

## PHYTOSOCIOLOGICAL ATTRIBUTES OF THE PLANT BIODIVERSITY OF THE FORT RANIKOT AND ADJOINING AREA (KIRTHAR RANGE)

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### Abstract

The plant biodiversity, floristic composition and phytosociological attributes of the vascular plants of Fort Ranikot were analyzed. A total of 107 taxa were collected belonging to 41 families and 78 genera. The largest family was Poaceae containing 9 taxa, while the other major families were Papilionaceae with 6 species; Asclepiadaceae, Mimosaceae, and Solanaceae comprising of 5 species each respectively. Majority of the taxa are common throughout the study area, however, 6 species viz. *Aristolochia bracteolata*, *Physorrhynchus brahuicus*, *Plantago ciliata*, *Polygala erioptera*, *Salvadora persica* and *Viola stocksii* were found to be very rare. The flora is dominated by Chamaephyte, followed by Therophytes, Phanerophytes, Hemicryptophytes and climbers. The aim of the present study is to provide comprehensive inventory of the study area along with its phytosociology and ecological parameters. Collectively on the basis of important value index six plants communities were recognized from different sites of the study area. The study area was categorized into six ecological sites on the basis of microclimatic conditions and topography. For comparison in these sites similarity index, beta diversity, diversity index, species evenness and maturity index was also calculated. The soil texture classes varied from loam to sandy loam and slit loam with pH of 7.78-8.24, electrical conductivity varied from 687-827 EC  $\mu\text{S}/\text{cm}$ , Total dissolved salts varied from 0.36-0.71  $\text{mg}^{-1}$ ,  $\text{CaCO}_3$  varied from 3.48-4.21% and organic matter varied from 0.39-1.24%. Present study predict that there are certain edaphic factors, altitudinal variation, soil texture and amount of organic matter which are responsible for variation in vegetation.

**Key words:** Kirthar range, Fort Ranikot, Plant biodiversity.

### Introduction

The fort Ranikot (The great wall of Sindh) is the world largest fort with a circumference of about 26 Km or 16 miles. The name "Ranikot" derived from the word Rani or Reni Nai means fort of a rain stream. Beside main fort there are two sub forts i.e. Miri and Shergarh inside. UNESCO has declared Fort Ranikot as World Heritage site. The fort is located in Kirthar National park in the Kirthar range, about 30 Km Southwest of Sann, in the ashore District, Sindh, Pakistan. The fort is situated between 25°- 45' to 26°-00' North latitude and 67°, 45' to 68°-00' East longitude, with an altitude of 483m above the sea level. It is approximately 90 Km North of Hyderabad city.

Biodiversity may be defined as the number of different native species and individuals in an ecological habitat or geographical area, with the variety of different habitats within an area & the variety of interactions that occur between different species in a habitat which results in a range of genetic variation among individuals within a species" (Jones & Strokes, 1992). Biodiversity provides indirect benefits to human; forming the foundation for sustainable development, ecosystem services and benefits provided by the biodiversity include environmental health of our planet, providing clean air, drinkable water, Pollination, maintenance of slopes, protection of watersheds and soil formation with fertility. Ecosystem services are necessary for the humanity, supporting life, supplying so many materials, energy and most importantly absorbing waste products (Daily, 1997).

Pakistan is mostly a dry region characterized by great extremes of altitude and temperature. It has five significant mountain systems: Western Himalayas, Karakoram, Hindu Kush, Suleiman and Kirthar range. Kirthar range typical of arid and semi-arid mountain terrains. The mountains of

Kirthar range are 380 million years old while other mountains in Sindh are not older than 193 million years old. Kirthar range is the evolutionary bed of the Sindh civilization (Anon., 2005).

Investigation of the phytosociological attributes from different parts of the country were conducted by various scientists i.e., Chaudhri & Qadir (1958), Chaudhri (1960, 1961), Qadir *et al.* (1966), Shaukat & Qadir (1970, 1972), Ahmed (1976), Ahmed *et al.*, 1978, Hussain *et al.* (1981), Amin & Ashfaq (1982), Beg & Khan (1984), Qadri (1986), Rashid *et al.* (1987), Malik & Hussain (1987), Ahmed (1988a). Marwat *et al.*, 1990, Hussain & Illahi (1991), Hussain & Shah (1991), Dasti & Malik, 2000; Malik *et al.*, 2000). Durrani & Hussain (2005), Khan & Shaukat (2005) and Ahmed *et al.*, 2006.

There is no complete floristic and phytosociological information available of Fort Ranikot. However, some reports are available on Kirthar National Park (KNP), such as baseline study of KNP was conducted by Enright & Miller (2000); Environmental impact assessment for the exploratory wells on Dumbar (KNP) was carried out by Qaiser *et al.* (2002). Akhtar (2003) reported 502 taxa in (KNP) while plant diversity of Gorakh Hill, Dureji (KNP), and Tiko Baran (KNP) were studied by Perveen & Hussain (2007), Perveen *et al.*, 2008 and Hussain & Perveen (2009) respectively.

