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Status of Medicinally Important Herbs along Canopy Disturbance in *Quercus leucotrichophora,* A. Camus Forest of Central Himalaya, India

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***Abstract*:** The present study focuses on the structure of the herb community and the status of selected medicinal plants across the different canopies of the *Q. leucotrichophora* forest. The study revealed that 81 herbaceous species encountered in the sample and 26 species had shown IVI≥5. The maximum number of species were from Asteraceae (14 nos.), followed by Poaceae (10 nos.), Lamiaceae (9 nos.), and Acanthaceae (4 nos.) families. Around 54% of species were common across the canopies, 17% species restricted in open, 10% in moderate, and 1% in close canopy. LSD indicated significantly high species richness ($p<0.05$) in the open canopy. Most of the recorded herb communities were in the rare category in all the three canopies, while no species was under the mostly and constantly present categories among the different canopies. The frequency distribution of selected medicinal plants also indicated *Origanum vulgare* was rarely present in the moderate and close canopy, while *Hedychium spicatum* in the open and moderate canopy. Further, *Rubia cordifolia* and *Boenninghausenia albiflora* were rarely and seldom present in all the three canopies. Therefore, the conservation and management of selected medicinal plant species should be given high priority.

***Keywords*:** Canopy, Distribution, Ecology, Himalaya, Oak Forest

The ecosystem services primarily rely on the species composition and structure of a forest community (Joshi et al 2022). Assessment of forest community's composition and structure is crucial to understand the population, regeneration, and diversity for conservation purposes (Mishra et al 2013). The study of vegetation in its totality, and the individual species as indicators are equally considered to be specific subjects for evaluating the levels of the analytical loads on ecosystems (Burianek et al 2013). It also plays an essential role in the maintenance of biodiversity (Jayakumar et al 2011) and helpful in the assessment of ground vegetation tracking, and constitutes an acknowledged basis for biodiversity assessment (Burianek et al 2013). Oak forests are an ecologically and socio-economically important late-successional forest formation of central Himalaya (Naudiyal and Schmerbeck 2021). *Quercus leucotrichophora,* is one of the keystone tree species between 1500 to 2200 m elevation in the central Himalaya which maintains the diversity of many other species (Prasad and Ram 2017). Broadleaf Oak forests are locally utilized for various provisional services viz. fuel wood, fodder for livestock, wood for agricultural implements, and many NTFPs (Negi 2022). Due to continuous dependence of local communities on oak forests, most of the species of Quercus are over-exploited and *Quercus leucotrichophora* is worst affected (Bargali et al 2015, Singh et al 2016, Naudiyal and Schmerbeck 2021).

The medicinal plants grow in different communities and a group of species is essential component of forest in Uttarakhand Himalaya (Ram et al 2010). The utilization of various medicinal plants in therapeutic drugs have also signifies the option for livelihoods and local healthcare in the country (Gakuya et al 2020). The increasing human disturbances directly or indirectly influence the medicinal plant diversity of oak forests. Due to this, the dense canopied forest converted into open canopied and, therefore, the herb species diversity has been adversely affected by these disturbances. The opening of canopy also changes the structure and distribution of species by altering the ecosystem habitats. This may lead to the addition and deletion of many species and effect the distribution of medicinal plants (Gafna et al 2017). Although such disturbances have negative effects on plant communities however, it also acts as positive force to increase the species diversity by minimizing competition among the species. Therefore, a better understanding of interactions between spatial pattern and disturbance is needed (Prasad et al 2015). The species is an important component of any ecosystem and attends as decent indicators of the ecological situations of a system (Palit and Banerjee 2014). Further, the

major portion of oak forests in the hilly areas of Uttarakhand is owned by local inhabitant, therefore the nature and frequency of disturbance in these forests are under explored (Prasad et al 2015). Further, the species diversity in the Himalayan region varies from habitat to habitat, and community to community, thus location specific studies are essential for its conservation and management (Rana and Samant 2010). Keeping in view the vulnerability and significance of oak forest, the present study thus focuses on the structure of the herb community and species diversity concerning some important medicinal plants along with the canopy disturbances of *Quercus leucotrichophora* forest in the central Himalaya of India.

