

Full Length Research Paper

Phytodiversity and endemic richness in high altitude Rama Valley, Western Himalayas, Northern Pakistan

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Vegetation diversity, distribution and species endemism were studied in high altitude (>3300 m) Himalayan plateau in Northern Pakistan. A heterogeneous vegetation structure and distribution was observed due to complex environmental variables. A total of 83 species belonging to 31 families were recorded from the area. The recorded range of species diversity (1.02 to 2.17) and species richness (1.19 to 1.97) was very low as compared to other Himalayan regions. Detrended correspondence analyses (DCA) revealed slope steepness and associated moisture gradient as the main limiting factors controlling vegetation distribution and community structure. Species diversity and richness were negatively whereas evenness was positively correlated with slope steepness and moisture content. Chorological spectrum of vegetation revealed a high (41%) level of species endemism with 34 recorded Himalayan endemic species. Dominance of unpalatable species indicated prevalent impacts of overgrazing on the local flora and possible threats to endemic plant diversity. The high species endemism suggests the conservative value of the area.

Key words: Detrended correspondence analyses, Himalayas, moisture gradient, species endemism, slope steepness.

INTRODUCTION

Himalayan high altitude plains above the tree line are cold and dry hyper optimal habitats with varying "phytodiversity" (Nautiyal et al., 2004). The vegetation of these cold desert exhibits low levels of richness, diversity and productivity (Sharma et al., 2009; Grytnes and Vetaas, 2002). The vegetation types have a direct relationship with the regional altitude, and it has been an area of special interest for vegetation researchers since the early 19th century (Mani, 1978). Vegetation of this geographically diverse zone is mainly controlled by rainfall and redistribution of water that decreases with the increase in altitude. Mean annual temperature decreases with increase in elevation, more rapidly in summer than in winter. This altitude based temperature gradient is the vital factor shaping the vegetation types and determining their diversity and distribution (Heaney and Proctor, 1989; Tanner et al., 1998; Vazquez and Givnish, 1998). These areas are characterized by scanty rainfall, high ultraviolet (UV) radiation, high wind velocity, blizzards, low

temperature and snowstorms. The plants of this zone show an adaptation to these conditions and are generally dwarfed, stunted, woolly or spiny, and develop a mosaic patch of different forms (Rhoades and Thompson, 1975; Walker et al., 1994). They possess an early growth initiation with a short vegetative span ranging from several days to a few months (Bowman and Damm, 2002). The community as a whole usually exhibits seasonal fluctuations, and its structure and composition are strongly influenced by the extent to which periodic phenomena in the individuals are adjusted to each other (Korner, 2003; Kershaw, 1973).

Diversity and richness are the direct measures of human and livestock impacts on the ecosystems (Buntaine et al., 2007). Variation in species diversity along environmental gradient is a major topic of ecological investigation in latest years and has been explained by reference to climate, productivity, biotic interaction and habitat heterogeneity (Givnish, 1999; Willig et al., 2003; Currie and Francis, 2004). This fragile alpine habitat is however rich in endemic biodiversity subjected to anthropogenic disturbances. About 3000 dicot and 1000 monocot species are reported to be endemic to Himalayas (Mani, 1994; Polunin and Stainton,

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1997; Heywood and Watson, 1995). Western Himalayan region harbours 967 endemic angiosperm taxa out of 3054 belonging to 872 genera, showing a high degree of (31.7%) endemism (Behra et al., 2002). These 967 endemic species are further classified as 363 (11.9%) short range and 604 (19.8%) broad range endemics (Kala, 2005). Himalayan alpine vegetation has become a significant focus in research of ecology and biodiversity for a long period (Gerald, 2004; Lovett et al., 2006).

Mountain ecosystems all over the world usually have diverse biological communities and high level of variability in plant species due to their landscape, climate and history (Herben et al., 2003; Fossa, 2004). Although, extensive research has been conducted in Indian and Nepal Himalayas about the general vegetation attributes and community structure; but less effort has been made in Pakistani high altitude Himalayas due to remoteness and inaccessibility of the area. Very few researchers have focused on species endemism which is one of the most important ecological attributes of the Himalayan vegetation. In this paper, we present the results of an ecological study to investigate the vegetation distribution pattern, species endemism and community structure in Rama Lake and surrounding landscape system in high altitude Himalayas.

