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Rodent Communities in Thar Sand Dune Ecosystem

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Abstract : The desert-adapted rodent species (*Gerbillus*, *Meriones*) are found in a relative abundance in sand dune ecosystem of the Thar desert. *Tatera indica* is more common in the sandy plains receiving 100-400 mm annual rainfall, whereas *Millardia meltada* and *Golunda ellioti* inhabit semi-arid zones. It is conjectured that the bandicoot, *Bandicota bengalensis* has invaded the south-eastern and northern parts of the desert in recent years, mainly due to escalation of irrigated agriculture. It is revealed that with the increasing aridity the body size of gerbils decreases and tail and ear length increases. *G. gleadowi* has been found to be the most desert-adapted rodent of the Indian Thar and is considered as the biological indicator of enhancing desertification processes. The most preponderant and omnipresent rodent, *Meriones hurrianae* in the sandy biome of Thar is a serious agent of soil erosion as it excavates about 61,500 kg stabilized soil sq. km^{-1} day^{-1} from its extensive burrow system. The loosely piled sand is quickly air borne due to strong desert winds.

Key words : Desertification, gerbils, sand dunes, Thar desert.

Meteorologically, the vast arid region from the Thar desert in the east to the Sahara in the west, is more or less a homogeneous entity. In India, the Thar desert extends from the southern part of Punjab in the north to the northern part of Gujarat in the south. The eastern boundary lies along the Aravalli ranges. Sandy plains and sand dunes cover more than 60 per cent of the desert, although non-sandy plains and rock outcrops also cover significant area. In spite of the inhospitable survival conditions, species richness of certain biota and abundance of some species are spectacular. We have been carrying out studies on vertebrates in the Thar, especially on rodents, for the last four and a half decades. A few aspects of their community ecology are presented here.

Rodent Communities

We undertook a trapping exercise in the entire Thar desert of Rajasthan, covering sandy, gravel, rocky and ruderal habitats. Fourteen rodent species were collected, representing the families Sciuridae and Muridae (including Gerbillinae). Their relative abundance synchronises with the bioclimatic zones of the desert which are identified on the basis of terrain, mean annual rainfall and vegetation type (Table 1).

100 mm Rainfall Zone

The extreme arid region is located to the west of Ramgarh in Jaisalmer district (26°40'-28°N and 69°30'- 70°30'E). The average annual rainfall varies from 80 to 90 mm and rainy days from 2.7 to 2.9 (Prakash and Gupta, 1976). The topography of this tree-less zone is dominated by tall sand dunes. Some are old and have greater stability, but the others are active crescentric dunes.

In the south western part, between Dhanana, Shahgarh, Mondhlo and the international border with Pakistan, numerous recently-formed barchanoid dunes of 5-10 m

Table 1. Relationship between rainfall, habitat, vegetation type and rodent communities

	Major soil formation	Predominat vegetation	Rodent community*
Very arid (100 mm rainfall)	Sand dunes inter dunal plains	*Cyperus conglomeratus, Tribulus alatus, Dipteryngium glaucum, Calligonum polygonoides, Haloxylon salicornicum, Panicum turgidum*	*Gerbillus gleadowi*
Arid (100-250 mm rainfall)	Sandy plains with dunes	*Prosopis cineraria, C. polygonoides, Haloxylon salicornicum, Capparis decidua, Ziziphus nummularia, Lasiurus sindicus, Aristida* spp.	*G. gleadowi, M. hurrianae, Gerbillus nanus*
Arid (250-400 mm rainfall)	Sandy plains, sand dunes and rainfed crop fields	*P. cineraria, Acacia nilotica, C. decidua, Z. nummularia, Cenchrus* spp.	*M. hurrianae, Tatera indica, G. nanus*
Semi-arid (more than 400 mm rainfall)	Sandy plains with hilly outcrops and irrigated agriculture	*A. nilotica, Lycium barbarum, Maytenus emarginatus, Sporobolus halvolus, Eleusine* spp., *Dicanthium annulatum*	*Tatera indica, Millardia meltada, Golunda ellioti, Bandicota bengalensis, Cremnomys cutchicus, Mus phillipsi*

* Relatively abundant species is listed first.

