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FLORISTIC COMPOSITIONS ALONG AN 18 – KM LONG TRANSECT IN AYUBIA NATIONAL PARK DISTRICT ABBOTTABAD, PAKISTAN

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Abstract

The floristic variation in Himalayan moist temperate coniferous forests in Pakistan is poorly understood. Wet temperate forests of Pakistan are interesting because at suitable elevations it merge downward with the tropical thorn forests and upward with the alpine meadows. The very situation of these forests thus make making them a sort of enclave in which the diversity of natural sites has allowed a number of relict species to persist. We recorded the vegetation pattern along a continuous 18 Km long transect that crossed a mixed coniferous forest. Vegetation data was analyzed by multivariate statistics including cluster analysis, Detrended Correspondence Analysis (DCA) and Spearman's Rank Correlation Coefficient to detect relationship between environmental factors and species distribution. Soils were physically and chemically analyzed. Soil texture, pH and tree density were the major determinant of vegetation pattern in these forests. Plant diversities and assemblage with respect to environmental features in these broad forest categories were discussed.

Introduction

Champion *et al*., (1965) and Hussain & Ilahi (1991) described the study area (Fig. 1) as Himalayan moist temperate forests. These forests are most attractive in the Himalayas with varying degree of coniferous species including *Abies pindrew*, *Pinus wallichiana, Taxus wallichiana* and *Cedrus deodara* with varying admixture of evergreen and deciduous patches of broad leaved forests. The forest canopy may be varying from dense to broken open grassy patches. The density of under growth depends mainly on the over-wood and intensity of the grazing. Rich herbaceous vegetation is developed during the monsoon. A variety of ferns being the first to develop in the spring after the snow melts; followed by a variety of perennial species. There is a good deal of mosses and lichens on the trees trunks.

Wet temperate forests of Pakistan merge downward with the tropical thorn forests and upwards with the alpine meadows. The precipitation may reach or even sometimes exceed 600 mm, thus making of these montane forests a sort of enclave in which the diversity of natural sites and plants make it a sort of bio-geographical crossroad between submontane and alpine meadow vegetation.

Studies on temperate forests of Pakistan and India have mainly been floristical and/or phyto-geographical (Champion *et al.*, 1965; Hussain & Ilahi, 1991; Ahmed *et al.*, 2006). Modern synecological methods have developed techniques for use at local and regional level, seeking to reduce the complexity of field data set by classification and ordination of floristic data and then relating the results to environmental information (ter Braak, 1987). Such objective approaches have rarely been applied to the vegetation data of Pakistan. Primary objective of this study was to explore the factors that determine the boundaries and composition of plant communities in Himalayan wet temperate forests of Pakistan.

Materials and Methods

Study area

Study sites were selected in and around the Ayubia National Park District Abbottabad (72-74 °E and 34-36 °N). The surface topography displays only moderate relief that results from forest heave and the presence of shallow ephemerals streams and ponds that are active during spring melt or during heavy rain. Sampling sites were selected keeping in view including maximum possible heterogeneity in vegetation. All sites were located along the increasing altitude from South to North of the Ayubia National Park (Fig. 1).

The precipitation from the south-west monsoon falls during July to September. The intra annual variation in rainfall is the general characteristic of the study area. Due to inadequate climatological data the nearest stations (Fig. 2) may be taken as typical for the outer ranges of the study area. There is always heavy snowfall to maintain the soil moisture during the summer months. The average winter accumulation of snow is about 660cm (Champion *et al*., 1965; Hussain & Ilahi, 1991). Snow slides often occur and wipe out strips of forest along their course.

A single transect was used instead of discrete plots as continuous sampling allows comparison of spatial changes between data sets, and assessment of whether turnover is spatially continuous or occur more rapidly at certain points (Tuomisto *et al*., 2003a). Vegetation parameters were recorded systematically in 18 Kilometer long transects. The direction of transect was from south to the north. At each Kilometer, 100 m^2 stands were established and vegetation parameters were monitored by placing 10 randomly placed $5m^2$ quadrats in each stand. All the vascular species were recoded except grasses because they form a little proportion of the total ground cover. All the stands were demarked within an estimated 2.0 m to the left side of transect during monsoon season (May to August, 2004). Thus a total of 180 samples were obtained containing 142 species. To facilitate observation and sampling, only the individuals with at least one leaf longer than 10 cm were considered, and climbing individuals whose lower most green leaves were higher than 2 m above ground were ignored.

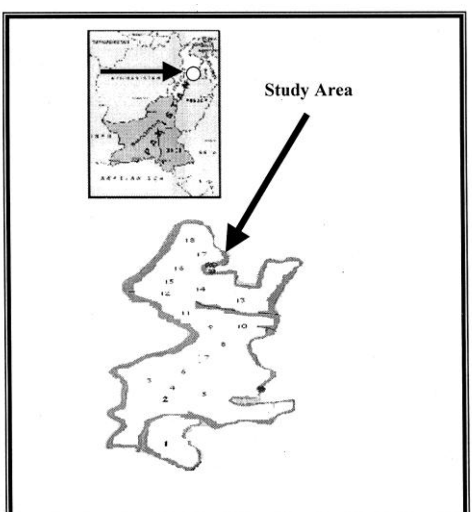

Fig. 1. The location of study area and sampling sites.

