Tropical Ecology **42**(1): 25-33, 2001 ISSN 0564-3295

Composition and species diversity of small mammals in the hilly tracts of southeastern Rajasthan

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Abstract: The Aravalli range diagonally bisects the state of Rajasthan and this oldest Archaean rock formation is also spread in southern and southeastern Rajasthan. The latter zone is an conglomeration of Aravallis, Vindhyans and Deccan trap and it has undergone a change in landuse pattern, from forest to irrigated crop land, during recent years. Studies were taken up in this biologically interesting hilly tract to investigate the spatial diversity of small mammals as practically no information exists on this aspect. Small mammals were trapped in 35 habitats at 11 locations during 1997-99 and 386 individuals belonging to 15 species were collected in 5210 trap days. On an overall basis, the house shrew, *Suncus murinus* was found to be the most abundant small mammal in all habitats at all localities. Another commensal mammal, the house rat, *Rattus rattus* predominated in crop fields along with the mesic species like *Millardia meltada, Golunda ellioti* and *Bandicota bengalensis*. However, the typical faunistic element of hills, the rock rat, *Cremnomys cutchicus* occurred in low numbers in the Vindhyan scrap and Deccan trap due to presence of cracks and crevices which are its preferred ecological niche. Six mice species preferred the Vindhyan scrap as 62 per cent of them occurred in this rock formation. Among the four rock types, Aravallis, Vindhyan scrap, Vindhyan plains and Deccan trap; the Vindhyans were the most occupied as well as species rich rock type. Among the habitats, cropfields and scrubland were most diversified (α diversity 3.17 and 2.66 respectively) and species rich habitats. The impact of transformation of forests into irrigated crop field is evident due to a significantly higher frequency of occurrence of commensal small mammals in croplands apparently due to relatively superior soil moisture regime, food resource and shelter.

Resumen: La sierra Aravalli disecta diagonalmente al estado de Rajasthan; esta Antigua formación rocosa del Arqueano también se extiende en el sur y sudeste de Rajasthan. Esta última zona es una conglomeración de trapps de Aravallis, Vindhyans y Deccan y durante años recientes ha sufrido un cambio en el patrón de uso del suelo, pasando de ser bosque a ser tierras agrícolas con irrigación. Se emprendieron estudios en esta región de lomeríos biológicamente interesante para investigar la diversidad especial de mamíferos pequeños fueron capturados en 35 hábitats distribuidos en 11 localidades durante 1997-99, y se recolectaron 386 individuos pertenecientes a 15 especies en 5210 días-trampa. En terminus generales, se encontró que la musaraña doméstica, *Sincus murinus*, es el mamífero pequeño más abundante en todos los habitats de todas las localidades. Otro mamífero comensal, la rata doméstica, *Rattus rattus* predominó en campos de cultivo junto con especies mésicas tales como *Millardia meltada, Golunda ellioti* y *Bandicota bengalensis*. Sin embargo, el elemento faunístico típico de las Colinas, la rata de la roca, *Cremnomys cutchincus* estuvo presente con números bajos en el escarpe de Vindhyan y en el trapps de Deccan debido a la presencia de grietas y hendeduras, las cuales son su nicho ecológico preferido. Seis especies de ratones prefirieron el escarpe de Vindhyan, ya que 62 por ciento de ellos estuvieron presentes en esta formación rocosa. Entre los cuatro tipos de roca, Aravallis, escarpe de Vindhyan, planicies de Vindhyan y trapps de

Deccan, las Vindhyans fueron en general un tipo de roca rico en especies y estuvieron ocupadas casi siempre. Entre los habitats, los campos de cultivo y los matorrales fueron los más diversos (diversidad α 3.17 y 2.66, respectivamente) y ricos en especies. El impacto de la transformación de estos bosques en campos de cultivo irrigados es evidente debido a las frecuencias significativamente más altas de la presencia de especies de pequeños mamíferos comensales en tierras agrícolas, lo cual a su vez aparentemente se debe a sus características relativamente superiors respecto a su regimen de humedad edáfica, recursos alimenticios y protección.

