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# Small Mammalian Diversity on the Abu Hill

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Trapping of small mammals, carried out during 1993-94, on the Abu hill located on the southern fringe of Aravalli ranges yielded 821 specimens in 8871 trap days and comprised of two insectivore and 12 rodent species. The trapping data collected from 31 habitats, 8 localities and four elevations was subjected to the analysis of Alpha and Beta species diversity. It has been indicated that the information thus collected can also be calculated to determine relative abundance, trap index, species richness and the two diversity indices. However, various computations yield different results and, therefore, Alpha and Beta diversity indices should be used to explain the species diversity in a habitat, locality or altitude since it takes into account the number of species collected, number of individuals and the variance in the number of specimens collected for every species.

**Key Words : Abu hill, Alpha diversity, Aravalli range, Beta diversity, Community ecology, Insectivora, Small mammals, Rodentia**

## Introduction

During our studies on community ecology of small mammals of Aravallis, we collected 2 insectivora and 12 rodent species (821 specimens, 753 during 1993 and 68 in 1994) in 8871 trap days from various trapping sites on the Abu hill located on the southern fringe of Aravalli range (Prakash et al. 1995). From the analysis of data it was revealed that the Aravallis form a broad transitional belt between the two biomes — The Thar and the Oriental region — where the diversity of small mammals is relatively much superior on the montane ecosystem. Moreover, it has been found that the Aravalli ranges and the Thar desert are witnessing an invasion of Peninsular elements in recent times, mostly due to escalation of human activities (Prakash, 1995).

To study the diversity of small mammals on the Abu hill, Alpha diversity (Fisher et al. 1943) and Beta diversity (Wolda, 1981) have been computed. The advantage of using these two indices is that in addition to number of species these take into account the number of individuals trapped in different habitats, localities and altitudes. Interesting results have been obtained.

## Trapping Sites

The Abu hill is slightly detached from the main Aravalli range by a 11 km wide valley and is located between 24° 31′ and 24° 43′ N and 72° 38′ and 72°53′ E (see map in Prakash et al., 1995). The small mammals were snap trapped in 31 habitats on the eastern and western foothills and in various habitats at 500 m, 1000m and 1500 m altitudes at the following localities.

*Anadra*: It is situated on western side of Abu hill and is 36 km from Sirohi on Mandar Road. Average annual rainfall is about 300 mm. Our trapping plots were on foothills which exhibit typically deserticolous vegetation like *Acacia nilotica, Prosopis spicigera, Zizyphus nummularia, Salvadora persica and Cassia auriculata.*

*Abu Road*: It is situated on the eastern side of the Abu hill in Sirohi district. This site is frequented by vegetation like *Butea monosperma, Anogeissus pendula, Phoenix sylvestris, Bauhinia variegata* and *Wrightia tinctoria. Lantana camara* has profusely encroached the land especially in the vicinity of cropfields. The vegetation of the eastern foothills is more mesic as compared to dry-deciduous type on the western, rain shadow side.

*Chepaberi*: It is located at an altitude of 500 m on the way to Mount Abu from Abu Road. The topography of site is dominated by runnels and steep slopes. The tree vegetation consists of *Anogeissus pendula, Butea monosperma, Wrightia tinctoria, Aegle marmelos* and *Dendrocalamus strictus.*

*Arna*: It is located at an altitude of 1100m on the Mount Abu road. Many mesic species of vegetation like *Mangifera indica, Syzygium cumini, Carissa congesta* and several *Ficus* species make their appearance at this elevation. The vegetation in remote areas is very dense but is being degraded due to over grazing and logging of trees.

*Gomukh*: It is situated about 7 km from the main road at altitude of 1000 m, and is covered with dense forest of *Mangifera indica* and *Carissa congesta. Lantana* bushes were quite abundant in the region and grasses like *Cynodon dactylon* and *Cymbopogon martinii* formed ground cover.

*Mount Abu*: A plateau situated at the top of the hills, Mt. Abu is situated at an elevation of 1500 m. Trapping in Mt. Abu was carried out at three sites *viz.*, Sunset point, Oria (1600 m) and Kodra dam. *Mangifera indica, Syzygium cumini, Phoenix sylvestris, Carissa congesta, Erythrina striata, Lantana camara* and Bamboo clumps form the major flora at all the three sites. This locality withstands a severe pressure of human as well as livestock populations and that of tourists.