MATERIAL AND METHODS

Study area: The study area lies between 29°21' and 29°23'N latitude and 79° 27' and 79° 29' E longitude within an elevational range 1800 to 2000 masl in the Central Himalayan region (Fig. 1). The aspect of the study area falls in North East and East aspect with *Q. leucotrichophora* (Banj Oak) as the dominant tree species. The climate of the study area is influenced by the monsoon pattern of rainfall. The average rainfall was 2090 mm and mean annual temperature ranged from 9.1°C to 21.2°C. The rocks in the study area are mainly sandstones, conglomeration, limestone, quartzite, schists, and granites. The *Quercus leucotrichophora* (Banj Oak) is the dominant (IVI > 70%) forest forming species. The other species associated with oak are *Myrica esculenta* Buch. -Ham.ex D. Don, *Rhododendron arboreum* Sm., *Acer oblongum* Wall. Ex DC., *Pinus roxburghii* Sarg., *Cedrus deodara* (Roxb.ex D. Don) D. Don., *Quercus lanuginosa* D. Don and *Quercus floribunda* Lindl. Ex A. Camus (Prasad and Ram 2017).

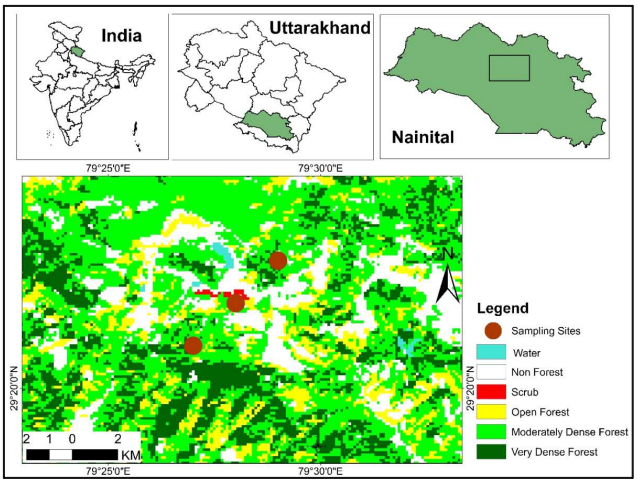

Fig. 1. Location map of the study area

Selection of important medicinal plants: Based on the ethnomedicinal uses and IUCN status, four important medicinal plant species, i.e., *Boenninghausenia albiflora* (Hk.) Reichb. Ex Meissn, *Hedychium spicatum* (Ham. Ex Smith), *Origanum vulgare* (Linn.), and *Rubia cordifolia* (Linn.) were selected (Table 1) to determine their status in the *Q. leucotrichophora* forest. *Boenninghausenia albiflora* is an erect, perennial herb, distributed in Himalayan ranges between 1000 and 2800 m above sea level (Joshi et al 1993); *Hedychium spicatum* is distributed with diverse growth habitats in sub-tropical to temperate zones (Negi et al 2014), *Origanum vulgare* is widely distributed in the subtemperate/temperate Himalaya (Mukerjee 2005) and *Rubia cordifolia* is distributed in sub-tropical and temperate regions of the world (Deshkar et al 2008).

Sampling and analysis: After thorough reconnaissance of the *Quercus leucotrichophora* forest, 10 line transects of 10 m were randomly placed to determine the canopy cover of the forest and categorized as open (< 40%), moderate (40–70%), and close (>70%) canopy (FSI 2013). In each canopy, three sites were selected for the detailed vegetation characteristics. The size and number of the sample were determined following Saxena and Singh (1982). At each site, ten quadrats of 1x1 m were randomly placed on the ground for assessment of herb vegetation and thus a total of 30 samples were present for each canopy. The herb cover was also determined by placing 10 line transects of 1 m in each site. The vegetation parameters were quantitatively analysed for density, frequency, and abundance. The Importance Value Index (IVI) for herbs was determined as the sum of

Table 1. Description of selected medicinal plant species

Species & family	Local name	Habit	Ethnomedicinal uses[#]	Status *
Boenninghausenia albiflora (Rutaceae)	Pissumar	Herb	Juice of whole plant is implemented externally to cure headache, and pain in eyes.	Common
Hedychium spicatum (Zingiberaceae)	Ban Haldi	Herb	Root stock powder or decoction is taken orally for body aches and inflammation related problems	Threatened
Origanum vulgare (Lamiaceae)	Ban Tulsi	Herb	Decoction of the whole plant is taken orally in Urinary disorder.	Rare
Rubia cordifolia (Rubiaceae)	Manjishtha	Climber	Paste of root implemented externally in leucoderma	Rare

