International Journal of Ecology and Environmental Sciences 48: 63-69, 2022
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2023.2507

Epiphytic Bryodiversity of *Cedrus deodara* (Roxb. ex D. Don) G. Don Forest at Lohaghat (Champawat), Uttarakhand

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ABSTRACT

The present bryoexploratory study deals with the documentation of epiphytic bryophytes species and communities flourishing on the *Cedrus deodara* (Roxb. ex D.Don) G.Don phorophytes at Lohaghat. The study site is located near the bank of Lohawati River, with an altitudinal range of 1600-1754 m at the North-East aspect of district Champawat. A total of 42 bryotaxa were recognized from the acidic (pH 4.20 - 4.74) bark of *C. deodara* phorophytes of varied girth classes ranging from saplings to giant ones. In all, 09 leafy liverworts and 33 mosses were recorded, belonging to 27 families. Amongst leafy liverworts, Frullaniaceae turned out to be the dominant family followed by Lejeuneaceae. Two species of *Frullania* viz., *F. benjaminiana* Inoue and *F. udarii* V. Nath & Ajit P. Singh have been identified as new records for Western Himalaya. Pleurocarpous epiphytic mosses were found to dominate over the acrocarpous ones. *Pylaisiadelpha capillacea* (Griff.) B.C. Tan & Y. Jia, (Pylaisiadelphaceae) is identified as a new record for Western Himalayan moss flora. The members of the family Meteoriaceae and Anomodontaceae were recognized as the dominant pleurocarps. Amongst acrocarpous mosses, the family Bryaceae was noticed as the most diversified epiphytes. Morphologically, the majority of epiphytic bryophytes were found to be mat-forming followed by the tuft. Leafy liverworts namely *Lophocolea minor* Nees and *Radula complanata* (L.) Dumort., as well as the mosses viz., *Brothera leana* (Sull.) Mull. Hal. and *Pylaisiadelpha capillacea* emerged as gemmiferous. The north and south aspects of the forest site were discovered to have the highest species richness. The water trickling site of the tree trunks, junction of the broad branches, humus accumulated areas, as well as giant tree bases, were observed to be the suitable habitat and microhabitats for the colonization of epiphytic bryophytes on Cedar phorophytes. The present study will provide firm bases for comparative and quantitative bryosociological investigations and would be useful to future workers.

Key words: Bryophyte, Deodar, Diversity, Gemmiferous, Gymnospermous, Phorophyte.

INTRODUCTION

Bryophytes are naturally occurring poikilohydric green groups of shade-loving, non-vascular cryptogams. These surface-dwellings plants constitute important components of different ecosystems forming miniature forests in a variety of habitats. Himalayan forests at different elevations are the sites of bryophytic diversity and luxuriance. Western workers have repeatedly observed that the gymnospermous phorophytes do not have much adaptive support for the growth of bryophytes in comparison to angiosperms (Richards 1932, Barkman 1958, Watson 1971). Vitt (1981) stated that "I believe a general survey of host species of epiphytes would show that mosses rarely occur on coniferous trees, rather they are abundant on angiosperms only". In contrast, the general belief that bryophytes shun coniferous trees, are known to support the growth of epiphytic bryophytes (Tewari and Pant 1994). Throughout the Kumaun region of Western Himalayas, natural *Cedrus* forests were not there earlier but later on planted and are now naturalized as mature forests (Atkinson 1882, Yadav et al. 2014). The pure stands of the coniferous forest have high biomass and soil carbon sequestration potential (Sheikh et al. 2021). The *C. deodara* forest at Lohaghat is a picturesque site surrounded by well-stratified tall trees, forming a dense forest canopy. The selected forest was found to support the growth of both epiphytic as well as epilithic (forest floor) bryophytes species and communities. Earlier, some sporadic bryophyte collections were made by Srivastava (1984), Tewari et al. (2002) and Saxena

et al. (2006) from the forest site at Lohaghat but a thorough exploration of epiphytic bryodiversity flourishing on *Cedrus* phorophytes has not been surveyed. Due to the constant mounting pressure of urbanization and deforestation, the forest area is shrinking day by day. Consequently, the existing diversity and luxuriance of epiphytic and forest floor bryovegetation are also reducing markedly. Given this, the present exploratory study is undertaken to register the existing epiphytic bryophyte species and communities on *C. deodara* phorophytes at Lohaghat before the disappearance from the site of their occurrence. The present exploratory study will form a firm basis for future multidisciplinary quantitative investigations.