Resumo: A cordilheira de Aravalli divide diagonalmente o Estado de Rajasthan e esta mais antiga formação rochosa de Archaean também se estende no sul e sudeste do Rajasthan. A última zona é uma conglomeração de Aravallis, Vindhynas e desfiladeiro de Deccan e sofreu uma mudança no padrão de uso da terra que passou da cobertura florestal a terra de cultivo irrigado em anos recentes. Neste trato declivoso, biologicamente interessante, foram efectuados estudos para investigar a diversidade espacial dos pequenos mamíferos dado que não existe praticamente informação sobre este aspecto. Os pequenos mamíferos foram armadilhados em 35 habitats e 11 localizações durante 1997-99. Foram colectados 386 indivíduos pertencendo a 15 espécies em 5210 dias de armadilha. Em termos globais, o musaranho das casas *Suncus murinus* foi a espécie mais abundante em todos os habitats em todas as localizações. Outro mamífero comensal, o rato doméstico, *Rattus rattus*, predominava nos campos em simultâneo com espécies mésicas como a *Millardia meltada*, *Golunda ellioti* e *Bandicota bengalensis*. Contudo, os elementos faunísticos típicos nas colinas, o rato da rocha, *Cremnomys cutchicus*, ocorria em número reduzido na escarpa de Vindhyan e no desfiladeiro de Deccan devido à presença de gretas e fendas que são o seu nicho ecológico preferido. Seis espécies de ratos preferiam a escarpa de Vindhyan pois que 62 por cento ocorriam nesta formação rochosa. Entre os quatro tipos de rochas, Aravallis, escarpa de Vindhyan, planícies de Vindhyan e desfiladeiro de Deccan, os Vindhyans eram os mais povoados assim como o tipo de rocha com maior riqueza específica. Entre os habitats, os campos de cultura e as zonas arbustivas eram as mais diversificadas (δ diversidade de 3,17 e 2,66 respectivamente) e os habitats mais ricos em espécies. O impacto da transformação das florestas em terrenos de cultura irrigados é evidente dado a uma maior frequência na ocorrência de pequenos mamíferos comensais no campos de cultura devido, aparentemente, a um regime de humidade superior no solo, aos recursos alimentares e ao abrigo.

Key words: Deccan trap, impact of landuse pattern, insectivores, rodents, spatial distribution, species diversity.

Introduction

The geologically unique Aravalli mountain is one of the oldest hill ranges in the world. It bisects the State of Rajasthan into western Thar desert and the eastern semi arid and sub humid regions. The Aravalli rock formations extend into southern and southeastern Rajasthan also. In the latter part of the State the Aravallis merge with exposures of Vindhyans and in extreme southeast with Deccan basalt (Krishnan 1956). The biodiversity occurring in the west of this range is deserticolous whereas on the east it is sub-mesic to mesic. Aravallis, by virtue of its Archaean origin as well as geographical location is an important ecosystem. Moreover, during the last five decades, the dense forests in the entire range of the rocky tract have dwindled and have been replaced by irrigated cropping which has an impact on the flora and fauna. In spite of its ecological and zoogeographical significance only two worthwhile studies are available on the mammals of one locality, Mt Abu. Ryley (1913) studied a collection of mammals and Hrdy (1977) worked upon the strategies of reproduction in Hanuman langur, *Semnopithecus entellus*. Realising the extreme paucity of zoological information on the entire range of Aravallis, work was taken up on small mammals on the Abu hill,

the main range extending from Abu Road to Alwar; southern zone, Udaipur to Banswara; and in southeastern tract, from Ranthambore to Jhalawar; during 1991-1999. In the present communication, composition and species diversity of small mammals in the hilly tracts of southeastern Rajasthan are being presented. Since this region is an assemblage of three types of rock formations, attempts have been made to study the differences in composition and species diversity of insectivores and rodents in each of them.

