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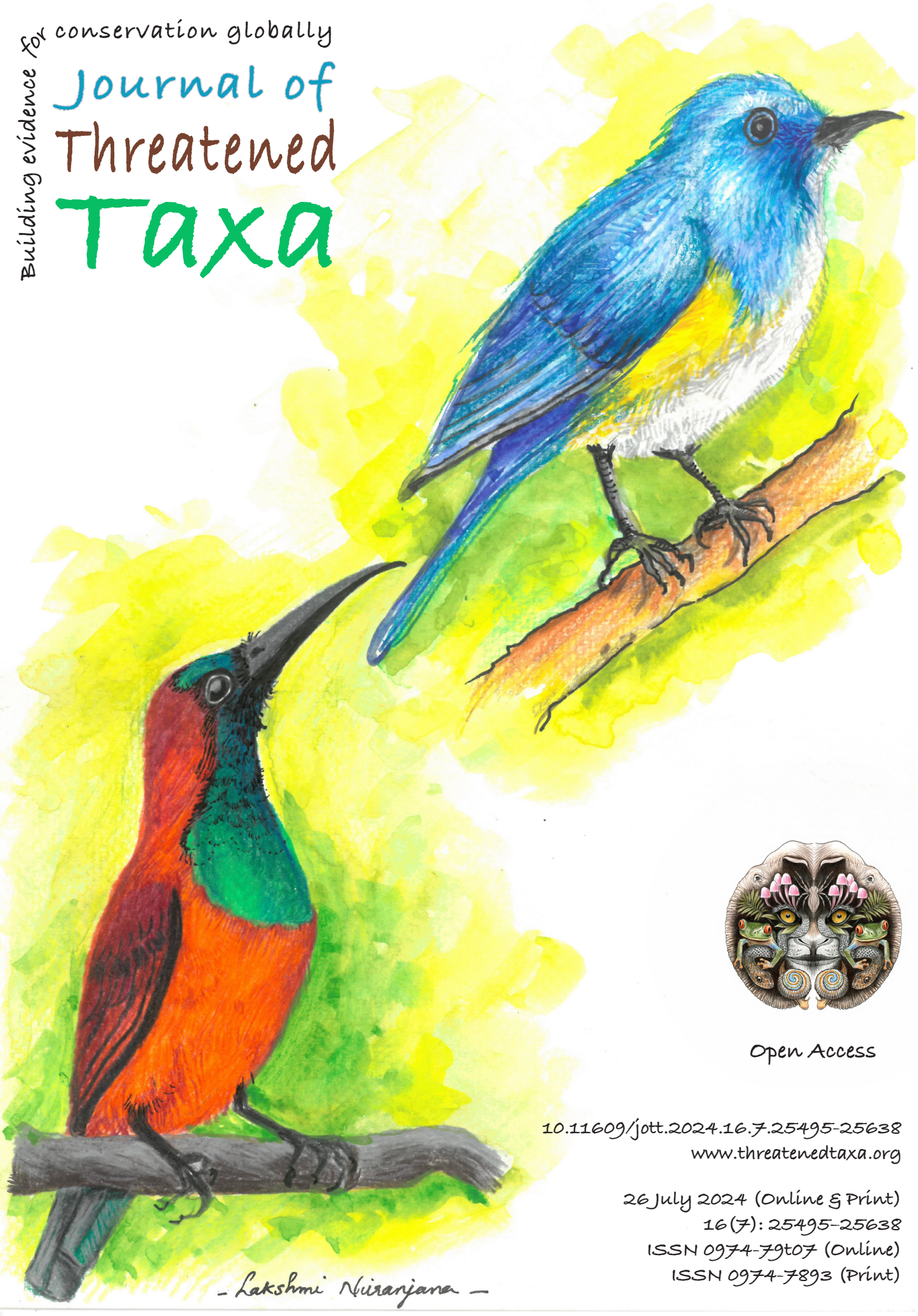

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COMMUNICATION

Bryophyte diversity of Berinag (Pithoragarh District) in Kumaun Himalaya, Uttarakhand, India