## Methods

*Trapping Procedure*: During the year 1993-94, extensive trapping of small mammals was carried out on the Abu hill in 8 localities, 31 habitats and 4 altitudes. Both snap and Sherman traps (for live animals) were used for capturing small mammals. In each plot two trap lines of 30 traps each were fixed at a distance of 15m. The distance between two traps was 10m in each trap line. Peanut butter was used as the bait material and the traps were run for 72 hours in each plot. Ideally same number of traps should have been used in all study plots, but a fairly large number of traps were lost due to predators. In making comparison possible, we have,

therefore, transformed the capture data for every habitat to 700 traps.

*Data Analysis*

*Alpha Diversity*: Many indices of Alpha diversity (within habitat, locality, altitude) such as the Shanon Weiner diversity index (Margalef 1958), Simpson's index (Simpson 1949) and Alpha of log series (Fisher et al. 1943) were computed. However, the results pertaining to Alpha of log series are presented because it is somewhat better than others as it combines information about number of species as well as the number of individuals of a species and the total number in the sample of a unit. Alpha of log series was computed by an iterative procedure using the equation

$$S = \alpha \log_e (1 + N/\alpha)$$

where S is the number of species in the sample, N is the number of individuals in the sample, and $\alpha$ is the index of diversity. The standard deviation of Alpha was estimated as $\alpha$/-log (1-*X*), where X = N/(N + $\alpha$) (Anscombe 1950). Using this standard deviation, significant difference in diversity between habitats/localities/altitudes was judged by a Z test.

*Beta Diversity*: Beta diversity (between site or altitude) was estimated as coefficient of similarity given by the Morishita — Horn Index (after Wolda, 1981).

$$C\lambda = \frac{2 \sum (n1i \cdot n2i)}{(\lambda 1 + \lambda 2) \cdot N1\, N2}$$

where,

$$\lambda_j = \frac{\sum n^2{}_{ji}}{N_j^2}$$

where $n_{ji}$ is the number of individuals of species i in sample j and $n_j$ is the number of individuals in sample j. The index was computed with data logarithmically transformed as $\ln(n_{ji} + 1)$. Cluster analysis was performed using a single linkage alogarithm.

## Results

A summary of the small mammal catch data in the form of number of individuals per seven hundred traps, number of species, Alpha of log series as an index of diversity for each of 31 habitats and trap index (per hundred traps) are shown in table 1.

*Alpha Diversity Habitats* : In any given habitat 2-10 species and 15-198 individuals were trapped (table 1) indicating a wide variance in the species composition and density of small mammals. The highest number of individuals (198) were collected in sparsely vegetated rocky habitat at Sunset point (Habitat No. 24, table 1) but the highest Alpha diversity was calculated to be in protected scrubland at Anadra (Habitat No. 7) though only 64 small mammals of 9 species were trapped. Likewise, the cropfield at Oria (Habitat No. 29) was second most diverse (although the most species rich among 31 studied habitats), followed by sparsely vegetated rocky habitat at Anadra (Habitat No. 5), rocky sparse habitat (No. 2) and the cropfield (Habitat No. 1) at Abu Road. Among 31 habitats dry runnel at Kodra dam was found to be showing least diversity (table 1).

If the data of habitat number 24 and habitat number 5 (table 1) are compared it is apparent that the number of species collected at 2 habitats was 3 and 5, total number of individuals collected was 198 and 15, and the Alpha diversity index is calculated to be 0.50 and 2.63. This data indicates that Fisher's method of calculating Alpha