### Material and Methods

The study area was thoroughly surveyed throughout the year from time to time to collect the botanical and ecological data. phytosociological attributes was calculated in different sites of the study area during March-May to August-November 2009 by Quadrante method of Cottam & Curtis (1956). six stands were studied, in each stand 20

quadrates were taken, absolute measurement of Frequency, Density & cover along with their relative value were calculated and Important value index (IVI) was obtained by summation of their relative attributes. The community was named according to first & Second dominant species on the basis of their IVI values. Diversity index was also calculated by (Shannon-Wiener index, 1949),  $H' = -\sum P_i \log P_i$ , Species evenness (Pielou, 1975) was calculated by  $E = H' / \ln S$ . Maturity index was calculated by (Rodolfo & Sermolli, 1948), Maturity index was obtained by the adding of the frequencies of all species; and dividing this sum by the number of species in the plant community.

Herbarium specimens were collected and deposited in KUH. Field notes and detailed observations were also accumulated. The life forms of each species were also determined according to the Raunkiaer system of classification (Raunkiaer, 1934). For the purpose of the species abundance i.e. number of individuals of a species in a unit area were randomly counted in each habitat and then categorized as Very Rare= $<10\%$ ,

Rare= $11-20\%$ , Infrequent =  $21-40\%$ , Common= $41-60\%$  and Very Common= $>60\%$  (Oosting, 1956). For the identification of the plants Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1992; Ali & Qaiser, 1993 till to-date) and authentically identified specimens present in Karachi University Herbarium (KUH) were used. Soil samples were obtained from each site at 45 cm depth. The soil samples were sieved through 2 mm mesh and dried for physical and chemical analysis. Mechanical analysis of soil samples were carried out by Bouyoucos (1962) Calcium carbonate was determined by a method of acid neutralization, as described by Qadir *et al.* (1966). Soil pH was determined by direct pH reading meter (Mettler Toledo, MP 220). Estimation of Organic matter was carried out by (Jackson, 1958). Soil Electrical Conductivity (E.C.) and total dissolved salt (TDS) were determined by AGB 1000 (England) conductivity reading meter. For calculating grazing and browsing index grazed and browsed individuals of each species were counted in a unit area and their percentage was calculated according to Qaiser *et al.*, 2002 scale.

S. No.	% of Grazed/Browse individual	Grazing and Browsing index	Pictogram
1.	1-20%	Less grazed/browsed	+
2.	21-50%	Moderate grazed/browsed	++
3.	51-80%	Highly grazed/browsed	+++
4.	81-100%	Critically grazed/browsed	++++

## Result and Discussion

A phytosociological survey was conducted for plant biodiversity and soil characteristic of the plants growing in and around the Ranikot fort. phytosociological characteristics of study sites were described in Table 1. Soil characteristic of different sites was recorded in Table 2. General feature of the different plant community was recorded in Table 3 and similarity index and beta diversity was recorded in Table 4.

The general characteristics of 107 taxa are described including species habit, habitat and life form. Ten families formed the bulk and represented 49.5% of the total flora of the study area: Poaceae (9), Papilionaceae (6), Asclepiadaceae (5), Mimosaceae (5) and Solanaceae (5). Asteraceae, Boraginaceae, Capparidaceae, Euphorbiaceae and Zygophyllaceae with 4 species each were the major plant families of the area. On the other hand, 14 families contained only one taxon each i.e., 13.8% of the total 107 taxa. As far as the genera are concerned, *Euphorbia*, consisted of 4 taxa while *Heliotropium*, *Cleome* and *Acacia* were represented by 3 taxa each. However, 15 genera had 2 species each.

Most of the species in the study area (88.12%) belonged to the dicotyledonous group. The monocotyledonous group contained (11.88%) species (Fig. 4). Within the dicotyledonous group the family Papilionaceae contributed the largest number of species (6.7%) followed by Asclepiadaceae, Mimosaceae and Solanaceae with (5.61% each). The monocotyledonous group contained 10 genera and 12 species belonging to 4 families. However, the families Palmae and Typhaceae had only single taxon, while Poaceae had 7 genera and 9 species.

Herbs dominated the flora with 66 species (61.682%), followed by shrubs with 31 species (28.971%), while only 10 species (9.345%) of tree were recorded (Fig. 3). The 107 plants identified in the study area belonged to 5 life form categories (Fig. 2). Most of

the species were Chamaephytes, Therophytes and Phanerophytes with few species of the Hemicryptophytes and climbers. Many of the species of Chamaephytes belonged to Asteraceae, Papilionaceae, Solanaceae and Boraginaceae while, Poaceae was dominated by Therophytes and Hemicryptophytes. Climbers, the least frequent life form category were represented by Papilionaceae and Asclepiadaceae. During present study 6 species (6.0%) were found to be very rare including *Aristolochia bracteolata*, *Physorrhynchus brahuicus*, *Plantago ciliata*, *Polygala erioptera*, *Salvadora persica* and *Viola stocksii*, 15 species (14%) were rare in the study area whereas, 52 species (48%) were infrequent, 30 species (28%) were common and 4 species (4%) i.e., *Calotropis procera*, *Cassia holosericea*, *Indigofera oblongifolia* and *Dichanthium annulatum* were very common, (Fig. 1).

