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Comparative studies on species richness, diversity and composition of oak forests in Nainital district, Uttaranchal

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Species richness, diversity and composition of herb species in oak forests, viz. Banj oak (*Quercus leucotrichophora*) A. Camus, Tilonj oak (*Quercus floribunda*) Rehder and Kharsu oak (*Quercus semecarpifolia*) Smith were evaluated. The total number of species, genera and families observed for Kharsu oak forest was higher than Banj and Tilonj oak forests. Only a few species were dominant in all study sites. Asteraceae and Lamiaceae were found to be the dominant families in all the forest types. Regarding ecological structure and composition, the study revealed that Banj and Tilonj oak forests were less complex in comparison to Kharsu oak forest.

Keywords: Composition, diversity, oak forests, species richness.

HIGH biodiversity favours ecological stability, whereas accelerating species loss could lead to collapse of the ecosystem. Human domination of earth's ecosystems, which is markedly reducing the diversity of species with many habitats worldwide, is accelerating species extinction[1].

Biotic disturbances generally have caused substantial reduction in forest cover, which has led to serious ecological disasters such as soil erosion, loss of fertility and violent floods in the adjacent plains[2].

The forest vegetation of Himalaya has been of major interest to ecologists since long. Osmaston[3] worked out the forest flora of Kumaun Himalaya, and Dudgen and Kenyor[4]

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Table 1. Species and their corresponding families in the study area

Species	Family	Oak		
		Banj	Tilonj	Kharsu
Achyranthes bidentata Bl.	Amaranthaceae	+	+	+
Agrimonia pilosa Ledeb.	Rosaceae	+	+	+
Ainsliaea aptera DC.	Asteraceae	–	+	+
Ainsliaea latifolia (D. Don) Sch.-Bip.	Asteraceae	+	+	–
Anaphalis busua (Buch.-Ham. ex D. Don) DC.	Asteraceae	–	+	+
Anaphalis contorta (D.Don) Hook. f.	Asteraceae	+	+	–
Anaphalis margaritacea (L.) Benth.	Asteraceae	+	+	–
Anemone vitifolia Buch.-Ham. ex DC.	Ranunculaceae	–	–	+
Arisaema tortuosum (Wall.) Schott	Araceae	–	–	+
Artemisia nilagarica Clarke	Asteraceae	+	–	+
Arthraxon lanceolatus (Roxb.) Hochst.	Poaceae	+	+	–
Arthraxon prionodes (Stud.) Dandy	Poaceae	+	+	–
Aster asperulus (DC) Hook. f.	Asteraceae	–	+	+
Aster thomsonii Clarke	Asteraceae	+	+	–
Athyrium foliolosum Wall. ex Sim	Athyriaceae	+	–	–
Athyrium rupicola (Hope) C. Chr.	Athyriaceae	–	–	+
Bidens biternata (Lour.) Merrill & Sheriff	Asteraceae	–	+	–
Bupleurum hamiltonii Balak.	Apiaceae	–	–	+
Campanula colorata Wall.	Campanulaceae	–	–	+
Carex cruciata Wahlenb.	Cyperaceae	+	–	–
Carex nubigena Tilloch & Taylor	Cyperaceae	–	+	–
Carpesium cernuum L.	Asteraceae	–	+	+
Carum anathifolium Benth.	Apiaceae	+	–	–
Cassia mimosoides L.	Caesalpiniaceae	+	–	–
Circaea alpina L.	Onagraceae	–	–	+
Circaea lutetiana L.	Onagraceae	–	+	–
Clematis buchananiana DC.	Ranunculaceae	–	–	+
Clinopodium umbrosum (Bieb.) Koch	Lamiaceae	+	–	–
Commelina benghalensis L.	Commelinaceae	+	–	+
Conyza japonica (Thunb.) Less. ex DC.	Asteraceae	+	+	+
Conyza stricta Willd.	Asteraceae	–	+	–
Craniotome furcata (Link) Ktze.	Lamiaceae	–	+	–
Cynoglossum glochidiatum Wall ex Benth.	Boraginaceae	–	–	+
Cyperus niveus Retz.	Cyperaceae	+	–	–
Desmodium multiflorus DC.	Fabaceae	+	–	–
Dicliptera bupleuroides Nees	Acanthaceae	+	–	–
Dipsacus inermis Wall.	Dipsacaceae	–	–	+
Epilobium royleanum Haussk.	Onagraceae	–	–	+
Epipactis royleanum Lindl.	Orchidaceae	+	–	–
Erigeron annuus (L.) Pers.	Asteraceae	+	–	–
Erigeron karvinskianus DC.	Asteraceae	+	+	–
Fragaria indica Andrews	Rosaceae	+	+	–
Galium aparine L.	Rubiaceae	–	+	+
Galium elegans Wall.	Rubiaceae	+	–	+
Geranium nepalense Sweet	Geraniaceae	–	+	–
Geranium wallichianum D. Don ex Sweet	Geraniaceae	+	–	+
Gerbera gossypina (Royle) P. Beauv.	Asteraceae	–	–	+
Goldfussia dalhousiana Nees	Acanthaceae	+	–	+
Gonostegia hirta (Bl.) Miq.	Urticaceae	–	–	+
Goodyera repens (L.) R.Br.	Orchidaceae	–	+	–
Habenaria latilabris (Lindl.) Hook. f.	Orchidaceae	–	+	–
Hedychium spicatum Buch.-Ham. ex J. E. Smith	Zingiberaceae	+	–	+
Impatiens amphorata Edgew.	Balsaminaceae	–	–	+
Justicia simplex D.Don	Acanthaceae	–	+	–
Leucas lanata Benth.	Lamiaceae	–	+	–
Lindenbergia indica (L.) Vatke	Scrophulariaceae	–	–	–
Melissa flava Benth.	Lamiaceae	–	–	+
Nervilia prainiana (King & Pantl.) Seidenf. & Smith	Orchidaceae	+	–	–
Onychium cryptogrammoides Christ	Cryptogrammaceae	–	–	+

