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Species composition and diversity of tree species along an altitudinal gradient in Sewa catchment of north-western Himalayas, Jammu and Kashmir, India

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Abstract

Species diversity along altitudinal and latitudinal gradient differs in different tree layers at different scales. Thirteen community groups characterized by different dominants in the tree layer were encountered within an altitudinal range of 580 m asl to 3500 m asl and above in Sewa catchment of Bani region, district Kathua, Jammu and Kashmir. The sub-tropical and temperate elements of vegetation reveal predominance of closed canopy forests, wherein the sub-tropical tree species outnumber the temperate tree flora. The pattern of plant diversity as observed by the values of species richness and diversity indices show a decreasing trend from lower to higher altitudes. The study suggests that distribution and species richness are largely regulated by physiography (altitude, latitude, slope, aspect etc.) and climatic factors.

Keywords: *community, diversity, richness, gradient, canopy, random sampling, Sewa catchment, physiography*

Introduction

Species diversity along an altitudinal gradient differs in different tree layers at different scales. There exists a gradient of diversity distributions across multiple spatial scales (Brown & Lomolino 1998; Field *et al*. 2009). Latitudinal and altitudinal gradients are the most conspicuous patterns of diversity. Generally, species richness tends to decrease with altitude. Altitude itself represents a complex combination of related climatic variables closely correlated with numerous other environmental properties *i.e.,* soil texture, nutrients, substrate stability etc. (Ramsay and Oxley, 1997). Within one altitude the co-factors like topography, aspect, inclination of slope and soil types further effect the forest composition as reported by Holland and Steyn (1975), Austin *et al*. (1996) have analysed association between species, climate, slope protection and soil nutrient status. Kharkwal *et al*. (2005) reported that along the altitudes the geographic and climatic conditions change sharply. Along an altitudinal gradient, the upper limit of species richness remains high up to a considerable altitudinal limit (*i.e.,* 2500 m asl) and tree richness increases with increasing soil moisture in Indian Himalayan region (Rikhari *et al*.,1989).

Many workers have described altitudinal variation in vegetation in western Himalayas. Saxena *et al*. (1985), Adhikari *et al*. (1992), Sharma *et al*. (2009) and Majila and Kala (2010) have reported that vegetation types differ with change in altitude. A few studies specifically related to plant species diversity, quantitative analysis, species richness their population density and dispersion pattern for the Himalayan tract have been conducted by Nath *et al*. (2000), Singh and Rawat (2000), Pande *et al*. (2001 & 2002), Singh and Kaushal (2006), Dash *et al*. (2009), Tynsong and Tiwari (2011) and Shameem *et al*. (2011). Similar parameters have also been worked out by Kour (2001), Singh (2002), Kesar (2002), Sharma (2003), Jhangir (2004), Dutt (2005), Kumar (2007) for the forests of Jammu province. However no authentic database is available regarding the studies on altitudinal gradation of vegetation from the present study area.

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Study Area

The present investigation was carried out in variable vegetation strata from sub-tropical dry deciduous forests to dry alpine scrub along an altitudinal gradient involving Shiwaliks and Pir-

Panjal range of Northwestern Himalayas. The main objective of this paper is to describe the species diversity and richness of tree flora of the area under study. The study was conducted in 13 forest stands in Bani and Sarthal areas of district Kathua of Jammu Shiwaliks (32° 36' 38" N to 32° 41' 00" N latitude and 75° 48' 38" to 75° 48' 38" E longitude) covering an area of 381 km². The tract can be altitudinally divisible into subtropical (580 m asl to 1500 m asl), temperate (1500 m asl to 3500 m asl) and alpine (>3500 m asl) zones as reported by Saxena *et al*. (1985). Mean annual maximum temperature range from 34.5 $\pm$ 4.30 ^{0}C, whereas mean annual minimum temperature is recorded as 6.35 $\pm$ 2.50 ^{0}C. Average annual rainfall ranges from 260 mm at moderate altitudes (< 2000 m) and gradually declines to 80 mm beyond 2500 m. However, higher elevations receive plenty of precipitation in the form of snow. The study area is characterized by four major seasons: short spring (February - March); warm and dry summer (mid April to mid July); warm and wet *monsoon* (mid July to mid September) and relatively dry winter (mid-October to February).