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Abstract: This study reports the diversity of bryophytes of Berinag (Dist. Pithoragarh), Uttarakhand (India). In the investigation, a total of 33 species were reported, out of which eight were liverworts and 25 were mosses. Majority of the taxa were terricolous and corticolous. Liverwort species belonged to six genera of five families and two orders whereas mosses belonged to 24 genera of 17 families and eight orders. Out of the 10 orders dealt in the present work, Hypnales was the largest consisting of seven families, nine genera, and nine species followed by Dicranales and Marchantiales both consisting of three families, five, and four genera, respectively. In mosses, Bryaceae was the dominant family consisting of three genera and four species followed by Calymperaceae, Leucobryaceae, Anomodontaceae, Leskeaceae, and Polytrichaceae. Out of 25 mosses, 15 were acrocarpous and 10 were pleurocarpous. Aytoniaceae was dominant among liverworts. *Marchantia*, *Frullania*, and *Bryum* were the dominant genera of the region.

Keywords: Acrocarpous, bryoflora, corticolous, hornworts, hypnales, liverworts, Marchantiales, mosses, pleurocarpous, Pottiaceae.

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Author details: Deeksha Dhami completed her M.Sc. thesis on diversity of bryophytes in Berinag. Her research interests include different aspects of bryophytes and medicinal plants. Dr. P. Chaturvedi is currently professor & head, Department of Biological Sciences, G.B. Pant University of Agriculture & Technology, Pantnagar. For the last 25 years, she has been working on biodiversity and bioprospecting of bryophytes and conservation biology of threatened medicinal flora of Uttarakhand.

Author contributions: DD collected the samples, prepared the herbarium specimens and wrote the first draft. PC conceptualized and designed the study and prepared the final draft.

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INTRODUCTION

India is one of the mega diverse countries blessed with four global diversity hotspots, home to more than 49,000 species of plants, bestowed with 18,800 species of Angiosperms, 82 species of Gymnosperms, 1,307 species of Pteridophytes, 7,434 species of Algae, 2,786 species of Bryophytes, and 2,917 species of Lichens. According to Plant Mao et al. (2020), bryophytes constitute 5.57 % of total plants of India.

State-wise distribution list of liverworts and hornworts in India (Singh et al. 2016) suggested that the state of Uttarakhand ranked second in the country holding 47 families of liverworts and hornworts. The state is home to 84 genera and 259 species and infraspecific taxa of liverworts and hornworts ranking fourth and fifth in the country, respectively, for number of genera and species. There are 339 species belonging to 129 genera of mosses in Uttarakhand (Suman et al. 2010).

Luxuriant forests, varied topography, and suitable climatic conditions made Kumaun Himalaya of Uttarakhand, very rich in bryophyte diversity. Pithoragarh is the easternmost district in the Kumaun region of Uttarakhand. The study area (29.781–29.778 °N & 80.045–80.048 °E), Berinag, is a hill station and one of the six administrative subdivisions (tehsil) of Pithoragarh famous for tea estates (Figure 1). It is located at an elevation of 2,540–1,674 m (source: Google Earth). It got its name from Naga Devta temple locally called 'Bedinag' situated at the top of Berinag Hill. Limestone, sandstone, slate, gneiss, and granite rocks are very common in the region. It has a humid and cold climate. Earlier, most of the land was covered by the forest, however, due to rapid urbanization, biodiversity of this area is under threat. Today, various types of new projects like electricity production from pine needles, tourism and small-scale industries are flourishing in this area, however, threat to the biodiversity remains unaddressed. For the biodiversity conservation of the area, a complete taxonomic data of the region is essential. In the ongoing decade of ecosystem restoration (www.unep.org), diversity of the pioneers of vegetation needs to be assessed for getting the up-to-date health profile of the fragile mountain ecosystems. The present study, attempts to document the bryophytic flora of Berinag and prepare a preliminary checklist based on this.