On the basis of important value index, six plant communities were recognized. *Rhazya-Heliotropium* community was present in the site I on eastern side A, 27 taxa were recorded from the site. Excluding dominant taxa, other recorded dominant species included *Aerva javanica*, *Tephrosia uniflora*, *Cassia holosericea*, *Fagonia indica*, *Corchorus depressus*, *Capparis decidua* and *Acacia senegal*. It was observed that the vegetation of the eastern site A depleting due to heavy anthropogenic pressure including grazing and browsing. *Rhazya stricta* was dominant species having IVI value 40.277, followed by *Heliotropium ophioglossum*= 34.081, *Cassia holosericea* = 23.171 Community preferred to grow in sandy loam soil with (pH 8.07), Organic matter (0.98%), Electrical conductivity (709  $\mu\text{S}/\text{cm}$ ), total dissolved salts ( $0.36\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (3.48). Diversity index was low (3.063) as compared to other sites of the study area, where as species evenness (0.929) and community maturity index was recorded as 28.70.

Table 1. Phytosociological attributes of the different sites of the study area.

S. No.	Species	Total no stand in which a species occur	Total IVI	Maximum IVI	Minimum IVI	Mean IVI	Leading Dominant		
							1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
1.	<i>Barlaria acanthoides</i> Vahl	1	3.678	3.678	3.678	3.678	-	-	-
2.	<i>Blepharis scindica</i> Stocks ex Ander.	1	10.201	10.201	10.201	10.201	-	-	-
3.	<i>Corbichonia decumbens</i> Scop.	4	21.504	7.552	3.849	5.376	-	-	-
4.	<i>Limnium indicum</i> Stocks	1	2.345	2.345	2.345	2.345	-	-	-
5.	<i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.	2	18.107	12.524	5.583	9.053	-	-	-
6.	<i>Amaranthus viridis</i> L.	1	2.016	2.016	2.016	2.016	2	-	-
7.	<i>Rhazya stricta</i> Dene.	3	75.568	40.277	12.437	25.189	-	-	-
8.	<i>Nerium oleander</i> L.	1	4.139	4.139	4.139	4.139	-	-	-
9.	<i>Aristolochia bracteolata</i> Lamk.	1	1.978	1.978	1.978	1.978	-	-	-
10.	<i>Dicoma tomentosa</i> Cass.	1	7.057	7.057	7.057	7.057	-	-	-
11.	<i>Echinops echinatus</i> Roxb.	1	7.906	7.906	7.906	7.906	-	-	-
12.	<i>Iphiona grantioides</i> (Boiss.) Anderb.	1	8.343	8.343	8.343	8.343	-	-	-
13.	<i>Pulicaria angustifolia</i> DC.	1	4.948	4.948	4.948	4.948	-	-	-
14.	<i>Calotropis procera</i> (Ait.) Ait. f.	1	6.941	6.941	6.941	6.941	-	-	-
15.	<i>Leptadenia pyrotechnica</i> (Forssk.) Dene.	2	10.506	5.674	4.832	5.253	-	-	-
16.	<i>Pentstemon spiralis</i> (Forssk.) Dene.	2	8.183	4.486	3.697	4.091	-	-	1
17.	<i>Pergularia tomentosa</i> L.	2	31.426	19.986	11.44	15.713	-	-	-
18.	<i>Periploca aphylla</i> Dene.	4	38.867	11.521	8.843	9.716	-	-	-
19.	<i>Tecomella undulata</i> (Roxb.) Seem	1	4.153	4.153	4.153	4.153	1	-	-
20.	<i>Heliotropium ophioglossum</i> Boiss.	2	66.943	34.081	32.862	33.471	-	-	-
21.	<i>Heliotropium crispum</i> Stocks	1	11.958	8.025	3.933	5.979	-	-	-
22.	<i>Heliotropium subulatum</i> (DC.) Vatke	1	6.248	6.248	6.248	6.248	-	-	-
23.	<i>Arnebia hispidissima</i> (Lehm.) A.DC.	1	13.447	13.447	13.447	13.447	-	-	-
24.	<i>Farseeta jacquemontii</i> Hook.f. & Thoms.	2	9.099	4.822	4.277	4.549	-	-	-
25.	<i>Physorrhynchus brahuiticus</i> HK. f.	2	8.477	3.373	3.104	4.238	-	-	-
26.	<i>Commiphora wightii</i> (Arn.) Bhandari	2	12.844	7.013	5.831	6.422	-	-	-
27.	<i>Cassia holosericea</i> Fresen	1	6.356	6.356	6.356	6.356	-	-	-
28.	<i>Capparis decidua</i> (Forssk.) Edgew.	2	17.142	11.068	6.074	8.571	-	-	-
29.	<i>Cleome viscosa</i> L.	2	12.961	6.558	6.403	6.48	-	-	-
30.	<i>Cleome brachycarpa</i> Vahl ex DC.	2	17.542	12.528	5.013	8.77	-	-	-
31.	<i>Cleome scapoza</i> DC.	4	31.816	10.461	3.15	7.954	-	-	-
32.	<i>Chenopodium album</i> L.	2	12.644	7.423	5.221	6.322	-	-	-
33.	<i>Salsola imbricata</i> Forssk	1	6.113	6.113	6.113	6.113	-	-	-
34.	<i>Suaeda nudiflora</i> (Willd) Moq.	1	5.982	5.982	5.982	5.982	-	-	-
35.	<i>Cyperus arenarius</i> Retz.	1	4.611	4.611	4.611	4.611	-	-	-
36.	<i>Cyperus rotundus</i> L.	1	10.533	10.533	10.533	10.533	-	-	-

