BIOECOLOGY OF INDIAN GERBIL

Tatera indica (Hardwicke, 1807)

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All India Network Project on Vertebrate Pest Management

(Indian Council of Agricultural Research)

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Dated: Oct.28, 2017

FOREWORD

Rodents are one of the major pests causing damage to agricultural production throughout the world. Besides causing direct damage by feeding on different food items and other commodities, rodents also cause indirect damage by spoiling, contaminating and hoarding food grains during pre- and post-harvest stages. They also act as reservoirs of a large number of infectious organisms, many of which are of zoonotic importance. The average damage by rodents in India varies from 5-10%. To feed the increasing human population we need to protect our food grains from rodent pests. The Indian gerbil, *Tatera indica* is an economically important rodent pest found in almost all the states of India. For protecting our agricultural produce from this species, complete knowledge about its habitat, ecology, biology, reproduction and behaviour is required.

Study of bio-ecology of different rodent species was a new initiative of ICAR under which information regarding *T. indica* was generated and has been documented in the form of present bulletin entitled 'Bioecology of Indian gerbil, *Tatera indica* (Hardwicke, 1807)' which provides a complete information on this species. The information included in this bulletin has been compiled by the scientists working under All India Network Project on Vertebrate Pest Management (Rodent control), Department of Zoology, Punjab Agricultural University, Ludhiana and Network Coordinating Unit, Central Arid Zone Research Institute, Jodhpur. Hope this publication will be useful for those involved in rodent pest management at all levels in the country.

I congratulate the authors and wish them all success in this endeavor and for their timely efforts in bringing out this publication. I am sure this will be of great help to students, researchers and other technicians engaged in rodent management.

(P K Chakrabarty)

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MESSAGE

I am delighted to learn that the scientists working under All India Network Project on Vertebrate Pest Management (Rodent Control), Department of Zoology in association with scientists of Central Arid Zone Research Institute, Jodhpur, Rajasthan, have brought out a publication on "Bioecology of Indian gerbil, *Tatera indica* (Hardwicke, 1807)". This publication will act as a rich source of information for students, researchers and scientific community involved in rodent pest management. Current status of scientific information on this rodent pest species in Indian scenario is presented. The species, besides causing direct damage to our agricultural produce is also involved in transmission of infectious organisms of zoonotic importance.

I hope this publication will provide an impetus to further studies by scientists and students. I appreciate the sincere efforts made by the Principal Investigator of the project and her team for bringing the useful information at one place.

(Navtej Singh Bains)

PREFACE

Indian agriculture has progressed a long way making India a significant exporter of different agricultural commodities. This was achieved by bringing larger portion of land under agriculture and introducing new farm technologies. However, thrust on intensive cropping and adoption of high yielding varieties coupled with increased fertilizer use and agricultural technology also resulted in increased population of various pests challenging the Indian agriculture in a big way. Therefore, there is a need to protect our agriculture from the vagaries of pest and diseases for ensuring national food security.

Rodents have been globally identified as the most important mammalian pests at pre- as well as post-harvest stages. These include rats, mice, bandicoots, gerbils, voles, bamboo rats, porcupines, squirrels etc. The Indian gerbil (*Tatera indica*) also known as "Antelope rat", belongs to sub-family Gerbillinae under family Muridae. This species is widespread in distribution ranging from the Near East, the North of the Arabian Peninsula and Iran to most of South Asia. It is a major rodent pest and vector species of the country as it causes extensive damage to various crops besides acting as reservoir for infectious organisms of zoonotic importance. Though adequate technology has been developed for managing rodent pests through Network projects but to manage a particular species, it is essential to have knowledge about its biology, ecology and behaviour in different agroclimatic conditions.

The ICAR sponsored All India Network Project (AINP) on Vertebrate Pest Management (formerly AINP on Rodent Control) has been publishing its findings on different pest rodent species in form of bulletins and this is fourth in the series after *Bandicota bengalensis, Bandicota indica* and *Hystrix indica*. Through this publication, an attempt has been made to compile all the information related to distribution, habitat, population ecology, burrow ecology, reproductive biology and behaviour of *Tatera indica.*

The authors are grateful to Indian Council of Agricultural Research (ICAR), New Delhi for providing financial assistance for promoting rodent management research in India. Sincere thanks are also due to Director General, ICAR and Secretary DARE (Govt. of India) and Deputy Director General (Crop Sciences), ICAR, New Delhi and for their kind support and guidance. We are also grateful to the Vice-Chancellor, Director of Research and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for providing moral support and encouragement in bringing out this publication. We express our special gratitude to Dr. P.K. Chakrabarty, Assistant Director General (Plant Protection & Biosafety), ICAR, New Delhi for constant support, guidance and for encouraging scientists for patronizing research on rodent management. At the end, we are also thankful to the technical and non technical staff working under the project for assistance in completion of this assignment.

We are hopeful that this publication will be of immense use to the students and scientists working on rodent pest management, especially in furthering research on this particular species.

Authors

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Bioecology of Indian gerbil *Tatera indica* (Hardwicke, 1807)

I. TAXONOMY

Kingdom	:	**Animalia**
Phylum	:	**Chordata**
Subphylum	:	**Vertebrata**
Infraphylum	:	**Gnathostomata**
Superclass	:	**Tetrapoda**
Class	:	**Mammalia**
Order	:	**Rodentia**
Family	:	**Muridae**
Subfamily	:	**Gerbillinae**
Genus	:	***Tatera* Lataste, 1882**
Species	:	***T. indica* (Hardwicke, 1807)**

II. SPECIES STATUS

The International Union for the Conservation of Nature and Natural Resources (IUCN) considers the Indian gerbil, *Tatera indica* (Hardwicke, 1807) as least concern species. It is included in schedule V of Indian Wildlife Protection Act 1972. It is a common pre-harvest pest of dryland agriculture in India and other parts of South Asia and is responsible for major crop damages and thus a serious constraint in agricultural production. Three subspecies of *T. indica* viz., *T. i. indica, T. i. hardwickei* and *T. i. cuvieri* are known to be present in India, however, only two of them, i.e. *T. i. indica* from North India (up to Maharashtra) and *T. i. cuvieri* from South India have been recognized.

III. DISTRIBUTION PATTERN

It has been proposed that many of the murid lineages from the mid-Miocene through the Pliocene originated in Asia and subsequently migrated to Africa. However, rodents of subfamily Gerbillinae provide an opposite pattern with several migration events from Africa towards Asia during the same periods. Therefore, it was suggested that *T. indica* has originated in Africa and migrated to Asia through some land bridges between Africa and Asia.

