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# Ecological Diversity of some common liverworts in Fambonglho Wildlife Sanctuary, Sikkim

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**Abstract**
Bryophytes form an extreme part of vegetation and they are important in the prospective of understanding Himalayan ecology. Sikkim Himalayan region is known for a large diversity of habitats necessary for the colonization of bryophytes. Bryophytes are critical components of ecosystem due to their high diversity and biomass, and they also fulfill essential ecological functions. Environmental variables play a vital role on the distribution of bryophytes. Terrestrial bryophytes are intimately dependant on the external environment and have a wide geographical distribution because of the interaction of their dispersal history, climate, environmental fluctuation, habitat availability and the substrate, where they tend to grow with their associated plants. The diversity study is an important concern because of anthropogenic pressure in the region. This work aims to study the diversity of liverworts of Fambonglho Wildlife Sanctuary. A short morphological description, habitat type and their associated plants are presented in this paper.

**Keywords:** Associated plants, Bryophytes, Diversity, Habitat, Key characters, Sikkim, Status.

## Introduction

Sikkim, one of the North-Eastern Himalayan states of India, is globally known for its rich biological diversity. The state has a unique biogeographical features having varied altitudinal ranges and climate, which make it an ideal home to diverse flora and fauna. According to floristic report of the Botanical Survey of India (2021), a total of 2800 taxa of bryophytes have been reported from India that comprises 5.09% of the total Indian plant resources.

History of the taxonomical studies on the bryophytes of Sikkim dates back to Mitten (1861), who listed 93 species of Hepaticae and Anthocerotae based on the collections made by Sir J.D. Hooker during 1848-49. Chopra (1938, 1943) listed 268 species of liverworts and hornworts from the state in his census of Indian hepatics. Herzog (1939) dealt with 27 species of hepatics from Sikkim. Hattori (1966, 1971, and 1975) listed 142 species based on the collections made by the members of the Botanical Expeditions of the University of Tokyo, Japan during 1960 and 1963. After a gap of many years, a number of critical studies by many botanists published monographs on bryophytes including a number of species from Sikim. Systematic studies on the hepatics of Sikkim has been started from 2004 onwards and so far 342 taxa of liverworts belonging to 88 genera in 44 families have been recorded from Sikkim (Dey *et al.*, 2007, 2008, 2009, 2010, 2011; Singh *et al.*, 2008) which is nearly 40% of the total liverwort

taxa in general. The present work highlights the diversity and distribution of liverworts of Fambonglho Wildlife Sanctuary which lies between 27°18′10″ N to 27°22′50″ N latitude and 88°27′15″ E to 88°35′25″ E longitude. Total area of the sanctuary is 51.76 sq. km. and the altitude ranges from 1200 to 2624 m. Information presented on the distribution of liverworts from the study area may considerably complement the existing information of liverworts diversity and distribution in Sikkim.

## Methodology

### Site Selection

Bryophytes are considered as the first land plants and have adopted the survival strategies modifying their body structure that help them to colonize on the barren areas. The areas which have little or no soil cover but have moisture for at least a few weeks are conducive for their growth and multiplication. They grow on rocky slopes of hills, the walls of old buildings, steep slopes in forests and along road sides (road cuts) and even the stems of other plants where the higher group of plants find it difficult to grow.

| Habitats with high bryophyte diversity |
|---|
| • High rainfall areas |
| • Edges of waterfall, streams, and other water bodies |
| • High elevation localities |
| • Old monuments and buildings |
| • Tree trunk and branches |

### Data Collection

Data collection is an important component of any field based research work which helps in the long term ecological monitoring of the plants. The table below lists the data that was collected along with the plant specimens.

| Field data collected along with specimens |
|---|
| • Substrate information (soil, rock, bricks, etc.) |
| • Host for epiphytes |
| • Associated plants |
| • Other information |

### Identification of specimens

Identification of specimen was done in the laboratory of the Department of Botany, Sikkim University based on morphological characters. Because of the size, limited morphological and color diversity, it becomes a challenge

to identify them without high resolution microscopes. Identification of the specimens presented in this paper is based on the publications by Pope Ralph (2016) and the Checklist of Botanical Survey of India prepared by Dandotiya *et al,* (2011).

