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STRUCTURE, COMPOSITION AND PATTERN IN *ACHYRANTHES ASPERA* L. DOMINATED RUDERAL VEGETATION IN THE SUBURBS OF KARACHI

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Abstract

The analysis of *Achyranthes aspera* dominated stands revealed that 45 species were associated with a mean number of 9.54 ± 1.02 species per stand though most of them were of minor importance. *A. aspera* itself had an average importance value index of 126.97 (range = 103.9-177.4). Species diversity of stands was low and the relative abundance pattern was geometric. Species diversity was predominately a function of equitability. The importance value of *A. aspera* was positively correlated with the humus content and proportion of fine sand in soil and negatively correlated with coarse sand percentage. All stands were associated with basic, non-saline and relatively calcareous soils. Significant negative associations were indicated with *Cenchrus biflorus, Leucas urticifolia* and *Rhynchosia minima.* Ordination of stands disclosed a continuous change in vegetation that was chiefly governed by soil pH and maximum water holding capaity. Analysis of population structure of *A. aspera* and some of its associates suggested that the pattern was non-random and contagious and the primary pattern scale was of reproductive origin. The negative correlations observed in the pattern correlation analysis demonstrated that large patches of *A. aspera* alternate with small patches of its associates.

Introduction

Archyranthes aspera L., a plant of medicinal importance, is common in wastelands, cultivated fields and other disturbed sites in most of the tropical regions of the world. In the suburbs of Karachi, *A. aspera* forms almost pure stands in waste-grounds. Such communities though ecologically interesting have received little attention locally. This paper emphasizes the phytosociological relations of *A. aspera* dominated stands in the suburbs of Karachi. The study involves the analysis of structure and composition of *A. aspera* dominated stands in waste places and also the distribution pattern of this species and its major associates within and between the vegetation samples.

Material and Methods

a) *Field Methods:* Thirteen stands dominated by *A. aspera* were sampled by 20 randomly placed quadrats of 30 x 30 cm. All stands were exposed to mild disturbance. Sampling was done between September, 1978 and December, 1978. Taxonomic nomenclature of Stewart (1972) was followed. Soil samples were collected at 3 different sites in a stand from 20 cm depth. The three sub-samples of a stand were pooled to obtain a composite sample.

b) *Soil Analysis:* Soil samples were air-dried and passed through a 2 mm sieve to separate gravel. Soil < 2 mm in diameter was used for chemical and physical determinations. Soil texture was analysed by pipette method (Anon., 1951), maximum water holding capacity (MWHC) by the method of Keen (1920), and total organic matter by the loss-on-ignition method (Jackson, 1958). Amount of calcium carbonate was measured by the method of Qadir *et al.*, (1966) and pH by glass electrode pH meter after preparing the samples according to Peech *et al.*, (1947). Filtrate of saturated soil-paste was employed for the measurement of electrical conductivity (EC) of soil.

c) *Vegetation Analysis:* (i) Quantitative vegetation parameters viz., relative density and relative frequency were computed from the quadrat data. The importance value index (I.V.I) for each species was obtained by direct summation of relative density and relative frequency.

(ii) Dominance for each stand was ascertained by Simpson's (1949) index:

$$c = \sum_{i=1}^{S} \left(\frac{n_i}{N}\right)^2$$

where n_i/N is the proportion of the individuals belonging to the ith species to the total number of individuals in the sample. The general diversity incorporates two components (a) the richness component and (b) the equitability or evenness component. The general diversity was determined by the information theory function $H = -\sum_{i=1}^{S} p_i . \log p_i$, where p_i is the proportion of the total density belonging to the ith species (Margalef, 1957). Equitability was measured by $e = \bar{H}/\bar{H}_{max}$, where $\bar{H}_{max} = \log S$ (Pielou, 1969) and also by the index of Hurlbert, (1971).

$$V = \frac{[N - \sqrt{\Sigma n_i^2}] - N - \sqrt{[(N-(S-l)]^2 + (S-l)}}{[N-N/\sqrt{S}] - N - \sqrt{[(N-(S-l)]^2 + (S-l)}}$$

The species richness was calculated as $d' = S\text{-}1/\log N$ (Margalef, 1957) where S and N are total number of species and total number of individuals repectively.

The relationships of conspicuousness (I.V.I) of *A. aspera* with diversity measures of its stands were also determined by computing correlation coefficients. Furthermore, dominance-diversity curves (Whittaker, 1965) were plotted to portray the underlying relative abundance pattern.

(iii) *Analysis of Interspecific Associations:* The quadrat data was utilized for the analysis of interspecific associations between *A. aspera* and its major associates by χ^2-test (with Yate's correction) using 2 x 2 contingency tables for each species pair (Mueller-

Dombois & Ellenberg, 1974). Product-moment correlations between relative density and I.V.I. of *A. aspera* and that of its major associates were computed to evaluate the interactions between species populations. Edaphic relationships of *A. aspera* were also ascertained.

