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PHYTOSOCIOLOGY OF THE VANISHING TROPICAL DECIDUOUS FOREST IN DISTRICT SWABI, PAKISTAN. II.-ORDINATION

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Abstract

The study deals with the multivariate analysis of the vegetation of Swabi District. Sociological relationships among the leading dominants in tree, shrub and herb layers are discussed separately. Chemical and physical analysis of soils of each stand are given. The vegetation pattern of each layer of the community and its relationship to soil were examined with the help of polar ordination. Soil pH, $CaCO_3$ and P_2O_5 were found to be the controlling factors in the distribution of vegetation. The overall vegetation is dominated by *Acacia modesta*, followed by *Ziziphus mauritiana* in the tree layer. *Asparagus, Cynodon, Torilis, Thymelaea, Oxalis* and *Desmostachya* were important in the lower strata.

Introduction

The location, hydrography, soil, climate and distribution of sampling sites of the investigated area have been given in an earlier paper (Hussain *et al.*, 1993). Community description and vegetation from the same area has also been described by Hussain *et al.*, (1993). Many multivariate studies of the vegetation have been made in other parts of the country (Shaukat & Qadir, 1971, Shaukat *et al.*, 1976, 1980, Ahmed & Qadir, 1976; Ahmed, 1976, 1986, 1988). However, no multivariate studies were conducted in the Swabi District especially and N.W.F.P in general. The main purpose of the present study was, to analyze the existing vegetation in relation to habitat conditions using multivariate (Ordination) approach.

Materials and Methods

The sampling procedure and summary of the phytosociological analysis has been outlined by Hussain *et al.*, (1993). The present analysis is based upon the same data. Soil was sampled in triplicate upto 15 cm depth from each stand and pooled together to make a composite sample. Physical and chemical analysis of soil samples were carried out by following methods of Bouyoucos (1951), Richards (1954), Jackson (1962) and Chapman & Pratt (1961).

Relationship among the leading dominant species in each layer were evaluated by the method described by Brown & Curtis (1952) explained by Shaukat *et al.*, (1976). Similarity coefficient between stands (vegetation and soil) were calculated according to Bray & Curtis (1957). Dissimilarities among stands were obtained from similarity matrix. These values were used in the multivariate analysis. The ordination technique described by Bray & Curtis (1957) was used in the investigation. The stands were projected on the axes using the formula of Beals (1960).

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Table 1. Mean Importance Value Index (I.V.I.) of species in Stands in which a given species occurs as a leading dominant (No. of stands in parenthesis)

Species	Leading Dominant (Trees)		
	Acacia modesta	*Dalbergia sissoo*	*Ziziphus mauritiana*
	(17)	(1)	(2)
Acacia modesta	74.72	15.72	15.52
Dalbergia sissoo	12.73	41.59	---
Ziziphus mauritiana	---	20.72	61.67

Results and Discussion

1.Relationship among the Leading Dominants: Relationship among the first dominant species in the multilayered stands are shown in Tables 1,2 and 3 separately. Stands in which *Acacia modesta* was the leading dominant in tree layer showed similar values of *Dalbergia sissoo* and *Ziziphus mauritiana*, while stands dominated by *Dalbergia* showed complete absence of *Z. mauritiana*. Similarly stands having *Z. mauritiana* as the leading dominant did not contain *A. modesta* (Table 1).

Shrub layer was composed of 10 leading dominant species in the area. Table 2 shows that species were either absent or had very low I.V.I in stands having *Opuntia, Ehretia* and *Broussonetia* as the leading dominants. The stands dominated by *A. arabica* favoured *Asparagus* and *A. modesta* only. The stands with *A. modesta* as the leading dominant in the under storey had considerable I.V.I. values of *A. arabica, Z. nummularia* and *Asparagus*. In stands where *Adhatoda* and *Z. nummularia* were the first dominants *Asparagus* and seedlings of *A. modesta* were present. However, the former species also favoured *Gymnosporea*. *Asparagus* dominated stands showed *Opuntia* and seedlings of *A. modesta*, while *Melia* dominated stands had greater number of *A. modesta* seedlings. *Asparagus, Adhatoda* and *Ehretia* had moderate I.V.I. values in *Gymnosporea* dominated stands.