MATERIAL AND METHODS

The study site, Lohaghat is located on the bank of the Lohawati River. The area is one of the most pristine and unsullied destinations in the Kumaun region lies between 29.4042°N latitude and 80.0842°E Longitude at the North-East aspect with an altitudinal range of 1600-1754 m of district Champawat (Fig. 4A). The average humidity (21-93%) and temperature range (11-38°C) were measured over the collection period of 2019 (rainy, winter, and summer seasons). Thorough year-round bryo-collections were made almost from all the girth classes ranging from saplings to giant trees of pure *C. deodara* forest. Bryophytes of host trees were collected from tree base up to CBH (1.37 m) and above CBH along with some notable amount of underlying substrates and brought to the laboratory. Substrate pH was estimated by means of a pH meter. Field as well as microphotographs of gametophytic and sporophytic parts of the collected bryo-samples were taken for identification. Temporary slides were prepared in 30% glycerine and permanent in gum chloral mounting medium (Watson 1955). With the help of available literature, floras, monographs, viz., Kashyap (1929), Watson (1955), Gangulee (1969-1980), Chopra (1975), Vohra (1983), Zander (1993), Tewari and Pant (2002), Lal, (2005), Singh and Nath (2007), Aziz and Vohra (2008), Singh et al. (2016), and herbarium consultation as well as by seeking expert advice, the identification work was performed. In the present study, Goffinet and Shaw (2008) classification Scheme is followed. The voucher specimens are placed in the Herbarium of Botany Department, I.P.G.P.G.G.C.C. Haldwani, Nainital.

RESULTS

The epiphytic bryodiversity of pure deodar forest revealed the occurrence of 42 bryotaxa, (9 leafy liverworts and 33 species of mosses) belonging to 27 families (Figs. 1, 2) spanning a wide distributional range from typical Himalayan endemics to cosmopolitan ones (Table 1). Mosses were recognized as dominant colonizers of the host tree trunk succeeded by the leafy liverworts. Frullaniaceae turned out to be the dominant family followed by Lejeuneaceae amongst leafy liverworts. Pleurocarpous moss families viz., Meteoriaceae and Anomodontaceae were observed to be dominant over the acrocarpous moss family Bryaceae (Fig. 2). The dominant growth forms of the colonizing bryophytes species were recognized as mat followed by tuft, pendent, turf, dendroid, and tail (Fig. 3). The members of Sematophyllaceae, Anomodontaceae, and Fissidentaceae were noticed as constant bryo-epiphytes preferring the acidic bark pH (4.20-4.74) of *Cedrus* phorophytes. It is interesting to note that the leafy liverworts *Frullania* species were observed as constant primary invaders/colonizers of trees of different girth classes including saplings (Fig. 4F).

