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Deterended correspondence analysis of vegetation in district tor ghar, Westrn Himalaya

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Abstract

District Tor Ghar is phytosocilogically unexplored region in the western Himalaya. Field survey was carried out during the summers of 2012 and 2013 to study floristic diversity in the region. The vegetation data collected from whole district was analyzed using DECORANA, computer programs. Species abundance data were used in CANOCO version 4.5 for DCA. Deterended correspondence analysis (DCA) identified three vegetation zones in the study area on the basis of ecological amplitude. The results were interpreted with major environmental gradients. Ordination of the site and species for herbs, shrubs and trees reported from study area by DCA indicated that the 1st two axes showed best correlation and eigenvalues from 3rd and 4rth axes revealed less representation. The distribution of plant species on DCA axis 1 indicated that altitude was the main gradient affecting the distribution of most of the plant species. Some species showed no correlation with other plants which was indication of specific locality. The Ordination diagram revealed that the plants of habitats located at the left side of the DCA diagram representing humid subtropical habitat which were more influenced by anthropogenic disturbances. The plant species located at right side of the ordination diagram showing moist temperate and sub alpine habitats. The results of the present research also revealed that elevation, temperature and slope were the main factor affecting the distribution of plant species. These results will be used as base line to study vegetation analysis in future with reference to different ecological conditions.

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Introduction

The plants are important for human in many ways like source of food, livestock and wild life. The species diversity is a result of interaction of specific environmental conditions (Ricklefs, 2006). Different factors are essential for exploring environmental gradient of vegetation diversity (Lomolino, 2001). In rugged mountainous regions altitude is an important factor responsible for distribution of plants. Elevation from sea level shows a complex gradient which control many environmental variables. The change in elevation results in the change of floristic composition (Sakya and Bania, 1998). There is decrease in the species richness with increasing altitude as observed from equator to pole (Rahbek, 1995; Brown and Lomolino, 1998; Gaston, 2000; Willing *et al.* 2003) Temperature of a region is also dependent on altitude. It decreases with increasing elevation, which controls the distribution of plant species (Komer, 2000). The influence of different environmental variables on floristic diversity has been studied by different authors in different regions (Givnish, 1999).

Different Ordination methods are extensively used by the ecologists to study the relationship between vegetation and environment. DCA is one of the important and efficient methods of indirect gradient analysis and is used when there is no environmental data. The axes in DCA are measured by the average standard deviation of species turnover (sd units). Detrended correspondence analysis (Hill 1979) provides good results for complex and heterogeneous data (Hill and Gauch 1980; Gauch, 1982). Different comparative indirect ordination techniques have proved that DCA is easy to use, more robust and powerful ordination technique (Gauch, 1982).

Pakistan is blessed with rich biodiversity of fauna and flora due to diverse climatic and edaphic conditions. Most of the natural forest resources of Pakistan are located in the Himalaya region. A lot of research is reported in the area of phytosociology on different scales in the world and Pakistan. However, the review of literature revealed that classification and ordination techniques have been rarely used for mapping the high elevation vegetation in Pakistan (Afza *et al.* 2016).

D.M. Currie, started the phytosociological research work in Pakistan. Monsi and Khan (1960) analyzed the vegetation of That and the flora of other regions of Pakistan was compared with vegetation of Thal region. In Northern region of Pakistan phytosociological study was conducted by Ahmed (1976, 1986, and 1988). Ahmed (1986) described the vegetation of some foot hills of Himalaya range in Pakistan. He studied many phytosociological attributes in the research area. Whittaker (1965) investigated that the phytodiversity is dependent on different soil moisture regimes. Malik *et al.* (1990) described three plant associations in Sund Gali Muzzafarabad Azad Jummu and Kashmir. They reported that Therophytes and Nanophytes vegetation was dominant. The phytosociological survey was carried out in different climatic zones of the country by Ahmed *et al.* (2006) and recorded 24 plant communities in the study area. They reported that many plant communities which differ quantitatively show similarities in floristic composition. Malik *et al.* (2007) described the vegetation classification of Pir Chinasi hills and reported 13 plant communities from the research area.

Many other ecologists have presented their research work in different regions of the country i.e., Malik *et al.* (2001); Malik and Malik (2004); Malik (2005), Ahmed *et al.* (2006), Ahmad *et al.* (2008), Choudhary *et al.* (2001); Choudhary *et al.* (2005); Sher and khan (2007); Badshah *et al.* (2013); Ahmed *et al.* (2012); Saima *et al.* (2009); Saima *et al* . (2010); Qureshi *et al.* (2014); Khan *et al.* (2014); Zareen *et al.* (2015) and Afza *et al.* (2016).

Although many research workers have explored phytosociologically different Himalayan regions but certain areas in the north of the country are phytosociologically unexplored. District Tor Ghar Kyber Pakhtunkhwa, Pakistan is one of the such area situated in lesser Himalayas. A number of social, administrative and communication problems were

the main hurdles in the exploration of such a remote area.

There was no previous record of ecological study in the area. In these scenarios, it is imperative to classify vegetation of the area (Khan *et al.* 2011).

The present study was involved in the phytosociological survey of vegetation in the district Tor Ghar and mainly focuses the importance of different ecological habitats. The main objectives of the present study were to quantify the vegetation of the remote and phytosociologically unexplored district of the Khyber PakhtunKhwa using ordination techniques.

The present investigation will provide valuable information for further ecological study and conservation of flora of the region. Furthermore, this research project will serve as baseline for planning, management and sustainable utilization of natural resources and comparison of different floras in future.

Materials and methods

Study area

The study area district Tor Ghar is found at the North of Khyber Pakhtunkhwa province of Pakistan in the western Himalayas (Fig. 1).