Table 3 shows a similar relationship among the various leading species in the herb layer. In stands where a species emerges as a first dominant favours some associates while other species are either absent or have low I.V.I. values. *Oxalis* supports *Cynodon* only while *Sporobolus* favours *Desmostachya*. All these are reportedly allelopathic and it might be one of the several reasons for the exclusion or poor I.V.I of associated herbs. All the leading dominants are present in stands having *Desmostachya* as the leading dominant. Similarly, *Cynodon* has all the abundant species especially *Sporobolus, Oxalis* and *Desmostachya* with higher I.V.I.. *Oxalis* is absnet in stands dominated by *Panicum antidotale* which is allelopathic (Begum & Hussain, 1980). Stands dominated by *Thymelea* did not have *Panicum, Oxalis, Cynodon* and *Sporobolus*. The stands with *Torilis* as the leading dominant support *Oxalis* and *Cynodon*.

Table 2. Mean I.V.I. of Leading shrubby dominants in stands in which a given species occurs as a leading dominant (No. of stands in parenthesis).

Species	*Acacia arabica*	*Acacia modesta*	*Opuntia delenii*	*Ehretia obtusifolia*	*Broussonetia papyrifolia*	*Adhatoda vasica*	*Ziziphus nummularia*	*Asparagus gracilis*	*Melia azedarach*	*Gymnosporea royleana*
	(3)	(6)	(1)	(1)	(1)	(1)	(2)	(2)	(1)	(2)
Acacia arabica	70.00	13.47	---	---	---	---	---	25.66	---	---
Acacia modesta	17.15	46.52	---	---	---	---	17.97	8.00	20.36	7.60
Opuntia delenii	---	4.08	95.91	---	---	---	---	---	---	---
Ehretia obtusifolia	---	---	---	56.58	8.95	---	---	---	11.14	---
Broussonetia papyrifolia	---	---	---	---	42.60	---	---	---	---	---
Adhatoda vasica	---	10.71	---	---	---	42.60	---	15.38	---	31.12
Ziziphus nummularia	1.04	31.69	4.44	---	---	---	36.53	21.07	6.43	---
Asparaqus gracilis	---	17.63	12.09	6.48	---	---	---	38.16	4.76	---
Melia azedarach	5.59	40.30	---	---	---	---	1.14	---	51.81	---
Gymnosporea roylcana	---	2.81	---	9.17	---	11.08	---	17.93	2.63	39.34

Table 3. Mean importance index of species in stands in which a given species occurs as a leading dominant (No. of stands in parenthesis).

Species	*Sporobolus arabicus*	*Desmostachya bipinnata*	*Cynodon dactylon*	*Oxalis corniculata*	*Cenchrus ciliaris*	*Panicum antidotale*	*Thymelaea passerina*	*Torilis nodosa*
	(1)	(6)	(8)	(1)	(1)	(1)	(1)	(1)
Sporobolus arabicus	26.17	17.00	2.71	---	1.92	---	---	1.15
Desmostachya bipinnata	1.63	30.39	4.91	16.05	3.16	3.15	2.03	3.20
Cynodon dactylon	8.92	6.48	40.04	7.60	5.45	00.17	2.72	2.80
Oxalis corniculata	---	---	10.31	21.29	0.93	---	---	---
Cenchrus ciliaris	1.36	4.60	1.35	0.50	22.45	---	5.07	1.19
Panicum antidotale	00.38	00.75	00.66	---	6.72	24.84	1.12	00.20
Thymelaea passerina	---	17.98	---	---	10.29	---	18.13	00.20
Torilis nodosa	---	---	13.79	12.20	00.56	---	---	23.78