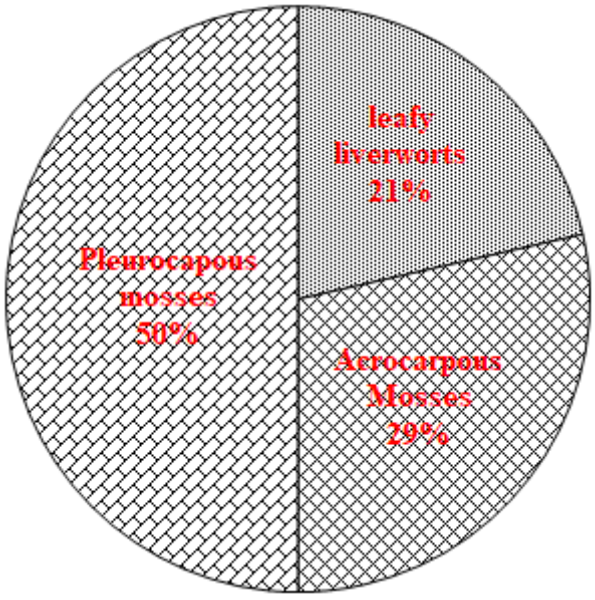

Figure 1. Epiphytic bryophytes of *C.deodara* phorophytes

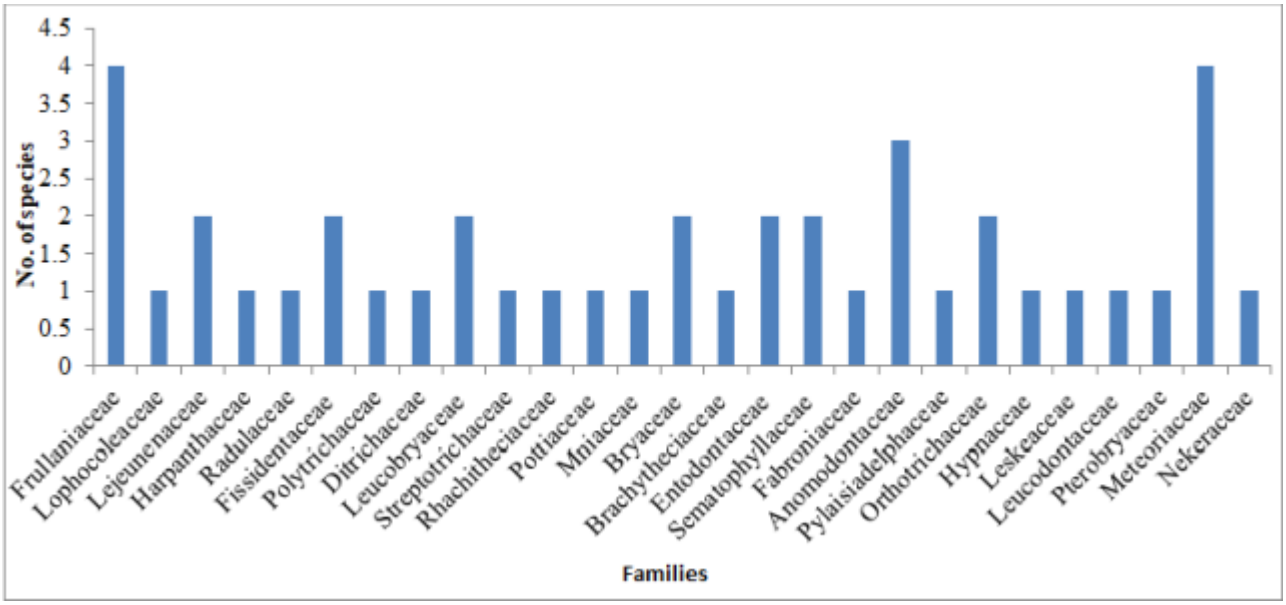

Figure 2. Family-wise distribution of bryo-epiphytes of *Cedrus*

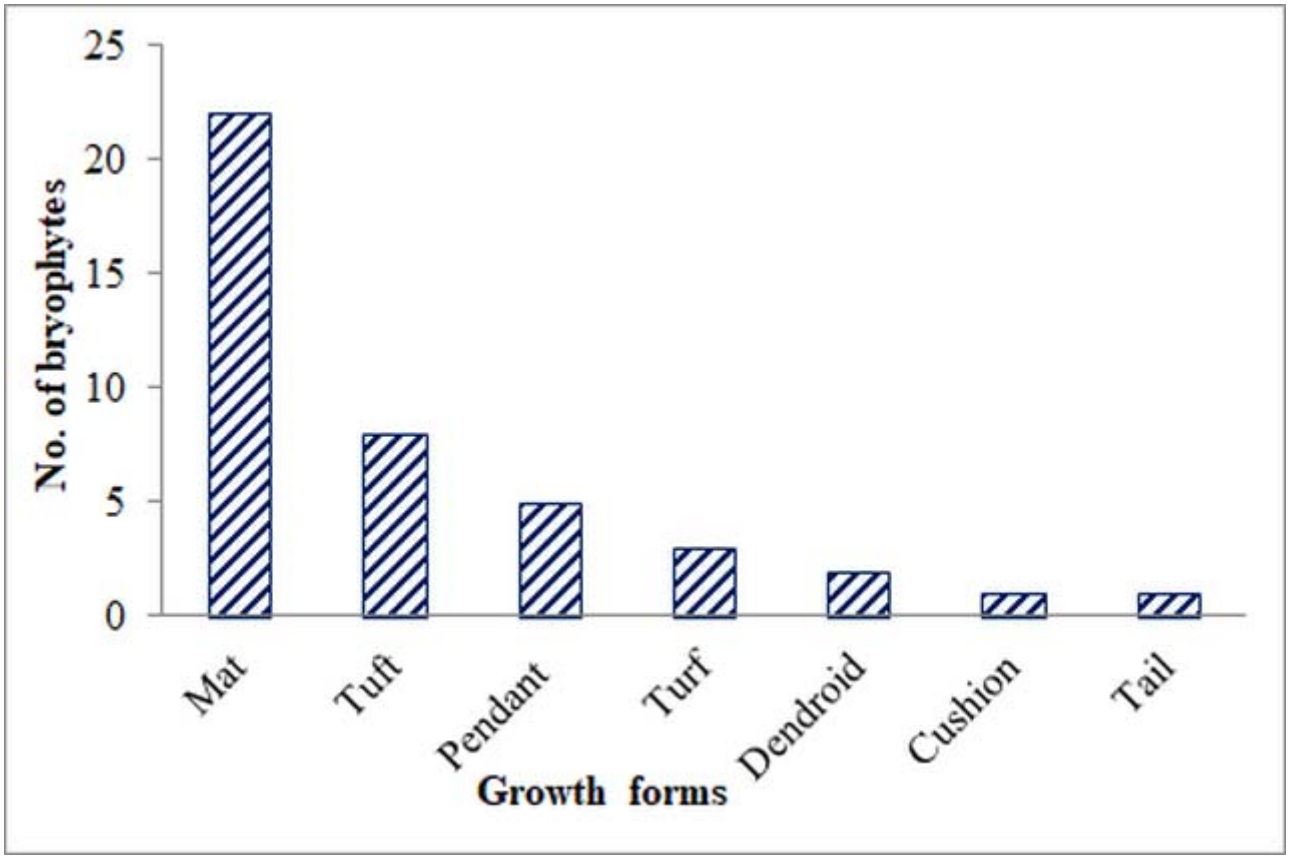

Figure 3. Different bryophyte growth forms recognized on deodar trees

Leafy liverworts viz., *Lophocolea minor* Nees and *Radula complanata* (L.) Dumort. were found to be gemmiferous, producing abundant marginal gemmae. Amongst mosses, multicellular leafy propagules in *Brothera leana* and filamentous axillary gemmae of *Pylaisiadelpha capillacea* were frequently observed as prominent asexual reproductive bodies. *Frullania benjaminiana* and *Frullania udarii* amongst leafy liverwort, and pleurocarpous moss *P. capillacea* of the family