## Result and Discussion

In the present paper, 13 species of liverworts belonging to 9 families and 9 genera have been recorded from Fambonglho Wildlife Sanctuary which is enumerated alphabetically irrespective of their taxonomic positions. It is found that most of the liverworts are terricolous (grows on soil), rupicolous (grows on rocks, cemented wall etc.), followed by corticolous (grows on tree trunk/bark),

## Identification key of the studied specimens based on morphological characters

**1.** Plants have light green 3.5-8.7mm long, 1.5-1.6mm wide with leaves, irregularly branched. Leaves imbricate, lead lobe ovate, margin entire, apex rounded. Rhizoids numerous, monoecious, usually fertile, gemmae is not present, perianth ovotate, well-developed dorsal papillosity on the leaf cells. Plant lacking underleaves, stylus (a lanceolate flap found between a lobule and the stem) is present.....*Cololejeuna latilobula*

**2.** Thallus dark greenish, in large patches of overlapping individuals, 5-10cm x 1-1.5cm, repeatedly dichotomous, margin undulate, midrib broad, dorsal surface sometimes with a faint network, covered densely with papillate cells, epidermal cells thin, ventral surface green, scales simple, hyaline, midrib more prominent below, male receptacles terminal, disciform, with bristles on the margin, resemble the female receptacles when young, female receptacles sessile when young, with a few bristle like hairs, stalked at maturity, stalk thick, with two rhizoid furrows. When matues it becomes dark brown in colour.....*Duomortiera hirsuta*

**3.** Plant yellow to whittish or milky-green. It is a small leafy liverwort, its shoots being 3mm wide and 40mm long at most, but usually much smaller. It usually grows intermixed with other bryophytes but sometimes forms small mats. The leaves are bilobed with pointed lobes and rather opaque. The underside of the stem has much smaller underleaves that are cleft almost to the base, so that they appear as pairs of tiny prongs (each of the two or more long pointed parts of the leaves). Leaves ovate-lanceolate to oblong, lobes parallel, linear-lanceolate, entire. Rhizoids are long in length. Small trigones are present

.....*Geocalyx graveolens*

**4.** This species is easily rocognised by the appendages of median scales yellow with orange red borders; ovate and acuminate apically. Dorsal

surface is dark green. It has a conspicuous midrib and is marked on the dorsal surface by a shallow groove and on the ventral surface by a low ridge. The midrib ends in a depression at the apical region forming an apical notch in which growing point is situated. Gemma cup develops on the midrib on dorsal surface. The ventral surface of the thallus bears scales and rhizoids along the midrib.....*Marchantia geminata*

5. Thallus prostrate, dark greenish-black, 15-30mm long and 3-7mm wide, slightly purplish at margins, dichotomously branched, crowded together, midrib narrow, prominent, black; pores scarse, small, not prominent, ventral branches absent, surface possess rhizoids and scales on either side of the midrib, scales in four rows; gemmae present at the apex of the midrib, cup soft, globose, abundant, discoid in gemma cups with margins fringed, ciliate, lobed, or entire; always present at the dorsal surface; dioecious. Thallus margin entire or slightly lobed.....*Marchantia linearis*

6. It is easily recognised vegetatively by the large thallus without median band on dorsal surface and cupules with ciliate lobes. Bright green to bluish green, sometimes blotched with dark red pigmentation, firm, rather leathery, margins mostly deep red or pink, entire, when dry margins crinkled, not raised or incurved. Branches repeatedly furcate, terminal segments oblong, upto 15 mm long. Apex notched, median scale appendages recurved over edge, groove absent, thallus dorsally flat, margins acute. Ventral surface medianly keeled, dark red entirely or medianly, the remain green. Gemmae are present at the dorsal surface of the thallus, rhizoids extends from ventral surface of the median.....*Marchantia paleaceae*