Table 1. (Cont'd.).

S. No.	Species	Total no stand in which a species occur	Total IVI	Maximum IVI	Minimum IVI	Mean IVI	Leading Dominant		
							1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
37.	<i>Convolvulus glomeratus</i> Choisy.	3	12.58	5.806	3.294	4.193	1	-	-
38.	<i>Convolvulus spinosus</i> Burm f.	2	42.82	28.213	14.607	21.41	-	-	-
39.	<i>Cressa cretica</i> L.	2	4.049	2.111	1.938	2.024	-	-	-
40.	<i>Citrullus colocynthis</i> Mill.	1	12.838	12.838	12.838	12.826	-	-	-
41.	<i>Cucumis prophetarum</i> L.	1	3.214	3.214	3.214	3.214	-	-	-
42.	<i>Cuscuta europaea</i> L.	1	2.043	2.043	2.043	2.043	-	-	-
43.	<i>Cuscuta reflexa</i> Roxb.	1	2.397	2.397	2.397	2.397	-	1	-
44.	<i>Euphorbia caducifolia</i> Haines	2	23.78	18.132	5.648	11.89	-	-	-
45.	<i>Euphorbia granulata</i> Forssk.	1	6.344	6.344	6.344	6.344	-	-	-
46.	<i>Euphorbia hirta</i> L.	2	10.172	6.772	3.4	5.086	-	-	-
47.	<i>Euphorbia prostrata</i> Ait.	1	5.552	5.552	5.552	5.552	-	-	-
48.	<i>Cometes surattensis</i> L.	1	4.412	4.412	4.412	4.412	-	-	1
49.	<i>Hibiscus micranthus</i> L.f.	1	20.709	20.709	20.709	20.709	1	-	-
50.	<i>Seddera latifolia</i> Hochst. & Steud.	3	54.118	31.682	11.038	18.039	-	-	-
51.	<i>Senra incana</i> Cav.	2	11.383	6.756	4.627	5.691	-	-	-
52.	<i>Cocculus pendulus</i> (J. R. Forst. & G. Forst.) Diels	2	15.434	9.826	5.608	7.717	-	-	-
53.	<i>Cocculus hirsutus</i> (J. R. Forst. & G. Forst.) Diels	1	3.354	3.354	3.354	3.354	-	-	-
54.	<i>Acacia senegal</i> (L.) Willd.	2	18.095	10.054	8.041	9.047	-	-	-
55.	<i>Acacia nilotica</i> (L.) Delile	1	10.258	10.258	10.258	10.258	-	-	-
56.	<i>Acacia jacquemontii</i> Benth.	3	43.608	18.86	9.219	14.536	-	-	-
57.	<i>Prosopis juliflora</i> (Swartz) DC.	2	21.656	12.17	9.486	10.828	-	-	-
58.	<i>Prosopis cineraria</i> (L.) Durce	2	18.341	10.392	7.949	9.17	-	-	-
59.	<i>Boerhavia procumbens</i> Banks ex Roxb.	4	27.934	8.187	6.1	6.983	-	-	-
60.	<i>Commicarpus boissieri</i> (Heinsen) Cufod.	1	10.871	10.871	10.871	10.871	-	-	-
61.	<i>Nannorrhops ritchiana</i> (Griff.) Aitch.	3	33.971	17.737	7.109	11.323	-	-	-
62.	<i>Crotalaria burhia</i> Buch.-Ham. ex Benth.	5	21.897	5.583	3.481	4.379	-	-	-
63.	<i>Indigofera oblongifolia</i> Forssk.	2	18.706	11.367	7.339	9.353	-	-	-
64.	<i>Rynchosia pulverulenta</i> Stocks	1	4.34	4.34	4.34	4.34	-	-	-
65.	<i>Rynchosia minina</i> (L.) DC.	1	3.786	3.786	3.786	3.786	-	-	-
66.	<i>Tephrosia strigosa</i> Santapau & Maheshwari	1	13.376	13.376	13.376	13.376	-	-	-
67.	<i>Tephrosia uniflora</i> Pers.	1	4.283	4.283	4.283	4.283	-	-	-
68.	<i>Plantago ciliata</i> Desf.	3	10.288	4.297	1.902	3.429	-	-	1
69.	<i>Aristida hystriacula</i> Edgew.	2	23.061	18.247	4.814	11.53	-	-	-
70.	<i>Aristida funiculata</i> Trin. & Rupr.	3	50.833	20.459	10.945	16.944	-	-	-
71.	<i>Cenchrus ciliaris</i> L.	2	31.566	18.134	13.432	15.783	-	-	-
72.	<i>Cenchrus setigerus</i> Vahl	3	39.368	16.013	9.432	13.122	1	-	-