(*contd...*)

Table 1. (*Contd...*)

Species	Family	Oak		
		Banj	Tilonj	Kharsu
Oplismenus compositus (L.) P. Beauv.	Poaceae	–	–	+
Origanum vulgare L.	Lamiaceae	+	+	+
Oryzopsis aequiglumis Hook. f.	Poaceae	–	+	–
Oxalis corniculata L.	Oxalidaceae	+	–	–
Oxalis dehradunensis Raizada	Oxalidaceae	+	–	–
Paris polyphylla J. E. Smith.	Liliaceae	+	+	–
Pilea scripta (Buch.-Ham. ex D. Don) Wedd.	Urticaceae	+	–	–
Pilea umbrosa Wedd.	Urticaceae	+	–	–
Pimpinella acuminata (Edgew.) Clarke.	Apiaceae	–	–	+
Pimpinella diversifolia DC.	Apiaceae	–	–	+
Platystemma violoides Wall.	Gesneriaceae	+	–	–
Plectranthus japonicus (Burn. f.) Koidz.	Lamiaceae	+	+	–
Plectranthus striatus Benth.	Lamiaceae	–	+	+
Polygonum amplexicaule D. Don	Polygonaceae	–	–	+
Polygonum hydropiper L.	Polygonaceae	+	+	+
Potentilla nepalensis Hook.	Rosaceae	–	+	+
Prunella vulgaris L.	Lamiaceae	–	–	+
Pteris cretica L.	Pteridaceae	–	+	–
Roscoea purpurea J.E. Smith.	Zingiberaceae	+	+	+
Rubia cordifolia L.	Rubiaceae	–	+	+
Sanicula elata Buch.-Ham. ex D. Don	Apiaceae	+	+	+
Satyrium nepalense D. Don	Orchidaceae	–	–	+
Scutellaria scandens Buch.-Ham. ex D. Don	Lamiaceae	–	+	–
Selinum wallichianum (DC) Raizada & Saxena	Apiaceae	–	–	+
Siegesbeckia orientalis L.	Asteraceae	+	–	–
Stachys sericea Wall ex Benth.	Lamiaceae	–	–	+
Swertia angustifolia Buch.-Ham. ex D. Don	Gentianaceae	–	+	+
Swertia ciliata (D. Don. ex G. Don) Burtt	Gentianaceae	–	–	+
Swertia tetragona Edgew.	Gentianaceae	+	–	+
Synotis rufinervis (DC.) C. Jeffrey & Y. L. Chan	Asteraceae	–	–	+
Thalictrum foliolosum DC.	Ranunculaceae	–	+	–
Thalictrum saniculaeforme DC.	Ranunculaceae	–	+	+
Torilis japonicus (Houtt.) DC.	Apiaceae	+	–	+
Viola canescens Wall.	Violaceae	+	+	+
Viola pilosa Bl.	Violaceae	–	–	+

+ and – indicate presence and absence of species.

studied the pine forests of the Himalayan region. Qualitative and quantitative parameters were also studied by others[5–7].

