A STUDY OF DIVERSITY AND BEHAVIOUR OF SPECIES IN SERAL COMMUNITIES OF KOHAT

by

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Abstract. *Species diversity in the seral communities of Kohat was determined and the relationship between species diversity and its components was studied. Species diversity and its components were correlated with the structural characteristics of the communities. The general behaviour of some important species has also been discussed.*

Introduction. Species diversity is a measurable characteristic of the ecological community and manifests the organizational features important in the functioning of the community. It deposes an important aspect of species structure in a community. The stability of an ecological community largely depends on the diversity in the composition of species (MacArthur, 1955). The species diversity varies from community to community and is affected by several physiological factors. The communities having many niches exhibit high species diversity than those possessing a few niches. Many attempts have been made to use particular functions to describe how species and individuals are related in a community (Hairston, 1959). The relationships are often called diversity indices and are of great value in comparing the species composition of different communities or in making comparison of the same community with respect to productivity and structure at different times of the year. Most of the measures of diversity, proposed from time to time, have been meant for large collections (Fisher, Corber and Williams, 1943; Preston, 1948; Simpson, 1949 and MacArthur, (1957). The use of some other indices, which depend upon the assumption that the distribution of individuals among the species follows a particular mathematical form, has also been avoided. Menhinick (1964) compared the efficiency of different indices of species diversity and concluded that only the index of species/square root of individuals is not sensitive to sample size and it differentiates between habitats having different number of species for a given number of individuals. In ecology, Shannon-Weaver's function (Shannon and Weaver, 1963) derived from information theory (Margalef, 1957) has widely been used to describe species diversity in natural communities. The drawback of this index is that it requires the reduction of absolute numbers to a proportional scale that leads to a considerable concealment of information which is of importance in judging diversity for species habitats (Johnson et al., 1975). However this index is still believed to be most reliable by many workers (Fager, 1972; and Heip and Engels, 1974). This measure has two separate components, species richness and the relative abundance or equitability (Lloyd and Ghelardi, 1964). The species richness is the expression of simple ratios between the number of species and the total number of individuals

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of all species. Equitability is the measure as how equally the species are represented in a community. Since the components of this index can vary independently of one another, it is obvious that the two samples having identical species diversity may in fact be very different (Tramer, 1969). It is, therefore, a common practice to resolve the formula into its components when studying the diversity pattern.

The authors sampled and analyzed the vegetation in the suburbs of Kohat town (Chaghtai and Yusaf, 1976). The data thus collected was used to measure species diversity and its components. An attempt has been made to study the relationship between the general species diversity and its components. The general diversity, species richness and equitability have been correlated with the structural characteristics of the community. The general behaviour of some of the important species in the communities has also been discussed in detail.

Materials and Methods. The general diversity was measured by Shannon-Weaver's index. The modified form of this index is:

$$g = 3.3219 \quad (\log_{10} N - \frac{1}{N} \quad \Sigma_{ni} \quad \log_{10} ni)$$

g is general diversity; N is total number of individuals of all species; ni equals number of individuals of the ith species and 3.3219 is the conversion factor from $\log_{10}$ to $\log_2$.

Species diversity combines two components, the species richness and the equitability. The richness component is the expression of simple ratios between the number of species and the square root of the total number of individuals of all species and is calculated by the formula

$$d = \frac{S}{\sqrt{N}}$$

d is species richness; S is total number of species and N equals total number of individuals of all species. The equitability component is related to the evenness of allotment of individuals among the species (Peet, 1974). Of the several expressions employed to measure the equitability (relative abundance) component, the index used here is

$$e = \frac{g}{g_{max}}$$

in which e is equitability; g is observed general diversity and g_{max} is maximum species diversity which is calculated by the formula

$$g_{max} = 3.3219 \, (\log_{10} S)$$

The equitability index represents the ratio of the observed diversity to the maximum diversity possible for the same number of species. It has a maximum value of unity when all species are equally abundant, while minimum value is observed under the conditions when all species except the most abundant are represented by one individual.

Results and Discussion. *Diversity relations.* General species diversity (g), species richness (d) and equitability (e) of the communities are given below:

Community	General species diversity (g)	Species richness (d)	Equitability (e)
Acacia-Adhatoda	3.169	0.898	0.916
Acacia-Malcolmia	3.198	0.936	0.924
Acacia-Rhazya-Adhatoda	2.474	0.443	0.915
Salvadora-Malcolmia	3.049	0.923	0.881

No definite and consistent pattern of relationship emerges between species diversity and its components.

In *Acacia-Adhatoda* and *Acacia-Malcolmia* communities, the diversity of species is equally governed by its two components. The degree of similarity in relationship between species diversity and its components in both communities is almost of the same magnitude probably because of similar habitats these communities occupy. In *Acacia-Rhazya-Adhatoda* community, the number of species encountered is lower than other communities which is also manifested by comparatively low value of species richness. This community exhibits minimum species diversity which is governed by the evenness of allotment of individuals among the species. A comparatively lower value of equitability in *Salvadora-Malcolmia* community is explainable because of sporadic vegetation. Equitability shows negative linear relationship with general species diversity. A very low and insignificant value of correlation coefficient (—0.166) indicates that the latter has no major effect on the former. The relationship between general diversity and species richness is strongly positive. The high correlation coefficient of 0.979 suggests that species diversity is solely governed by species richness. The regression equations are:

$$g = 1.867 + 1.382 \ d$$
$$g = 5.464 - 2.742 \ e$$
$$d = 1.241 + 0.687 \ g$$
$$e = 0.932 - 0.008 \ g$$