Material and Methods

After the reconnaissance survey, thirteen forest types interspersed in different climatic and physiographic regimes have been identified and recorded. The forest types have been classified as per Champion and Seth (1968). Physiographic factors like altitude, slope and aspect across different cover types were measured by Global Positioning System (Garmin make). A total of 750 plots each measuring 20 x 20 m were laid for quantitive analysis of tree vegetation. Plots were laid by stratified random analysis with the objective to include at least 0.01 % of the total area and the quadrat area was determined by using species area curve.Trees were considered to be individuals > 10 cm dbh (Knight, 1963). Total species richness was simply taken as a count of number of species present in the respective forest type. Species richness (number of species per unit area) was calculated as Margalef's Index (1968) using formula SR = S-1/ln (N) and Menhinik's index of richness (Whittaker, 1977) was calculated as Richness = S/√N, where, S = number of species and N = Total number of individuals (of all species in case of Menhinik's index). The diversity (H') was determined by using Shannon-Weiner information index (Shanon and Weaver 1963) as H'= - ∑ni/n log2 ni/n ; where ni was the IVI value of a species and n was the sum total IVI values of all species in that forest type. Simpson's diversity index (Simpson, 1949) was calculated as D: I-Cd, Where Cd = Simpson's concentration of dominance = $(\sum ni/n)^2$.

Results and Discussion

a) Community structure and composition

The distinct gradation was observed for different vegetation layers along the altitudinal gradient (Table 1). The lower altitudes (580 m asl - 1100 m asl) exhibited the prevalence of sub-tropical dry deciduous tree species with marked dominance of Chirpine community till 1450 m asl. The mid altitudes (1500 m asl- 2200 m asl) exhibited the preponderance of temperate broadleaved species. Most of the higher ranges (2000 - 3250 m asl) are occupied by gregarious patches of temperate coniferous species like *Pinus wallichiana* (Kail), *Cedrus deodara* (Deodar), *Abies pindrow* (Fir) and *Picea smithiana* (Spruce). Population structure of encountered species revealed that *Pinus wallichaina* in the mid altitude and *Picea smithiana* at higher ranges contained an expanding population occupying majority of space in study area. Ban Oak has been observed to be dominant among different broadleaved species and also occurs in association with conifers mostly *Pinus wallichiana* at an altitudinal range of 1300 – 1750 m asl. The temperate coniferous stands were encountered on steeper slopes with rocky base. The quantitative analysis revealed that each forest type, except a few, reveal a single representative species outweighing the other associates. The dominant temperate coniferous species found included *Pinus roxburghii* (Chirpine), *Pinus wallichiana* (Kail), *Cedrus deodara* (Deodar), *Abies pindrow* (Fir), *Picea smithiana* (Spruce), whereas the dominant broad leaved species included, *Quercus semicarpifolia* (Ban Oak), *Quercus leuco-trichophora* (Kharsu Oak), *Betula utilis* (Birch) and *Lyonia ovalifolia*. The subtropical elements were predominated by *Pinus roxburghii*, *Acacia modesta* and *Lannea coromendelica* (Table 1).