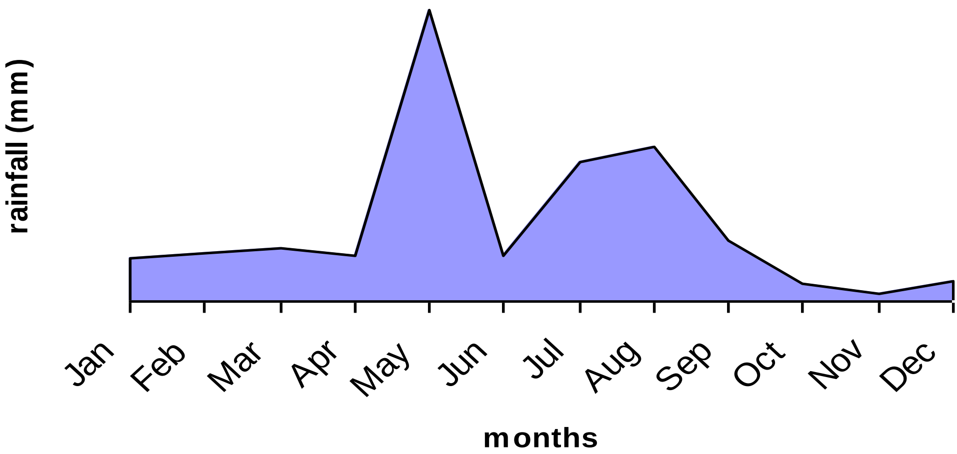

Fig. 2. Mean monthly rain fall (mm) of Ayubia National Park (A record of 60 years).

Soil samples (2-10cm depth) were taken from each site (Dasti *et al.*, 1998). Soil depth to 2-cm was sampled in the rocky sites because the main root zone occurred within the first 2-cm. However, in the non rocky soil the rooting zone was deeper, and the top layers of soil were very disturbed; hence, these soils were sampled up to 10-cm depth. The samples were air-dried and passed through a 2-mm sieve. The portions finer than 2 mm was used for physical and chemical determinations following Champion & Pratt (1961). The soil soluble salts i.e., sodium, potassium and magnesium were analyzed by atomic absorption spectrophotometer.

Data analysis: The classification and ordination methods were used to analyze the data structure. The main emphasis was on classification while ordination was used in part to check whether the classification results reflect an adequate way the main floristical gradients in the data set and to detect relations between some environmental factors and the composition and structure of vegetation. We used the hierarchical subdivision using the Monothetic Information Statistic. This technique is based on the method of a divisive species and was used as a quick and efficient way to obtain clustering of 180 samples (Fig. 3).

Species Presence/absence values were ordinated by Detrended Correspondence Analysis (DCA) using the program DECORANA (Hill, 1979; Causton, 1988). The ordination axes 1 and 2 were used for data interpretation. Scatters of classification groups were plotted as an overlay of the ordination to assess the compatibility of the two methods of data simplification (Dargie & Demerdash, 1991; Dasti & Agnew, 1994).

The soil data was subjected to an analysis of variance between the communities for each soil variable. The 5% level of significance was adopted. The multiple range test (Duncan, 1955) was used to detect and compare any significant difference between the means of different communities delineated by cluster analysis. Correlation of soil variables with scores on the axes 1 and 2 of the ordination was calculated according to Pearson correlations using MINITAB-a statistical computer package.