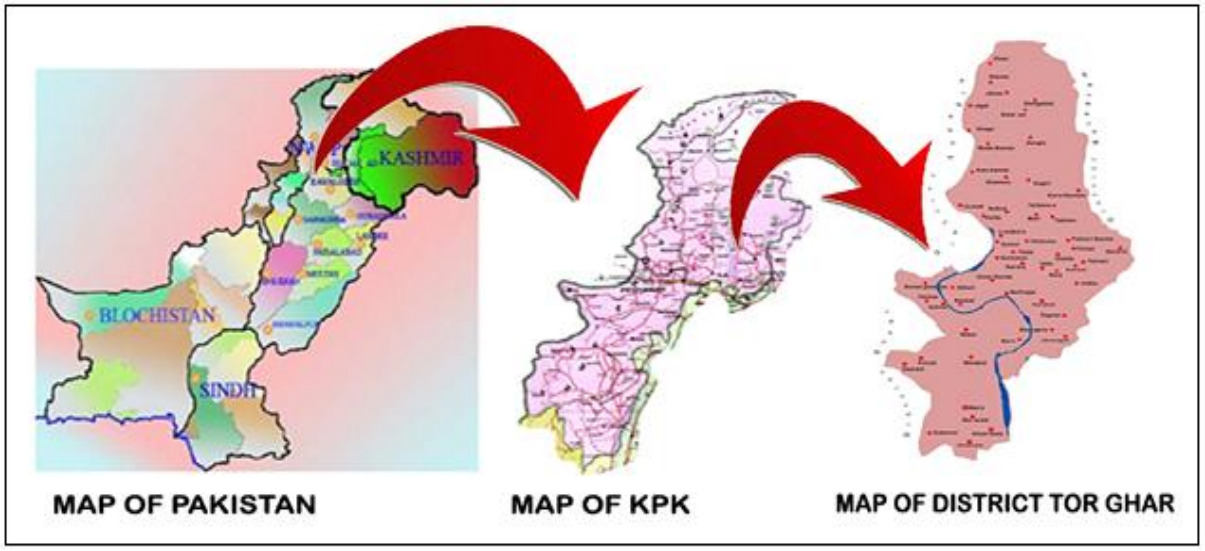

Fig. 1. Map showing location of study area.

Tor Ghar is regarded as one of the most ignored and deprived area of the Khyber Pakhtunkhwa province, where basic needs of life are not available. Inhabitants of the area are mostly uneducated and do not know the importance of biodiversity. Most of the people are dependent on agriculture and livestock (Mehmood *et al.* 2014). The area is deprived of modern facilities of life. In the absence of modern facilities of life people are entirely dependent upon plants resources. They are using plants for different ecosystem services (Shah *et al.* 2015, Shah *et al.* 2014). It has been given a status of the District of Khyber Pakhtunkhwa on 28 January, 2011. It can be located on 34° 32' - 34° 50' N, and 72° 48' - 72°58' E. It is largely dominated by mountains and hills. The altitude of district ranges from 450 to 2950 masl. Due to steep slopes and deforestation soil erosion and landslides are common.

Survey of Study area

Phytosociological data about 331 plant species were collected from 960 quadrats in study area during 2012-13. Map of the investigated area was obtained from forest Department. Climatic data of research area was obtained from Pakistan metrological department and general information about the area was collected during field visits. The whole district was extensively visited throughout the flowering and fruiting seasons during 2012-13. Plant species collected from different areas of the district were tagged and given voucher numbers. The plant specimens were identified with the help of flora of

Pakistan (Stewart, 1972; Nasir and Ali, 1971-1995; Ali and Qaiser, 1995-2005).

Study design

In the study area 64 stations from 12 localities were selected (table 4). Base line was established at Indus River. Transects were made perpendicular to the base line. Each transect was approximately situated at a distance of 5Km. These selected localities were divided into altitudinal belts of 200 masl. Samplings were started from Indus River. The selection of starting point for systematic sampling was random; the remaining sampling was carried out at the interval of 200 msl from this starting point.

Number and size of Quadrats

Three quadrats each having an area of 10 × 10m, 5 × 5 m and 1 × 1m were placed randomly for determining the community structure of trees, herbs and shrubs respectively following the protocol of Mishra *et al.* (1968) and Khan *et al.* (2012). There were 5 replicates in each stand. In each quadrat, trees were recorded with >31.5cm cbh (circumference at breast height i.e., 1.37m above ground). Individuals within the cbh range of 10.5 to 31.4cm were considered as shrub and <10.5cm cbh as herb. Coordinates including altitude, longitude and latitude of selected site was recorded using GPS of Garmin e trex Hc series, vista HCx, while aspect was recorded by compass.

Data analysis

Data was organized and summarized using MS EXCEL (2013). The IVI data calculated for each station was used in ordination. Ordination analyses were done using DCA available in CANOCO (ter Braak, 1988; ter Braak, 1989; ter Braak and Smilauer, 2002).

Results and discussion

The study area is blessed with rich floristic diversity. A research project has been conducted by Mehmood *et al.* (2015) to explore floristic diversity of the area. They reported 331 plants belonging to 101 families from whole district. Families Asteraceae and Leguminosae were the richest families with 25 & 24 species followed by Poaceae (21 species), Lamiaceae (17 species) and Rosaceae (14 species). In present study species abundance data was used to study the species distribution in the investigated area. Default setting of CANOCO was adapted using DCA that resulted in AX1 and AX2 from which ordination diagram was constructed. Every point on the graph corresponded to species.

Table 1. Detail of the four axes of the DCA for 54 tree species and 64 stations data.

Axes	1	2	3	4	Total Inertia
Eigenvalues	0.630	0.212	0.103	0.083	3.543
Lengths of gradient	6.325	5.043	3.902	3.570	
Cumulative percentage variance of species data	17.8	23.8	26.7	29.0	

Table 2. Detail of four axes of DCA for 48 shrub species and 64 stations data.

Axes	1	2	3	4	Total Inertia
Eigenvalues	0.641	0.189	0.132	.099	3.299
Lengths of gradient	5.627	5.248	2.431	2.114	
Cumulative percentage variance of species data	19.4	25.1	29.1	32.1	

The different species which occur with same abundances in the same site would occupy the same point. The distances among the points on the graph represent the distribution of a plant species.

The DCA diagrams are interpretable in ecological terms and show the distribution of plant species in the study area. The axes 1 of the DCA diagrams show distribution of plant species with relation to low altitude on the left to high altitude on the right.

Table 3. Description of four axes of the DCA for 229 herb species (using IVI data) for all 64 stations.

Axes	1	2	3	4	Total
Eigenvalues	0.508	0.360	.270	.208	7.232
Lengths of gradient	6.723	5.074	6.242	5.231	
Cumulative percentage Variance of species data	7.0	12.0	15.7	18.6	

Table 4. Detail of stations and their abbreviations.

