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Biodiversity of Oak (*Quercus leucotrichophora*) Dominated Forest Stands in Mussoorie Garhwal Himalaya, Uttarakhand, India

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ABSTRACT

The current study was carried out to examine the diversity of plant species in the oak stands of the Garhwal Himalaya, Uttarakhand, spanning an altitude range of 1500 to 2200 meters from the warm temperate zone to the cold temperate zone. A good number of genera are represented by the altitudinal diversity and relatives at every Oak stand, many of them are helpful in different ways.

INTRODUCTION

About 45% of geographical area of Uttarakhand is under forest cover and a major portion of this forest cover is distributed between 1000-3000 m of altitudinal ranges (ISFR, 2021). Numerous trees, shrubs, herbs, and climbers with ecological and financial potential were documented in various studies. Indian Himalayan Region represents the unique biological diversity (Dhar, Rawal & Samant, 1997; Maikhuri, Rao & Semwal, 2001). It includes around 9000 species of angiosperms and is considered hotspot of biodiversity. About 3470 species are considered exclusively endemic to the Himalayas (Kumar *et al.*, 2001). Growing from the subtropical to the sub-alpine zones, oaks (*Quercus species*) are one of the most common vascular plants in the Himalayas. They are crucial for preserving the stability of ecosystems, preventing soil erosion, and preserving local biodiversity. They are also one of the most over-exploited species and fail to regenerate adequately in disturbed or undisturbed natural habitats (Shrestha, 2003). *Quercus leucotrichophora* is an evergreen tree of moderate to large size that grows between 1000 and 2400 meters in the North Western Himalayan region, extending from Kashmir to Nepal. With its primary uses as fuelwood, fodder, and for the production of agricultural tools, it plays a subsistence role in the rural population's economy.

Because these plant life forms regulate the structural and functional state of that ecosystem, the presence of trees, shrubs, herbs, climbers, grasses, etc., in any natural forest defines the sustainability and balanced ecosystem. In addition to preventing soil erosion, the under storey vegetation—which includes shrubs, herbs, climbers, grasses, and more—offers a variety of faunal species food, shelter, and places to nest. The herbivore population in forest ecosystem depends to a large extent on the availability of existing under-storey vegetation. Present study is an attempt to highlight the floral diversity in Oak (*Quercus leucotrichophora*) forest stands in different altitudinal ranges of Garhwal Himalaya.

MATERIAL AND METHODS

Study area

The study was conducted in Uttarakhand, India's Garhwal Himalayan area, in natural stands of oak (*Quercus leucotrichophora*). Data collection and field research were conducted on north and south-facing aspects of all oak stands between 1500 and 2200 meters above sea level at various locations in the Uttarakhand state's Mussoorie Garhwal Himalayan region. The area contains a variety of land use classifications, including government reserve forests, scrub, barren terrain, solitary fruit tree patches, cultivated land, and village common land, known locally as "Panchayat Bhumi," which is under forest.

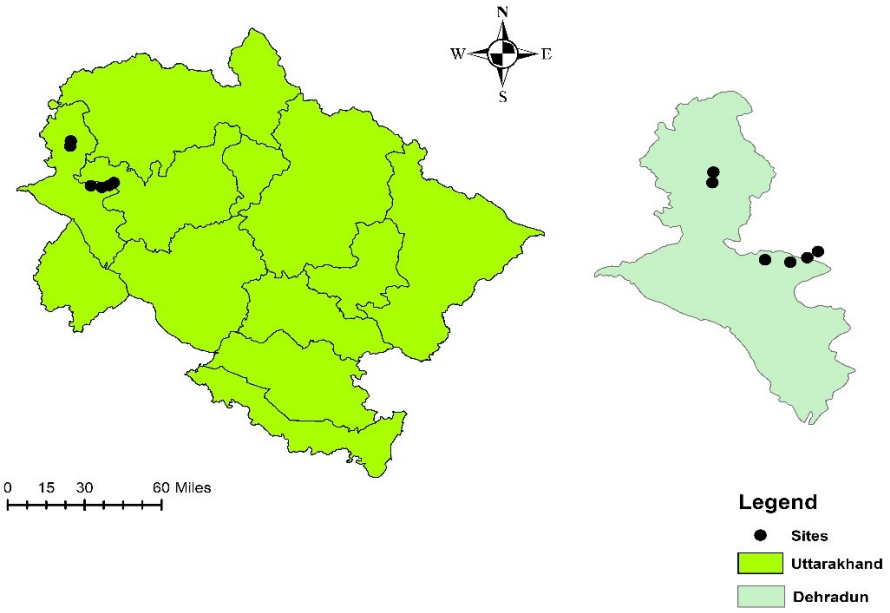

Fig.: Study Area

Vegetation analysis

The line transect sampling approach was used to conduct reconnaissance field surveys in order to identify and analyze specific oak forest stands. For spatial information at various locations, toposheets and satellite photos of various regions were utilized. Each site was surveyed in reconnaissance using a well-traced map.