7. Plants thick, light green-dark green, dichotomously repeated, profusely branching, air-pores visible; thallus 20-50mm long, 3-5mm wide, dorsal dark median band, margin entire, apex notch; ventral scales 4 rows, median two rows appendiculate, appendages ovate-subrounded and toothed with 1-2 uniseriate cells towards apex, brownish to reddish colour; Laminar scales slightly ligulate; rhizoids extends from the ventral surface of the thallus and are long thread-like, gemma cup fringed on the margin; dioecious..... *Marchantia papillata*

8. It is a thallose liverwort which forms a rosette of flattened thalli with forked branches. The thalli grow up to 10cm long with a width of upto 2cm. It is usually green in colour but older plants can become brown or purplish. Margins are smooth. The upper surface has a pattern of polygonal markings. The under-side is covered by many root-like rhizoids which attach the plant to the soil. The plants produce umbrella-like reproductive structures known as gametophores. The gametophores of female plants consist of a stalk with star-like rays at the top. These contain archegonia. Male gametophores are topped by a flattened disc containing

the antheridia. This Gemmae are lentil shaped and are released by droplets of water.....*Marchantia polymorpha*

9. This thallose species forms yellowish green patches. The thalli that are just 1mm wide and have a forked tip; possess a thick midrib. The margins are flat or slightly down curved. Rhizoids are thin thread-like which attaches with the substratum. Narrow, almost linear gemmae are sometimes found on the thallus margin.....*Metzgeria furcata*

10. This thalloid liverwort develops into a low mat of irregularly branched and overlapping lobes. The margins are irregularly sinuous and rather flat. The lobed thalli are usually green on both sides, although they sometimes become purplish green in sunlight. The underside of each lobed thallus is similar to its upper side, except there are relatively long fibrous rhizoids along its length in the middle. The archegonia are located a little behind the growing tip of one or more fertile lobe of the thallus. The antheridia are located in small shaped bumps behind the flap-like structure containing the archegonia on the same lobe.....*Pellia epiphylla*

11. Thalli are characterized by large, purplish green patches, thick, 20mm long and 5mm wide, dichotomously branched and occasionally with adventitious shoots. Lobes oblong, dorsal surface smooth margins undulate. Midrib distinct passing into lamina, ventral surface purple. Scales in one row on each side of the midrib purple, broadly lunate, body with 1 or 2 appendages reaches half way to the margins, appendages large, fan-shaped, and entire and ocasionally purple. Male receptacle horse-shoe shaped sometimes scattered on the thallus or in acropetal order. Female receptacle sessile or stalked, usually with 2-5 lobes, situated on the thallus in row or scattered or some time at the basal part of the part of the plant. This species is mainly separated from the other species on the basis of the scale structure which has typical from shaped on broad lunate appendages.....*Plagiochasma appendiculatum*

12. Plants light green to yellowish green, upto 25mm long, 1.8-2mm wide including leaves, irregularly brached, pinnately branched, branching of Radula-type; rhizoids numerous, arises in the middle. Leaves loosely imbricate to contiguous, widely spreading, lobe ovate, 1-1.2 mm long, 0.8-1.1 mm wide, apex rounded, margin entire; gemmae absent or sometimes present. Monoecious and commonly with sporophytes, or atleast perianth.....*Radula javanica*

13. Thallus greenish, simple, rarely dichotomously branched, fixed to the soil only at the base, margin entire, ventral surface purple, scales broadly triangular, involure purple, ventral scales arranged in two rows. Midribs prominent below and rather suddenly passing into the lamina, rhizoids are unicellular, smooth walled and tuberculate. Antheridia are aggregated on the disc of the short ventral shoots or on the dorsal side of the main shoot

forming a long and broad mid-dorsal cushion. Archegonia are present on the under surface of the thallus towards the apex..... *Targonia hypophylla*