Table 1. (Cont'd.).

S. No.	Species	Total no stand in which a species occur	Total IVI	Maximum IVI	Minimum IVI	Mean IVI	Leading Dominant		
							1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
73.	<i>Dichanthium annulatum</i> (Forssk.) Stapf	3	64.078	29.017	10.827	21.359	-	-	-
74.	<i>Eragrostis ciliaris</i> (L.) R. Br.	2	17.293	12.524	4.769	8.646	-	-	-
75.	<i>Melanocenchris abyssinica</i> (R. Br.) Hochst.	1	5.983	5.983	5.983	5.983	-	-	-
76.	<i>Panicum turgidum</i> Forssk.	4	49.043	14.071	10.243	12.258	-	-	-
77.	<i>Saccharum griffithii</i> Munro ex Boiss.	2	14.861	9.804	5.012	7.408	-	-	-
78.	<i>Pteropyrum aucheri</i> Jaub. & Spach	1	3.407	3.407	3.407	3.407	-	-	1
79.	<i>Pteropyrumoliveri</i> Jaub. & Spach.	2	19.996	14.771	5.225	9.998	-	-	-
80.	<i>Polygala irregularis</i> Boiss.	1	4.437	4.437	4.437	4.437	-	-	-
81.	<i>Polygala erioptera</i> DC.	2	4.427	2.593	1.834	2.213	-	-	-
82.	<i>Reseda aucheri</i> Boiss.	1	5.261	5.261	5.261	5.261	-	1	-
83.	<i>Ziziphus nummularia</i> (Burm.f.) W. & Arn.	2	26.573	17.842	8.731	13.286	-	-	-
84.	<i>Khautia aspera</i> (Roth.) Bremek	1	1.478	1.478	1.478	1.478	-	-	-
85.	<i>Khautiaretroxa</i> (Boiss.) Bremek	1	1.112	1.112	1.112	1.112	-	-	-
86.	<i>Salvadora oleoides</i> Dene.	3	42.216	14.945	13.045	14.072	-	-	-
87.	<i>Salvadora persical.</i>	1	12.236	12.236	12.236	12.236	-	-	-
88.	<i>Anticharislinearis</i> (Bth.) Hochst. ex Asehers.	2	14.303	8.81	5.493	7.151	-	-	-
89.	<i>Schweinfurthia papilionacea</i> (Burm.f.) Boiss.	2	7.696	4.834	2.862	3.848	-	-	-
90.	<i>Solanum surattense</i> Burm. F.	1	5.335	5.335	5.335	5.335	-	-	-
91.	<i>Lycium edgeworthii</i> Dunal	1	14.987	14.987	14.987	14.987	-	-	-
92.	<i>Solanum forskalii</i> Dunal	1	4.479	4.479	4.479	4.479	-	-	1
93.	<i>Withania coagulans</i> Dunal	3	41.209	19.509	6.292	13.736	-	-	-
94.	<i>Withania somnifera</i> (L.) Dunal	1	2.045	2.045	2.045	2.045	-	-	-
95.	<i>Tamarix dioica</i> Roxb. ex Roth	2	19.285	11.495	7.79	9.642	-	-	-
96.	<i>Tamarix aphylla</i> (L.) Karst	3	35.659	15.996	7.279	11.886	-	-	-
97.	<i>Corechorus depressus</i> (L.) Stocks	3	32.451	12.144	8.468	10.817	-	-	-
98.	<i>Corechorus tridens</i> L.	2	12.515	6.334	6.181	6.257	-	-	1
99.	<i>Grewia tenax</i> (Forssk.) Fiori.	3	32.656	17.899	4.86	10.885	-	-	-
100.	<i>Grewia villosa</i> Willd.	1	6.903	6.903	6.903	6.903	-	-	-
101.	<i>Typha domingensis</i> Pers.	2	17.007	10.076	6.931	8.503	-	-	-
102.	<i>Viola stockii</i> L.	2	8.119	4.174	3.945	4.059	-	-	-
103.	<i>Fagonia indica</i> Burm. f.	2	18.698	12.505	6.193	9.349	-	-	-
104.	<i>Tribulus longipetalus</i> Viv	1	4.866	4.866	4.866	4.866	-	-	-
105.	<i>Tribulus terrestris</i> L.	1	6.728	6.728	6.728	6.728	-	-	-
106.	<i>Zygophyllum propinquum</i> Decne.	1	3.833	3.833	3.833	3.833	-	-	-
107.	<i>Zygophyllum simplex</i> L.	1	11.064	11.064	11.064	11.064	-	-	-

Table 2. General features of the plant communities recognized from different sites of the study area.