Based on morphological and taxonomical characteristics, 12 species of genus *Tatera* were identified of which 11 are present in Africa and only one species (*T. indica*) is found in Asia. Based on morphological characters, *T. indica* can be strictly considered as *Tatera* (=*Gerbilliscus*) *sensu stricto* and consequently all the 11 African species of genus *Tatera* were placed in genus, *Gerbilliscus* Thomas. Molecular characterizations of genomic DNA data has shown that the genus *Tatera* is a polyphyletic taxon.

This species is widespread in distribution ranging from the Near East, the north of the Arabian Peninsula and Iran to most of South Asia. It has been recorded from southeastern Turkey, eastern Syria, Kuwait, Iraq, central and southern Iran, Pakistan, Afghanistan, India, Sri Lanka and Nepal. Its existence ranges in elevation up to 2,000 m from sea level. *T. indica* is found throughout India, the northern limit being the Jammu region (Jammu & Kashmir) and eastern limit is West Bengal. The North Indian sub species *T. i. indica* is distributed in Jammu, Himachal Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Odisha, Uttar Pradesh, Kumaon region in Uttarakhand, Bihar and West Bengal. Likewise, the South Indian sub species, *T. i. cuvieri* occurs in the states of Maharashtra, Goa, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala (Fig. 1).

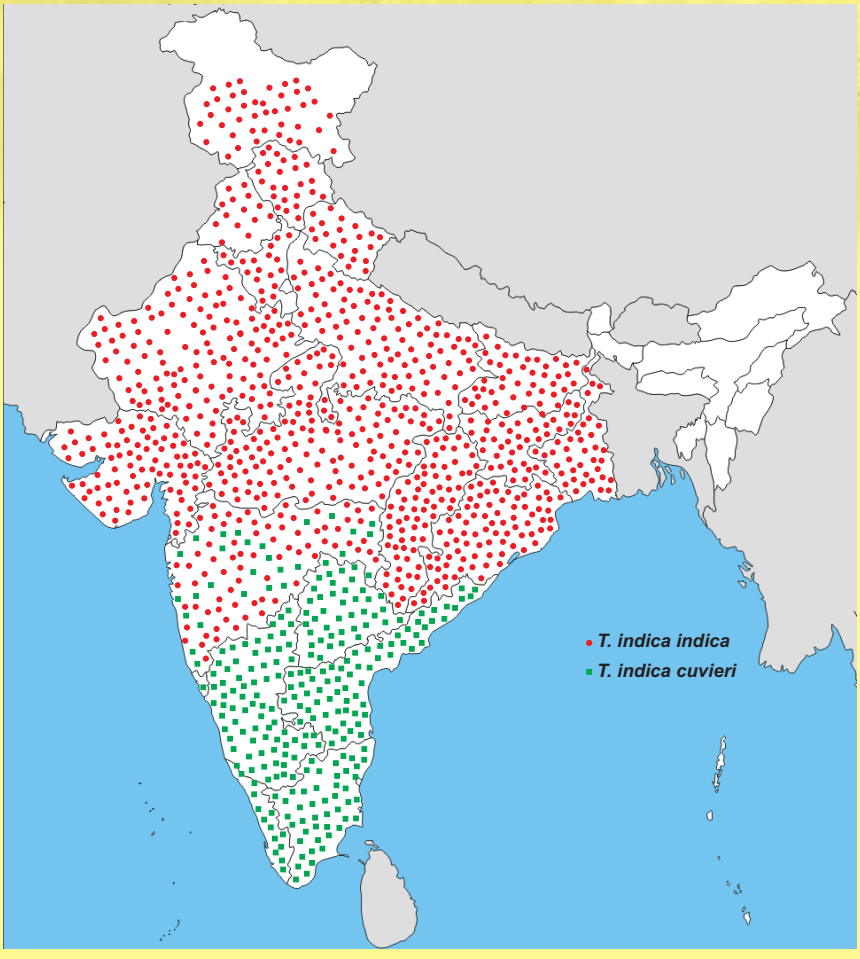

Fig.1: Distribution in India

IV. HABITAT

Amongst all the gerbil species (desert gerbil, *Meriones hurrianae*; hairy footed gerbil, *Gerbillus gleadowi*; Wagner's gerbil, *Gerbillus nanus* and *T. indica*) reported from India, *T. indica* appears to be the most ecologically adopted species. It is found in a range

of arid to semi-arid habitats. It is the most widely distributed and predominant rodent pest of agriculture in South Asia where it occurs in forests, grasslands, rocky areas, undisturbed barren open areas (Fig. 2), hot deserts, arid and semi-arid regions, dry river slopes, cultivated plains, gardens, orchards, crop fields and uncultivated waste lands. *T. indica* is one of the economically important species of rodents occurring in India. It is the predominant rodent pest species of the Rajasthan desert in northwest of India constituting about 63% of total rodent fauna. Here it inhabits the mud fences and backyards of houses. In the western Rajasthan, it is the major pest of dry farming systems. In Punjab, it constitutes about 10% of the total murid fauna. It is the prominent pest species of wheat, maize, sugarcane, oilseeds, groundnut, fodder and cotton fields particularly in arid and semi arid regions. In crop fields of Punjab, it occupies second position in predominance next to lesser bandicoot rat, *Bandicota bengalensis* in total murid fauna. In Haryana also it is a fairly predominant species where it inhabits wastelands as well as croplands. The species also occurs in sub-humid and humid zones of central, eastern and southern India. It is also found in the sandy areas on the sides of roads (Fig. 3) on the outskirts of the cities. It is well adapted to survive in almost any kind of habitat which is nearby the agricultural fields and is having enough food thereby playing an important role in Indian agriculture.

Fig. 2: Burrows in undisturbed barren open areas

Fig. 3: Burrows in sandy areas on the sides of roads

V. KARYOTYPE

The karyotype of *T. indica* consists of 68 chromosomes including eight bi-armed pairs and 25 acrocentric pairs of autosomes. The X chromosome is large and metacentric, while the Y chromosome is small and acrocentric.

VI. MORPHOLOGICAL CHARACTERS

The Indian gerbil, *T. indica* (see Figure cover page) also called "naked soled gerbil" and "the antelope rat" is one of the largest species of gerbils measuring upto 38 cm from head to the tip of the tail. Tail is slightly longer than head and body. Length of head and body varies from 14-19 cm and that of tail from 15-20 cm. Males are slightly larger than females. Gerbils of both sexes possess a genital papilla that coveres the penis in males

and the clitoris in females. Sexes can be distinguished based on distance between the anus and genital papilla, which is more in males than in females. Body weight of adult gerbils ranges from 100-230g.

Body colouration: There is a clear demarcation between the colour of dorsum and ventrum (Fig. 4a). Colour of dorsum ranges from light blackish brown to fawn and the ventrum is pure white in colour. The fore and hind limbs are also whitish in colour.