Kumaun Himalaya supports a variety of forests, of which the major type is a hemi-sclerophyllous broad-leaf forest dominated by oak species (*Quercus* spp.) at an elevation range of 1800–2600 m. *Quercus semecarpifolia*, locally known as Kharsu oak, is found at 2500–3500 m elevation[3].

This communication compares and contrasts plant species richness, diversity and compositional characters of different broad leaf forests occurring in the Kumaun Himalaya.

The study site lies between 1980 and 2600 m asl elevation (29°22′–29°23′N lat. and 79°26′–79°28′E long.) in Nainital, Kumaun Himalaya. The climate is monsoon temperate and annual rainfall in the area is 2668 mm/yr. The mean maximum temperature varies from 13.9 (February) to 23.7°C (April), and the mean minimum from 4.9 (February) to 16.5°C (July). The monsoon strikes from the middle of June to the middle of September, which sometimes extends to late September or the first week of October. Because of the high altitude the temperatures are similar to those of temperate regions, but latitudinally the region comes within the subtropical belt. Three main seasons could be recognized: cold and dry winter (December–February), warm and dry summer (April-mid June) and warm and humid rainy season (mid June–September). The transition between winter and summer seasons and between rainy and winter seasons is referred to as spring and autumn respectively. Snowfall is frequent during winter months (December–February). The Blaini rocks consist of conglomerates, siltstones, and purple and red limestone. Krol Formation consists predominantly of carbonate, limestone, marl and slates in the lower part and dolomites in the upper part. The pyretic, carbonaceous rocks exposed in Banj oak forest belong to the Infra Krol Member[8]. The limestone rocks of Tilonj oak forest are in the form of isolated massive blocks, which are cut by deep and dump fissures, found interbedded in thick, purple sandstones

Table 2. Family-wise contribution to genera and species

Species	Banj oak		Tilonj oak		Kharsu oak	
	Genus	Species	Genus	Species	Genus	Species
Acanthaceae	3	3	1	1	1	1
Amaranthaceae	1	1	1	1	1	1
Apiaceae	2	2	1	1	3	4
Araceae	0	0	0	0	1	2
Asteraceae	6	7	9	10	8	10
Athyriaceae	1	1	1	1	1	1
Balsminaceae	0	0	0	0	1	1
Boraginaceae	0	0	0	0	1	1
Caryophyllaceae	0	0	0	0	1	1
Caesalpiniaceae	1	1	0	0	0	0
Commelinaceae	1	1	0	0	1	1
Campanulaceae	0	0	0	0	1	1
Cryptogrammaceae	0	0	0	0	1	1
Cyperaceae	1	1	1	1	0	0
Dipsacaceae	0	0	0	0	1	1
Fabaceae	2	2	1	1	0	0
Gentianaceae	1	1	1	1	1	3
Geraniaceae	1	2	1	1	1	1
Lamiaceae	4	4	7	7	5	5
Liliaceae	1	1	1	1	0	0
Oleaceae	0	0	0	0	1	1
Onagraceae	0	0	1	1	2	1
Orchidaceae	2	2	2	3	1	1
Oxalidaceae	1	2	1	1	0	0
Poaceae	1	1	2	2	2	2
Polygonaceae	1	1	1	1	1	2
Ranunculaceae	1	1	1	1	3	3
Rosaceae	2	2	2	2	2	2
Rubiaceae	1	1	2	2	2	3
Scrophulariaceae	0	0	0	0	1	1
Urticaceae	3	3	1	1	1	1
Violaceae	1	1	1	1	1	2
Zingiberaceae	2	2	1	1	1	1

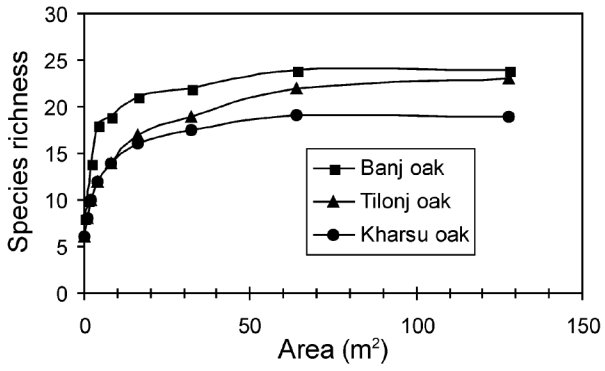

Figure 1. Species–area curve.

and intervening between the subsidiary shale with strong purple grit. The Kharsu oak forest has only a thin layer of limestone, followed by a singular shale or slate series with interbedded bonds of sandstones and limestone, dolomite or siliceous in nature[8].