Study area

The present investigation was undertaken in southeastern Rajasthan (Fig. 1) in the region of Ranthambore to Pidawa (23°75′ to 26°52′N) in north-south axis and from Rawatbhata to Shahbad (75°56′ to 77°45′E) in the east-west axis. The entire study area is a hilly tract with diverse topography having the great boundary fault running parallel to the course of river Chambal. The northern part of the study area is bounded by Aravallis which are composed of foliated and folded schists, quartzites and limestone with fragment bindings of marble. It differs from the granitic main Aravalli range in not possessing crevices and caverns which are preferred niches of certain small mammals. The overlying soil cover, where rocks are not exposed, is not very deep. The central zone is covered by the rocks of Vindhyan system. This scarpland is well wooded though the foothills are denuded due to severe mining activity. The Vindhyans further south have been subjected to various degrees of laterisation and thick black soils overlie the rocky basement. The extreme south is composed of Deccan traps and the Jhalawar plains stretch in a wide belt with very fertile soil. The entire southeastern Rajasthan is a riverine and lacustrine region. As a consequence, the crop fields are spread throughout. The northern region receives an annual rainfall of 650 to 750 mm, the central region 750 to 900 mm and the Deccan trap receives highest rainfall, exceeding 950 mm.

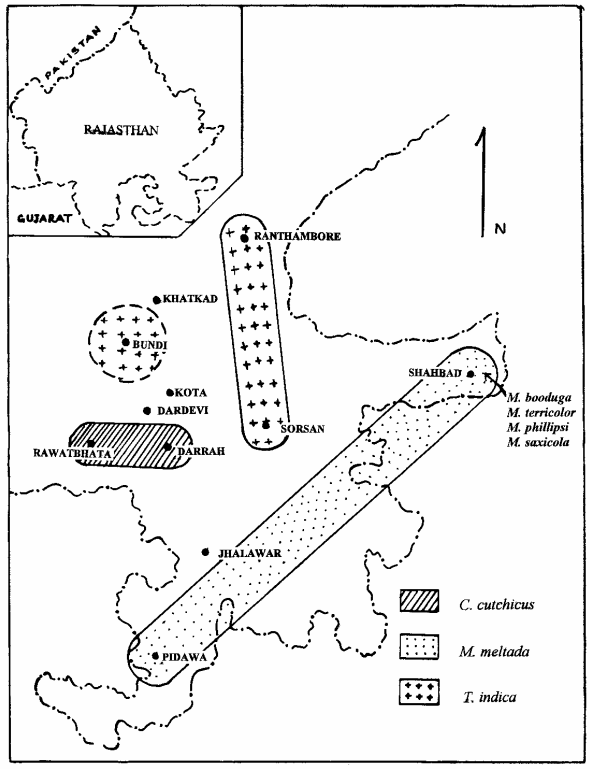

Fig. 1. Discontinuous distribution of small mammals in Southeastern Rajasthan.

The vegetation is characterised by trees *Anogeissus pendula-Boswellia serrata* formation. The other trees are *Sterculia urens, Acacia catechu, Aegle marmelos, Cassia fistula, Terminalia* spp. The under story is composed by shrubs (*Ziziphus nummularia, Lantana camara, Capparis decidua*) and grasses (*Aristida depressa, Apluda mutica, Heteropogon contortus, Dichanthium annulatum* and *Chrysopogon* spp.).

Methods

The southeastern Rajasthan is a conglomeration of three rock types and therefore, study sites were selected from every formation and rainfall zone. Accordingly, small mammals were collected at 11 localities. At every locality, six habitats were identified to investigate the habitat preference of small mammals. Hill tops which once supported dense forest have presently turned into rocky grasslands. A large number of lakes occur in the region, therefore, lank bank was identified as one of the habitats for the study. Gullys drain rain water from hills and carry superior moisture regime and sprouting vegetation. They are also species rich habitat. The man-introduced crop fields are well suited to small mammals due to availability of food and shelter throughout the year. In every habitat 60 snap traps were fixed in two lines of 30 snap traps each. The distance between the

two trap lines was 15 meters and each trap in the line was kept 10 meters apart. The traps were baited with peanut butter and were run for 72 hours. Fresh bait was applied at an interval of six hours when the trapped mammals were also retrieved. The freshly collected animals were measured and weighed for identification purpose.