Fur texture and hair: Thick fur covers the body but the tail hair is sparse. Fur texture is soft having two kinds of hair i.e. contour hair and guard hair. Contour hair make the bulk of the externally visible fur. Guard hair are long black in colour and often quite thick and project some distance beyond the contour hair (Fig. 4b). The vibrissae are generally black and are both small and large.

Eyes and ears: The eyes are large and prominent with whitish hair on the upper side (Fig. 4c). The ears are somewhat oblong in shape (Fig. 4d) with fine hair towards inner margin of the pinna.

Fig. 4: Characteristic morphological features, (a) colour of dorsum and ventrum, (b) two types of hair, (c) large and prominent eyes with patch of white hair on upper side, (d) ear pinna oblong with fine hair towards inner margin and (e) bicolour tail with tuft of black hair at the tip

Tail: Tail is brownish black on its dorsal side and off white on its ventral side. Tail bears a tuft of black hair at the terminal end (Fig. 4e), a characteristic feature of all gerbil species.

Incisors: Two pairs of incisors are found in each jaw. They are usually covered with yellow enamel. Incisors in the upper jaw are grooved (Fig. 5).

Fig. 5: Grooved incisors in upper jaw

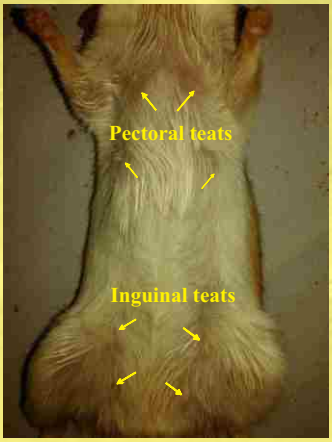

Fig. 6: Four pairs of teats in female

Teats: These are paired in *T. indica* i.e. equal number of teats is present on the two sides. Four pairs of teats, two pectorals and two inguinal are present (Fig. 6).

Fore limbs: The manus or fore-paw of gerbils has five digits, each with a recurved claw. One digit is very small. Horizontal lamellae are present on the ventral side of median digits (Fig. 7a). The palm is naked without hair and has interdigital pads at the base of the digits and two large metacarpal pads situated further back. Length of fore limbs ranges from 4-6 cm.

Hind limbs: The pes or hind-paw has five distinct digits, the middle three are the longest (Fig. 7b). Well-formed claws are present on all the five digits. The sole has small interdigital pads at the base of the digits and small metatarsal pads situated further back. The skin between the interdigital pads and metatarsals is some time granular. Upper surface of the pes is covered with hairs extending on to the toes. Length of hind limbs ranges from 5-7 cm.

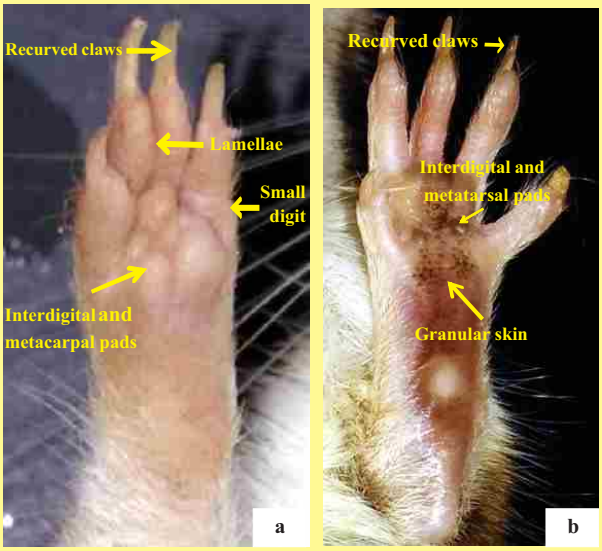

Fig. 7: Characteristic morphological features of fore and hind paws

VII Food and Feeding

Indian gerbil is a crop pest. In fields, it inflicts severe losses to the standing crops by feeding upon the sown seeds,

sprouting saplings and maturing crop ear heads. It mainly feeds on grasses, leaves, roots, tubers, nuts, grains, seeds and fruits (Fig. 8a,b). It is omnivorous in diet. It also eats grubs, insects and nestling ground birds. This species is known to kill and eat smaller rodents and other mammals. It stores food in burrows for consumption in the dry season (Fig. 9 a,b). During the wet season insect availability increases and the proportion of insects and other arthropods in its diet rises to as high as 40%. Cannibalism on young is common in both captivity and the wild. Indian gerbils are also hunted for food in southern and northeastern India. Examination of regurgitated pellets of Barn Owl, *Tyto alb*a revealed the presence of skull remains of *T. indica* (Fig. 10 a, b) indicating this to be the prefered food of Barn Owl.

Fig. 8: Damage to bottle gourd and pumpkin

Fig. 9. Hoarding of wheat ear heads and moong beans in the burrow of *Tatera indica*

During monsoon, with the abundance of green food it turns out to be a selective feeder, switching over to choicest plant species having superior nutritive value. In laboratory, mean daily consumption of food varied from 13-20 g of dry grains, which equals 10% of the gerbils' body mass. In laboratory, the order of food preference of *T. indica* to different grains was bajra, maize, wheat, rice and moong grains.

VIII. Reservoir of Zoonosis

The Indian gerbil also acts as a reservoir for a number of micro and macroparasites of

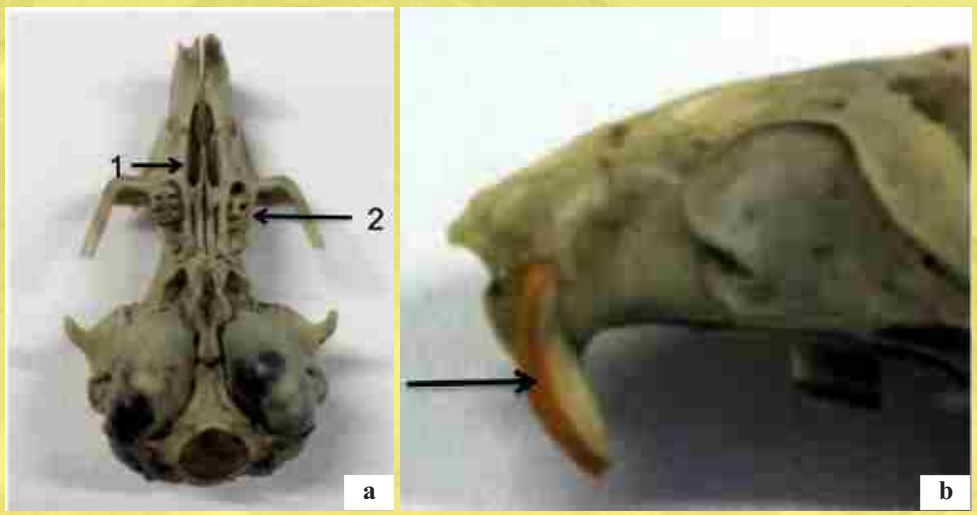

Fig. 10: Skull remains of *Tatera indica* found in regirgitated pellets of Barn Owl, *Tyto alba, (*a) ventral view of skull arrow (1) shows anterior palatal foramina extending posteriorly upto the molars, arrow (2) shows upper molar root sockets and (b) lateral view of skull, arrow shows grooved incisors