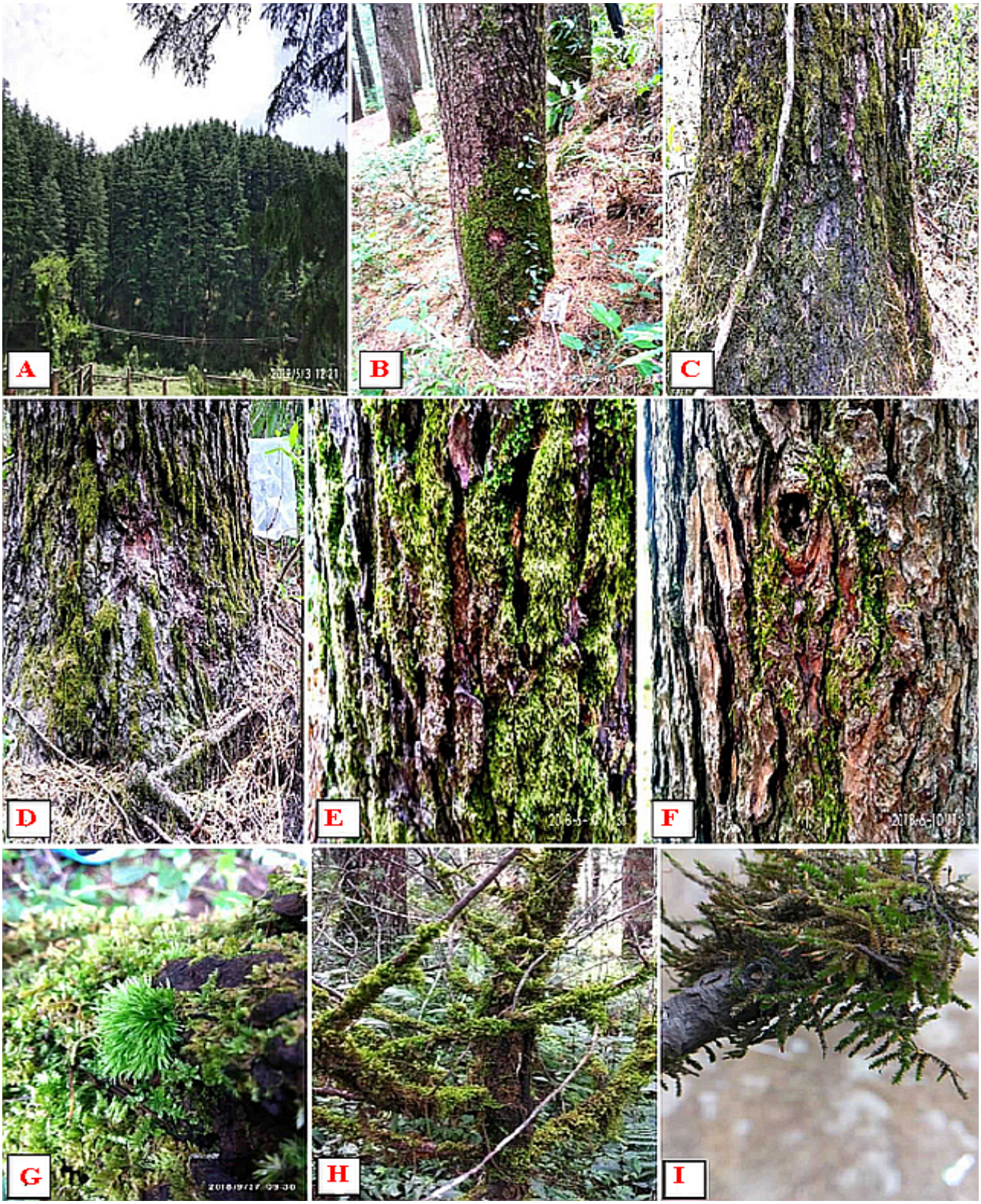

Figure 4. (A) Pure *Cedrus* forest view at the study site, Lohaghat. (B) Bryophytic layer on the host tree trunk. (C) Liverwort and moss-laden water trickling site of *Cedrus* phorophyte. (D) Bryo colonization on a tree base. (E) Growth of *Sematophyllum humile* on rough and fissured bark of host tree. (F) Leafy liverwort, *Frullania udarii* as pioneer invader of cedar phorophyte. (G) Intermingled leafy liverwort and moss community flourishing on a tree base. (H) *Cedrus* saplings densely writhed with hanging meteoriaceous mosses. (I) Deodar twig loaded with an epiphytic Orthothricaceous moss, *Macromitrium hymenostomum*