S.No.	Stations	S. code	Al. msl	Aspect
1	Kot key 1	Ktky 1	467	E
2	Dadam E	Ddme1	506	E
3	Judbah 1	Jdbh1	530	E
4	Kotley	Ktly1	540	E
5	Char daroo	Shgi	540	E
6	Toot Banda	Ttbda1	550	E
7	Shah dak	Shdk1	550	E
8	DadamN	Dmn1	600	N
9	Dehri 1	Dri 1	600	E
10	Gorial 1	Gorl 1	600	E
11	Tor kando1	TK EC1	640	S
12	Darbani 1	Dbni1	650	E
13	Zizari	Zzari1	650	E
14	Kotkey 2	kky2	667	E
15	Dadam e 2	Ddme2	706	E
16	Judbah 2	Jdbh2	730	E
17	Kotkley 2	Ktly2	740	E
18	Shagae 2	Shgi2	740	E
19	Toot Banda 2	Ttbda	750	E
20	Jagal	Shdk2	750	E
21	Sarbago 2	Dmn2	800	N
22	Mera	Dri2	800	E
23	Gorial 2	Gorl2	800	E
24	Tor kando 2	Tk2	840	E
25	Soralsaydan	Zzari2	850	E
26	Darbani 2	Dni2	850	E
27	Behri	Ktky3	867	E
28	Sahbah hill	Ddme3	900	E
29	Toot banda 3	Ttbda3	935	E
30	Arnil	Jdbh3	935	E
31	Kotley	Ktly3	940	E
32	Kalesh	Shgi 3	940	E
33	Sahbah hill 3	Ddn3	950	N
34	Nawagae	Shdk3	950	E
35	Danda	Gorl3	1000	E
36	Matorh	Dhri3	1000	E

37	Gut hill	Tk3	1040	E
38	Darbani 3	Dni3	1050	E
39	Dada banda	Zzari3	1050	E
40	Gut area	Ktky4	1060	E
41	Pian top	Shdk4	1100	E
42	Shatal	Jdbh4	1130	E
43	Sargae	Shgi4	1140	E
44	Matorh top	Dri4	1210	E
45	DarbaniAkaze	Dni 4	1250	E
46	Banda	Zzari4	1250	E
47	Gut top	Ktky5	1260	E
48	Shahtal 2	Jdbh5	1325	E
49	Sargae 2	Shgi 5	1400	E
50	Haleema	Zzari5	1450	E
51	Shahtal 3	Jdbh6	1530	E
52	Shangaldar	Shgi 6	1600	E
53	Bakain 1	Jdbh7	1730	E
54	Bakain 2	Judbh 8	1930	E
55	Chorkalan	Dni 8	2050	E
56	Arekh 1	Jdbh 9	2130	E
57	Chorkalan 2	Dni9	2250	E
58	Arekh 2	Jdbh 10	2330	E
59	Chotakando	Dni 10	2450	E
60	Bratho	Jdbh 11	2530	E
61	Manasar	Dni 11	2650	E
62	Kandogali	Jdbh 12	2660	E
63	Dodagata	Dni 12	2850	E
64	Tor ban (Machasar)	Dni 13	2950	E

The gradients on the ordination axes 2 could be related to relatively dry and hot habitat at the top and cooler habitat at the bottom.

Ordination of tree species and Habitat

DCA diagram (Fig. 3) shows the distribution of tree species and habitat type in 64 stations. In DCA ordination for 54 tree species and 64 stations, the maximum gradient length recorded for axis 1 was 6.325 with eigenvalue 0.630. The gradient length for axis 2 was 5.043 with eigenvalue 0.21. The total variance in the tree species data was 3.543 (table 1).

The present research provides first ever phytosociological exploration based on robust multivariate classification and ordination procedure via Canoco and PCORD soft wares.

In study area 3 vegetation zones i.e. Humid sub-tropical, Sub tropical Chir pine and Mixed coniferous forests were reported. Finding of this project confirmed elevation from sea level, slope and temperature as significant environmental variables responsible for distribution of plant species. Ordination of the site and tree species reported from the district Tor Ghar by DCA revealed that the Ist two axes have given useful information about the distribution of species. The eigenvalue 0.63 and 0.212 from Ist two axes of DCA reflected that habitat and species were showing strong correlation with first and second axes while the eigenvalues 0.13 and 0.83 from 3rd and 4rth axes indicated that there was less correlation with these axes.

The localities Judbah (Jdbh I), Shagai Basikhel (Shagi I), and Kotkey Hasanzai (Ktky I), Shadak (Shdk 1) and Zizari BasiKhel (ZZari 1) (representing Sub humid tropical forest) are present at the upper right side of the DCA diagram.

Fig. 2. a) Tropical Chir Pine forest b) Tropical Sub humid forests (c & d) Moist temperate habitat.

These sites occur near the Indus River showing negative correlation with Darbani Akazai (Dni2), Dadam Hasan Zai (Ddme 1), Toot banda (tbda), Ttbda 3, Dmn2, Darbani Dni 1 most of these sites are also located at lower altitude presenting sub humid tropical forests but representing the degraded localites. The DCA diagram reflected that the vegetation of these habitats were different from rest of the region due to the presence of these localities near the human settlements and are exposed to anthropogenic disturbances. Some of the stations like Chorkalan and Chota kandow are present at higher altitude but due to heavy human interference and severe climatic conditions showing resemblance with subtropical habitat.

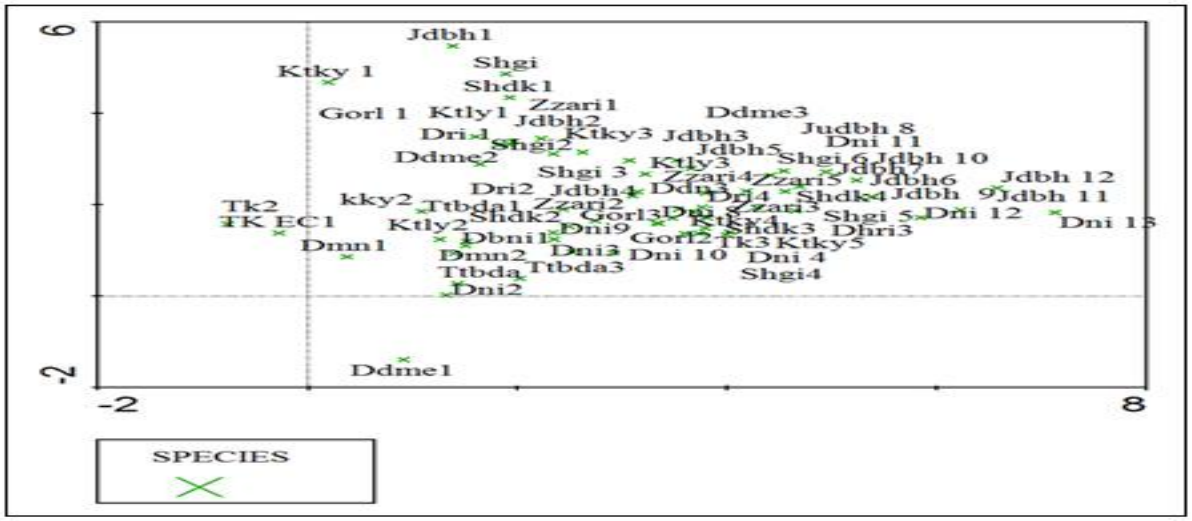

Fig. 3. DCA diagram displaying distribution of tree species and habitat types among 64 stations. (Codes in diagram indicates stations names refer to table 4).

