the characteristic features of major pests. The procedures involved in inspection of the poultry premises and assessing the rodent infestation were spelled out to facilitate planning the rodent management measures. The available management practices of prevention of the unwanted creatures in to the poultry premises along with curative practices viz., using traps and rodenticides were spelled out. It is expected that by managing rodent pests/vectors, both food and health security would be ensured.

Keywords: rodents, salmonellosis, *Rattus rattus*, *Mus musculus*, inspection, management

Volume 2 Issue 3 - 2015

Mohan Rao AMK, Sakhivel P

National Institute of Plant Health Management, India

Correspondence: AMK. Mohan Rao, Sai Viswanatha Residency, MIGH 16, Mehdiapatnam, Hyderabad, India, Tel +91 944 065 4555, Email mohanrao.arasada@live.com

Received: April 19, 2015 | **Published:** June 24, 2015

Introduction

Commercial poultry production is rapidly expanding worldwide to meet the needs of the increasing human population. Further, with the reduced cost and enhanced incomes the per capita poultry meat consumption is increasing. Many poor and middle class farmers in developing countries are taking up poultry to supplement their income and this industry has become a major income source to them. The industry has been growing at 2-3% per year and is expected to continue expansion in the foreseeable future. Global poultry production is anticipated to increase 1.8 percent to 106 million tonnes in 2013.¹ As per Global Production Trends in 2012, the egg production in the world was about 65.5 million tonnes and Asia took a share of 38.3 million tonnes (58.5%). The egg industry growth from 2000 to 2011 was 2.6 per cent per year compared to global growth of 2.3 per cent. India, second in egg production in Asia, produced 3.49 million eggs during 2011. In India the production has increased from 2 million tonnes in 2000 to 3.5 million tonnes during 2011 with an average growth of 5 to 6 per cent per year.² This large poultry industry requires extensive housing for the birds to increase the meat and egg production. This intensive production by housing a large number of individuals in relatively small area generates large quantities of wastes (manure, used litter, dead birds) and provides favourable environment for the exponential growth of arthropod and rodent pests. Hence, effective pest management became an essential component for poultry industry. An attempt is made in this review to identify the existing rodent problems as pests as well as vectors transmitting zoonotic diseases, the existing planning strategies and management measures to achieve food and health security.

Poultry pests

Both ecto-parasites and premise pests constitute pest component

in poultry environs. The ecto-parasites include mites, lice, fleas, ticks etc. The premise pests include beetles, flies, moths, cockroaches and rodents. Poor quality sheds and their proximity to the crop fields and village habitats result in migration of these pests in to the poultry environs contributing to significant financial losses. The minor pests are attaining often major pest status in high-density large production systems. Among the pests, rodents are the most destructive pests which cause damage directly to the poultry structures by their burrowing nature, gnawing habits and consumption of poultry feed, eggs and chicks. Their indirect impact include contamination of the poultry feed through their urine, faeces and hair. In addition, they also transmit various diseases to poultry birds as well as workers.

Rodent pests: Rodent pests contribute significant losses to poultry farms throughout the world. It is not easy to estimate precisely the losses caused by rodent pests in the poultry situation since both qualitative and quantitative losses occur.³ There is no concerted effort also to estimate the rodent borne losses. As a result precise data on their losses are lacking. An attempt is made to put the available information in this review.

Feed loss: Rodents eat poultry feed and they waste and contaminate more than they eat. With a modest estimate of their feed consumption at 10% of their body weight, the rats consume about 25g per day and 9.1kg per year. If that daily figure is converted to a yearly estimate and if as many as 20 rats are present in a rural poultry shed, the annual loss per shed could reach 0.18 ton. If the feed costs \$175/ton, that cost would be \$31.50 or \$1.57 per rat. Brooks & Fiedler⁴ estimated similar loss with respect to Norway rat, 8-12 per day with 3-4kg per year for Roof rat and 2-3g per day with 0.7 to 1kg per year for House mouse. In big poultry houses and poultries having heavy infestation the feed loss would be much higher. Hamilton⁵ and Greeves⁶ reported an annual loss of 23 and 2kg per animal respectively in the case of Norway rat

and House mouse. Rats take 10g of feed for day but destroy 10times of feed and poultry birds refused to take such contaminated feed. This refused contaminated food is unaccounted, while taking rodent related losses. The estimate by ICAR Rodent Research Project in India projected the losses as Rs. 94 per 1000 birds in Punjab. Chopra⁷ reported feed loss ranging from 0.05 to 0.14kg in sheds, 0.18 to 6.38kg in feed store and spillage up to 20kg/day in heavily infested poultry houses. In addition to the feed loss, rodents also spoil the feed through their spillage behaviour. Feed spillage losses were never scientifically estimated.