Table 1. Epiphytic bryophytes of *C. deodara* forest at Lohaghat

	NAME	FAMILY	LOCATION ON TREE TRUNK	GROWTH FORMS	RANGE OF DISTRIBUTION
1.	*Frullania benjaminiana* Inoue	Frullaniaceae	Tree base up to CBH (1.37 m)	Mat	Subtropical and Tropical Eastern Asiatic species
2.	*Frullania ericoides* (Nees ex Mart.) Mont.	Frullaniaceae	Tree base up to CBH (1.37 m)	Mat	Widely distributed Asiatic species
3.	*Frullania dilatata* (L.) Dumort.	Frullaniaceae	Tree base up to CBH (1.37 m)	Mat	Cosmopolitan species
4.	*Frullania udarii* V. Nath & Ajit P. Singh	Frullaniaceae	Above CBH	Mat	Endemic to India
5.	*Lophocolea minor* Nees	Lophocoleaceae	Tree base up to CBH	Mat	Widely distributed Asiatic species
6.	*Lejeunea tuberculosa* Stephani	Lejeuneaceae	Tree base up to CBH	Mat	Widely distributed Asiatic species
7.	*Trocholejeunea* sp.	Lejeuneaceae	Tree base up to CBH	Mat	Widespread species
8.	*Chiloscyphus polyanthos* (L.) Corda.	Harpanthaceae	Tree base up to CBH	Mat	Widespread species
9.	*Radula complanata* (L.) Dumort.	Radulaceae	Tree base up to CBH	Mat	Cosmopolitan species
10.	*Fissidens bryoides* Hedw.	Fissidentaceae	Tree base up to CBH	Turf	Widespread species
11.	*Fissidens pokhrensis* Nork.ex S.S. Kumar	Fissidentaceae	Tree base up to CBH	Turf	Widespread species
12.	*Atrichum undulatum* (Hedw.) P. Beauv.	Polytrichaceae	Extreme tree base,	Tuft	Himalayan variety
13.	*Brothera leana* (Sull.) Mull. Hal.	Leucobryaceae	Tree base, up to CBH	Turf	South and East Asiatic American species
14.	*Leucobryum cucullifolium* Card.	Leucobryaceae	Tree base up to CBH	Cushion	Himalayan species
15.	*Ditrichum heteromallum* (Hedw.) E. Britton	Ditrichaceae	Tree base up to CBH	Tuft	Almost cosmopolitan
16.	*Anoectangium thomsonii* Mitt.	Pottiaceae	Tree base up to CBH	Tuft	South and East Asiatic American species
17.	*Rhachithecium papillosum* (R.S.Williams) Wijk. & Margad.	Rhachitheciaceae	Tree base up to CBH	Tuft	Indo-malesian species
18.	*Microleptodontium flexifolium* (Dicks.) R.H.Zander	Streptotrichaceae	Tree base up to CBH	Tuft	North- Hemisphere species
19.	*Mnium cuspidatum* Hew.	Mniaceae	Tree base up to CBH	Tuft	Almost cosmopolitan species
20.	*Rhodobryum roseum* (Hedw.)Limpr.	Bryaceae	Tree base up to CBH	Dendroid	Indo-pacific species
21.	*Brachymenium ochianum* Gangulee	Bryaceae	Tree base up to CBH	Tuft	Indo- Chinese species
