Pak. J. Bot., 47(4): 1399-1405, 2015.

VEGETATION DESCRIPTION AND PHYTOCLIMATIC GRADIENTS OF SUBTROPICAL FORESTS OF NANDIAR KHUWAR CATCHMENT DISTRICT BATTAGRAM

FAIZUL HAQ[1*], HABIB AHMAD[2] AND ZAFAR IQBAL[1]

[1]*Department of Botany, Hazara University Mansehra Pakistan*
[2]*Department of Genetics, Hazara University Mansehra Pakistan*
[*]*Corresponding author email: faizulhaq80@yahoo.com*

Abstract

This paper communicates an analytical exploration of the vegetational profile in the subtropical zone of Nandiar Khuwar catchment area, District Battagrtam, Pakistan. On the basis of physiognomy of vegetation the study area was divided into 16 stands. Six plant communities were recognized by TWINSPAN classification. Among biological spectrum nanophanerophytes was dominated with 36 species and leaf size spectra were dominated by microphyll contributing 63 species. Similarity index was maximum (33.61) between *Pinus, Micromeria*, *Rubus* community and *Pinus, Rubus, Cynodon* community. In Bray-Curtis ordination the maximum ordination scores were recorded for axis 2 (0.921). The gradient length was maximum (3.35) for axis 1 with eigenvalue 0.50. Total variance (inertia) in the species data were 2.92, explanatory variables account for 100%. Among environmental variables the maximum positive strength were recorded for altitude (0.818) and Phosphorous (0.801) while maximum negative strength were recorded for wind speed (-0.864), barometric pressure (-0.825) and temperature (-0.820).

Key words: Multivariate analysis, Similarity index, Life form, Leaf spectra, Nandiar Khuwar.

Introduction

Phytosociology is concerned with plant communities, their relationships, structure, composition, distribution, development and the temporary processes modifying them (Poore, 1955). Phytosociological surveys helps in planning, management and exploitation of natural resources. The aim of Phytosociology is to achieve a sufficient empirical model of vegetation using plant species combinations that characterize univocally vegetation units which may express largely abstract vegetation concepts or actual readily recognizable vegetation types (Weber *et al*., 2000). The presence or absence of vegetation is controlled by environmental variables (Leonard *et al*., 1988). In a community on the basis of similarity in structure and function the plant can be classified in different life form and leaf size classes which indicate the adaptation of plants to certain ecological condition. Life form is the indicator of climate (micro and macroclimate) and can be used in comparing geographically widely distributed plant communities (Haq *et al.,* 2015).

Nandiar Kuhwar catchment is located in the northeast part of Khayber Pakhtunkhwa Province of Pakistan between 34˚ 33́ and 34˚ 47́ N and 72˚ 55́ and 73˚ 14́ E (Haq *et al.,* 2011*)*. The area is generally rough and mountainous having variable slopes from gentle to precipitous. Conditions of altitude, aspect, disposition of mountain ranges and prevailing wind currents in the Nandiar Khuwar catchment area results in climates varying from sub tropical at the base of the hills to "alpine" conditions prevailing in the higher reaches (Haq *et al.,* 2010).

Material and Methods

In the subtropical zones of Nandiar Khuwar catchment 16 stands were selected on the basis of physiognomy of vegetation. Line transect method were used for quantitative sampling. The vegetative characteristics (density, relative density, cover, relative cover, frequency, relative frequency and important value index) of each stand were recorded (Brown and Curtis, 1952). The plant community was named on the basis of dominant species (Song, 1992). The IVI data calculated for each stand were further analyzed for classification and ordination. To classify species and samples cluster analysis by TWINSPAN was used (Hill, 1979). Bray-Curtis ordination was used for ordination scores, regression coefficient and variance. DCA analysis was used to investigate the relationship among vegetation types. Canonical correspondence analysis was used in the ordination of main matrix constrained by multiple regression on variables included in the second matrix (Ter Braak, 1986, 1994). The biological spectra, leaf size spectra, similarity and dissimilarity index were recorded for each plant community.