The relationship between general species diversity and species richness and equitability; and density and coverage is given below:

	Density (D)	Coverage (C)
	(Correlation coefficients)	
General species diversity (g)	0.678	0.502
Species richness (d)	0.529	0.351
Equitability (e)	0.692	0.507

Regression equations:

D	=	238905.070 + 160570.620 d	.. d =	0.162 + 0.522 D
D	=	—1876725.300 + 2468885.800 e	.. e =	0.847 + 0.051 D
D	=	— 67829.832 + 146464.410 g	.. g =	1.799 + 0.959 D
C	=	3.722 + 10.282 d	.. d =	0.657 + 0.012 C
C	=	—149.837 + 177.981 e	.. e =	0.894 + 0.001 C
C	=	— 18.935 + 10.391 g	.. g =	2.686 + 0.024 C

The relationship between diversity measures and density and coverage was positive and linear but insignificant. The value of correlation coefficient between coverage and species richness was minimum indicating that the species richness had no pronounced influence on coverage. A comparatively higher value of correlation coefficient between density and equitability suggests that the former is largely controlled by the latter, whereas it is least influenced by species richness.

Behaviour of some important species. The importance values of some prominent species are given below:

Species / Community	Stand 1 Acacia-Adhatoda	Stand 2 Acacia-Malcolmia	Stand 3 & 4 Acacia-Rhazya-Adhatoda	Stand 5 Salvadora-Malcolmia
Acacia modesta	195	192	175	25
Salvadora oleoides	36	25	67	176
Capparis decidua	54	46	58	71
Zizyphus nummularia	14	36	0	28
Adhatoda vasica	64	33	97	26
Rhazya stricta	0	54	100	73

Acacia modesta, which constitutes a climatic climax with *Olea ferruginea* in the district of Kohat, has dominated three out of a total of four communities. It is a typical species of the plains, and of rocky and sandy soils which are not subjected to waterlogging (Champion et al. 1965). In the area under study, the maximum importance values were observed in the stands where soil was largely clay-loam in texture and poor in organic matter (Table 4). In *Acacia-Rhazya-Adhatoda* community, which is confined to dry stream beds, this species grows on the raised banks of the dry streams which are clay-loam in texture. According to the findings of Champion et al. (1965), its importance value should have been maximum in stand 5, where in addition to extremely xeric conditions the soil is sandy and rocky. But the importance value of *A. modesta* is comparatively very low in this stand. Besides being outclassed by *Salvadora oleoides* under these conditions, other reason of its low importance value may be the disturbed state and exposed nature of this stand. It probably needs considerable shade during its early stages of growth which was not available in stand 5. This is further confirmed by the complete absence of saplings of *A. modesta* from stand 5 (Chaghtai and Yusaf, 1976). The importance values of *A. modesta* are higher only in those communities in which the importance values of *S. oleoides* are low. *A. modesta* and *S. oleoides* occupy two opposite poles of an ecological gradient.

Salvadora oleoides, a slow growing plant, is a leading dominant of *Salvadora-Malcolmia* community which is confined to stand 5. *S. oleoides* is an indicator of soil moisture conditions and inhabits the dry tracts (Jafri, 1966). In the mesic stands, it shows low importance value; whereas in stand 5, where the conditions are extremely xeric, it has completely outclassed *A. modesta*, the other leading favourite. It is better represented in *Acacia-Rhazya-Adhatoda* community but is inconspicuous in *Acacia-Adhatoda* and *Acacia-Malcolmia* communities. The controlling factor again seems to be the soil moisture. In the drier parts of the plains of Punjab, *S. oleoides* grows in association with *Capparis decidus* (Kashyap and Joshi, 1936). In the area under study, the highest importance value of *C. decidua* was noticed in *Salvadora-Malcolmia* community showing its close association with the dominant woody species of this community. *S. oleoides* frequently reproduces under the shade of *C. decidua* (Parker, 1956), but no young specimens of *S. oleoides* were noticed in *Salvadora-Malcolmia* community where sufficient shade was available.

The presence of *Capparis decidua*, a widely distributed plant of arid and semiarid areas of Pakistan, in all the four communities hints at the vast ecological amplitude this species has. The highest importance value of *C. decidua* in *Salvadora-Malcolmia* community suggests that the ecological niches of *C. decidua* and *S. oleoides* overlap each other but the range of the ecological amplitude of the former is wider than the latter with regards to soil moisture and structure and shade. Sandy soil may be held responsible for the high importance value of *C. decidua* in *Salvadora-Malcolmia* community (Qaiser and Qadri, 1971). It is represented in all the four communities but the absence of young plants in most of communities may be attributed to fast declining viability of the seeds (Qaiser and Qadri, 1971). Most of the seeds produced under unfavourable conditions of growth fail to germinate few months later at the advent of favourable conditions.

Adhatoda vasica, a perennial shrub of dry stream beds (Salim and Shahid, 1973), is represented in all stands but is co-dominant in two communities only. It shows highest importance value in *Acacia-Rhazya-Adhatoda* community which is confined to dry stream beds. It owes its presence in all the four communities to its immunity from being damaged by grazing animals.

Rhazya stricta, a plant of open, rocky and stony ground (Nasir and Ali, 1972), is dominant in stands 3 and 4. The habitat of stand 5 is most ideal for its growth, but because of being easily accessible, *R. stricta* is the main target of the fuel-hunters in this stand. Its significant absence from *Acacia-Adhatoda* community is largely because of the closed canopy of this community.

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