

Species composition and diversity of bryophytes in Jajpur district of Odisha, India

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Abstract

The present study reports on the first systematic survey of samples, species identification and analysis of community composition of bryophytes in Jajpur district of Odisha, India. During the course of extensive bryofloral exploration and collection of plant samples a total of 37 species of bryophytes distributed under 31 genera and 20 families were recorded. Of these, the mosses were represented by 28 species belonging to 25 genera and 14 families, while liverworts were comprised of 8 species under 5 genera and 5 families, besides 1 species under 1 genus belonging to 1 family represented the hornworts in the area under study. The most common families in number of records were Bryaceae and Dicranaceae with 4 species each followed by Aytoniaceae, Funariaceae, Fissidentaceae, Marchantiaceae, and Pottiaceae with 3 species each.

Keywords: Bryoflora, Diversity, Jajpur, Odisha

1. Introduction

Bryophytes were some of the first green plants to successfully colonize land 470-551 million years ago from aquatic algal ancestors [1]. Traditionally, the term “bryophytes” has been used to describe a paraphyletic assemblage of three phyla, Anthocerotophyta (hornworts), Bryophyta (mosses), and Marchantiophyta (liverworts), whose relationships have long been a source of debate within the scientific community [2]. The bryophytes are widely distributed predominantly between the altitudes of 1000-8000 meters and considered important components of the vegetation in many regions of the world including the forest ecosystems. They constitute a major part of the biodiversity in moist environments, wetland, and mountain ecosystems [3]. Being pioneers of the terrestrial vegetation, they usually grow as varieties of life forms contributing to the main component of mountain forest in view of their high degree of soil binding capacity besides the water retention characteristics [4]. Bryophytes play a significant role as indicators of environmental pollution [5]. They are ecologically significant in playing a key role in ecosystem dynamics [6]. Bryophytes are also potential sources of new antibiotics and anti-cancerous substances [7]. They constitute one of the richest groups of plants in India and occupy a wide range of substrata. Currently, about 2489 taxa of bryophytes are reported from India comprising about 1786 species under 355 genera of mosses, 675 species in 121 genera of liverworts and 25 species in six genera of hornworts [8]. The present knowledge on the bryophytes of India began with studies by European bryologists such as Montagne [9], Müller [10], Mitten [11, 12], and Dixon [13]. The works of Benedix [14], Chopra [15], Asthana and Srivastava [16], Asthana *et al.* [17], Nath and Asthana [18], Parihar *et al.* [19], Singh [20, 21], and Lal [22], and many others, contain records of collections from India. Recently, a number of workers have made important contribution to the Bryophyte flora of the region of India and adjacent plains [23],

Meghalaya [24], Nagaland [25]. A good number of species of liverworts and hornworts have also been reported from Assam by Singh and Barbhuiya [26].

2. Material and Methods

Study area

Jajpur an interior district of Odisha (India), situated between 86°33'663" East longitude and 20° 85'145" North latitudes, covers an area of 2,888 sq.kms. with normal climate of Indian standard (Fig. 1). The average height of the district from the sea level is 330 m with an average rainfall of 1015.5 mm, besides a maximum and minimum temperatures of 40 °C and 10 °C respectively. It is surrounded by other four districts such as Bhadrak in east, Dhenkanal in west, Keonjhar in north and Cuttack in the south. The types of soil found in the district are alluvial, saline and red laterite. The district is wildly festooned with many diversified flora, which are completely unique in their habitat and shows idiosyncrasy in ecological condition. Even though this district is bestowed with a quite rich bryodiversity, no attempt had yet been made to study and document the diversity of Bryophytes of this area. To cover the knowledge gap and in view of the need for generation of floral diversity lists of this region an important tool for species and ecosystem conservation as well as for the detailed taxonomic studies the present investigation was undertaken.

Methodology

An extensive bryological inventory was carried out in different parts of Jajpur district of Odisha during 2016-2018 which included areas of Mahavinayak forest, Gunthuni, Gokarneswar, Langudi, Kaima, Ashokjhar and Lembo. Samples were also collected from different habitats including natural forests, agro-forests, urban ecosystems and road sides from different localities in the district, during March, 2018 to November, 2018. Simple methodology was

adopted to collect specimens in the field using a knife to peel off specimens from the substratum. The collected materials were dried at room temperature on blotting paper and placed carefully in simple thick paper envelopes. Date of collection, locality and habitat along with the substratum type were recorded in the field note-book and also on the

packets containing the materials. The collected bryophytes were identified carefully and deposited to Bryological Laboratory of NBRI, Lucknow. The identification of taxa has been done in the laboratory by studying the specimens and consulting various relevant literatures, flora, monographs and research publications [27-31].