Losses to the eggs: Several studies in India estimated loss was 0.5% in egg production and some time it reaching up to 10% under poor storage conditions. Similarly, the damage to eggs was estimated as Rs. 0.63/100 eggs/day in Punjab.⁸ In southern Sindh of Pakistan, rats caused a great loss to poultry farmers by attacking over the eggs, young ones and feed of poultry.⁹

Losses to the structures: Physical damage to the building and equipment is another way rodents can be costly. One of the main characteristic features of rodents is their gnawing habit. Their upper incisors grow perennially at 0.4mm per day. This has led to their acquired habit of gnawing objects in an attempt to arrest the growth of the incisors. This often results in damage to the non-edible items in their habitat. Rodent damage may start as small initially, but quickly develop into a major problem that will be expensive to correct. Due to the gnawing behaviour, even poultry buildings with fibre glass insulated walls are reported to be vulnerable to rodent damage since they attack and make nest in the insulated walls.¹⁰ They gnaw the support structures, plastic curtains, egg belts, egg elevators with sponge fingers, and burrowing under walls and concrete.¹¹ They can inflict severe damage to poultry buildings by establishing the burrows through foundation from underneath or making holes on the roofs resulting in water leakage during rainy seasons, gnawing and nibbling of wooden doors, windows etc.

In feed manufacturing units damage to food conveyer belts have frequently reported over the repair and replacement cost up to \$15000.³ Some USDA estimates of the actual cost of rats wasting feed and damaging the house and equipment are as high as \$25per rat per year. Another potential problem is the danger of fire due to rodents' gnawing insulation on electrical wiring. Damage to building insulation is expensive, and the chronic energy losses and associated effects on poultry production magnify that expense.¹² Operational shutdowns or power failures due to electrical or mechanical malfunctions as a result of rodent damage can cost an operation thousands of dollars and the possible loss of an entire house of birds in only a few short minutes.

Nuisance value: In addition, rodents, especially *Rattus rattus* and *Bandicota bengalensis* cause general nuisance for birds in the poultry house due to their noise and movements. This frightens the birds resulting in poor performance.¹³ The rodents also cause high mortality rates of chicks and production losses. Rats have been known to kill baby chicks and break and eat eggs and frighten birds by their movements or by noises they create. Research has shown that by reducing the rodent population in poultry houses the bird mortality rate can also be lowered.¹¹

Threat as vectors and reservoirs: Rodents serve as vectors and reservoirs of a large number of infectious organisms, of which *Salmonella* spp. is of particular concern to poultry producers in recent years. Rodents primarily contaminate animal feed in storage

areas and feeders through urine and faeces.¹⁴ Rodents can transmit about 35 different diseases affecting man and other domestic animals. Rats and mice are linked to poultry diseases such as Salmonellosis, Colibacillosis, Coryza, Pasteurellosis, Mycoplasmosis, Hemorrhagic enteritis, Hymenolepiasis, Capillariasis, and Ascaridiasis.¹⁵ The bacterial diseases include Leptospirosis, Fowl Typhoid, Avian Paratyphoid, Salmonellas, Pseudo Tuberculosis, Fowl Cholera, Erysipelas. Viral diseases include New Cattle disease, Ornithosis and Protozoan infections include Toxoplasmosis and Coccidiosis. All these diseases impact seriously in poultry production.¹⁶ Disease problems can have serious consequences of a rodent infested poultry house. Diseases caused by *Salmonella* species and fowl cholera are those of greatest concern to poultry producers. Rodents also carry ecto parasites such as lice, fleas, and mites.

Salmonella is a dreaded disease characterised by acute gastroenteritis in poultries with vertical transmission spreading over generations.³ Umali DV et al.¹⁷ have isolated the salmonella bacteria from the faeces of roof rat in Japan.¹⁷ The number of salmonella bacilli per faecal pellet was as high as 1×10^8 . *Salmonella* infection of poultry and the resulting contamination of poultry products can result in multi-state outbreaks of human food poisoning, causing symptoms that range from mild nausea to severe illness, and sometimes death in infected persons.¹⁸ In terms of economics, total costs associated with human illness caused by *Salmonella* infection, and those accrued by poultry producers and the food service industry are substantial. Estimates of medical costs and loss of productivity of infected persons range from \$983million to \$1.4billion annually. Costs to poultry producers include deaths of animals, reduced feed efficiency and a loss of market value from infected products.¹⁹

Rodents have been implicated as one of the epidemiological reasons for regional and worldwide increases in egg-associated *Salmonella* infection.¹⁴ Therefore, decreasing animal feed contamination by rodents and controlling rodent populations should be a primary objective of poultry producers.

Major rodent pest species in poultry

In order to translate ecological features of rodents into their management, it is necessary to examine the species, biology and management principles in relation to the types of poultry management and housing. The most effective control measures can be planned only if the kinds of rodents are correctly identified. Very few species of rodents, not more than three at any given situation, are responsible for their negative role in poultry environs. Mostly these include Black rat, *Rattus rattus*, House mouse, *Mus musculus* and Brown rat, *Rattus norvegicus*. The available data on country wise major rodent species are in Table 1.