**Table 1** *Summary of Catch Data on the Abu Hill*

| Habitat No. | Altitude | Locality | Habitat | No. of indiv.* | No. of spp. | Alpha of log series | Trap-index** |
|---|---|---|---|---|---|---|---|
| 1 | Foothills | Abu Road | Cropfield | 59 | 8 | 2.50 | 8.66 |
| 2 | Foothills | Abu Road | R. Sparse | 38 | 7 | 2.52 | 5.55 |
| 3 | Foothills | Abu Road | O. Scrubland | 48 | 4 | 1.04 | 7.06 |
| 4 | Foothills | Abu Road | R. Dense | 24 | 4 | 1.37 | 3.37 |
| 5 | Foothills | Anadra | R. Sparse | 15 | 5 | 2.63 | 2.03 |
| 6 | Foothills | Anadra | Cropfield | 71 | 5 | 1.23 | 10.18 |
| 7 | Foothills | Anadra | P. Scrubland | 64 | 9 | 2.85 | 9.37 |
| 8 | Foothills | Anadra | Riverbank | 49 | 4 | 1.03 | 6.92 |
| 9 | Foothills | Anadra | O. Scrubland | 70 | 6 | 1.57 | 10.06 |
| 10 | Foothills | Anadra | R. Dense | 36 | 3 | 0.78 | 5.20 |
| 11 | 500mts | Cheppberi | R. Dense | 38 | 6 | 2.00 | 5.60 |
| 12 | 500mts | Cheppberi | Runnel | 63 | 4 | 0.95 | 8.92 |
| 13 | 500mts | Cheppberi | R. Sparse | 29 | 3 | 0.84 | 4.08 |
| 14 | 1000mts | Arna | Cropfield | 45 | 5 | 1.44 | 6.51 |
| 15 | 1000mts | Arna | R. Dense | 48 | 5 | 1.40 | 6.85 |
| 16 | 1000mts | Arna | R. Sparse | 47 | 3 | 0.71 | 6.79 |
| 17 | 1000mts | Arna | Runnel | 72 | 3 | 0.63 | 10.24 |
| 18 | 1000mts | Gomukh | R. Dense | 58 | 3 | 0.67 | 8.38 |
| 19 | 1000mts | Gomukh | R. Sparse | 64 | 3 | 0.65 | 9.20 |
| 20 | 1500mts | Kodradam | W. Runnel | 120 | 3 | 0.56 | 17.14 |
| 21 | 1500mts | Kodradam | D. Runnel | 72 | 2 | 0.38 | 10.37 |
| 22 | 1500mts | Kodradam | R. Sparse | 94 | 5 | 1.13 | 8.23 |
| 23 | 1500mts | Sunset pt | R. Dense | 57 | 2 | 0.40 | 28.09 |
| 24 | 1500mts | Sunset pt | R. Sparse | 198 | 3 | 0.50 | 10.34 |
| 25 | 1500mts | Sunset pt | P. Scrubland | 72 | 3 | 0.63 | 12.96 |
| 26 | 1500mts | Sunset pt | Runnel | 91 | 5 | 1.14 | 12.46 |
| 27 | 1500mts | Sunset pt | Cropfield | 87 | 7 | 1.79 | 13.39 |
| 28 | 1500mts | Oriya | P. Scrubland | 61 | 7 | 2.04 | 8.63 |
| 29 | 1500mts | Oriya | Cropfield | 96 | 10 | 2.81 | 13.61 |
| 30 | 1500mts | Oriya | R. Sparse | 71 | 4 | 0.92 | 9.93 |
| 31 | 1500mts | Oriya | N. Fence | 62 | 2 | 0.40 | 5.55 |

*Per seven hundred traps; **Per hundred traps

N = Nursery, P = Protected, R = Rocky, O = Open, D = Dry, W = Wet

diversity does not wholly depend on the two parameters but also on the variance in the number of individuals of different species. In habitat number 24, individuals of 3 species were 24, 28, 146 whereas in habitat number 5 these were 2, 2, 2, 2 and 7 in numbers. It is apparent, therefore, that uniformity of the number of individuals of species in a habitat is an important factor in determining Alpha diversity. Likewise, in the habitat number 29 (Oria cropfield) the number of species collected was 10 and number of individuals 96, whereas in Anadra rocky sparse habitat (No. 5) the number of species was 5 and total number of individuals collected was only 15, yet the Alpha of log series is computed to be almost equal (2.81 and 2.63) for the two habitats. This further corrobrates our conclusion that uniformity in the number of various species in a catch plays an important role in the diversity calculation.