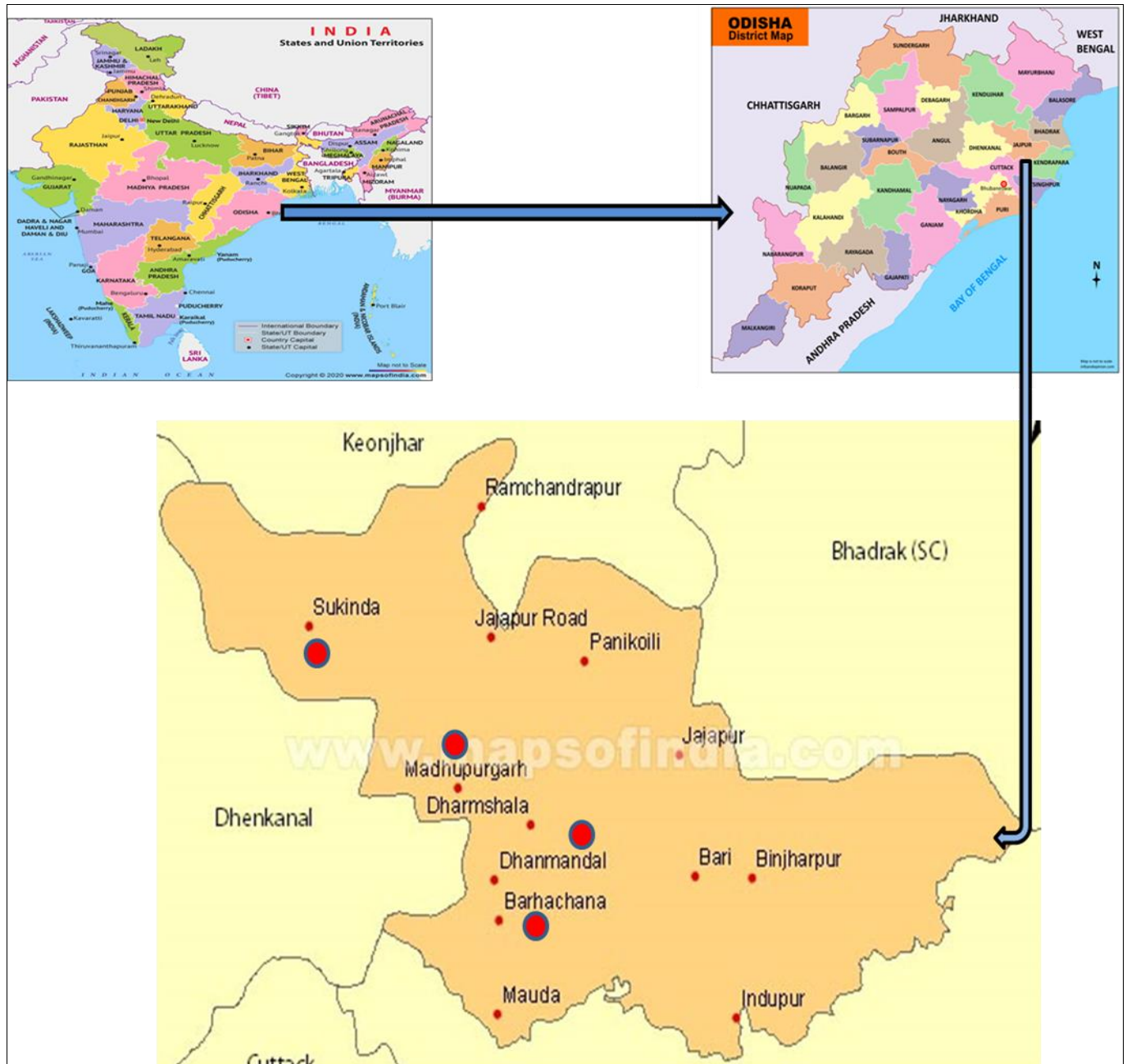


Fig 1: Map showing location of study area in Jajpur district, Odisha, India

3. Result and Discussion

As a result of the extensive floristic exploration on bryophytes followed by detailed taxonomic study a total of 37 taxa of Bryophytes distributed under 31 genera and 20 families have been recorded. Out of them, the mosses comprised of 28 species from 25 genera of 14 families, while Liverworts were represented by 8 species from 5 genera of 5 families. One species of hornwort was recorded belonging to 1 genus and 1 family. The data presented in the Table-1 revealed that Bryaceae and Dicranaceae were the two dominant families in the study area representing 4 species each followed by Aytoniaceae, Funariaceae,