MATERIALS AND METHODS

Rama valley is located at 35.34'48° N and 74.79'63° S in Astore District of Northern Pakistan. Area lies at an altitudinal range of >3300m a.s.l. in the basin of Nanga Parbat, world's 9th highest peak. It remained snow covered for 6 to 7 months and visited by nomadic herds from May to July. Winter is always below freezing reaching down to -30°C whereas summers are cool and dry with an average temperature of 10 to 12°C. Area lies outside the monsoon range with an average annual precipitation of 510mm. The phytosociological expeditions to the field were carried out in the June to July 2008. Line transect method was used to study and analyse the vegetation dynamics as well as to collect the primary data for statistical analyses. Transects were laid in selected sites having best representation of floral biodiversity and geographic extent of the area. A total of 30 transects, 10 m each, 6 per site were laid in 5 selected sites of the study area. Sites were selected according to the altitude, topography, slope and moisture to get an accurate image of the whole area vegetation.

Vegetation attributes including frequency, density, cover and richness were recorded along with environmental coordinates like latitude, longitude, altitude and slope using global positioning system (Garmin corp. 2005). Plants from the premises of sampling points as well as isolated vegetation patches were also collected to record maximum number of species and their distribution patterns. Collected samples were pressed, dried and transported to herbarium of Quaid-I-Azam University Islamabad, Pakistan, where they were identified and classified following Stewart (1961); and Nasir and Ali (1971 to 1995).

The primary data regarding species cover and abundance was analyzed by DCA (Detrended correspondence analysis, Hill and Gauch, 1980) to determine natural plant associations as well as to measure the variations in dynamics and distribution of species. The index of diversity was calculated after Shannon-Weiner (1948).

"Shannon index" is a measure of the amount of information needed to describe every member of the community. If p_i is the proportion of individuals (from the sample total) of species i , then

diversity (H') is:

$$H' = - \sum_{i=1}^S p_i p_i \ln p_i$$

Where \ln is natural logarithm of p_i .

"Species evenness" was calculated using the Shannon evenness index:

$$J' = H'/\ln(S),$$

Where H' is the Shannon-Wiener diversity index and S is species number (Pielou, 1975).

The Shannon evenness index ranges from zero (when one species is dominant) to one (when all species are equally abundant). Species richness was calculated after Menhinick (1964), as:

$$d = \frac{S}{\sqrt{N}}$$

Where d = Species richness, S = Total number of species in a community and N = Total number of individuals of all the species in a community.

RESULTS

A total of 83 plants belonging to 31 families were recorded from the study area. Predominant plant families of the area included Asteraceae (19%), Poaceae (13%), Ranunculaceae (11%), Rosaceae (8%), Saxifragaceae (8%) and Labiateae (7%). Five different plant communities were identified at 5 sampled sites described as follows:

***Juniperus communis* - *Bergenia ciliate* - *Rumex nepalensis* community**

This community was found at the altitude of 3300 m at steep and dry southern slopes. Community comprised of 37 species in all. Co-dominant species included *Primula denticulata*, *Pedicularis pyramidata*, *Stachys emodii*, *Oxalis corniculata*, *Tussilago farfara* and *Onopordium acanthium*. A diversity value of 1.53; evenness value of 0.81; and richness value of 1.19 was calculated for the community.

***Sibbaldia cunneata* - *Poa alpine* - *Fragaria nubicola* community**

This community was recorded at an altitude of 3500 m in a plain alpine meadow. A total of 52 species were recorded from the site. Co-dominant species included *Artemisia vulgaris*, *Gnaphalium affine*, *Achillea millefolium*, *Geum elatum*, *Minuartia kashmirica*, *Strobilanthes glutinosus* and *Epilobium laxum*. Community showed a diversity value of 1.98; evenness value, 0.64; and richness, 1.85.

***Prunella vulgaris*-*Trollius acaulis*-*Caltha alba* community**

This community was recorded at an altitude of 3500 m

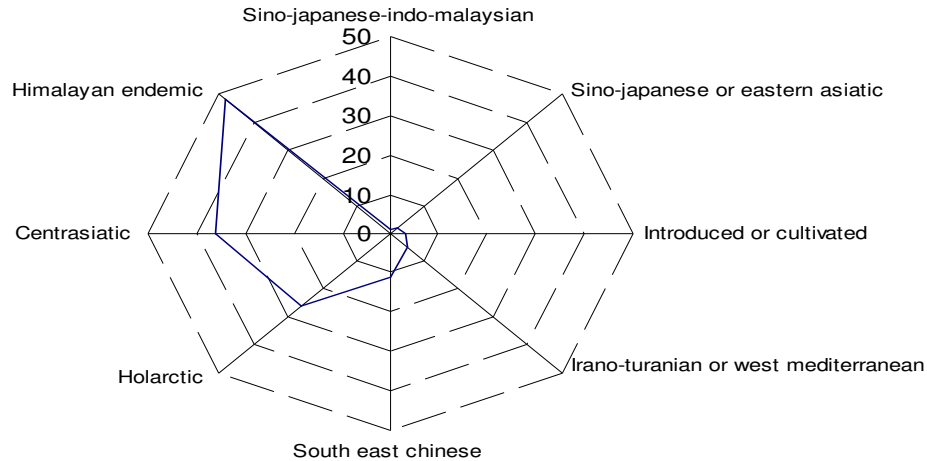


Figure 2. Chorological spectrum of Rama valley vegetation.