(*IUCN 1993, [#]Kumari et al 2011)

relative density, relative frequency, and relative dominance (Phillips 1959). The presence of four medicinally important herbs was calculated and placed into their respective frequency classes in different canopy covers, Oosting (1956) gave five class scales based on presence, frequency, and constancy percentages. Thus, these were classified on the presence of species as class I (1-20%) rare, class II (21-40%) seldom present, class III (41-60%) often present, class IV (61-80%) mostly present, and Class V (81-100%) constantly present. The percent contribution of medicinal plant species from the total species present in the community was also determined. Total Species Richness was taken as a count of the number of species present in that forest type and calculated following Margalef's (1958). Species diversity was calculated based on density using the Shannon-Weaver information index (Shannon and Weaver1963). The Concentration of dominance was calculated using eq. (1) following Simpson's Index (1949).

$C = (Ni / N)^2$ ……eq. (1)

The index of similarity was calculated after Sorenson (1948) by using in eq. (2)

$$S = \frac{2C}{A+B} \times 100 \quad \text{..... eq (2)}$$

Where, A and B represent the number of species in canopy A and B, respectively and C is the number of species common to both the canopy.

The percent contribution of medicinally important herb species in the community was calculated following the equations (3), (4), and (5).

$$\text{Percent cover} = \frac{\text{Cover of a plant species}}{\text{Total cover of all species}} \times 100 \quad \text{..... eq (3)}$$

$$\text{Percent Density} = \frac{\text{Density of a plant species}}{\text{Total density of all species}} \times 100 \quad \text{..... eq (4)}$$

$$\text{Percent IVI} = \frac{\text{IVI of a plant species}}{\text{Total IVI of all species}} \times 100 \quad \text{..... eq (5)}$$

Statistical analysis: The data were statistically analysed using IBM SPSS 20(trial version).

RESULTS AND DISCUSSION

Vegetation structure: Many species contributed to the forest floor vegetation of *Q.leucotrichophora* forest. Eighty-one (81) herbaceous species with 32 families were encountered in the oak forest. Out of the total species present in the forest, 71 species were present in the open, 61 species in the moderate, and 51species in the close canopy (Table 2). About 54 % of the species were common in all three canopies while, 10% species were common in open-moderate, 6% were common in open-close, and <1% were common in moderate-close. In comparison, 17% species were restricted in open, 10 % in moderate, and 1 % in the close canopy.

Among the species, none of the species showed its clear-cut dominance in the forest floor vegetation. There were 26 species with IVI≥ 5 in different canopies (Table 3). In open canopy, the most dominant species was *Erigeron karvinskianus* (IVI = 26.78), followed by *Capillipedium assimile*. In contrast, the most dominant species in the moderate canopy was *Arthraxon lanceolatus* (IVI = 23.61) followed by *Carex nubigena*. In the close canopy, the most prevalent species was *Carex condensata* (IVI = 29.65) followed by *Arthraxon lanceolatus*. The percent contribution of individual species to the total Importance value is low (<10%), indicating the poor dominance of the herbaceous species in the forest. However, many species contributed to the total dominance of the forest floor vegetation. Dicot families were dominant in the oak forest, while Poaceae was the only dominant monocot family. Species richness varied significantly only in the open-close canopy and was higher in the open canopy and the vegetation parameters also varied significantly for richness and density among the canopies. The opening of the canopy in the oak forest provides abundant light to the forests floor and triggers the regeneration of many species and forest floor vegetation (Arya et al 2012). The continued human pressure in grazing, leaf litter removal, fire, and other disturbances might have affected the distribution of herbaceous species. Prasad and Ram (2017) also reported similar results for *Q. leucotrichophora* forest. However, *Q. leucotrichophora* forests maintain high biodiversity for forest floor vegetation and conserve the herbaceous biodiversity in the area.