MATERIAL AND METHODS

The present work is the outcome of several plant surveys done in the study area by the first author (DP) from September 2018 to June 2019. Systematic collection of bryoflora was done from the various localities. Plants from different terrestrial habitats were collected, air dried and were kept in paper packets (15 x 10 cm). Field data such as name, locality from where the collection was done, date of collection, habitat, substratum, collector's name, associated species were written on the paper packets followed by the identification of collected samples using the available monographs of Gangulee (1969–1980), Chopra (1975), & Aziz & Vohra (2008) for mosses and Kashyap (1929), Watson (1968), Singh & Singh (2009), & Dey & Singh (2012) for liverworts. Bryonet and bryophyte experts were also consulted to confirm the identity of some confusing taxa. Standard abbreviations of authors' names have been followed according to Brummit & Powell (1992). The collected samples have been deposited in Cryptogam section of Herbarium of G.B. Pant University of Agriculture & Technology, Pantnagar (GBPUH). Enumeration is done in accordance with the classification given by Crandall-Stotler et al. (2009) for liverworts and Goffinet et al. (2009) for mosses. Orders and families have been arranged as per adopted classifications. The genera within each family and the species within each genus have been arranged alphabetically. All species were verified against TROPICOS data base (www.tropicos.org), The Plant List 2013 (www.theplantlist.org), and Catalogue of Life (CoL 2021).

RESULTS

Increased tourism activities, unabated biological resource usage and unrestricted infrastructure development in the hills have been the major factors responsible for diminishing plant diversity of the region. Bryophytes along with pteridophytes and herbaceous angiosperms form the major ground flora of the hill forests. Besides, the miniature cryptogams also adorn the tree barks and rocky surfaces. Habitat preference of bryophytes itself signifies their role as an important indicator of ecosystem health. To recreate and restore diminishing health of fragile ecosystems of mountainous tourist spots, bryofloristic assessment and conservation is essential. Bryophytes of Berinag along with their local distribution, information about their substratum and taxonomic hierarchies of species are listed in Table 1. Out

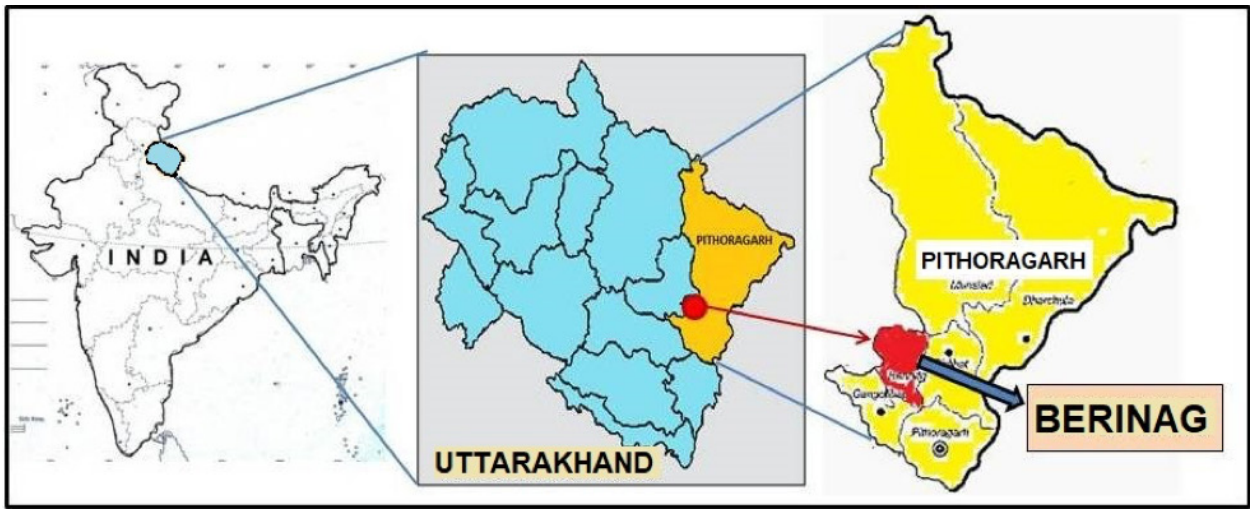

Figure 1. Map of study site in Uttarakhand, India.

of the 33 taxa reported in the region, eight taxa belonged to liverworts and remaining 25 were mosses. Hornworts were not found in the study area. This accounted for 1.18% of total bryophytes in just around 0.0002% of total geographic area of the country. Substratum details give the idea of dominance of terrestrial and corticolous forms of bryophytes in Berinag (Figure 2). Out of 25 mosses, 15 were acrocarpous mosses and 10 mosses were pleurocarpous making acrocarpous growth forms most dominant amongst mosses (Figure 3).