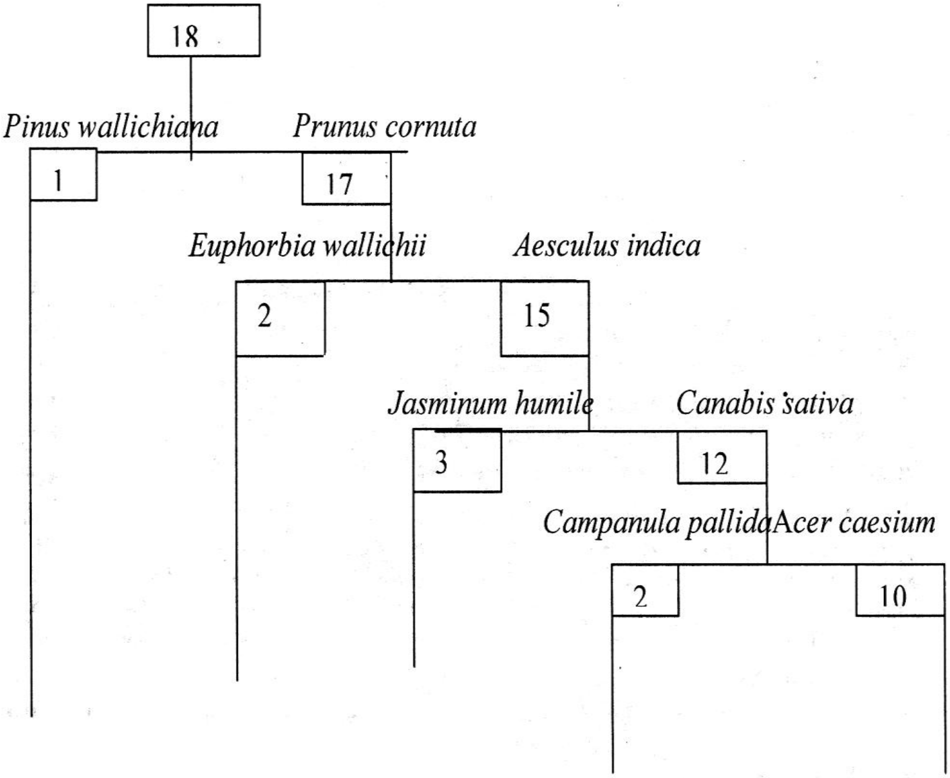

Fig. 3. The hierarchy of classification of 18 samples from the Ayubia National Park by the monothetic divisive technique. Divisor species are given. The number of samples (stands) in each association is given in boxes.

Results

Classification: Five plant associations with different botanical composition were recognized on the basis of cluster analysis (Table 1). The most noticeable feature indicated by multivariate analysis was the separation of the open disturbed sites (stands belonging to association E) from the over-wooded ones (stands belonging to association A-D) as evident in the left of Fig. 4. The 20 samples of community E were separated from the rest at the first hierarchical level by *Berula erecta* and *Prunus cornuta* (Fig. 4). In the over wooded region the samples belonging to association D (stands 8 and 11) were separated from those belonging to associations A-C at level two by *Euphorbia wallichii*, *Medicago laciniata* and *Micromeria biflora*. The third hierarchical level separated the three sites (3, 4 and 6) belonging to association C having *Ficus palmata* and *Jasminum humile* from the rest. *Campanula pallida*, *Cuscuta reflexa*, *Potentilla nepalensis* and *Marrubium vulgare* were the divisor species for associations A and B.

The vegetation types were named after the dominant species. If several co-dominant species occur, the one most restricted to the vegetation type was chosen. Dominance frequencies are listed in Table 1.

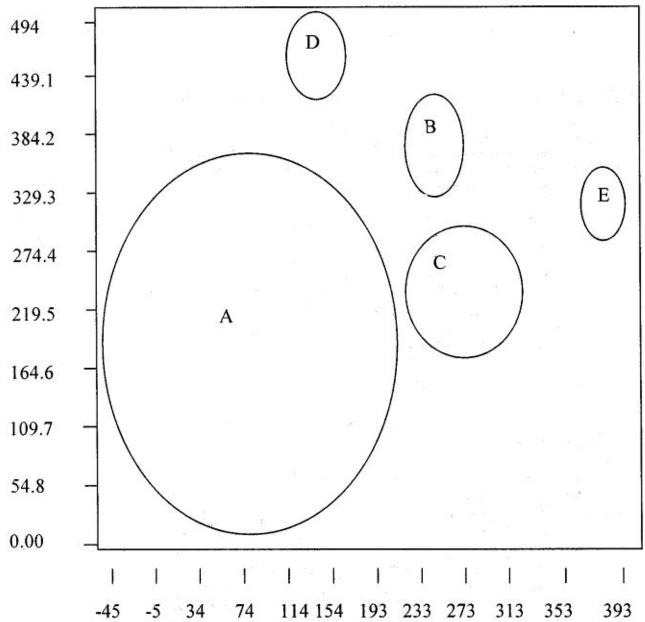

Fig. 4. Results of detrended correspondence ordination of the sites grouped by associations produced by cluster analysis.

1. *Pinus wallichiana-Fragaria indica* association: Floristic composition of this association appeared to be varied in response to small-scale altitudinal differences, although most species showed fairly broad distribution patterns. This association was mostly occupied by *Abies pindrow, Quercus dilatata, Acer caesium,* and *Pinus wallichiana*. Deciduous shrubby undergrowth was almost present. *Viburnum coninifolium, Lonicera quinquelocularis, Rubus gracilis, Cannabis sativa, Debregeasia salicifolia, Fragaria indica, Indigofera gerardiana* and *Plectranthus rugosus* were the common species. Luxuriance of these second storey shrubs seemed to be linked with density of the canopy and the intensity of grazing. Some evergreen shrubs such as *Sarcococa saligna* and *Skimmia laureola* were often met with. Climbers such as *Rosa, Clematis* and *Hedera nepalensis* were more frequent. There was typically luxuriant herbaceous flora between the shrubs. The herbaceous flora included a great many genera and families many of them were of Sino-Japanese origin. The most common among them were *Fragaria indica, Viola canescens, Podophyllum emodi, Polygonum, Euphorbia wallichii.* Ferns like *Adiantum venustum* and *Pteris* were frequent at all the moist sites.

2. *Fragaria indica-Gallium apparine* association: This association was rich in herbaceous flora, mostly perennials, developing as soon as the snow melts. The characteristic species were *Campanula pallida, Marrubium vulgare* and *Potentilla nepalensis*. These species were not found in any association delineated by the normal cluster analysis. This association was normally confined to localized shallow enclosed basins which receive plentiful run on before they discharge. *Pinus wallichiana* often occurred in more or less pure patches marking the site of old landslips or other clearings. Blue pine colonized often most open spots except where soil drainage was very poor.