	Site.I. (East A)	Site.I. (East B)	Site.II. (North)	Site.III. (West A)	Site.III. (West B)	Site.IV. (South)
Community name	Rhazya-Heliotropium	Heliotropium-Euphorbia	Dicamhium-Ziziphus	Convolvulus-Capparis	Rhazya-Aristida	Seddera-Dicanthium
Altitude	600-700m	700-800m	550-600m	100-150m	150-200	300-350m
Diversity index 'H'	3.063	3.187	3.235	3.114	3.067	2.934
Species evenness	0.929	0.937	0.903	0.876	0.885	0.9
Maturity index	28.70	20.67	20.97	22.57	21.09	22.88
Total taxa recorded	27	30	36	35	32	26
Common associates	Cassia holosericea, Aerva javanica, Tephrosia uniflora, Corchorus depressus, Arnebia hispidissima and Fagonia indica	Grewia tenax, Accacia jacquemontii, Corchorus depressus, Capparis cartilaginea and Withania coagulans	Pteropyrum oliverii, Panicum turgidum, Seddera latifolia, Blepharis scindica, Convolvulus spinosus and Ziziphus nummularia	Pergularia tomentosa, Cenchrus setigerus, Cenchrus ciliaris, Panicum turgidum, Tamarix aphylla and Typha latifolia	Aristida hystricula, Eragrosis ciliaris, Cyperus rotundus, Cleome scaposa and Panicum turgidum	Withania coagulans, Aristida funiculata, Hibiscus micranthus, Accacia jacquemontii and Cleome brachycarpa
IVI of dominant species	Rhazya stricta = 40.27, Heliotropiumophioglossum= 34.08, Cassia holosericea= 23.17	Heliotropium ophioglossum= 32.8, Capparis cartilaginea= 19.21, Euphorbia caducifolia= 18.13	Dicanthium annulatum= 24.23, Ziziphus nummularia= 17.84, Pteropyrumoliverii= 14.77	Convolvulus spinosus= 28.21, Capparis cartilaginea= 27.87, Pergularia tomentosa= 19.98	Rhazya stricta= 22.85, Aristida funiculata= 20.45, Aristida hystricula= 18.24	Seddera latifolia= 31.68, Dicanthium annulatum= 29.01, Withania coagulans= 19.50
Floristic condition	Depleting	Thick	Thick	Thin	Thin	Depleting
a) Grazing intensity	+++	++	+	+	++	++++
b) Browsing intensity	Less	Less	High	Moderate	Less	High
c) Tourism site(Y/N)	Yes	Yes	No	No	No	Yes

*Heliotropium-Capparis* was present in the site I on eastern side B, a total of 30 taxa were recorded from the site. *Heliotropium ophioglossum* was dominant species IVI=32.863, followed by *Capparis cartilaginea*=19.213, *Euphorbia caducifolia*=18.133. Other common associates including *Withania coagulans*, *Grewia tenax*, *Dicanthium annulatum*, *Accacia jacquemontii*, *Corchorus depressus*, *Capparis spinosus* and *Panicum turgidum*. The vegetation of this site was thick as compared to previous study site i.e. Eastern Site A, mainly due to less anthropogenic activities. This community preferred to grow in slit loamy soil with pH (8.14), Organic matter (1.24%), Electrical conductivity (810  $\mu\text{S}/\text{cm}$ ), total dissolved salts (0.41 $\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (3.72%). Diversity index was higher (3.187) as compared to previous site with 0.937 species evenness and maturity index was 20.67.

*Dicanthium-Ziziphus* community was present in the site II on Northern site, a total of 36 taxa were recorded from the site. On the basis of highest value index of IVI, *Dicanthium annulatum* (24.234) and *Ziziphus nummularia* (17.842) were recognized as dominant species. Other common associates of this community were *Pteropyrum oliverii*, *Salvadora oleoides*, *Convolvulus spinosus*, *Indigofera oblongifolia*, *Seddera latifolia* and *Blepharis scindica*. The vegetation was comparatively thicker than adjacent sites of the study area. The community preferred to grow in loamy soil with pH (7.98), Organic matter (0.67%), Electrical conductivity (754  $\mu\text{S}/\text{cm}$ ), total dissolved salts (0.68  $\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (4.11%). Diversity index was higher (3.235) as compared to adjacent site with 0.903 species evenness and maturity index was recorded as 20.97.