2. ***Relationship with the Edaphic Variables:*** The results of soil analysis indicate that 12 of the stands (2-8, 10, 11, 13, 14 and 19) are sandy loam while 5 stands (1, 15-17 & 20) have loamy soil (Table 4). Stand 9 and 12 are sandy and 18 has clayey-loam soil. The soils are generally light textured. The total soluble .salts varied from 0.0128 to 0.09288% among the various stands showing little variation. The pH varied from 7.6 to 9.36 among the stands with distinctly basic or neutral characters with the exception of stands 1,6,12,13, 15, 18 and 19. The EC ranged in between 0.11 to 0.40, phosphorus 10-174 ppm, potassium 157-3300 ppm, nitrogen 0.04-0.17, Organic matter 0.83 to 3.52% and $CaCO_3$ 6.25 to 14.80 among the various stands. Highest amount of phosphorus and potassium with high pH is shown by stands dominated by *Sporobolus* and *Desmostachya*. However, the later species also showed highest amount of nitrogen and organic matter (Table 4). Stands dominated by *Cynodon* also showed higher values of phosphorus, potassium and organic matter. Chaghtai *et al*., (1976, 1978, 1983) and Chaghtai & Yousaf (1976) reported similar results for soils of grave-yards of Peshawar and Kohat areas. The soils in the Peshawar valley including Swabi are basic in nature and our findings agree with them (Malik *et al*., 1984). The amount of organic matter was highest in Akhoon baba, Swabi Kozajara, Bamkhel stands. All these stands have well stratified vegetation. The same sites are also rich in various nutrients. Ample organic matter provides better supply of nutrients. Stands with open canopy or with degraded vegetation have generally poor organic matter and nutrients (Table 4). The surface layer is generally rich in littter and organic matter as the death and deeay of herbaceous and grassy species results in the deposition of litter in the top soil layer.

3.***Multivariate Analysis of Vegetation:*** Figs.1, 2 and 3 show a two-dimensional phytosociological ordination for trees, shrub and herb layers, respectively. Similar communities or types are closer to each other while dissimilar stands are placed far apart. There are three distinct groups for tree layer (Fig.1). Stands having *A. modesta* as the leading dominant clustered towards the middle to the left of the diagram. *Dalbergia* dominated stands occupied the extreme upper side, while stands dominated by *Z. mauritiana* as the leading species positioned on the extreme right side of the diagram. The Fig.1 also shows that stands dominated by *A. modesta* as the first leading dominant show 4 sub-groups. Stands in which *A. modesta* accompanied by *Z. nummularia* as the second dominant species (stand 12 & 14) were arranged in the middle of the ordination. Stands with *Dalbergia* as the second dominant lies in the middle to the lower portion of the Y-axis and towards the left side of the previous sub-groups. Stands co-dominated by *Melia* tend to occupy the extreme upper left side of the diagram, while highest density stands without any co-dominant species (pure *A. modesta* stands) are located towards the lower left region of the figure. Fig.2 indicates 10 groups of shrubby species. *Opuntia, Broussonetia, Melia* and *A. arabica* groups occupy the extreme left, lower, right and upper positions, respectively. The largest group dominated by *A. modesta* (stands 3,5,6,16,17,19) occurred on the right side of the diagram. Stands 18 and 20 dominated by *Gymnosporea* occupied relatively middle position of the X and Y axes while *Asparagus* group (stands 12 & 14) is distributed between *Gymnosporea* and *A. modesta* group.

The distribution of herbaceous species is indicated in Fig.3. *Panicum* and *Cenchrus* occur on the upper right while *Oxalis* is found in the lower left region of the ordination plane. *Cynodon* and *Desmostachya* dominated stands show wide range of

Table 4. Physio-chemical Analysis of soils from different stands investigated.

