Proc Indian Natn Sci Acad **80** No. 2 June 2014 pp. 235-245
© *Printed in India*.
DOI: 10.16943/ptinsa/2014/v80i2/55104

Review Article

Non-Empirical Validation of Indigenous Rodent Control Methods Practiced in Northeastern India

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(Received on 11 November 2013; Revised on 06 May 2014; Accepted on 12 May 2014)

Of late, interest in alternative eco-friendly rodent control methods have paced up owing to the known shortcomings of rodenticides, particularly anticoagulants. The present study reports 15 such non-chemical rodent control methods practiced in the upland areas of Northeast India. Most of these (80%) methods include indirect means of rodent control i.e. use of repellents, by attracting predators and by trapping. About 50% of the methods have been non-experimentally validated to be highly effective. The striking feature of these methods appears to be the probable minimal effect on non-target organisms, which is the main constraint with chemical rodenticides. However, thorough investigation of these methods involving extensive field trials is critical and may provide valuable clues for developing some highly effective alternatives to chemical rodenticides.

Key Words : Rodent Pests; Rodenticides; Traditional Method; Trapping; Prey-Predator Relationship; Northeast India

Introduction

Pests have been a hindrance in man's sincere efforts to increase grain production and ensure food security. Among all types of pests, rodents are economically most important. Rodents, one of the diverse groups of mammals comprising rats, mice, bandicoots, gerbils, voles, squirrels etc. are characterized by their chisel shaped incisors, which is their main weapon of destruction. There are 128 species of rodents recorded in India (Roonwal, 1987), of which 18 species are regarded as pests. Recently Pradhan and Talmale (2011) reported 103 species and 89 subspecies under 46 genera belonging to 7 families in India. In Northeast India, 15 species of rodent pests have been reported to occur (Singh, 1995). The rodents of Northeast India are dominated by the Indian mole rat (*Bandicota bengalensis*) followed by the Himalayan rat (*Rattus nitidus nitidus*) and the common house mouse (*Mus musculus*) both in terms of population as well as the extent of damage (Pathak and Kumar, 2001).

The economic injury caused by rodent pests is much higher than that by any other pests. Rodents inflict serious damage to all types and all stages of crops, from sowing to storage. Though a pragmatic estimate of the damage caused by rodents is difficult to make due to the varied approaches and methods used in evaluating damage in crops and storage, approximately 10-20% damage have been recorded (Pathak and Kumar, 2001). The extent of damage reaches the 50% mark during rodent outbreaks; in some crops, it may be as high as 75% as in oil palm crops in Mizoram (Thakur *et al*., 2012). Sometimes crops are completely devastated (Singh, 1995). In addition to crop damage, rodents also damage almost all other household items including buildings, telecommunication equipments etc. Further, rodents also harbour a good variety of ecto- and endo-

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parasites, which are responsible for transmission of more than 20 dreaded diseases in humans (Anonymous, 1974). In fact, they act as reservoir of parasites (Singla *et al*., 2003, 2008 and 2013).

So far, use of chemical rodenticides, mainly anticoagulants is the most common and dominant approach of rodent control in agriculture, rural and urban environment (Prasad, 1999). However, application of these rodenticides is limited due to the reported intoxication of domesticated as well as wild animals through direct consumption of baits (primary hazard) and/or secondary hazard resulting from eating of poisoned rodents by non-target predators and scavengers (Valchev *et al*., 2008). The development of rodenticide resistance by rodents is also another serious drawback of anticoagulants. The situation is alarming due to the intoxication of endangered and threatened species (Lemus *et al*., 2011). In view of the criticality of controlling rodents and the reported shortcomings of chemical rodenticides, it has become extremely imperative to look for alternative, non-chemical and ecological methods of rodent pest management. The present paper describes a few such methods practiced by the traditional farmers in the upland areas of Northeast India and their efficacy and possible applicability in a wider scale is discussed with the help of existing scientific knowledge.

Materials and Methods

An extensive field survey was undertaken in 5 hill districts of Northeastern India namely West Garo Hills (WGH) and Jaintia Hills (JH) in Meghalaya, Ukhrul and Senapati districts in Manipur and North Cachar Hills (NCH) district in Assam to document non-chemical methods of rodent pest control. The tribes covered in the present study were Garo in WGH; Jaintia in JH; Mao, Maram, Poumai and Thadou in Senapati; Tangkhul in Ukhrul and Hmar in NCH. In each tribe, 5 relatively backward villages were selected and in each village, 5 promising respondents (households) were selected in consultation with the village headman. More emphasis was given to women farmers for their reported greater involvement in farming in this region (Anonymous, 2004). Information on traditional rodent pest management methods was collected through informal interactions in a participatory manner with the assistance of a separate interpreter for each tribe.