Trap index for each habitat and locality was computed by following formula following Jackson (1952).

$$\text{Trap index} = \frac{\text{Total no. of small mammals}}{\text{No. of trapping days} \times \text{No. of traps}} \times 100$$

Alpha diversity of small mammals was estimated to compare the species richness in different habitats and localities. It was calculated by applying equation of alpha of Fisher's log series (Anscombe 1950).

$$S = \text{alpha log e } (1 + N/\text{alpha})$$

where, S is number of species in the sample, N is the number of individuals in the sample and alpha is the index of diversity.

Beta diversity is a function of the difference between habitats or localities (Whittaker 1972) and its values were estimated by using Morishita-Horn Index (Wolda 1981).

$$C\lambda = \frac{2\sum(n_1 - n_2)}{(\lambda_1 + \lambda_2).N_1 N_2}$$

where,

$$\lambda j = \frac{\sum n^2 ji}{N^2 j}$$

$$\text{Beta diversity } (\beta) = (1 - C\lambda)$$

where, $C\lambda$ is Morishita-Horn Index, nji is the number of Individuals of i^{th} species in sample j and nj is the number of individuals of sample j. The index was computed with data logarithmically transformed as ln (nji + 1).

The similarity of species between localities or habitats is shown by dendrograms, which were prepared by using single linkage cluster analysis (Mark & Roger 1984).

Results and discussion

Fifteen species of small mammals, one insectivore and 14 rodents, were collected from 35 habitats at 11 localities during 1997-1999.

Species composition

Out of 386 specimens collected in 5210 trap days, house shrew, *Suncus murinus sindensis* was found to be the most abundant species (38.9 per cent), followed by house rat, *Rattus rattus alexandrinus* (13.7 per cent), Indian gerbil, *Tatera i. indica* (10.4 per cent) and the golund, *Golunda ellioti* (9.1 per cent). The other species occurred in low numbers (Table 1). Comparison of species composition in hilly tracts of southeastern Rajasthan (present study) with that found in montane environment of Udaipur - Banswara zone (Prakash & H. Singh 2000) and Aravallis (Prakash *et al.* 1995) depict a conspicuous low frequency of the rock rat, *Cremnomys cutchicus* and also that of the five-striped squirrel, *Funambulus pennanti*. A relatively higher preponderance of house rat, *Rattus rattus* in scrubland, lake bank and crop fields as compared to that in two other zones is also noticed. The occurrence of house rat in large numbers can be explained as in the southeastern zone, the irrigated cropping is very extensive creating very conducive soil moisture environment. In addition to crop fields, the house rat has even shifted to scrubland and lake bank also. Its abundance in these habitats may indicate that the species has turned into a 'wild' form, and may be it has replaced the closely related taxon, the rock rat, *C. cutchicus*. The poor representation of the rock rat, *C. cutchicus* can be explained because of the absence of its typical ecological niche, the crevices, is more or less absent in this region. Even the Aravalli rock formation in the region does not exhibit granitic rocks in which large number of crevices occur. In this region, rock rat mostly occurred in the Vindhyan scarpland which is constituted by sandstone having fissures in between the various layers which are occupied by the rock rat.

Habitat diversity

Crop field and scrubland have been found to be the most diversified (α diversity 3.17 and 2.66 respectively), as well as most species rich habitats inhabited by 13 and 11 species each (Table 1). In both the habitats a preponderance of *S. murinus* was found followed by that of *R. rattus* and *G. ellioti*. The Indian gerbil, *T. indica* was trapped in a higher proportion (85.0 per cent) in the scrublands. Gully (α diversity 1.63), rocky (α diversity 1.42) habitats were also found to be quite diversified, occupied by 7 and 6 small mammal species each (Table 1). Majority of rock rats, *C. cutchicus* (42.3 per cent) were collected in rocky, gully (47.4 per cent) and hill top (10.1 per cent) habitats. Surpris-

Table 1. Frequency of occurrence of small mammals in different habitats in hilly tracts of southeastern Rajasthan.