Hypnales and Marchantiales were the most dominant orders with representation of seven and three families respectively. *Bryum*, *Frullania*, and *Marchantia* were represented by two species each in the study area. A preliminary checklist enlisting 51 taxa has earlier been reported by Alam et al. (2012) from Dharchula and Munsyari tehsils of Pithoragarh wherein, Hypnales was the most dominant order represented by seven families followed by Bryales and Dicranales representing three families each among mosses. Marchantiales was the most dominant order among liverworts representing eight families. According to the moss checklist of western Himalaya (India) by Alam (2013), there are 745 species of mosses belonging to 230 genera and 55 families. Hypnales is the most diversified order of mosses followed by Pottiales and Bryales. In the present study also, Hypnales was the most dominant group of mosses followed by Dicranales.

Family wise comparison of distribution of collected genera and species in the world, in western Himalaya, in Uttarakhand, in Pithoragarh District and in the study area (Berinag) is provided in the Table 2. According to The Plant List (2013), a total of 1,822 plant genera in 177

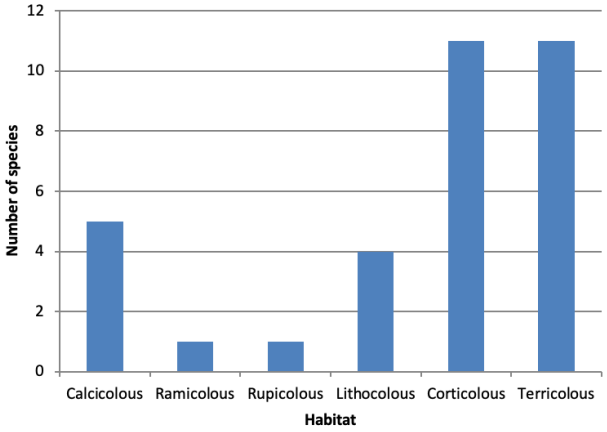

Figure 2. Distribution of mosses on the basis of their habitat.

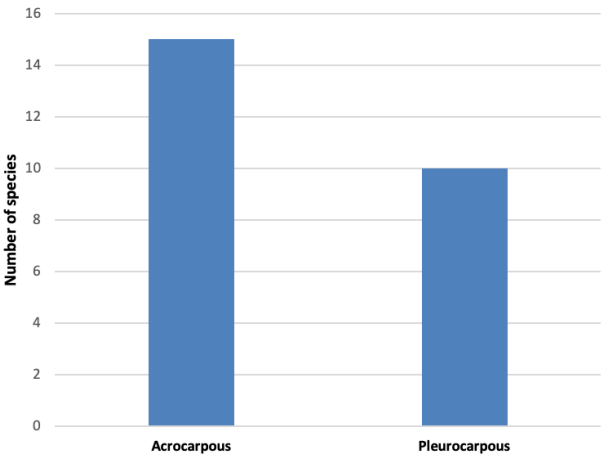

Figure 3. Total number of investigated species of pleurocarpous and acrocarpous mosses.

Table 1. Bryophytes of Berinag (Pithoragarh District), Uttarakhand.

