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Original Research Article

Structure and Floristic Composition of Oak Forests in Kandi Forest Range of District Rajouri, J&K, India

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Abstract: The present study was conducted to explore the key phytosociological and diversity characteristics of Oak dominated forests (Kandi forest range) in Rajouri Forest Division of Jammu and Kashmir. The study area is dominated by three species of oak viz. *Quercus leucotrichophora*, *Q. floribunda* and *Q. semecarpifolia* and hosts a good deal of floral diversity including certain endemic species. *Boxus wallichiana*, *Rhododendron arborium* and *Viburnum grandiflora* are the main associate species. Density, dominance and species diversity was assessed in three localities each represented by twenty randomly laid $10\times10m^2$ quadrats. A total of 20 tree species were found growing in the area with *Quercus leuchotrichophora* dominating at all sites with highest density (975), frequency (100%), basal cover (133 m^2/ha) and IVI (167.20). Total density ranges from 770 to 975 individuals/ha for trees and 225 to 405 for shrubs whereas the total basal area for trees lies between 88.84 and 133 m^2/ha. Species richness and diversity indices slightly vary across the stands studied. Shannon-Wiener Index ranges between 0.93 to 1.99 for trees and 1.34 to 1.93 for shrubs. Simpson's diversity index varies from 0.70 to 0.93 for tress and 0.73 to 0.84 for shrubs. Margalef Index ranges between 0.74 to 1.88 for trees and 0.73 to 1.17 for shrubs; Menhenick's Index lies between 0.20 to 0.44 for trees and 0.33 to 0.41 for shrubs and Peilio's index ranges from 0.49 to 0.75 for trees and 0.92 to 1.92 for shrubs. The forests are under severe anthropogenic pressure and demand appropriate management and conservation measures.

Key words: Conservation, ecosystem, floral diversity, forest stands, phytosociology

Introduction

Forests cover 38% of land and 11% of the earth surface and account for 71% of terrestrial net production and about 93% of terrestrial biomass (Whittaker and Woodwell, 1969) and serve as an invaluable natural resource besides being huge repositories of floral, faunal and microbial biodiversity. They occupy a unique and highly important place among all the ecosystems for their vast and varied ecological services like species conservation, soil protection, water and nutrient recycling, climate control and carbon absorption (Armenteras *et al.*, 2009). Replete with a wide range of vegetation types (Arora, 1995) and supporting forest growth up to 3000-4000m elevation (Singh *et al.*, 1984), the Himalayas constitutes one of the richest and the most remarkable ecosystems on the earth (Salick *et al.*, 2009). It is endowed with diverse vegetation types, ranging from tropical moist deciduous to temperate and sub-alpine forests, grasslands, alpine scrub and meadows (Champion & Seth, 1968). Of these, the temperate broadleaved forests constitute the most important vegetation type across the Western Himalayas. These forests are mainly dominated by one or the other species of oak (*Quercus* spp.) which represents climax vegetation between 1000 - 3500 m asl in the region (Troup, 1921; Singh & Singh 1992; Upreti *et al.*, 1985).

of more than 100 species of oak growing in various parts of the world (Nixon, 2006) at least 35 species of oak (*Quercus* spp.) naturally occur in the Himalayas (Singh and Rawat, 2012). Five species of evergreen oaks viz: *Quercus leucotrichophora* A. Camus (banj oak), *Q. oribunda* Lindl. ex A. Camus (tilonj oak), *Q. lanuginosa* (Lam.) Thuill. (rianj oak), *Q. semecarpifolia* Smith (kharsu oak) and *Q. glauca* Thunb. (phaliyat oak) abundantly grow between 1500 and 3300m or more elevations in the Western Himalayan region (Champion and Seth, 1968). Of them three species, namely *Quercus leucotrichophora*, *Q. floribunda and Q. semecarpifolia* form extensive forests between 1200m to 3500 m one replacing the other along altitude as dominant species (Singh and Singh, 1986; Singh and Rawat, 2012) and *Quercus leucotriphora* covering the largest area (Singh and Singh, 1987). These oak dominated forests are very crucial not only for their ecological significance (Pande, 2012; Saxena and Singh, 1982) but also for their socio-cultural importance (Patnaik, 1986; Akhter *et al*., 2009; Singh *et al*., 1984; Singh and Singh, 1986; Jazib and Rather, 2015) as the local communities heavily rely on them for their subsistence and welfare.