Each method includes the detailed procedure and the farmer's perceptions and rationale of the effectiveness of the method followed by qualitative non-experimental validation based on existing scientific knowledge. While validating, firstly the actual plant/animal part used with the mode of action as stated by the farmers was searched in the existing scientific literature. If the plant/animal part with mode of action as perceived by the farmers was found to match exactly with those in the established scientific literature, the method was rated as *highly effective*. Secondly, if the plant/animal part was known to act with mode of action other than the traditionally perceived one, then the method was rated *effective*. This was rated so because, the traditional farmers may believe that the leaves of a plant act as a toxicant while it actually repelled the rat. Thirdly, if parts of the particular plant/animal other than the traditionally used one were reported to have biologically active properties against rodents, then those methods were rated as *moderately effective*. Other methods were rated as *irrational* and/or *ineffective*.

Methods of Rodent Pest Control

There is unanimous perception among all the traditional communities that among all non-insect pests, rodents, especially rats, are more harmful and cause maximum damage to crops and household items. Rats are differently known to the communities as *Missi* (Garo), *Mazu* (Hmar), *Masha/Shihok* (Tangkhul) and *Khne* (Jaintia). Altogether 15 ***Rodent Control Methods*** have been documented and described here.

A. Toxic Methods

1. *Method* : Fresh leaves of *Dendrocnide sinuata* (Bl.) Chew (Urticaceae), locally called as '*Gilmat*' are put in between boiled rice in the form of sandwich and left as such for 12-24 hrs. Next day the treated rice is placed in possible rat runways in crop fields and in and around houses to poison rats. This method is

practiced by around 30% of the Garos. The locals believe that '*Gilmat'* is a poisonous plant and when its leaves are placed in between hot rice, the poison is transferred to the rice. The rats die after consuming the poisoned rice.

***Empirical Evidences* :** The plant, including leaf surface, has highly irritant small stinging hairs that cause acute burning pain when they come in contact with the skin. The effect is so powerful that the plant can be used to repel wild elephants from entering crop fields (Paul and Kumar, 2009). The stinging hairs are nothing but glandular trichomes that contain toxic chemicals such as formic acid in *D. excelsa*, moroidin in *D. moroides* and histamine in *Urtica diocia*, which are responsible for stinginess. Further, leaves of *D. sinuata* contain different biologically active compounds such as terpenoids, tannins and flavonoids (Tanti et al., 2010). Terpenoids are nothing but modified terpenes and many of the terpenes are active ingredients of natural pesticides. Condensed tannins are known to inhibit herbivore digestion by binding to consumed plant proteins. It is apparent that placing of *D. sinuata* leaves in between hot rice might rupture the glandular trichomes and the chemicals as mentioned might be released into the rice, consumption of which might lead to death of rats. This method is categorized as *highly effective*.

2. *Method* : Seeds of *Entada purseatha* DC, (Mimosaceae) are used for the control of rats. The seed kernel is grinded and mixed with equal proportion of grinded rice grains. Then the mixture is placed in paths where rats are supposed to come, both in crop fields and in houses. The method is practiced by 20% of the Garos and 50% of the Poumai farmers. The local farmers believe that the seed is poisonous and rats die after consuming the treated rice grains. The plant is locally called '*Sui***'** in Garo and '*Kah***'** in Poumai.

***Empirical Evidences* :** Seeds of *E. purseatha* contain triterpenoid saponins such as phaseoloidin and pursaethosides A-E (Tapondjou *et al*., 2005). These triterpenoid saponins isolated from seed kernel of *E. phaseoloides* are reported to have high haemolytic activity against cattle erythrocytes and cause high mortality in fish (Siddhuraju et al., 2001). Consumption of raw seeds is known to produce toxic symptoms such as vomiting and drowsiness and the seeds are also used as fish poison in some parts of India, South Africa and Philippine (Chopra and Chopra, 2006). Saponin obtained from *E. purseatha* seed kernels was found to be highly toxic to rabbits and guinea pigs and also have strong haemolytic properties (Bacon and Marshall, 1906). The saponins affect mainly the haemopoietic system causing haemolysis of RBCs and lowering of blood pressure, besides having depressant effects on the respiratory system leading to death due to respiratory failure in target organisms (Chopra and Chopra, 2006). This method is categorized as highly effective.

