



Research article

Diversity and distribution of bryophytes in different microclimatic conditions of Mount Panchase, Central Nepal

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Abstract: Mount Panchase, situated at the bordering areas of three districts *i.e.* Syangja, Kaski, and Parbat in Central Nepal, is considered to be one of the biodiversity hotspot. The present study aimed to explore the diversity and distribution of bryophytes in different microclimatic conditions of Mount Panchase. Bryophytes were collected from all habitats (soil, rock and plant bark) following the standard protocol. Altogether 62 species belonging to 30 families and 44 genera were recorded from the elevational range 1,648 m to 2,517 m above mean sea level. Among the classes, Bryopsida was found largest with 36 species followed by Marchantiopsida (10 species), Jungermanniopsida (10 species), Polytrichopsida (4 species) and Anthocerotopsida (2 species). Among the three habitats maximum bryophytes were collected from soil. Similarly, different microclimatic conditions contributed by south (dry) and north-facing slopes (moist) and hilltop (mixed type) provide unique pattern of bryophyte distribution. Altogether, 32 species were recorded from the north-facing slope and 24 species from the south-facing slope, this number included 13 common species from both slopes. Additionally, 19 bryophyte species collected from the hilltop (2,517 m) were unique as they were absent in both slopes.

Keywords: Bryopsida - Elevational range - Habitat preference - Slope direction - Terrestrial.

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INTRODUCTION

Bryophytes are an important component of the ecosystem and show their dominance throughout the forest floor especially in a temperate forest (Sun *et al.* 2013). Although high humidity and rainfall are the important factors which provide a favorable environment for their luxuriant growth, few bryophytes can tolerate extreme desiccation and temperature (Pradhan 2013, 2014a, Puri 1973). Among the 25,000 species of bryophytes globally, Nepal hosts 1,215 species and represents 4.86 % (Asakawa *et al.* 2013, Pradhan 2018). Being a mountainous country there are a variety of habitats suitable for bryophytes in Nepal, which are however still not explored properly.

Mount (Mt.) Panchase, located in the mid-hills along the Mahabharat range in central Nepal, covers an elevation range from 900 to 2,517 m. Additionally, its east-west orientation provides distinct south and north-facing slopes that contribute to different microclimatic conditions on two faces. Besides, the area falls in the region that receives the highest annual rainfall in Nepal (Nayava 1980). These features in aggregate provide a variety of habitats suitable for the growth of different plants. Mt. Panchase has already been explored for the diversity of vascular plants and come up with the existence of significant number of Pteridophytes (92 spp.) Gymnosperms (5 spp.), and Angiosperms (608 spp.) including 125 species of Orchids (Bhandari *et al.* 2015, Bhandari *et al.* 2018, Thakur & Rajbhandary 2018). Despite this, the area has remained unexplored for the diversity of bryophytes. Therefore, present study aimed to explore diversity and distribution of bryophytes in different microclimatic conditions of Mt. Panchase.

MATERIALS AND METHODS

Study area

Mt. Panchase ($28^{\circ} 01' 25''$ to $28^{\circ} 15' 56''$ N and $83^{\circ} 48' 03''$ to $83^{\circ} 49' 53''$ E) is situated in Mahabharat range, at the border of three districts viz., Syangja, Kaski, and Parbat (Fig. 1). It covers an area of 57.75 km^2 with peak at 2,517 m. amsl. Beyond these areas, there are major settlements as Arthar Dandakharka, Ramja Deurali and Bhadaure Tamagi. Present study covers the bryophyte diversity along the trail started from Arthar Dandakharka upwards to Panchase temple (1,600–2,450 m. amsl; south-facing slope), top of the Mt. Panchase ($2,500 \pm 15$ m. amsl.) and then downwards from Panchase to Bhadaure Tamagi (2,450–1,700 m. amsl.; north-facing slope) (Fig. 2).

