FLORISTIC COMPOSITION OF BRYOPHYTES IN DISTURBED HABITATS OF TWO DIFFERENT ELEVATIONS IN CHANDRAGIRI HILL, CENTRAL NEPAL

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ABSTRACT

Bryophytes are small, photosynthetic plants, capable of growing on variety of habitats, so are pioneer of ecological succession. In Nepal bryophytes have been studied floristically in different parts of the country, but the impact of disturbance on floristic composition was lacking. Therefore, present study aimed to determine floristic composition of bryophytes especially on disturbed habitat generated by recently established Cable Car facility in Chandragiri hill, Kathmandu. The study area, highly disturbed at the base (1550-1600 m asl) and top of the hill (2400-2450 m asl), were selected for the collection of bryophytes. Altogether, 17 species of bryophytes including 5 liverworts, 11 mosses and 1 hornwort were recorded from the disturbed habitats. Among the 5 classes, Bryopsida was the most dominant class followed by the class Marchantiopsida, Polytrichopsida, Jungermanniopsida and Anthocerotopsida. Impact of elevation on diversity of bryophytes was observed in both sites of disturbed habitats. The diversity of bryophyte was found higher (13 species) at the base of the hill as compared to the top (8 species). Among the 17 species of bryophytes, 5 taxa (*Aerobryidium filamentosum, Anomobryum auratum, Atrichum undulatum* var. *subserratum*, *Chiloscyphus profundus* and *Plagiomnium ellipticum*) that have not been enumerated from the study site so far were also documented.

Keywords: disturbance, elevation, hornworts, liverworts, mosses

INTRODUCTION

Bryophytes, are second largest diverse group of land plants after angiosperms that comprised 15,000 to 25,000 species worldwide (Gradstein *et al.*, 2001; Klavina, 2015; Marko *et al.,* 2001). Although, abundant in tropical rain forests, they are found everywhere from desert to ice cold polar region except sea. They are even been re-

ported from volcanic rocks (Ah-Peng *et al*., 2007). In Nepal, bryophytes are also recorded from the highest elevation of 5200 m asl, in Khumbu region of eastern Himalaya (Pradhan & Shrestha, 2002).

Among different countries of Eurasia, the largest continent which includes Europe and Asia, the highest number of bryophyte diversity has been recorded from China i.e. 3,040 species (Asakawa *et al.*, 2013). Second largest number has been reported from India with 2,486 species including 1,786 of mosses, 675 of liverworts and 25 species of hornworts (Dandotiya *et al.*, 2011). A large land mass namely Russia hosted about 2,200 species of bryophytes. Similarly, Europe comprises a total of 1,894 species including 1,392 species of mosses, 494 species of liverworts and 8 species of hornworts (Hodgetts *et al.,* 2020). Although, Nepal is a small country in terms of land area but reported to host a total of 1,215 species of bryophytes (Pradhan, 2018). In south Asia, Bangladesh represented the least bryophyte diversity with 183 species only (Asakawa *et al.,* 2013).

Bryophytes are small herbaceous plants densely grow like mat or cushions on variety of habitats. They are abundantly found as carpet on boulders, humid soil, poles and dead logs of trees, tree branches and epiphytic on leaf surfaces. Moist evergreen forests provide variety of microhabitats. The distribution of bryophytes is mainly influenced by different microclimatic factors, for example rainfall, temperature, elevation, and latitude (Sveinbjörnsson & Oechel, 1992). The micro environmental conditions like shade, humidity, humus and temperature have also impacts on bryophyte distribution (Alpert, 1991). Bryophytes prefer specific habitat for their distribution because of inherent adaptive capacity. For example, species of *Sphagnum* have potential to accumulate nutrients directly from atmosphere in their living cells (Sala *et al*., 2000).

In general, diversity of organism is affected by habitat disturbances, which however depend up on the size of the area at which they are measured (Hamer & Hill, 2000). The intermediate disturbance hypothesis well explained about the frequency of disturbance and diversity. Accordingly, the local species diversity is maximized when ecological disturbance is neither too rare nor too frequent (Connell, 1978). Understanding disturbance effects on floristic composition and functional diversity is fundamental to conservation planning. In this regard, habitat destruction caused by human may also affect floristic composition and distribution of bryophytes, the pioneer species of primary and secondary succession on land.