3. *Method* : To kill rats, fused electric bulbs are finely powdered and mixed with rice, which is then placed in possible rat runways. The rats die after consuming the treated rice. This method is practiced by around 30% of the Mao farmers.

***Empirical Evidences* :** Household bulbs are usually made of soda-lime glass (Maclsaac *et al*., 1999) which is composed of about 75% silica. Ingested silica nanoparticles are reported to have adverse effects such as membrane destabilization, increased cellular stress and death of the cells of the GI (gastrointestinal) tract of the exposed organisms (Pandey *et al*., 2013). It is apparent that the finer sharply pointed glass fragments of the electric bulb might inflict cuts and wounds on the GI tract leading to death of the rats. This method, if applied in large scale may have adverse impact on predator species feeding on rodents, thus, needs to be critically evaluated. This method is categorized as *effective*.

B. Rodent Repellent Methods

4. ***Method* :** Peels of *Citrus grandis* L. (Rutaceae) fruit is thrown in paddy fields just after the milky stage. This method is practiced by around 67% of the Mao farmers. The fruit is locally known as '*Momosikagi*' in Mao and the farmers are of the opinion that smell of the fruit peel acts as rat repellent.

***Empirical Evidences* :** Rutale limonoids have attracted greater apprehension for their growth

regulating activities (Champage *et al*., 1992) and citrus limonoids are reported to act as toxicants and feeding deterrents (Liu *et al*., 1990; Mendel *et al*., 1991; Murray *et al*., 1995). The main components of the volatile oil of *C. grandis* peel are D-limonene (37.18%) and â-myrcene (26.93%) (Yi *et al*., 2009). The peel also contains alakaloids, phenols, tannins and saponins (Okwu *et al*., 2007). *C. grandis* peel significantly increases the bioavailability of immunosuprressants in rats thereby having direct impact on the immunity of the organism. This method is categorized as *highly effective*.

5. *Method* : Fresh and/or dried branches of *Artemisia vulgaris* L. (Asteraceae), locally known as '*Shipriprikro*', are placed in paddy fields as well as in and around granaries. Its smell repels the rats. This method is practiced by around 33% of the Mao farmers.

***Empirical Evidences* :** Cineole is the major constituent; quebrachitol, tauremisin, sitosterol, tetracosanol, fernenol, thujone, a -amyrin, stigmasterol, b -sitosterol and a - and b -pinene are also present. The plant is reported to be toxic in large doses. Thujone can cause epileptic spasms (Duke *et al*., 2002). Toxicity of thujone has been extensively studied. Neurotoxicity is the principal toxic outcome in acute and chronic studies. There is also some equivocal evidence of carcinogenicity in rats (Pelkonen *et al*., 2013). This method is categorized as *effective*.

6. *Method* : The traditional farmers are using an innovative granary for controlling post-harvest loss of grains due to rats as well as insects. The structure is built at a height of about 1 meter from the ground supported by wooden or stone posts. The interesting and most important feature of the structure is that a barrier of either aluminium sheets or wooden plates or 20-litre mustard oil tins in inverted position are placed around the poles supporting the structure. It is ensured, however, that there is no space left in between the post and the barrier. The local farmers believe that rats cannot cross the barrier and thus protection of the grains from rats is ensured. Almost all the traditional communities use traditional granary, though with minor variations in the design of the structure. The indigenous granary of the Garo tribe is known as '*Jam*' (Fig. 1).

Fig. 1: '*Jam*'-the traditional granary of the Garos of West Garo Hills, Meghalaya. See inverted tins put on poles as rat barriers

***Empirical Evidences* :** There have been substantial studies on traditional grain storage structures and associated issues, particularly in African context (Nukenine, 2010). But their effectiveness in preventing rodent damage is unknown. Nevertheless, putting rat baffles or rat guards around poles of granaries is an effective measure to prevent rodents from climbing along the poles or gnawing (deGroot, 2004). The idea is to prevent the rodents from having access to the food. This method is categorized as moderately effective.