The poultry environs often have other burrowing rodent species like Lesser bandicoot, *Bandicota bengalensis*, Larger bandicoot, *Bandicota indica*, outside the premises. Other rodent pest species were also reported in India and they are minor (Table 2). There is no information existing on the population dynamics of the pest species in poultry environs except for a study in Bengaluru, India.²⁷ However, such study is desirable for an appropriate planning.

Planning rodent management

While undertaking rodent pest management, appropriate planning is necessary. The planning includes inspection of poultry environment and assessing rodent pest infestation.

Table 1 Major Rodent Species in Poultry environs

S. no	Country	Major rodent species	Source of information
1	Argentina	<i>R. rattus</i> and <i>M. Musculus</i>	Fraschina et al. ²⁰
2	Denmark	<i>Apodemus agrarius</i>	
3	Europe	<i>Rattus norvegicus</i> and <i>Mus musculus</i>	Mino et al. ²¹
4	India	<i>R. rattus</i> and <i>B. bengalensis</i>	Sakthivel P ²²
5	Mexico	<i>R. norvegicus</i>	Mino et al. ²¹
6	Nigeria	<i>Meriones species</i> and <i>Peromyscus natalensis</i>	Mino et al. ²¹
7	Pakistan	<i>Rattus rattus</i> , <i>Mus musculus</i> and <i>Rattus norvegicus</i>	Pervez et al. ²³
8	Taiwan	<i>Rattus losea</i> , <i>B. Bengalensis</i> and <i>Mus species</i>	Mino et al. ²¹
9	Thailand	<i>Bandicota bengalensis</i> and <i>B. indica</i>	Mino et al. ²¹

Inspection of poultry environment

The first step is to conduct a visual inspection of the premises. The purpose of inspection is to determine whether a current or potential rodent infestation exists at a specific location, if so areas of

Table 2 Rodent species found in Poultry farms in India

Species	Habitat	State	Reference
<i>R. rattus</i> *	Live mostly on roofs and feed storage areas	AP, MP, Haryana, Maharashtra, Punjab, Rajasthan, South India	Siddique ²⁴ Ahmad et al. ²⁵ Christopher et al. ²⁶ Sridhara & Krishnamurthy ²⁷
<i>M. musculus</i> *	Live in Feed storage areas.	Haryana, Punjab, Rajasthan, A.P.	Christopher et al. ²⁶ Bharadwaj D & Prakash ²⁸
<i>B. bengalensis</i> *		A.P. Uttar Pradesh, Punjab	Christopher et al. ²⁶ Sood & Malhi ²⁹
<i>B. indica</i> **	These make burrows either inside or along the outer periphery of the poultry sheds.	A.P. Karnataka	Christopher et al. ²⁷ Krishnamurthy ³⁰
<i>M. melitana</i> **		A.P. Rajasthan; Rajasthan	Christopher et al. ²⁶
<i>M. hurrianae</i> **			Saxena ³¹

*Major pest **Rare pest

Rodent infestation measurement

The infestation of rodents could be assessed based on

- Visual sighting
- Trapping index
- Tracking and
- Live burrows

Visual sighting: The first step in rodent control in poultry is to determine the extent of infestation which can be detected by sighting, droppings, tracks, burrows, pathways, egg damage, fresh gnawing

their infestation, routes through which they could establish. Rodent sightings, droppings, tracks, burrows, pathways, fresh gnawing marks, and dead rodents offer the information of their presence. The first line of attack on rodents is preventing their entry inside the structures. The inspection covers garbage dumps, drainage channels, pipes, holes, burrows, electrical or telephone wires, gaps between door and the floor, ventilators, exhaust ducts, water pipe lines and overhanging tree branches on the structures.

The standard Inspection procedure is to:

- Observe the rodent borrows, drainage canals, holes at the base of the compound walls, garbage dumps etc. around the poultry premises and mark them on the layout of the area.
- Observe the overhanging tree branches on the premises, wires from poles to the premises, Holes in the walls, Drainage pipes on the poultry structures.
- Observe for rodent "signs" Faecal pellets adjoining walls or corners, Rat holes, if any, active/inactive, Rat/mouse paw markings, rat runway, rat smears on beams, wiring etc. and observe the entry points such as base of the doors for space, windows/ventilators connecting any wiring or on roof, Drainage channels in inside the premises. Based on the layout marked suitable action plan may be drawn based on the severity/intensity of the problem. The severity of the problem could be judged by different methods.

and dead rodents. If the rodents are repeatedly seen in during day time it indicates high infestation.

Trapping method: In situation like storage godowns the rodent species like *M. Musculus* and *R. Rattus* are non-burrowing rodents. They hide in between the stacks and cracks and crevices and make damage to food grains. Under such situation the assessment rodent population can be done by using trapping index method. There are two ways of determining the trapping index.³²

There are two methods for evaluation of the rodent population through trapping –

- The Trapping Index Method and

ii. The Capture, Mark and Recapture (CMR) Method

Single catch traps are laid in the poultry in trap line/grid methods for continuously three nights and the trapping index is computed as follows:

$$\text{Trap Index (rodents / day / trap)} = \frac{M}{n} \times t$$

where M =total number of rodents trapped; n = number of traps used in a trap line; t =number of nights

In the CMR Method, the rodents trapped each night are marked and released, and a second trapping is undertaken 1–2 days after the first trapping, which may include some marked rodents as well. The population size may be calculated as proportion of marked ones with new ones as follows:

$$N = M \times \frac{n}{m}$$

where N =population size; M =number trapped in the first trapping; n =total number trapped in the second trapping and m =number of rodents re-trapped in the second trapping. This method is mostly not practised since farmers do not permit releasing the trapped rats.