Results

In the subtropical zones of Nandiar Khuwar catchment 157 species were recorded in sixteen stands between altitudinal zones of 530-1950m a.m.s.l. In subtropical vegetation biological spectrum was dominated by nanophanerophytes with 36 species followed by therophytes contributing 27 species. The leaf size spectra were dominated by microphyll with 63 species followed by mesophyll contributing 54 species. The maximum similarity index (33.61) was recorded between *Pinus, Micromeria*, *Rubus* community and *Pinus, Rubus, Cynodon* community. The maximum index of dissimilarity (94.91) was recorded between *Acacia, Dodonaea, Dalbergia* community and *Pinus, Quercus, Eleagnus* community (Tables 1-3).

TWINSPAN classification: The IVI data obtained from 16 stands in the subtropical vegetational zone of Nandiar Khuwar catchment were analyzed by TWINSPAN classification. A total of six plant communities were recognized in this zone (Fig. 1).

Table 1. IVI contribution of Biological spectrum in the subtropical plant communities.

Life form classes	ADD	PMR	PRC	PQE	QDQ	QSI
Phanerophytes	50.6	39.65	45.05	60.84	66.17	80.67
Chamaephytes	12.16	13.2	7.99	10.26	7.33	3.41
Hemicryptophytes	6.54	11.03	20.6	14.77	8.35	7.2
Geophytes	8.63	9.74	4.88	0	4.84	4.47
Therophytes	22.09	26.38	21.48	14.13	13.31	4.07

Table 2. IVI contribution of leaf size spectra in the subtropical plant communities.

Leaf size spectra	ADD	PMR	PRC	PQE	QDQ	QSI
Macrophyll	5.97	2.19	1.48	4.46	3.63	0
Mesophyll	26.73	34.33	25.91	31.23	36.97	35.17
Microphyll	41.59	28.25	33.02	34.96	33.72	38.96
Nanophyll	22.67	29.07	35.31	29.35	20.67	24.21
Leptophyll	2.27	4.82	4.14	0	5	1.48
Aphyllus	0.78	1.35	0.14	0	0	0

Table 3. Similarity and dissimilarity index of in the subtropical plant communities.

	ADD	PMR	PRC	PQE	QDQ	QSI
ADD		27.34	18.7	5.49	21.48	12.9
PMR	72.66		33.61	10	26.35	16.26
PRC	81.3	66.39		18.92	21.21	17.76
PQE	94.51	90	81.08		10	17.33
QDQ	78.52	73.65	78.79	90		27.82
QSI	87.1	83.74	82.24	82.67	72.18	

ADD: *Acacia, Dodonaea, Dalbergia* community; **PMR**: *Pinus, Micromeria*, *Rubus* community; **PRC:** *Pinus, Rubus, Cynodon* community; **PQE**: *Pinus, Quercus, Eleagnus* community; **QDQ**: *Quercus, Dodonaea*, *Quercus* community; **QSI**: *Quercus, Spiraea*, *Indigofera* community

