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Full Length Research Paper

Vegetational structure and plant diversity relation in a sub-alpine region of Garhwal Himalaya, Uttarakhnad India

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The present study investigated the community structure of a sub-alpine region of Mandal Valley (2200 to 3000 m) along the altitudinal gradient in Garhwal Himalay abased on analytic and synthetic characters. *Poa annua* was dominant and *Potentilla fulgence* was co-dominant along the altitudinal gradient, indicating that most of plant species in different communities were contagiously distributed. Species niche width indicated wide distribution of the species along all altitudinal gradients.

Key words: Garhwal Himalaya, altitudinal gradient, Diversity, IVI.

INTRODUCTION

The western Himalaya comprises of a variety of forest type at various altitudes and within one altitude, while the eco-factors such as topography, inclination of slope, aspect and soil types further affect the forest composition and vagour (Shank and Noorie, 1950). The diversity and richness of the vegetation in subalpine region of Garhwal Himalaya has lured researchers from time to time due to the rich diversity in this regions (Osmaston, 1922; Smythe, 1938; Gupta, 1962; Rau, 1975, 1982). The analysis of quantitative and qualitative characters of the vegetation of the Himalaya Region has been emphasized by some researchers (Ralhan et al., 1982; Sharma and Kumar, 1992; Sharma, 1996). Vegetation types along an altitudinal gradient between Mandal and Chopta have been undertaken to understand species composition, population structure and ecosystem stability in moist mixed temperature forests of higher Himalaya (Sharma et al, 2001). In Himalaya, infiltrations is snowfall cause rapid recession of glaciers presumably a natural phenomenon and the vegetation grow rapidly due to the moisture in soil, However, the current human induced changes are receding (Nautiyal et al., 2001). Impacts on alpine ecosystems are generally predicted in terms of variation in vegetation composition and invasion of species from lower altitude (Nautiyal et al., 2004). The ultimate concern is, therefore, stability of alpine and sub alpine soil as it is determined by vegetation cover (Körner, 1999). Due to some anthropogenic activities viz. over grazing, construction etc. the vegetation of study area are decreases.

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MATERIALS AND METHODS

Chamoli District is the central part of the Western Himalaya. It has attracted people over the world for its beautiful mountains, valleys, rivers, flora fauna, snowy peaks, religious shrines and the famous valley of flowers. The study area includes Mandal valley and adjacent places ranging from 2200 to 3000 m above sea level. The valley lies between 30° 10' N latitude and 79° 25' E longitudinal in Chamoli.

Three sites were selected for the present investigation along this altitudinal gradient. Site one was located at 2200 m above sea level, 2nd at 2700 m above sea leve and third at 3000 m above sea level. This study was carried during November 2002 to 2004 for consecutive years including four seasons. Viz winter, spring, summer and rainy.

The research site is characterized by a moderate and cool climate, with a mean maximum temperature of 10.85±2.0°C January and 27.89 ±18.03°C in July. The mean minimum temperature was recorded to be 7.56±2.2°C in January and 24.66±1.8°C in July. The average rainfall fluctuated between 17 mm (January) to 750 mm (July) during two study years. Mean relative humidity varied between 58% in February to 55% in September.

The vegetation investigation was done seasonally by recording the density of all species in twenty randomly placed 50 × 50 cm quadrats at each site. Frequency density and abundance were calculated following description by Curtis and McIntosh (1950). The abundance-frequency ratio was used to interpret the distribution

Table 1. Frequency and density of some plant species (Mean ± Standard deviation) in three stands.