Tracking Index: Tracking is one of the simple methods used for assessing rodent incidence. Generally, talcum, chalk or fine sand are used to track of rodent activity in indoor condition,³³ but these materials may cause adulteration of the feed and is drifted with air. The study made by Rao et al.,³⁴ have standardised the tracking method with the natural colouring material. Alcohol with colour powder was found to be the best one when compared to other products and it gives the clear foot prints (Figure 1). Vinyl tiles (30X15cms) were treated with different tracking materials like turmeric, colour powder, stamp pad ink, charcoal powder applied with alcohol slurry (to avoid the drifting) for generating clear foot prints. Tracking material, when applied as thin film in the middle area (10x15cm) of the tiles, leaves foot prints of moving rodents. Such tracking tiles with the foot prints can be considered as positive and without foot prints as negative. Even rodent species also could be identified based on nature of foot prints. The tracking index (T.I.) can be calculated using following formula:

$$\text{Tracking Index (T.I.) \%} = \frac{\text{No. of tracks touched by rodents}}{\text{No. of tracks laid}} \times 100$$

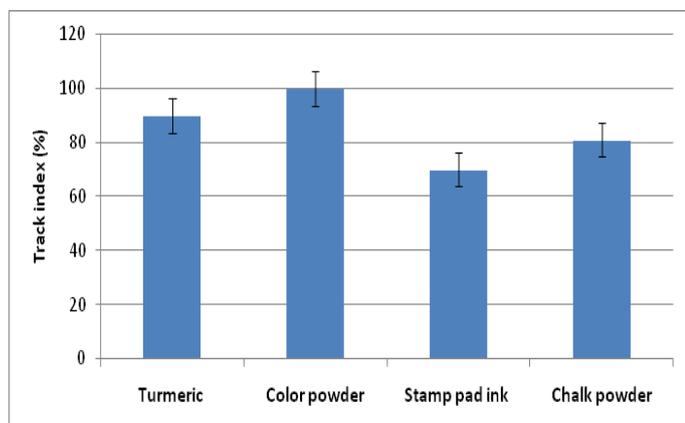


Figure 1 Tracking index of various tracks placed in poultry environs.

Live Burrow Count Method (LBC): This method is based on the active (live) burrows of rodents around the poultry premises. The species like *B. Bengalensis* leave fresh excavated (scooped) soil as small pebbles at the main entrance.³⁵ Since these bandicoots are solitary in living, number of active burrows indicate approximate rodent incidence in the area. This is a feasible method to estimate the burrowing rodent population in poultry environs. Other burrowing rodents like *B. Indica* and *Tatera indica* make their burrows near wet or dry conditions, especially in poultry manure and the ground below the slabs and along the walls outside.

Rodent pest/Vector management

Since poultry growers are unaware of the severity of rodent infestation and its impact on poultry and public health, the issue of rodents is rarely paid attention. Effective rodent control in and around the poultry houses involves both preventive–sanitation and rodent proofing; and curative measures with population reduction.¹²

Sanitation

Clean premises discourage rodents to inhabit in any area. Sanitation through maintenance of sheds, surroundings and equipment clean, removal of weeds, garbage, and waste material around the premises prevent the rodent infestation.¹⁶ The trees and other planting materials in and around the poultry house must be removed to reduce rodents harbouring the area. The sheds should be sanitized to minimize the risk of disease to incoming flocks of birds. The poultry house should not have proximity to residential houses to avoid unsanitary conditions. Proper storing of poultry feed is essential since rodent infestation is always high at storage level. The feed should be stored inside the storage bin or bags are properly stacked on wooden pallets. Debris such as old equipment, old boards, etc., affording rodents hiding or nesting place should be removed. Maintain at least a 3-foot space around the perimeter of the poultry house that is free of bushes and trash.

Rodent proofing

The basic philosophy of rodent proofing is elimination of all rodent entry points as per the inspection made. In most cases, it is often cost prohibitive, but rodent proofing needs to be undertaken in all feasible areas for long term maintenance of rodent free poultry premises.¹⁶ In addition all the storage areas need to be made rodent proof. Other measures could be:

- Plain tin sheets can effectively prevent rodent movement when installed vertically. The paired front (incisor) teeth of rats and mice curve slightly inward. This makes it difficult for them to gnaw into flat, hard surfaces.
- A perimeter strip of heavy gravel of at least 1 in. in diameter laid in a band at least 2ft. width and 1/2ft depth laid near poultry shed foundations prevents rodent burrowing.
- The floors should be made of concrete and the walls and doors should be free from large cracks and holes. The poultry houses (wall and floor) should be made with minimum 3inches thick cement concrete with 1:3 ratio of cement and sand. The outer walls should be provided with rat proof measures with concrete sloping.
- 2 feet projected plinth with the height of 3-4feet from the ground level prevents the entry of rodents.