(iv) *Vegetational Ordination: A. aspera* dominated vegetation samples were arranged in a 2-dimensional ordination according to Bray & Curtis (1957), incorporating the modifications described by Beals (1965). The ordination was based on Czekanowski's similarity coefficient. The polar ordination technique of Bray & Curtis (1957) was employed since this technique is relatively free from distortions because of non-linearity and relatively less vulnerable to the effects of β-diversity, sample clusters and outlier samples compared to many recently developed mathematically elegant ordination methods (Gauch & Whittaker, 1972; Gauch *et al.,* 1977).

For calculating the inter-stand similarity only those species were taken into consideration which occurred in at least two stands. Each similarity index value was subtracted from a maximum of 100 to obtain an inverse value (dissimilarity value). These values were used to order stands along X and Y axes using arithmetical method of Beals (1965). The polar stands for the two axes were selected according to Beals (1965).

(v) *Population Structure:* The technique of "Pattern Analysis" developed by Greig-Smith (1961) and Kershaw (1961) was used for the detection of pattern, determination of the scale and intensity of aggregation, and the elucidation of interactions between species populations. This technique has been successfully used for this purpose by Pemadasa *et al.,* (1974) and Shaukat *et al.,* (1983).

The data on small scale spatial pattern were collected from two sites (arbitrarily named A and B) where *A. aspera* was the leading dominant. Each site was systematically sampled by a grid of contiguous quadrats. The sample grid was of 4.80 x 1.20 m consisting of 64 square grid units of 30 cm side. Density data were collected from each grid unit in a sequence for all the species occurring in the grid units and analysed by analysis of variance of successive block sizes (NS) (Greig-Smith, 1961). In the graphs relating mean square to block size, different scales of pattern appear as "peaks" at block sizes corresponding to the mean area of "clump". The interaction between species populations was evaluated by pattern correlation analysis as given by Kershaw (1961):

$$r = C_{ab} / \sqrt{V_a \cdot V_b}$$

where C_{ab} represents covariance of species a and b and V_a and V_b are the variances of species a and b, respectively.

Results

a) *Vegetation composition and structure of A. aspera dominated stands:* The realtive phytosociological data on species occurring in *A. aspera* dominated stands (Table 1) gives the values of arithmetic mean of the I.V.I. for the species in those stands in which they occurred. Among 13 *Achyranthes* dominated stands 46 species were encountered with a mean number of 9.54 ± 1.02 species. *A. aspera* had very high mean importance value of 126.97. Most of the species of were minor importance. Only *Chloris barbata, Cenchrus pennisetiformis, Dichanthium annulatum, Cenchrus setigerus, Dactyloctenium scindicum, Eleusine compressa, Sporobolus coromendelianus, Rhynchosia minima, Tribulus terrestris, Tragus biflorus, Leucas urticifolia* and *Tephrosia uniflora* attained the position of second or third dominant. Among these, *C. barbata* was the most widespread and second dominant in 5 stands with an average importance value of 23.24. *C. pennisetiformis* occurred in 10 stands with relatively low I.V.I. The number of species which occurred in 6 stands were only 2 and those in 5 stands were 3, whereas 38 species were restricted to 4 or less than 4 stands. The species occurring in one stands only constituted a major proportion (43.2%).

Species diversity ($\bar{H}$) of stands was very low ranging from 0.30694 to 0.3205 (mean species diversity being 0.4048 ± 0.0405 (Table 2). The coefficient of variability of information theory function ($\bar{H}$) was low (36.107%). Equitability (V) ranged from 0.09102 to 0.47842 with a mean value of 0.299 ± 0.0408 and equitabilty(e) ranged from 0.0346 to 0.1761 with a mean value of 0.1328 ± 0.01203). Richness component(d) ranged from 0.00237 to 0.090909 ($\bar{x}$ = 0.685 ± 0.598). Dominance(c) was very high and ranged from 0.41651 to 0.80977 ($\bar{x}$ = 0.6096 ± 0.045). Dominance varied by 26.81% only. The very high values of dominance indicate the high predominance of *A. aspera* in these stands. It appears from the regression equations (Table 2) that variation in general diversity ($\bar{H}$) in our data largely depends (ca. 70%) on equitability component. Richness component determined the general diversity by about 30% only.

The I.V.I. of *A. aspera* was significantly positively correlated with Simpson's index ($P < 0.001$) and negatively with information theory function H and equitability measure ($P < 0.001$) and also with species richness(d) and number of species(s) at somewhat reduced level (Table 3). The dominance-diversity curves for all the stands except 1, 4 and 5 followed a geometric distribution. The stands 1, 4 and 5, however, appeared to follow the relative abundance pattern intermediate between geometric and lognormal (Fig. 1).

b) *Relationship of A. aspera with the edaphic variables:* The edaphic features of *A. aspera* dominated stands are given in Table 4. In general, soils were basic, non-saline, rich in $CaCO_3$, low in organic matter and MWHC and were sandy loam in texture. IVI of *A.*

Table 1: Summary of relative phytosociological data of *Achyranthes aspera* dominated stands.