Sampling was done in stratified random manner along the altitudinal transects. Transects were spatially distributed so as to minimize the auto-correlation among the vegetation. Quadrats were laid down along each transect in stratified random manner and placed at an interval of 100 m. Species area curve was used to determine minimal sample area which is based on quantitative variation of the vegetation in terms of species number. The adequacy of sample size was estimated by stopping sampling at the point at which additional quadrat did not significantly affect the mean of species. In each stand, minimal sample area was determined for sampling purpose by laying the random quadrat, on which the species composition of the community was adequately represented. Quadrats of 10 m x 10 m were used for tree layer, 2 m x 5 m for shrubs and 1 m x 1 m for herb species. The Phytosociological analysis was determined as per Muller-Dombois and Ellenberg (1974) and Mishra (1968).

RESULTS

The altitudinal distribution of trees, shrubs and herbs in all studied Oak stands is presented in Table 1. In context of plant diversity, a total of 134 species representing 107 genera under 63 families was recorded from all studied altitudes. These include 31 species of trees, 47 shrubs and 56 species of herbs. Among all altitudinal ranges, middle ranges (1700-1900 m) had greater species richness. At every oak stand, the number of species and families represented by understory shrub and herb flora was higher. Species richness declined in all vegetative layers as the altitudinal range increased from 2000 to 2200 meters. The observed plant species diversity at all studied oak stands along altitudinal ranges are shown in Table 2, 3 and 4. In tree layer, species like *Alnus nepalensis, Benthamidia capitata, Cedrus deodara, Myrica esculenta, Pinus roxburghii, Prunus cerasoides, Pyrus pashia, Quercus leucotrichophora, Rhododendron arboreum* and *Taxus baccata* have ethno botanical and other uses. In the middle layer the dominant shrub species are: *Eupatorium adenophorum, Berberis aristata, Myrsine africana, Rosa macrophylla, Rubus ellipticus, Colebrookea oppositifolia, Cotoneaster bacillaris, Desmodium elegans* and *Daphne papyracea.* The dominant species in ground vegetation are: *Andropogon munroi, Boenninghausenia albiflora, Cynodon dactylon, Fragaria nubicola, Heteropogon contortus, Micromeria biflora, Valeriana jatamansi* and *Viola canescens.* Among the vegetation some species bear edible fruits for human, animal and bird consumption. Further, distribution of greater number of upper-storey and under-storey vegetation at different altitudes may be associated with habitat for various faunal species in these forest stands.

Table 1: Altitudinal plant diversity in studied Oak stands

Altitude (m)	Tree layer			Shrub layer			Herb layer		
	Species	Genera	Family	Species	Genera	Family	Species	Genera	Family
1500	10	10	8	23	22	14	20	20	11
1600	15	15	12	29	25	18	29	27	16
1700	17	17	12	38	30	20	43	37	19
1800	21	19	12	44	33	20	44	36	18
1900	19	17	12	38	31	19	42	37	18
2000	19	16	11	39	31	19	43	36	18
2100	18	17	11	40	32	20	39	34	17
2200	15	15	10	30	24	18	38	32	16

Table 2: Diversity and distribution of trees at different ranges:

S No.	Name of Species	Family	Altitudinal Ranges							
			1500	1600	1700	1800	1900	2000	2100	2200
1	*Acasia dealbata*	Mimosaceae		+		+				