Fissidentaceae, Marchantiaceae and Pottiaceae with 3 species each. Habitat-wise categorization indicated that 19 of the reported species were found thriving on the surface of soil, 11 species were found growing on the surface of rocks, and 6 species namely *Macromitrium richrdii*, *Meteoriopsis reclinata*, *Metzgeria furcata*, *Neckera pennata*, *Octoblepharum albidum* and *Racopilum cuspidigerum* were observed to be epiphytic and 1 species such as *Riccardia multifida* was found growing on rotten bamboo surface. All the bryophytes specimens collected during the present investigation were located within the altitudinal range of 390 m to 1000 m above the sea level. Genus-wise

distribution shows that *Fissidens* and *Bryum* bear three species each while *Marchantia* and *Leucobryum* having 2 species each [Table-1]. Some of the recorded species namely *Rhodobryum roseum*, *Dumortiera hirsuta*, *Atrichum undulatum* and *Marchantia* sp. were reported to possess medicinal value being used by the local inhabitants. It is pertinent to mention that the district of Jajpur harbours a

rich bryodiversity. It has been observed from the study that Jajpur district of Odisha harbours rich bryodiversity and no systematic data on them in this region were earlier available. It is expected that the present study may serve as valuable contribution to the knowledge of the bryoflora of the state and in Indian context as well to use the present data-base for the future conservation aspects.

Table 1: List of the species of Bryophytes with family, habitat and altitude of occurrence

Sl. No.	Name of the Species	Family	Habitat	Altitude
1.	<i>Asterella wallichiana</i> (Lem. et Lindenb.) Pande <i>et al.</i> ex Grolle	Aytoniaceae	Soil	730 m
2.	<i>Atrichum undulatum</i> (Hedw.) P. Beauv.	Polytrichaceae	Soil	669 m
3.	<i>Bryum argenteum</i> Hedw.	Bryaceae	Rock	779 m
4.	<i>Bryum coronatum</i> Schwägr.	Bryaceae	Rock	900 m
5.	<i>Bryum lanatum</i> (P. Beauvois) Bridel	Bryaceae	Rock	450 m
6.	<i>Campylopus introflexus</i> (Hedw.) Brid.	Dicranaceae	Soil	676 m
7.	<i>Cyathodium cavernarum</i> Kunze.	Targioniaceae	Rock	822 m
8.	<i>Dumortiera hirsuta</i> (Sw.) Nees	Marchantiaceae	Rock	390 m
9.	<i>Entosthodon drummondii</i> Sullivant	Funariaceae	Soil	885 m
10.	<i>Fissidens bryoides</i> Hedw.	Fissidentaceae	Soil	665 m
11.	<i>Fissidens diversifolius</i> Mitt.	Fissidentaceae	Soil	345 m
12.	<i>Fissidens taxifolius</i> Hedw.	Fissidentaceae	Soil	746 m
13.	<i>Funaria hygrometrica</i> Hedw.	Funariaceae	Soil	669 m
14.	<i>Gymnostomiella vernicosa</i> var. <i>tenerum</i> (C. Müll. ex Dus.) Arts	Pottiaceae	Soil	546 m
15.	<i>Hyophila involuta</i> (Hook.) A. Jaeger	Pottiaceae	Rock	450 m
16.	<i>Leucobryum albidum</i> (P. Beauvois) Lindberg	Dicranaceae	Soil	633 m
17.	<i>Leucobryum glaucum</i> (Hedw.) Ångstr.	Dicranaceae	Soil	689 m
18.	<i>Macromitrium richardii</i> Schwägr.	Orthotrichaceae	Tree bark	989 m
19.	<i>Marchantia linearis</i> Lehm. & Lindenb.	Marchantiaceae	Soil	856 m
20.	<i>Marchantia polymorpha</i> L.	Marchantiaceae	Soil	789 m
21.	<i>Meteoriopsis reclinata</i> (Müll. Hal.) M. Fleisch.	Meteoriaceae	Tree bark	667 m
22.	<i>Metzgeria furcata</i> (L.) Corda.	Metzgeriaceae	Tree bark	956 m
23.	<i>Neckera pennata</i> Hedw.	Neckeraceae	Tree bark	756 m
24.	<i>Octoblepharum albidum</i> Hedw.	Dicranaceae	Tree bark	635 m
25.	<i>Phaeoceros laevis</i> (L.) Prosk.	Anthocerotaceae	Soil	684 m
26.	<i>Physcomitrium pyriforme</i> (Hedwig) Hampe	Funariaceae	Soil	650 m
27.	<i>Plagiochasma appendiculatum</i> Lehm. & Lindenb.	Aytoniaceae	Rock	880 m
28.	<i>Plagiommium ellipticum</i> (Brid.) T. Kop.	Mniaceae	Soil	420 m
29.	<i>Racopilum cuspidigerum</i> (Schwägr.) Ångström.	Racopilaceae	Tree bark	986 m
30.	<i>Reboulia hemisphaerica</i> (L.) Raddi	Aytoniaceae	Soil	550 m
31.	<i>Rhodobryum roseum</i> (Hedwig) Limpricht	Bryaceae	Soil	450 m
32.	<i>Riccardia multifida</i> (L.) Gray	Aneuraceae	Rotten log	450 m
33.	<i>Riccia fluitans</i> L.	Ricciaceae	Rock	480 m
34.	<i>Targionia hypophylla</i> L.	Targioniaceae	Rock	880 m
35.	<i>Taxiphillum cuspidifolium</i> (Cardot) Z. Iwatsuki	Hypnaceae	Rock	900 m
36.	<i>Tortula atrovirens</i> (Smith) Lindb.	Pottiaceae	Rock	765 m
37.	<i>Trematodon ambiguus</i> (Hedw.) Hornsch.	Bruchiaceae	Soil	800 m