S. No.	Species	Presence No. of stands	Average I.V.I.	Maximum I.V.I.	Minimum I.V.I.	No. of stands first dominant	No. of stands second dominant	No. of stands third dominant
1.	*Achyranthes aspera* L.	13	126.073	177.379	103.947	13	–	–
2.	*Chloris barbata* Swartz.	10	23.242	52.337	2.446	–	5	1
3.	*Cenchrus pennisetiformis* Hochest. & Steud.	8	10.416	22.383	2.785	–	1	2
4.	*Dichanthium annulatum* (Forssk.) Stapf.	6	8,2565	16.439	2.699	–	2	–
5.	*Eleusine compressa* (Forssk.) Aschers. & Schweinf. Ex. C. Christ.	6	7.667	12.296	4.566	–	1	1
6.	*Rhynchosia minima* (L.) DC.	5	5.374	8.098	2.933	–	–	1
7.	*Withania somnifera* (L.) Dunal	5	4.861	8.900	2.446	–	–	–
8.	*Abutilon pakistanicum* Jafri & Ali	5	9.182	14.092	5.348	–	–	–
9.	*Tribulus terrestris* L.	4	4.339	8.873	2.674	–	1	1
10.	*Tragus biflorus* Schultes	4	16.190	37.118	6.136	–	1	1
11.	*Leucas urticifolia* R. Br.	3	10.932	12.905	8.879	–	1	2
12.	*Peristrophe bicalyculata* (Retz.) Nees.	3	6.812	11.355	2.699	–	–	–
13.	*Amaranthus viridis* L.	3	6.681	8.263	2.841	–	–	–
14.	*Calotropis procera* (Willd.) R. Br.	3	4.296	5.571	2.878	–	–	–
15.	*Dactyloctenium aegyptium* (L.) P. Beauv.	2	4.658	5.681	3.636	–	–	–
16.	*Cenchrus setigerus* Vahl	2	7.107	11.515	2.699	–	–	1
17.	*Xanthium strumarium* L.	2	2.776	2.878	2.674	–	–	–

(Table 1. Contd.)

S. No.	Species	Presence No. of stands	Average I.V.I.	Maximum I.V.I.	Minimum I.V.I.	No. of stands first dominant	No. of stands second dominant	No. of stands third dominant
18.	*Dactyloctenium scindicum* Boiss.	3	6.826	12.696	3.766	–	–	1
19.	*Salsola baryosma* (R. & S.) Dandy	2	2.859	2.878	2.840	–	–	–
20.	*Sporobolus coromandelianus* (Retz.) Kunth.	2	8.323	13.971	2.674	–	1	–
21.	*Suaeda fruticosa* (L.) Forssk.	2	2.693	2.840	2.546	–	–	–
22.	*Atriplex griffithii* Moq. var. Stocksii Boiss.	2	5.591	8.900	2.281	–	–	–
23.	*Launaea procumbens* (Roxb.) Ramayya & Rajgopal	2	6.281	6.880	5.681	–	–	–
24.	*Sporobolus halvolus* (Trin.) Dur. & Schinz.	2	5.579	8.460	2.699	–	–	–
25.	*Cenchrus biflorus* Roxb.	1	10.478	10.478	10.478	–	–	–
26.	*Digera muricata* (L.) Mart.	1	2.670	2.670	2.670	–	–	–
27.	*Abutilon indicum* (L.) Sweet	1	2.446	2.446	2.446	–	–	–

28. *Corchorus olitorius* L.	1	2.699	2.699	2.699	–	–	–
29. *Corchorus trilocularis* L.	1	2.699	2.699	2.699	–	–	–
30. *Ziziphus nummularia* (Burm. f.) Wight & Arn.	2	5.021	7.343	2.699	–	–	–
31. *Euphorbia prostata* Ait.	1	5.659	5.659	5.659	–	–	–
32. *Eclipta prostata* (L.) L. Mant.	1	2.699	2.699	2.699	–	–	–
33. *Ruellia petula* Jacq.	1	3.604	3.604	3.604	–	–	–
34. *Commicarpus stellatus* (Wight & Arn.) Berhaut	1	8.861	8.861	8.861	–	–	–
35. *Tephrosia uniflora* Pers.	1	18.549	18.549	18.549	–	–	–
36. *Setaria verticillata* (L.) B. Beauv.	3	11.382	16.110	3.507	–	–	–
37. *Abutilon glaucum* (Cav.) Sweet	1	3.604	3.604	3.604	–	–	–
38. *Barleria prionotis* L.	1	3.578	3.578	3.578	–	–	–
39. *Paspalidium geminatum* (Forssk.) Stapf.	1	5.959	5.959	5.959	–	–	–
40. *Datura metel* L.	1	13.746	13.746	13.746	–	–	–
41. *Amaranthus graecizans* L.	1	5.348	5.348	5.348	–	–	–
42. *Cassia holosericea* Fresn.	1	2.878	2.878	2.878	–	–	–
43. *Prosopis juliflora* Swartz	1	3.587	3.578	3.578	–	–	–
44. *Sonchus asper* (L.) Hill	1	3.611	3.611	3.611	–	–	–
45. *Cassia obovata* Collad.	1	4.859	4.859	4.859	–	–	–
46. *Setaria tomentosa* (Roxb.) Kunth	1	3.604	3.604	3.604	–	–	–