Chandragiri hill is among the four high ridges bordering Kathmandu valley. Pradhan (2014) collected bryophytes along elevation gradient from 1,365 to 2,300 m asl of Chandragiri hill. Altogether, 58 species of bryophytes were reported which belong to 39 genera and 25 families. Present study aimed to determine floristic composition of bryophytes as well as their distribution at two major locations of the hill to check the impact of land exposure during road construction and establishment of cable car facility hereafter referred as disturbed habitat.

Study area

The present study was carried out at two different sites of Chandragiri hill located in Chandragiri municipality of Kathmandu valley (Bagmati Province), Central Nepal (Fig. 1). Chandragiri municipality lies in 27°32'45'' N to 27°43'36'' N latitude and 85°11'8'' E to 85°16'39'' E longitude.

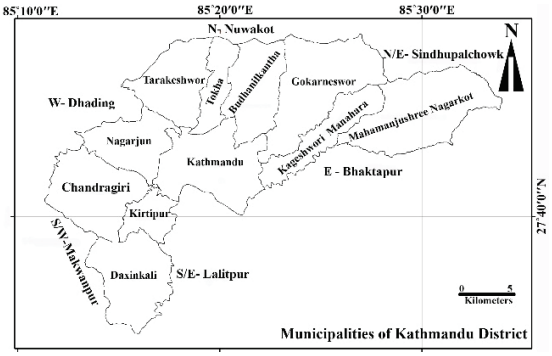

Fig. 1. Map of Kathmandu district showing Chandragiri municipality and study area.

Chandragiri municipality is bordered to Kirtipur municipality in the east, Dhunibeshi in the west, Nagarjun in the north and Dakshinkali in the south. Topography of the municipality mainly includes hilly terrain with a wide range of elevations which starts from 1,310 m. and reaches up to 2,551 m asl. The mountain connects the district of Makwanpur to Kathmandu through road. The present work was conducted in adjoining areas of two main stations of cable car i.e., at the base (27°41'11'' N and 85°12'47'' E; elevation between 1,550 to 1,600 m asl) and top of the hill (27°40'04'' N and 85°12'21'' E; elevation between 2,400 to 2,450 m asl). These two sites were heavily disturbed due to construction of road and establishment of cable car stations.

The climate of the study area is highly influenced by summer monsoons and winter rain. The highest rainfall was recorded during the month of July (474 mm) followed by August (410 mm), June (265 mm) and September (224 mm). Average minimum temperature (11.8 °C) was recorded in the month of January and average maximum (24.6 °C) in the month of August (DoHM, 2019). The Chandragiri hill represents subtropical forest dominated by *Schima-Castanopsis* and *Alnus nepalensis* in lower elevation and temperate forest dominated by Oak-*Rhododendron* in upper elevation.

MATERIALS AND METHODS

The bryophytes were collected from two different disturbed habitats, adjoining areas of base (1,550–1,600 m) and top (2,400–2,450 m) of the cable car station covering road sides as well as the construction sites twice during November, 2019 to March, 2020 spending 6 days each time in the field. The bryophytes were firstly photographed at natural habitats, then collected either by peeling off from the substratum with the help of pocket knife, or simply removed from the substratum by hand. Thereafter, collected specimens were preserved in paper bags with proper tagging.

Preservation of collected specimens was carried out following the standard methods (Pradhan, 2010). Firstly, the specimens were soaked with water for an hour, and then removed the soil with the use of forceps and brush. Cleaned and dried specimens were then transferred in well labeled paper packets for future references. The characterized specimens were identified using magnifying hand lens (20X), stereomicroscope and light microscope along with the help of standard literatures (Kashyap, 1929; Kashyap & Chopra, 1932; Grout, 1965; Gangulee, 1969-1980; Casas *et al*., 2009). The author's citation of each species was checked following TROPICOS. The identified specimens were further classified following the classification of Stotler and Crandall- Stotler (2005) for hornworts; Crandall-Stotler *et al*. (2009) for liverworts; and Goffinet *et al.* (2009) for mosses. The voucher specimens were deposited at the Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Data analysis

Data collected from the field were kept in tabular form in databases and presented graphically using Microsoft Excel 2010.

RESULTS AND DISCUSSION

Floristic composition

Altogether 17 bryophytes species representing 15 genera, 14 families, 8 orders, and 5 classes were recorded from the disturbed habitats of Chandragiri hill (Table 1). Among the different lineages of bryophytes, mosses were the most dominant with 11 species (64.7%) followed by liverworts with 5 species (29.4 %) and hornworts with only one species (5.8 %) (Table 1, Fig. 2).

Table 1. Bryophytes of the disturbed habitats.