zoonotic importance. It is believed to be the main reservoir host of zoonotic cutaneous leishmaniasis (ZCL), an endemic disease in more than 80 countries in the world. Close contact with infected reservoir host increases the probability of transmission of *Leishmania* parasite infections to susceptible humans. *T. indica* has also been incriminated as the main reservoir for transmission of plague bacillus through rat fleas to humans resulting in plague. It transfers fleas from wild to domestic rodents, which are responsible for the transmission of bubonic plague in and around India. *T. indica* also serves as reservoir host of a number of helminth parasites. New species of a cestode, *Mathevotaenia tateri* and a nematode, *Seuratum bilqeesae* were found in the small intestine of *T.* ***indica*** trapped from Pakistan which may be responsible for transmission of diseases. In Punjab province of India, 20% of the *T. indica* trapped from crop fields were found infected with one or more helminth parasite. In one of the *T.* ***indica***, numerous metacestodes of *Taenia taeniaeformis* were found attached to the mesentery and the abdominal wall. Out of the total *T. indica* collected, 29.4% were infected with nematodes, 9.8% with cestodes and 5.9% with acanthocephalans. Endoparasites of zoonotic importance such as *Spirurida, Hymenolepis diminuta, Hymenolepis nana, Trichuris trichiura, Skerjabino taenia, Trichostrongylus* spp., *Entamoeba muris, Chilomastix mesnili* and *Leishmania* spp. have been reported in *T. indica* collected from southeastern Iran.

IX. Burrow Ecology

Burrows provide a stable microclimate and provide protection from extreme temperatures and predators. The burrows of *T. indica* may be deep or shallow and characterized with single (Fig. 11a) or multiple openings with or without heap of excavated soil around the holes. The main entrance of burrow runs deep into the soil in the form of a slanting tunnel. Burrows usually follow 'Y' or 'V' shaped pattern (Fig. 11b).

The burrow architecture of Indian gerbil vary in different seasons according to different soil types (Fig. 12a-d). In loamy sand type of soil, the length of the burrows was found to be more in winter season (upto 255 cm) as compared to that in summer season (upto 200 cm), whereas the depth of the burrow was less in winter season (upto 53 cm) as compared to that in summer season (upto 85cm). This may be to avoid high ambient temperature in summer season and to get more environmental heat in winter season. Higher sand content leading to lesser water holding capacity and lesser moisture content in loamy-sand soil is more suitable for the burrowing activity of *T. indica*. The length and depth of the burrow was more in loamy-sand over sandy-loam soil. The mean number of branches of burrows is also more in loamy-sand soil (2.49-5.29) than in sandy-loam soil (1.52-3.78). The orientation of surface openings also changes with respect to the season so as to get sufficient sunlight during winter season and minimum during summer season. The number of burrow openings in different seasons varied from 1-3 with diameter of 8-15 cm.

Fig. 11. Characteristic burrow entrances running deep into the soil in the form of, (a) single slanting tunnel and (b) following 'Y'or 'V' shaped pattern

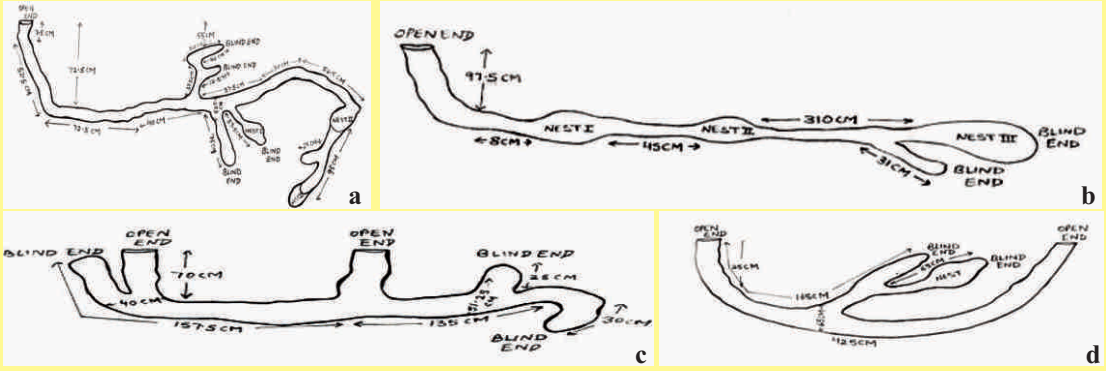

Fig. 12: Burrow architecture in different seasons and soil types, (a) loamy sand soil in winter season, (b) sandy loam soil in winter season, (c) loamy sand soil in summer season and (d) sandy loam soil in summer season

X Population Ecology

In agricultural fields of Punjab, Haryana and other northern states, *T. indica* has been found to co-exist with other field species such as *B. bengalensis*; soft furred field rat, *Millardia meltada*; Indian bush rat, *Golunda ellioti* and *field mouse, Mus booduga*. In Rajasthan, it has been found associated with *M. hurrianae; G. gleadowi*; *G. nanus*; sand coloured rat, *Rattus gleadowi*; short tailed mole rat, *Nesokia indica*; *M. meltada; G. ellioti; M. booduga* and *B. bengalensis*.

In Punjab, population dynamics of the *T.indica* was studied by trapping them from crop fields at monthly intervals. In the last 4-5 years, there was observed no trapping of Indian gerbils in the months of April-May. Trapping was maximum (13.3-40 animals trapped/100 trap nights) in the months of June and November (Fig. 13) indicating breeding peaks prior to these two months. Population remained low from July to September, started building up in October and reached maximum in November. All the animals trapped in October were mature whereas, in November, both mature and immature gerbils were trapped indicating August-October to be the breeding months. Similarly, both mature and immature gerbils were trapped in June indicating March-May to be the breeding months. Availability of green and nutritive food enhances their reproduction and survival of fresh recruiters in the population. Total burrow count recorded was maximum during monsoon season (10.66) and minimum during summer season. Monthly trapping in Jodhpur, Rajasthan revealed Indian gerbil to be the predominance species with maximum trapping in the months of March and November. More numbers of mature and pregnant females were trapped in the months of March-May.