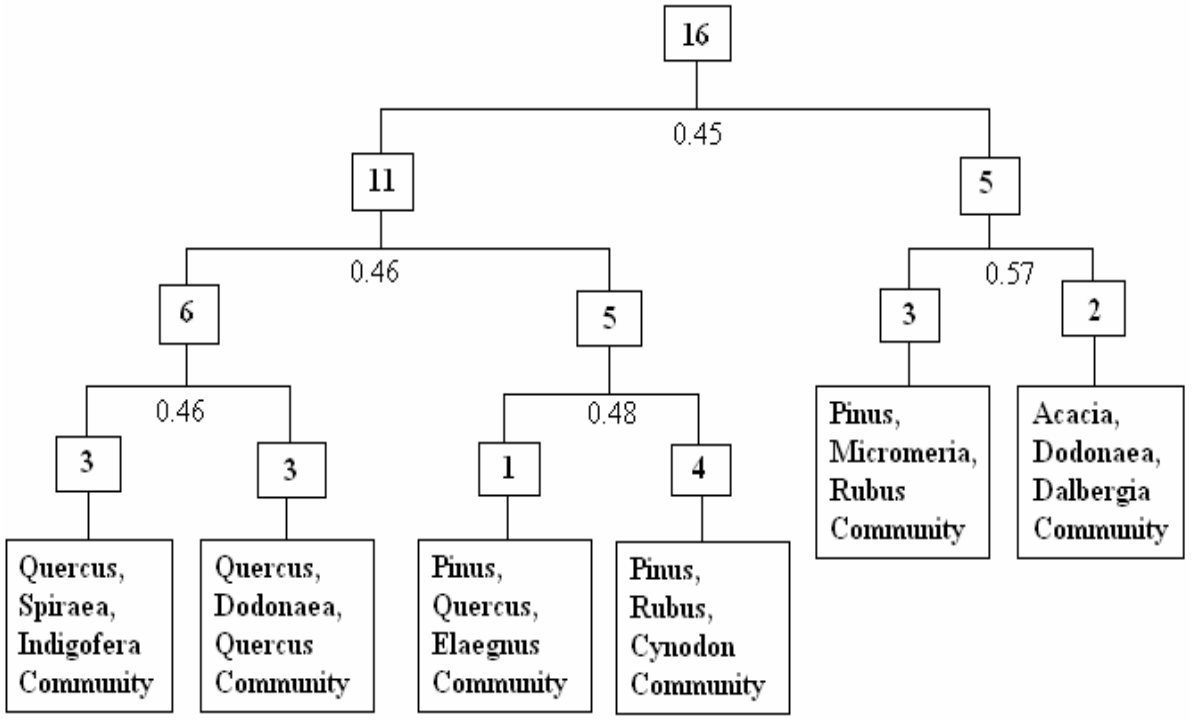

Fig. 1. TWINSPAN classification of the subtropical vegetation of Nandiar Khuwar catchment.

***Acacia, Dodonaea, Dalbergia* community:** *Acacia modesta, Dodonaea vescosa, Dalbergia sisso* community was recorded from two stands Thakot I on south facing steep slope and Thakot II north facing steep slope between an altitudes of 530-700m. In this community phanerophytes were dominated with 32 species followed by therophytes (14), geophytes (9) chamaephytes (8) and hemicryptophytes by 7 species. A leaf size spectrum was dominated by mesophyll by 26 species followed by microphyll (24), nanophyll (12), macrophyll (4) and leptophyll with 2 species while 2 species were aphyllus in nature.

***Pinus, Micromeria, Rubus* community:** *Pinus roxburghii, Micromeria biflora, Rubus fructicousus* community was studied at three stands Peshora, Gajikot and Naraza between elevations of 850-1250m. Among life form classes phanerophytes were dominated by 27 species followed by therophytes with 14 species, chamaephytes by 10 species, hemicryptophytes by 9 species and geophytes by 9 species. Among leaf spectra mesophyll were dominated with 27 species, microphyll by 24 species, nanophyll by 12 species, leptophyll by 3 species and macrophyll by 2 species while single species was aphyllus.

***Pinus, Rubus, Cynodon* community:** *Pinus roxburghii, Rubus fructicousus, Cynodon dactylon* community was recorded in 4 stands Batangi, Khaiabad, Nowshera and Paimal I between elevations of 1200–1650m. Phanerophytes were dominated with 18 species among life form classes followed by therophytes (12), hemicryptophytes (11), geophytes (7) and chamaephytes (5). The leaf size spectrum was dominated by microphyll with 21 species. It was followed by mesophyll (18), nanophyll (10), leptophyll (2) and single species was contributed by macrophyll.

***Pinus, Quercus, Eleagnus* community:** *Pinus roxburghii, Quercus incana, Elaegnus umbellata* community was studied from Lamai between elevations of 1800-1900m. Phanerophytes were represented by 11 species, chamaephytes by 2 species, hemicryptophytes by 4 species and therophytes by 4 species. Among leaf size spectra macrophyll were represented by 1 species, mesophyll by 7 species, microphyll by 8 species and nanophyll by 5 species.