22.	*Brachythecium buchananii* (Hook.) A. Jaeger	Brachytheciaceae	Tree base up to CBH	Mat	Widespread in East – Asiatic species
23.	*Entodon plicatus* Mull. Hal.	Entodontaceae	Tree base up to CBH	Mat	Southeast Asiatic species
24.	*Entodon lateus* (Griff.) A. Jaeger	Entodontaceae	Tree base up to CBH	Mat	Himalayan species
25.	*Sematophyllum humile* (Mitt.) Broth.	Sematophyllaceae	Tree base, above CBH	Mat	Southeast Asiatic species
26.	*Sematophyllum subhumile* (Mull. Hal) M.Fleish.	Sematophyllaceae	Tree base, above CBH	Mat	Southeast Asiatic species
27.	*Fabronia pusilla* Raddi	Fabroniaceae	Tree base, reaching up to the branches	Mat	Widespread species
28.	*Anomodon minor* (Hedw.) Lindb.	Anomodontaceae	Tree base up to CBH	Mat	Widespread species
29.	*Haplohymenium triste* (Ces.)Kindb.	Anomodontaceae	Tree base up to CBH	Mat	East-Asiatic subspecies
30.	*Herpetineuron toccoae* (Sull. & Lesq.) Cardot	Anomodontaceae	Tree base up to CBH	Mat	Widely distributed species
31.	*Pylaisiadelpha capillacea* (Griff.)B.C. Tan & Y.Jia	Pylaisiadelphaceae	Tree base up to CBH	Mat	Temperate species
32.	*Macromitrium moorcroftii* (Hook. & Grev.) Schwagr.	Orthotrichaceae	Tree branch and branchlets	Tuft	Indo- Chinese species
33.	*Macromitrium hymenostomum* Mont.	Orthotrichaceae	Tree branch and branchlets	Mat	East Asiatic to American species
34.	*Isopterygium* sp.	Hypnaceae	Tree base up to CBH	Mat	Cosmopolitan species
35.	*Lindbergia koelzii* R.S.Williams	Leskeaceae	Tree base up to CBH	Mat	Himalayan species
36.	*Leucodon secundus* (Harv.) Mitt.	Leucodontaceae	Tree base up to CBH	Tail	South East Asiatic species
37.	*Pterobryopsis frondosa* (Mitt.) M. Fleisch.	Pterobryaceae	Tree base up to CBH	Pendant	Indoceylonese species
38.	*Aerobryidium filamentosum* (Hook.) M. Fleisch.	Meteoriaceae	Tree base to upper branches	Pendant	South and East Asiatic American species
39.	*Meteoriopsis formosana* Nog.	Meteoriaceae	Tree base to upper branches	Pendant	Taiwan –East Himalayan species
40.	*Meteorium buchananii* (Brid.) Broth.	Meteoriaceae	Tree base to upper branches	Pendant	South and East Asiatic American species
41.	*Trachypodpsis serrulata* (P.Beauv.) M.Fleisch.	Meteoriaceae	Tree base up to CBH	Dendroid	Widespread species
42.	*Cryptoleptodon flexuosus* (Harv.) Renauld & Cardot	Neckeraceae	Tree branch and branchlets	Pendant	Himalayan Species