Table 1. Frequency percentage of the species in each association from the Normal Cluster Analysis.

Species	Associations				
	A	B	C	D	E
Abies pindrow Royle	3.98278	0.43478	2.71903	3.33333	--
Acer caesium Wall. ex Brandis	0.21529	--	--	--	--
Achillea millefolium L.	0.53821	--	--	1.11111	--
Achyranthus bidentata L.	0.21529	0.43478	0.60423	0.55556	1.19048
Adiantum venustum D. Don.	1.82992	0.43478	3.32326	1.11111	--
Aesculus indica (Wall. ex Camb.) Hk.	0.64586	0.43478	2.71903	--	--
Agrimonia eupatoria L.	0.32293	1.73913	0.30211	--	1.19048
Ajuga bracteosa Wall. ex Bth.	0.53821	0.43478	0.30211	--	--
Allium ascolonicum Bioss.	0.21529	--	--	--	--
Androsace foliosa Dcne. ex Duby	0.43057	--	--	1.11111	--
Androsace rotundifolia Hardw.	0.43057	--	--	0.55556	--
Aquilegia purviflora Wall.	0.43057	0.43478	--	0.55556	--
Arisaema jacquemontii Blume	3.55221	2.6087	2.41692	1.66667	--
Arisaema wallichianum Hk. f.	0.10764	0.86957	--	--	--
Artimisia purviflora Roxb.	0.10764	0.86957	0.60423	--	1.19048
Artimisia roxburghiana Wall. ex Besser	0.21529	2.6087	0.90634	--	4.7619
Asplenium trichomanass L.	3.98278	1.30435	3.32326	0.55556	--
Astragalus chlorostachys Lindl.	--	--	1.51057	0.55556	--
Berberis pachyacantha Koehne.	0.43057	--	0.30211	--	--
Berginia ciliata (Haw.) Sternb.	0.53821	--	0.30211	--	1.19048
Berula erecta (Huds.) Cav.	--	--	--	--	2.38095
Bidens chinensis (L.) Willd.	0.43057	--	1.51057	1.11111	2.38095
Boerhaavia coccinea Mill.	0.21529	--	0.90634	--	--
Prunella vulgaris	1.07643	--	--	--	--
Bupleurum linearifolium DC.	0.64586	1.30435	0.90634	1.66667	3.57143
Calamintha vulgaris (L.) Druce	2.79871	0.86957	1.20846	3.88889	--
Campanula pallida Wall.	--	0.86957	--	--	--
Cannabis sativa Lamk.	0.43057	0.43478	--	0.55556	--
Capsella bursa-pastoris (L.) Medic.	0.96878	1.30435	--	0.55556	--
Cardamine macrophylla Willd.	0.7535	1.30435	1.20846	1.11111	--
Cedrus deodara (Roxb. Ex Lamb.) G.Don.	0.32293	--	0.90634	--	--
Celosia argentea L.	0.96878	--	1.20846	1.11111	2.38095
Cenchrus ciliaris L.	0.21529	--	--	--	2.38095
Cerastium davuricum Fish. Ex Spreng	1.18407	0.86957	--	0.55556	--
Cissampelos pareira L.	0.10764	--	--	--	--
Clandula arvensis L.	1.18407	0.43478	0.60423	--	--
Clematis montana DC.	0.21529	0.86957	0.60423	--	--
Cuscuta reflexa Roxb.	--	0.43478	--	--	--
Debregeasia salicifolia (D. Don.) Rendle	0.21529	--	0.30211	0.55556	1.19048
Dicliptera roxburghiana Nees	--	0.43478	1.20846	0.55556	--
Dioscorea deltoidea Wall. ex Kunth	0.53821	1.73913	--	2.22222	--
Diospyros lotus L.	0.53821	--	--	--	--
Dipsacus inermis D. Don	--	--	0.30211	--	1.19048
Dryopteris ramosa (Hope) C. Chr.	0.32293	--	1.20846	--	--
Ehretia laevis Roxb.	0.10764	0.43478	0.60423	--	2.38095
Epilobium hirsutum L.	--	0.43478	0.30211	--	--
Epipecits heliborine (L.) Crantz stirp.	--	--	0.90634	1.66667	2.38095

Table 1. (Cont'd.).