Table No. 1:- The environmental variables across different altitudes

S.No	Forest type	Altitude (in m above mean sea level)	Climate	Aspect	Slope (degrees)	Nature of slope	Position
1)	Alpine scrub	Above 3500	Alpine	Mixed aspect	20	Steep	Upper
2)	Fir / spruce mixed forest	2700-3250	Temperate	Northeast	33	Very steep	Upper
3)	Deodar / blue pine mixed forest	1900-2600		Southeast & northwest	30	Very steep	Upper
4)	*Taxus wallichiana* forest	2000-2580		Northeast	25	Steep	Upper
5)	Pure *Cedrus deodara* forest	1450-1700		Northeast	28	Steep	Middle
6)	Pine / Oak mixed forest	1400-1750		Northwest	30	Very steep	Middle
7)	*Pure Betula forest*	3100-3500		Northeast	22	Steep	Upper
8)	*Rhododendron Oak mixed forest*	1600-2200		Northeast & northwest	25	Steep	Middle
9)	*Mixed Oak forest*	1300-2150		Northwest	28	Steep	Middle
10)	*Lyonia / Alnus / Rhododendron forest*	1250-1500		Southwest	25	Steep	Middle
11)	Himalayan Subtropical Pine Forest	780 -1450	Sub-tropical	Northwest	17	Moderate	Lower
12)	Northern Dry Mixed Deciduous Forest	600-1100		South	16	Moderate	Lower
13)	Himalayan Subtropical Scrub	580-850		South east	14	Gentle	Lower

b) Species richness and diversity parameters:

The highest level of diversity and species richness was recorded for subtropical forests, followed by temperate broadleaved and coniferous forests, respectively (Table 2). Maximum value of species richness and Margalef's index was recorded for Northern dry mixed deciduous forests (28 and 7.342) followed by Himalayan sub-tropical scrub (23 and 5.879), Himalayan sub-tropical Pine forests (14 and 4.945), mixed Oak forest (10 and 3.184), *Rhododendron*-Oak mixed forest (9 and 1.3420) and the least values were depicted by Alpine scrub (2 and 0.613). However, steady levels of species richness (8 - 9) and (5 - 6) were recorded for the temperate forest communities at an altitudinal range of 1250 to 2200 m asl and 1450 to 3250 m asl, respectively. The Margalef's index (1.021 - 1.980) also did not vary considerably in the given altitudinal range. Above 3100 m asl, both the parameters decreased abruptly with the species richness dipping to 2-3 and Margalef's index valuing 0.525 to 0.613.

Menhinik's index was recorded with a maximum value of 1.779 for Northern dry mixed deciduous forests followed by Himalayan sub-tropical scrub (1.098), *Lyonia* / *Alnus* / *Rhododendron* forest (1.078), Pine Oak (1.023), Pure *Cedrus deodara* (0.986), *Rhododendron* - Oak mixed forest (0.694).

Minimum value of 0.240 was observed at highest elevation for alpine scrub above 3500 m asl.

Maximum species diversity was observed for sub-tropical forests at an altitudinal range of 580-1450 m asl, wherein maximum value of Shanon Wieners' index was recorded for Northern dry mixed deciduous forests (4.348) followed by Himalayan sub-tropical scrub (3.793) and Himalayan subtropical pine forests (2.878). The uniform pattern of species diversity was encountered in the latitudinal range of 1500 – 2600 m asl with Shanon Wieners' index varying between 2.023 to 2.992 except for a dip (1.801) in case of pure *Cedrus deodara* forests at an altitudinal range of 1450 - 1700 m asl. However the species diversity (1.213 to 0.950) falls exponentially with the increase in elevation beyond 2700 m asl.

Table No. 2 :Total species richness and diversity parameters of tree species along altitudinal gradient

S.no	Forest type	Climate	Altitude (in meters above mean sea level)	SR	MI	MeI	H'	D
1)	Alpine scrub	Alpine	Above 3500	2	0.613	0.240	0.950	0.410
2)	*Pure Betula* forest	Temperate	3100-3500	3	0.525	0.342	0.183	0.797
3)	Fir / spruce mixed forest		2700-3250	5	1.021	0.456	1.213	0.810
4)	Deodar / blue pine mixed forest		1900-2600	6	1.980	0.675	2.337	0.835
5)	*Taxus wallichiana* forest		2000-2580	5	1.654	0.544	2.590	0.753
6)	Pure *Cedrus deodara* forest		1450-1700	6	1.724	0.986	1.801	0.834
7)	Pine / Oak mixed forest		1400-1750	8	1.876	1.023	2.058	0.874
8)	*Rhododendron Oak* mixed forest		1600-2200	9	1.342	0.694	2.023	0.885
9)	*Mixed Oak* forest		1300-2150	10	3.184	0.905	2.922	0.866
10)	*Lyonia / Alnus / Rhododendron* forest		1250-1500	8	3.132	1.078	2.564	0.798
11)	Himalayan Subtropical Pine Forest	Sub-tropical	780 -1450	14	4.945	0.675	2.878	0.876
12)	Northern Dry Mixed Deciduous Forest		600-1100	28	7.342	1.779	4.348	0.988
13)	Himalayan Subtropical Scrub		580-850	23	5.879	1.098	3.793	0.882