S.No.	Stand Location	Clay	Silt	Sand	Textural Class	T.S.S. %	pH	$ECx10^3$	P_2O_5 ppm	K_2O ppm	N %	OM %	$CaCO_3$%
1.	Said Khan, Yar Hussain	14.6	40	45.4	Loam	0.0128	8.87	0.40	174	3300	0.04	0.86	6.25
2.	Akhoon baba, Yar Hussain	8.6	26	65.4	Sandy loam	0.0928	7.6	0.29	92	480	0.17	3.52	6.50
3.	Saisado, Yar Hussain	8.6	34	63.4	Sandy loam	0.0480	7.96	0.15	33	255	0.06	2.21	6.75
4.	Gadomaidan, Yar Hussain	8.6	28	69.4	Sandy loam	0.0608	7.85	0.19	73	225	0.15	3.11	6.25
5.	Chan Dheri, Adina	10.6	26	63.4	Sandy loam	0.0384	7.74	0.12	46	660	0.09	1.86	7.50
6.	Dagai-I	12.6	24	63.4	Sandy loam	0.0640	7.99	0.20	53	285	0.12	2.48	6.25
7.	Dagai-II	8.6	16	75.4	Sandy loam	0.0640	7.11	0.20	60	382	0.08	1.66	8.00
8.	Turlandi	8.6	14	77.4	Sandy loam	0.0352	7.45	0.11	94	255	0.08	1.59	7.75
9.	Nawa Kaley	6.6	12	81.4	Sand	0.0480	7.6	0.15	64	165	0.06	1.24	9.75
10.	Shewa	10.6	28	61.4	Sandy loam	0.0448	7.71	0.14	39	300	0.096	1.93	11.25
11.	Chota Lahore	8.6	22	69.4	Sandy loam	0.386	7.45	0.12	5	247	0.05	0.93	16.25
12.	Jalbai	6.6	6	87.4	Sand	0.048	7.92	0.15	27	195	0.05	1.38	4.50
13.	Tordher	12.6	28	59.4	Sandy loam	0.048	9.36	0.15	69	2940	0.05	1.04	11.00
14.	Poray Jehangira	4.6	16	79.4	Sandy loam	0.0704	7.99	0.22	199	375	0.04	0.83	8.00
15.	RaPoray Jehangira	12.6	40	47.4	Loam	0.0608	8.17	0.19	10	435	0.10	2.07	14.50
16.	Swabi (Koza jara)	12.6	42	45.4	Loam	0.0480	7.95	0.22	33	255	0.10	3.24	8.25
17.	Maneri Bala	14.6	42	43.4	Loam	0.0480	7.81	0.15	60	510	0.12	2.36	11.50
18.	Maneri Payan	16.6	38	45.4	Clay-loam	0.0480	8.00	0.19	27	255	0.15	2.97	10.75
19.	Zarobi	14.6	28	57.4	Sandy loam	0.0608	8.04	0.19	33	157	0.12	2.32	6.75
20.	Bamkhel	12.6	40	47.4	Loam	0.0640	7.99	0.22	41	255	0.16	3.21	12.25

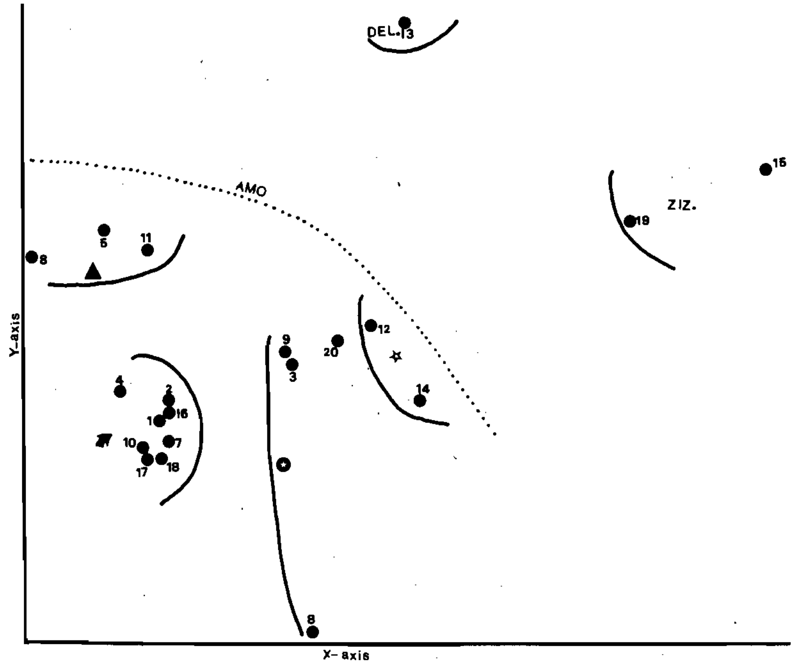


Fig.1. Stand positions on two-dimensional vegetation ordination for tree layer. Numbers indicate stand numbers. Largest group (Shown under broken lines) is dominated by *Acacia modesta*, as a first leading dominant species. Stands in this group are clustered in four sub-groups. For stand number see Table 4. ZIZ = *Ziziphus mauritiana*, DEL = *Dalbergia sissoo*, AMD = *Acacia modesta* * = ZIZ = as a second dominant, = DEL as a second dominant, = Pure stands, high density.