The stations Kando Gali (Jdbh 12), Bratho (Jdbh 11), Tor Ban (Dni 13), Doda Gatta (Dni 12), Arekh (Jdbh 10) and Jdbh 9 (presenting mixed coniferous) are located at the right side of the diagram. These localities were indicating moist temperate type of habitat. Important environmental variables responsible for grouping the plant species was altitude associated with low soil depth and grazing pressure. Severe deforestation, over grazing, steep slope and soil erosion have changed the community structure. Some important plants such as *Abies, Cedrus deodara, Picea smithiana, Pyrus pashia* and *Taxus wallichiana* were destroyed. Due to unavailability of alternate source, people are dependent on these forests for fuel wood.

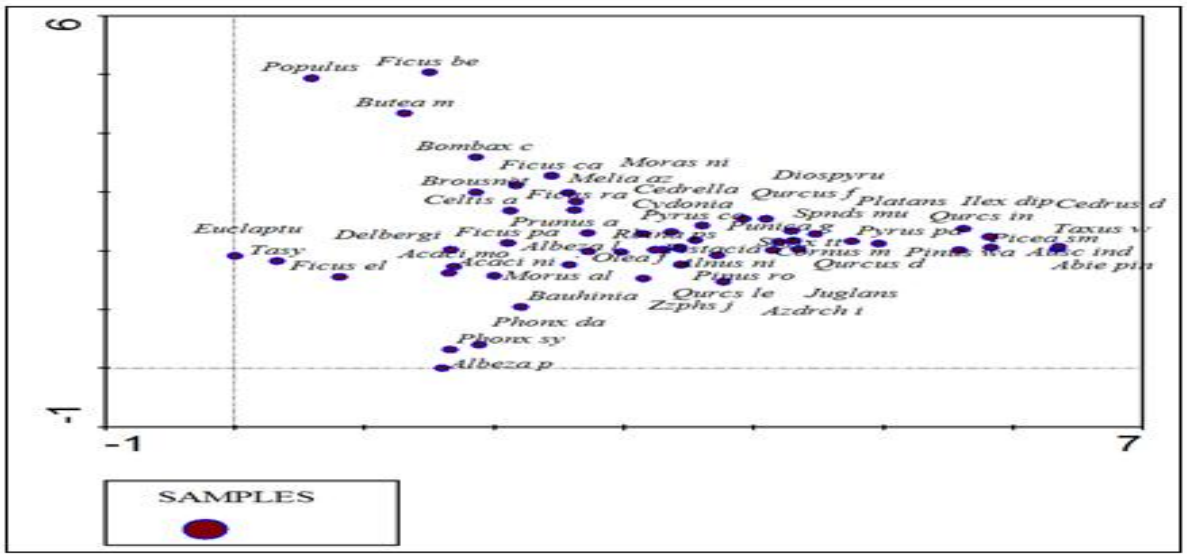

Fig. 4. DCA diagram presenting the distribution of tree species in the district Tor ghar.

The local inhabitants use these plants for different benefits, causing degradation of plant community. The sites present at the left side reflecting subtropical habitat.

The DCA diagram(Fig.4) for trees revealed that most of tree species like *Acacia modesta, Delbergia sisso, Pinus roxburghii, Olea ferruginea* and *Acacia nilotica* are present in the centre of the diagram and were found in many habitats. Similar results were obtained by many authors like Khan *et al.* (2014) recorded *Acacia modesta* community from Poonch valley, Azad Kashmir Himalaya region at altitude of 3500 feet. Ahmed *et al.* (2006) documented the dominance of *Acacia modesta* and *Olea ferruginaea* community on the southern aspects of lower hills of Murree. The dominance of *Pinus roxbergii* in subtropical forests is reported in previous study from Himalaya by Champion *et al.* (1965).

In ideal conditions, the *Pinus* is dominant due to its wide ecological amplitude and specific niche in this zone (Ahmad *et al.* 2010). Soil moisture and organic matter due to deposition of litter was high under *Pinus roxbergii* community. Whereas tree species *Abies pindrow, Cedrus deodara, Picea, Aesculus and Taxus wallichiana* are present at right side of DCA diagram showing strong correlation with Ist axis and are found in one plant association (Mixed coniferous forests). These species were clustered together depicting similar ecological amplitude. These species were depicting moist temperate and subalpine vegetation. Similarly the species, *Ficus benghalensis, Poplus, Butea monosperma and Bombax ceiba* were present at the upper right side of the DCA diagram showing no correlation with most of the tree species and are negatively correlated with the species *Albezzia procera and Phoenix* spp.

These tree species show maximum axis 2 score indicating their preference at lower altitude in hot and dry habitat of the study area. The results also revealed that most of the plant species followed arrangement similar to sites indicating that distribution of these species is influenced by topographic factors.

Ordination of Shrub Species and Habitat

DCA diagram (Fig.5) produced through CANOCO revealed that majority of shrub species stations were strongly correlated with 1st and 2nd axis (eigenvalue 0.64 and 0.189 respectively), while less correlation with 3rd and 4th axis (eign value 0.132, 0.099) (table 2). The total inertia in the shrub species data was 3.299.The localities distributed at margins of the diagram represent habitat specificity while the stations located in centre were showing similarity among each other.

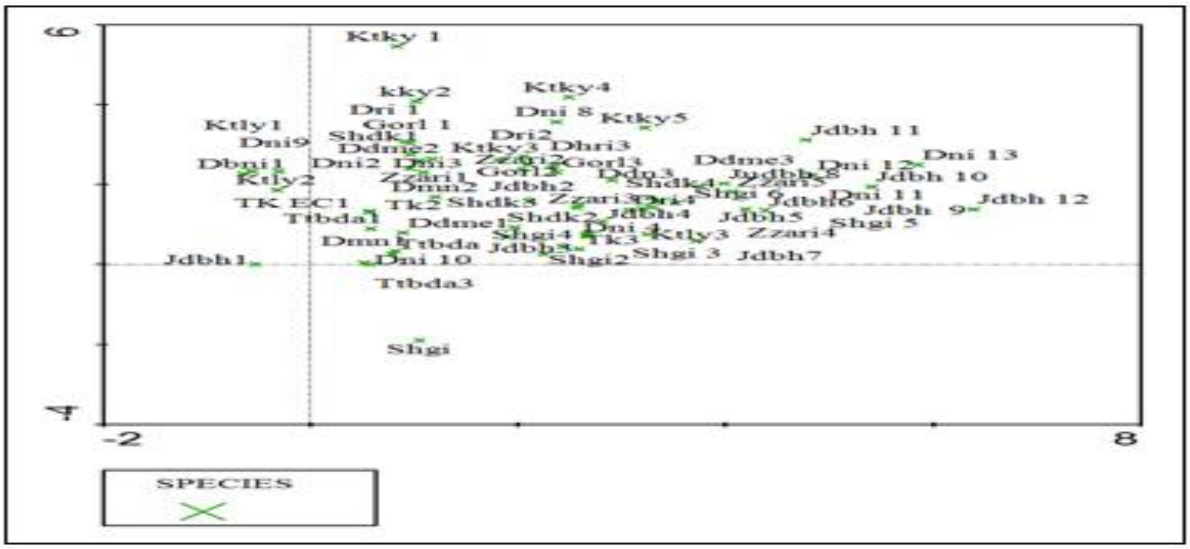

Fig. 5. DCA diagram indicating the distribution of shrub species and habitat types among 64 stations. (Codes in diagram indicates station's names refer to table 4).