- e) All the doors should be made with the metal sheets to prevent rodent gnawing. Placing metal strips along the bottom of doors prevents the entry at the bottom. Where wooden frames are used, the lower sections should be covered with sheet iron.
- f) Screening windows with wire mesh, and edging door and window frames with metal prevents rodents entering by gnawing.
- g) Drain cover holes should be less than 6mm in size to prevent rodents through the drain holes in the poultry houses.
- h) Openings around pipes and wires needs to be closed with Portland cement mortar, masonry, or fix metal collars where from they enter inside the poultry structures.
- i) Sealing the openings surrounding feed augers, water lines, and electrical conduits that enter the house from outside prevent rodent entry.

Curative measures

Where rodent proofing isn't practical, other techniques of rodent control need to be considered. In spite of measures taken for prevention of rodent entry into the poultry structures, sometimes they may enter inside through feed bags or any other source. In such an eventuality they need to be managed. The methods which are in vogue include trapping and chemical application. The methods like biological control or ultra-sonic devices will not yield desirable success in poultry environs.

Trapping:

Trapping is an effective, quick, and economical control approach to

- a. remove stray rodents and
- b. to complimenting a poison baiting programs.¹⁶

Traps are used in situations where baits may pose a hazard. Rodents will not travel far from their normal activity areas and hence more numbers of traps should be placed. Trapping is more effective where a rodent population is high. There are different types of traps used to control the rodents in poultry. They include non-poisonous sticky (glue) traps and mechanical traps.

A. Non-poisonous sticky (glue) trap: Glue boards are made of cardboard sheet/ plastic coated with highly adhesive poly butane (glue) to get the rodent stuck to the board. They are to be placed on rodent runways and when the rodents pass through the area, they will try to explore the glue board and struck on the board.³⁶ These traps are most effective against juvenile mice to be used single time. Glue traps should not be set in wet or dusty areas, which will render the traps ineffective. They are very effective in egg, feed store rooms or in rooms where waste equipment or junk is accumulated. They will not be, however, effective in dusty areas. They should be checked regularly and should be disposed of on capture of rodents. It is considered that their use is inhumane method claiming psychological stress on these caught animals, which resulted several countries to ban their use.

B. Mechanical traps: Mainly two types of mechanical traps are available - single catch trap and Multi-catch trap: The single catch trap can be live trap trapping the rodents live or kill trap killing the rats instantaneously. Animals trapped in live include

Sherman trap, wooden box trap while kill type are snap traps.³² The traps can be baited with locally available cereals like, cracked wheat, millets, maize, flour etc.

C. Kill (snap) traps: These traps are available in both the metal and wood base (Figure 2). They are simple trap, inexpensive and very effective when are set up properly. These traps should be used in layer houses where the birds are caged safely. They are designed to kill animal quickly and humanely. Rodents are theigmotactic and move along edges, so traps should be set on their runways along walls. Traps for mice should be set 6 to 10 feet apart due to their shorter home ranges. Roof rats prefer to travel above the ground and are easier to trap along these precarious pathways than on the ground.

D. Live traps: Single-catch live traps capture the rat or mouse alive and unharmed, but we have to deal with the captured ones. Rodents should not be freed without killing, because they will return to the poultry sheds due to their home range. Rodents caught in these traps are best dispatched by submerging entire trap in a bucket of water. These traps should be placed aligning the walls or in runways.

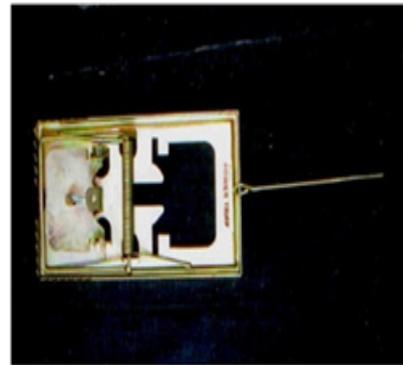


Figure 2 Metallic snap trap.

Multi-catch traps are designed to repeatedly catch several numbers of rodents with one setting and the scent from the captured rodents entices others to the trap (Figure 3). However, these traps are expensive. Also, the captured rodents should be killed by drowning them in to water for 5minutes. Releasing captured rodents outside is not a solution, since they will quickly find a way back into the structure. Traps must be checked regularly to prevent the captured rodents from starving or dying of thirst and creating an odour problem.



Figure 3 Multi catch trap.

Other types of traps can also be used. One of the inexpensive and eco-friendly indigenous trap - Palmyrah basket kill trap is made up of bamboo was evaluated in poultry sheds (Figure 4). The trap was found

to be effective against the *R. Rattus* and *B. Bengalensis*. Total 21,827 rodents were trapped during January 2011 to 2013 in the poultry premises around Hyderabad, India (Table 3).