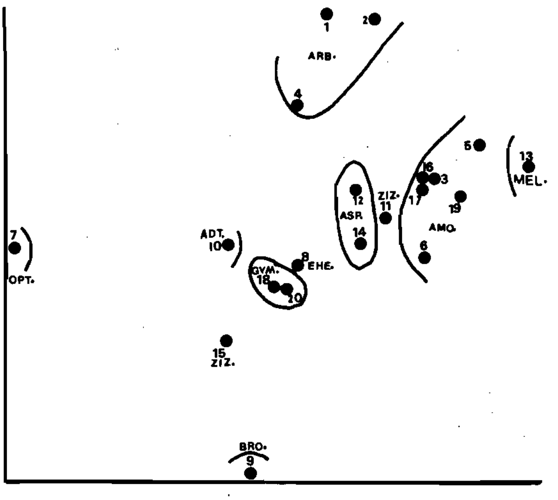
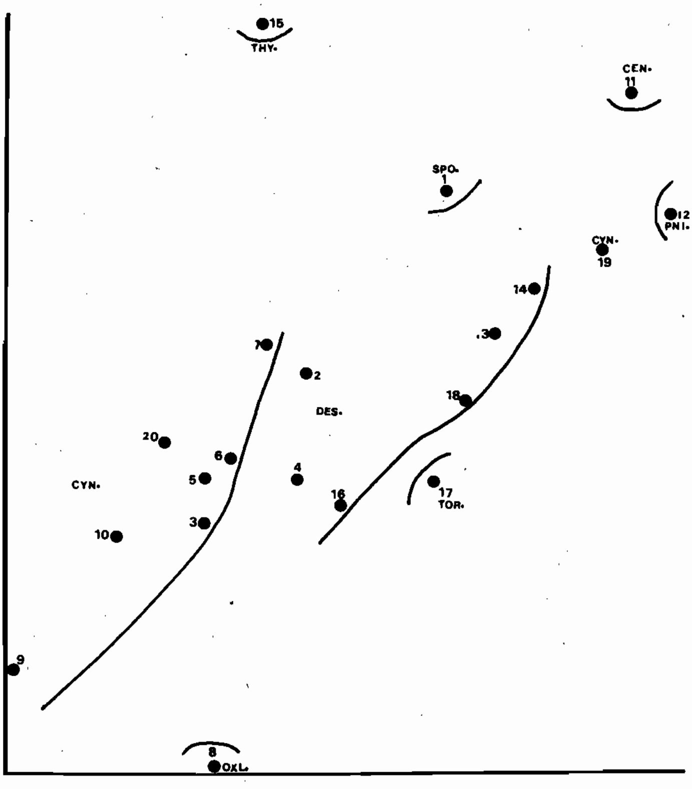


Fig.2. Stand positions on two dimensional vegetation ordination for shrub species. Dominant shrubs are shown within each group. MEL = *Melia azedarach*, ARB = *Acacia arabica*, AMO = *Acacia modesta*, ASP = *Asparagus gracilis*, GYM = *Gymnosporia royleana*, EHE = *Ehretia obtusifolia*, OPT = *Opuntia delenii*, ADT = *Adhatoda vasica*, BRO = *Broussonetia papyrifera*, ZIZ = *Ziziphus nummularia*. For stand see Table 4.