Where **SR**: Species Richness; **MI**: Margalef's Index; **MeI**: Menhinik's index; **H':** Shannon-Weiner's index, and **D**: Simpson's diversity index.

The maximum value for Simpson's diversity was recorded for Northern dry mixed deciduous forests (0.988). However the values of Simpson's diversity indicated a uniform pattern (0.876 – 0.885) at an altitude of 1450 to 2600 m asl, whereas a small dip in the values was observed beyond 2600 meters till 3500 m from where the values further decrease (0.835 to 0.797) with the minimum recording of 0.410 for alpine scrub at an elevation beyond 3500 m asl.

The study reveals that tree species found in this part of Himalayas exhibit varying patterns of distribution along different altitudinal and climatic gradients. Kharakwal *et al*. (2005) has segregated the distributional ranges of several species along the widened altitudinal ranges. Pausas and Austin (2001) also suggested that over any large region the distribution of species richness is likely to be governed by two or more environmental factors and not by a single factor.

It is well observed that mixed broadleaved coniferous forests are under high biotic pressure to meet daily requirements of local inhabitants resulting in poor and stunted growth. The variation in quantitative parameters, species richness as well as composition between different communities is also due to elevation, bioclimatic and edaphic factors. All the above information is in parallel consonance with the findings of various ecologists for moist Himalayan temperate forests (Rawat, 2001; Pande *et al*., 2002; Singh and Kaushal, 2006 and Sharma *et al*., 2009).Shanon Weiner's index values ranging from 0.950 to 2.922 is in accordance with the values reported for other temperate forests (Pande *et al*., 2001; Rawat, 2001; Pande *et al*., 2002; Singh and Kaushal, 2006; Sharma *et al*., 2009). Low diversity in some areas could be due to the lower rate of diversification of communities (Fisher 1960) and severity in the environment (Connel and Oris, 1964).The diversity indices reveal that north aspects presents more favourable opportunities for growth of tree species, which has also been reported by Rawat and Pant (1999). Maximum species richness at lower elevations in the present area as compared to higher elevations is in consonance with the findings of Kumar and Ram (2005) and Sharma *et al*. (2009). Burns (1995) and Austin *et al*. (1996) have also reported greater species richness at lower elevation and warmer sites. More than two thirds of plant species were encountered at the elevation range of 580-1450 m asl with the temperature fluctuating between 8^0C to 37^0C. The low elevational sites were relatively densely populated probably because human interference in these areas facilitates the introduction and establishment of non-native species as also reported by Rawal and Pangtay (1994).

Species richness shows a general pattern of intermediate altitude peak (Whittaker 1977, Whittaker *et al*. 2001, and Brown and Lomolino, 1998). This is mainly due to the double gradient of temperature and precipitation. In the temperate forests, the species richness was found maximum in mixed board leaved forests as also reported by Kumar and Ram (2005) and Sharma *et al.* (2009). The occurrence of *Quercus leucotrichophora*, *Quercus semicarpifolia, Lyonia ovalifolia* and *Alnus nitida* almost on all the sites along the temperate altitudinal gradient suggests their tolerance to biotic pressures and wider ecological amplitude. *Pinus roxburghii* is an early successional species and Oak a climatic climax (Champion and Seth, 1968)

Conclusion

The present study highlights the poor status of species richness especially for the temperate and alpine forests. The investigations revealed that lower and comparatively warmer elevations suport higher species richness and diversity than the cold and higher elevational cover types, which implies that temperate and alpine forests need effective monitoring and conservation. The study suggests that the distribution and species richness pattern of different tree species are largely regulated by altitude and climatic factors.

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