The site Kando Gali (Jdbh 12), Torban (Dni13), Bratho (Jdbh 11), Arekh (jdbh 9) and Jdbh 10 are higher altitude of the study area representing moist temperate and sub alpine habitat and showing different vegetation from rest of the sites. The localities like Kotkey Hasan Zai (Kotly1), Kotly 2 and Tor kandow (Tk 1), Kotley NusratKhel (Ktly 1), Gorial BasiKhel (Gorl 1), Dheri (Dri 1) and Shadak (Shdk 1) are present at low altitude near the Indus River representing Tropical Sub Humid climate. The stations Shagai and Judbah were showing different shrub vegetation due to occurrence near human settlements.

The stations, Dada Banda (Zizari3), Banda (Zizari 4), Shangal Dar (Shagai 6), Danda (Gorl 3) and Shatal (Shdk 4) are located at the center of DCA diagram showing similarities and representing Sub tropical Chir pine forests. Most of these localities are found at same altitude, share similar climatic condition therefore, hosting similar shrub vegetation. Ordination of the site and shrub species reported from the district Tor Ghar by DCA is depicted in DCA diagrams.

Detrended Correspondence Analysis (DCA) diagram Fig. 6 revealed that the 1st and 2nd DCA axis show strong correlation with shrub species. Some shrubs show no correlation with other plants like *Bambusa, Yucca aloifolia* and *Nannorrhops ritchieana*. The plant species located at left side of the DCA diagram is the indication of sub humid tropical habitat and shrub species present on right side of the DCA diagram showing moist temperate and sub alpine habitat.

Species like *Skimmia laureola, Sarcococca saligna* and *Hedra nepalensis* are present on the right side of the diagram. These species were grouped together due to similar ecological amplitude. Similar altitude is the main environmental variable responsible for grouping these plant species and representing moist temperate coniferous type of habitat. Comparison of localities and species DCA diagram showed that these shrubs are absent from rest of localities due altitudinal differences.

The species like *Yucca aloifolia, Calotropis procera* and *Nannorrhops ritchieana* were present at the right side of the diagram indicated sub-tropical habitat. Most of these species are the indicator species of the subtropical habitats (Haq *et al*., 2010). Important factors affecting plants distributions in this zone were elevation from sea level, soil depth and temperature. Most of the localities are found on Gentle slope and at low altitude.

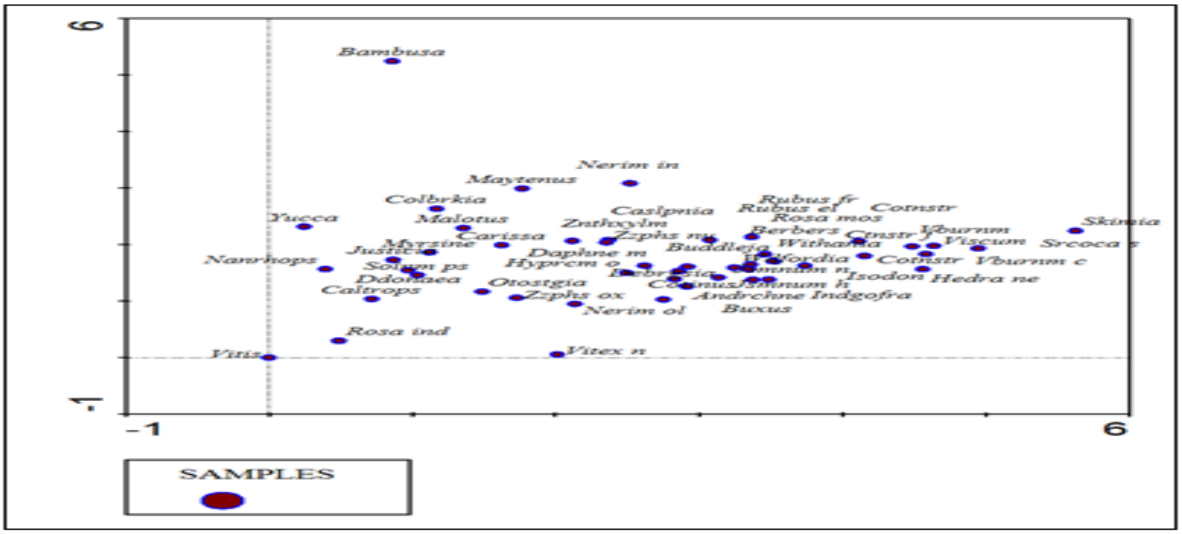

Fig. 6. DCA diagram presenting distribution of shrub species in district Tor ghar along the gradient.

The occurrence of shrub species *Vitis* and *Nannorrhops ritchieana* on negative axis is indication of habitat specificity of these species in study area. Where as many shrub species are located at the center of diagram which shared many vegetation types such as *Carissa opaca, Cotinus coggyria, Otostegia limbata and Zanthoxylum*. Some shrubs show no correlation with other plants like *Bambusa, Yucca aloifolia* and *Nannorrhops ritchieana* which is indication of specific locality. The species distribution along the first axis of DCA reflected altitudinal gradient. In hilly regions, elevation shows the greatest influence in controlling plant species and community classification (Chawla *et al*., 2008).

The second axis represented the distribution of species along specific habitat condition. The results of the study revealed that elevation, soil depth and temperature are the main factors affecting the distribution of plant species.

Ordination of Herb Species and Habitat

Results of Deterended Correspondence Analysis (DCA) for all herbaceous flora and habitat types among 64 stations are represented in the Fig 7. In DCA ordination for all 228 herbaceous species and 64 stations, the maximum gradient length recorded for axis 1 was 6.723 with eigenvalue 0.508. The gradient length for axis 2 was 5.074 with eigenvalue 0.360. The total inertia for the herb species data was 7.232 (table 3). Results revealed that most of the sites are located in the center of DCA diagram showing similarities and are found in many habitats. Clustering of these herbs in the center of DCA diagram reflects that these species do not prefer specific habitat. The eigenvalue 0.508 and 0.360 from Ist two axes of DCA indicating that habitat and species show strong correlation while the eigenvalues 0.270 and 0.208 from 3rd and 4rth axis indicated that there was less correlation with these axes.