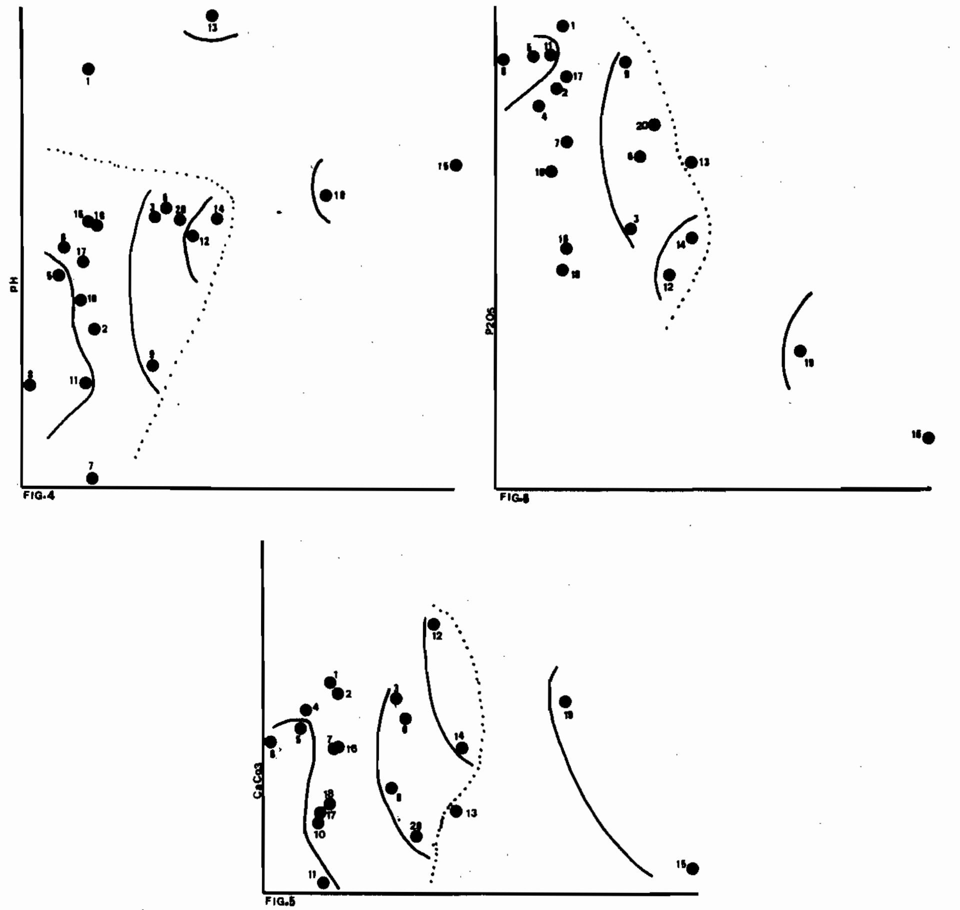
distribution on both the axes, yet they tend to form a loose group. Both these grasses are very well distributed in the area (Hussain *et al.*, 1980, 1981; 1988; Chaghtai *et al.*, 1978, 1983). Both the grasses have wide ecological amplitude with respect to soil moisture and salinity.

4.Relationship between Vegetation and Soil Gradient: Based on the dissimilarities among various stands in their soil variables, the stands were ordinated. Each soil characteristics were plotted on Y-axis against vegetation on a X-axis of each layer separately and compared. It was observed that pH, $CaCO_3$ and P_2O_5 showed distinct groupings while other variables do not show any relation with the vegetational gradient. Figs.4 (pH), 5 ($CaCO_3$) and 6(P_2O_5) show relation with tree layer while Figs.7 (pH), 8($CaCO_3$) and 9(P_2O_5) indicate shrub layer. Figs. 10 and 11 represent the herb layer. It is evident that there is correspondence between the two gradients.

The area is dominated by *Acacia modesta, Ziziphus mauritiana, Z. nummularia, Asparagus, Adhatoda, A. arabica* which are the original components of the area (Champion *et al.*, 1965; Beg, 1978). *A. modesta* occupied 85% of the total sampled