***Quercus, Dodonaea, Quercus* community:** *Quercus incana, Dodonaea vescosa, Quercus glauca* community was studied from Chorlangay, Shagai and Paimal II between elevations of 730-1160m. In this community phanerophytes were represented by 43 species, chamaephytes by 8 species, hemicryptophytes by 7 species, geophytes by 8 species and therophytes by 13 species. Leaf size spectra were represented by macrophyll with 4 species, mesophyll by 27 species, microphyll by 30 species, nanophyll by 15 species and leptophyll by 3 species.

***Quercus, Spiraea, Indigofera* community:** *Quercus incana, Spirea vaccinifolia, Indigofera heterantha* community were recorded from Nilishung Reen, Paimal III and Paimal IV between elevations of 1220–1320m. Phanerophytes were represented by 30 species, chamaephytes by 6 species, hemicryptophytes by 6 species, geophytes by 7 species and therophytes by 5 species. Among leaf size spectra mesophyll were represented by 19 species, microphyll by 22 species, nanophyll by 10 species and leptophyll by 3 species.

Ordination: The IVI data used in TWINSPAN classification were further analyzed for ordination. The response data were compositional with gradient length of 3.3 SD units long. In Bray-Curtis ordination the ordination scores was maximum for axis 2 (0.92). The ordination scores on axes 1 were from Naraza (0.00) to Paimal III (0.82). The regression coefficient for axis 1 were -8.81, variance in distance from the first end point were 0.37. Axis 1 extracted 24.69% of original distance matrix. The ordination scores for axis 2 was from Paimal I (0.00) to Thakot II (0.92). The regression coefficient for axis 2 were –11.32, variance in distance from the first end point were 0.34. Axis 2 extracted 22.89% of original distance matrix. The ordination scores for axis 3 was from Thakot I (0.00) to Lamai (0.70). The regression coefficient for axis 3 were -5.92, variance in distance from the first end point were 0.15. Axis 3 extracted 8.53% of original distance matrix (Fig. 2).

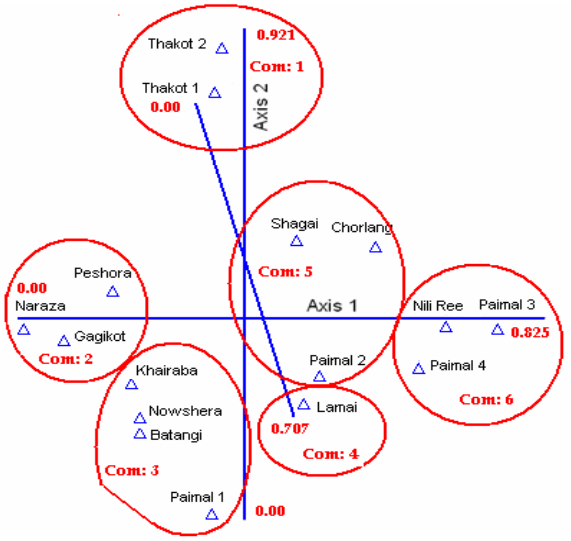

Fig. 2. Bray-Curtis ordination of stands of the subtropical vegetation.

In DCA ordination maximum gradient length (3.35) were recorded for axis 1 with Eigenvalue 0.50. The gradient length for axis 2 was 2.38 with Eigenvalue 0.30. Total variance ("inertia") in the species data were 2.92, supplementary variables account for 100%. The DCA clearly indicates that the whole data set is dominated by a single dominant gradient (Fig. 3).

In CCA ordination the maximum Eigenvalue were recorded for axis 1 (0.50) followed by axis 2 (0.42) and axis 3 (0.31). The percentage variance explained for axis 1, 2 and 3 were 17.21%, 31.88% and 42.64% respectively. The total variance (inertia) in the species data were 2.92, explanatory variables account for 100%. The pseudo-canonical correlation for axis 1, 2 and 3 were 0.996, 0.967 and 0.999. The correlation between sample score for an axis derived from the species data and the sample scores that are linear combination of the environmental variable. The permutation test results for all axes were pseudo-F<0.1, P=1.