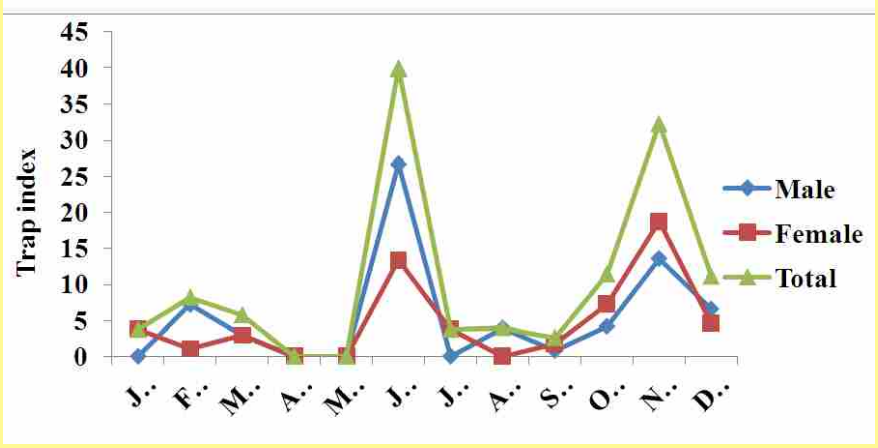

Fig. 13: Population dynamics in different months

XI. Behvioural Biology

This species appears to be the most adapted ecologically. It has acute sense of smell, taste, touch and hearing but is colour blind. Little is known about its social and sexual behaviors, memory and cognition, responses to changes in ecology and the behavioral regulatory mechanisms. However, from the available information following conclusions can be drawn about its behaviour.

Life expectancy: In the wild, most individuals don't survive their first year of life and adults probably live only for a few years. In captivity, they have lived for up to 7 years.

Sex ratio: The sex ratio (male: female) of field trapped *T. indica* recorded in different seasons was more in favour of females. The sex ratio of laboratory born pups was, however, found to be male biased.

Nocturnality: The Indian gerbil is nocturnal, therefore able to avoid the extreme heat of the day. Generally it lives within burrows during the day and comes above ground during night for feeding, defecation and social and sexual interactions with other individuals. It evades extreme cold by ceasing its feeding activity at midnight but during the summer, it is active throughout the night. Its several individuals were also found foraging or copulating near their burrows during afternoon hours in February-March.

Kinship and non-kinship related behavior: Generally, individuals living in social groups can distinguish kins from non-kins and differentiate classes of kins as siblings, half siblings and cousins. Related individuals do not breed among themselves and can recognize their family and kins similar to other mammalian systems. Though the large number of individuals have been found living in a single burrow system, they may live single or in pairs.

Running and swimming: It is very fast runner and can leap meters into the air when surprised. It is a good swimmer and can continuously swim for hours if exposed to water. This behavior enables it to adapt to deep-water crop conditions where it can swim to the middle of the field for feeding.

Neophobia: It shows neophobic behaviour when introduced to a new food/ object.

Fossoriality: It lives in self-constructed shallow as well as deep and elaborated burrow systems and prefers sandy plains and grasslands that allow extensive burrowing. It makes complex burrows with number of openings spread in large areas for the purpose of safe shelter, reproduction, family care and hoarding food stuff. Its burrowing activities aid in soil turnover and the re-distribution of soil nutrients. Plugging of burrow openings twice at 15 days interval with spiny twigs of *Acacia* spp. resulted into 39.3% burrow desertion by the occupants.

Food hoarding: During excavation of burrows, broken ear heads of wheat and rice crops, grains, straw, moong beans, grass stems, bushes etc. were found in specialized food chambers made in their burrow systems. The food hoarding per burrow varied from 25-900g.

Bait shyness: As they live in dry areas with scarcity of food, they have keen ability to discriminate between harmless and harmful foods. Therefore they easily develop aversion towards poison bait. Bait shyness and poison aversion once developed can persist for several months (120 days). As they have acute sense of smell, bait shynes behavior has been reported to be mitigated by adding conspecific urine in poison bait.

Home range: The home range of male gerbil was found overlapping with that of female gerbils. Females moving longer distances as compared to males. Estimated maximum home range for male gerbils is 30m, whereas for female gerbils it varies from 46-105m around the burrow.

Social organization: In desert grasslands, *T. indica* lives singly or in pairs in burrows but in urban settlements, their social organization is gregarious, where 4-70 gerbils may

occupy a burrow system. They are polygynous in gregarious social life and involve multi dominance of both males and females. Studies indicated that within colonies the individuals develop social hierarchy based on body mass and behavioral acts such as fighting, chasing, sniffing, sideways and upright postures and aggressive acts.

Scent glands: The scent marking gland is situated on the mid ventral side. The size of gland is positively and significantly correlated with body weight. It is smaller in females than in males. In females, the scent marking is compensated by urine marking. The growth of the gland is a continuous process throughout the life of gerbils. Scent marking activity may start prior to attaining sexual maturity. The scent marking in *T. indica* has been attributed to a number of functions like territoriality, familiarization, denoting the home range, reproduction, advertising ready-to-mate stage in females and social hierarchy. Frequency of scent marking is more in dominating animals in a social group, which decreases with increasing population density.

Communication: Olfactory communication is more when gerbils are at distance from each other but when their population density is high, they communicate with each other either by direct contact, visual and/or auditory means.

XII. Reproductive Biology

Breeding season: Indian gerbils can breed multiple times throughout the year. Generally, inbreeding among kins is avoided. Unrelated individuals could breed in the laboratory with up to 90% breeding success. Though *T. indica* lives in colonies but forms monogamous pairs for breeding. Paired gerbils usually begin to mate at about 3-4 months of age. Mating can be identified by a ritual of chasing and mounting, with both gerbils checking their undersides after each round. The gestation period ranges from 21 to 30 days. Litter size ranges from 4 to 10 young ones, with 5 to 6 being the most common number. Average birth mass is of 3 g. Most of the parturitions usually take place during day time. Lactation commences immediately after delivery of pups and continues up to weaning (Fig. 14). Young gerbils become independent as early as 21 days of age.

In Rajasthan, the percentage of field trapped pregnant females varied from 9.7-61%. Breeding peaks occurred during February, July-August and November. However, in Punjab, peak breeding seasons have been found to occur from March to May and August to October coinciding with maturity of wheat and rice crops. In Karnataka, gerbils collected from fields experienced a seasonal breeding periodicity from August

Fig. 14: Lactating female during post natal period

with intervening quiescent period between May to July. This is the effective period to initiate control operations in agricultural fields when the population is at its base level. The peak breeding activity was seen from October to December (72 to 80% pregnancy) with a mean litter size of 6. This variation in breeding activity could be due to the environmental factors such as day length, temperature, rainfall, cropping pattern and availability of food. The breeding rate (productivity) was calculated to be 53 young ones/female/breeding season. Breeding activity of *T. indica* can also be correlated to the mean monthly day length. The reproductive activity is low during winter when day length is shortest. *T. indica* continued to reproduce even in January and February which are the coldest months of the year in Iraq. The mean numbers of embryos ranged between 7.2 and 8.0.