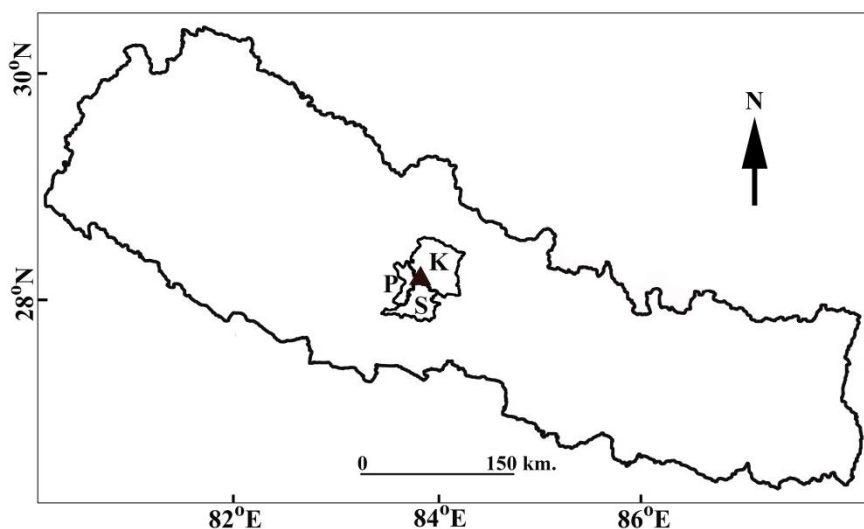


Figure 1. Map of Nepal showing Kaski district (K), Syangja district (S), Parbat district (P) and Mount Panchase (Black triangle).

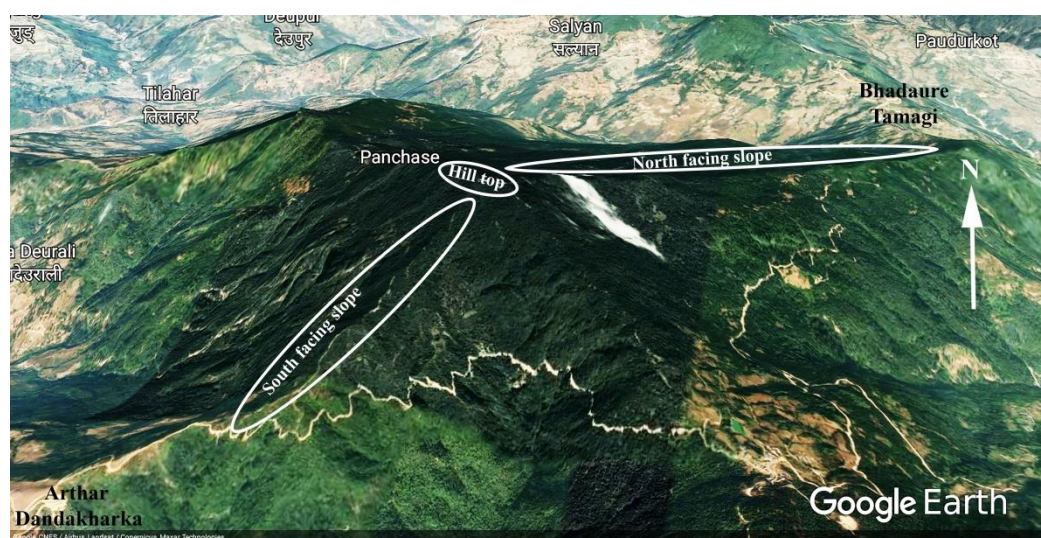


Figure 2. Aerial view of the study area showing south-facing slope, top of Mt. Panchase and north-facing slope.

The study area includes different forest types including *Quercus semecarpifolia* Sm. and *Rhododendron arboreum* Sm. (1,800–2,300 m amsl), and *Castanopsis hystrix* Miq. and *Rhododendron arboreum* (2,300–2,517m amsl). As the area receives high annual precipitation, it may favor the growth and development of liverwort, hornworts and mosses over rocks as well as on the bark of the trees. Forest floor with abundant humus may also support the luxuriant growth of bryophyte species.