*Convolvulus-Capparis* community was present on the site III on West A site, a total of 35 taxa were recorded from this site. On the basis of highest values of IVI, *Convolvulus spinosus* (28.214), *Capparis cartilaginea* (27.870) were recognize as dominant species. Other common associates of this community were *Pergularia tomentosa*, *Cenchrus setigerus*, *Cenchrus ciliaris*, *Panicum turgidum*, *Tamarix aphylla* and *Typha latifolia*. *Convolvulus-Capparis* community preferred to grow in sandy loamy soil with pH (8.19) Organic matter (0.77%), Electrical conductivity (687  $\mu\text{S}/\text{cm}$ ), total dissolved salts (0.71  $\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (3.81%). Diversity index was higher (3.114) with 0.876 Species evenness and maturity index was recorded as 22.57.

*Rhazya-Aristida* community was present in the site III on West B, A total of 32 taxa were recorded from this site of the study area. On the basis of highest value of IVI, *Rhazya stricta* (22.854) and *Aristida funiculata* (20.459), were recognized as dominant species. Other common associates were *Aristida hystricula*, *Eragrosis ciliaris*, *Cyperus rotundus*, *Cleome scaposa* and *Panicum turgidum*. The vegetation of the community was thin and sparse. The community preferred to grow in slit loamy soil at an altitude ranging from 150-200m above sea level with pH (8.24), Organic matter (0.82%), Electrical conductivity (745  $\mu\text{S}/\text{cm}$ ), Total dissolved salts (0.44  $\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (4.21%). Diversity index was (3.067) with 0.885 species evenness and maturity index was recorded as 21.09.

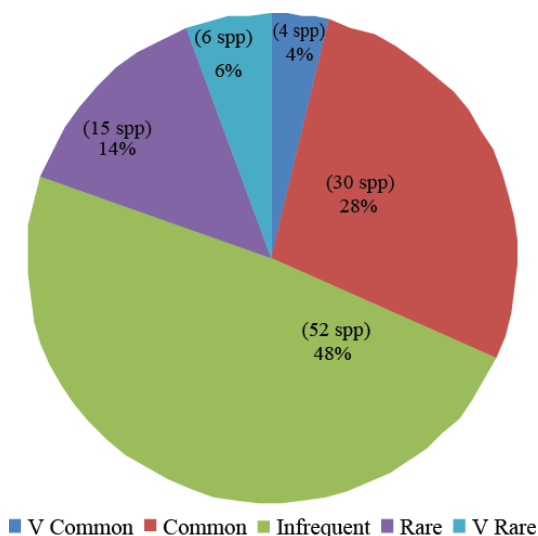


Fig. 1. Abundance of the flora of the study area.

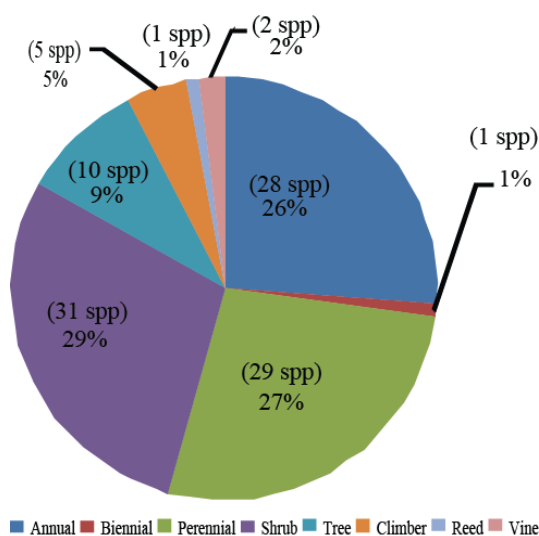


Fig. 3. Showing plants habits of the flora of study area.

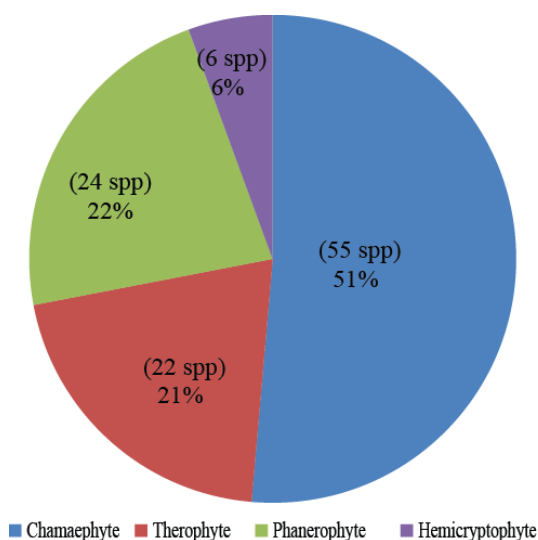


Fig. 2. Life form classes found in the study area.