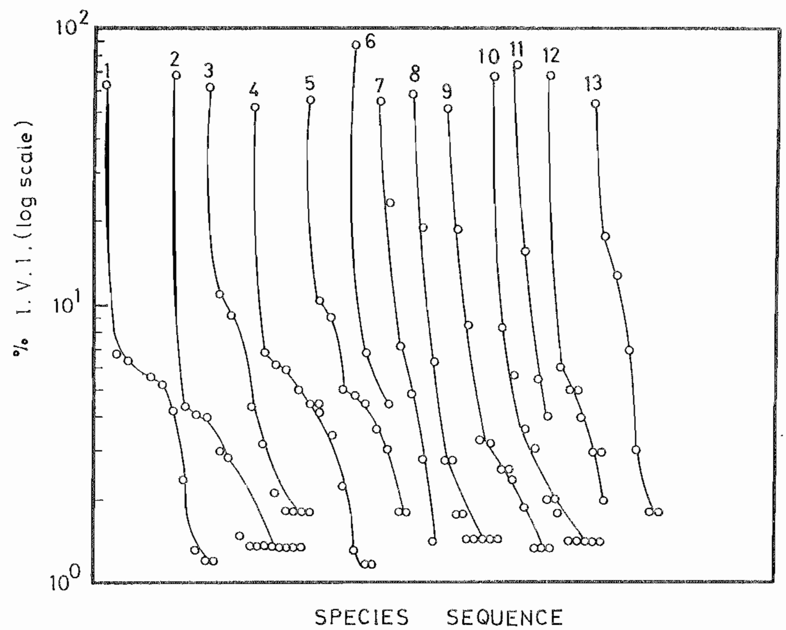

Fig. 1. Dominance-diversity curves for the stands sampled.

aspera correlated positively with humus (r = 0.7098, P < 0.01) and fine sand (r = 0.7115, P < 0.01) but correlated negatively with coarse sand fraction of soil (r = – 0.8088, P < 0.001). Regression equations related to these correlations are as follows:

1. I.V.I. = 82.798 + 30.547 humus
2. I.V.I = 369.715 – 4.682 coarse sand
3. I.V.I = 59.520 + 2.997 fine sand

c) *Analysis of inter-specific associations: A. aspera* exhibited negative associations with *Cenchrus biflorus* (χ^2 = 46.47, P < 0.001), *C. pennisetiformis*, (χ^2 = 9.65, P < 0.01) *C. setigerus* (χ^2 = 7.12, P < 0.05), *T. biflorus* (χ^2 = 9.96, P < 0.01), *L. urticifolia* (χ^2 = 6.96, P < 0.05) and *R. minima* (χ^2 = 8.91, P < 0.01) and exhibited positive association with none except a marginally insignificant positive tendency towards *C. barbata* (χ^2 = 5.07, n.s.).

Significant linear correlations among I.V.I. of *A. aspera* and its major associates were not observed. However, relative density (D_3) of *Achyranthes* was observed to be negatively correlated with that of *C. barbata* (r = -0.4938, P < p.01), *C. pennisetiformis* (r = – 0.4318, P < 0.10 and *Setaria verticillata* (r = – 0.5045, P < 0.1).

d) *The Stand Ordination:* The fundamental object of ordination is to present in graphic form the similarities of each stand with all others. Fig. 2 shows the 2-dimensional

Table 2. Species richness(d′), equitability(v), diversity($\bar{H}$) and dominance(c) of thirteen *Achyranthes aspera* dominated staands.

Stand No.	S	d′ = S-1/ log N	V	$e = \bar{H}/\bar{H}_{max}$	$\bar{H} = -\Sigma$ pi log pi	$c = \Sigma pi^2$
1	11	3.77453	0.23056	0.10855	0.36003	0.67523
2	15	5.41726	0.09102	0.07925	0.30694	0.80997
3	10	4.32114	0.34846	0.15141	0.47879	0.50891
4	13	4.61948	0.46846	0.17529	0.63205	0.41651
5	10	4.04909	0.42358	0.17606	0.556674	0.46157
6	3	0.19825	0.04177	0.03459	0.05991	0.94866
7	6	2.18337	0.44054	0.16362	0.40078	0.52563
8	12	5.05493	0.28813	0.13033	0.45149	0.55208
9	12	4.86198	0.44474	0.16802	0.37387	0.68777
10	13	4.95539	0.18522	0.10369	0.34716	0.72597
11	4	1.33747	0.27099	0.17358	0.34716	0.72579
12	8	3.19179	0.18717	0.11190	0.31651	0.71006
13	7	2.40295	0.4742	0.15007	0.39704	0.47949
X =	9.54	3.56674	00.29992	00.13279	00.40487	00.60960
% C.V. =	38.66	45.00700	49.13400	32.65470	36.10700	26.81400

Regression equations of $\bar{H}$ with its components and C:

$\bar{H} = -0.16187 + 0.8119V$, $r = +0.8177^{***}$, $r^2 = 0.6696$

$\bar{H} = -0.02792 + 2.8393e$, $r = +0.8413^{***}$, $r^2 = 0.7077$

$\bar{H} = -0.20250 + 0.05670d$, $r = +0.6229^{*}$, $r^2 = 0.3880$

$\bar{H} = -0.20156 + 0.02132S$, $r = 0.5372^{\dagger}$, $r^2 = 0.2886$

$\bar{H} = 0.10035 + 0.82877C$, $r = 0.9257^{***}$, $r^2 = 0.8569$

† $P < 0.10$, * $P < 0.05$, *** $P < 0.001$.