Collection and identification

The study was conducted along the above mentioned route in October 2017. Standard methods were adopted for the collection of different types of bryophytes (Pradhan 2010). Identification was done at Central Department of Botany, Tribhuvan University. As the vegetative and sporophytic parts of bryophytes were small-sized, hand lens of 20x and light microscope were used to study morphological characters. The specimens were identified with the help of standard literatures (Grout 1965, Gangulee 1969–1980, Kashyap 1972, Higuchi &

Takaki 1988, 1990, Zhu & So 1996, Casas *et al.* 2009). Author citation to the specimen was given following TROPICOS. The taxa were arranged according to the recent classification of bryophytes (Anthocerotophyta: Stotler & Crandall-Stotler 2005, Marchantiophyta: Crandall-Stotler *et al.* 2009, Bryophyta: Goffinet *et al.* 2009). Genera and species are listed alphabetically under each family.

RESULTS

In the present investigation a total of 62 species of bryophytes belonging to 5 classes, 12 orders, 30 families and 44 genera were recorded (Table 1). Among the classes Bryopsida was found largest with 4 orders, 14 families, 25 genera and 36 species while Anthocerotopsida was poorly represented with 2 orders, 2 families, 2 genera and 2 species. The number of orders, families, genera and species belonged to the remaining three classes Marchantiopsida, Jungermanniopsida and Polytrichopsida were represented in between (Fig. 3).

Table 1. List of bryophytes collected from Mount Panchase.

	Species Name	Habitat	Elevation (m. amsl)	Location
Class: Marchantiopsida	Order: Marchantiales			
Family: Marchantiaceae	<i>Marchantia emarginata</i> Reinw., Blume & Nees	T	1,716–2,500	A, C
	<i>Marchantia polymorpha</i> L.	T	1,716	A
Family: Aytoniaceae	<i>Asterella khasiana</i> (Griff.) Grolle	T	2,510	B
	<i>Asterella multiflora</i> (Stephani) Pandé <i>et al.</i>	L	1,684–2,148	A, C
	<i>Asterella wallichiana</i> (Lehm.) Grolle	L	2,500	B
	<i>Plagiochasma appendiculatum</i> Lehm. & Lindenb.	T	1,648–1,915	A, C
	<i>Plagiochasma pterospermum</i> C. Massal.	T	2,500	B
	<i>Plagiochasma rupestre</i> (G. Forst.) Stephani	T	2,490	B
Family: Targioniaceae	<i>Targionia hypophylla</i> L.	L	2,500	B
Family: Dumortieraceae	<i>Dumortiera hirsuta</i> (Sw.) Nees	T	1,750	C
Class: Jungermanniopsida	1. Order: Pelliiales			
Family: Pelliaceae	<i>Pellia epiphylla</i> (L.) Corda	T	1,800	A
	2. Order: Metzgeriales			
Family: Metzgeriaceae	<i>Metzgeria conjugata</i> Lindb.	T	1,750	A
	3. Order: Porellales			
Family: Porellaceae	<i>Porella</i> sp.	E	1,700	C
Family: Frullaniaceae	<i>Frullania</i> sp.	E	1,910	C
	4. Order: Jungermanniales			
Family: Lepidoziaceae	<i>Bazzania trilobata</i> (L.) Gray	E	1,841	C
Family: Plagiochilaceae	<i>Plagiochila fruticosa</i> Mitt.	T	2,148	C
	<i>Plagiochila</i> sp.	T	2,000	C
Family: Scapaniaceae	<i>Tritomaria exsecta</i> (Schmidel ex Schrad.) Schiffner ex Loeske	T	1,800	A, C
Family: Geocalycaceae	<i>Heteroscyphus argutus</i> (Nees) Schiffner	L	1,785	C
Family: Jungermanniaceae	<i>Jungermannia atrovirens</i> Dumort.	T	1,715	C
Class: Polytrichopsida	Order: Polytrichales			
Family: Polytrichaceae	<i>Atrichum undulatum</i> var. <i>subserratum</i> (Harv. & Hook. f.) Paris	T	1,648–2,148	A, C
	<i>Pogonatum cirratum</i> (Sw.) Brid.	T	1,815	A
	<i>Pogonatum pensilvanicum</i> (W. Bartram ex Hedw.) P. Beauv.	T	1,800–2,000	C
	<i>Polytrichum commune</i> Hedw.	T	2,500	B
Class: Bryopsida	1. Order: Funariales			
Family: Funariaceae	<i>Funaria hygrometrica</i> Hedw.	T	2,500	B
	<i>Physcomitrium</i> sp.	T	2,500	B
	2. Order: Dicranales			
Family: Fissidentaceae	<i>Fissidens</i> sp.	T	2,510	B
Family: Bruchiaceae	<i>Trematodon longicollis</i> Michx.	T	1,715	C
Family: Rhabdowesiaceae	<i>Dicranoweisia cirrata</i> (Hedw.) Lindb.	T	1,648	C
Family: Dicranaceae	<i>Dicranum scoparium</i> Hedw.	T	1,700–1,900	A, C
	<i>Dicranum</i> sp.	T	1,920	C