S.N.	Class	Order	Family	Scientific name	*Location
1.	**Marchantiopsida**	Marchantiales	Marchantiaceae	*Marchantia emarginata* Ren. Blume and Nees	A, B
				Marchantia paleacea Bertol.	A
				Marchantia polymorpha L.	B
			Aytoniaceae	*Plagiochasma pterospermum* C. Massal.	B
2.	**Jungermaniopsida**	Jungermanniales	Lophocoleaceae	*Chiloscyphus profundus* Nees	B
3.	**Polytrichopsida**	Polytrichales	Polytrichaceae	*Atrichum undulatum* Hedw. var. *subserratum* (Hook.)	A
				Polytrichum commune Hedw.	A, B
4.	**Bryopsida**	Dicranales	Bruchiaceae	*Trematodon longicollii* Michx.	B
			Leucobryaceae	*Campylopus richardii* Brid.	B
		Funariales	Funariaceae	*Funaria hygrometrica* Hedw.	A, B
		Bryales	Bryaceae	*Anomobryum auratum* (Mitt.) A. Jaeger	B
			Mniaceae	*Plagiomnium ellipticum* (Brid) T.J. Kop.	B
			Batramiaceae	*Philonotis thwaitesii* Mitt.	A, B
		Hypnales	Meteoriaceae	*Aerobryidium filamentosum* (Hook.) M. Fleisch	A
			Thuidiaceae	*Thuidium glaucinum* (Mitt.) Bosch and Sande Lac	B
			Hypnaceae	*Hypnum pleumaforme* W. Wilson	A
5.	**Anthocerotopsida**	Anthocerotales	Anthocerataceae	*Anthoceros punctatus* L.	B

* A: Top (2400-2450 m asl) and B: base (1550-1600 m asl) of the Chandragiri hill

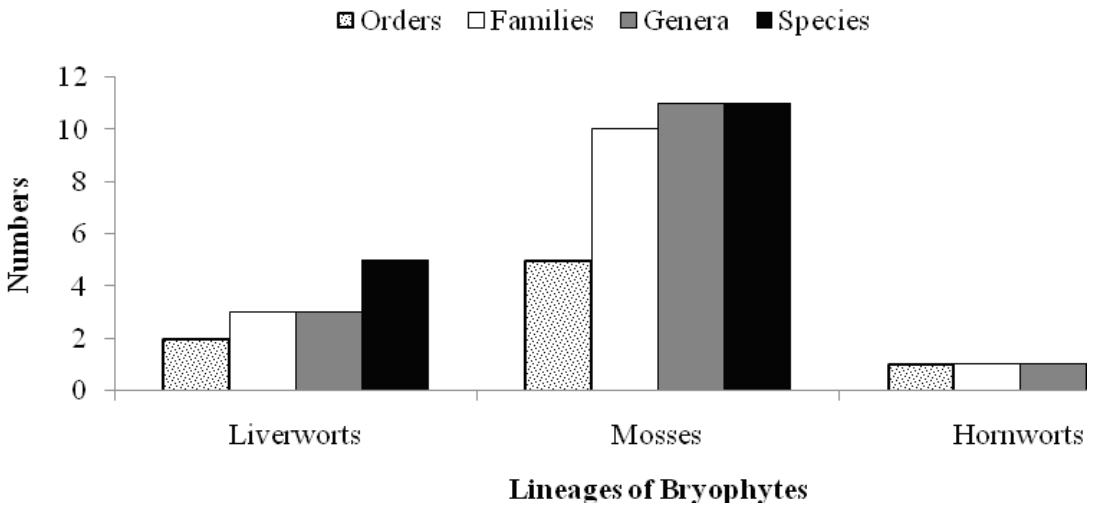

Fig. 2. Total number of orders, families, genera and species of each lineage.

Among the 5 classes, Bryopsida was the dominant with 9 species belonging to 9 genera, 9 families and 4 orders followed by Marchantiopsida with 4 species belonging to 2 genera, 2 families and one order. Similarly, Polytrichopsida with 2 species belonging to 2 genera, one family and one order followed by Jungermanniopsida with one species belonging to one genera, one family, and one order, and Anthocerotopsida with one species belonging to one genera one family and one order (Fig. 3).