	Family	Species	Local distribution	Substratum
A)	**LIVERWORTS**			
1	Aytoniaceae	*Plagiochasma appendiculatum* Lehm. & Lindenb.	New Bazar Berinag, 29.778°N, 80.053°E	Cemented wall
2		*Reboulia hemisphaerica* (L.) Raddi	New Bazar Berinag, 29.778°N, 80.053°E	Cemented wall
3	Dumortieraceae	*Dumortiera hirsuta* (Sw.) Nees	Kanera (Site rich in water) 29.672°N, 80.055°E	Stone
4	Marchantiaceae	*Marchantia papillata* Raddi	Degree College Berinag, 29.775°N, 80.050°E	Cemented wall
5		*Marchantia polymorpha* L.	Naula Berinag, 29.778°N, 80.053°E	Stone
6	Frullaniaceae	*Frullania ericoides* Nees (Mont).	Kanera, 29.672°N, 80.055°E	Bark of *Quercus leucotricophora* A.Campus and *Mangifera indica* L.
7		*Frullania muscicola* Steph.	Kalibinayak, 29.704°N, 80.054°E	Bark of *Q. leucotricophora* A.Campus
8	Porellaceae	*Porella caespitans* (Steph.) S.Hatt.	Kanera, 29.672°N, 80.055°E	Bark of *Q. leucotricophora* A.Campus
B)	**MOSSES**			
9	Bartramiaceae	*Philonotis mollis* (Dozy & Molk.)	Forest of Berinag, 29.780°N, 80.055°E	Soil
10	Bryaceae	*Bryum argenteum* Hedw.	Berinag Main Market, 29.778°N, 80.053° E	Humus mixed soil
11		*Bryum mildeanum* Jur.	Berinag forest 29.780°N, 80.055°E	Soil
12		*Ptychostomum capillare* (Hedw.) Holyoak & N.Pedersen.	Berinag forest, 29.780°N, 80.055°E	Soil
13		*Rhodobryum roseum* (Hedw.). Limpr.	Berinag forest, 29.780°N, 80.060°E	Soil
14	Mniaceae	*Mnium integrum* Bosch & Sande Lac.	Berinag forest, 29.780° N, 80.055° E	Soil
15	Calymperaceae	*Octoblepharum albidum* Hedw.	Kanera, 29.672°N, 80.055°E	Bark of *Q. leucotricophora* A.Campus
16		*Syrrhopodon gardneri* (Hook.) Schwagr	Kalibinayak, 29.704°N, 80.055°E	Bark of *Q. leucotricophora* A.Campus and *Q. glauca* Thunb.
17	Ditrichaceae	*Ditrichum heteromallum* (Hedw.)	Forest of Berinag, 29.780° N, 80.060° E	Rock
18	Leucobryaceae	*Brothera leana* (Sull.) Müll.	Kalibinayak, 29.704° N, 80.054°E	Bark of *Q. leucotricophora* A.Campus
19		*Thysanomitrion involutum* (Mull.Hal.) P.de la Varde	Degree College Berinag, 29.775°N, 80.050°E	Stone
20	Funariaceae	*Funaria hygrometrica* Hedw.	Forest of Berinag, 29.780°N, 80.055°E	Soil
21	Anomodontaceae	*Anomodon minor* (Hedw.) Lindb.	Kanera, 29.672°N, 80.055°E	Bark of *Toona ciliata* M.Roem.
22		*Herpetineuron toccoae* (Sull. & Lesq.) Cardot.	Dhanouli, 29.761°N, 80.053°E	Bark of *Q. leucotricophora* A.Campus and *Q. glauca* Thunb.
23	Brachytheciaceae	*Oxyrrhynchium vagans* (A.Jaeger) Ignatov & Huttunen.	Kanera, 29.672°N, 80.055°E	Soil
24	Entodontaceae	*Entodon concinnus* °	Kanera, 29.672°N, 80.055°E	Cemented wall
25	Leskeaceae	*Haplocladium schimperi* Ther.	Kanera, 29.672°N, 80.055°E	Bark of *T. ciliata* M.Roem. and *M. indica L.*
26		*Rozea pterogonioides* (Harv.) A. Jaeger	Kanera, 29.672°N, 80.055°E	Soil
27	Meteoriaceae	*Trachypodopsis serrulata* (P. Beauv.) M. Fleisch.	Naula site Berinag, 29.778°N, 80.053°E	Cemented wall
28	Neckeraceae	*Neckeropsis exserta* (Hook. ex Schwagr.) Broth.	Kanera, 29.672°N, 80.055°E	Wood of *M. indica* L
29	Thuidiaceae	*Thuidium tamariscellum* (Mull. Hal.) Bosch & Sande Lac.	Dhanouli, 29.761°N, 80.053°E	Stone
30	Orthotrichaceae	*Macromitrium moorcroftii* (Hook. & Grev.) Schwagr.	Kalibinayak,29.704°N, 80.054°E	Branch of *Q. leucotricophora* A.Campus
31	Polytrichaceae	*Atrichum obtusulum* (Mull. Hal.) A.Jaeger.	Berinag forest, 29.780°N, 80.055°E	Soil
32		*Pogonatum aloides* (Hedw.) P.Beauv.	Berinag forest,29.780°N, 80.055°E	Soil
33	Pottiaceae	*Hyophila involuta* (Hedw.) P.Beauv.	Kanera, 29.672°N, 80.055°E	Soil

Table 2. Family wise comparison of distribution of genera and species in the world, in India, in western Himalaya, in Uttarakhand and in the study area.