Species	Associations				
	A	B	C	D	E
Eremostachys vicaryi Bth. ex Hk.	0.21529	2.17391	--	--	--
Euphorbia wallichii Hk. f.	--	--	--	2.22222	--
Ficus palmata Forssk.	--	--	0.90634	--	--
Fragaria indica (Andr.) Focke	4.41335	3.47826	3.62538	2.77778	--
Gallium apparine L.	0.7535	3.47826	1.20846	0.55556	2.38095
Gentiana argentea (Royle ex D. Don.) DC.	0.32293	--	--	1.66667	3.57143
Geranium lucidum L.	0.10764	0.43478	--	2.22222	--
Geranium rotundifolium L.	1.82992	--	2.41692	--	--
Geranium wallichianum D. Don. ex Sweet	0.21529	3.47826	--	1.11111	1.19048
Geum urbanum L.	0.43057	--	--	--	--
Gnaphalium luteo-album L.	0.32293	--	0.90634	1.66667	2.38095
Hedera nepalensis K. Koch	2.36814	0.43478	0.30211	2.22222	--
Hypericum dyeri L.	0.64586	1.73913	2.41692	0.55556	2.38095
Impatiens bicolor Royle	0.21529	--	--	--	--
Impatiens brachycentra Kar. & Kir.	0.53821	--	2.41692	0.55556	--
Impatiens edgeworthii Hk. f.	1.18407	2.6087	0.90634	0.55556	--
Indigofera gerardiana Wall. ex Baker	0.32293	2.17391	2.1148	1.11111	4.7619
Jasminum humile L.	--	--	0.90634	--	--
Juglans regia L.	0.86114	--	--	--	--
Lactuca dissecta D. Don.	0.21529	--	1.51057	--	--
Lamium album L.	--	1.30435	--	1.11111	--
Lavatera kashmiriana Camb.	0.32293	0.86957	0.60423	--	1.19048
Leonurus cardiaca L.	0.32293	--	--	--	--
Lespedeza sericea (Thunb.) Miq.	--	0.86957	--	--	2.38095
Lonicera quinquelocularis Hardw.	2.15285	3.04348	1.20846	2.22222	2.38095
Malva neglecta Wall.	--	--	--	1.11111	2.38095
Malvastrum coromandelianum L.	0.10764	1.30435	0.60423	0.55556	3.57143
Marrubium vulgare L.	--	1.73913	--	--	--
Medicago laciniata Urb.	--	--	--	2.77778	--
Micromeria biflora (Ham.) Bth.	--	--	--	2.22222	--
Myosotis palustris (L.) Nath.	0.53821	0.86957	--	--	--
Myriactus wallchii Less.	2.04521	--	0.30211	--	--
Nepeta govaniana Bth.	0.21529	1.73913	--	--	--
Oniychium contiguum Wall. ex Hope	1.18407	0.86957	1.20846	1.11111	--
Origanum vulgare L.	0.43057	--	0.60423	1.66667	--
Oxalis corniculata L.	0.86114	--	0.30211	--	--
Parnassia nubicola Wall. ex Royle	0.21529	--	--	1.66667	--
Peristrophe bicalyculata (Retz.) Nees	0.21529	--	1.20846	1.11111	--
Pinus wallichiana A. B. Jackson	4.19806	2.6087	3.62538	5	--
Plantago lanceolata L.	0.32293	0.86957	0.60423	0.55556	1.19048
Plantago major L.	0.43057	0.86957	0.90634	0.55556	1.19048
Plectranthus rugosus Wall. ex Bth.	--	3.91304	0.30211	1.66667	4.7619
Podophilum emodi Wall. ex Royle	0.10764	--	1.20846	--	--
Polygonum nepalense Meissn.	0.21529	0.86957	0.30211	--	1.19048
Polygonun amplexicaule D. Don.	2.47578	2.6087	3.02115	1.66667	--
Polygonun aviculare L.	0.21529	0.43478	0.90634	--	--
Populus ciliata Wall. Ex Royle	0.53821	--	0.90634	--	--
Potentilla nepalensis Hk.	--	1.73913	--	--	--

Table 1. (Cont'd.).