Oestrous cycle: Examination of vaginal smear of female gerbils revealed average duration of oestrous, met-oestrus, di-oestrus and pro-oestrus stages in one oestrous cycle to be 0.38, 0.62, 1.37 and 0.61 days, respectively. The total duration of one oestrous cycle was found to vary from 3 to 5 days in the laboratory. The length of oestrous cycle increases slightly with age and lasts about 6 days near the end of the reproductive life span.

Postpartum oestrous: Coming back of a female into heat within hours after parturition is called postpartum oestrus. Laboratory studies revealed that when the male was not separated from female after parturition the female came to heat immediately or within a day resulting in mating and back to back pregnancy. The incidence of mating was unaffected by nursing. Difference in two parturitions was 21-23 days. The second litter was born just at the same time, the first litter was weaned. The average litter size during second parturition was, however, reduced (3.0) compared to that during first parturition (6.5). Moreover, the juveniles of second litter were observed to be weak which may be because of stress on the mother. In some cases, more cannibalism of juveniles was observed when the male was not separated from the female after parturition. Whether the cannibalism of juveniles is more by the female or by the male partner could not be established. When the males were separated from females before parturition, the females resumed cyclicity but the oestrous stage was not observed immediately after parturition.

Postnatal growth: The young ones are born in a relatively helpless state (altricial) in a nest chamber of the burrow. Females nurse and care for their youngs until they become independent. Laboratory studies on postnatal development revealed a significant increase in body weight, head and body length, tail length, and the length of fore and hind limb of juveniles of both sexes from the day after birth. Average body weight of both male and female juveniles increased from 13.1 g on day 8 after birth to 87.4 g and 85.6 g, respectively on day 72. Increase in length of head and body, tail and of fore and hind limbs in juveniles of both sexes was significant from day 8 to day 48 after birth, but after that the increase in length was gradual.

The appearance of different morphological characters in juveniles from the day after birth is depicted in Fig. 15. The new born young ones were hairless and toothless with short limbs and tails. They were pinkish in colour when born. Two large dark spots

of eyes were clearly visible. The ears were folded and enclosed in a membrane at birth and started unfolding by day 5. Gradually dorsum started becoming darker than ventrum and the length of the body as well as the tail and limbs started increasing. On day 6 after birth, dorsum became blackish in colour and from day 10 onwards, fine black hair became visible on the dorsal side. Short pelage appeared all over the body by the end of day 13. The ears unfolded completely by day 17. Tip of the tail started becoming black from day 17 onwards and a tuft of black hair was clearly visible from day 20 onwards. The eyes started opening from day 15 and completely opened by day 18. White pelage was visible on the ventral side from day 18 onwards.

Up to the age of 90 days, testes in male juveniles were found located inside the body i.e. abdominal in position. Testes descended to scrotum after the age of 105 days (Fig. 16). In juvenile females, the vagina remained non-perforated until these were kept with the mother and kins in the laboratory. There may be the requirement of vaginal stimulation or mating by unrelated male to induce vaginal perforation. When disturbed, the mother gerbil used to pick up her young ones in mouth, huddling them in a corner or under the cotton pad. Juveniles separated from the mother for taking morphometric

Fig. 15: Appearance of different morphological characters in juveniles during postnatal growth

measurements were accepted by the mother when kept back. Although weaning process began when the juveniles opened their eyes (by day 18), but the complete weaning occurred after about 4 weeks. They began exploring and nibbling adult food and tasting water after their eyes opened.

Fig. 16: Mature male with scrotal testes

Onset of sexual maturity in juveniles:

In males : Laboratory born male juveniles of different ages (30 days, 45 days, 60 days, 75 days, 90 days, 105 days and 120 days old) were observed for studying the onset of sexual maturity. A significant increase in weight of testis, epididymis, seminal vesicles and prostate gland was observed from day 30 to 120 after birth indicating their development. The body weight and size of reproductive organs was also found increasing simultaneously.

No spermatozoa were observed in the cauda epididymal fluid of gerbils of age groups 30 to 90 days. There were present non spermatozoal cells in the cauda fluid of gerbils of these ages. Spermatozoa were observed in the cauda epididymal fluid of gerbils of ages 105 and 120 days, indicating the onset of sexual maturity. In gerbils of these two age groups, the sperm motility, viability and density were found to vary from 73-87%, 70.75-75.33% and 99.60-146.20 millions/ml, respectively. The level of male gonadal hormone, testosterone in blood plasma of male gerbils was also found increased from 0.40 ng/ml on day 30 after birth to 1.95 ng/ml on day 120 after birth.

Histology of testicular tissue of gerbils of different age groups revealed significant increase in diameter of seminiferous tubules from 0.04 mm on day 30 to 0.21 mm on day 120 after birth. At the age of 30-75 days (Fig. 17a), cells of first meiotic prophase were observed in the seminiferous tubules, whereas the cells of second meiotic division i.e. round spermatids were visible at the age of 90 days. At the ages of 105 and 120 days, large number of elongated spermatids leading to the formation of spermatozoa in the lumen (Fig. 17b) were observed indicating complete sexual maturity in male gerbils at the age of 3-4 months.

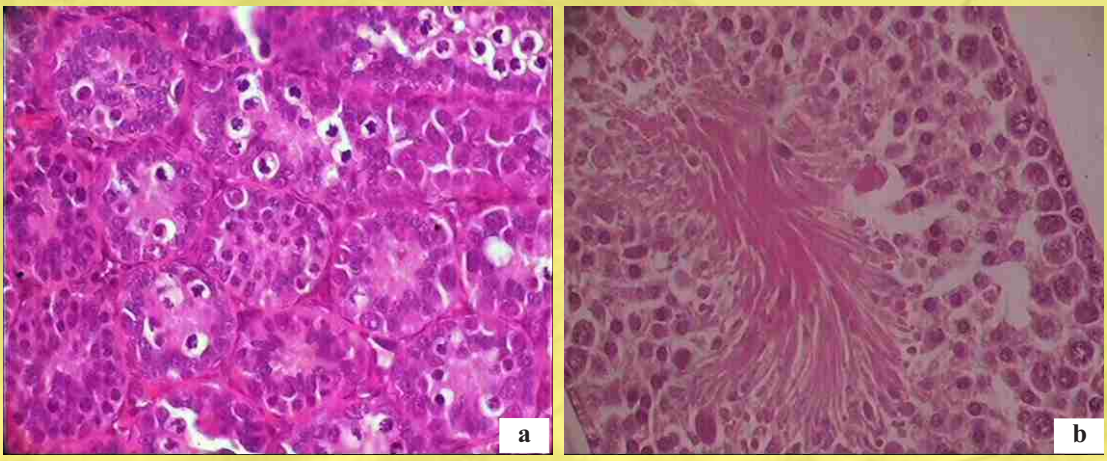

Fig. 17: Section of testis showing seminiferous tubules, (a) in 30 days old gerbil and (b) in 120 days old gerbil (1000x)

In females: Laboratory born female juveniles of different ages (30 days, 45 days, 60 days, 75 days, 90 days, 105 days and 120 days old) were also observed for studying the onset of sexual maturity. A significant increase in weight of ovaries from 0.01 to 0.13g/100g bwt and of uterus from 0.01 to 0.17 g/100g bwt was observed from day 30 to day 120 after birth indicating their development. The number of corpora lutea was found to vary from 2 to 5 per ovary in gerbils of ages 90 to 120 days. The number of ovulations and hence the number of corpora lutea increased with increasing age of gerbils. The average level of female gonadal hormone, the estradiol in blood plasma of gerbils of different age groups was found increased from 0.45 ng/ml on day 30 to 2.05 ng/ml on day 120 after birth.