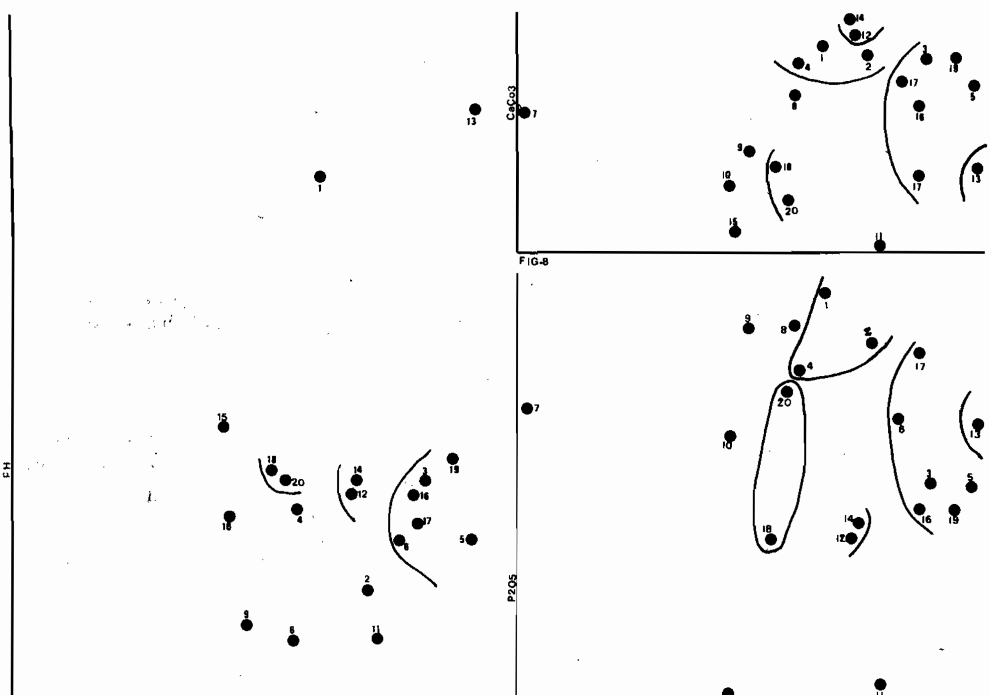
Figs.3. Stand position on two dimensional vegetation ordination for herb species.
THY = *Thymelaea passerina*, SPO = *Sporobolus arabicus*, CEN = *Cench rus ciliaris*, PNI = *Panicum antidotale*, CYN = *Cynodon dactylon*, DES = *Desmostachya bipinnata*, OXL = *Oxalis corniculata*, For stand see Table 4.



Figs.4,5 and 6. Two dimemsional stand/environmental ordination for tree layer. Vegetational gradient (X-axis) is plotted against pH, $CaCO_3$ and P_2O_5 gradient (Y-axis) respectively. For stand, groups and species refer to Fig.1 and Table 4.

plots. It was followed by *Z. mauritiana*. The seedlings of the canopy layer were widely distributed in the understorey layers. The mean I.V.I. of the first dominat species was low due to rich shrubby and herbaceous layers. The leading dominant technique was successfully applied by Shaukat *et al.*, (1976) and Ahmed (1986) in Pakistan. The order in which the leading dominants are arranged is decided by some perceived relationship to the environment in terms, perhapes of dynamic position of species or their sociological relationships. It may, therefore, be suggested that *Dalbergia* do not show ecological affinity with *Z. mauritiana*. The former is a mesophyte and later is a xerophyte and this contrast is responsible for their separation along the moisture gradient. An ecological relationship exists between *Z. mauritiana* and *A. modesta* both of which are characteristic components of the thorny plain forests (Champion *et al.*, 1965; Beg, 1978; Hussain & Tajulmalook, 1984; Chaghtai *et al.*, 1976, 1983; Chaghtai &

Yousaf, 1976). *Opuntia, Ehretia* and *Broussonetia* were ecologically dissimilar with all other leading dominant species probably due to narrow ecological range of these species. *Opuntia* has been almost eliminated by the rising water table in the area. *Broussonetia* is cultivated and naturalized species confined to mesic places. *Z. nummularia* shows close ecological affinity with *Asparagus* and seedlings of *A. modesta*. Similarly, *Asparagus* is ecologically related with the seedlings of *Acacia modesta* and *Opuntia*. Champion *et al*., (1965) regarded it as the importnat associated component of *A. modesta* forests. *Melia* is a naturalized and cultivated species in the area. Its association with *A. modesta* is due to proximity of stands (grave-yards) to the settlements. *Oxalis* restricted itself to *Cynodon* only in mesic and shady places. *Thymelaea* is both a heliophyte and a halophyte and therefore, occurred with *Cenchrus* and *Desmostachya* (Malik *et al*., 1984). It may be concluded that sociological relationships among the leading dominant species can be effectively evaluated by using the leading dominant technique. It is also shown that edaphic factors play an important role in the distribution of vegetation. High pH was associated with *Thymelaea, Sporobolus* and *Desmostachya* communities and this agree with Malik *et al*., (1984) and Chaghtai *et al*., (1978). High amount of $CaCO_3$ was observed for *Cenchrus* and *Cynodon* stands. Amount of nitrogen was generally more on stands dominated by *Torilis* and *Desmos-*