Some localities like Tor Kandow (TK EC1), Tk2, and Toot Banda (Ttbda 3), Ttbda located at the left upper half of the DCA diagram showing different habitats than rest of the locations. The Localities like Kotkey (Ktky 1), Ktky 2, Behri (Ktky 3), Guth hill (Ktky 4,Ktky 5) present at the lower left half of the DCA diagram are the sites reflecting lower altitude. The vegetation of these habitats differs due to more anthropogenic interference.

Anthropogenic interferences are the major controlling factors regulating species distribution (Muller & Ellenberg, 1974). The herbaceous habitats; Kandow gali (Jdbh 12), Tor ban (Dni 13), Doda gatta (Dni 12), Mana Sar (Dni 11), Arekh (Jdbh 10) are the moist temperate habitat located at higher altitude.

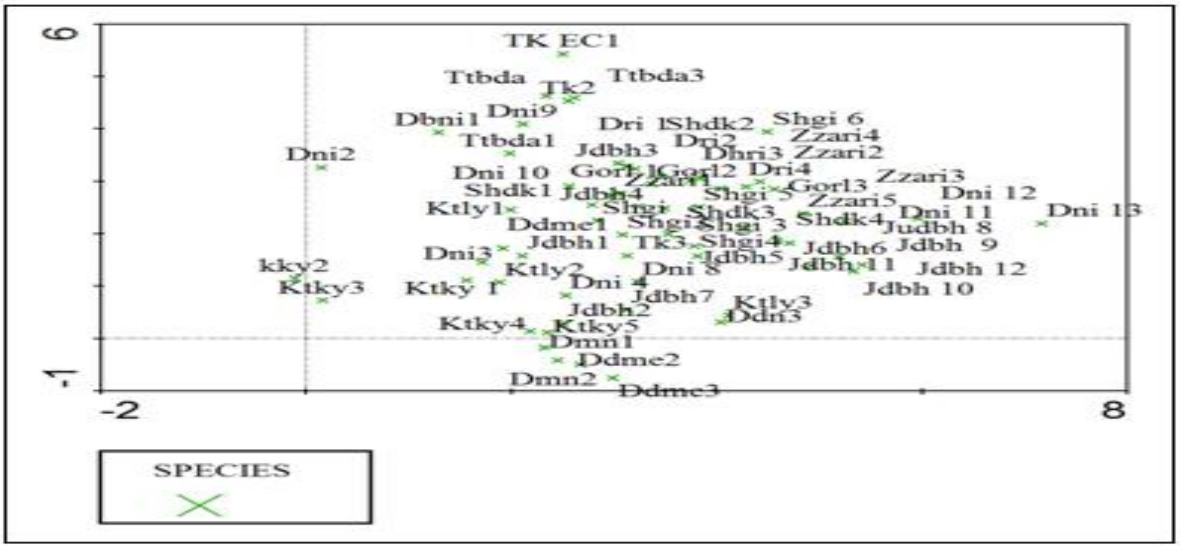

Fig. 7. Detrended Correspondence Analysis (DCA) diagram showing distribution of herbaceous flora and habitat types among 64 stations. (Codes in diagram indicates stations names refer to table 4).

DCA diagram 8 illustrates the distribution of herbaceous species in the study area. This diagram shows the location of each species along the 2 axes and their correlation with gradients. Most of the herbs are present in more than one association showing degree of similarity. eg, Cyperus cyperoides, *Cynodon dactylon, Chrysopogon serrulatus and Digitaria nodosa*. These grasses were found in most of the localities. Cyperus is a very noxious weed. It occurs in waste lands, along pavements and farms. *Cyperus* is allelopathic to many plant species growing in the locality and can reduce yield of crop to a great extent as it compete for mineral resources with crop plant (Zareen *et al.* 2015) Cynodon dactylon propagates by seeds and due to this reason it flourishes in all types of habitat (Nasir and Rafique, 1995). Their seeds are dispursed by wind to long distances and show good percent cover values. *Cynodon* is considered as an important fodder grass (Cope, 1982.).

Due to high grazing pressure most of the dicot species were eradicated. Only less palatable and non-palatable species were present. *Cynodon dactylon* was dominant because it occurs on almost all types of soils and was common in the habitat disturbed by man and under severe grazing pressure, unused lands etc. (Martin *et al.*, 1951).

It has capability to resist the drought and high temperature and can survive in the area where only few grasses are found (Shah and Rozina, 2013). Whereas, many plant species were showing specific habitat in the research area. *Rumex vesicarius* was present at top right of the DCA diagram. It requires hot and dry climate and does not show correlation with rest of the herb species. It was found in one locality only.

Herbaceous flora located at the extreme right side of the diagram, *Boenninghausenia albiflora*, *Impatiens bicolor, Valeriana, Urtica pilulifera* and *Arisaema utile* showing strong correlation with axis 1 (representing mixed coniferous forest). The first axis represents altitudinal gradient.

These high score of axis 1 depicts the preference of these herbs at higher altitude and require similar microclimatic conditions.

Comparison of herb species and habitat revealed that these species are characteristic of moist temperate forest type habitat and are absent from rest of the habitats. The dominance of these plant species decreased from higher altitude to lower altitude. These species are showing negative correlation with species located at the left side. ie *Opuntia, Canna, Solanum virginianum* which are located at low altitude and poor soil condition.

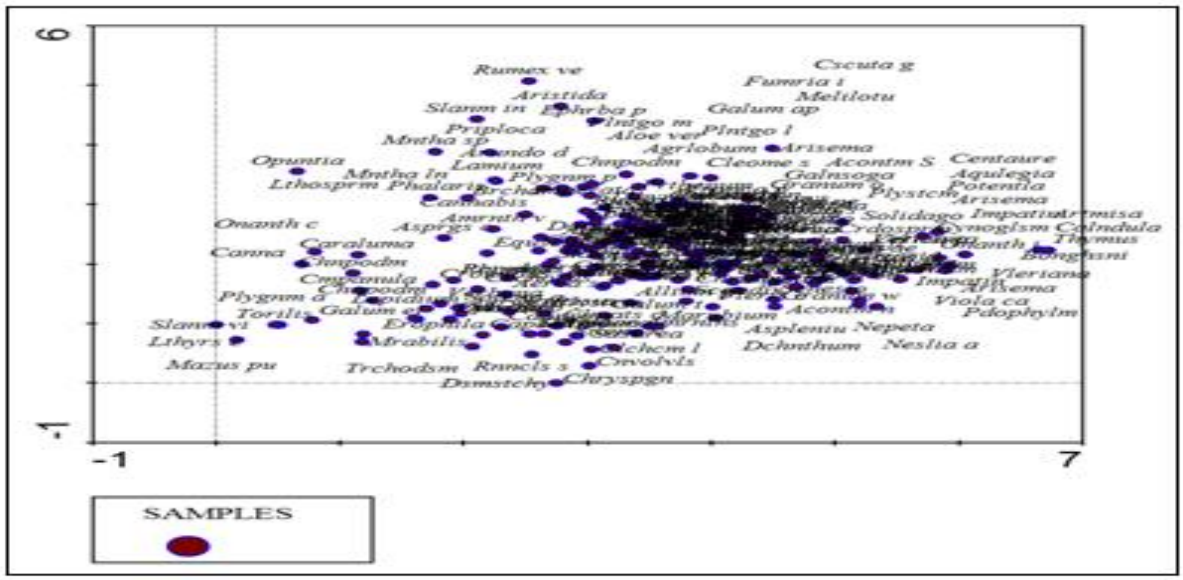

Fig. 8. DCA diagram presenting the distribution of total herbs species among along gradient.