along the sides of a water channel with a gentle slope. A total of 47 species were recorded from the site. Co-dominant species included *R. nepalensis*, *Urtica dioica*, *Pleurospermum brunonis*, *Androsace rotundifolia*, *Nepeta erecta*, *Cichorium intybus*, *Trifolium repens* and *Asplenium* spp. Community showed a diversity value of 1.68; evenness, 0.72; and richness, 1.65.

Ephedra gerardiana -Scirpus-Geranium wallichianum community

This community was recorded at an altitude of 3800 m on an uneven moderately steep slope, with a total number of 55 species. Co-dominants included *Euphrasia himalaicus*, *Bistorta affine*, *Ranunculus muricatus*, *Gentiana olivieri*, *Saussurea fastuosa*, *Arabidopsis himalaica*, and *Valeriana jatamansi*. Recorded value of diversity was 2.17; evenness, 0.74; and richness, 1.97.

Primula denticulata-Fritillaria roylei-Bergenia ciliata community

This community was recorded at very steep northern slopes at an altitude of 4000 m with a total number of 33 recorded species. Co-dominant species included *Taraxacum officinale*, *Thlaspi andersonii*, *Astragalus scorpioides*, *Senecio chrysanthemoides*, *saxifrage asarifolia* and *Potentilla eriocarpa*. The calculated value of diversity was 1.02; evenness 0.88; and richness 1.28.

Chorological spectrum of Rama valley vegetation

Chorological spectrum of studied vegetation revealed that major proportion of local flora was comprised of Himalayan endemic species having 41% share. Centrasianic (23%) and Holarctic (11%) elements were represented in medium proportions in the area (Figure 2). The Introduced elements (7%) along with the Irano-

Turanian (9%), Sino-Japanese (5%) and South-East Chinese (4%) elements had poor distribution in low proportion in the study area. Exclusively endemic Himalayan species recorded from the study area included: *A. rotundifolia*, *Arabidopsis himalaica*, *Astragalushemalayanus*, *A. grahamiana*, *Bergenia ciliata*, *Corydalis falconeri*, *C. crassissimus*, *Delphinium cashmerianus*, *D. vestitum*, *Dubyaea oligocephala*, *Echinops cornigerus*, *Ephedra gerardiana*, *Epilobium latifolium*, *Eritrichium canum*, *Gagea elegans*, *Jurinea ceratocarpa*, *Lloydia serotina*, *Lonicera hypoleuca*, *L. spinosa*, *Minuartia kashmirica*, *Nepeta discolor*, *Oxytropis crassiuscula*, *Pedicularis pyramidata*, *Polygonum tortuosum*, *Potentilla curviseta*, *P. eriocarpa*, *Primula buryana*, *P. denticulata*, *P. macrophylla*, *Rheum spiciformis*, *Saussurea simpsoniana*, *Saxifraga asarifolia*, *S. hirculus*, *S. stenophylla*, *Senecio chrysanthemoides* and *S. kongboensis*.

DCA RESULTS

DCA results showed the clustering of apparently distant and physically separated communities together. The "Juniperus-Bergenia-Rumex" community at 3300 m and "Primula-Fritillaria-Bergenia" community at 4000 m, recorded from dry locations having a fair degree of slope steepness were grouped together at left most of DCA axis (Figure 1). With increasing slope moisture content gradually decreases resulting in a drier state which limits the presence of moisture loving herbs, colonized by xerophytic herbs and shrubs (Sherman et al., 2008). The second group of communities 2, 3 and 4 were recorded from plains and moist places having a very little slope steepness in an altitudinal range of 3500 to 3800 m. Here the degree of slope steepness and associated moisture gradient at the sites appears to be the main limiting factor rather than altitude, determining the vegetation distribution and community structure.