2	*Alnus nepalensis*	Betulaceace		+	+	+	+	+	+	+
3	*Benthamidia capitata*	Cornaceae			+	+	+	+	+	+
4	*Cedrus deodara*	Pinaceae			+	+	+	+	+	+
5	*Cupressus turolosa*	Cupressaceae					+		+	
6	*Ilex diptera*	Aquifoliaceae		+	+	+			+	
7	*Myrica esculanta*	Myriaceae		+	+	+	+	+	+	+
8	*Lyonia ovifolia*	Ericaceae	+	+	+	+	+	+	+	+
9	*Persea odoratissima*	Lauraceae			+	+				
10	*Pinus roxburghii*	Pinaceae	+	+	+	+	+	+	+	+
11	*Pinus wallichiana*	Pinaceae								+
12	*Prunus cerasoides*	Rosaceae	+	+	+	+	+	+		
13	*Prunus cornuta*	Rosaceae				+	+	+	+	+
14	*Pyrus pashia*	Rosaceae								
15	*Quercus floribunda*	Fagaceae				+	+	+	+	+
16	*Quercus leucotrichophora*	Fagaceae	+	+	+	+	+	+	+	+
17	*Quercus semicarpifolia*	Fagaceae							+	+
18	*Rhododendron arboreum*	Ericeae	+	+	+	+	+	+	+	+
19	*Rhus punjabensis*	Anacardiaceae							+	+
20	*Sapium insigne Royle*	Euphorbiaceae	+	+						+
21	*Symplocos paniculata*	Sympolaceae		+	+	+	+	+	+	+
22	*Taxsus bacata*	Taxaceae								+
23	*Thuja capiata*	Cupressaceae							+	
24	*Toona hexandra*	Meliaceae	+	+	+	+				
25	*Albizia julibrissim*	Mimoaceae	+	+		+	+			
26	*Juglans regia*	Juglandaceae							+	+
27	*Engelhardtia spicata*	Juglandaceae		+	+					
28	*Lindera pulcherrima*	Lauraceae			+	+	+	+	+	
29	*Neolitsia cuipala*	Lauraceae					+	+	+	

Table 3: Diversity and distribution of shrubs at different altitudinal ranges

S No.	Name of species	Family	Altitudinal ranges							
			1500	1600	1700	1800	1900	2000	2100	2200
1	*Artemisia roxburghiana*	Euphorbiaceae				+	+	+	+	+
2	*Asparagus filicinus*	Liliaceae	+	+	+	+	+	+	+	+
3	*Asparagus adscendens*	Liliaceae			+	+	+	+	+	+
4	*Berberis aristata*	Berberidaceae	+	+	+	+	+	+		
5	*Berberis chitria*	berberidaceae	+	+	+			+	+	+
6	*Berberis lycium*	berberidaceae	+	+	+	+	+			
7	*Caryopteris foetida*	Verbenaceae	+	+	+	+	+	+	+	+
8	*Cotoneaster bacillaris*	Rosaceae	+	+	+	+	+	+	+	+
9	*Desmodium elegans*	Fabaceae	+	+	+	+	+	+	+	+
10	*Deutzia staminea*	Hydrangeaceae			+	+	+	+	+	
11	*Elsholtzia flava*	Lamiaceae			+	+		+	+	
12	*Eranthemum pulchellum*	Acanthaceae						+	+	+
13	*Eupatorium adenophorum*	Asteraceae	+	+	+	+	+	+	+	+
14	*Excoecaria acerifolia*	Euphorbiaceae	+	+	+	+	+	+	+	
15	*Glochidion velutinum*	Euphorbiaceae			+	+	+	+	+	+
16	*Hypericum uralum*	Hypericaceae			+	+	+	+	+	
17	*Indigofera atropurpurea*	Fabaceae			+	+		+	+	
18	*Indigofera heterantha*	Fabaceae	+	+	+	+	+	+	+	+
19	*Inula cappa*	Asteraceae		+	+	+	+	+	+	
20	*Inula cuspidata*	Asteraceae	+	+	+	+	+	+	+	
21	*Leptodermis lanceolata*	Rubiaceae		+	+	+	+	+	+	+
22	*Myrsine africana*	Myrsinaceae	+	+	+	+	+	+	+	+
23	*Nepeta govaniana*	Lamiaceae	+	+	+	+	+	+	+	+
24	*Perilla frutescens*	Lamiaceae	+	+	+	+	+	+	+	+
25	*Prinsepia utilis*	Rosaceae		+	+	+	+	+	+	
26	*Pyracantha crenulata*	Rosaceae	+		+	+	+	+	+	+
27	*Rhamnus persica*	Rhamnaceae			+	+	+	+	+	+
28	*Rhamnus purpurea*	Rhamnaceae			+	+	+	+	+	
29	*Rhamnus virgatus*	Rhamnaceae				+	+	+	+	
30	*Rhus parviflora*	Anacardiaceae	+	+	+	+	+	+	+	
31	*Rubus ellipticus*	Rosaceae	+	+	+	+	+	+	+	+
32	*Rubus foliolosus*	Rosaceae	+	+	+	+	+	+	+	+
33	*Rubus paniculatus*	Rosaceae				+			+	
34	*Solanum anguivi*	Solanaceae					+			
35	*Spiraea canescens*	Rosaceae		+	+	+	+	+	+	
36	*Viburnum erubescens*	Caprifoliaceae	+	+	+	+				+
37	*Viburnum grandiflorum*	Caprifoliaceae				+	+	+	+	