4. Description of the specimens

Asterella wallichiana (Lem. et Lindenb.) Pande *et al.* ex Grolle, *Ergebn. Forsch.-Unterne. Nepal Himal.* 1: 262 (1966). [AYTONIACEAE]

Plants virid with deep purplish lower sides and margins; ramification dichotomous, ventral intercalary ramification occasional. Thalli: 4-16×1-3 mm; epidermis leioic, cells psilo-muralis, 24(35)-24 (28) µm, trigones tiny or absent, oleocytes few, dispersed; air pores covered by 2-3 tiers of 6-8 sparsely differentiated cells; ventral scales purpureous with scanty oleocytes; appendages 1-2, lanceolate. Sexual condition: parocious; androecia purpureous, bunches of papillae dorsal to bases of gynoecial stalks, infrequently on distinct branches, then ovate; gynoecia terminal on dichotomous ramification; stalks 1-4 cm, nude above, bases purplish and inevent, subulate, deciduous scales;

carpocephala semispheric, 2-4 mm across, upper surface leioic, becoming low tuberculate on xeric condition, bi-tetra lobed below; pseudoperianths nannus, directed obliquely downward, segments generally eight, free with age. Sporophyte: capsules fulvo-phaeoic; spores flavid, 60-86 µm; elaters luteus, bi-tri spiral, 150-210 µm; spores: merulo-phaeoic, orbicular-triangular, anisopolar, trilete, 50-120×40-100 µm in size; elaters: fulvo-phaeoic, generally monospirate, occasionally bispirate or trispirate in some portions, 75-180×12-32 µm in size, occasionally ramified.

Habitat: Moist soil over rock, usually calcareous.

Atrichum undulatum (Hedw) Palisot de Beauv. *Prodr.* 42. 1805. [POLYTRICHACEAE]

Plants pusillus to copious, porraceous. Stems: 2-6 cm. Leaves: not dense beneath, more dense above, 4-8 ×

0.6-1.6 mm, lingulate to lanceolate, serpentine, keeled distally, concave to campestrial proximally, with oblique rows of abaxial teeth on undulations, apex acute; costa percurrent, with teeth on abaxial surface in distal half; lamellae 2-7×2-5(-8) cells high; central leaf cells 20-33 µm wide, asymmetrically angled to hexagonal, occasionally orbicular, frequently transversely elongate, convex amphilaterally, leioic or with tiny, verrucose or striate papillae on abaxial surface, walls strong, deeply collenchymatous with trigones. Sexual condition: polygamous, few shoots hermaphrodite, others evidently male or female; perigonal bracts grandiform, forms antheridial buds, frequently many buds per plant. Seta: 1(-2-3) per perichaetium, 1-4 cm, rubro-phaeoic. Capsule: 2-5(-9)×0.4-1 mm, crispus to distinctly arcuate, almost horizontal; operculum 2-4 mm; spores: (12-)15-29 µm.