Table 3. Linear correlation coefficiens of importance value of *Achyranthes aspera* with various diversity measures and the stand dominance.

	S	$\bar{H}$	C	V	d′ = S-1/Log N
I.V.I. of *A. aspera*	–0.5148†	–0.9016***	–0.7528**	–0.8623***	–0.6004*

† $P < 0.10$; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 4. Edaphic characteristics of *Achyranthes* dominated stands.

S. No.	pH	$CaCO_3$ (%)	EC: dS. m^{-1}	Organic matter (%)	MWHC (%)	Coarse Sand (%)	Find sand (%)	Silt (%)	Clay (%)	I.V.I. of *A. aspera**
1	7.4	15.84	1.12	1.031	34.83	51.6	26.5	12.7	9.2	126.28
2	7.2	15.03	0.14	1.732	28.51	48.7	29.5	16.1	5.7	138.62
3	7.7	17.52	1,22	1.012	30.52	52.3	22.5	17.6	7.6	124.07
4	7.4	14.88	0.24	0.967	27.83	53.8	18.3	15.8	12.8	103.94
5	7.9	18.93	0.81	1.508	24.06	55.0	20.9	14.1	10.0	114.08
6	7.5	20.21	1.10	2.568	26.36	46.2	30.5	16.0	7.3	177.37
7	8.1	19.96	1.22	1.635	31.65	54.3	21.1	19.8	4.2	114.68
8	8.1	23.65	0.77	0.868	29.16	51.4	22.1	15.1	11.4	116.14
9	7.7	24.03	1.39	0.981	23.67	51.6	14.6	19.6	14.2	104.84
10	7.6	21.57	1.09	1.192	22.22	47.4	18.2	25.3	9.1	132.57
11	8.2	22.92	0.30	1.592	27.02	45.3	20.6	28.9	5.2	149.08
12	7.5	15.22	0.80	1.926	32.89	50.5	28.7	12.6	8.2	138.51
13	8.0	22.31	0.91	1.786	21.52	57.3	19.1	11.3	12.3	109.92
X =	7.72 ± 0.09	19.33 ± 0.95	0.95 ± 0.10	1.45 ± 0.14	27.71 ± 1.14	51.18 ± 1.16	22.51 ± 1.35	17.30 ± 1.41	8.99 ± 0.85	127.00 ± 5.71
% CV =	4.12	17.582	41.32	34.303	14.833	6.921	21.684	29.375	34.012	16.199

*Values out of a total of 200 I.V.I.

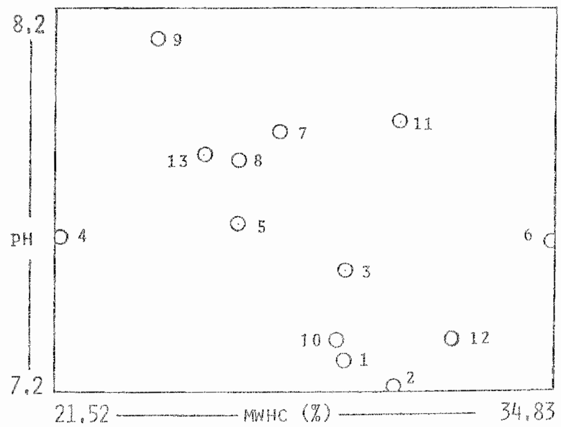

Fig. 2. A two-dimensional ordination of stands surveyed showing two major environmental gradients (pH and MWHC). Numbers against the points corresponds to the serial number of stands.

stand ordination in which minute circles represent the stands, and those close together represent similar samples, whereas two circles far apart represent highly dissimilar samples. The mechanical validity of the ordination, i.e., how far the interstand distances between pairs of stands varied as a function of dissimilarity values, was checked. To accomplish this 30 stand pairs were selected for each case and product-moment correlation was computed between interstand distances and the corresponding dissimilarity values which was found to be significant ($r = 0.4002$, $P < 0.05$).

The primary axis (X-axis) of ordination was largely determined by the proportions of *A. aspera, C. barbata, C. pennisetiformis, S. coromendelianus* and *Datura metel* and the secondary axis (Y-axis) by *A. aspera, C. barbata. T. biflorus, L. urticaefolia* and *R. minima.*

e) *Nature of Phytosocioloical Gradients:* To ascertain the relationship between phytosociogical gradients and edaphic variables, correlation coefficients were calculated between each of the ordination axes and the physical and chemical soil characteristics.