	3. Order: Pottiales			
Family: Pottiaceae	<i>Barbula constricta</i> Mitt.	E	1,700–2,100	A, C
	<i>Barbula</i> sp.	E	1,700–2,100	A, C
	<i>Bryoerythrophyllum dentatum</i> (Mitt.) P. C. Chen	E	2,490	B
	<i>Hymenostylium recurvistratum</i> (Hedw.) Dixon	E	1,700–1,900	A, C
	<i>Hyophila involuta</i> (Hook.) A. Jaeger	L	1,620	A
	4. Order: Bryales			
Family: Bryaceae	<i>Anomobryum auratum</i> (Mitt.) A. Jaeger	T	2,500	B
	<i>Anomobryum</i> sp.	L	2,500	B
	<i>Bryum argenteum</i> Hedw.	E	2,490	B
	<i>Bryum capillare</i> Hedw.	E	1,800–2,100	A, C
	<i>Bryum cellulare</i> Hook.	L	2,490	B
	<i>Bryum coronatum</i> Schwägr.	L	1,648–2,148	A, C
Family: Mniaceae	<i>Mnium rostratum</i> Schrad.	T	1,885	A
	<i>Plagiomnium cuspidatum</i> (Hedw.) T. J. Kop.	T	1,648–2,000	A, C
	<i>Pohlia cruda</i> (Hedw.) Lindb.	T	2,500	B
	<i>Pohlia elongata</i> Hedw.	T	1,800	A
	<i>Pohlia nutans</i> (Hedw.) Lindb.	T	2,148	B
Family: Batramiaceae	<i>Bartramia ithyphylla</i> Brid.	E	2,500	B
Family: Orthotrichaceae	<i>Macromitrium microstomum</i> (Hook. & Grev.) Schwägr.	E	1,700	C
	<i>Ulotia crispa</i> (Hedw.) Brid.	T	2,148	C
Family: Thuidiaceae	<i>Actinothuidium hookeri</i> (Mitt.) Broth.	T	1,915	C
	<i>Thuidium glaucinum</i> (Mitt.) Bosch & Sande Lac.	T	2,100	A
	<i>Thuidium tamariscinum</i> (Hedw.) Schimp.	T	1,700	A
Family: Meteroriaceae	<i>Aerobryidium filamentosum</i> (Hook.) M. Fleisch.	T	1,800	C
	<i>Meteoriopsis reclinata</i> (Müll. Hal.) M. Fleisch.	E	1,600	C
	<i>Trachypodopsis serrulata</i> (P. Beauv.) M. Fleisch.	L	1,900	A
Family: Hypnaceae	<i>Hypnum curvifolium</i> Hedw.	L	1,648–2,148	A, C
	<i>Hypnum cupressiforme</i> Hedw.	L	1,970	C
	<i>Hypnum plumiforme</i> Wilson	T	2,510	B
Family: Plagiotheciaceae	<i>Plagiothecium neckeroideum</i> Schimp.	L	1,620	A
Class: Anthocerotopsida	1. Order: Anthocerotales			
Family: Anthocerataceae	<i>Anthoceros punctatus</i> L.	T	2,500	B
	2. Order: Notothyladales			
Family: Notothyladaceae	<i>Phaeoceros laevis</i> (L.) Prosk.	T	1,800	C