height and megabarchanoid dunes of 20-40 m height occur in elliptical fields within a vast linear dunefield (Kar, 1990). The dunes are devoid of vegetation, highly mobile and are locally known as *okhli*. These *okhli* dunes are inhabited by a tiny toad agama, *Phrynocephalus laungwalensis* (Prakash, 1972). The sandy plains in between the *okhli* dunes sustain a very dense population of rodents. In the Shahgarh-Mondhlo-Murar area, 20-30 m high linear dunes with narrow interdune plains support luxuriant tree and shrub vegetation. Very large trees, *Salvadora oleoides* and *Prosopis cineraria* and abundant shrubs, *Calligonum polygonoides* and *Acacia jacquemontii* occur mainly due to availability of subsurface water in the interdune plains. *Lasiurus sindicus*, which is the predominant grass of this region, is replaced by *Cenchrus ciliaris* and *Eleusine compressa* (Prakash and Gupta, 1976).

The hairy-footed gerbil, *Gerbillus gleadowi*, was found to be the most abundant rodent in this region, constituting 82.1% of the total number of rodents collected. The only other rodent collected in the sand dune biotope was the Indian desert gerbil, *Meriones hurriane* (17.9%), but on the broad crestal part of the old dunes, where some human settlements were constructed, few Indian gerbil, *Tatera indica*, could be noticed in the vicinity of the hutments. The house rat, *Rattus rattus*, and the house mouse, *Mus musculus*, were collected inside old forts and buildings which were being used as human dwellings. The gerbils apparently form the natural population of rodents in the driest part of the hot desert and the commensal species appear to have been transported by man (Prakash and Rana, 1973). We collected porcupine quills near wells at Asutar and Shahgarh in a low lying sandy interdune plain, surrounded by tall, fixed, vegetated sand dunes. Our survey revealed that porcupine inhabits this very arid region in very long burrows within the dunes. The five-striped squirrel, *Funambulus pennanti*, and the little gerbil, *Gerbillus nanus indus*, were not collected.

Table 2. Relative abundance of various rodent species in the sandy habitat (modified from Prakash et al., 1971).

Species	Per cent of total collection
Funambulus pennanti	1.1
Gerbillus nanus indus	4.1
G. gleadowi	16.6
Tatera indica	19.0
Meriones hurrianae	41.6
Millardia meltada pallidior	13.0
M. gleadowi	1.1
Mus saxicola sadhu	1.7
Golunda ellioti gujerati	1-1

Trap lines fixed in various sub-habitats revealed that the crestal part of bare sand dunes were not at all inhabited, apparently due to unstable soil conditions and lack of vegetation. However, dune crests with vegetation sustained rodents (5.74 per 24 hrs per 100 traps). The maximum density of rodents (39.2 per 24 hrs per 100 snap traps) was found in the interdune plains. The dune slopes were poorly inhabited (trap index 3.3). The interdune plains were supporting a very large number of gerbils, because of the abundance of bushes and grass cover. Most of the burrow openings of rodents were located under shrubs like *C. polygonoides*, *H. salicornicum* and coppicing *S. oleoides* trees. There was sufficient food as we found freshly cut parts of *Cleome barchycarpa, Tribulus alatus, Cyperus conglomeratus, Boerhavia diffusia, Dipterygium glaucum, Aristida adscensionis* and *Bracharia ramosa*, near burrow openings of the gerbil species (Prakash and Rana, 1973).

The species richness of vegetation in the interdune plains in the low rainfall region may be due to availability of a high perched water table which was 5-10 m deep in dug wells. A relatively higher soil moisture regime creates more conducive micro-climate inside the rodent burrows and, hence, a higher density of rodents in this region.

The preponderance of *G. gleadowi* in this zone may be due to its preference to inhabit areas which are largely dominated by loose sand dunes (Prakash and Purohit, 1967), whereas *M. hurrianae* prefers somewhat consolidated sand (Prakash *et al.*, 1971). Secondly, the gerbils feed on salt-loving plants and *Gerbillus* is more salt tolerant than *M. hurrianae* (Ghosh and Gaur, 1966). On an average, the salt ingestion (and fluid intake) by the latter species was about one sixth that of the former gerbil on unit body weight basis. *G. gleadowi* is also more renal efficient than *Meriones*. Moreover, it is nocturnal in habit and *M. hurrianae* is diurnal and is more exposed to environmental stresses.