Primary axis of ordination was significantly positively correlated with MWHC (%) ($r = 0.4961$, $P < 0.10$) and secondary axis with pH ($r = 0.7343$, $P < 0.01$).

f) *Behaviour of species along Phytosociological Gradients: A. aspera* showed relatively high tolerance to a wide range of pH and supposedly to a substantial range of soil moisture regimes (Fig. 3).*C. barbata* showed its high importance nearly in the upper right corner of the ordination plane associated with moderately basic soil with intermediate water holding capacity. The distribution pattern of *C. pennisetiformis* and *E. compressa* though roughly corresponded to *C. barbata,* they had highest I.V.I. in marginally basic soils with relatively greater moisture retaining capacity. *Dichanthium annula-*

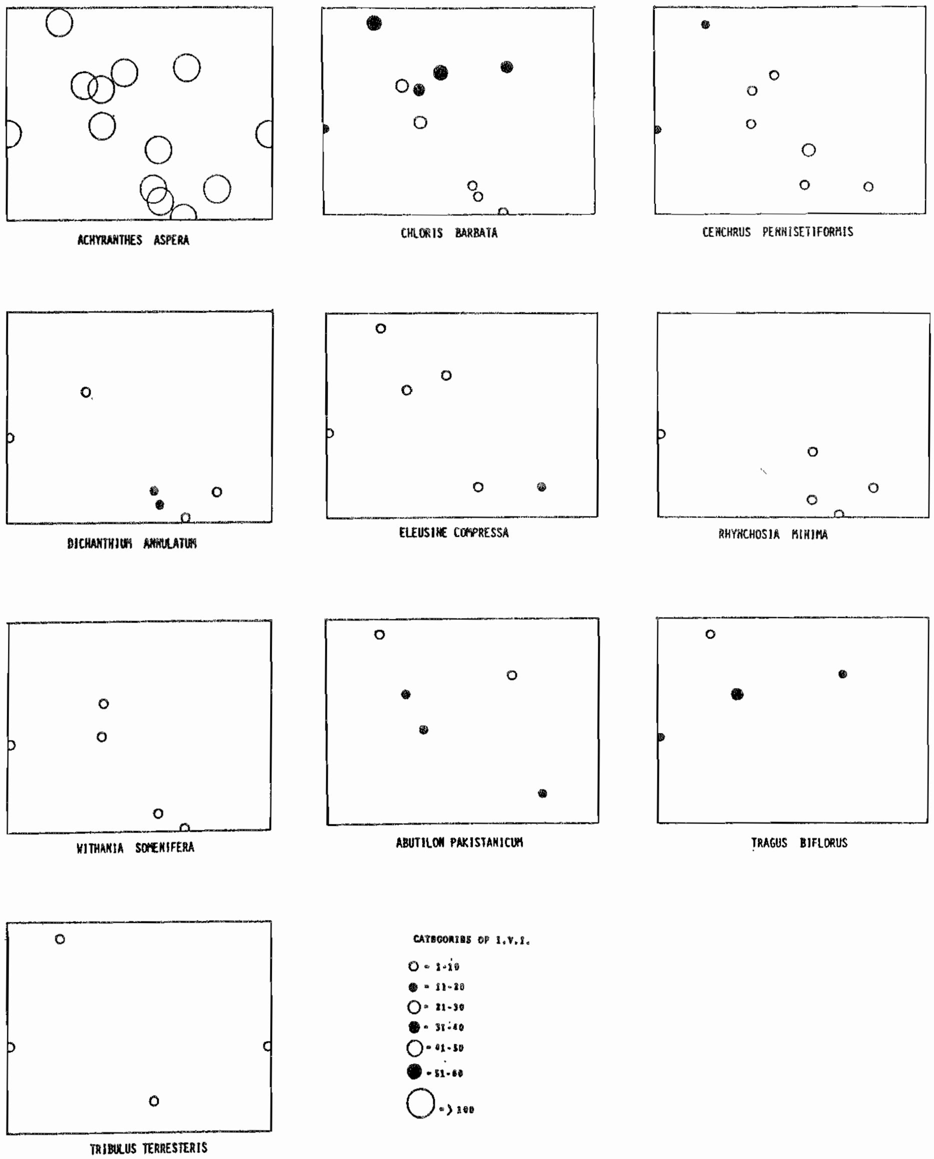

Fig. 3. The behavioural pattern of 9 major species of *Achyranthes aspera* dominated stands in the framework of stand ordination.