7. *Method* : Different types of manual as well as wind-operated scarecrows and sound creating devices are put in jhum, terrace and kitchen gardens to protect crops from rodents and other wild animals.

***Empirical Evidences* :** In the literature, there are instances of use of scarecrows and sound-creating devices for rodent control (Sharma, 1994), but the effectiveness of this method is not known. Such mechanical repellents are known to be effective against birds and other wild animals to certain extent. This method is categorized as *moderately effective*.

C. Predator Attraction Methods

8. *Method* : Branches of plants (preferably bamboo) are put in terraces to attract Owls, which are good predator of rats. This method is practiced by around 10% of the Garos.

Empirical evidences: Putting branches of plants in crop fields acts as perches for owls, which predate on rats at night. Consumption of 1-6 rats per night per owl in experimental plots with owl perches have been reported (Nagarajan, 1994). Further, paddy fields with owl perches have been recorded with no increase in the number of occupied burrows and hence increase in crop yield (Gunathilagaraj, 1996). Further, these branches also attract other predatory birds like myna (*Acridotheres tristis*) and drongo (*Dicrurus adsimilis*) which feed on rodents during daytime (Bonny and Vijayaragavan, 2001). This method is categorized as *highly effective*.

9. *Method* : *Sapium baccatum* Roxb. (Euphorbiaceae) is planted in or near Jhum fields, kitchen gardens and near terraces to attract predatory birds. This method is practiced by around 30% of the Garo farmers. The plant is locally termed as '*Changsim*'.

***Empirical Evidences* :** *S. baccatum* bears purple black, sweet berries, which are eaten by imperial pigeon, *Ducula sp.* (Chaudhuri, 1993). Birds are the main consumers and dispersers of *S. baccatum* fruits (Datta and Rawatt, 2008); may include opportunistic omnivorous birds such as common myna (*Acridotheres tristis*) which feeds on whatever food sources available including mice (Counsilman, (1974). Further, the plant may act as perch for other predatory birds such as owls and white-throated kingfisher (*Halcyon smyrnensis*) which is known to feed on small vertebrates including mice (Ali, 1996; Burton, 1998) and recently the bird has also been reported to predate on the common wolf snake, *Lycodon aulicus* (Soud *et al*., 2010). This method is categorized as *highly effective*.

10. *Method* : *Dendrophthoe falcata* (L.) Spreng. (Loranthaceae) is a hemiparasite and is transplanted on other trees in or near Jhum fields, kitchen gardens and near terraces to attract predatory birds. This method is practiced by around 30% of the Garo farmers. The plant is locally called '*Tuthekme*'.

***Empirical Evidences* :** The fruit of *D. falcata* is a pseudo berry; the bright red colour of the berries attracts insects and birds. Birds such as hair-crested drongo, sunbirds (*Nectarinia asiatica*, *N. zeylonica*), oriental white-eye (*Zosterops palpebrosus*) and flowerpecker (*Dicaeum erythrorhynchos*) are reported to feed on ripe fruits of *D. falcata* (Kunwar *et al*., 2005; Raju and Rao, 2005). Some of these birds, like drongo, occasionally feed on rodents (Bonny and Vijayaragavan, 2001). Further, *D. falcata* fruit contains bioactive chemicals like tannins and terpenes with known toxicity to rats (Mallavadhani *et al*., 2006; Pattanayak and Mazumder, 2009; Manthri *et al*., 2011). Rats may die of occasional feeding of the seeds. This method is categorized as *effective*.

11. *Method* : *Morus macroura* Mig. (Moraceae) is planted in or near Jhum fields, kitchen gardens and near terraces to attract predatory birds. This method is practiced by around 30% of the Garo farmers. The plant is locally called '*Rakseng*'.

***Empirical Evidences* :** *M. mocroura* bear polymeric berries, which are consumed by birds and mammals (Zhi_jun *et al*., 2000). The fruits are heavily consumed by the frugivorous bats, *Rousettus leschenaultia* and *Cynopterus sphinx* in Southwestern China (Tang *et al*., 2008). Moreover, it may act as owl perch during night. This method is categorized as *moderately effective*.