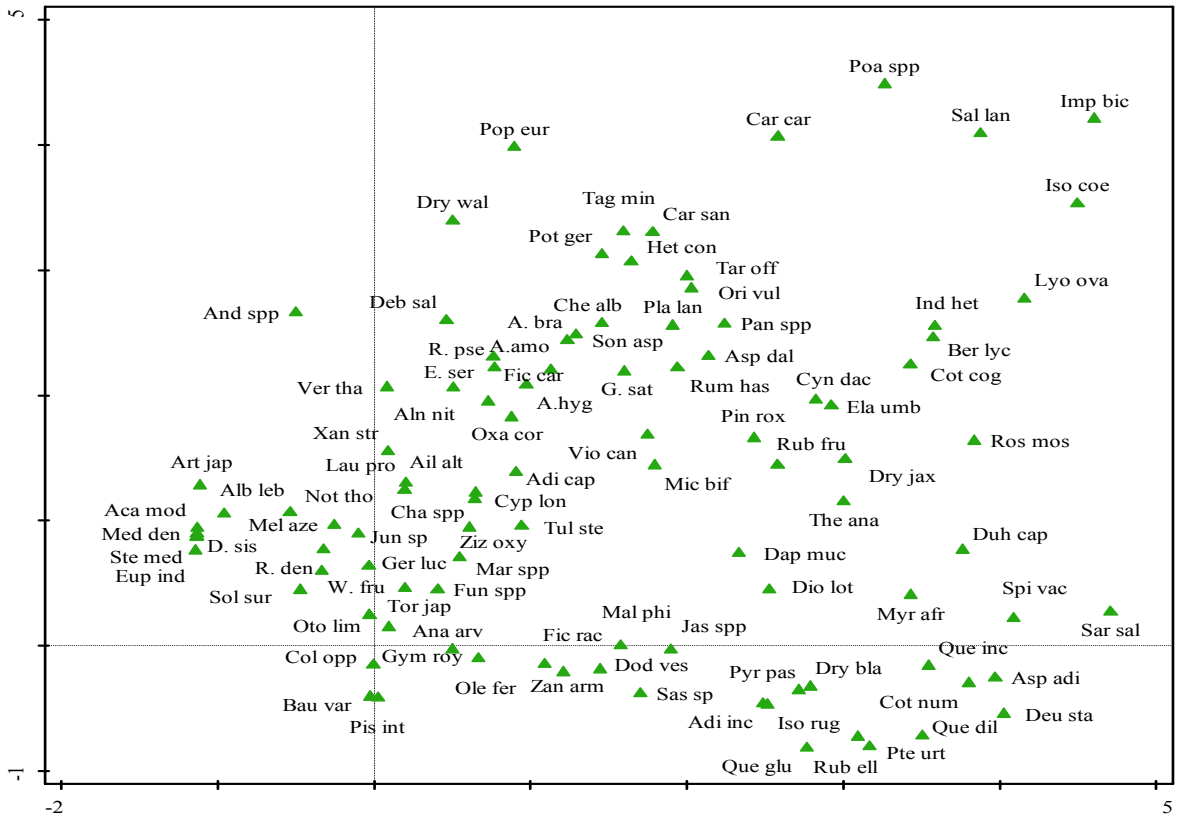

Fig. 3. DCA ordination of the species of subtropical zone of study area.