All the herb species recorded in the oak forest (Table 2) belonged to 32 families. The maximum herbs species were from the Asteraceae (14), followed by Poaceae (10 nos.), Lamiaceae (9 nos.), and Acanthaceae (4 nos.) families. The rest of the herbs were 1-3 in 28 families (Fig. 2). The Asteraceae, Poaceae, and Lamiaceae were the widely distributed family across the canopy. Among the different species, four families were restricted in the open canopy, two families were restricted in the moderate canopy, and none were restricted in the close canopy. Kharkwal et al (2005) and Pusalkar and Singh (2012) reported the dominance of the Asteraceae and Poaceae family in the Himalayan vegetation. Joshi et al (2022) also reported the dominance of Poaceae and Asteraceae for trees, shrubs, and herbs from different forests of Kumaun Himalaya. The present study revealed that Asteraceae, Poaceae, and Lamiaceae are the dominant families of herbs in the *Q. leucotrichophora* forest of Kumaun Himalaya.

Table 2. Herb species in different canopies of *Q. leucotrichophora* forest

Herb species	Family	Open	Moderate	Close
Achyranthes bidentata Blume	Amaranthaceae	+	+	+
Ageratum conyzoides (L.) L.	Asteraceae	+	-	-
Ainsliaea aptera DC.	Asteraceae	+	+	+
Ajuga parviflora Benth	Lamiaceae	+	+	-
Anaphalis busua (Buch. -Ham.) DC.	Asteraceae	+	-	+
A. contorta (D.Don)Hook.f.	Asteraceae	-	+	-
Anemone vitifolia Buch. -Ham.ex DC.	Ranunculaceae	-	-	+
Apluda mutica L.	Poaceae	+	+	+
Arisaema tortuosum (Wall.) Schott	Araceae	+	+	+
Artemisia nilagirica (C.B. Clarke) Pamp.	Asteraceae	+	+	+
Arthraxon lanceolatus (Roxb.) Hochst.	Poaceae	+	+	+
Arundinella nepalensis Trin.	Poaceae	+	+	+
Asparagus racemosus Willd.	Asparagaceae	+	+	+
Aster asperulus (DC.) Wall. Ex Hook.f.	Asteraceae	+	-	-
Barleria cristata L.	Acanthaceae	+	+	+
Begonia picta Sm.	Begoniaceae	-	+	+
Bidens biternata (Lour.) Merr. & Sherff	Asteraceae	+	+	+
B. pilosa L.	Asteraceae	+	+	+
Boenninghausenia albiflora (Hook.)Rchb.ex Meisn	Rutaceae	+	+	+
Capillipedium assimile (Steud.) A.Camus	Poaceae	+	-	+
Carex condensata Nees	Cyperaceae	+	+	+
C. nubigena D.Don ex Tilloch & Taylor	Cyperaceae	+	+	+
Chrysopogon serrulatus Trin.	Poaceae	+	-	-
Cirsium wallichii DC.	Asteraceae	-	+	-
Clinopodium umbrosum (M.Bieb.)Kuntze	Lamiaceae	+	-	-
Commelina benghalensis L.	Commelinaceae	+	+	+
Craniotome versicolor Reichb.	Lamiaceae	+	+	+
Cynodon dactylon (L.) Pers.	Poaceae	+	+	-
Cynoglossum lanceolatum Forssk.	Boraginaceae	-	+	-
Cyperus rotundus L.	Cyperaceae	+	+	+
Dicliptera bupleuroides Nees	Acanthaceae	+	+	+
Eleusine indica (L.) Gaertn	Poaceae	-	+	-
Erigeron karvinskianus DC.	Asteraceae	+	+	+
Flemingia strobilifera (L.) W.T. Aiton	Fabaceae	+	-	-
Fragaria indica Andrews	Rosaceae	+	+	+
Fragaria vesca L.	Rosaceae	+	-	-
Galinsoga parviflora Cav.	Asteraceae	+	+	-
Galium aparine L.	Rubiaceae	+	+	+
G. rotundifolium L.	Rubiaceae	+	+	+
Geranium nepalense Sweet	Geraniaceae	+	+	+
G. ocellatum Camb.	Geraniaceae	+	-	-
Gerbera gossypina (Royle) Beauverd	Asteraceae	+	-	-
Goldfussia dalhousiana Nees	Acanthaceae	+	+	+

Cont...