38	*Woodfordia fructicosa*	Lythraceae			+	+	+	+	+	
39	*Zanthoxylum armatum*	Rutaceae	+	+	+	+	+	+	+	

Table 4: Diversity and distribution of herbaceous species at different altitudinal ranges

S No.	Name of species	Family	Altitudinal ranges							
			1500	1600	1700	1800	1900	2000	2100	2200
1	*Ainsilaea latifolia*	Asteraceae	+		+	+	+	+	+	+
2	*Anaphalis busua*	Asteraceae			+	+		+	+	+
3	*Andropogon munroi*	Poaceae	+	+	+	+	+	+	+	+
4	*Apluda mutica*	Poaceae			+	+			+	+
5	*Arabis amplexicaulis*	Brassicaceae						+	+	+
6	*Bergenia ciliata*	Saxifragaceae		+	+	+	+	+	+	+
7	*Bidens pilosa*	Asteraceae	+	+	+	+	+	+	+	+
8	*Boerhavia diffusa*	Nyctaginaceae		+	+	+		+	+	
9	*Carex caricina*	Cyperaceae	+	+	+	+		+	+	+
10	*Chrysopogon grylllus*	Poaceae			+	+	+	+	+	+
11	*Euphorbia hirta*	Euphorbiaceae				+	+	+		
12	*Euphorbia peplus*	Euphorbiaceae		+	+	+				
13	*Euphorbia pilosa*	Euphorbiaceae			+	+	+	+	+	+
14	*Fragaria nubicola*	Rosaceae	+	+	+	+	+	+	+	+
15	*Galium acutum*	Rubiaceae		+	+	+	+	+	+	+
16	*Galium asperifolium*	Rubiaceae	+	+	+	+	+	+	+	+
17	*Galium elegans*	Rubiaceae		+						
18	*Geranium nepalense*	Geraniaceae			+				+	+
19	*Gerbera maxima*	Asteraceae	+	+	+	+	+	+	+	+
20	*Heteropogon contortus*	Poaceae	+	+	+	+	+	+	+	+
21	*Hypericum elodeoide*	Hyperiaceae						+		
22	*Lathyrus erectus*	Fabaceae			+	+	+	+	+	+
23	*Leucas lanata*	Lamiaceae					+		+	+
24	*Micromeria biflora*	Lamiaceae	+	+	+	+	+	+	+	
25	*Ocimum americanum*	Lamiaceae					+	+	+	+
26	*Origanum vulgare*	Lamiaceae			+	+	+	+	+	+
27	*Oxalis corniculata*	Oxalidaceae			+	+	+	+	+	+
28	*Perilla frutescens*	Lamiaceae		+	+	+	+			
29	*Phytolacca acinosa*	Phytolaccaceae				+	+	+	+	
30	*Potentilla fulgens*	Rosaceae			+	+		+	+	+
31	*Primula denticulata*	Primulaceae					+			
32	*Prinsepia utilis*	Rosaceae			+	+				
33	*Ranunculus arvensis*	Ranunculaceae			+	+	+	+	+	+
34	*Reinwardita indica*	Linaceae	+	+	+	+	+	+		
35	*Rosularia adenotricha*	Crassulaceae	+	+	+	+	+	+	+	
36	*Rosularia rosulata*	Crassulaceae			+	+	+	+	+	
37	*Rumex hastatus*	Polygonaceae	+	+	+	+	+	+	+	+
38	*Salvia lanata*	Lamiaceae			+	+	+	+	+	+
39	*Taraxacum officinale*	Asteraceae							+	+
40	*Valeriana jatamansi*	Valerianaceae	+	+	+	+	+	+	+	+
41	*Vicia tenera*	Fabaceae		+	+	+	+	+	+	+
42	*Viola biflora*	Violaceae				+	+	+	+	+
43	*Viola canescens*	Violaceae		+	+	+	+	+	+	+
44	*Androsace sarmentosa*	Primilaceae	+	+	+	+				
45	*Ajuga chamaepitys*	lamiaceae	+			+	+	+		