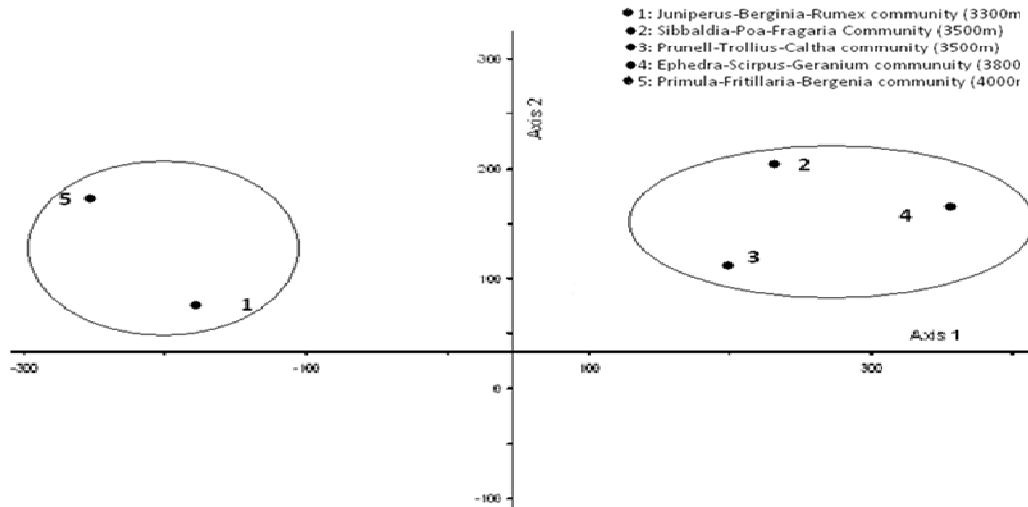


Figure 1. DCA plot showing distribution of communities in the area.

Similarity in species composition decreased with increasing distance between different sites, indicating high level of beta diversity in the area.

DISCUSSION

The overall area exhibited heterogeneous vegetation composition due to a complex mosaic of environmental factors. Predominant families including Asteraceae, Poaceae and Ranunculaceae have wide ecological amplitude and are considered as pioneer angiosperm families of alpine zone. The recorded diversity values for Western Himalayan alpiners in 1.02 to 2.17 is lower than the results of similar investigations in different Himalayan regions; 1.53 to 2.88 in western Himalayas (Samant et al., 1998); 2.39 to 4.63 in Gharwal Himalayas (Kunwar and Sharma, 2004); and 2.5 to 3.10 in trans Himalayan alpiners of Nepal (Panthi et al., 2007). The species evenness showed a negative correlation with richness, decreasing with increasing number of species (Fosaa, 2004). Maximum evenness values (>80%) were represented by uniformly distributed, homogeneous communities having with low (31 to 33) species number as compared to species rich in 2, 3 and 4 communities having 45 to 50 species.

Alpine communities lack the ultra dominant tree cover which allows the herbs and grasses to flourish freely. Moreover repeated grazing also removes the excessive cover of local dominants allowing smaller and out shaded species to persist increasing the degree of evenness (Austrheim and Eriksson, 2001). Average species number was low in 30 to 50 range, in accordance with the results of several related phytosociological investigations in Himalayan alpiners (Kunwar and Sharma, 2004; Behra et al., 2005; Kharakwal et al., 2005). A gradual monotonic decrease in species richness with increasing altitude is considered a general pattern (Brown and Lomolino, 1998;

Steven, 1992). The environmental severity in High altitude Himalayas results in the declined species abundance and richness. The patchy distribution of herbs and grasses can be attributed to the sharp temperatures fluctuations, uneven moisture contents, wind exposure, snow melting time and avalanche activity (Wilkes, 2006). Mean annual temperature decrease with increase in elevation, more rapidly in summer than in winter. This altitude based temperature gradient is the vital factor shaping the vegetation types and determining their diversity and distribution (Heaney and Proctor, 1989; Tanner et al., 1998). Unlike the species richness, species endemism increases with increase in altitude in Himalayas reaching a climax in 3000 to 4000 m range (Dharr, 2002). This increase in endemic species abundance is correlated with decreasing intensity of anthropogenic disturbances along altitudinal gradient (Yi et al., 2007). Highly endemic taxa were found restricted to isolate and preserved geographic locations receiving minimum grazing pressure (Uninal et al., 2006).

The unsustainable anthropogenic activities are posing a serious threat to these endemic taxa (Byers, 2005). It is recommended by vegetation scientists that grazing practices in these fragile alpine communities above 2500 m should be very limited and controlled (Blanken, 1999). Himalayan pastures have been a victim of severe human exploitation from centuries (Miller, 1997). The degraded vegetation is further not allowed to repair itself by harsh climatic conditions and very short growing period. Dominance of unpalatable herbs like *Sibbaldia cunneata*, *Ephedra gerardiana* and *Primula denticulata* also indicates the prevalent impacts of seasonal grazing on local flora. Overconcentration of nomadic flocks causing significant vegetation disturbances is a serious threat to the plant biodiversity in the area (Ge et al., 2005).

The high percentage of species endemism in Himalayas suggests the conservative value of the area. It requires

immediate attention of monitoring authorities as well as to create awareness among locals about sustainable utilization and conservation of alpine pastures to maintain ecosystem balance.

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