Table 2. Herb species in different canopies of *Q. leucotrichophora* forest

Herb species	Family	Open	Moderate	Close
Hedera nepalensis K. Koch	Araliaceae	+	+	+
Hedychium spicatum Buch. -Ham. ex Sm.	Zingiberaceae	+	+	+
Impatiens edgeworthii Hook.f.	Balsaminaceae	+	-	-
Impatiens sulcata Wall	Balsaminaceae	+	+	+
Justicia simplex D. Don	Acanthaceae	+	+	+
Lactuca lessertiana (Wall.ex DC.) C.B. Clarke	Asteraceae	-	+	-
Leucas lanata Benth.	Lamiaceae	+	+	+
Malaxis acuminata D.Don	Orchidaceae	-	+	-
Micromeria biflora Benth.	Lamiaceae	+	+	+
Microstylis wallichii Lindl.	Orchidaceae	-	+	-
Nepeta leucophylla Benth.	Lamiaceae	+	+	+
Ophiopogon intermedius D. Don	Asparagaceae	+	+	+
Oplismenus undulatifolius Roem. & Schult.	Poaceae	+	+	+
Origanum vulgare L.	Lamiaceae	+	+	+
Oxalis corniculata L.	Oxalidaceae	+	+	+
O. latifolia Kunth	Oxalidaceae	+	+	-
Phlomis bracteosa Hook.	Lamiaceae	+	-	-
Pilea scripta D. Don	Urticaceae	+	+	+
Poa annua Schur	Poaceae	+	-	-
Polygonum alatum D. Don	Polygonaceae	+	-	+
Potentilla indica (Jacks.) Th. Wolf	Rosaceae	-	+	-
Pouzolzia hirta Blume	Urticaceae	+	+	+
Ranunculus diffuses DC.	Ranunculaceae	+	+	-
Reinwardtia trigyna (Roxb.) Planch.	Linaceae	+	+	+
Roscoea procera wall.	Zingiberaceae	+	+	-
Rubia cordifolia Roxb. Ex Fleming	Rubiaceae	+	+	+
Scutellaria angulosa Benth.	Lamiaceae	+	+	+
Setaria intermedia Roem. & Schult.	Poaceae	+	-	+
Siegesbeckia orientalis L.	Asteraceae	+	-	+
Smilax aspera L.	Smilacaceae	+	+	+
Stellaria media (L.) Vill.	Caryophyllaceae	+	-	-
Swertia japonica	Gentianaceae	+	+	-
Thalictrum foliolosum DC.	Ranunculaceae	+	+	+
Tragopogon gracilis D. Don.	Compositae	+	-	-
Urtica dioica L.	Urticaceae	+	+	+
Valeriana wallichii DC.	Valerianaceae	+	+	+
Viola canescens Wall.	Violaceae	+	-	-
Vitis himalayana (Royle) Brandis	Vitaceae	+	+	-
	Total species	71	61	51

Species richness (Margalef's index) varied across the canopies and was high (10.8) in the open canopy and low (7.9) in close canopy. The opening of the canopy provides abundant light exposures to the forest floor and generate growth of ground vegetation, thus the species richness generally increased with increase in canopy gaps (Tiwari et al 2019). Shannon and Wiener Index (H) was highest (5.4) for open canopy and low for close canopy. However, the Simpson Index was high for close canopy and low for open canopy (Table 4). Similarly, the diversity was high in the open canopy as compared to close canopy and reverse for Cd. The results are well supported by the study of Joshi et al (2022) in *Q. leucotrichophora* forest, where the species richness for herb layer was in the range of 5 to 26, and species diversity H' was 3.29. The Concentration of dominance (Cd) is more or less like those reported previously for other temperate and subtropical forests of the Himalaya. Raturi et al (2012), working in the different temperate and subtropical forests of Garhwal Himalaya, reported Cd between 0.09 to 0.63. Joshi et al (2022) reported Cd values of 0.16. The Cd values is strongly affected by the importance value index of the first three relatively important species in a community. Further, H' and Cd are inversely related to each other in the study area, generally in established forests (Devlal and Sharma 2008). Among the canopies, the similarity was higher between moderate and close canopies (80.4%) compared to open-moderate (78.8%) and open-close (80.3%) canopies.