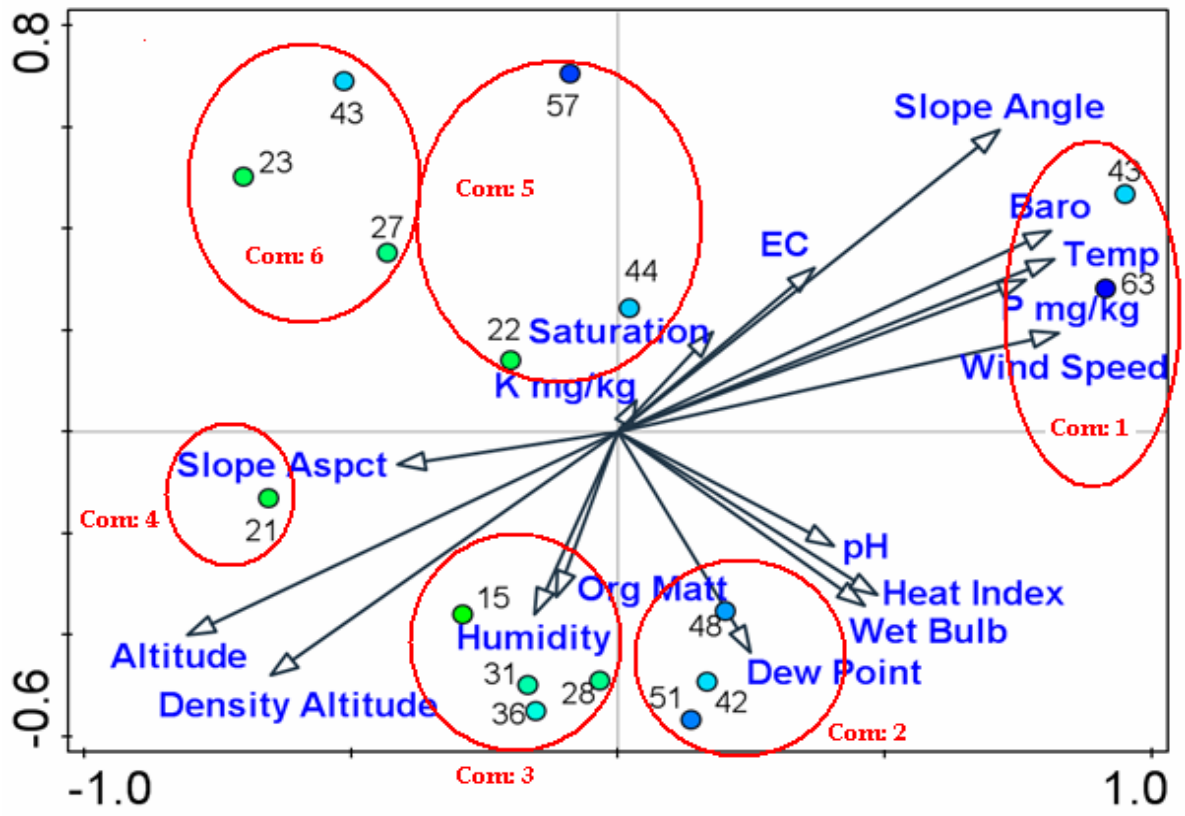

Fig. 4. CCA ordination of the stands of subtropical zone of study area.