In DCA diagram the position of some species is not similar to site indicated that the distribution of these species is not affected by topographic and edaphic factors. Species distribution is controlled by a combination of environmental and anthropogenic influence (Dolezol and Srutek, 2002). Similar results were reported by Jabeen and Ahmad (2009).

They conducted a research project to study the vegetation and environment data of Ayub National Park, Rawalpindi. Khan *et al*. (2011) studied 5 plant communities of Naran valley, Pakistan by using TWCA and indicator species analysis and reported that aspect, altitude and soil depth were important variables responsible for species distribution in study area. Our result agrees with that of Dasti and Malik (1998) who stated that altitude is an environmental factor which affects plants association.

Conclusion

The deterended correspondence analysis has proved useful in understanding distribution of plant species in phytosociologically unexplored region of Himalaya. Study area shows rich floristic diversity, including endemic and endangered species.

DCA results divided the vegetation of study area into three vegetation zones characterized by specific indicator species. i.e. Humid tropical forests, subtropical Chir pine forests, Moist temperate and sub alpine regions. Altitude was found to be main environmental factor affecting the distribution of plant species. Most of the herbs are present in many associations showing degree of similarity. e.g, Cyperus cyperoides, *Cynodon dactylon, Chrysopogon serrulatus and Digitaria nodosa*.

Most abundant species found everywhere in the study area was *Cynodon dactylon*, which showed growth at wide range of every selected area. Flora is under severe anthropogenic pressure like deforestation, grazing and soil erosion. It is expected ordination model and distribution pattern of herbs, shrubs and trees species in study area could be starting point for further research.

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References

Ahmed M. 1986. Vegetation of some foothills of Himalayan Range of Pakistan. Pakistan Journal of Botany **18(2),** 261-269.

Ahmed M. 1976. Multivariate analysis of the vegetation around Skardu. Pakistan Agricultural Research Council **27**, 177-187.

Ahmed M. 1988. Plant communities of some northern temperate forests of Pakistan. Pakistan journal of forestry **38(1),** 33-40.

Ahmad S.S, Abbasi Q, Jabeen R, Shah MT. 2012. Decline of conifer forest cover in Pakistan: a gis approach. Pakistan Journal of Botany **44(2),** 511-514.

Ahmad S.S, Wahid A, Akbar K F. 2010. Multivariate classification and data analysis of vegetation along motorway (M-2), Pakistan. Pakistan Journal of Botany **42(2),** 11731185.

Ahmed M, Hussain T, Sheikh AH, Hussain SS, Siddiqui MF. 2006. Phytosociology and Structure of Himalayan forests from different climatic zones of Pakistan. Pakistan Journal of Botany **38(2),** 361-383.

Ahmad K, Khan ZI, Ashraf M, Hussain M, Ibrahim M, Valeem EE. 2008. Status of plant diversity at Kufri (Soone valley) Punjab, Pakistan and Prevailing Threats Therein. Pakistan Journal of Botany **40(3),** 993-997.

Afza R, Ahmad H, Saqib Z, Ali N, Khan J. 2016. Phytodiversity of Ayubia National Park Pakistan: Conservation and Management issues. Journal of Biodiversity and Environmental Sciences **8(2),** 327-336.

AliSI Qaiser M. (eds). 1995-2005. Flora of Pakistan, Botany Department, University of Karachi.

Badshah L, Hussain F, Sher Z. 2013. Floristic inventory, Ecological Characteristics and Biological Spectrum of Rangeland, District Tank, Pakistan. Pakistan Journal of Botany **45(4),** 1159-1168.

Brown JH, Lomolino MV. 1998. Biogeography. 2nd ed. Sinauer Associates, Sunderlands, MA.

Champion GH, Seth SK, Khattack GM. 1965. Forest types of Pakistan. Forest Institute, Peshawar. 233p.

Chawla A, Rajkumar S, Singh KN, Lal B, Singh RD, Thukral AK. 2008. Plant species diversity along an altitudinal gradient of Bhabha Valley in western Himalaya. Journal of Mountain Science **5(2),** 157-177.

Choudhary AA. 2001. Phyto-Sociological studies in Chhumbi Surla wildlife sanctuary, Chakwal, Pakistan II. Phytoecology. International Journal of Agriculture and Biology **3(4),** 369-374.

Choudhry MS, Batool Z, Khan AG. 2005. Preliminary assessment of plant community strycture and *Arbuscular mycorrhizas* in rangeland habitats of Cholistan desert, Pakistan. Mycorrhiza. **15(8),** 606-611.

Cope TA. 1982. Poaceae, No. 143. In: E. Nasir and S. Ali (Eds), Flora of Pakistan. National Herbarium, Pakistan Agriculture Research council, Islamabad.

Dolezol J, Srutek M. 2002. Altitudinal changes in composition and structure of mountain temperate: A case study from the western Carpathians. Springer Netherlands, **158**, 201–21.

Gaston K. 2000. Global patterns in biodiversity. Nature **405,** 220-227.

Gauch HG. 1982. Multivariate analysis in community ecology. University Press, Cambridge**.**

Givnish TJ. 1999. On the causes of gradients in tropical tree diversity. Journal of Ecology **876**, 193-210.

Haq FU, Ahmad H, Alam M, Ahmad I, Ullah R. 2010. Species diversity of vascular plants of Nandiar Valley Western Himalaya, Pakistan. Pakistan Journal of Botany **42(S.I.),** 213-229.

Hill MO, Gauch HG. 1980. Detrended correspondence analysis, an improved ordination technique. Journal of Vegetation Science**42**, 47-58.

Hill MO. 1979. *DECORANA—a FORTRAN* program for detrended correspondence analysis and reciprocal averaging. Cornell University, Ithaca, New York.