Name of species	Frequency			Density			Niche width (Bi)
	1	2	3	1	2	3	
Anaphalis triplineris	22.50±3.54	51.25±1..77	13.75±8.84	4.85±2.48	18.05±13.08	6.55±6.01	2.21
Apluda mutica	16.25±22.98	22.5±10.61	2.50±3.54	21.65±25.00	10.55±3.75	2.85±4.03	2.09
Artemisia nilogirica	23.75±5.30	12.5±3.54	*	2.70±1.50	2.5±0.42	*	2.00
Fragaria nubicola	7.50±10.61	10.00±14.14	58.75±8.84	1.45±1.67	3.25±4.60	19.22±2.09	1.50
Gentiana capitata	18.75±22.98	46.25±15.91	71.27±22.98	5.5±2.31	10.55±3.32	22.9±8.63	1.36
Gnaphalium hypoleucum	17.50±14.14	25.00±3.54	22.5±14.14	2.75±1.21	2.25±1.06	2.9±1.98	2.28
Hemiphragma heterophyllum	58.75±15.91	62.5±7.07	6.25±8.84	35.93±17.81	26.2±8.49	1.15±1.63	2.02
Oxalis corniculata	22.50±0.00	6.25±8.84	6.25±1.77	8.95±3.18	4.35±6.15	3.87±2.50	2.59
Poa annua	81.25±12.37	81.25±15.91	45.00±21.21	160.45±6.41	190.00±42.64	72.8±29.84	2.67
Polygonatum cirrhifolium	11.25±15.91	12.50±10.61	8.75±1.77	2.30±2.66	2.9±3.11	1.85±0.07	2.90
Polygonum emodi	13.75±1.77	15.00±7.07	45.00±3.54	14.95±1.56	13.00±1.13	13.00±0.57	2.97
Potentilla atrosanguinua	43.75±15.91	30.00±7.07	45.00±3.54	14.95±1.56	13.00±1.13	13.00±0.57	2.99
Potentilla cuneata	18.75±8.84	26.25±1.77	10.00±14.14	18.50±14.32	40.90±38.33	4.35±6.15	2.00
Potentilla fulgence	43.75±19.45	48.75±12.37	27.50±28.28	4.95±0.87	6.55±1.06	3.2±3.11	2.78
Primula denticulate	7.50±3.54	12.5±14.14	5.00±3.54	2.05±1.79	3.7±4.95	0.65±0.49	2.24
Prunella vulgaris	15.00±3.54	16.25±1.77	13.75±1.77	1.9±0.46	1.95±0.64	1.5±0.00	2.96
Rumex nepalensis	3.75±1.77	18.75±8.84	25.00±21.21	0.1±0.12	3.25±2.33	4.01±2.39	2.03
Senecio amlexicaulis	7.50±10.61	5.00±3.54	21.25±12.37	6.65±7.68	0.6±0.14	2.45±2.05	1.86
Stelleria decumbens	11.25±15.91	3.75±5.30	30.00±3.54	12.2±14.09	2.75±3.89	83.75±11.24	1.36
Swertia angutifolia	48.75±5.30	46.25±1.77	21.25±8.84	10.91±3.39	8.30±0.28	4.75±0.35	2.73
Swertia cordata	35.00±3.54	27.5±14.14	16.25±5.30	6.95±1.67	5.30±1.41	1.87±1.10	2.50
Trigonella pubescens	11.25±15.31	8.75±1.77	8.75±1.77	8.25±9.53	1.4±1.27	1.4±1.98	1.33
Viola bifloa	10.00±3.54	3.75±1.77	10.00±7.07	3.65±3.06	0.4±0.14	2.8±2.26	2.20

pattern of species (Whiiford, 1949). The diversity index was calculated using Shannon-Wiener information function (Shannon- Wienerr 1963) and concentration of dominance (Cd) was measured by Simpson's index (1949). The coefficient of community similarity (Jaccard, 1912) was worked out after computing importance value index (IVI) of the species to assess the similarity among the vegetation on different slopes.

Similarly niche width was calculated for important species using the following equation (Levins, 1968): $ßi = \sum (Nj)^2/Nj^2$ Where j is density value (plant m-^{2}) in selected stands.

RESULT

A total of 90 species were collected from the study area. Of these 46 species were present at site 1st, 60 species at site 2nd and 65 species at site 3rd. The frequency and density data is presented in Table 1. *Poa annua* had the highest mean frequency and density at all three sites. Total basal coverage (TBC) and IVI are presented in Table 2. *Potentilla fulgence* showed the highest TBC in all the three sites. By comparison, *P. annua* exhibited the highest IVI and therefore was dominant species in study area. *Gnaphalium hypoleucum* and *Polygonum emodi* (2.97) showed the highest niche width (Table 2).

Except a few species showing random distribution, most species displayed contagious distribution patterns. Regular distribution was rarely observed in this area. The maximum contagious distribution was found at site 1st and followed by

Table 2. Total basal cover and important value index (Mean ± Standard deviation) in three stands.