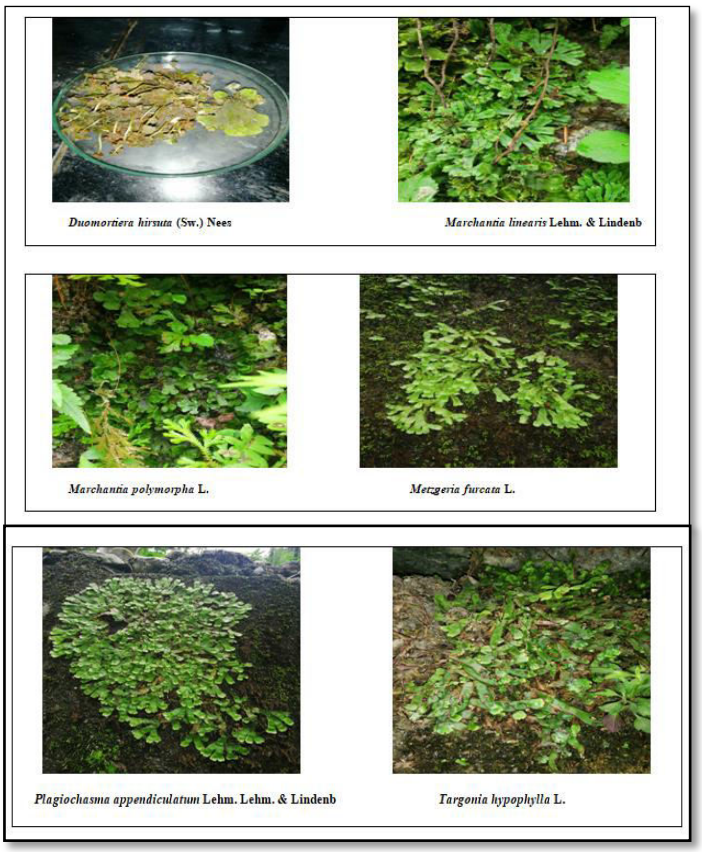
### 3.2. List of mosses and their habitat, associated plants and local distribution in East district of Sikkim

| Sl. No. | Name of the plant | Family | Habitat & Habit | Associated plants |
|---|---|---|---|---|
| 1 | *Cololejeuna latilobula* (Herzog) Tixier | Lejeuneaceae | Bark of the tree Epiphytic | Angiospermic trees and leaves |
| 2 | *Duomortiera hirsuta* (Sw.) Nees | Duomortieraceae | Moist soil and on wet hills, and on roots of higher plants. Terricolous | *Marchantia polymorpha, moss* such as *Polytrichum* and with some angiospermic shrub *Houttuynia cordata, Erigeron karvinskianus* |
| 3 | *Geocalyx graveolens* (Schrad.) Nees | Geocalycaceae | Peaty humus on a more or less at the edge of stone or soil. Terricolous | Fern: *Selaginella kraussiana* (Kunze) A. Braun. Angiosperm: *Ageratum conyzoides* L., *Persicaria nepalensis* (Meisn.) H.Gross. |
| 4 | *Marchantia geminata* Reinw, Blume & Nees | Marchantiaceae | Soil, Soil, rocks (shady or open places) Terricolous | *Marchantia sp., Ocimum sp., Impatiens sp., Oxalis sp.* |
| 5 | *Marchantia linearis* Lehm. & Lindenb. | Marchantiaceae | Area Cemented wall, soil and rock Mainly Terricolous | *Marchantia polymorpha, Duomortiera hirsuta, Marchantia geminata, Lemna sp.,* mosses such as *Brachythecium rutabulum* and angiospermic plants such as *Hottuynia cordata, Coleus sp., Erygeron sp.* |
| 6 | *Marchantia paleaceae* Bertol. | Marchantiaceae | Soil, rock, and walls. Mainly terricolous | *Marchantia polymorpha Hottuynia cordata* |
| 7 | *Marchantia papillata* Raddi. | Marchantiaceae | Moist and shady areas Such as soil, rock. Terricolous and Rupicolous | Liverworts: *Doumortiera hirsuta* (Sw.) Nees., *Marchantia polymorpha* L. *Marchantia linearis* Lehm. & Lindenb., *Plagiochasma appendiculatum* Lehm. & Lindenb., Moss: *Brachythecium rivulare* W.P.Schimper Angiosperm: *Cynodon dactyolon* (L.) Pers. |
| 8 | *Marchantia polymorpha* L. | Marchantiaceae | Moist soil and rock in Damp areas. | *Marchantia geminata, Marchantia linearis, Plagiochasma appendiculatum,* |