Pir Panjal Mountains extending in a northwest to southeast direction across Jammu and Kashmir in India form the largest range in the western Himalayas and support wide range of vegetation including grasslands, scrubs and luxurious coniferous and broadleaved forests. Pure or mixed stands of Oak (*Quercus* sp) form the principal floral group on the southern slopes of the range between 1200m and 3500m elevation. These forests are the main representatives of broadleaved Himalayan forests in Jammu and Kashmir. Though there is ample amount of scientific information available on taxonomic and ecological aspects of rest of the Western Himalayan forests (Troup, 1921; Champion and Seth, 1968; Singh *et al*., 1984; Singh and Singh, 1987; Rawat and Bhainsora, 1999, Negi *et al*., 2002). Jammu and Kashmir is floristically the most underexplored region of the Himalayan ecosystems (BSI, 2000; Dar *et al*., 2014). A few studies available on vegetation characteristics of Jammu Shivaliks (Sharma and Raina, 2013), Chenab catchment (Bhellum and Magotra, 2012) and Kashmir valley (Dhar and Kachroo, 1983; Sharma and Jamwal, 1988; Singh and Kachroo, 1994; Kawoosa, 2001) provide considerable information on composition, distribution pattern and floral diversity of certain geographic and climatic regions of the state. The Pir Panjal Himalayan range, however, still remains the least surveyed areas in the western Himalayas scanty and scattered information available on its flora (Singh and Kirn, 1981; Malik *et al*., 2010; Dar *et al.,* 2014). No substantial data on community characteristics of temperate broadleaved forests of the region is available. Present work is an attempt to provide baseline information on phytosociology and diversity of one of the representative and ecologically significant forests of the Himalayan region.

Materials and methods

Study area

Situated on its southern slope, Rajouri district of Jammu and Kashmir in India forms an important part of the mighty Pir Panjal mountain range. It lies between 30° 50′N to 33° 30′N latitude and 70° E to 74° 10′E longitude with an altitudinal range from 370-6000 m above sea level spread over an area of 2630 sq km. Shivalik ridge lies to its south whereas towards south eastern its bounded by Dhauladhar range. Topography of the district varies from plains or gentle slopes in the southern part to hilly and very hilly towards the northern part which also comprises of several high peaks. Higher reaches support characteristic alpine vegetation whereas lower slopes exhibit rich coniferous and broadleaved forests. Major slope is towards south and southwest. District is drained by numerous perennial rivers originating from northern snow capped mountains. Controlled by natural topography and geology of the region, river Munawar and river Ans with their tributaries form two main river systems which eventually form the important tributaries of the River Chenab. Northern side of the district comprises of older crystalline and metamorphic rocks consisting of Salkhala, Tanawal and Ramban Formations of Precambrian to Eocene age. The southern part of the district comprises of Siwalik formation (Anon, 2013). About 80% of the district comprises of Murree group of rocks of late Eocene-

Site I

Site II

Site III

early Miocene age and is disconformably underlained by the rocks of Subathu Formation in Main soil types present in the area include Utisols, Sub-Mountainous Soil (Alfisols) and Bhabar soil (Entisols). Climate is generally mild with warmer in lower southern plains and harsher and cold with heavy snowfall on northern mountains. Average annual rainfall is 1150 mm and average temperature varies from 7.42 degree celsius to 37.4 degree celsius. The maximum rainfall in the area is received through southwest monsoon during July-September. Main vegetation types are subtropical in lower foothill plains and temperate in upper northern areas. 47% of geographic area in the district is under forest cover that supports great biodiversity including several endemic plant and animal species. District is divided in two forest divisions viz. Nowsheha and Rajouri and five ranges. Kandi range of Rajouri forest division offers a valid representation for the entire division in terms of soil, topography, climatic conditions and vegetation types. It hosts several mountainous peaks, high altitude lakes and numerous alpine meadows. The range is characterized by the presence of rich coniferous and broad leaved forests between 1000m to 3000m asl elevations. Different species of oak grow extensively throughout the range.

Sampling and data collection

Extensive field surveys in the entire forest areas of Rajouri district to select the most representative yet accessible forest stands for the present study. Oak dominated forests are found in Rajouri and Kandi ranges of Rajouri forest division. Kandi forest range offers more extensive and approachable oak dominated forests along its numerous hillocks, depressions and slopes in different altitudinal zones ranging from 1200m to 2500 m asl. Three sites within 1200-2200m altitudinal zones were selected in this range for the present study (Table 1). Physiographic factors (like elevation, aspect and slope steepness) were recorded using GPS. Twenty quadrates (each measuring 10×10 m for trees and 5×5m for shrubs) were laid at each site as per stratified random sampling technique for collection and analysis of phytosociological information on trees and shrubs.