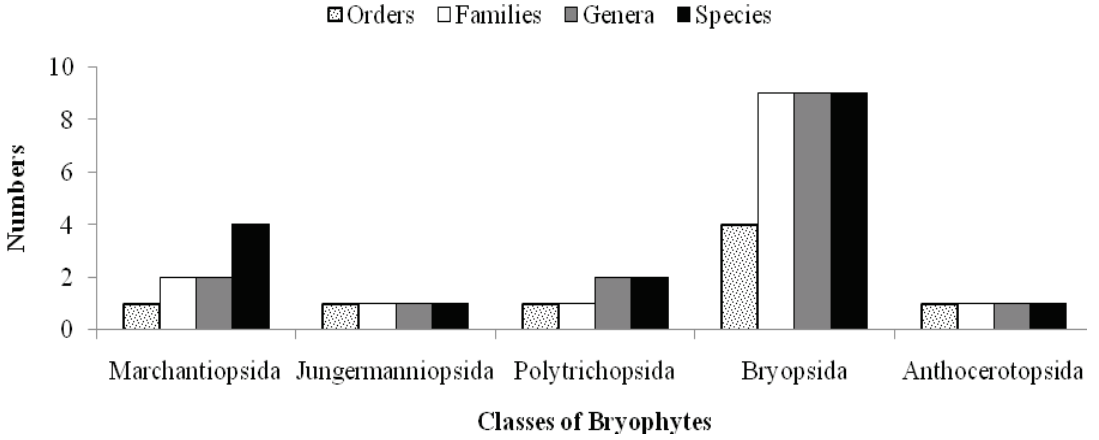

Fig. 3. Total number of orders, families, genera and species of each class.

Among the recorded 8 orders of bryophytes, Marchantiales (with 4 species) was the most dominant followed by Hypnales and Bryales (3 species each). Likewise, Dicranales and Polytrichales (2 species each) whereas, Jungermanniales, Funariales and Anthocerotales were represented by only one species each (Fig. 4).

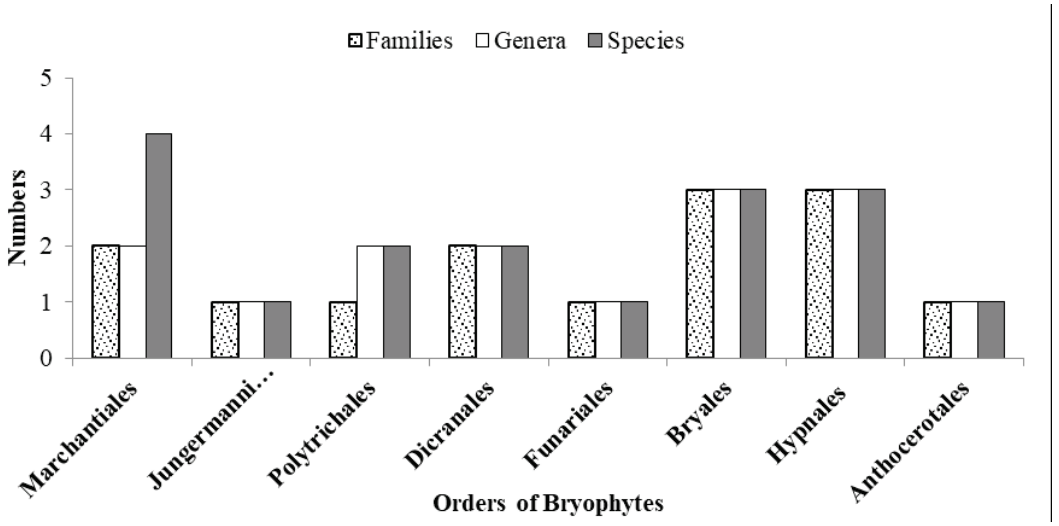

Fig. 4. Total number of families, genera and species of each order.

Among the 14 families of bryophytes recorded, Marchantiaceae (3 species) was the dominant family followed by Polytrichaceae (2 species). The remaining families namely Aytoniaceae, Lophocoleaceae, Bruchiaceae, Leucobryaceae, Funariaceae, Bryaceae, Mniaceae, Batramiaceae, Meteoriaceae, Thudiaceae, Hypnaceae and Anthocerataceae were represented by one species each (Fig. 5).