Habitat: Soil, dry weedy habitats, especially roadside ditches; usually low elevations.

Bryum argentum Hedw. Sp. Musc. Frond. 181. 1801. [BRYACEAE]

Plants pusillus, up to 7 mm, pale virid, cladate from the base. Leaves: uniformly and glutately arranged along the stem, ovate, tip acuminate, 1-1.5×0.4 mm, leaf cells tenuiform, elongated, longer, pellucid, hyaline cells 0.06×0.01 mm, basal cells elongated, rhomboidal, quadrate-rectangular, chlorophyllous, 0.05×0.02 mm, upper 2/3 leaf is highly vitreous, remaining leaf olivaceous. Pericheatal leaves: large, 2-3 mm long, 0.8 mm wide, apical cells tenuiform, elongated, rhomboidal, 0.1×0.01mm, costa evident, percurrent, archaegonia in between two branches, 0.5 mm long, 0.03 mm broad, rubicund, intermingled with paraphyses.

Habitat: Red soil on rocks at high altitude, in moist deciduous forest.

Bryum coronatum Schwägr. Sp. Musc. Frond., Suppl. 1, 2: 103. pl. 71 103. 1816. [BRYACEAE]

Plants densely caespitose, slender, fulvo-rasinus above, rubrus beneath, about 2 cm long along with sporophyte, tomentose at base, stem ramified from base, tuft at apex. Leaves: lower leaves pusillus, upper leaves grandiform, ovate to oblong-lanceolate, 3.2 mm long, 1 mm wide erectopate, erect, spreading when moist, contorted when dry, acuminate apex, 0.06×0.1 mm, pellucid, basal cells hexagonal to rectangular, 0.07×0.1 mm, psilomuralis, chlorophyllous, marginal 2-3 rows of cells narrow elongated, margin serrate at apex, costa ferrugineous, evident, excurrent with denticulate arista. Reproductive branch very short. Sporophyte: at apex, seta ferrugineous, erect, ca. 1.8 cm, capsule pendulous, crassus, cupuliform, 2 mm long, 1 mm broad.

Habitat: Red soil on rocks at high altitude, in moist deciduous forest.

Bryum lanatum (P. Beauvois) Bridel, Muscol. Recent., suppl. 3: 20. 1817. [BRYACEAE]

Plants gregarious or in dense mats, hoary white. Stems 0.5-1(-1.5) cm, evenly foliate, weakly julaceous. Leaves erect-spreading when moist, ovate to ovate-lanceolate, somewhat concave, 0.3-1(-1.5) mm; base concolorous; margins recurved proximally, plane distally; apex acute, not cucullate, hyaline in distal 1/2 of leaf; costa long-excurrent,

awn slender, hyaline; proximal laminal cells quadrate or short-rectangular, 10-16 µm wide, 1-2:1; distal cells elongate-hexagonal, 40-60×10-16 µm, 4-5:1, walls somewhat thickened to distinctly incrassate. Specialized asexual reproduction absent. Seta brown to red-brown, 1-2 cm. Capsule brown to red-brown, ovate, (1-)2-3 mm; hypophysis differentiated, somewhat thickened and rugose; spores 8-15 µm.

Habitat: Soil over rock, rock in dry climates.

Campylopus introflexus (Hedwig) Bridel, Mant. Musc. 72. 1819. [DICRANACEAE]

Plants 0.4-6 cm, in thick mats, fulvus to olivaceous, with or without tomentum. Leaves: 3-6 mm, erectopate when moistened, appressed at dry condition, lanceolate, orthic, with entire margins; devoid of alar cells or psilo-muralis, pellucid to rubicund, inflated cells; basal laminal cells perlucidulus, rectangular, psilomuralis, spreading higher at margins and forming a V-shaped area; distal laminal cells incrassate, pumilo-rectangular to oblique, viridophyllose; costa filling 1/2 - 3/4 of leaf width, excurrent in a vitreous hair tip, which is prominently 90° reflexed, in transverse section showing adaxial hyalocysts and abaxial stereids, pumilo lamellose at back with ribs one-two cells high. Specialized asexual reproduction: rarely by deciduous stem tips. Seta: 6-13 mm, fulvo-phaeoic to phaeoic in age, often many sporophytes from the same plant, crispus or sinuose. Capsule: phaeoic, 1.6 mm, scarcely asymmetric and campylar when empty; calyptra: ciliate at base; spores: 12-16 µm.