Data analysis

Density, frequency, abundance, basal area and IVI (Provenance index, PI, in case of shrubs) were calculated as per standard methods:

IVI=Relative Density+ Relative Frequency + Relative Dominance)

PI= Relative density + Relative frequency (for shrubs)

Distribution pattern of all the tree species was examined through abundance/frequency (A/F) ratio (also known as Whitford index) and was categorized as regular (if A/F < 0.025), random (if A/F between 0.025 – 0.05) or contagious (if A/F > 0.05). Number of species present were taken simply as Species richness. Margalef index (MI) and Menhinik index (MeI) of richness were calculated as MI= S-1/log N and MeI=S/"N where S=number of species and N= total number of individuals. Shannon–Wiener diversity index (H′) and Simpson's diversity index were calculated using the formulae:

$$\text{Shannon-Wiener diversity index } (H') = -\sum_{i=1}^{s} \text{pi ln pi}$$

$$\text{Simpson index of diversity (SI)} = 1 - \left(\sum_{i=1}^{s} (\text{pi})^2\right)$$

where, pi is the proportion of *i* th species and s is the number of individuals of all the species. It was expressed as 1-Cd to avoid confusion.

Peilo index of evenness (e) was calculated as e=H′/ log N, where H′ is Shannon Wiener index and N is total number of species.

Results

It's revealed that the forest community under study is composed of various broadleaved and a conifer (*Pinus roxburgii*) species. A total of 32 species (20 trees and 12 shrubs) belonging to 30 genera were reported from the area and analyzed for their dominance, distribution, importance and diversity. *Quercus leuchotrichophora*, being the dominant tree species throughout the community, shows maximum values for basal cover, density and frequency at all sites followed by *Boxus wallichian*a, *Quercus floribunda* and *Quercus semecarpifolia* (Tables 2-7). *Quercus leuchotrichophora* also exhibits the maximum Importance Value Index (IVI) equal to 176.20 Provenance Value (PV) was observed maximum for *Viburnum grandifolia* (PV=69.04) followed by *Berberis*

Table 1. General profile of study sites

Site	Longitude/latitude	Aspect	Slope/terrain	Anthropogenic interference
I. Kotjar (Gadyog)	74°33′E & 33°18′ N	South western	Gentle	Least disturbed
II. Perinar (Jaglanoo)	74°32′E & 33°20′ N	South eastern	Steep	Moderately disturbed
III. Badhal Mahl	74°33′E & 33°20′ N	Western	Gentle	Disturbed

Table 2. Vegetation analysis (trees) at Site I (Kotjar forest)

Species	Frequency (%)	Density	Abundance	Mean circumference (cm)	Total basal cover	Abundance/ Frequency	IVI
1. *Quercus leuocotrichophora*	90	440	4.88	126	55.617	0.054	148.410
2. *Quercus floribunda*	25	40	1.6	115	4.212	0.064	16.470
3. *Rhododendron*	40	40	1	70	1.561	0.025	16.369
4. *Bombax ceiba*	10	20	2	58	0.536	0.200	5.329
5. *Grevia optiva*	20	25	1.25	47	0.440	0.063	8.203
6. *Pyrus pashia*	55	110	2	44	1.696	0.036	27.495
7. *Pinus roxburgii*	20	50	2. 5	56	1.248	0.125	11.941
8. *Puma granatum*	30	70	2.3	24	0.321	0.077	15.146
9. *Ficus palmata*	20	60	3	53	1.342	0.150	13.103
10. *Zanthoxylum armatum*	20	35	1.75	32	0.285	0.088	9.004
11. *Celtis australis*	25	35	1.4	48	0.642	0.056	10.772
12. *Morus alba*	10	10	1	36	0.103	0.100	3.676
13. *Melia azaderachta*	20	20	1	49	0.382	0.050	7.607
14. *Ulmus wallichiana*	15	20	1.3	54	0.464	0.087	6.476
Total		975			68.848		

Table 3. Vegetaion analysis (shrubs) at Site I (Kotjar forest)

Species	Frequency	Density	Abundance	Abundance/Frequency	PV
1. *Ellaegnus umbellata*	20	55	1.5	0.075	24.107
2. *Zizipus mauritiana*	20	25	1.25	0.063	16.699
3. *Berberis lycium*	40	100	2.5	0.063	45.744
4. *Carrisa spinarum*	10	25	1.25	0.125	11.436
5. *Indigofera heterantha*	30	75	2.5	0.083	34.308
6. *Rosa maschuta*	10	15	1.5	0.150	8.967
7. *Rubus ellipticus*	30	65	2.1	0.070	31.839
8. *Sarcococca salinga*	30	45	1.5	0.050	26.901
Total		405			