Histology of ovarian tissue of gerbils of different age groups revealed predominance of primordial follicles in the cortex region of the ovary at the age of 30 days (Fig. 18a). Development of primary, secondary, tertiary and pre-antral follicles was found in gerbils at the age of 45 days. More number of pre-antral and mature antral follicles was found at the ages of 60 to 75 days (Fig. 18b). Simultaneously there was ovulation from day 90 onwards indicating complete sexual maturity in female gerbils at the age of 3 months.

XIII. Management

Technologies for control of rodent pests are available with us. But no single method is 100% effective in different pest situations. For long-term effects of control operations and to effectively prevent economic losses caused by *T. indica,* suitable strategies by integrating lethal and non-lethal methods should be adopted. Decision regarding the type of methods to be integrated would depend upon the kind of pest situation. Selection of suitable bait formulation, method and timing of application are important for delivering the rodenticide to the target animal. Whole or broken grains of wheat, millet, rice or sorghum or their mixture with addition of 2% vegetable oil and/ or 2% sugar are

Fig. 18: Section of ovary, (a) in 30 days old gerbil (400x) and (b) in 75 days old gerbil (100x)

preferred by *T. indica* and are used in bait formulations with different rodenticides. Rodenticide bait can be placed within burrow or within the fields on pieces of paper. Knowlewdge about the ecology and behavior of *T. indica* is important for successful management of the species. Baiting with freshly prepared loose baits of zinc phosphide (2%) followed by that of bromadiolone (0.005%) is recommended for management of field rodents including *T. indica* in field crops.

Bibliography

Agarwal V C 2000) Taxonomic studies on Indian Muridae and Hystricidae (Mammalia: Rodentia). *Records of Zoological Survey of India* (Occasional paper No 180). Zoological Survey of India, Kolkata. pp 177.

Agren G (1984) Incest avoidance and bonding between siblings in gerbils. *Behav Ecol Sociobiol* **14**: 161-69.

Barnett S A and Prakash I (1975) *Rodents of Economic Importance in India*. Arnold Heinemann, New Delhi and London.

Beg M A and Ajmal A (1977) Reproduction in the Indian gerbil *Tatera indica* (Hardwicke). *Mammalia* **41**: 212-20.

Bhaduria A S and Mathur Y K (1994) Food/ bait preference of Indian gerbil, *T. indica indica* Hardwicke and bandicoot rat, *Bandicota bengalensis* Gray. *J Entomol Res* **18**: 85-87

Bhatnagar J K (1966) The role of rodents in the epidemiology of plague in Uttar Pradesh. Proceedings of the Indian Rodent Symposium, Calcutta. pp 204-15.

Bland K (1969) Reproduction in the female Indian gerbil *(Tatera indica* Hardwicke). *J Zool London* **157**: 47-61.

Chandna S S and Pasahan S C (1981) Field observations on the ecology of the Indian gerbil, *Tatera indica* (Hardwicke) in Hissar (Haryana). *An Arid Zone* **20(**1): 62-70.

Chandrahas R K and Krishnaswami A K (1974) Studies on the ecology of the Indian Gerbil *Tatera indica hardwickei* (Gray) in Kolar (Mysore State). *Indian J Med Res* **62**(7): 971-78.

Colangelo P, Civitelli M V and Capanna E (2005) Morphology and chromosomes of *Tatera* Lataste 1882 (Rodentia; Muridae: Gerbillinae) in West Africa. *Trop Zool* **14**: 243-53.

Ellerman J R (1961) *The Fauna of India including Pakistan, Burma and Ceylon.* Mammalia, Vol 3 (Rodentia), Part I & II. Govt. of India, Delhi. pp 884.

Garg S K and Chandna S S (1982) A note on the population of gerbils in irrigated and unirrigated fields. *Indian J Ecol* **11**: 321-22.

Gayathri Elayidan U (2012) Histomorphological studies on the ovary of the South Indian Gerbil *Tatera indica cuveri*. *Millennium Zool* **13**(1): 9-13.

Ghazi R R, Bilqees F M, Noor un Nisa (2002) *Mathevotaenia tateri* sp. from *Tatera indica* Hardwicke, 1807 with a note on its public health importance. *Pakistan J Zool* **34**: 279-81.

Ghosh P K and Taneja G C (1968) Estrous cycle in desert rodents, *T. indica* and *Meriones hurrianae. India J Exp Biol* **6**: 54-55.

Govinda R G and Sri H K (1987) Effective period for the control of gerbils *Tatera indica cuvierii* (waterhouse) in dry land crops- A study based on its reproductive biology. *Zeitschrift fur Angewandte Zoologie* **74**: 231-41.

Goyal S P and Ghosh P K (1993) Burrow Structure of two gerbil species of Thar desert, India. *Acta Theriologica* **38(4)**: 453-56.

Idris M and Prakash I (1982) Behavioral responses of the Indian gerbil, *Tatera indica* to conspecific sebum odour of the ventral scent marking gland. *Proc Indian Acad Sci* **92**(3): 259-65.

Idris M and Prakash I (1983) Response of the male Indian gerbil, *Tatera indica* to urine from females. *Indian J Exptl Biol* **21**: 97-98.

Idris M and Prakash I (1985) Social and scent marking behaviour of the Indian gerbil,

Tatera indica indica. *Biol Behav* **20**: 31-39.

Idris M and Prakash I (1986) Influence of odours of Indian gerbil, *Tatera indica* on the social and scent marking behaviour of sympatric desert gerbil, *Meriones hurrianae*. *Proc Indian Nat Sci Acad B* **52**: 333-40.

Idris M and Prakash I (1987) Scent marking activity in Indian gerbil, *Tatera indica* in relation to population density. *Anim Behav* **35**: 920-22.

Jain A N (1970) Body weights, sex ratio, age structure and some aspects of reproduction in the Indian gerbil, *Tatera indica indica* Hardwicke, in the Rajasthan desert, India. *Mammalia* **34**: 415-32.