Name of species	TBC			IVI		
	1	2	3	1	2	3
Anaphalis triplineris	0.88±1.03	1.03±1.00	0.69±0.64	11.71±3.81	16.39±2.36	3.64±0.93
Apluda mutica	0.57±0.81	0.20±0.06	0.06±0.08	5.31±7.51	6.82±0.54	1.00±1.41
Artemisia nilogirica	0.19±0.16	0.12±0.13	*	8.22±4.25	5.69±2.40	*
Fragaria nubicola	0.69±0.76	0.04±0.06	1.54±0.37	1.82±2.57	1.00±1.41	13.44±6.31
Gentiana capitata	0.50±0.69	0.55±0.01	0.01±0.01	5.31±5.76	5.28±0.63	0.68±0.96
Gnaphalium hypoleucum	0.32±0.06	0.09±0.08	0.27±0.30	6.51±3.64	3.08±0.98	3.20±2.35
Hemiphragma heterophyllum	1.05±0.84	0.92±0.12	0.04±0.05	16.82±6.83	23.97±3.70	0.89±1.25
Oxalis corniculata	0.12±0.04	0.44±0.06	0.46±0/03	5.98±0.25	2.03±2.86	3.15±1.68
Poa annua	1.78±0.68	2.06±0.35	0.08±0.04	43.18±2.31	86.79±16.33	28.87±10.99
Polygonatum cirrhifolium	0.25±0.35	0.48±0.31	0.05±0.00	1.61±2.31	6.68±2.31	3.19±3.01
Polygonum emodi	0.01±0.00	0.16±0.04	0.11±0.04	1.01±1.43	1.81±0.45	1.26±0.29
Potentilla atrosanguinua	0.18±0.04	0.53±0.23	0.60±0.62	6.67±0.71	13.95±1.31	12.32±3.72
Potentilla cuneata	0.20±0.21	0.09±0.01	0.05±0.06	10.17±4.96	31.28±12.57	2.22±3.13
Potentilla fulgence	0.91±0.01	2.25±0.35	0.57±0.54	27.53±4.39	32.52±7.74	10.63±3.42
Primula denticulate	0.05±0.01	0.35±0.24	0.04±0.05	1.85±0.71	8.06±2.98	1.69±1.38
Prunella vulgaris	0.75±0.04	0.17±0.10	0.03±0.01	2.34±0.88	3.36±0.86	0.87±1.2
Rumex nepalensis	0.03±0.00	0.15±0.18	0.23±0.22	1.99±1.36	2.90±1.70	3.49±2.33
Senecio amlexicaulis	0.20±0.28	0.09±0.05	0.90±0.01	3.82±5.40	1.15±0.05	1.52±0.0
Stelleria decumbens	0.09±0.13	0.03±0.05	0.69±0.35	3.99±5.64	0.63±0.88	36.73±10.73
Swertia angutifolia	0.63±0.49	0.72±0.35	0.07±0.08	13.46±2.46	16.59±3.63	6.84±3.84
Swertia cordata	0.22±0.09	0.35±0.33	0.01±0.00	7.37±4.24	6.40±1.80	2.20±1.62
Trigonella pubescens	0.05±0.08	0.05±0.01	0.01±0.01	2.95±4.16	1.91±0.86	0.59±0.83
Viola bifloa	0.55±0.06	0.01±0.00	0.04±0.01	2.66±2.14	0.68±0.20	2.50±2.19

site 3rd and site 2nd. The regular distribution was completely absent at the site 2nd and site 3rd. The general diversity index showed variation for different communities in the same season during two consecutive years. For instance, the diversity index increased in some communities while it declined in other communities in the second sampling year. Tables 3 and 4 present the dominance, general diversity, alpha diversity and evenness value.