Figs.7,8 and 9. Two dimensional stand/environmental ordination for shrub species. Vegetational gradient (X-axis) is plotted against pH, $CaCO_3$ and P_2O_5 (Y-axis) respectively. For stand and species refer to Fig.2 and Table 4.

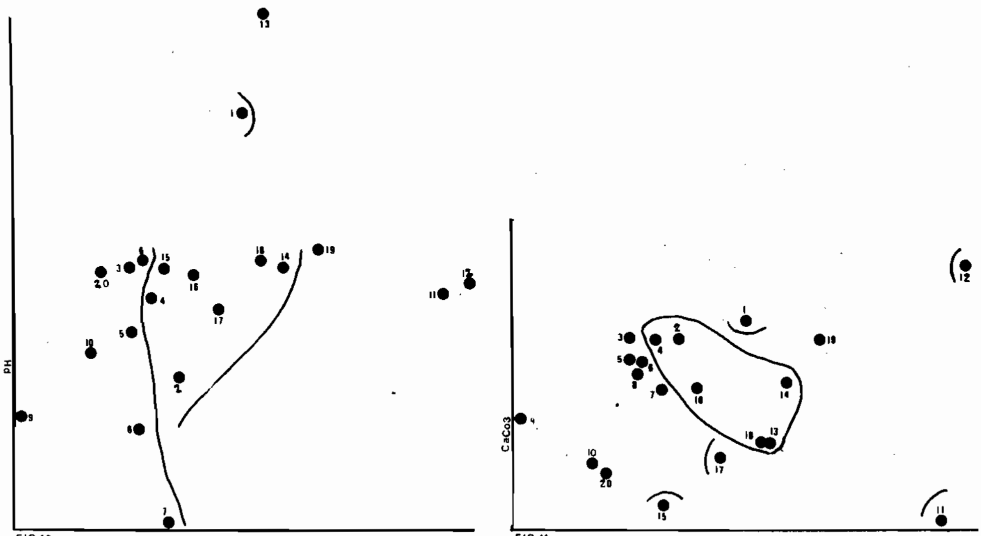


FIG.10 FIG.11

Figs.10 and 11. Two dimensional stand/environmental ordination for herb species. Vegetational gradient (X-axis) is plotted against pH, and $CaCO_3$ (Y-axis) respectively. For stand and species refer to Fig.3 and Table 4.

tachya. Stands dominated by *Torilis, Thymelaea, Cynodon* and *Desmostachya* have high soil organic matter. The annual and deciduous plants contribute more to the organic matter contents and hence release of nutrients. The findings agree with other workers in this respect (Chaghtai *et al*., 1983; Chaghtai & Yousaf, 1976).

Two-dimensional ordination successfully displayed the pattern of the vegetational composition and some soil vegetation relationship of the study area. Multivariate analysis showed that the distribution of stands in the ordination space is essentially discontinuous. The arrangement of stands on the ordination provides an evidence that most of the variation in vegetational composition and edaphic variables are expressed by the primary axes that in turn are related to soil pH, $CaCO_3$ and P_2O_5. Other edaphic variables do not show any proper relationship probably due to human disturbance or owing to the wide ecological amplitude of the various species in the area with respect to these factors. Grouping of stands in the multilayered vegetation is similar to that reported by Hussain *et al*., (1993). Classification serves only as the pointer to the main directions of variation while ordination exposes the lower level variation in the vegetation. The authors, therefore, are of the opinion that a combination of both the approaches of vegetational analysis are more informative than either alone.

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