100-400 mm Rainfall Zone

This region is the most species-rich. The Indian desert gerbil, *M. hurrianae* is the most abundant rodent, followed by *T. indica* and *G. gleadowi* (Table 2). The relative abundance is based on the results of trapping rodents in five habitats at 12 localities distributed in 100-400 mm rainfall zone (Prakash *et al.*, 1971). *Millardia meltada* and *Golunda ellioti* occur in the vicinity of rainfed crop fields. Their preferred niche is mud wall, covered with dried thorny bushes, usually of *Ziziphus nummularia*. Other rodent species were found in small number.

A typical region, located in this rainfall zone is the Sri Ganganagar district in the north, wherein the land use pattern has totally changed during the last 50 years. Due to the introduction of Gang Canal from Punjab, good quality Himalayan water is being used for irrigated agriculture. Our studies have clearly indicated that the xeric rodent species are being replaced by mesic ones, along with the transformation of desert grasslands into irrigated crop ecosystem. *Gerbillus* spp. were not found. Merion gerbils were trapped in sandy areas which were not irrigated. There was, however, preponderance of *Tatera indica* (44.7% of total collection), *Millardia meltada* (21.1%) and *Mus musculus* (7.9%). In one field a *Nesokia indica* was also collected. *Bandicota bengalensis*, a Peninsular species, has invaded the northern desert and constitute 7.9% of the total rodent population (Prakash, 1978; Prakash *et al.*, 1971). Human intervention in the desert ecosystem has introduced a very harmful species from the epidemelogical as well as agricultural point of view. We collected *B. bengalensis* from the grain market at Bikaner town (Prakash and Mathur, 1979). With the extensive development of irrigated agriculture in the Indira Gandhi Canal Command region, the biodiversity pattern is expected to change in the whole of the northern desert.

More than 400 mm Rainfall Zone

The semi-arid region extends from Sirohi to Beawar, situated along the Aravalli range. A clear preponderance of arboreal squirrel, *F. pennanti* (18.7%), *T. indica* (29.3%), *M. meltada* (13.5%) and *Golunda ellioti* (24.0%) was observed (Prakash *et al.*, 1995). This zone with numerous hills is fairly species-rich. However, in our earlier trapping schedules during 1953-55 (Prakash, 1957) and 1970 (Prakash *et al.*, 1971), we had not collected *Golunda ellioti* and *Bandicota bengalensis*. But, in a recent exploration of the western sandy foothills of the Aravallis, both the species were collected, former species in fair abundance and the latter in few numbers. Irrigated agriculture occupies large areas of this bioclimatic region also. It is conjectured that these two Deccanean species have intruded the desert in recent years due to creation of more conducive micro-climatic environment in their burrows (Prakash, 1995).

The hill top and slopes in the zone are dominated by high density of *Euphorbia caducifolia*, some exceeding a total diameter of four metres. These shrubs and crevices in Archaean granite rocks provide excellent shelter to various species of rodents. The rock-rat, *Cremnomys cutchicus*, and the spiny mouse, *Mus phillipsi*, were found to be more abundant than the squirrel, *F. pennanti*, and the saxi mouse, *Mus saxicola sadhu*. Porcupine, *Hystrix indica* quills indicated their presence (Prakash *et al.*, 1971).

Aridity and Body Size

Bodenhiemer (1957) observed that the increase in desertic conditions run parallel to smaller size of animals and found that *Gazella leptoceros* inhabiting the Central Sahara are smaller than those living on the fringes of the desert. Morphometric analysis of body parts (Table 3) of two gerbil species inhabiting the Thar desert in different bioclimatic zones exhibiting different aridity index (water deficiency as a per cent of water need; Krishnan, 1977) is corroborated with Bodenheimer's (*loc. cit.*) observations (Prakash and Kumari, 1978; Rana *et al.*, 1975). It is evident (Table 4) that the head and body length of gerbils decrease with the increasing aridity, but correspondingly the tail and ear length increase. It has been argued that the population of the same species tend to be more saltatorial in a relatively more xeric environment to escape the radiating heat. To further examine this observation, the tibio-fibular length of *Gerbillus gleadowi*, an endemic species of the

Table 3. Aridity and body size of deserticolous gerbils (modified from Prakash and Kumari, 1978; Rana et al., 1975)

Location	Sind*		Jodhpur/Bikaner		Jhunjhunu	
Aridity index	-94		-80*		-73	
Body part/species	G.g	M.h	G.g	M.h	G.g	M.h
Head and body (mm)	80.1	121.2	85.8	126.6	86.5	126.0
Tail (mm)	132.5	120.8	127.5	111.9	125.5	112.1
Ear (mm)	12.1	10.5	11.4	8.6	10.3	8.1

* Measurements are drawn from Ellerman (1961), G.g = *Gerbillus gleadowi*, M.h = *Meriones hurrianae*.