Family	Number of genera and species													
	In the World (The Plant List 2013)		In India (Dandotiya et al. 2011)		In western Himalaya (Alam 2013)		In Uttarakhand (Suman et al. 2010)		In Pithoragarh (Sahu & Asthana 2015)		In Pithoragarh (Alam et al. 2012)		In Berinag (Dhami 2019)	
	G	S	G	S	G	S	G	S	G	S	G	S	G	S
Aytoniaceae	10	115	6	30	-	-	7	22	-	-	3	6	2	2
Dumortieraceae	-	-	1	1	-	-	-	-	-	-	1	1	1	1
Marchantiaceae	7	50	3	24	-	-	3	5	-	-	1	3	1	2
Frullaniaceae	-	-	1	42	-	-	1	7	-	-	-	-	1	2
Porellaceae	5	134	1	24	-	-	1	16	-	-	1	1	1	1
Bartramiaceae	14	686	8	48	7	28	4	12	1	2	1	1	1	1
Bryaceae	43	2108	09	103	6	45	6	32	5	9	4	5	3	4
Mniaceae	13	222	7	64	7	38	3	20	2	3	1	1	1	1
Ditrichaceae	34	347	9	30	4	12	4	9	1	1	-	-	1	1
Calymperaceae	19	417	7	35	2	4	3	4	-	-	-	-	2	2
Leucobryaceae	-	-	8	69	2	5	5	9	-	-	-	-	2	2
Pottiaceae	138	3223	38	207	32	116	17	60	6	8	3	4	1	1
Funariaceae	24	452	4	47	3	15	3	11	2	2	2	2	1	1
Anomodontaceae	-	-	5	17	-	-	3	8	-	-	1	1	2	2
Brachytheciaceae	62	1117	9	66	-	-	7	19	2	3	1	1	1	1
Entodontaceae	13	314	3	19	3	3	5	15	1	3	1	2	1	1
Leskeaceae	22	383	10	35	12	30	5	17	1	1	-	-	2	2
Meteoriaceae	30	650	21	80	11	21	4	5	4	5	3	4	1	1
Neckeraceae	37	827	19	93	8	21	6	12	1	1	-	-	1	1
Thuidiaceae	33	504	3	27	5	27	1	4	5	6	1	-	-	1
Orthotrichaceae	44	1265	13	64	1	18	2	4	1	1	1	1	1	1
Polytrichaceae	31	536	5	55	5	24	4	18	2	3	2	2	2	2

-—indicates that respective species is not included in the source | G—number of genera | S—number of species.

families of bryophytes are present in the world out of which maximum number of genera and species belong to family Pottiaceae (138 genera, 3,223 species) followed by Bryaceae (43 genera, 2,108 species). Dandotiya et al. (2011) reported total 1,786 species of mosses in 355 genera and 675 species of liverworts in 121 genera in India, out of which maximum number of taxa belonged to family Pottiaceae (38 genera, 207 species) followed by Lejeuneaceae and Notothyladaceae. Sahu & Asthana (2015) reported 72 moss taxa belonging to 24 families from Pithoragarh and adjoining areas with Bryaceaee being the most diverse family represented by nine genera. The present bryofloristic study of Berinag also reports maximum number of species belonging to Bryaceae but with a lesser representation, i.e., three genera and four species only (Tables 1 & 2). According to Alam (2013), maximum diversity of mosses in western Himalaya (India) is represented by family Pottiaceae which included 116 species belonging to 32 genera. Unlike the general trend in western Himalaya or India or Uttarakhand, in the present study, Bryaceae is having maximum diversity. This may be due to dominance of mixed pine-oak forests in the region. Bryaceae members prefer shade and lower temperature while Pottiaceae is more common in comparatively drier and open areas. Habitat preference of the bryophytic vegetation suggests the dominance of both terricolous and corticolous forms represented by 11 species each. Habitat wise distribution of bryophytic vegetation of district Nainital and selected mineralized localities of Almora and Pithoragarh districts of Kumaun Himalaya have earlier been reported by Tewari and Pant (1994).

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