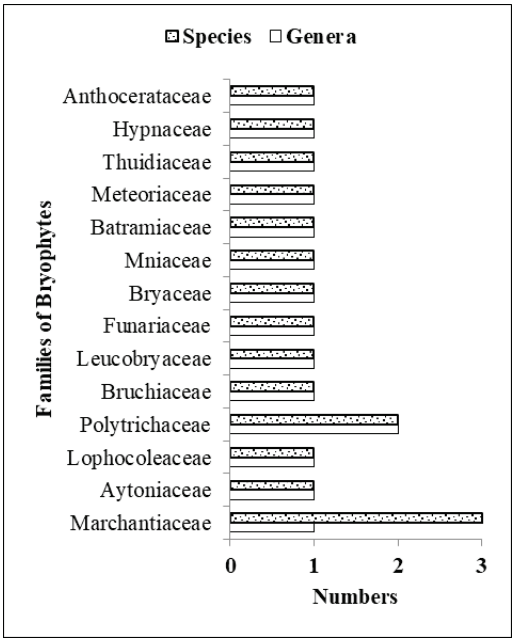

Fig. 5. Total number of genera and species of each family.

Among 15 genera, *Marchantia* was dominant genus with 3 species. However, the remaining genera namely *Plagiochasma*, *Chiloscyphs*, *Atrichum*, *Polytrichum*, *Trematodon, Campylopus*, *Funaria*, *Anomobryum*, *Plagiomnium, Philonotis, Aerobryidium, Thuidium*, *Hypnum* and *Anthoceros*, each were represented by single species (Fig. 6).

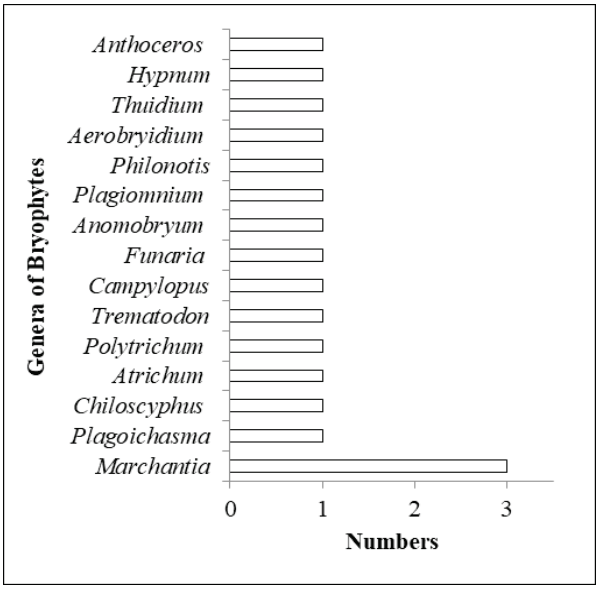

Fig. 6. Total number of species of each genus.

The data obtained for the distribution of bryophytes in present study (disturbed habitat) has been compared with the results of previous work done by Pradhan (2014) in the same area. Class wise comparison of percentage representation of bryophyte species showed highest representation from the class Bryopsida followed by Marchantiopsida and Anthocerotopsida (Fig. 7).

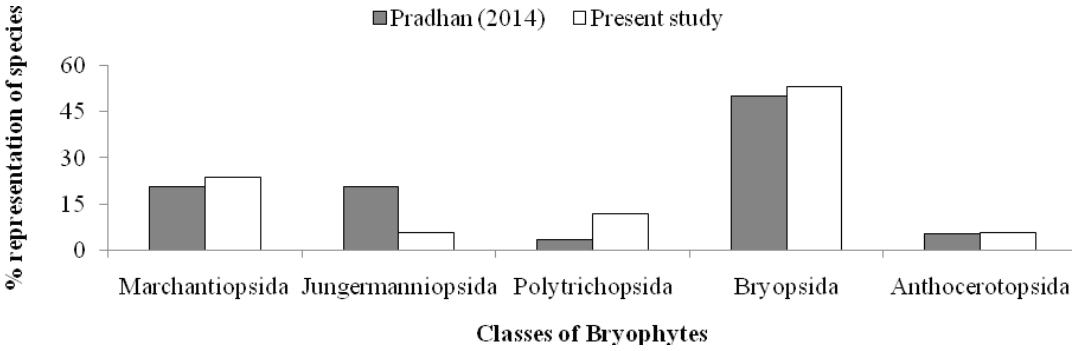

Fig. 7. Class wise comparisons between the present study (disturbed habitat) and the study carried out by Pradhan (2014) in Chandragiri hill.

Distribution pattern with respect to elevation

Out of 17 species recorded from the disturbed habitat of Chandragiri hill, 13 species were found at the base of the hill (1550–1600 m asl) and 8 species at the top (2400–2450 masl) with 4 species common to both elevations (Table 1). Among the common species, two belonged to Bryopsida (*Funaria hygrometrica, Philonotis thwaitesii*), while the remaining two belonged to Marchantiopsida and Polytrichopsida (*Marchantia emarginata*, *Polytrichum commune*). The members of Anthocerotopsida and Jungermanniopsida were confined only to the lower elevation. Members of Marchantiopsida and Bryopsida were confined more towards lower elevation than higher elevation. In contrast, members of Polytrichopsida were confined more towards higher elevation than lower elevation.