Thar desert, collected from 100 mm and 400 mm annual rainfall regions, were compared. It was found that the population inhabiting more arid parts possessed a significantly longer hind limb (Rana *et al.*, 1975). The longer tail maintains the balance of the gerbils while jumping. Bodemheiner (1957) mentioned that it functions as the "fifth leg" in saltatorial rodents.

The ear size of desert mammals, especially those of fossorial species, are relatively large (Bodenheimer, 1957; Schmidt-Nielsen, 1964). The morphometric analysis of gerbil pinna has further indicated that it increases with enhancing aridity. This adaptation is explained in the context of auditory communication between conspecifics and to perceive and discriminate between noises made by predatory animals and harmless sympatric species (Prakash, 1981). The perceptory and discriminatory behaviour of gerbils is also assisted by the hypertrophy of tympanic bullae which resonates the sound (Prakash, 1959; Webster, 1960). However, Bodenheimer (1957) suspected that the hypertrophy of tympanic bullae is primarily a morphological reaction to the dry environment.

In spite of these variations, our comparative studies on cranial characters of *Meriones hurrianae*, a Turano-Tharian element, and that of *Gerbillus gleadowi*, a Sindo-Tharian species, have clearly indicated that their populations are fairly homogenous, which suggests that these highly adapted rodents are living in the Thar desert for considerably long time. The Thar desert is, therefore, a very old desert, confirming the views expressed earlier (Prakash, 1963, 1974).

Impact of Droughts

Drought is a frequent feature in the desert and due to its influence, the population of Indian gerbil, *Tatera indica*, phases out in the sand dune ecosystem, followed by the desert gerbil, *Meriones hurrianae*. However, the hairy-footed gerbil, *Gerbillus gleadowi*, not only sustains the drought but replaces the other two gerboids (Prakash, 1988). It may be due to its superior adaptability to withstand acute xeric conditions by way of surviving

Table 4. Replacement of gerboid species due to drought (Prakash, 1988)

Species	Rainfall			
	Normal	Poor		Good
	1969	1972	1973	1974
Meriones hurianae	20.0	6.6	–	1.1
Gerbillus nanus indus	40.0	–	–	1.9
G. gleadowi	40.0	93.4	100.0	95.3
Tatera indica	Present	–	–	1.1

on halophytic food and due to its more efficient renal function (Ghosh, 1975).

Feeding Behavior Under Stress Conditions

Summer creates stress conditions for desert mammals. Our studies reveal that the mammals withstand the high temperature and paucity of food through shifting of their diurnal activities to comfortable temperature regimes (Prakash, 1993) and by becoming omnivore. The seedivorous *M. hurrianae* switches to insects, especially grass hoppers and beetles. This shift in food items also helps it to maintain water balance in the body as insects contain about 80% water. During winter, however, its stomach contains 60% seeds only. During monsoon, it becomes a selective feeder, consuming only grass blades and leaves of a variety of herbaceous plants and shrubs (Prakash, 1962, 1969). The elasticity in its feeding behavior is an important survival strategy, which makes it the most abundant rodent of the Thar.

Gerbils and Desertification

The relative preponderance of gerbils inhabiting sand dunes in various bio-climatic zones of the Thar desert has indicated that the hairy-footed gerbil, *G. gleadowi*, is an indicator of increasing aridity.

The merion gerbil, *M. hurrianae*, has been recognized as a biological factor of desertification, as it compliments soil erosion which is the foremost causative agent of this process (Mann and Prakash, 1983). This abundant desert gerbil digs extensive burrows. Each burrow has, on an average, 15 openings (Fitzwater and Prakash, 1969). For maintaining a conducive microclimate inside the burrow, it continues to shovel dried soil out of the burrow which accumulates outside the burrow openings. Sharma and Joshi (1975) estimated that in Shekhawati sand dune ecosystem in the eastern part of the Thar, the merion gerbils excavate 61,500 kg soil km^{-2} day^{-1}. This loose sand is shifted by strong summer wind and deposited at other locations in the form of mobile dunes. The finer particles become airborne and reach the upper atmosphere, and help in producing the dust bowl.

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