Table 4. Vegetaion analysis (trees) at Site II (Perinar)

Species	Frequency	Density	Abundance	Mean Circumference (cm)	Total basal cover	Abundance/Frequency	IVI
1. *Quercus leuocotrichophora*	100	495	4.95	149	87.496	0.010	167.248
2. *Quercus floribunda*	40	90	2.25	146	15.274	0.025	39.216
3. *Aesculus indica*	25	50	2.80	145	8.370	0.056	22.882
4. *Lyonia ovalifolia*	10	25	2.50	112	2.497	0.100	9.108
5. *Rhododendron arborium*	30	85	2.83	157	16.681	0.033	35.423
6. *Pyrus pashia*	30	95	3.16	60	2.723	0.033	26.122
Total		840			133.041		

Table 5. Vegetation analysis (shrubs) at Site II (Perinar)

Species	Frequency	Density	Abundance	Abundance/Frequency	PV
1. *Elaeagnus umbellate*	20	55	2.750	0.138	32.492
2. *Berberis lycium*	40	75	1.870	0.047	52.020
3. *Rubus ellipticus*	30	40	1.330	0.044	32.997
4. *Viburnum grandifolium*	30	45	1.500	0.050	34.848
5. *Rosa maschuta*	25	35	1.400	0.056	28.114
6. *Amelocissus latifolia*	20	20	1.000	0.050	19.529
Total		270			

Table 6. Vegetation analysis (trees) at Site III (Badhal Mahl)

Species	Frequency	Density	Abundance	Mean Circumference (cm)	Total basal area	Abundance/FrequencyI	IVI
1. *Quercus leuocotrichophora*	90	420	4.66	150	75.239	0.052	162.868
2. *Boxus wallichiana*	40	115	2.87	40	1.465	0.072	31.210
3. *Pyrus pasia*	30	55	1.83	50	1.095	0.061	19.345
4. *Quercus floribunda*	60	120	2.00	132	16.647	0.033	54.399
5. *Quercus semecarpifolia*	20	25	1.25	80	1.274	0.063	11.924
6. *Aesculus indica*	20	20	1.00	112	1.997	0.050	11.996
7. *Lyonia ovalifolia*	10	15	1.50	148	2.616	0.100	8.259
Total		770			100.333		

Table 7. Vegetation anlaysis (shrubs) at Site III (Badhal Mahl)

Specis	Frequency	Density	Abundance	Abundance/Frequency	PV
1. *Skimmia laureola*	30	70	2.16	0.072	52.540
2. *Elaeagnus umbellate*	20	35	1.75	0.088	29.841
3. *Vibrnum grandiflora*	50	75	1.50	0.030	69.048
4. *Berberis aristata*	40	45	1.25	0.031	48.571
Total		225			

Table 8. Diversity and phytosociological attributes of study sites

Parameter	Site I - Kotjar		Site II – Perinar		Site III - Badhal Mahl	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Species Richness (Total Number)	14	8	6	6	7	4
Margelef Index	1.88	1.17	0.74	0.89	0.90	0.73
Menhinik Index	0.44	0.41	0.20	0.36	0.25	0.33
Pelio Index (Evenness)	0.75	0.92	0.51	1.02	0.49	0.96
Shanon Wiener Index (H)	1.99	1.93	0.93	1.84	0.96	1.34
Simpson Index of Diversity (SI)	0.77	0.84	0.93	0.73	0.70	0.73
Total Basal area	68.84	-	133.04	-	100.33	-
Total Density	975	405	840	270	770	225

lycium (PV=52.02) among shrubs. *Viburnum grandifolia* and *Berberis lycium* also exhibited maximum frequency (60% and 40% respectively) and density (75 and 100 individuals/ha respectively). Total density of trees across all stands ranges from 770 to 975 individuals/ha for trees and 225 to 405 for shrubs whereas total basal area for trees lies between 88.84 and 133 m^2/ha (Table 8). Total density for shrubs stands between 225 to 405 individuals/ha.

Species richness and diversity indices (Table 7) slightly vary across the stands studied. Shannon-Wiener Index ranges between 0.93 to 1.99 for trees and 1.34 to 1.93. Simpson's diversity index varies from 0.70 to 0.93 for tress and 0.73 to 0.84 for shrubs. Margalef index ranges from 0.74 to 1.88 for trees and 0.73 to 1.17 for shrubs; Menhenick's index from 0.20 to 0.44 for trees and 0.33 to 0.86 for shrubs and Peilio's index from 0.49 to 0.75 for trees and 0.92 to 1.92 for shrubs.