12. *Method* : *Bridelia retusa* Spreng (Phyllanthaceae) is also planted in or near Jhum fields, kitchen gardens and near terraces to attract predatory birds. This method is practiced by around 30% of the Garo farmers. The plant is locally called '*Khasi-bol*'

***Empirical Evidences* :** Fruit of *B. retusa* is globose, purple-black fleshy sweetish drupe, about the size of a pea. Mynas and barbets are the known consumers and dispersers of fruits of *B. retusa* (Datta and Rawat, 2008). Common myna (*Acridotheres tristis*) occasionally feeds on rats (Bonny and Vijayaragavan, 2001; Sengupta, 1982). All plant parts

contain saponins (Mali and Borges, 2003), which are highly toxic and neurotoxic, and ecdysones. Triterpenes and saponins isolated from *B. retusa* showed high molluscicidal, insecticidal activities (Jayasinghe and Fujimoto, 2005). Rats may die of occasional feeding of the seeds. This method is categorized as *highly effective*.

D. Trapping

Trapping is the most common and effective method of controlling rats in the study area. This is usually preferred as majority of the tribals consume rats and trapping rats can provide a food item for them, which is not possible if rats are killed with rodenticides.

13. *Method* : Glue extracted from the fruit of the epiphyte *Scurrula parasitica* L., (Loranthaceae) is fixed to a bamboo stick and is placed in possible rat runways, in terraces, Jhum fields as well as near stored granaries. The rats get stuck in the gum and are caught and killed. This method is practiced by around 33% of the Mao farmers and the epiphyte is locally known as **'***Chithi thou***'**.

***Empirical Evidences* :** *S. parasitica* is a parasitic shrub under the Mistletoe group, which is the common name for obligate hemi-parasitic plants in several families including Loranthaceae. The sticky juice of mistletoe berries is used as adhesive to trap small animals or birds (Johnson, 1848). However, the adhesive properties of *S. parasitica* in terms of its efficacy to trap rats need experimental evidences. This method is categorized as *moderately effective*.

14. *Method* : Inflorescence of *Cyathula tomentosa* Moq. **(**Amaranthaceae) locally known as **'***Changha kakhra***',** sticks to any rough surface like cloth, animal skin etc. The Mao communities of Senapati are taking advantage of this property in controlling rats. They put the inflorescences in and around the granaries, other possible rat runways and in crop fields. When rats come in contact with inflorescence, these get stuck to their body. This helps in two ways. First, it makes the body of the rat heavy and slows down their movement and are caught and killed. Secondly, after the attachment of the inflorescence in their body, infighting between the rats leads to their injury, even leading to death to some. This method is practiced by around 67% of the Mao farmers.

***Empirical Evidences* :** The Malani community of Kullu district, Himachal Pradesh put the hard hairy flowering spikes of *C. tomentosa* in the holes to control movement of mouse (Sharma *et al.*, 2005). Practice of an exactly same method by two different tribes, of completely different culture and traditions, inhabiting geographically distant areas indicates some sort of efficacy of the method and merits further investigation. Singla and Parshad (2005) reported 39.3 and 23.9% reduction in live burrow density by plugging burrow openings with twigs of *Acacia* spp. and fruits of *Xanthium* spp., respectively. This method is categorized as *effective*.

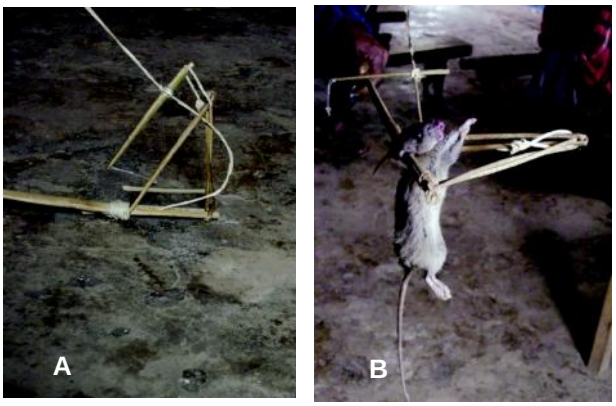

Fig. 2: *'Yiang Khne'* – traditional rat trap of the Jaintias of Jaintia Hills, Meghalaya. A. the trap, B. the trap with a caught rat

Fig. 3: *'Changkhol'* – traditional rat trap of the Hmars of North Cachar Hills, Assam