Species	Associations				
	A	B	C	D	E
Prunella vulgaris L.	1.07643	--	--	--	--
Prunus cornuta (Wall. ex Royle) Steud.	--	--	--	--	1.19048
Pteris cretica L.	0.86114	0.43478	0.30211	1.66667	--
Quercus baloot Griffith	0.32293	--	--	0.55556	--
Quercus dilatata Lindle. ex Royle	0.7535	0.43478	1.20846	1.66667	--
Quercus incana Roxb.	0.21529	--	0.60423	0.55556	--
Ranunculus leatus Wall. ex H. & T.	1.29171	0.86957	1.81269	0.55556	--
Robinia pseudoacacia L.	0.64586	--	--	--	--
Rosa brunonii Lindl.	1.82992	1.73913	0.90634	2.22222	5.95238
Rosa macrophylla Lindl.	0.53821	0.86957	1.51057	--	2.38095
Rubia cordifolia DC.	0.32293	1.30435	0.90634	0.55556	--
Rubus pedunculosus D.Don,	0.53821	--	--	--	--
Rumex acetosa L.	2.58342	1.73913	0.60423	2.77778	1.19048
Rumex nepalensis Spreng.	--	0.43478	--	--	1.19048
Salix acmophylla Bioss.	0.53821	--	0.30211	--	--
Salvia nubicola Wall. Ex Sweet	0.21529	--	0.30211	--	2.38095
Sarcococa saligna (Don.) muell.	1.39935	--	0.30211	2.77778	--
Sauromatum venosum (Ait.) Schott	0.7535	--	--	0.55556	--
Scrophularia latifolia (Bth.) Penn.	0.21529	--	0.90634	--	--
Selinum tenuifolium Wall. ex Clarke	--	0.86957	0.30211	--	--
Senecio chrysanthemoides DC.	0.53821	--	--	1.11111	--
Seudum ewersii Ledeb.	0.32293	2.17391	--	--	--
Silene vulgaris (Moench) Garcke	0.32293	--	--	1.11111	--
Silybum marianum Gaertn.	0.86114	0.43478	--	--	--
Skimmia laureola (DC.) Sieb. Zucc. ex Walp	2.04521	2.17391	0.60423	--	1.19048
Solanum miniatum Berh. Ex Willd.	0.10764	0.86957	--	--	3.57143
Sorbaria tomentosa (Lindl.) Rehder	1.18407	--	--	--	3.57143
Spiraea vaccinifolia D. Don.	0.32293	1.30435	1.51057	--	--
Strobilanthus glutionousus Nees	0.96878	2.6087	3.02115	1.11111	--
Swertia chirayita (Roxb. ex Fleming) Karst.	1.39935	1.30435	0.30211	--	1.19048
Tagetus erecta L.	0.10764	0.86957	0.90634	1.66667	--
Taraxacum officinale Wigg.	0.43057	--	0.30211	--	1.19048
Taverniera nummularia auct. non DC.	0.21529	--	--	2.22222	--
Taxus wallichiana Zucc.	1.39935	--	1.51057	1.66667	--
Torilis leptophilla (L.) Reichb. F	0.10764	1.30435	0.30211	--	--
Tricholepis stewartii Clarke ex Hk. f.	--	--	0.90634	0.55556	2.38095
Trifolium repens L.	1.39935	1.30435	0.60423	--	1.19048
Urtica ardens Link	0.10764	0.86957	0.60423	0.55556	--
Urtica dioica L.	2.36814	1.30435	2.1148	--	--
Valerianella dentata Pall.	0.21529	--	0.90634	--	--
Verbena bonariensis L.	0.53821	0.86957	--	--	--
Verbescum thapsus L.	0.53821	0.43478	--	--	1.19048
Veronica arvensis L.	0.7535	--	0.30211	1.11111	1.19048
Viburnum continifolium D. Don.	3.12164	0.86957	1.81269	2.22222	--
Viola canescens Wall. ex Roxb.	3.12164	1.30435	2.41692	3.33333	--
Vitex negundo L.	0.10764	--	--	--	--
Wulfenia ambherstiana (Wall.) Bth.	--	--	0.30211	0.55556	2.38095
Zeuxine strateumatica (L.) Schlecther	0.32293	0.43478	0.90634	--	--

3. *Adiantum venustum-Asplenium trichomanes* association: The vegetation type occupied the moist and humid soils covered with plentiful litter and was also common along the perennial water courses and springs. The steep cool slopes and the flatter ground with deep soil had deciduous broad leaf species of several genera of circumpolar distribution like *Aesculus* and *Populus* which often formed a close canopy. The important coniferous genera of this association were *Pinus, Abies* and *Cedrus*. Deciduous shrubby undergrowth was almost present with *Lonicera* and *Viburnum* as important genera. Some evergreen shrubs i.e. *Sarcococa* and *Strobilanthus* also met with and fern species generally occurred luxuriantly over considerable areas. Various climbers of temperate genera viz., *Rosa, Clematis* and *Hedera* were also present in this association but unimportant.

4. *Pinus wallichiana* association: The chief conifers of this association were *Pinus wallichiana, Abies pindrow* and *Taxus wallichiana*. Among the broad leaved trees the genus *Quercus* with three species contributed to the floristic composition of this association. Among the shrubs, *Indigofera, Lonicera, Rosa* and *Viburnum* were typical. The herbaceous flora included *Impatiens, Euphorbia* and *Fragaria*.

5. *Plectranthus rugosus-Indigofera gerardiana* association: Trees were absent in this association. It was dominated by *Plectranthus rugosus, Indigofera gerardiana, Malvastrum coromandelianum, Rosa brunonii* and *Spiraea vaccinifolia* with ground flora of *Artimisia roxburghiana, Bupleurum linearifolium, Gentiana argentea* and *Solanum miniatum*. This association was found at open gently sloping grounds. The vegetation was reduced to scrub and grassland. Regeneration of trees was greatly hampered due to grazing and trampling, leading to the open treeless pastures.

Gradient analysis: In the DCA ordination based on the floristic inventory data, rare species were down weighted and the eigenevalues for the four DCA axes were 0.250, 0.203, 0.181 and 0.125 respectively. The axis 1 and 2 showed significant correlations with soil attributes and altitude (Table 2) and no further use was made of the remainder of the axes.

It was clear that this main ordination is along the pH and altitudinal gradient from the bottom and to the top of transect. The DCA axis showed the strongest correlation with pH ($R = 0.688$) and elevation ($R = 0.518$). The both DCA axes 1 and 2 have significant correlation with many soil variables.

Discussion

Vegetation correlation with environment: Most of the edaphic factors included in the present investigation were associated with the distribution of the species in the study area. In terms of correlation, the rank of the factors was pH > altitude > tree density > bulk density > phosphorus > calcium + Mg > porosity > texture. All these factors significantly correlated with DCA axis 1 (Table 2) that determined the boundaries and the composition of the plant communities. Apart from the fact that the edaphic variables are indeed relevant for explaining the main vegetation types, the correspondence between the results of cluster analysis and DCA planes permit a direct interpretation of scores of stand data in DCA plane in relation to soil variables. The five associations produced by cluster analysis are plotted on first two axes as a scattered diagram (Fig. 4). The ordination axes may represent in some

Table 2. Spearman's Rank Correlation Coefficients between DCA first and second axes scores, soil parameters and altitude for Ayubia National Park.