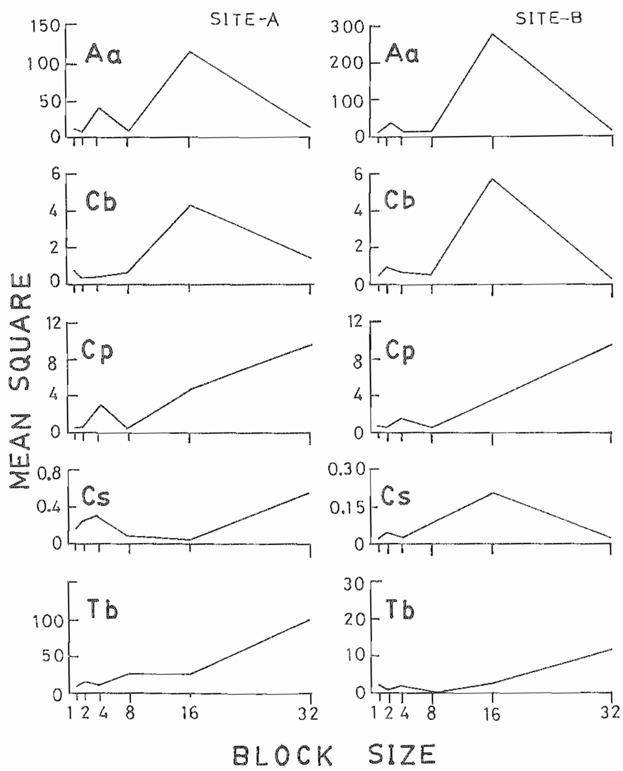

Fig. 4. A representative series of mean/block size graphs showing pattern of *Achyranthes aspera* (Aa) and its associates. Cb, *Chloris barbata;* Cp, *Cenchrus pennisetiformis;* Cs, *Cenchrus setigerus;* Tb, *Tragus biflorus.*

tum and *Withania somnifera* are distributed in the lower right half of ordination plane. *Abutilon pakistanicum* occurred somewhat diagonally in the middle region of ordination in stands of relatively wide variation of pH and MWHC. Like *Chloris, Tragus biflorus* achieved its highest I.V.I. slightly at upper right side of middle region of the ordination. *Rhynchosia minima* resembled with *Withania* in distribution and both species remained restricted to first category of I.V.I. *Tribulus terrestris* was irregularly distributed indicating its capacity to withstand relatively wide range of edaphic characteristics.

h) *Detection of pattern and Inter-species Correlations:* The graphs of mean square against block size of some selected species, at two *Achyranthes* dominated sites are given in Fig. 4. The non-random pattern of the species present in the sites examined is evident. Generally, the scale of species pattern are fairly consistent between sites except where "merging" and "drifting" (Greig-Smith, 1961) have probably occurred. Almost all of the species show two pattern scales of which the smaller one will, for the sake of simplicity, be referred to as"primary pattern scale" and the larger one as"secondary pattern scale".

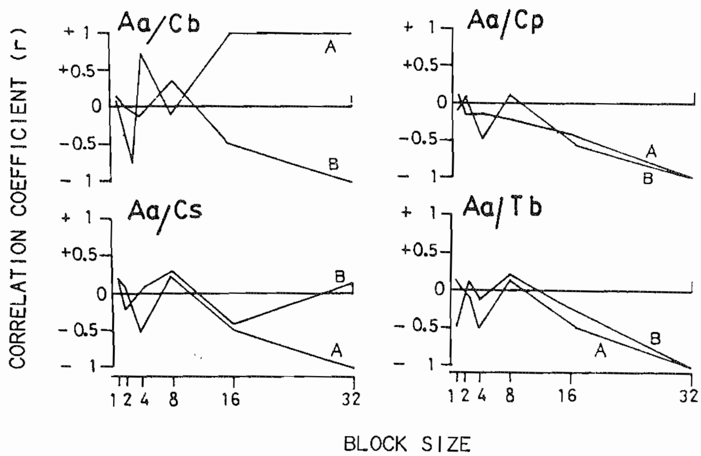

Fig. 5. A respresentative series of pattern correlation/block size graphs between *Achyranthes aspera* and its associates (Key to abbreviations as in Fig. 4) at two sites A and B.

Some indications about the inter-species correlations may be obtained from mean square/block size analysis, but more complete information is usually provided by pattern correlation analysis. The results of this analysis are presented in Fig. 5.

A. aspera shows the primary pattern at NS 4 and 2 in sites A and B, respectively, and secondary pattern at NS 16 in both the sites (Fig. 4). *C. barbata* likewise exhibits primary peak of pattern at NS 1 and secondary peak at NS 16 in site A and those at NS 2 and 16 respectively in site B.

The primary and secondary peaks of *C. pennisetiformis* are consistently located at NS 4 and 32, respectively, in each site. *C. setigerus* shows its primary pattern at NS 4 and 2 in site A and B, respectively, whereas secondary peak at NS 32 and 16 in site A and B, respectively. Primary peak of *T. biflorus* is located at NS 2 and 1 in site A and B and secondary peak at NS 32 in both the sites.

Interaction of *A. aspera* with its 4 associates, as elucidated by pattern correlation analysis, is presented in Fig. 5. The block sizes at which the correlation peaks occurred are generally comparable to those found in the variance analysis. *C. barbata* shows negative correlation with *A. aspera* at NS 2 in site A and NS 4 and 32 in site B, whereas it is positively correlated with *Achyranthes* at NS 4 and 32 in site A and at NS 8 in site B. *C. setigerus* is negatively, correlated at NS 4 and 32 at site A and NS 16 in site B. *C. pennisetiformis* in site A is negatively correlated at all block sizes and in site B at NS 4 and 32. *T. biflorus* is negatively correlated with *Achyrantes* at NS 4 and 32 in site A and at NS 1 and 32 in site B.