The small mammal catches from all the habitats permit a comparison between them. On the basis of variance of Alpha it is concluded that Anadra protected scrubland holds significantly more small-mammalian diversity than Arna rocky sparse ($p < 0.05$), Gomukh rocky dense ($P < 0.05$), Gomukh rocky sparse ($P < 0.05$), Arna runnel ($P < 0.05$), Sunset point protected scrubland ($P < 0.05$), Kodra dam wet runnel ($P < 0.05$), Sunset point rocky sparse ($P < 0.05$), Sunset point rocky dense ($P < 0.05$), Oria nursery fence ($P < 0.05$), and Kodra dam dry runnel ($P < 0.05$). Similarly, Oria cropfield is much more diverse (2.81) than all of above mentioned habitats at 5% level of significance except last three in which level of significance reaches 1% level. Likewise, Abu Road rocky sparse habitat has significantly ($P < 0.05$) more diversity with regard to small mammals than Sunset point rocky sparse and rocky dense, Oria nursery fence and Kodra dam dry runnel. Abu Road cropfield is significantly ($P < 0.05$) more diverse than Kodra dam wet runnel and all other habitats of lower diversity. Oria protected scrub land is more diverse in small mammal composition than Sunset point rocky dense ($P < 0.05$), Oria nursery fence ($P < 0.05$) and Kodra dam dry runnel ($P < 0.05$).

*Localities*: The computation of Alpha diversity index for the pooled habitats at 8 localities permits us to arrange them in decreasing order of diversity as shown in table 2, which clearly depicts that the foot hill at Abu Road is most diverse among all the 8 localities as far as small mammal diversity is concerned and Gomukh is least diversified. However, Abu Road is significantly more diverse than Gomukh ($P < 0.05$) and Kodra dam ($P < 0.05$). Likewise, Anadra has significantly greater diversity ($P < 0.05$) than Gomukh. These results also conform with the dendrogram (figure 1) projecting Beta diversity of eight localities.

**Table 2** *The eight localities arranged in decreasing order of diversity*

| Sr. No. | Altitude | Alpha diversity | No. of species |
|---|---|---|---|
| 1 | Abu Road | 2.95 | 12 |
| 2 | Anadra | 2.76 | 13 |
| 3 | Oria | 2.26 | 11 |
| 4 | Arna | 2.18 | 10 |
| 5 | Sunset point | 1.56 | 09 |
| 6 | Chepaberi | 1.30 | 06 |
| 7 | Kodra dam | 1.07 | 06 |
| 8 | Gomukh | 0.79 | 04 |

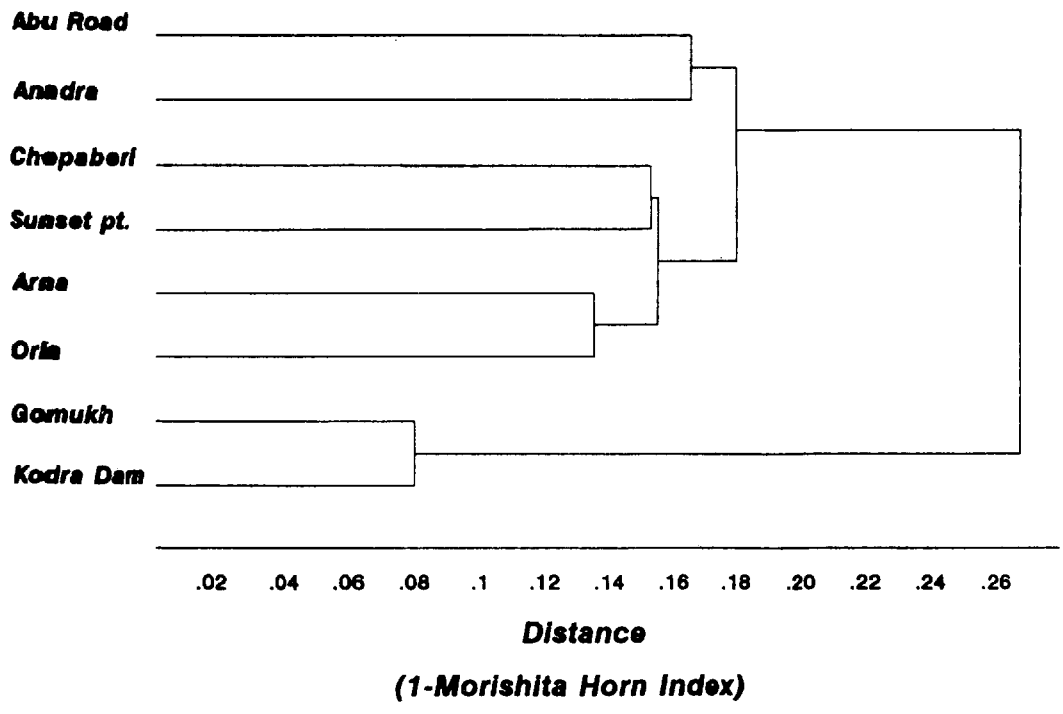


Figure 1 Dendrogram projecting similarity index among locationally pooled habitats