Factors	Axis 1	Axis 2
Potassium (K)	0.387	-0.452*
Soil reaction (pH)	0.688***	-0.121
Electrical Conductivity (Ec)	0.297	0.237
Total Soluble Salts	0.312	0.217
Calcium & Magnessium (Ca & Mg)	0.429*	0.171
Organic Matter	0.088	0.136
Phosphorus	-0.417*	0.073
Saturation %	0.122	-0.374
Sodium (Na)	0.056	0.215
Bicarbonate (HCO_3)	0.342	0.310
Chloride (Cl)	0.068	-0.009
Organic Carbon	0.240	0.275
Nitrogen	-0.164	-0.005
Sodium Adsorption Ratio (SAR)	-0.189	0.044
Exchangable Sodium Percentage (ESP)	-0.197	0.032
Bulk Density	0.403*	-0.255
Porosity	-0.403*	0.263
Sand	0.447*	0.526*
Silt	-0.303	-0.219
Clay	-0.353	-0.497*
Altitude	0.518**	-0.124
Litter	-0.233	0.252
Bare	0.318	0.144

way the major substrate influenced which effect the stands in these data, and have been used the plant and soil characteristics of the association (Table 3) to discuss the overriding features of the environment. The importance of altitude as an environmental factor affecting plant species association is not surprising, considering its close correlation with rainfall and redistribution of rainfall water (Dasti & Malik, 1998; Danin *et al.*, 1975; Evenari *et al.*, 1982). The analysis and assessments of pattern and zonation along the first ordination axis suggest that the most important environmental gradients and boundaries across the landscape are associated with down slope movement of water. The variations in runoff patterns and soil texture might be responsible for the occurrence of such correlations. If this assumption is true then it is suggested that some combined effect is important in determining the distribution pattern of the plant species. This assumption is supported by the fact that all species show differential distributions in relation to edaphic factors over relatively short environmental gradients in such forests.

Among the edaphic factors, changes in soil pH along the altitude have overriding importance in determining the pattern of species distribution over the landscape. Soil pH usually rises with altitude as is evident from the significant positive correlation between soil pH and altitude (R = 00). This correlation confirms the findings of Veneklaas (1991) who reported a higher pH in upper mountain soils than the soils of lower altitudes and the valley bottom but contradicts the findings of Pendry & Proctor (1996) who reported opposite trends.

Table 3. Mean values and standard deviations (S.D.) for all soil variables for the five association types identified by the Normal Cluster Analysis.

Factors		Associations				
		A	B	C	D	E
Potassium, ppm	**Mean**	361.00	357.50	397.33	331	458
	S.D.	32.56	12.74	26.16	26.87	0.00
Soil pH	**Mean**	6.22	6.75	6.8333	6.3	6.9
	S.D.	6.22	6.83	6.75	6.30	6.90
Electrical Conductivity dSm^{-1}	**Mean**	190.20	219.50	256.67	244.50	275
	S.D.	190.20	256.67	219.50	244.50	275
Total Soluble Salts (%)	**Mean**	0.127	0.155	0.177	0.17	0.19
	S.D.	0.03561	0.03512	0.00707	0.15556	0.00
Calcium + Magnessium, meq/L	**Mean**	1..074	1.185	1.75	1.4	1.8
	S.D.	0.3653	0.2427	0.0495	1.1031	0.00
Organic Matter, %	**Mean**	6.643	7.950	6.460	7.545	7.75
	S.D.	1.617	1.865	0.240	0.375	0.00
Phosphorus, ppm	**Mean**	18.5	19.5	15.33	18.5	19
	S.D.	1.716	1.528	0.707	3.536	0.00
Saturation, %	**Mean**	58.8	49.52	54.667	52	52
	S.D.	2.898	1.155	1.414	5.657	0.00
Sodium, $meql^{-1}$	**Mean**	0.778	1.01	0.8167	1.045	0.95
	S.D.	0.2105	0.3349	0.1838	0.9829	0.00
Bicarbonate, meq/L	**Mean**	0.848	1.03	1.42	1.13	1.41
	S.D.	0.02656	0.3439	0.1556	0.9758	0.00
Chloride, $meql^{-1}$	**Mean**	0.912	0.955	1.0067	1.05	1.02
	S.D.	0.2940	0.2250	0.2333	0.8344	0.00
Organic Carbon, %	**Mean**	3.8460	5.2000	3.7500	5.1100	5.6600
	S.D.	0.9306	1.0845	0.6788	0.8061	0.00
Nitrogen, ppm	**Mean**	0.10200	0.12000	0.08667	0.11000	0.10000
	S.D.	0.01549	0.01155	0.01414	0.00	0.00
Sodium Adsorption Ratio	**Mean**	1.069	1.32	0.87	1.15	1.01
	S.D.	0.2520	0.3516	0.2828	0.7345	0.00
Exchangable Sodium Percentage	**Mean**	1.928	2.21	1.6833	2.015	1.86
	S.D.	0.3102	0.4329	0.3394	0.8839	0.00
Bulk Density, g/cm^3	**Mean**	0.442	0.45	0.4667	0.43	0.44
	S.D.	0.03190	0.02887	0.04243	0.01414	0.00
Porosity, %	**Mean**	83.29	82.6	82.367	83.8	83.4
	S.D.	1.198	1.097	1.556	0.566	0.00
Sand, %	**Mean**	9.3	13	17.667	18.5	11
	S.D.	1.889	3.786	5.657	3.536	0.00
Silt, %	**Mean**	29.9	30.5	28	29.5	29
	S.D.	2.514	2.646	2.121	2.121	0.00
Clay, %	**Mean**	60.8	56.6	54.33	52	60
	S.D.	1.751	2.517	3.536	1.414	0.00
Altitude, m	**Mean**	2244	2250	2286.7	2270	2300
	S.D.	26.7	11.5	70.7	42.4	0.0
Litter content, %	**Mean**	66.60	73.5	67.33	74	62
	S.D.	14.98	14.57	9.19	8.49	0.0
Bare area, %	**Mean**	1.1	1	1	2	3
	S.D.	0.87	0.00	0.00	0.00	0.00
Tree Density	**Mean**	75.4	29	73	58.5	0
	S.D.	40.60	28.69	32.53	40.31	0.00
Species	**Mean**	41.8	53.5	53.667	44	47
	S.D.	7.757	9.866	4.950	0.00	0