The highest value of H was recorded to be 2.77±0.58 to 2.99±0.47 at site 2nd and the lowest ranged from 2.59±0.23 to 2.64±0.48 at site 1st. Site 1st and 2nd showed the highest alpha diversity, with 44 and 41 species in rainy seasons during two sampling years. The alpha diversity exhibited significant variation between different seasons. It increased from summer to rainy. The highest species rich richness was reported to be 44 (site 2nd) in rainy season, while it declined to 11 in winter (stand 2nd). Beta diversity (within habited diversity) was observed to be highest between site 1st and 3rd (1.05) followed by stand 1st and stand 2nd (0.98). The dominance value increas at most of the sites in the consecutive years. The mean value varied between 0.09±0.02 and 0.09±0.04 at site 1st, between 0.08±0.05 and 0.10± 0.05 at site 2nd, and between 0.08±0.04 and 0.09 ± 0.04 at site 3rd.

The evenness values indicated the maximum

Table 3. Distribution pattern (%) of the plant species in different season and stands.

	2002 – 2003				2003 – 2004			
	Winter	Spring	Summer	Rainy	Winter	Spring	Summer	Rainy
Stand 1								
Regular	*	*	*	4.54 (1)	*	*	*	*
Contagious	66.66 (8)	80.00 (12)	94.44 (17)	72.72(16)	92.85 (13)	93.33 (14)	95.23 (20)	60.0(15)
Random	33.33 (4)	20.00 (3)	5.88 (1)	22.72 (5)	7.14 (1)	6.66 (1)	4.76 (1)	40.00(10)
Stand 2								
Regular	*	*	*	*	*	*	*	*
Contagious	54.54 (6)	50.00(10)	60.00 (18)	52.27(23)	75.00 (12)	63.63 (14)	67.64 (23)	53.84 (21)
Random	45.45 (5)	50.00 (10)	40.00 (12)	47.72 (21)	25.00 (4)	36.36 (8)	32.35 (11)	46.15 (18)
Stand 3								
Regular	*	*	*	*	*	*	*	*
Contagious	85.71 (12)	83.33 (15)	81.81 (18)	75.60 (31)	80.95 (17)	84.21 (16)	82.35 (28)	80.55 (29)
Random	14.28 (2)	16.66 (3)	18.18 (4)	24.39 (10)	19.47(4)	15.78 (3)	17.64 (6)	19.44 (7)

Table 4. Concentration dominance (Cd), General Diversity Index (H), Alpha diversity and evenness value of plant species in different season and year at all stands.

	2002 – 2003						2003 – 2004					
Stand 1												
	Winter	**Spring**	**Summer**	**Rainy**	**Mean**	**SD±**	**Winter**	**Spring**	**Summer**	**Rainy**	**Mean**	**SD±**
Cd	0.11	0.10	0.08	0.07	0.09	0.02	0.13	0.12	0.07	0.05	0.09	0.04
H	2.33	2.52	2.65	2.87	2.59	0.23	2.21	2.37	2.89	3.10	2.64	0.42
Alpha	14.00	18.00	19	41	23.00	12.19	17	21	34	37	27.25	9.74
Evenness	2.03	2.00	2.07	1.78	1.97	0.13	1.72	1.79	1.89	1.98	1.85	0.11
Stand 2												
	Winter	Spring	Summer	Rainy	Mean	SD±	Winter	Spring	Summer	Rainy	Mean	SD±
Cd	0.14	0.13	0.08	0.04	0.10	0.05	0.15	0.06	0.05	0.05	0.08	0.05
H	2.30	2.41	2.77	3.59	2.77	0.58	2.34	2.96	3.23	3.42	2.99	0.47
Alpha	11.00	20.00	21.00	44.00	24.00	14.07	16.00	22.00	35.00	39.00	28.00	10.80
Evenness	2.21	1.85	2.09	2.18	2.08	0.16	1.94	2.20	2.09	2.15	2.10	0.11
Stand 3												
	Winter	Spring	Summer	Rainy	Mean	SD±	Winter	Spring	Summer	Rainy	Mean	SD±
Cd	0.1	0.12	0.07	0.03	0.08	0.04	0.11	0.08	0.04	0.13	0.09	0.04
H	2.45	2.43	2.83	3.55	2.82	0.52	2.48	2.76	3.38	2.86	2.87	0.38
Alpha	12.00	16.00	18.00	22.00	17.00	4.16	14.00	15.00	21.00	27.00	19.25	6.02
Evenness	2.27	2.01	2.25	2.64	2.29	0.26	2.16	2.35	2.56	2.00	2.27	0.24

sharing percentage of all species and no single species contributed significantly to all habitats. Evenness value (mean) varied between 1.85±0.11 and 1.97±0.13 at site 1st, between 2.08±0.16 and 2.10±0.11 at site 2nd, 2.27±0.24 and 2.99±0.26 at site 3rd. Jaccard's similarity index was calculated between two stands, which resemble each other in physiognomy. Maximum mean similarities were observed for stand 1st and 3rd (20.00) followed by stands 2nd and 3rd, 1st and 2nd.