| | | | | |
|---|---|---|---|---|
| | | | Terricolous and Rupicolous | *Radula javanica,* mosses such as *Brachythecium rivulre, Polytrichum juniperum, Atrichium undulatum, Bryum argenteum* angiospermic plants such as *Bidens pilosa, Galinsoga Parviflora, Erygeron sp, Hottuynia cordata, Impatiens drepanophora, Hydrangea, Chrysanthemum sp., Plagiochasma appendiculatum* |
| 9 | *Metzgeria furcata* L. Corda. | Metzgeriaceae | Trees, rocks, and Cemented walls. Epiphytic, Terricolous, Rupicolous | |
| 10 | *Pellia epiphylla* (L.) Corda. | Pelliaceae | Bank of rivers, stream, And ditches, wet Woodlands, marshes, Wet rocks. Terricolous and Rupicolous | Fern sp. *Pteridium, Nephrolepsis* mosses such as *Brachythecium rivulre,* angiospermic plants such as *Commelina sp.* etc. |
| 11 | *Plagiochasma appendiculatum* Lehm. Lehm. & Lindenb | Aytoniaceae | Moist soil, wet cemented Walls, rock on semi- Shaded areas, old Buildings. Terricolous and Rupicolous | *Metzgeria lindbergii Marchantia linearia Marchantia polymorpha, Duomortiera hirsuta* some mosses such as *B. rivulre, Polytrichum sp, Selaginella sp.,* angiospermic plants such as *Frageria sp, H. cordata, Salvia, Commelina sp, Galinsoga parviflora, Psidium guajava, Bougainvillea sp.* |
| 12 | *Radula javanica* Gottsche, Lindenb & Nees. | Radulaceae | Plant grows on tree trunk Terrestrial sheltered road sides, sometimes hanging loosely from bark, as well as growing on leaves. Corticolous, Terricolous sometimes epiphyllous. | Angiospermic plant such as *Garcinia sp,* liverworts such as *Cololejeunea sp, Metzgeria sp, ,* mosses such as *Brachythecium sp., Octoblepherum sp. and Atrichium sp.* |
| 13 | *Targonia hypophylla* L. | Targoniaceae | Moist and shady regions of tea of tea estates Terricolous | *Camilla sinensis, Cajanus cajan, Ageratum sp* |

All the above mentioned liverworts were identified from the checklist of Singh *et al.,* 2016.

## 4. Some photo plates of liverworts studied in Fambonglho Wildlife Sanctuary




## Conservation of Bryophytes

Generally bryophytes are not considered as a flagship species for conservation due to its size that makes inconvenient for the public to appreciate their beauty and unique morphological features. Therefore, the protection of bryophytes is best achieved by protecting the habitats (Sastre-D & Tan 1995). Even though, most of the bryophytes are too small and inconspicuous to serve as the flagship plant, still, the protection of them is necessary because some rare and unique species need species-specific protection measures. The work to identify these species includes setting a priority system to make sure that cost-effective measures are to be applied. Focus should be made on rapidly declining and extremely rare species. It is therefore, identification of species that are rapidly declining, or are close to the brink of extinction, both at the regional and global levels are required. Rapid surveys need to be conducted to identify more hotspots of bryophytes diversity.

## Conclusion

Sikkim Himalayan region exhibits one of the richest angiosperm diversity in the country and it is equally rich in bryophytes diversity. Among the members in plant kingdom, bryophytes are more sensitive to external environment and they act as an indicator of climate change. However, their occurrence and importance has not been clearly appreciated yet; and that may be due to very less studies about them. Thus, the basic data on common liverworts presented in this paper may be used as a baseline data, which may encourage further studies aiming to bio-monitoring characteristics and phyto-chemical analysis in future.

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