Across the canopy, the frequency distribution indicated that 62 species were rare, eight species seldom present, while only one species was often present in the open canopy. In the moderate canopy, 50 species were rare, seven species were seldom present, and four herb species were often

Table 3. Herb species importance value in different canopies

Herb species	IVI in different canopy class		
	Open	Moderate	Close
Achyranthes bidentata Blume	2.3	5.5	9.2
Anaphalis busua Buch. -Ham	5.7	-	1.6
Apluda mutica L.	5.0	8.2	4.5
Arthraxon lanceolatus Roxb. Hochst.	16.6	23.6	25.5
Arundinella nepalensis Trin.	7.6	16.9	3.5
Bidens biternata Lour. Merr. & Sherff	10.6	4.8	3.1
Boenninghausenia albiflora Hook. Rchb.ex Meisn	10.7	19.3	18.5
Capillipedium assimilie Steud. A. Camus	21.6	-	1.4
Carex condensata Nees	14.0	20.8	29.7
Carex nubigena D.Don ex Tilloch & Taylor	16.5	21.2	21.2
Cyperus rotundus L.	0.8	1.8	5.6
Erigeron karvinskianus DC.	26.8	16.0	22.0
Fragaria indica Andrews	5.2	5.8	7.0
Galium aparine L.	5.2	3.0	9.3
Geranium nepalenses Sweet	5.0	1.8	1.9
Goldfussia dalhausania Nees	3.2	6.9	12.2
Hedychium spicatum Buch. -Ham.ex Sm.	6.0	4.3	13.3
Micromeria biflora Benth.	7.1	5.7	8.0
Nepeta leucophylla Benth.	2.5	5.5	8.8
Ophiopogon intermedius D. Don	7.7	18.7	3.4
Oplismenus undulatifolius Roem. & Schult.	7.7	19.8	24.7
Origanum vulgare L.	14.0	1.6	1.2
Oxalis corniculata L.	6.6	5.6	4.9
Reinwardtia trigyna Roxb. Planch.	2.5	8.4	1.5
Rubia cordifolia Roxb. Ex Fleming	4.9	6.9	6.4
Scutellaria angulosa Benth.	5.8	5.7	3.0
Others (*)	77.7 (45)	52.2 (37)	48.7 (25)

present. Similarly, in close canopy 41 species were rare, seven species seldom present, and three herb species were often present. However, no species was available in the mostly and constantly present categories. The variation in distribution across the vegetation layers seems to relate to number of factors, particularly the microenvironment and biotic nature. Various researchers also reported the contagious distribution pattern as a common phenomenon in temperate forests (Dar and Sundarapandian 2016, Tiwari et al 2019, Prasad and Tomar 2020).

Status of selected medicinal plants in oak forest: The distribution status of four selected medicinal herbs indicated that *Boenninghausenia albiflora* was seldom present. Across the canopy, the percent density, herb cover, and IVI for *B. albiflora* were higher in the moderate and close canopy. The percent density, herb cover, and IVI for *Hedychium spicatum* showed a higher value in the close canopy, and rarity in the open and moderate canopy. Low density of *Hedychium spicatum* in moderate canopy and open canopy may be due to sciophytic nature and thus grow well in moist soil (Bisht et al 2017, Bhatt et al 2010). The occurrence of *Hedychium spicatum* in grassy slopes, shady and moist places in the Banj Oak forest (Prasad and Tomar 2020) also support our study. The natural population is easily available in shady moist and rocky habitats, near water courses or dense oak dominated forest region in the Central Himalaya (Negi et al 2014). All four medicinal plants contributed a small percentage to the total vegetation composition. *Rubia cordifolia* was rarely present in all three canopies, however showed higher vegetation parameters in the moderate and

Table 4. Diversity parameters in *Q. leucotrichophora* forest

Parameters	Canopy class		
	Open	Moderate	Close
Margalef's Index	10.8	9.3	7.9
Shannon and Weaver Index (H')	5.4	4.9	4.7
Simpson Index (Cd)	0.04	0.05	0.06