Nepal although a small mountainous country, represents a good diversity of 1,215 species of bryophytes including 30 endemic species (Pradhan, 2018). The overall diversity of bryophytes among different continents including islands suggested that tropical condition is more appropriate than cool climatic conditions i.e. towards North and South Pole. Similar pattern has also been observed in tropical mountains where species richness initially increases with elevation and after certain limit it starts to decrease. Earlier study documented 58 species of bryophytes from Chandragiri hill (Pradhan, 2014). In contrast, present study documented only 17 species from the disturbed sites of same area, which is about one third of the total diversity. These results suggested that disturbance itself provides a unique habitat and among the bryophytes which prefer to grow in such habitat. Furthermore, among the 17 species diversity was found higher in lower elevation (ca. 1,500 m) than that in higher elevation (ca. 2,500 m). It may be because of change in microclimatic conditions due to disturbance.

The worldwide distribution data of different lineages of bryophytes including Europe, southern South America, tropical America, North America and Australia showed the values ranged from 60–74% for mosses, 26–40% liverworts and 0.4–0.8% hornworts (Hallingback & Hodgetts, 2000). The distribution pattern is even consistent in Islands like Greenland and Madagaskar (Hassel *et al.,* 2014; Marline *et. al.,* 2012). Similar distribution pattern has also been reported from different parts of Nepal (Pradhan, 2013, 2014) and India (Asthana & Sahu, 2013; Aruna & Krishnappa, 2014; Sahu & Asthana, 2015). The results of the present study is consistent with the global trend

and showed mosses as a most dominant lineage (i.e. 64.7%) followed by liverworts (29.4%) and hornworts (5.8%). The three lineages of bryophytes distributed almost with the same proportion even in case of disturbed habitat indicates the possibility of diverse adaptive potential of different species of different lineages.

Comparing the present data to the previous study conducted by Pradhan (2014), Bryopsida followed by Marchantiopsida and Anthocerotopsid were the highly representative classes in the same study area. In case of remaining two classes, members of Polytrichopsida showed higher representation than Jungermanniopsida. In general members of Jungermanniopsida prefer moist and dark habitat (Sharma *et al.,* 2021) but as the disturbed sites of the present area was dry and exposed, it was possibly not favorable for them to grow.

Similarly, order-wise comparison between bryophytes in Chandragiri hill that were reported earlier (Pradhan, 2014) and the results of present study showed that members of the two orders were absent in disturbed habitats. Among the 10 orders reported earlier, the number of species belonging to Polytrichales was same. In case of remaining orders except two (Metzeriales & Pottiales) the number of species decreased in disturbed habitats. This comparison again suggested that the members of these two orders may be very selective or it can be said that, they do not prefer disturbed habitats.

Disturbances are defined as changes in the biotic or abiotic environment that alter the structure and dynamics of ecosystems (Donohue *et al*., 2016). The disturbances happened naturally or induced by human beings play an important role in shaping global vegetation (Foley *et al.,* 2005). Impact of disturbances has been studied for different plant groups. In case of higher plants diversity of species has found to decrease with disturbances. However, in case of bryophytes, human induced disturbances impacted at both habitat and landscape-scale (Zechmeister & Moser, 2001; Patino *et al*., 2009; Lehosmaa *et al.,* 2017). As the bryophytes are pioneer plants in degraded land, they can grow comfortably and recorded with either high diversity or with unique diversity (Zielinska *et al.,* 2017; Fenton & Bergeron, 2008; Jiang *et al*., 2018; Liu *et al.*, 2019). The results of the present study also supported the observations of previous work as the disturbed habitat harboured altogether 17 species and of them 5 species (*Aerobryidium filamentosum, Anomobryum auratum, Atrichum undulatum* var. *subserratum*, *Chiloscyphus profundus* and *Plagiomnium*

ellipticum) were not recorded in the previous study conducted by Pradhan (2014).

The diversity of bryophytes was found to decrease in disturbed habitats compared to the overall diversity of Chandragiri hill reported earlier. Despite the low species diversity, nearly one third of the species were unique to the disturbed habitats. Additionally, class and order wise distribution pattern of bryophytes in disturbed habitats is consistent with overall distribution of bryophytes in Chandragiri hill.

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