DISCUSSION

The study of phytosociological attributes is useful for comparing one community with the other from season to season and year to year (Singh, 1972). Each species within a community has large measure of its structural and functional individualism and has more or less different ecological amplitude and modality (Singh and Joshi, 1979). The species diversity reflects the gene pool and adaptation potential of the community (Odum, 1971).

The temperature remained constant during morning hours with little variation and experiencing cold winds, the cumulative effect enhanced the senescence in most of the herb species immediately after the completion of flowering and fruiting with the onset of winter period. On the other hand in the case of perennial herb the above-ground part stored food and parented during the winter season.

For the particular species, higher frequency indicated its more frequency distribution at sites due to optimum soil and environmental conditions. *P. annua* showed 90% frequency in stand 1st and stand 2nd while *Fragaria nubicola* showed the maximum frequency in stand 3rd. Flat slope favours grazing and repeated defoliation in the heavily grazed areas stimulate tillering (Harper, 1977). It is from the present investigation that most of the species were contagions distribution in all season and sites. The regular and random distribution patterns are indicative of uniformity of environment report for temperate Himalayan forests (Sexsena and Singh, 1982; Singhal et al., 1986).

Bankkotii and Tewari (2001), Khera et al. (2001), Sharma and Baduni (2000), Bhandari et al. (1998) and Ghildyal et al. (1998) etc. worker reported the similar pattern of species diversity in distributed forest of central Himalaya, with special reference aspect and altitudes. The present finding for diversity index falls well within the range of other temperate forest. Monk (1967) and Risser and Rice (1971) obtained 2.3 as the highest value for diversity index for temperate vegetation. The diversity ndex for Himalayan grazing land ranged between 1.91 and 3.74 (Pandey, 1997), which was higher than temperate tree and lower rate of evolution and diversification of communities (Simpson, 1949) and moreover due to severity in the environmental condition (Connell et al., 1964).

The other component of diversity is evenness or equability, which means the apportionment of individuals among the species. The evenness varied between 1.72 (Stand 1st) to 2.64 (Stand 3rd). Most cooler conditions with moderate soil temperature and lower degree of human disturbances is the main factors for equal share of individuals among species in all species in all stands. The highest evenness value was recorded at stand 3rd at the upper elevation while the least value was calculated as stand 1st. Grazing and fodders collection was more frequent in this stand as compared to other. In this stand diversity varied in each quadrate for same species because the women folk collected fodder and other important medicinal plants for traditional uses, while goat and sheep grazed the twinges of herbs species at steeper slopes. The other ground vegetation completed their life cycle in short period. Most of the other species were not able to complete their life cycle in short life period. Most of the other species were not able to complete their life cycle due to the grazing by livestock for the long time for the winter season.

Alpha diversity expresses the species richness in a community or given area. In present investigation it has been observed that all aspects in upper elevation represent more species richness as compared to lower elevation. In stand 1st the mean alpha diversity was 25.12, in stand 2nd 26.00 and at stand 3rd alpha diversity was recorded 18.13. These stands had highest diversity as the communities were having more open canopy. These finding are agreement with those of Khera (2001).

Beta diversity is other important factor of habit diversity of two different habitat system and provides information about the degree of partitioning of habitats by species and together with alpha diversity provides information about the overall diversity and biotic heterogeneity of area (Rawat, 2003). Higher beta diversity values are indicative of the high rate of species change as a function of environmental gradient.

The low diversity stands are associated with higher level of exchangeable potassium, soil nitrogen and maximum water holding capacity and have relatively higher standing crop. This indicated that competition closely regulated the number of species capable of coexisting in comparatively more productive environments (Shuakal et al., 1981). Conclusively this area experiences more anthropogenic pressure, as evident by absence of higher girth classes and low rates of succession. Thus herb species of this region need the conservation strategies.

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