Table 3 Trap index data of rodent species trapped from Palmyra basket trap in poultry farm during January 2011-December 2013

Year	Total trap nights	<i>R. rattus</i>		<i>B. bengalensis</i>		Overall rats trapped	Overall trap index
		Number of rats trapped	Trap index	Number of rats trapped	Trap index		
2011	29200	7257	0.24	604	0.02	7866	0.26
2012	18200	4738	0.26	899	0.04	5637	0.3
2013	32400	7286	0.22	1028	0.03	8324	0.25
Combined	79800	19281	0.72	2531	0.09	21827	0.81



Figure 4 Palmyra basket trap.

Chemical control

Use of rodenticides is the most common, expedient and humane method to control pest rodents and became a normal practice for rodent management strategy in most parts of the world.³ They have greater scope in large-scale control operations, since a mixed population of several species are encountered in the poultries. Many rodenticides in different formulation have been tested and being used throughout the world. Although both acute (fast acting) and chronic (slow acting) rodenticides are available, only chronic ones are desirable in poultry premises due to hazard of accidental or secondary poisoning. The chronic rodenticides in most of the countries are anticoagulants and act on multiple feeding or death is delayed. This will prevent possible non target animal mortality.

A. Chronic (anticoagulant) rodenticides: Warfarin was the first important anticoagulant, but 'second generation' compounds which act on single dose were later developed due to development of genetic resistance.^{37,38} Among the second generation anticoagulants, several molecules, viz., bromadiolone,³⁹ brodifacoum⁴⁰ and flocoumafen⁴¹ are being used against the several species of rodents in different countries. These anticoagulants cause death by internal bleeding and preventing the blood from clotting. Generally, the toxic effect of these chemicals starts from the 3rd day of bait intake and continues for 10–12 days for effective killing of pest rodents. In addition to their small requirements in baits in a single dose and the availability of an effective antidote (vitamin K1), the second generation anticoagulants have an edge

over other rodenticides not only in efficacy but also in safety. Presently, only bromadiolone (0.005%) is registered by the Government of India for rodent control in fields and commensal situations. It is available in both wax and loose formulation containing (0.005%) of the active ingredient.

B. Non-anticoagulant rodenticides: Two most common non-anticoagulant chemicals (bromethalin and cholecalciferol) are available for controlling rodents.⁴² Bromethalin kills rodents by disrupting the energy production within the cells of the body. Eventually, this results in a decrease in nerve impulses, paralysis and death. A single dose of bait is usually lethal within 1 to 3 days. Rodents stop feeding on bromethalin after they have consumed a lethal dose. Thus, only relatively small amounts of this bait need to be available. The second common one is cholecalciferol (vitamin D3) which acts as a single-dose poison if a sufficient amount is consumed by a rodent in one feeding and acts as a multiple-dose poison if consumed in lesser amounts over several days. Since the mode of action is not blood coagulation, these two can be used against anticoagulant resistant rodents.

C. Bait placement: The loose baits are more economical than wax baits.⁴³ However, loose baits tend to get spoiled rapidly compared to wax baits. Safety to poultry birds is very essential while treating the poultry farms. Hence application technique plays key role in the efficacy of the anticoagulant. Appropriate placement of the bait is one of the most important aspects for an effective chemical rodent control strategy. The unprotected application of poison baiting can pose hazards to the poultry birds.⁴⁴ Hence, the bait may be placed either in the burrows or in safe containers-bait stations. The basic idea of using bait containers is that the bait should be easily accessible to the target species and reduce the hazard to other animals. This will also protect the bait from rain and other weathering. The bait stations create an enclosure inside and are made up of bamboo, metal sheet or mud. Several types of indigenous bait containers such as mud channels, hollow bamboo pieces, broken pitchers, coconut shells etc., are being used for keeping poison baits. Rao et al.⁴³ tested various bait stations in poultry premises and results shows that metallic bait stations are superior (Figure 5).⁴³

D. Cellulose base rodenticide: Due to higher toxicity of anticoagulants, efforts are in progress to develop newer safer molecules. Cellulose base rodenticide is one of the eco-friendly products developed made from the powder of corn cobs. It retains the water in the gut and disrupts water transport through the gut

wall and interferes with the normal digestion of the rodent.⁴⁵ A study was carried out by the authors in the Project Directorate on Poultry, Hyderabad providing the cellulose bait for a period of 8 days. Mortality data under no-choice feeding trials revealed 55.5% mortality with the mortality time as 6.66 days with a range of 4-8 days. It is an eco-friendly rodenticide and safe for higher vertebrates used to control the rodent population in Argentina.