Gomukh and Kodra dam form one cluster and all other localities form a separate cluster indicating that Gomukh and Kodra dam are very different from all other sites in small mammal diversity. The low diversity of small mammals at Gomukh and Kodra dam can be attributed to relatively degraded forests, human interference in the eco-system and steep slopes.

Table 3 *The four altitudes arranged in decreasing order of diversity*

| Sr. No. | Altitude | Alpha diversity | No. of species |
|---|---|---|---|
| 1 | Foothills | 2.71 | 14 |
| 2 | 1000 m | 1.94 | 10 |
| 3 | 1500 m | 1.89 | 12 |
| 3 | 500 m | 1.30 | 06 |

*Altitudes*: The reuslts with respect to 4 pooled altitudes reveal that foothills are most diverse, followed by 1000 m, 1500 m and then 500 m (table 3) in that order. It is also evident that foothills are most species rich followed by 1500 m, 1000 m and 500 m. The highest diversity in the foothills is attributable to presence of protected scrublands which have good canopy as well as ground cover. Similarly, the very low diversity at 500 m can be attributed to the presence of steep slopes as well as absence of cropfields.

*Beta Diversity*

The Morishita — Horn index, an index of the extent of similarity in species composition between the localities or altitudes is projected in the form of dendrograms. Morishita—Horn

index has been calculated for 8 localities pooling all habitats of a locality, and that of 4 altitudes which comprises of pooling of all localities according to elevation at which these are situated. The comparisons between various localities and altitudes in the form of dendrograms using single linkage alogarithm are shown in figures 1 & 2. It is apparent from these diagrams that Gomukh and Kodra dam are similar to each other but are very different from all other localities (figure 1). Likewise, Abu Road and Anadra, Chepaberi and Sunset point, and Arna and oria are some what similar to each other in small mammalian diversity.

In the comparison of 4 altitudes it is found that 500 m is very different from all other altitudes, whereas, foothills and 1500 m elevations are somewhat similar with regard to diversity of small mammals (figure 2).

*Trap Index*: The trap index (no. of individuals trapped/100 traps/24 hours, table 1) indicates that rocky dense at Sunset point is most densely populated habitat followed by cropfield at Oria, and cropfield and protected scrubland at Sunset point. Among 14 small mammal species, *C. Cutchicus* was collected from all but 7 habitats, all localities, and at all elevations and was the preponderant species on the Abu hill. Anderson's shrew, *S. stoliczkanus*, was trapped from only one habitat (rocky sparse at Anadra) and was the least abundant among 14 small mammal species.

## Discussion

Analysis of data based on trapping of small mammals for the purpose of evaluating community ecology has been described as 'Relative abundance' (Prakash et al., 1971) or as 'Trap index' (Prakash & Rana, 1972) or as 'Species richness' (Prakash et al., 1995). We have used the Alpha and Beta diversity indices for analysing the catch-data of small mammals found on the Abu hill, probably for the first time in India. It is, therefore, logical to discuss its advantages and to show that various terms such as