Note: Habitat: T - Terrestrial, L - Lithophytic, E - Epiphytic.

Location: A - Arthar Dandakharka, B - Panchase (top), C - Bhadaure Tamagi.

Similarly, among the families, Pottiaceae was largest with 4 genera followed by Polytrichaceae, Miniaceae, Meteroriaceae with 3 genera each, and Aytoniaceae, Funariaceae, Bryaceae, Orthotrichaceae and Thuidiaceae with 2 genera each. Other families were poorly represented as each of them included a single genus (Table 1). In terms of the number of species class Bryopsida possessed highest number (36) followed by, Marchantiopsida (10), Jungermanniopsida (10), Polytrichopsida (4) and Anthocerotopsida (2) (Fig. 3).

Furthermore, the distribution of bryophytes were also analysed for their place of occurrence. The result showed only three types of habitats viz. soil, rock and tree bark. Highest numbers of species were collected from soil (61.3%) then from rocks and tree barks (Fig. 4). Regarding the distribution pattern of different classes of bryophytes, members of Jungermanniopsida and Bryopsida were found on all three types of habitats. Similarly, members of Marchantiopsida were found on two types of habitat (soil and rock), while remaining were only collected from soil (Fig. 5).

Diversity of bryophytes was analyzed in three different sites; south and north-facing slopes and at the top of Mt. Panchase (Table 1). The south-facing slope covers an elevation range from 1,600 to 2,400 m. amsl. (Arthar Dandakharka to Mt. Panchase) harbors 24 species. Similarly, the north-facing slope covering almost the same elevation range (2,400–1,700 m. amsl.) downward from Mt. Panchase to Bhadaure Tamagi consists of 32

species. These numbers included 13 common species present in either slopes of the mountain. In addition of that, a total of 19 unique bryophytes, not found in either of the slopes, were recorded from the top of the Mt. Panchase (2,517 m. amsl.).