Species	Number of individuals												Total	Percent occurrence
	Rocky		Hill top		Gully		Scrubland		Crop field		Lake bank			
S. murinus	7	(4.66)[@]	2	(1.3)[@]	3	(2.0)	49	(32.6)	81	(54.0)	8	(5.3)	150	38.9
F. pennanti							7	(36.8)	12	(63.1)			19	4.9
T. indica							34	(85.0)	5	(12.5)	1	(2.5)	40	10.4
V. oleracea							1	(33.3)	2	(66.6)			3	0.8
R. rattus	2	(3.7)					25	(47.1)	22	(41.5)	4	(7.5)	53	13.7
C. cutchicus	6	(50.0)	1	(8.3)	5	(41.6)							12	3.1
M. meltada					5	(29.4)	1	(5.8)	11	(64.7)			17	4.4
Mus musculus					1	(33.3)			2	(66.6)			3	0.8
M. booduga									1	(100)			1	0.3
M. terricolor					2	(66.6)	1	(33.3)					3	0.8
M. saxicola					2	(50.0)			2	(50.0)			4	1.0
M. phillipsi	10	(35.7)	5	(17.8)	3	(10.7)	2	(7.1)	8	(28.6)			28	7.2
M. platythrix	1	(14.2)					1	(14.2)	5	(71.4)			7	1.8
G. ellioti							11	(31.4)	24	(68.5)			35	9.1
B. bengalensis	1	(9.1)					1	(9.1)	9	(81.8)			11	2.9
Trap index	8.57		1.66		3.75		8.03		9.74		3.17			
α diversity	1.42		0.64		1.63		2.66		3.17		0.65			

*Percent occurrence in each habitat is shown in parenthesis.

ingly, *Millardia meltada* was trapped in gullys in a relatively higher abundance (29.4 per cent) though its preferred habitat is crop field (Prakash *et al.* 1995). Hill top (α diversity 0.64) and lake bank (α diversity 0.65) were least diversified and were found to be occupied by three species each. Most of the *Mus* species were trapped from crop field and gully (Table 1).

A few decades ago this subhumid hill tract was densely forested but presently due to human pressure the landuse pattern has altered to irrigated agriculture in all the valleys and plains. As stated earlier, the crop field habitat was found to be the most densely populated as 184 out of 386 small mammals belonging to 13 species were collected from there. The irrigated crop fields provide green as well as insect food to insectivores and rodents all the year round. Moreover, the soil moisture regime is maintained at a higher level which is relatively more conducive to fossorial small mammals which constitute 87 per cent of the 15 species collected in the zone under study. They can excavate their burrows rather easily in softer soils. The more prominent impact of the landuse transformation is evident though a higher frequency of occurrence of three house-dwelling species, the house shrew, *Suncus murinus* (54.0 per cent), house rat, *Rattus rattus* (41.5 per cent) and house mouse, *Mus musculus* (66.6 per cent) (Table 1). They have ventured out from residential premises to more favourable conditions of crop fields, in a way, a case of behavioural atavism. Moreover, the mesic rodents, *Millardia meltada* (64.7 per cent), *Mus booduga* (100 per cent), *Golunda ellioti* (68.5 per cent) and *Bandicota bengalensis* (81.8 per cent) predominate in this habitat as compared to that in any other habitat (Table 1). The trap index (TI) figures indicate that crop field (TI = 9.74, 13 species) was the most occupied habitat followed by rocky (TI = 8.57, 6 species) and scrubland (TI = 8.03, but 11 species) habitats (Table 1). However, scrublands were more diversified (α diversity = 2.66) as compared to others.

In hilly tracts of Ranthambore - Jhalawar zone, as per their abundance, the small mammal communities in various habitats were registered as follows :

Rocky : *M. phillipsi - S. murinus - C. cutchicus*
Hill top : *M. phillipsi - S. murinus -C. cutchicus*
Gully : *C. cutchicus - M. meltada -M. phillipsi*
Scrubland: *S. murinus - T. indica -R. rattus*
Crop field: *S. murinus - G. ellioti -R. rattus*