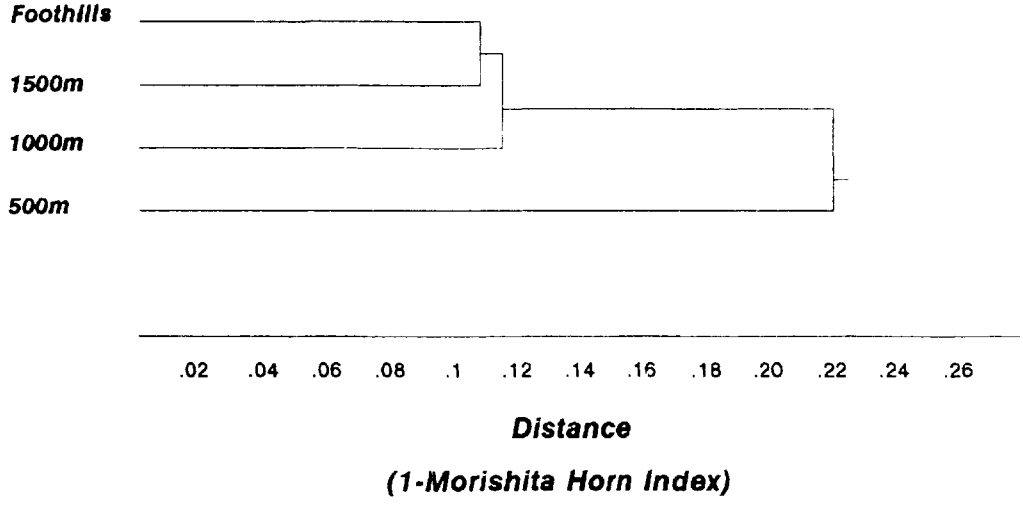


**Figure 2** Dendrogram projecting similarity index among altitudinally pooled habitats

**Table 4** *Comparison of various methods of analysing the catch data*

| Habitat | Alpha diversity value | Species richness (No. of species collected) | Trap index (per 100 traps/ 24 hours) | Relative abundance (No. of individual collected) | Variance in no. of individuals of every species |
|---|---|---|---|---|---|
| Scrubland Anadra | 2.85 | 9 | 9.37 | 64 | 3,10,23,1,10,3, 1,12,1 |
| Rocky dense Sunset point | 0.40 | 2 | 28.09 | 57 | 9,48 |
| Rocky sparse, Anadra | 2.63 | 5 | 2.03 | 15 | 2,2,7,2,2 |
| Rocky sparse, Sunset point | 0.50 | 3 | 10.34 | 198 | 28,146,24 |

species richness, relative abundance or trap index and diversity, calculated from the same data indicate different results as is evident from table 4.

Maximum trap index was calculated for rocky dense habitat at Sunset point (28.09 small mammals/100 traps/24 hours) but it was the least species rich (only 2 species) and thus exhibited a low species diversity. The relative abundance of small mammals was found to be maximum in rocky sparse habitat at Sunset point (198) but it was poor in species richness, resultantly showed a low diversity. On the contrary, relative abundance of small mammals was lowest at Anadra rocky sparse vegetation habitat consequently exhibited a lowest trap index but it was more species rich as compared to previous habitats and the species diversity is very high (2.63) because of uniformity in the number of individuals of five species (table 4). At Anadra scrubland although a much higher number of species (9) was collected, but the diversity value (2.85) was not significantly higher than 2.63. This small difference in the diversity value of the latter two habitats differing widely in species richness (5 and 9) can be explained due to a large variance in the number of individuals of various species at Anadra scrubland as compared to that at Anadra rocky sparse habitat (table 4). Moreover, diversity computations take in account the number of species, as well as the number of individuals of different species and also the variance in it. Species diversity is, therefore, entirely different from species richness or trap index. The term species diversity should be used more carefully.

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## References

Anscombe F J 1950 Sampling theory of the negative binomial and logarithmic series distributions; *Biometrika* **37** 358-382

Fisher R A, Corbett A S and Williams C B 1943 The relation between the number of species and the number of individuals in a random sample of an animal population; *J. Anim. Ecol.* **12** 42-58

Margalef F R 1958 Information theory in ecology; *Gen Syst* **3** 36-71

Prakash I 1995 Invasion of Peninsular Small mammals towards the Aravalli ranges and the Thar desert; *Intl. J. Ecol. Envatl. Sci.* **21** 17-24

—— Gupta R K, Jain A P, Rana B D and Dutta B K 1971 Ecological evaluation of rodent population in the desert biome; *Mammalia* **35** 384-423

—— and Rana B D 1972 A study of field population of rodents in the Indian desert. II. Rocky and Piedment zones; *Z. angew. Zool.* **59** 129-139

—— Singh P and Saravanan A 1995 Ecological distribution of small mammals in the Aravalli ranges; *Proc. Indian natn. Sci. Acad.* **61B** 137-148

Simpson E H 1949 Measurement of diversity; *Nature* **163** 688

Wolda H 1981 Similarity indices, sample size and diversity; *Oecologia* **50** 296-302