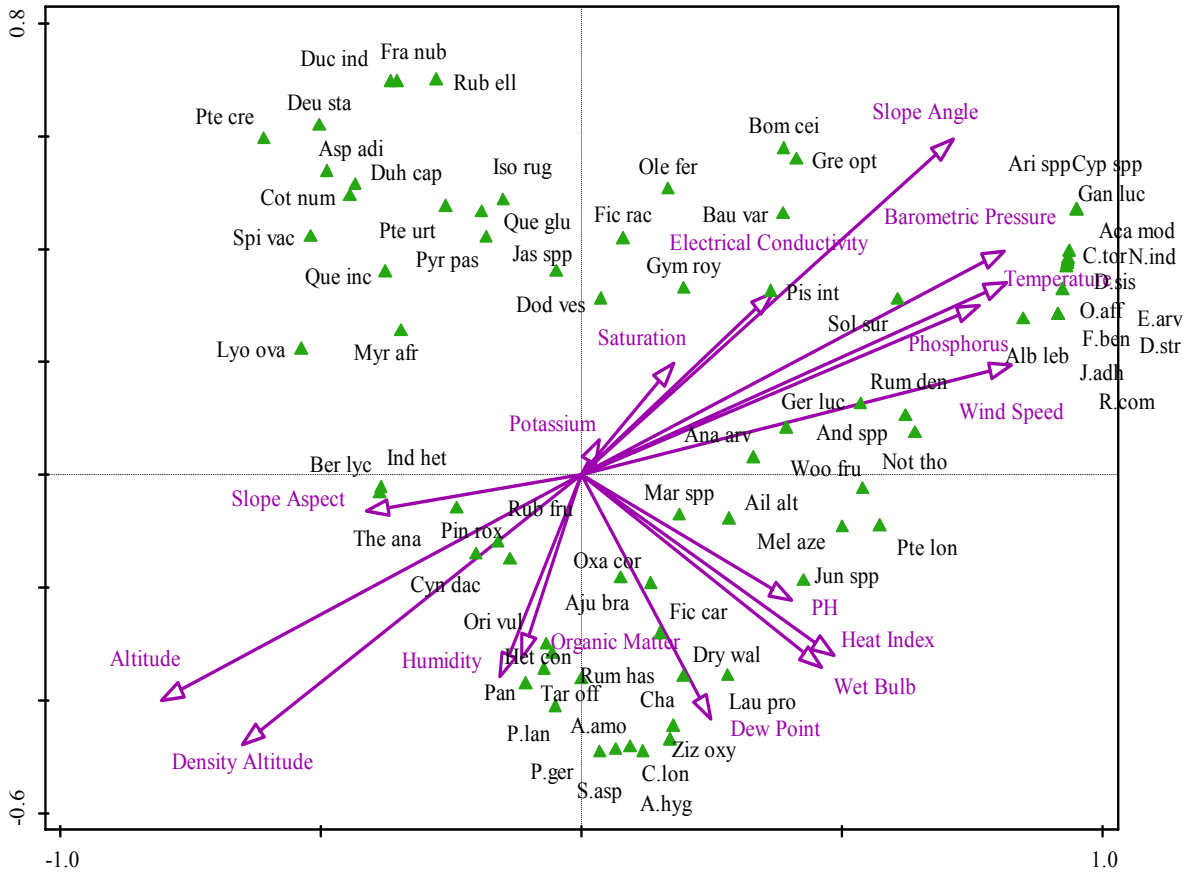

Fig. 5. CCA ordination of species and environmental variables.

In CCA ordination showed that the different stands of *Acacia, Dodonaea, Dalbergia* community clustered at high temperature, barometric pressure, Phosphorus, slope angle and wind speed. *Pinus, Micromeria*, *Rubus* community were positively correlated with dew point, wet bulb, heat index and pH value. *Pinus, Rubus, Cynodon* community was positively correlated with humidity and organic matter. *Pinus, Quercus, Eleagnus* community was positively correlated with slope aspect and high altitude. *Quercus, Dodonaea*, *Quercus* community were recorded at high soil Potassium and soil saturation. *Quercus, Spiraea*, *Indigofera* community were negatively correlated with most of the environmental variables. These results showed that a particular environmental variable has a great affect on the distribution of different plant communities in Nandiar Khuwar catchment (Fig. 4).

The ordination of species and environmental variables showed that different species clustered along different environmental variables. The maximum strength were recorded for temperature, barometric pressure, altitude, density altitude, P mg/kg and wind speed. The minimum environmental variable strength was recorded for organic matter, K mg/kg and soil saturation. *Indigofera heterantha* and *Berberis lycium* are positively correlated with altitudes. *Plantago lanceolatum, Panicum species, Origanum vulgare, Taraxicum officinale* are positively correlated with high atmospheric humidity and soil organic matter. *Xanthium stromarium, Ficus carica* are positively correlated with high pH values, heat index and wet bulb. Similarly *Artemisia japonica*, *Acacia modesta, Albezia lebbeck* are positively correlated with high barometric pressure, temperature, wind speed and P mg/kg. These results showed that a specific environmental variable has a great impact on species distribution in different stands of the study area (Fig. 5).

Discussion

Microclimate is a local atmospheric zone where climate differs from surrounding area. Microclimate depends on slope or aspect of an area beside altitude, latitude and longitude. Altitudinal, latitudinal and longitudinal spatial variation of temperature greatly affects climates and biodiversity (Haq *et al*., 2015). Slope aspect has directly impact on the diversity and species richness (Hoveizeh, 1997). A variety of environmental factors determines the boundaries of altitudinal zones found on mountains, ranging from direct effects of temperature and precipitation to indirect characteristics of the mountain itself, as well as biological interactions of the species. Zonation produces discrete communities along an elevation gradient (Haq *et al*., 2015). Present external factors and historical plant geography are responsible for the determination of a plant community (Poore, 1955).