Based on the Morishita-Horn Similarity Index, the Single Linkage dendrogram pertaining to various habitats, pooled for all the eleven localities, shows that crop field and scrubland are similar habitats as they are inhabited by maximum number of overlapping species (10 spp.) indicating a high degree of similarity in species composition of small mammals (Fig. 2). Likewise hill top and Rocky habitats are also similar although are less diversified (α diversity = 0.64, 1.42) and are shared by 3 species each. Surprisingly it was found that gully is least similar habitat, though it resembles with rocky and hill top habitat to some extent. So it joins them at a long distance in the dendogram. Geologically gullies are runways of water in hilly terrains and due to good moisture regime, they provide favourable niche for several species of small mammals, as was found on the Abu hill (Prakash *et al.* 1995). Lake bank of southeastern Rajasthan shows affinity toward cropfields (β diversity = 0.26) (Table 2) though only three species were caught from lake bank habitat (α diversity = 0.652) i.e. *Rattus rattus, T. indica* and *S. murinus*.

Diversity of localities

An equal number of traps were fixed in every habitat but some were lost due to predators. To assess equal trapping effort, the number of trapped small mammals was transformed to animals per 2000 traps for diversity calculation.

α Diversity

The diversity of eleven localities was calculated by pooling trapping data of all habitats at each locality (Table 3). The diversity index (alpha of log) revealed that protected sanctuary at Darrah

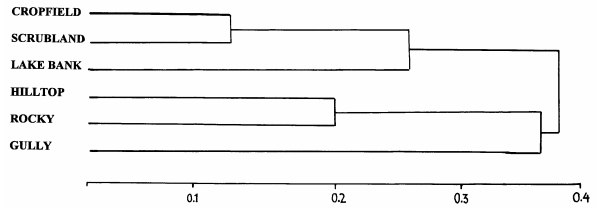

Fig. 2. Dendrogram showing similarities between habitats.

Table 2. Beta diversity between various habitats.

Habitats	Hill top	Gully	Scrub-land	Crop field	Lake bank
Rocky	0.21	0.38	0.46	0.39	0.45
Hill top		0.39	0.66	0.63	0.64
Gully			0.66	0.50	0.74
Scrubland				0.13	0.26
Crop field					0.54

Table 3. The eleven localities arranged in decreasing order of diversity.

Localities	α diversity	No. of species	No. of individuals
Darrah	2.76	10	45
Shahbad	2.28	10	80
Bundi	2.17	8	42
Sorsan	2.01	8	48
Khatkad	1.71	4	8
Pidawa	1.59	6	32
Dardevi	1.44	5	18
Jhalawar	1.35	6	52
Rawatbhata	1.26	5	31
Ranthambore	1.01	4	24
Kota	0.62	2	6

is most diversified (α diversity = 2.76) with 45 individuals of 10 species followed by Shahbad protected area (α diversity 2.28) with 80 specimens of 10 species. Kota locality was found to be least diversified (α diversity = 0.62) with 6 individuals of only two species. Darrah locality was also significantly different in its diversity index ($P < 0.05$) with Kota.

β Diversity

Similarity between localities of southern Rajasthan was calculated by Morishita-Horn Index, using single linkage cluster analysis (Mark & Roger 1984) It shows (Fig. 3) the clustering of localities on the basis of similar species composition between them. It is indicated that various localities fall under four clusters of similarity (Fig. 3) : Bundi, Sorsan and Ranthambore; Darrah and Shahbad, coming close to Rawatbhata, Jhalawar, Khatakad and Dardevi. Bundi and Sorsan (β diversity = 0.126, Table 5) were similar localities.

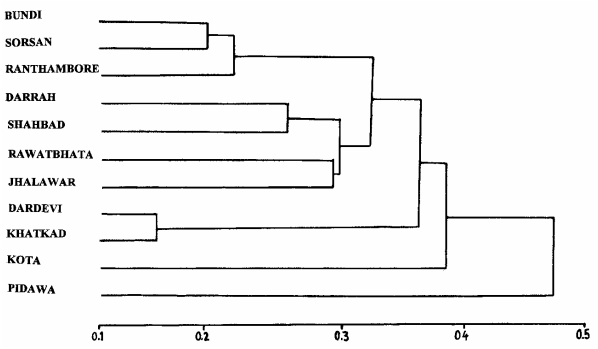

Fig. 3. Dendrogram showing similarities between localities.