Discussion

Information on vegetational aspects of an ecosystem is vital for its subsequent ecological studies and conservation. Floral makeup and particularly its dominant groups represent as well as affect the overall ecological realm and environmental factors of an area.

Broad leaved forests in the north western Himalayas are often represented by pure and mixed stands of Oak between altitudinal ranges of 1000m to 3000m. Three species of oak viz. *Quercus leuchotrichophora, Q. floribunda* and and *Q. semecarpifolia* are found dominant in the study area. This is in accordance with the characteristic composition of temperate broadleaved forests throughout the western Himalayas where different species of oak often dominate the vegetation (Singh and Rawat, 2012, Troup, 1921, Singh *et al*., 1984). *Quercus leuchotrichophora*, exhibiting highest frequency (100%), density (420 to 495 individuals per hectare), basal cover (55.61 m^2 and 87.49 m^2) and IVI (148.41 to 67.24), predominates at all the three sites. It has different groups of associates in different localities like *Pinus roxburgii* (IVI= 11.94), *Xanthoxylum aratum* (IVI=9.00), *Morus alba* (IVI=10.77), etc at site I, *Quercus floridunda* (IVI=39.21), *Lyonia ovalifolia* (IVI=9.10), *Aeseculus indica* (22.88) at site II and *Quercus semecarpifolia* (IVI= 11.92), *Q. floribunda* (IVI=54.39), *Boxus Wallichiana* (IVI =31.21), *Vibrunmum grandifolia* (PV=69.04), etc at site III. Several tree and shrubs like *Rhododendron arborium, Pyrus pasia, Berberis lyceum*, etc, however, grow almost ubiquitously in the region. Values obtained in the present study on phytosociological aspects are comparable with those observed by other workers for similar vegetations in Uttrakhand (Lal and Laudhiyal, 2016), Kumaon (Singh and Singh, 1986), Gharwal (Singh *et al*, 2016), parts of Jammu (Sharma and Raina, 2013) and other parts of the Himalayas (Paul *et al,* 2018; Ahmed *et al,* 2006; Khera *et al*, 2001; Singh and Singh, 1986). Oak shows regular, random as well contagious patterns of distribution at various sites as indicated by Whitford index (Abundance/Frequency) values ranging between 0.01 to above 0.05. It's because Oak is generally a gregarious tree species when growing in its natural habitat. However contagious distribution is also very common under natural conditions owing to variations in environmental factors.

Total density ranging from 770 to 975 for trees and 225 to 425 is comparable with those found by Pande (2012) in Nainital, by Singh *et al*. (1987) in Kumaon, by Singh *et al* (2016) in Uttrakhand and by Dar and Sundarapandian (2016) in Liddar valley of Kashmir. However it's much lower than that observed by Paul *et al* (2018) and Khera *et al* (2001) for very dense undisturbed forests of the Eastern and Central Himalayas and considerably higher than that of some open and disturbed forests found by Singh *et al* (2016) and Sharma and Raina (2013). Total basal area for dominant tree species ranges between 68.84 m^2 to 133.04 m^2 which similar as found by other workers (Singh and Singh, 1986,) but considerably higher than that found by Sharma and Raina (2013) in some forests of Jammu province. Values of Mergalef index, Manhinik Index, Shannon index and Simpson's diversity index are similar as often recorded (Sharma and Raina, 2013; Pande, 2012; Kharkhwal *et al*, 2010 and Mandal and Joshi, 2014) for the temperate Himalayan forests and suggest presence of a good deal of biodiversity in the study area. Generally, tree species in the area exhibits more diversity (total number of species approaching 20) than shrubs (total species recorded=12). Site I shows maximum number of species of trees and shrubs and it could be attributed to comparatively lower altitude as well lesser anthropogenic interference.

Conclusion

The information on diversity and phytosociological attributes of the studied area presents a broad depiction of temperate broadleaved forests along southern slopes of the Pir Panjal Himalayan range (in Rajouri Forest Division). It also offers significant baseline data required for scientific management of forest crop or implementation of any conservation strategy. Though Oak (*Quercus leucotrichophora, Q. floribunda*) is, ecologically as well as socioeconomically, the most significant species, the region is rich in plant diversity including several endemic and endangered species like *Boxus wallichiana*. These forests are, however, under severe anthropogenic pressure and demand further ecological investigations and conservation measures.

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