Jain A P (1973) The organ: body weight relationships in the Indian gerbil, *Tatera indica indica* Hardwickei, 1807. *Mammalia* **37**(2): 353-58.

Jain A P (1978) *Eco-physiology of the Indian gerbil, Tatera indica indica Hardwicke, 1807.* Ph. D. Dissertation, University of Jodhpur.

Jain A P (1984) Ecological distributional patterns of the Indian gerbil, *Tatera indica* Hardwickei, in the Rajasthan desert. *Mammalia* **48**(4): 523-27.

Jain A P and Tripathi R S (1988) Major rodent pests of Agriculture: An illustrated guide. AICRP on Rodent Control, CAZRI, Jodhpur. pp 1-14.

Javadian E, Dehestani M, Nadim A, Rassi Y, Tahvildar-bidruni G H, Seyedi-Rashti M A and Shadmehr A (1998) Confirmation of *Tatera indica* (Rodentia: Gerbillidae) as the main reservoir host of zoonotic cutaneous leishmaniasis in the west of Iran. *Indian J Public Hlth* **27**(1–2): 55-60.

Kadhim A H (1998) Winter breeding of the Indian Gerbil, *Tatera indica* (Rodentia: Gerbillinae), with reference to its first recorded outbreak in Iraq. *Zool Middle East* **16**: 9-12.

Kaur M (2008) *Gerontological changes in reproductive organs of Tatera indica (Hardwicke)*. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.

Kaur P, Kaur B and Guraya S S (1997) Follicular growth and kinetics in the Indian gerbil (*Tatera indica*) ovary during oestrous cycle. *J Biosci* **22**(4): 489-95.

Kaur R (2004) *Kinship related spatial dynamics in the Indian gerbil, Tatera indica (Hardwicke)*. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.

Kaur R and Bilaspuri G S (1995) Environmental factors in relation to the reproductive activity of Indian Gerbil, *Tatera indica* in Punjab. *Indian J Ecol* **22**(2): 118-22.

Khajeh A and Meshkani J (2010) A study of intraspecies variations of Indian gerbil, *Tatera indica* Hardwicke, 1807 (Muridae, Rodentia) in eastern border of Iran. *Pakistan J Biol Sci* **13**(2): 59-65.

Kumar P V and Khan J A (1977) Food preferences of the gerbil, *Tatera indica indica* Hardwicke. *Zool J Linnean Soc* **64**: 51-58.

Kumari P V and Khan J A (1979) Food hoarding by Indian gerbil, *Tatera indica indica* (Hardwicke). *Proc Indian Acad Sci* **88B**(1): 131-35.

Kumari S and Prakash I (1983) The mid ventral gland of the Indian gerbil, *Tatera indica* and soft furred field rat, *Rattus meltada*. *Acta Theriologica* **28**: 425-34.

Measroch V (1954) Growth and reproduction in the females of two species of gerbil, *Tatera brantsi* (Smith) and *Tatera afra* (Gray). *Proc Zool Soc London* **124**: 631-58.

Mehrabani D, Motazedian M H, Oryan A, Asgari Q, Hatam G R and Owji S M (2011) Leishmania major in *Tatera indica* in Fasa, Southern Iran: microscopy, culture, isoenzyme, PCR and morphologic study. *Asian J Anim Vety Adv* **6**(3): 255-64.

Mirshamsi O, Darvish J and Kayvanfar N (2007) A preliminary study on Indian Gerbils, *Tatera indica* Hardwicke, 1807 at population level in eastern and southern parts of Iran (Rodentia: Muridae). *Iranian J Anim Biosyst* **3**(1): 49-61.

Mumtaz A (1989) Seasonal and age specific variations in body weight and cranial measurements of Indian gerbil (*Tatera indica*). UAF. pp 86.

Parveen F and Kashyap N (1990) A note on the food of the Indian gerbil *Tatera indica indica* Hardwicke in an arid environment. *J Bombay Nat Hist Soc.* **87**: 448.

Prakash I (1962) Ecology of gerbils of Rajasthan desert in India. *Mammalia* **26**: 311-31.

Prakash I (1968) Biology of the rodents of Rajasthan desert. *Proc Symp Natl Resources. pp* 337-52. Rajasthan University, Jodhpur.

Prakash I (1971) Breeding season and litter size of Indian desert rodents. *Zangew Zool* **58**: 442-52.

Prakash I (1975) Population ecology of ·rodents in the Rajasthan desert, India. In: Prakash I and Ghosh P K (eds): *Rodents in Desert Environments.* Dr. W Junk b.v. Verlag Publishers, The Hauge. pp 75-186.

Prakash I, Jain A P and Purohit K G (1971) A note on the breeding and post-natal development of the Indian gerbil *Tatera indica indica* Hardwicke, 1807 in the Rajasthan desert. *Sauget Mitteil* **19**: 375-80.

Prasad M R N (1954) Food of the Indian gerbil *Tatera indica cuvieri* (Waterhouse). *J Bombay Nat Hist Soc* **52**: 321-25.

Prasad M R N (1961) Reproduction in the female Indian gerbil *Tatera indica cuvieri* (Waterhouse). *Acta Zoologica* **42**: 245-56.

Rana B D, Prakash I and Jain A P (1970) Morphological variations in *Tatera indica indica* Hardwicke, 1807, inhabiting two types of Indian desert habitats. *Acta Theriol* **15**: 459-64.

Sabhlok V P and Pasahan S C (1989) Studies on rodent population structure and trap index in the fields of Haryana state. *Haryana Agric Univ J Res* **24**(2): 112-16.

Shehab A H, Al-Ahmad S A and Samara F F (2011) Morphology and distribution of the Indian gerbil, *Tatera indica* (Hardwicke, 1807), in Syria. *Zoology in the Middle East* **52**(1): 3-10.

Singla L D, Singla N, Parshad V R, Juyal P D and Sood N K (2008) Rodents as reservoirs of parasites in India. *Integr Zool* **3**(1): 21-26.

Singla N and Babbar B K (2010) Rodent damage and infestation in wheat and rice crop fields: District wise analysis in Punjab State. *Indian J Ecol* **37**(2): 184-88.

Singla N and Parshad V R (2005) Effects of prickly structures on burrow desertion by rodents. *Indian J Agric Sci* **75** (7): 425-27.

Tripathi R S, Jain A P Kashyap N, Rana B D and Prakash I (1992) North western Desert, special problem areas. In: Prakash I and Ghosh P K (eds): *Rodents in Indian Agriculture*, Vol I. Scientific Publishers, Jodhpur, India. pp 357-96.

Yigit N, Colak E, Verimli R, Ozkurt S and Sozen M (2001) A study on the distribution morphology and karyology of *Tatera indica* (Hardwicke, 1807) (Mammalia: Rodentia) in Turkey. *Turk J Zool* **25**: 65-67.

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