Khatkad and Dardevi though are less diversified (α diversity = 1.71, α diversity = 1.43) yet were almost similar (β diversity = 0.069) in the species composition as they shared 4 out of 5 species collected from both localities. Darrah, Shahbad, Rawatbhata and Jhalawar are found clustered together, because of five similar species are shared by them (Fig. 3). The least diversified Kota (α = 0.62) and extreme southern locality Pidawa were found significantly dissimilar ($P < 0.05$) from all other localities (Table 4).

Composition of small mammals in various rock formations

The present study is the first-time investigation on the small mammals of hilly tracts of southeastern Rajasthan, attempts have been made to study the species diversity in various rock types (Table 5). The shrew, *S. murinus* was found to be a habitat generalist as it was the most abundant species trapped in every rock type; so was the distribution of *Rattus rattus*. The Indian gerbil occurred in large number only in Aravallis and Vindhyan plain whereas predominance of *Millardia meltada* was observed in Deccan plateau and that of *Golunda ellioti* and *Mus* spp. in Vindhyan scarp. On an overall basis, Vindhyan scarp was most densely populated (40.4 per cent of total individuals) as compared to other rock formations (Table 5). As mentioned earlier, the soil depth as well as vegetation density are maximum in this tract and the availability of more resources and shelter may be the plausible reason of the higher occurrence of small mammals.

Our studies on the ecology of small mammals of the entire hilly region undertaken during 1992-1999 in the four zones of the expanse of Aravallis indicate that the southern Aravalli sector is least diversified (α diversity = 2.26) as well as less inhabited but its species richness more or less matches with other zones (Table 6). On the Abu hill (Prakash *et al.* 1995, 1996), main Aravalli range (Prakash & Singh 1999) and Udaipur - Banswara region (Prakash & H. Singh 2000), a preponderance of rock rat, *C. cutchicus* was observed but in the present study zone, the house shrew, *Suncus murinus* is the most abundant species (Table 5). The house rat, *R. rattus* is next in abundance. The relatively low numbers of *C. cutchicus* is due to the absence of its ecological niche in these rock formations whereas predominance of *R. rattus* may indicate that forests have been transformed into scrublands and croplands, creating appropriate habitat for the house rat to venture out of residential premises. A few house mouse, *Mus musculus* were also trapped in the field. As compared to other zones, the frequency of occurrence of *F. pen-*

Table 4. Beta diversity index of small mammals between various localities.

Localities	Darrah	Dardevi	Jhalawar	Khatkad	Kota	Pidawa	Rawatbhata	Shahbad	Ranthambore	Sorsan
Bundi	0.264	0.348	0.307	0.396	0.472	0.434	0.300	0.356	0.148	0.116
Darrah		0.282	0.313	0.300	0.498	0.566	0.225	0.188	0.466	0.281
Dardevi			0.314	0.059	0.432	0.673	0.490	0.375	0.339	0.401
Jhalawar				0.434	0.329	0.477	0.223	0.374	0.242	0.271
Khatkad					0.479	0.802	0.553	0.459	0.401	0.436
Kota						0.570	0.306	0.501	0.301	0.487
Pidawa							0.485	0.311	0.527	0.453
Rawatbhata								0.264	0.420	0.346
Shahbad									0.541	0.392
Ranthambore										0.226

Table 5. Composition of small mammals in various rock formations.