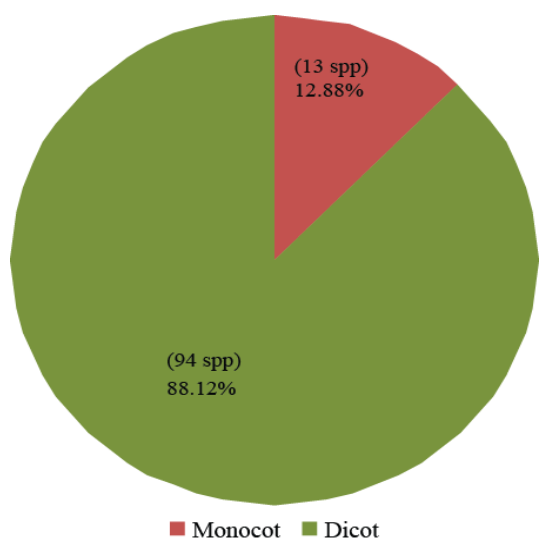


Fig. 4. Number of monocot and dicot in the area.

In South site IV, *Seddera-Dicanthium* community was recognized on the basis of highest value of IVI i.e. *Seddera latifolia* (31.683), *Dicanthium annulatum* (29.017). Other common associates were *Withania coagulans*, *Aristida funiculata*, *Hibiscus micranthus*, *Acacia jacquemontii* and *Cleome brachycarpa*. The vegetation of the community was vulnerable to human impacts as indigenous people and their livestock enter in the area from the adjoining lowlands in search of graze and browse for their livestock, and wood for fuel and fencing for their houses. This community preferred to grow in loamy soil at an altitude ranging from 280-300m above the sea level with pH (7.87), Organic matter (0.39%), Electrical conductivity (827  $\mu\text{S}/\text{cm}$ ), Total dissolved salts (0.59  $\text{mg}^{-1}$ ) and  $\text{CaCO}_3$  (4.05%). Diversity index was least (2.93) comparing all community sites with 0.90 species evenness and maturity index was recorded as 22.88.

The similarity index was low among ecological sites of the study area. The highest value of similarity index was

found between the West A & B of the site III i.e. 0.746. All the ecological sites of the study area collectively gave the beta diversity value as 2.29 (Table 4).

The recorded flora of the study area has marked similarity with adjoining areas of the Kirthar range reported by Perveen & Hussain, 2007 on the Gorakh Hill, Perveen *et al.*, 2008 for Dureji and Hussain & Perveen, 2009 for Tiko Baran. Plant diversity has been continuously declining due to severe anthropogenic pressure mainly due to over exploitation, habitat destruction, overgrazing & browsing, tourism and unchecked fuel wood cutting. Due to these threats rare and vulnerable species that are potentially important are at more risk, resulting in biodiversity loss in general and medicinal plants in particular. Human impacts associated with grazing and browsing by livestock can alter the abundance of palatable and unpalatable species, and of woody versus herbaceous cover, in a variety of ways (Dasti & Agnew, 1994; Ali, 2000).

**Table 3. Soil characteristic of the different sites of the study area.**

S. No.	Site	Altitude	STC	pH	EC $\mu\text{S/cm}$	TDS $\text{mg}^{-1}$	CaCO <sub>3</sub> %	OM %
1.	East A	600m-700m	Sandy loam	8.07	709	0.36	3.48	0.98
	East B	700m-800m	Slit Loam	8.14	810	0.41	3.72	1.24
2.	North	550m	Loamy	7.98	754	0.68	4.11	0.67
3.	West A	100m-150m	Sandy loam	8.19	687	0.71	3.81	0.77
	West B	150m-200m	Slit Loam	8.24	745	0.44	4.21	0.82
4.	South	300m	Loamy	7.87	827	0.59	4.05	0.39

STC=Soil texture class, EC= electrical conductivity, TDS= Total dissolved Salt, OM= Organic matter

**Table 4. Similarity index and beta diversity of the species between different study sites.**

Localities pairs	Shared species	Similarity index	$\beta$ Diversity
East A and East B	14	0.491	1.508
East A and North	00	00	2.0
East A and West A	06	0.193	1.809
East A and West B	05	0.169	1.83
East A and South	02	0.060	1.939
East B and North	11	0.338	1.661
East B and West A	08	0.258	1.741
East B and West B	06	0.214	1.785
East B and South	12	0.338	1.661
North and West A	07	0.205	1.742
North and West B	04	0.117	1.882
North and South	09	0.290	1.709
South and West A	02	0.065	1.934
South and West B	04	0.137	1.862
West A and West B	25	0.746	1.253
Over all Beta diversity of the six sites	115	-	2.29

### Acknowledgment

We are thankful to Higher Education Commission of Pakistan for providing financial support for the project. The author acknowledges the efforts and contribution of Dr. Ghulam Rasool Sarwar (Late) for current scientific work.

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(Received for publication 13 December 2013)