Pylaisiadelphaceae were turned out to be the new addition to Western Himalayan bryoflora. *F. benjaminiana* colonization was observed around the tree base. Conspicuous mats of *F. udarii* and *P. capillacea* were spotted above the CBH, reaching up to the junction of broad branches.

DISCUSSION

The present bryoexploratory study deals with the documentation of epiphytic bryophytes thriving on gymnospermous *C. deodara* phorophytes. The tall and well-stratified trees, as well as the under-canopy saplings, provide a suitable matrix of habitat and microhabitat for the growth of many epiphytic, acidophilic bryophytes species and communities. The bryophytic compositions of host trees were observed to be different from saplings to giant girth class in terms of their species richness and luxuriance. The tree base was found to support high bryodiversity than that of the upper height of the tree trunk. With the aging of trees, the bark structure becomes more stable thick, and rough for epiphytic growth also there is more surface area for the colonization of the large trees (Mezaka and Znotina 2006). The North and South facing aspects of the forest at the study site were observed to provide a suitable condition for the growth of rich bryodiversity. Almost in all the seasons, the maximum species richness was noticed near the tree base, humus accumulating sites such as the junction of broad branches and water trickling sites of the deodar tree trunks (Figs. 4C, D). Tewari and Pant (2002) stated that the mixed oak-deodar forest supported more bryodiversity and luxuriance in comparison to the pure deodar forest. In the present study, the epiphytic bryodiversity of pure *Cedrus* forest is recorded to be low in comparison to the earlier study. At lower elevations, Himalayan Cedar forests do not support much bryophytic growth in comparison to the forest at higher elevations. With increasing elevation, the mesicness of the forest sites provides congenial habitats and microhabitats for the growth of bryo-epiphytes. The increased girth size of mature *Cedrus* trees harbors more bryophytes in comparison to trees of the lower girth class. It is worth noting that as the height of the *Cedrus* tree trunk increases, the mesicness decreases, causing the bark to become more dry, rough, acidic, and less suitable for the spread of bryophytes. With the increasing height of tree trunk, the bryophytic colonization seems to be lowered while increasing bole size offers more surface area for the growth and spread of bryophytic species and communities.

Only sparse colonization of acidophilic bryophytes viz., species of *Frullania, Sematophyllum*, and *Fabronia* were observed as constant pioneers (Fig. 4E). Vitt (1981) stated that the epiphytic habitat shares many characteristics with those of the saxicolous habitat. Both have in general, high light intensities, vertical and slanting substrate surfaces, and periods of moisture-alternating with periods of extreme drought. This study examined the xerophytic tendencies of some bryophytes, viz., *Frullania, Lejeunea, Anomodon, Brachymenium, Fabronia, Herpetineuron, Microleptodontium, Leucobryum, Macromirtium,* and *Meteorium,* which were found on the epiphytic habitat and microhabitat of *C. deodara* phorophytes. Epiphytic taxa like *Cryptoleptodon*, *Macromirtium,* and *Meteorium* were recorded as perennial colonizers on higher branches and branchlets extending up to the height of 20-30 m.

CONCLUSION

The present investigation is the compilations of the total epiphytic bryo-diversity flourishing on the saplings to giant girth class trees of *Cedrus* phorophytes. The forest provides both macro and micro-habitats for the spread of liverworts and mosses. In all, 42 bryophytes were found to flourish on the bark of the *Cedrus* tree trunk. The young saplings were also observed to support the growth of hanging meteoriaceous mosses writhing around the bole (Fig. 4H). The Majority of epiphytic bryophytes were enumerated to be mat-forming followed by the tuft. Pleurocarpous mosses were dominant over the *Acrocarpous*. Frullaniaceae turned out to be the dominant family followed by Lejeuneaceae, amongst leafy liverworts. Meteoriaceae and Anomodontaceae were found to be commanding over the *Acrocarpous* family of Pottiaceae. Many of the epiphytic bryophytes have shown xerophytic tendencies. Enormous Gemmae production in some of the liverworts and mosses

indicates favorable/congenial habitat conditions for the growth of epiphytic bryophytes. The present inventory will provide insight into the bryodiversity pattern of epiphytic bryophytes of *C. deodara* phorophytes which will form the prime bases for future comparative and quantitative bryosociological investigations.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Hiroyuki Akiyama of Hyogo, Japan; Dr. Bernard Goffinet of Connecticut, USA, and Dr. Richard H. Zander of Missouri, USA for confirming the identification of some moss specimens and to Prof. Shashi Purohit, Principal, Indira Priyadarshini Govt. Girls P.G. College of Commerce, Haldwani, Nainital for providing necessary laboratory facilities. Our thanks are also due to the research scholars of the Bryology lab for their constant help.

Authors' contribution: The main author collected, designed, and prepared the first draft of the manuscript. The corresponding and co-authors supervised, confirmed the identification, and revised and finalized the manuscript.

Conflicts of interest: The authors declare no conflicts of interest.

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Received:20th April 2022
Accepted:27th June 2022