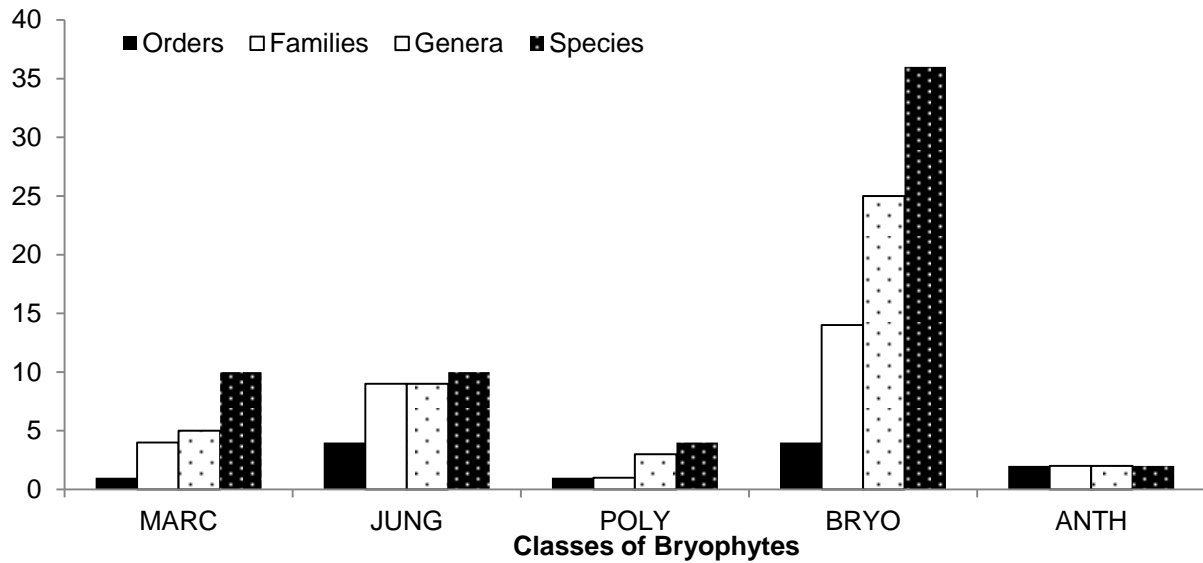


Figure 3. Total number of orders, families, genera and species of each class. [MARC - Marchantiopsida, JUNG - Jungermanniopsida, POLY - Polytrichopsida, BRYO - Bryopsida, ANTH - Anthocerotopsida]

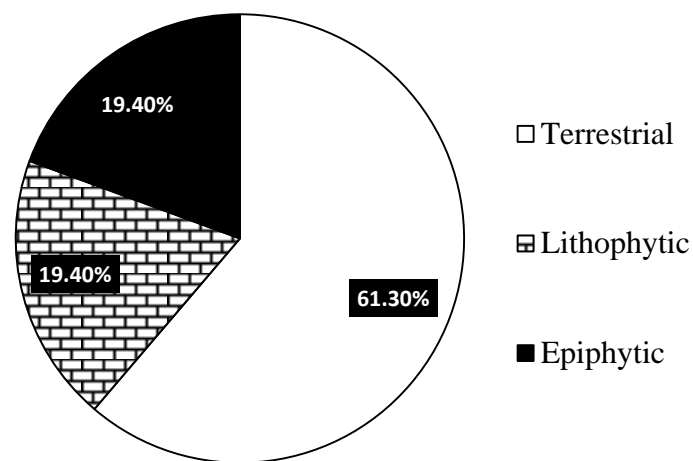


Figure 4. Distribution of bryophytes among various habitats.