DISCUSSION

The table displays the floral diversity of the oak forests in the various Garhwal Himalayan regions. The faunal richness at the oak stand research sites may also be significantly correlated with the diversity of tree species and understory vegetation in the current study. Studies on the faunal variety of the Garhwal Himalayan region are also accessible. According to Singh et al. (2021), Prasad, Sharma, and Kumar (2021a,b), Puspwan, Singh, and Pandey (2019), Naithani and Bhatt (2012), Joshi and Bhatt (2013), Chauhan et al. (2014), and others, altitude change significantly influences the distribution of flora and animals. A study on plant diversity in the Shiwalik region of the Garhwal Himalaya by Gaur and Sharma (2011) found 130 important plant species with a variety of traditional applications.

The plant species found in this study are likewise comparable to those reported by Prasad and Sharma (2018), who identified numerous significant wild edible plant species in the Garhwal Himalaya from valley of Kedarnath. According to the study, there are 32 plant species utilized for fuel wood, 36 edible plant species, and 46 therapeutic plant species. Asteraceae, Ericaceae, Fagaceae, Poaceae, and Rosaceae were more prevalent in all altitudinal ranges examined in this study, which is consistent with findings by Rawat et al. (2013) and Naithani (1984–85) at various elevations in the Garhwal Himalayan region.

The study also showed that plant variety is quickly declining as a result of overexploitation and natural disturbance. 49 tree species, 28 shrub species, and 144 plant species with significant ethnobotanical value were found in the Kedarnath valley of the Garhwal Himalaya between altitudinal ranges of 864 m and 4000 m, according to a study by Prasad, Sharma, and Kumar (2021a,b).

Numerous faunal species in the Garhwal Himalaya are also supported by the forest kinds and altitudinal ranges. Naithani and Bhatt (2012) examined the structure of a bird community at various elevations in the Pauri district (Garhwal Himalaya). A total of 125 bird species were reported in the study; 88.8% of them were found at high elevation (1600–2100 m), 63.2% at mid height (900–1300 m), and 58.4% at elevation range 500–900 m.

The plant species composition in the current study region is comparable to that found in the study mentioned above.

Different animal species in the forest consume different plant kinds in different ways. According to Joshi and Bhatt (2013), a significant number of avian species that are insectivores, omnivores, frugivores, carnivores, granivores, and nectarivores are supported by forests of sal (Shorea robusta), pine (Pinus roxburghii), and oak (Quercus leucotrichophora). Along various elevational zones, they discovered 79 bird species from 24 families in a bulge-shaped association between bird species richness and forest habitat. According to Cody (1985), the authors' personal usage is covered by copyright.

Ahmed, Bargali, and Khan (2019) noted that there was a higher diversity of bird species in Uttarakhand's Western Terai-Arc landscape. woodlands, followed by arid areas, water basins, scrublands, and human habitats. These results show that plant diversity depends on bird diversity and is associated with various land types.

A species' specific habitat is usually determined by the plant species that are found in the forest's natural habitat for wildlife, as well as the various types of forests and their composition. The animal diversity in different altitudinal ranges between the alpine forest zone (3000-4200 m) and the subtropical zone (below 1200 m) was recently assessed by Singh et al. (2021). In addition to important members of the cat and bear families, they discovered a diverse range of mammals, apes, herbivores, and birds. The Garhwal Himalaya is home to a wide variety of trees and understory vegetation, which are essential habitats for numerous animal species. The investigation was conducted throughout an altitudinal range of 1500 to 2200 meters, from the warm temperate zone to the cold temperate zone.

CONCLUSION

The goal of the current study was to assess the plant diversity in the 1500–2200 m elevation range of the Garhwal Himalayan oak forests. The ecological functioning of the examined oak stands, the ethnobotanical applications of different plants, and the associated faunal diversity may all benefit from this diversity. Some of the species that have been documented may become endangered as a result of growing biotic pressure and habitat loss brought on by changes in land use. To better comprehend the significance of floral and faunal diversity in the Garhwal Himalayan region, an integrated study should be conducted. As a result, it is important to prioritize research on and conserve these plant and animal species.

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