Hill MO. 1973. Reciprocal averaging: An eigenvector method of ordination. Journal of Ecology**61**, 237-249.

Khan M, Hussain F, Musharaf S. 2014. Floristic Composition and Ecological characteristics Shahbaz Garhi, District Mardan, Pakistan. Global Journel of science frontier Research. **14(1)** Version 1.

Jabeen T, Ahmed SS. 2009. Multivariate analysis of environmental and vegetation data of Ayub National Park Rawalpindi. Soil & Environment **28(2),** 106-112.

Khan MA, Khan MA, Hussain M, Mujtaba G. 2014. Plant diversity and conservation status of Himalayan Region Poonch Valley Azad Kashmir (Pakistan). Pakistan Journal of Pharmaceutical Science **27(5)**, 1215-1239.

Khan SM, Harper DM, Page S, Ahmad H. 2011.Species and community diversity of vascular flora long environmental gradient in Naran Valley: Amultivariate approach through indicator species analysis. Pakistan Journal of Botany **43,** 2337-2346.

Khan SM, Page S, Ahmad H, Shaheen H, Harper D. 2012. Vegetation Dynamics in the Western Himalayas, Diversity Indices and Climate Change. Science, Technology and Development **31 (3),** 232-243.

Komer C. 2000. Why are there global gradients in species richness? Mountains might hold the answer. Trends in Ecology & Evolution **15**, 513-514.

Lomolino MV. 2001. Elevation gradients in species density: historical and prospective views. Global Ecology and Biogeography **10,** 3-13.

Malik NZ, Arshad M, Mirza SN. 2007. Phytosociological attributes of different plant communities of Pir Chinasi Hills of Azad Jummu and Kashmir. International Journal of Agriculture and Biology **9(4),** 569–574.

Malik NZ, Malik ZH. 2004. Present status of subtropical chir pine vegetation of Kotli Hills, Azad Kashmir. Journal of Research (Science) **15**, 85-90.

Malik ZH, Malik NZ, Bashir S, Gorsi MS. 2001. Phytosociological studies on the vegetation of Dao Khan Hills. Journal of Science &technology **25**, 35-41.

Malik ZH, Awan AA, Murtaza G, Hussain F. 1990. Phytosociology of Sundgali near Muzzafarabad Azad Kashmir. Journal of Science &technology **14,** 111-116.

Malik ZH. 2005. Comparative study on the vegetation of Ganga Chotti Bedori Hills, District Bagh, Azad Jammu and Kashmir with special reference to Range condition. Ph. D Thesis, University of Peshawar.

Martin AC, Zim HS, Nelson AL. 1951. American wild life and plants: A guide to wild life food habitats. Dover Publications, New York.

Mehmood A, Shah AH, Khan SM, Shah AH, Ahmad H. 2014. Floristic Diversity of family Poaceae in District Tor Ghar ,Khyber Pakhtunkhwa, Pakistan. Pharmacologyonline **3(SI),** 42.

Mehmood A, Khan SM, Shah AH, Shah AH, Ahmad H. 2015. First floristic exploration of district Tor Ghar**,** Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Botany **47(SI),** 57-70.

Mishra R. 1968. Ecology Work Book. Oxford & IBH, Calcutta.

Monsi M, Khan AH. 1960. Some ecological studies on the natural vegetation in Thal (West Pakistan), Soil symposium, 157168 p.

Nasir YJ, Rafique RA. 1995. Wild Flowers of Pakistan. T. J. Roberts, Oxford University Press, Karachi.

Qureshi R, Shaheen H, Ilyas M, Ahmed W, Munir M. 2014. Phytodiversity and plant life of Khanpur dam, Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Botany **46(3),** 841-849.

Rahbek C. 1995. The elevational gradient of species richness- a uniform pattern. Ecography **18,** 200-205.

Sagers LC, Lyon J. 1997. Gradient analysis in a riparian landscape: contrasts among forest layers, Forest Ecology and Management **96**, 13-26.

Saima S, Dasti AA, Hussain F, WazirS M, Malik SA. 2009. Floristic compositions along an 18-km long transect in Ayubia National Park, district Abbottabad, Pakistan. Pakistan Journal Botany **41,** 2115-2127.

Saima S, Dasti AA, Abbas Q, Hussain F. 2010. Floristic Diversity during monsoon in Ayubia National Park, District Abbottabad, Pakistan. Pakistan journal of Plant Sciences **16(1),** 43-50.

Sakya SR, Bania AMS. 1998. Natural vegetation of Chandragiri region. Ecoprint **5,** 51-5.

Shah AH, Mehmood A, Khan SM, Shah AH, Ahmad H. 2014. Wild Edible Fruits of District Tor Ghar, Western Himalaya of Pakistan. Pharmacologyonline **3(SI),** 27.

Shah AH, Khan SM, Shah AH, Mehmood A, Rehman I, Ahmad H. 2015. Cultural Uses of plants among Basikhel tribe of district Tor Ghar, Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Botany **47(SI),** 17-35.

Shah M, Rozina. 2013. Phytosociological attributes and phytodiversity of Dheri baba hill and Peer Taab Graveyard, District Swabi, Khyber Pakhtunkhwa, Pakistan. Pakhtunkhwa Journal of Life Science **01(01),** 1-16.

Sher Z, Khan Z. 2007. Floristic composition, life form and leaf size spectra of the vegetation of Chagarzai valley, District Buner. Pakistan Journal of Plant Sciences **13(1),** 57 – 66.

Stewart RR. 1972. An annotated catalogue of Vascular plants of West- Pakistan and Kashmir. Karachi: Fakhri Printing Press.

Takhtadzhian AL, Cronquist A. 1986. Floristic Regions of the World. University of California press, Berkeley, Calif. London.

Ter Braak CJF, Smilauer P. 2002. CANOCO reference manual and user's guide to Canoco for Windows: Software for Canonical Community Ordination. Ithaca, NY, US.

Ter Braak CJF. 1989. CANOCO - an extension of DECORANA to analyze species- environment relationships. Hydrobiologia **184,** 169-170.

Ter Braak CJF. 1988. CANOCO-an extension of DECORANA to analyze species- environment relationships. Vegetation **75**, 159-160.

Whittaker RH. 1965. Dominance and diversity in land plant communities. Numerical relations of species express the importance of competition in community function and evolution. Science **147**, 250-260.

Willig MR, Kaufman DM, Stevens RD. 2003. Latitudinal gradients of biodiversity: Pattern, process, scale, and synthesis. Annual Review of Ecology Evolution and Systematics **34,** 273-309.

Zareen AS, Ahmad S, Sardar AA, Khan Z, Nawaz M. 2015. Multivariate analysis of the ecological data of natural vegetation of Lahore district. Journal of Biodiversity and Environmental Sciences **6(1),** 69-76.