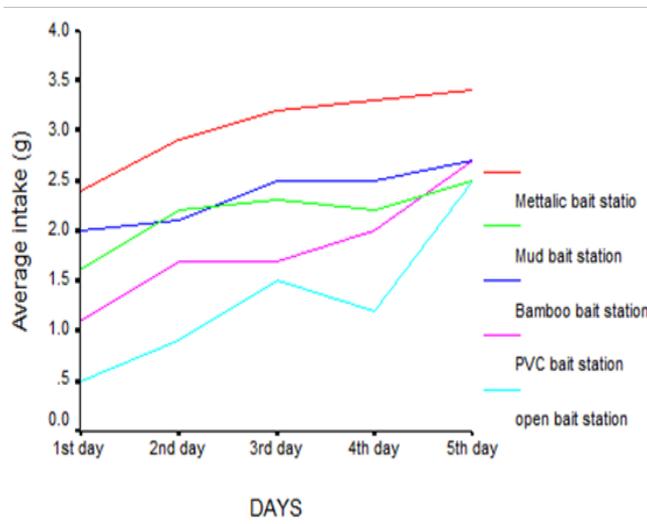


Figure 5 Daily feeding response of rodents towards the different bait station in poultry environ.⁴³

Conclusion

The poultry industries suffer from the rodents that cause economic losses to the poultry growers throughout the world. Looking at the economic loss caused by rodents in poultry sector by rodents, it is quite essential to create awareness among the poultry farmers and motivated to take up rodent control in an integral way as envisaged above for food and health security of the World. Integrating the preventive measures with cleanliness and structural improvements coupled with trapping and baiting with different rodenticides are the important tool for the management of rodents. At the same time safe and judicious use of the rodenticides will avoid secondary or accidental toxicity to the non-target animals.

Acknowledgements

The authors are grateful to the Director General for encouragement.

Conflict of interest

Author declares that there is no conflict of interest.

References

1. Anon. Food outlook: Biannual Report on Global Food Markets. *FAO*; 2014. p. 1-132.
2. Anon. Global Poultry trends 2013: Asia supplies 60% of World's eggs. *The Poultry site*. 2014.
3. Rao AMKM. Rodent control in poultry production. *Proc. Intern. Symposium on Emerging Challenges in Poultry Health and Disease Control*. Hyderabad, India; 1912. p. 113-116.
4. Brooks JE, Fiedler LA. Compendium of Post-Harvest Operations. *Chapter III: Vertebrate Pests: Damage on Stored Foods, Agro-Industries and Post-Harvest Management Service, Food and Agriculture Organization (AGSI-FAO)*. Rome, Italy; 1999.

5. Hamilton WJ. *The mammals of eastern United States*. New York: Hafner Publications Co; 1963. 432p.
6. Greaves JH. The control of commensal rodents in Britain. *EPPO Bulletin*. 1988;18(2):203-209.
7. Chopra G. Poultry forms. In: Prakash I, Ghosh PK, editors. *Rodents in Indian Agriculture*. India: Scientific Publisher; 1992. p. 309-330.
8. Parshad VR. Rodent rodent management in poultry farms. Technical Bulletin 8, AINP on Rodent Control, CAZRI, Jodhpur, India; 1999. 1-11.
9. Ali R, Fatima MS, Farhanullah Khan M. Estimation of rodent damage on coconut plantations and sugarcane in Sindh. *Pakistan Journal of Biological Sciences*. 2003;6(12):1051-1053.
10. Turner CEJ. Structural and litter pests. *Poultry Science*. 1986;65(4):644-648.
11. Berry J. Rodent Control in the Poultry House. *Oklahoma Cooperative Extension Service*. Oklahoma State University, Stillwater, Oklahoma; 2009;1-40p.
12. Loven J. *Controlling rodents in commercial poultry facilities*. West Lafayette, Indiana, USA: Publ No. ADM-3-W. Purdue Cooperative Extension Service. 2010.
13. Kandhwal S. Evaluation of Bait Carrier for *Rattus rattus L.* Infesting Commercial Poultry Facilities in India: A Step towards sustainable poultry management. *International Journal of Arts and Sciences*. 2009;3(1):50-60.
14. Henzler DJ, Opitz HM. The role of mice in the epizootiology of *Salmonella enteritidis* infection on chicken layer farms. *Avian Diseases*. 1992;36(3):625-631.
15. Donald JM, Eckman, Simpson G. How to control rats, mice, and darkling beetles. *Poultry Engineering, Economics, and Management Newsletter*. 2002;(20):1-4.
16. Singh D, Bhanja SK, Rao AMKM. *Rodent Pest Management in Poultry Farms, Feed Mills and Hatcheries*. India: Technical Bulletin, Project Directorate of Poultry. 2012. 1-12p.
17. Umali DV, Lapuz RR, Suzuki T, et al. Transmission and Shedding Patterns of *Salmonella* in Naturally Infected Captive Wild Roof Rats (*Rattus rattus*) from a *Salmonella*-Contaminated Layer Farm. *Avian Dis*. 2012;56(2):288-294.
18. Vought KJ, Tatini SR. *Salmonella enteritidis* contamination of ice cream associated with a 1994 multistate outbreak. *J Food Prot*. 1998;61(1):5-10.
19. Roberts T. Salmonellosis control: Estimated economic costs. *Poult Sci* 1988;67(6):936-943.
20. Frascina J, Leon V, Busch M. Role of Landscape Scale in the Distribution of Rodents in an Agroecosystem of Argentina. *Journal of Agricultural Science*. 2014;6(12):22-35.
21. Mino MH, Rojas Herrera EJ, Notarnicola J. The wild rodent *Akodon azarae* (Cricetidae: Sigmodontinae) as intermediate host of *Taenia taeniiformis* (Cestoda: Cyclophyllidea) on poultry farms of central Argentina. *Mastozoologia Neotropical*. 2013;20(2):407-412.
22. Sakhivel P. Efficacy of locally made trap for the management of rodents in poultry premises. *5th International Conference on Rodent Biology and Management*. China: Institute of Zoology; 2014. p. 122.
23. Prevez A, Rizvi SWR, Ahmed M. *Rodent control campaign in University of Karachi campus*. Report submitted to PARC, TARC and University of Karachi, Pakistan; 2001:1-8 p.
24. Siddique SM. Rat menace and its control. *Poultry Guide*. 1974;11(7):27-29.