During present study 157 species were recorded in 16 stands in the subtropical zone of Nandiar Khuwar Catchment District Battagram between altitudinal zones of 530-1850m. Six distinct plant communities were recognized by TWINSPAN. These communities are (1) *Acacia, Dodonaea, Dalbergia* community; (2) *Pinus, Micromeria*, *Rubus* community; (3) *Pinus, Rubus, Cynodon* community; (4) *Pinus, Quercus, Eleagnus* community; (5) *Quercus, Dodonaea*, *Quercus* community and (6) *Quercus, Spiraea*, *Indigofera* community. Similar results were also presented during phytosociological study of *Pinus roxburghii* forests in lesser Himalayan and Hindu Kush range of Pakistan (Siddiqui *et al.,* 2009).

In subtropical zone biological spectrum was dominated by nanophanerophytes with 36 species followed by therophytes contributing 27 species. The dominance of nanophanerophytes indicates that the vegetation of the study area was disturbed due to over grazing, loss of habitat and anthropogenic effects. Meher-Homji (1981) also presented similar results from India. The leaf size spectra were dominated by microphyll with 63 species followed by mesophyll contributing 54 species. The leaf size spectra showed that the study area receive a good amount of precipitation. Our results are n same agreement with the results of Haq *et al.* (2015).

The maximum similarity index value (33.61) was recorded between *Pinus, Micromeria*, *Rubus* community and *Pinus, Rubus, Cynodon* community. The maximum index of dissimilarity (94.91) was recorded between *Acacia, Dodonaea, Dalbergia* community and *Pinus, Quercus, Eleagnus* community. Similar results were also showed by Angelova and Tashev during complex analysis of the life forms of flowering plants in Mount Chepan and their vertical ranges of spread in altitude (Angelova & Tashev, 2005).

The response data were compositional and have a gradient 3.3 SD units long. The total variance (inertia) in the species data were 2.92, explanatory variables account for 100%. In DCA ordination the maximum gradient length (3.35) were recorded for axis 1 with eigenvalue 0.50. In CCA ordination the maximum eigenvalue were recorded for axis 1 (0.50). The Eigenvalue for axis 1 were same in both DCA and CCA. The permutation test results for all axes were pseudo-F<0.1, P=1. The same permutation test results were also obtained for 1st axis. The canonical correlation results also showed that the variation explained by the explanatory variable are same on all axis. Similar results were also showed in the pine forests of moist temperate areas of Pakistan (Siddiqui *et al.,* 2010; 2013; 2014).

The stands of *Acacia, Dodonaea, Dalbergia* community clustered at high temperature, barometric pressure, Phosphorus, slope angle and wind speed. *Pinus, Micromeria*, *Rubus* community were positively correlated with dew point, wet bulb, heat index and pH. *Pinus, Rubus, Cynodon* community was positively correlated with humidity and organic matter. *Pinus, Quercus, Eleagnus* community was more correlated with slope aspect and high altitude. *Quercus, Dodonaea*, *Quercus* community were recorded at high soil Potassium and soil saturation. *Quercus, Spiraea*, *Indigofera* community were negatively correlated with most of the environmental variables. These results showed that a particular environmental variable has a great affect on the distribution of different plant communities in Nandiar Khuwar catchment (Khan *et al.,* 2013).

Among environmental variables maximum strength were recorded for slope angle, temperature, barometric pressure, altitude and density altitude. The minimum strength were recorded for organic matter, K mg/kg and soil saturation. *Indigofera heterantha* and *Berberis lycium* were positively correlated with high altitudes. *Plantago lanceolatum, Panicum species, Origanum vulgare, Taraxicum officinale* were positively correlated with high atmospheric humidity and soil organic matter. *Xanthium stromarium, Ficus carica* were positively correlated with high pH values, heat index and wet bulb. Similarly *Artemisia japonica*, *Acacia modesta, Albezia lebbeck* were positively correlated with high barometric pressure, temperature, wind speed and Phosphorus. These results showed that a specific environmental variable has a great impact on species distribution in different vegetational zones of the study area (Haq *et al.,* 2015).

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(Received for publication 18 April, 2014)