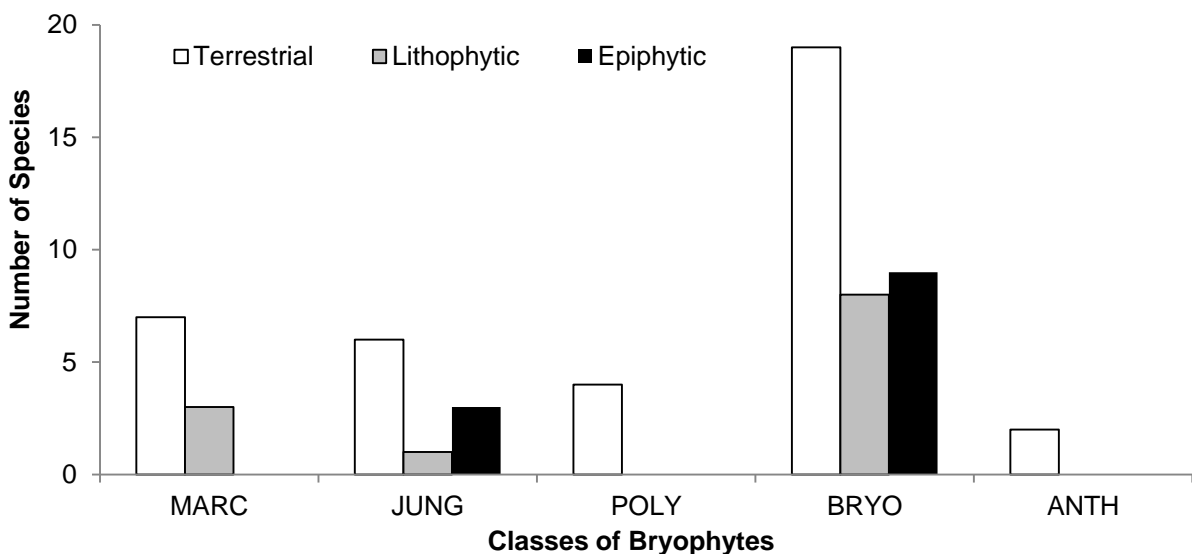


Figure 5. Distribution of bryophytes among various classes and habitats. [MARC - Marchantiopsida, JUNG - Jungermanniopsida, POLY - Polytrichopsida, BRYO - Bryopsida, ANTH - Anthocerotopsida].

Habitat specificity of bryophytes in three different sites was analyzed and found the highest number of terrestrial and epiphytes in north-facing slope compared to south-facing slope (Fig. 6). The result supported the view that bryophytes are specific to habitat. However, top of Mt. Panchase possessed a higher number of terrestrial than lithophytes and epiphytes.

Diversity of bryophytes belonging to different classes in three different sites were also analysed (Fig. 7). Among the members of the class Marchantiopsida and Jungermanniopsida, higher number was recorded from the hilltop and north-facing slope, respectively. The members of Bryopsida, although reported higher from the hilltop, they were evenly distributed in other sites. Distribution of members of Polytrichopsida was found even in the studied sites. In case of members of Anthocerotopsida, they were absent in south-facing slope.

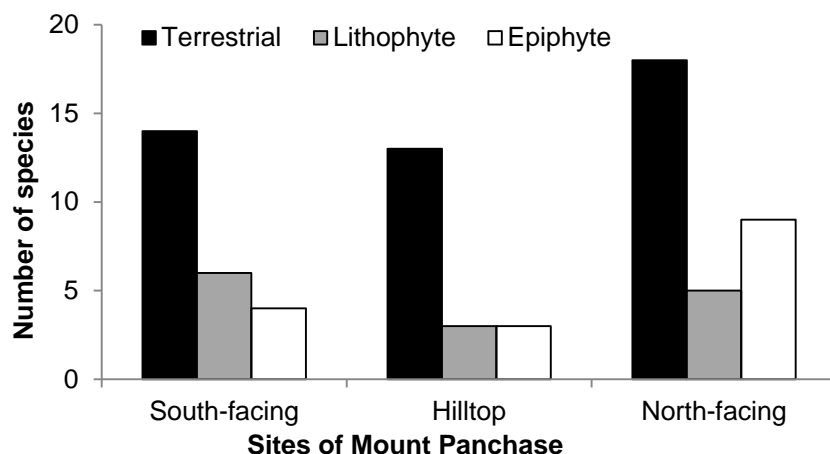


Figure 6. Number of bryophyte species and their habitat preference in three different sites of Mount Panchase (south and north-facing slopes and hilltop).