The lower limit of forests is dominated by species of *Pinus* and *Rhododendron*, whereas the upper limit predominantly comprises *Abies*, *Juniperus*, *Picea*, *Tsuga* and *Taxus* species. The broad-leaf evergreen forests occur between 2000 and 2600 m asl in the subtropical regions of the district. These forests are mainly represented by oak species associated with *Rhododendron arboreum* Smith, *Alnus nepalensis* D.Don. and *Pinus roxburghii* Sarg[2].

The species–area curve plotted using nested plot technique[9] followed the same trend, with gradual increase in the number of species up to 8 m × 16 m (plot) for the Banj and Tilonj oak forests, and 16 m × 16 m (plot) for Kharsu oak forest (Figure 1).

At each site the plots were placed randomly. Herbaceous vegetation was analysed using fifteen 1 m × 1 m randomly placed quadrats at the time of the peak cover during the first week of September. Each shoot of the herb was considered as an individual plant[10]. Vegetational data were analysed following Curtis[11]. Species evenness[12,13], dominance[14], diversity[15] indices and beta-diversity[16] were calculated following Hill[17].

In Banj oak forest, a total of 43 species were encountered that belong to 22 families and 39 genera (Tables 1 and 2). Asteraceae was the most dominant family (with seven species) followed by Lamiaceae (with four spe-

cies), Acanthaceae and Urticaceae (with three species), Apiaceae, Fabaceae, Orchidaceae, Oxalidaceae, Rosaceae, Zingiberaceae and Geraniaceae (with two species); the remaining 11 families were represented by one species each. Taxonomically, Asteraceae was the most diverse family (with six genera) followed by Lamiaceae (with four genera), Acanthaceae and Utricaceae (with three genera), Apiaceae, Fabaceae, Orchidaceae, Rosaceae, Zingiberaceae and Geraniaceae (with two genera); the remaining 14 families were represented by one genus only.

In Tilonj oak forest, a total of 41 species were encountered belonging to 21 families and 40 genera (Tables 1 and 2). Taxonomically well-represented families were Asteraceae (with ten species), followed by Lamiaceae (with seven species), Orchidaceae, Poaceae, Rosaceae, and Rubiaceae (with two species) whereas the remaining 16 families were represented by one species each. Asteraceae had nine genera, Lamiaceae seven, Orchidaceae, Poaceae, Rosaceae, and Rubiaceae each had two genera. The remaining 16 families were represented each by a single genus only.

A total of 56 species were encountered in Kharsu oak forest, belonging to 28 families and 52 genera (Tables 1 and 2). Asteraceae was the most dominant family (with ten species) followed by Lamiaceae and Apiaceae (with five species), Gentiaceae, Rubiaceae, Ranunculaceae (with three species), Poaceae, Polygonaceae, Rosaceae, Violaceae, Onagraceae (with two species), whereas the remaining 17 families were represented by one species each. Taxonomically, Asteraceae was the most diverse family (with eight genera) followed by Lamiaceae, Apiaceae (with four genera), Ranunculaceae (with three genera), Poaceae, Rosaceae, Rubiaceae, Onagraceae (with two genera) and remaining 20 families were represented by a single genus only.

The proportions of family to genera, family to species and genera to species were higher in Kharsu oak than the other forests (Table 3). Margalef's index for Tilonj oak was maximum. Shannon–Weaver index for species diversity showed a higher value for Kharsu oak forest (Table 4). Simpson index was higher for Tilonj oak than other forests, indicating that few species were dominant in that forest type (Table 4). Menhinick's index showed a comparative value for all the forest types. Whittaker value for Banj oak and Kharsu oak forests was similar to that of Tilonj oak forest.

Simpson index was higher for Banj oak and Tilonj oak forests compared to Kharsu oak forest, indicating lower stability of these forests. This analysis of structure, species richness, species composition and species diversity of oak forests will serve as baseline for the area.

Table 3. Ratio of species, genus and family

Forest type	Genus : Species	Family : Species	Family : Genus
Banj oak	1.075	1.869	1.739
Tilonj oak	1.025	1.864	1.818
Kharsu oak	1.146	2.037	1.777

Table 4. Comparison of various diversity indices

Index	Banj oak	Tilonj oak	Kharsu oak
Margalef	22.43	26.37	18.87
Menhinick	5.77	6.39	5.82
Shannon–Weaver	3.65	3.24	4.03
Simpson	0.34	0.39	0.08
Whittaker	2.06	1.71	2.12

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