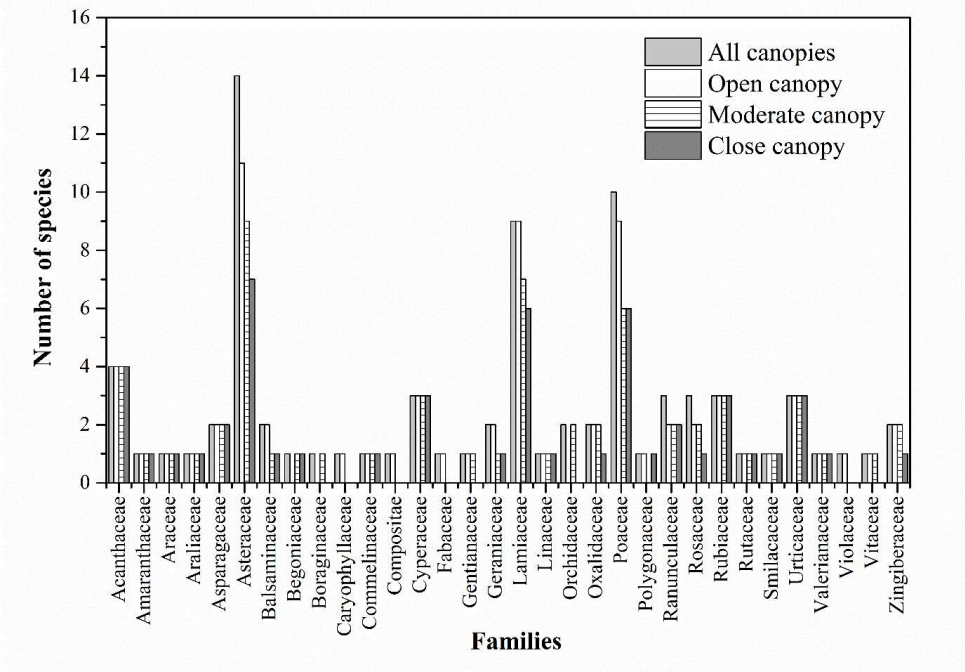

Fig. 2. Species occurrence in different families across the canopy

Table 5. Percent community contribution of selected medicinal plants in different canopies

Herb species	Parameters in different canopy class								
	Open			Moderate			Close		
	HC (%)	D (%)	IVI (%)	HC (%)	D (%)	IVI (%)	HC (%)	D (%)	IVI (%)
Boenninghausenia albiflora	4.2	2.4	3.6	10.0	4.7	6.4	8.3	5.3	6.2
Hedychium spicatum	2.6	1.4	2.0	2.8	0.8	1.4	9.9	2.2	4.4
Origanum vulgare	4.8	4.5	4.7	6.4	2.9	3.9	0.1	0.3	0.4
Rubia cordifolia	1.0	1.3	1.6	1.9	1.8	2.3	2.0	1.7	2.2

HC- Herb cover, D- Density, IVI- Importance Value Index

close canopy (Table 5). *Rubia cordifolia* was rare in all three canopies and indicated the existence of this will be in danger. This may be due to frequent use and overexploitation of the species in traditional medicine in Uttarakhand (Prasad and Tomar 2020). The percent density, herb cover, and IVI for *Origanum vulgare* showed a higher value for these parameters in the open to the moderate canopy, whereas rarity in the moderate and close canopy. The species showed greater density in open canopy compared to moderate and close canopy, which also indicated that herb require abundant light for growth and development apart from other resources (Arya and Ram 2016). According to IUCN (1993), *Origanum vulgare* and *Rubia cordifolia* were in the rare category. Although changes in the herbaceous layer are dependent on length of time of woody encroachment, percent woody cover, and site productivity (Murray and Cooper 2021), however the opening of canopy favours the invasion of herbs in oak forest (Arya 2012).

CONCLUSION

The conservation and management of forest floor vegetation are essential aspects of maintaining the functioning and structure of forest ecosystem. Most of the medicinal plants are associated with the livelihood of tribal and rural communities living around the forest in the Indian Himalayan region. The forests are on the verge of different stages of degradation, which influence the frequency, abundance, and status of these selected medicinal plant species. The frequency of recorded medicinal plant species indicated that most of the species are in the rare category in all three-canopy classes. Further, none of the species fall under the mostly and constantly present category. Among the selected four medicinal plants, three are under rare category. Thus, the conservation of *Origanum vulgare*, *Rubia cordifolia,* and *Hedychium spicatum* species should be considered for their protection. Further, utilization of *B. albiflora* should be in a sustainable way to maintain the population of the species. Therefore, the in situ as well ex-situ cultivation of these species should be given high priorities for conservation and management of these species.

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