Discussion

The *Achyranthes* dominated stands had low diversity and high dominance. Diversity is a measure of complexity of form and function within a community. On the other hand dominance expresses the importance or the success of one or a few species. Unlike diversity, its focus is the species rather than the community *per se.* A positive correlation, therefore, between Simpson's index and I.V.I. of *Achyranthes aspera* is to be expected since diversity is inversely related with dominance (Berger & Parker, 1970; Shaukat *et al.,* 1978). Thus, I.V.I. of *A. aspera* yielded inverse correlation with general diversity and its components. Whittaker (1965) viewed a natural community as an admixture of unequally successful species. The dominants not only influence the structure and function of the subordinates but also determine the structure and diversity of the community. The structure of *Achyranthes* dominated stands was simple in its organization as indicated by high dominance and low values of diversity. The relative abundance patterns of these stands were essentially linear on semi-log plot indicating geometric distribution. Such distribution is attributed by Whittaker (1975) to species poor and stressful situations. The results indicated that the two components of diversity were not equally important in determining the overall diversity of the community. In our data equitability appeared more influential (60-70%) in controlling the diversity variation than the species richness (30-40%). Tramer (1969) suggested that communities from rigorous environment (adverse environmental conditions) vary in diversity according to their relative abundance component whereas diversity in non-rigorous environment (biologically controlled environment) is a function of species richness. Smith (1980), however, stressed that there is no such entity as wholly physically controlled or wholly biologically controlled community. The community is rather influenced by the interaction of the two.

A. aspera dominated stands were associated with non-saline (EC:0.14-1.39 dS/m), basic pH: 7.2-8.2), calcareous ($CaCO_3$:14.88-24.04%) sites of high coarse sand and low fine sand proportion. The study of the distribution pattern of important species in the frame-work of vegetational ordination indicates that each species has its own characteristics behavioral pattern in relation to phytosociological-environmental gradients. Despite some irregularity in the distribution pattern of some species, the variation in species composition along the gradients was gradual. This is in accordance with well documented individualistic and continuum hypotheses, independently put forward by Gleason (1917, 1939) and Ramensky (1926, 1930).

Analysis of the relationships between compositional gradients and edaphic variables disclosed that the primary and the secondary axis of ordination correlated well with MWHC (%) and pH, respectively. Pattern analysis provided clear indications of the non-random contagious distribution of species present in *A. aspera* dominated stands. Most of the species showed two scales of pattern. An examination of the dispersion pattern of *A. aspera* and its associates revealed that most of the primary pattern of peaks appear at block size 2 and 4 which are equivalent to patch sizes of linear dimensions of 60 and 120 cm, respectively. *Chloris barbata* and *Tragus biflorus* however, showed their primary pattern peaks at block size 1 in at least one of the study sites. None of the species chosen for pattern analysis possess any special mechanism for seed dispersal. The most probable dispersal agency is wind. All the herbs are small plants (< 40 cm) and so long distance dispersal (> lm) of more than a very small proportion of seeds by wind is rather unlikely. *T. biflorus* is even much smaller plant (< 10 cm) and so in its case long distance dispersal (> 25 cm), of more than a very small proportion of seeds by wind seems unlikely. The seeds of *A. aspera* which remain enclosed within permanent bracts are a bit heavy and were seen lying below the parent plants. Therefore, it seems reasonable to suppose that dispersion of seeds in these species is limited to small distances (< lm). The frequent emergence of their seedlings in cluster around dead parents also strengthens this supposition. The latter phenomenon is particularly consistent for *A. aspera.* These considerations suggest that the aggregation of individuals of these species is a result of seed dispersal to a limited distance. The observed primary pattern is, therefore, presumably largely of reproductive origin. Similar interpretation of the small scale pattern has been given by Pemadasa *et al.*, (1974) and Shaukat *et al.*, (1983).

The negative correlations found in the pattern correlation analysis between *A. aspera* and most of its associates viz. *Cenchrus pennisetiformis, C. setigerus* and *Chloris barbata* at block size 4 indicates that patches (1.20 m in length) of *A. aspera* and those of its associates alternate with each other. *Tragus biflorus* shows negative correlation with *Achyranthes* at block size 1 which indicates that patches of *T. biflorus* (30 cm in length) alternate with patches of *A. aspera.* These observations are strongly suggestive of interference operating between *A. aspera* and the herbaceous associates in the field. The suppressive effects of *A. aspera* on other species occurring in its communities are also elucidated by negative inter-specific associations between *A. aspera* and herbs like *Leucas uriticifolia, T. biflorus, C. biflorus, C. pennisetiformis, R. minima* and *C. setigerus.* The relative density (D_3) of *A. aspera* was also negatively correlated with that of *Chloris barbata, Cenchrus pennisetiformis* and *Setaria verticillata* which suggests density dependent interactions between *Achyranthes* and other species. Such interactions are expected to lead eventually to spatial exclusion of most of these herbs resulting in simplication of community structure and composition.

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