15. *Method* : One of the main and most common methods of controlling rodents is trapping by using different types of indigenous traps. Rat traps are used in almost all the households. The Jaintias use a trap made of bamboo strips and canes and the trap is locally known as '*Yiang Khne*' (Fig. 2A, B). The Hmars call their traditional rat trap as '*Changkhol*' which is made from thick iron wires (Fig. 3). The Tangkhuls use different types of rat traps based on the place of application. One of the traps is locally called '*Satin tang khalan*' (*satin*-umbrella stick, *tang*-twig, *khalan*-trap) and is used both in the fields as well as in storage (Fig. 4A, B). Another type called '*Ashe khalan*' (*ashe*-road/way) is mainly used in the field and there are mainly two ways to put the trap taking into account the movement pathways of rats. Sometimes, the trap is laid perpendicular to the

Fig. 4: '*Satin tang khalan*' – traditional trap of the Tangkhuls of Ukhrul district, Manipur. A. the trap, B. shows the way rats are trapped

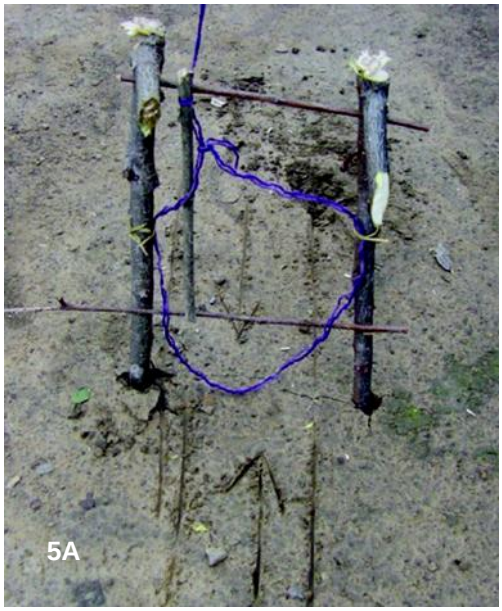

Fig. 5: '*Ashe Khalan*' – traditional rat trap of the Tangkhuls showing its application perpendicular to the ground. A. application of the trap, arrows on the ground indicates movement pathway of rats, B. demonstrating with a wooden piece as rat approaching the trap, C. shows how rats are trapped

ground (Fig. 5A-C) and sometimes laid horizontal on the ground (Fig. 6A-B).

***Empirical Evidences* :** Trapping rodents in fields and premises is a common old practice (Fitzwater and Prakash, 1989). Two basic types of traps are being used, the kill trap and the live trap. In the present study area, the second type is mainly practiced. Parshad *et al*. (2006) reported species-specific differences in trapping of rodents with live and kill traps. *B. bengalensis* were trapped more with snap traps and *Mus* spp. with live traps. There are sufficient evidences in the literature that locally made traps are effective in controlling rat population to a great extent (George, 1979; Prakash and Mathur, 1987; Pathak and Kumar, 2001). This method is categorized as *highly effective*.

Fig. 6: *'Ashe Khalan'* – traditional rat trap of the Tangkhuls showing its application horizontal with the ground. A. application of the trap, arrows on the ground indicates movement pathway of rats, B. demonstrating with a wooden piece as rat caught in the trap

Concluding Remarks

Documentation of 15 non-chemical rodent management methods indicates that the tribal communities have a good knowledge of rodent pests and their management methods including mode of actions. These methods have been developed and verified through ages of experience, which is implicit in the rationale for each method they put forth. Out of 15 methods, only three are categorized as directly toxic and the rest 12 methods are indirect means of rodent control. Non-experimental validation of about 50% (7 out of 15) of the traditional methods as highly effective indicates that these methods need special attention for possible replication. Prevalence and use of as many as five methods for attraction of rodent predators is an indication of the best utilization of the prey-predator principle which is one of the most important biological control methods of rodents based on ecological concept.

Thus, the striking feature of traditional rodent control methods appears to be the minimal effect on non-target organisms, which is one of the main constraints of chemical rodenticides. However, there are no species-specific control methods directed towards the dominant species like mole rat, Himalayan rat and common house mouse. It is needless to mention here that a single method alone may not be as effective as rodenticides but combined action of two or more methods may bring the desired result of controlling the rodents. However, there is a need for critical evaluation of these methods to assess their exact efficacy in order to use them on a wider scale and incorporation in formal rodent control campaigns.

Acknowledgements

The author is indebted to the tribal communities of the study area for sharing their experiences of rodent control, which is the basis of the present study, and also for their hospitality during the course of the survey. The author is also thankful to the Director, Zoological Survey of India, for infrastructure facilities.

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