25. Ahmad N, Chopra G, Sood MC. Assessment of rodent damage in poultry farms. *Poultry Guide*. 1984;21(3):57–60.
26. Christopher MJ, Balasubramanyam M, Purushotham KR. Rodent problems in poultry farms of Tirupathi, Andhra Pradesh. *Poultry Guide*. 1984;21:21–25.
27. Sridhara S, Krishnamurthy TR. *Population dynamics of Rattus rattus in poultry and implications for control*. In: Borrecco JE, Marsh RE, editors. Proc. 15th Vertebrate Pest conference. University of California, Davis; 1992. p. 224–228.
28. Bharadwaj D, Prakash I. Rodent pests in poultry at Jodhpur. *Rodent Newsletter*. 1983;7(3):11.
29. Sood ML, Malhi CS. Biology and control of rodents in poultry farms in Ludhiana District (Punjab). *Indian Poult Rev*. 1980;11:28–33.
30. Krishnamurthy TR. *Population dynamics and chemical methods of control of a few rodents in some villages of Karnataka*. Mysore University, Mysore, India; 1990.
31. Saxena Y. Management of rodent pests in poultry farms. *J Ecotoxicol Emt Monit*. 1999;9(1):67–69.
32. Barnett SA, Prakash I. *Rodents of economic importance in India*. New Delhi: Arnold-Heinemann; 1975. p. 175.
33. Greaves JH. Rodent control in agriculture. *FAO Plant Production and Protection Paper*. 1982;40:52.
34. Rao NS, Sakthivel P, Rao AMKM, et al. Use of tracking tiles- an effective method for rodent population assessment in structures. *Pestology*. 2014;38(4):54–57.
35. Rao AMKM. Demography and hoarding among lesser bandicoot rat, *Bandicota bengalensis* in Rice fields. *Saug Mitteil*. 1980;28:312–314.
36. Reddy KM, Rao AMKM. Responses to Non-poisonous sticky traps by different consumer bodies in controlling rodent pests. IPCA Souvenir 23rd Convention. 2000;39–42 p.
37. Quy RJ, Shepherd DS, Inglis IR. Bait avoidance and effectiveness of anticoagulant rodenticides against warfarin- and difenacoum-resistant populations of Norway rats (*Rattus norvegicus*). *Crop Protection*. 1992;11(1):14–20.
38. Smith P, Inglis IR, Cowan D, et al. Symptom-dependent taste aversion induced by an anticoagulant rodenticide in the brown rat *Rattus norvegicus*. *J Comp Psychol*. 1994;108(3):282–290.
39. Anonymous. Evaluation of second-generation anticoagulant rodenticides in India. I. Bromadiolone. All India Coordinated Research Project on Rodent Control, Central Arid Zone Research Institute, Jodhpur (Mimeo); 1986.
40. Jain AP, Tripathi RS. Evaluation of second generation anticoagulant rodenticides in India. II. Brodifacoum. All India Coordinated Research Project on Rodent Control. Central Arid Zone Research Institute, Jodhpur (Mimeo); 1988. 21p.
41. Jain AP, Mathur M, Tripathi RS. Bio-efficacy of flocoumafen against major desert rodent pests. *Indian J Plant Prot*. 1992;20(1):81–85.
42. Judy L, Raplh W. Controlling rodents in commercial poultry facilities. *Purdue Extension ADM-3-W*. 2010:1–15 p.
43. Rao AMKM, Sakthivel Rao NS, VDS Alva. Performance of different bait stations on bait intake in poultry and other structural environs. *Egg-Broiler*. 2013;12–15.
44. Parshad VR, Ahmad N, Chopra G. Deterioration of poultry farms environment by commensal rodents and their control. *Int Biodet*. 1987;23(1):29–46.
45. Mason GM, Littin KE. The humaneness of rodent pest control. *Animal Welfare*. 2003;12(1):1–37.