Species	Aravallis				Vindhyan Scarp				Vindhyan Plain				Deccan Plateau		
	Bundi	Khat-kad	Rantha-mbore	Total	Darrah	Sha-hbad	Rawat-bhata	Total	Dardevi	Kota	Sorsan	Total	Pidawa	Jhala-war	Total
S. murinus	9	1	10	20	16	37	14	67	3	5	14	22	10	31	41
F. pennanti	3	1	5	9	1	-	-	1	2	-	1	3	-	6	6
T. indica	15	-	5	20	-	-	-	0	-	-	18	18	2	-	2
V. oleracea	-	-	-	0	1	-	-	1	-	-	2	2	-	-	0
R. rattus	9	2	4	15	6	8	6	20	6	1	5	12	-	6	6
C. cutchicus	1	-	-	1	4	2	5	11	-	-	-	0	-	-	0
M. meltada	-	-	-	0	-	-	5	5	-	-	-	0	12	-	12
Mus musculus	1	-	-	1	1	-	-	1	-	-	-	0	1	-	1
M. booduga	-	-	-	0	-	1	-	1	-	-	-	0	-	-	0
M. terricolor	-	-	-	0	-	3	-	3	-	-	-	0	-	-	0
M. saxicola	-	-	-	0	2	2	-	4	-	-	-	0	-	-	0
M. phillipsi	1	4	-	5	10	5	-	15	6	-	2	8	-	-	0
M. platythrix	-	-	-	0	-	2	-	2	1	-	-	1	3	1	4
G. ellioti	3	-	-	3	3	15	5	23	-	-	3	3	4	2	6
B. bengalensis	-	-	-	0	1	-	1	2	-	-	3	3	-	6	6
Total	42	8	24	74	45	80	31	156	18	6	48	72	32	52	84

nanti and *B. bandicota* was found to be very low at all the localities in southeastern Rajasthan. Some of the hills have been afforested and the plantations have a very low herbaceous ground cover. This may be one of the reasons of low occurrence of the squirrel and the long-tailed tree mouse, *Vandeleuria oleracea*. *Suncus stoliczkanus*, the Anderson's shrew was found to be absent in this zone but *Mus booduga* was trapped only in this region.

Table 6. Comparison of frequency of occurrence of small mammals in four mountain zones of Rajasthan.

Species	Abu hill	Main Aravalli range	Udaipur Banswara Zone	South-eastern Rajasthan
S. murinus	13.4	21.6	12.7	38.8
S. stoliczkanus	0.1	-	-	-
F. pennanti	8.6	3.93	8.5	4.9
T. indica	8.0	9.8	12.7	10.3
V. oleracea	0.4	0.3	-	0.7
R. rattus	5.3	4.9	3.2	13.7
C. cutchicus	36.0	36.0	38.1	3.1
M. meltada	5.2	6.5	1.1	4.4
Mus musculus	-	-	0.8	0.7
M. booduga	-	-	0.5	0.25
M. terricolor	0.4	0.3	0.8	0.7
M. saxicola	2.7	1.0	1.6	1.0
M. phillipsi	3.6	4.2	9.6	7.2
M. platythrix	1.7	-	1.6	1.8
G. ellioti	13.1	5.9	8.1	9.0
B. bengalensis	1.5	5.2	1.1	2.8
No. of Species	14	12	14	15

In other hilly zones the geographical distribution of small mammals was more or less continuous but in the Ranthambore-Jhalawar tract a few species were found discontinuously or were concentrated in a particular zone. This may be due to presence of four types of rock systems in this region, as discussed earlier. For example, the metad, *M. meltada* was collected only from Shahbad and Pidawa. A high preponderance of various *Mus* spp. was observed at Shahbad. *C. cutchicus* occurred in Rawatbhata-Darrah region whereas *Tatera indica* was trapped in relatively low rainfall northern tracts (Fig. 1).

The eleven localities in the study zone fall under four broad categories of rainfall 650 mm, 750 mm, 900 and exceeding 950 mm per year. It is interesting to observe that minimum number of species as well as individuals were collected from lowest rainfall region and maximum from the most moist region. The number of species are positively correlated with amount of rainfall ($r = + 0.93$, P

<0.001) and also the number of individuals in each rainfall zone (r = +0.97, P <0.001).

Acknowledgements

The authors thank Dr. J.R.B. Alfred, Director, Zoological Survey of India, Calcutta and Dr. Q.H. Baqri, Jt. Director, Desert Regional Station, ZSI, Jodhpur for providing necessary facilities to carry out the work. We wish to thank Prof. Raghavendra Gadagkar, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, for his advice and assistance in statistical analysis of the data. The work was carried out with the financial assistance of Department of Science & Technology, Government of India, New Delhi (Project No. SP/SO/C-07/95).

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