Total nitrogen showed no significant correlation with altitude. The uniform distribution of nitrogen over the landscape suggested uniform rate of decomposition due to homogenous climatic conditions particularly temperature across the gradient. The total phosphorus exhibited a significant negative correlation with the altitude. This decrease in phosphorus concentration at high mountain soils has already been reported by several workers (Tie *et al*., 1979; Edwards & Grubb, 1982; Pendry & Proctor, 1996). A negative correlation between soil pH and phosphorus is in accordance to the fact that the soils with low pH had high potential for phosphorus fixation (Sanchez, 1976) due to iron and aluminium oxides. Although the concentrations of cations vary considerably depending on the parent material, the concentration of calcium and magnesium increased with the increase in altitude. From the foregoing discussion it is clearly evident that diversity in soil characteristics along the altitudinal gradient determines the assemblage of the species in the study area (Table 3). The reasons for these correlation must be hydrological particularly the pattern of run-off generation and redistribution of soil nutrients of the study area and probably are common to many mountainous terrain (Shmida *et al*., 1986; Dasti & Malik, 1998).

Plant assemblage: There is a clear relationship between physical and chemical features of the substrate and the associations as defined by numerical analysis (Table 3) which shows that these groupings of plant species are not arbitrary assemblages. In this respect, soil variables and altitude seems particularly important in plant association constitution and distribution.

Though considerable changes in floristic composition of communities of the coniferous forests of the study area due to human influences have occurred in the past, most of the plant communities can still be regarded as natural or sub-natural. This means that in most cases plant community composition is still mainly controlled by “natural” ecological factors and the impact of man on the position of boundaries between plant communities has remained relatively small. This assumption is supported by results obtained from the multivariate analysis of the vegetation data. All the communities defined by the cluster analysis display unique features which make them identifiable units with more or less overlap and definite ecological relationships. The primary dichotomy was the separation of denuded (gap) association from the other four over-wooded ones. This dichotomy arose from the presence of *Abies pindrow*, *Acer caesium, Aesculus indica, Cedrus deodara, Quercus baloot, Quercus dilatata*, *Quercus incana* and *Pinus wallichiana* in over-wooded associations. The gaps were characterized by *Berula erecta* and *Prunus cornuta*. The wooded associations did not have differential plant species as several species are common to all four wooded associations**.** Among these common species, the frequency of *Arisaema jacquemontii, Asplenium trichomanass, Fragaria indica* and *Impatiens edgeworthii* decreased as they move from association A to D while *Calamintha clinopodium, Cardamine macrophylla, Pteris cretica, Quercus dilatata, Strobilanthus glutionousus* and *Tagetus erecta* showed increasing trend.

The distribution of the species along the ordination axes reflected an important ecological gradient across the five associations: the un-disturbed, natural, wooded communities to disturb denuded one. This gradient was accompanied by two ecological factors: substrate and altitude. *Campanula pallida, Jasminum humile, Euphorbia wallichii* and *Potentilla nepalensis* were located at high altitudes while *Robinia pseudoacacia, Acer caesium, Impatiens bicolor, Impatiens brachycentra* and *Impatiens edgeworthii* at relatively lower altitude. *Ficus palmata* and *Jasminum humile* are found normally in phosphorus poor soils while *Artimisia roxburghiana, Gentiana argentea, Indigofera gerardiana, Malvastrum coromandelianum, Sorbaria tomentosa, Tricholepis stewartii* and *Rosa brunonii* are well presented in soils of higher electrical conductivity and rich in potassium.

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