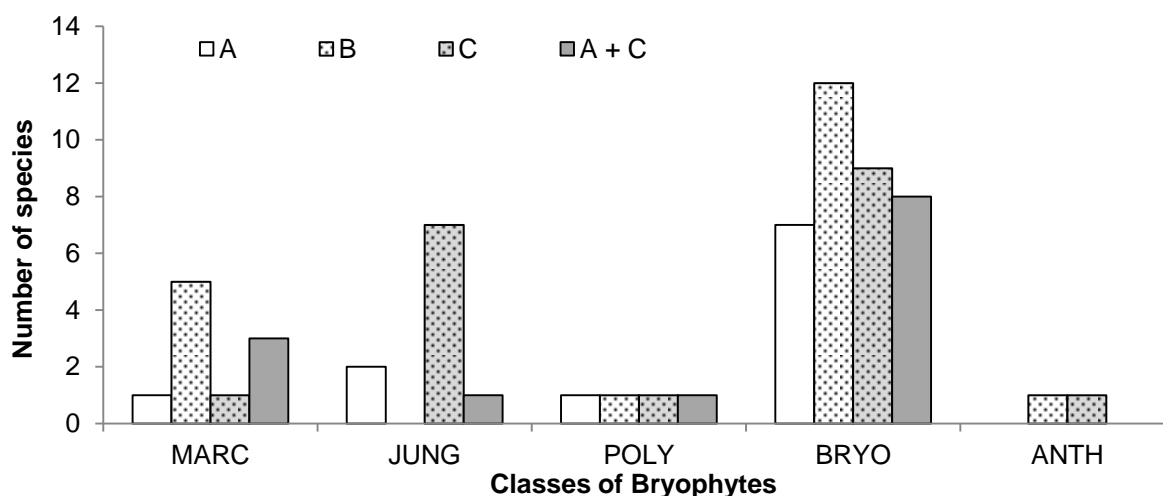


Figure 7. Distribution of bryophyte species of different classes. [A - South-facing slope, B - Hilltop, C - North-facing slope and A+C - Common species between south and north-facing slopes; MARC - Marchantiopsida, JUNG - Jungermanniopsida, POLY - Polytrichopsida, BRYO - Bryopsida, ANTH - Anthocerotopsida].

DISCUSSION

The present study showed higher number of mosses (64.5%) in comparison to liverworts and hornworts which is in accordance to the global distribution proportion of bryophytes *i.e.* higher proportion of mosses. Among the moss families Polytrichaceae, Pottiaceae, Bryaceae, Mniaceae, Thuidiaceae, Meteorioraceae and Hypnaceae were significantly contributed to the diversity of Mt. Panchase, reinforcing the importance of these families to the bryoflora of subtropical to temperate forests. Gradstein (2011) also suggested that dense forest and presence of rocks in an area between 1,000–2,000 m supports the growth of mosses, however, liverworts and hornworts prefer soils rather than other habitats. The epiphytic bryophytes mostly mosses and some leafy liverworts recorded from trunk of *Castanopsis* and *Quercus* as well as bark of shrubs was in accordance to the results obtained from Mt. Chandragiri (Pradhan 2014b).

Distribution and diversity of bryophytes are affected by various components of climate and local environment including precipitation, temperature, disturbance regimes, soil characteristics across the elevation and depth of the litter (Rosenzweig 1995, Lomolino 2001, Sun *et al.* 2013). Similarly, mountain peaks of variable

heights which influence moisture level, the maximum number of rainy days and cloud zone are also responsible for the diversity of bryophytes (Bhattarai *et al.* 2004). Additionally, the microhabitats such as tree trunk, knotholes of tree trunk, rotten wood logs, river bed, riverbank, earth cutting slopes are also responsible for luxuriant growth and spread of bryophytes (Barukial 2011). In the present study three different sites (north and south-facing slopes and top of the mountain) provide variation in microclimatic condition and resulted into the distribution of specific bryophytes in respective sites. The south-facing slope, characterized by less number of trees with almost open canopy and dry substratum, may be the reason of low bryophyte diversity. Similarly, the north-facing slope characterized by dense forest with high canopy cover and moist condition may be the reason of higher diversity. In contrast, the hilltop with both shaded and exposed condition differ from either of slopes provides a unique habitat (cool and moist), thus supports the existence of unique bryophyte diversity in very small area. Furthermore, highest diversity of the members of Jungermanniopsida (leafy liverworts) in north-facing slope provides an evidence of their habitat specificity; prefer to grow on moist and shady habitat.

CONCLUSION

The present study shows that Mt. Panchase encompasses different microclimatic conditions in different study sites and accommodates altogether 62 species of bryophytes. Distribution of bryophytes showed site-specific pattern *viz.* more species from north-facing slopes. The species also shows habitat-specific preferences as maximum was recorded from soil. Finally, the area with elevation range and slope direction provides variable microclimatic conditions which favors luxuriant growth of plants including bryophytes.

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