Habitat: Soil along trails, base of trees, flat roofs of buildings, peat in bogs, sand; 0-200 m.

Cyathodium cavernarum Kunze Nov. Stirp. Pug. 6: 18. 1834. [TARGIONIACEAE]

Plants monoecious; thallus dorsiventral, campestrial, psilic, fulvo-prasinus, delicate, 3-9 mm long, and 3-5 mm wide, dichotomously branched or repeated dichotomous with little separation of branches. Dorsal pores numerous, epidermal cells thin walled, subquadrate-polygonal, chlorophyllose, midrib lacking, air chambers in row, walls 1-2 cells high. Rhizoids: smooth and centrally distributed, ventral scales simple, abundant on thallus, filamentous with papillae. Antheridia and archaegonia numerous, antheridial receptacles lateral, terminal or at the anterior margin, disciform, archaegonial receptacles produced near the margin on the upper part of the thallus. Involucre: globose, capsule ovoid, 0.78 mm in diam, merulo-phaeoic, spores fuscus, 27-50 µm in diam, elaters ferrugineous, 4-9 in each capsule, bispiral.

Habitat: Thallus grows in moist soils, termite mounds and exposed road side earth cuttings of hilly regions of dry and moist deciduous forests.

Dumortiera hirsuta (Sw.) Nees, Fl. Bras. Enum. Pl. 1: 307. 1833. [MARCHANTIACEAE]

Plant terrestrial, very stout, dorsiventrally campestrial, prostrate, prasinus, semi-hyaline, repeatedly dichotomous branched or branching by apical innovations, individuals in grandiform clasping patches, 7-12 cm long and 1-1.7 cm wide, lobes flat or slightly concave above, apex notched, midrib prominent and broad on the dorsal surface, air chambers and gemmae lacking, margins wavy. Rhizoids: two types, ventral scales much reduced and pellucid,

occurring on each side of the midrib in one row; thalli dioecious, or monoecious. Male receptacles: terminal and disciform, depressed in the centre (0.4 mm), sub-sessile, circular with bristles on the margin of the disc.

Habitat: Wet situations with either continuous flow or dripping of water in very shaded places on rocky boulders near waterfalls and streams in pure populations in association with mosses.

Entosthodon drummondii Sullivant, *Musc. Hepat. U.S.* 156b. 1856. [FUNARIACEAE]

Plants 1-6 mm, luteus to phaeo-viridis. Leaves: incurved at xeric condition, oblong ovate to obovate, occasionally concave, imbricate, mostly 1.4-2.2 mm; margins scarcely serrulate to entire; apices broadly acute; costa percurrent or ending one-three cells before the apex; basal laminal cells rectangular, 60-90×22-36 µm, distal cells oblong-hexagonal, marginal cells longer, frequently forming a luteus border. Seta: 10-22 mm, orthic, not hygroscopic. Capsule: ovoid-pyriform from a nana apophysis, 1-1.5 mm, shrinking when dry and empty; exothecial cells crassus, tenuiformly oblong and transversely elongate in penta-hepta rows proximal to the mouth; operculum approximately campestrial, becoming convex when wet; peristome double, exostome teeth phaeoic, lanceolate, vertically striate throughout and occasionally perforate along the median line, endostome appears as a scarcely papillose membrane; calyptras: hooded, long-beaked, inflated throughout the capsule, prominent, leioic; spores: 26-37 µm, poorly baculate-insulate, few scarcely ridged, fulvo-fuscus.

Habitat: Usually somewhat sandy, soils in damp places; low to moderate elevations.

Fissidens bryoides Hedwig, *Sp. Musc. Frond.* 153. 1801. [FISSIDENTACEAE]

Plants 2-12×0.8-3.3 mm. Stem: akladate and cladate; axillary pellucid nodules not found; central strand generally found. Leaves: as many as 20 pairs, lanceolate to oblong-lanceolate or oblong-lingulate, acute to dwarf-acuminate or obtuse-apiculate, to 0.6-2.8×0.3-0.5 mm; dorsal lamina tenuiform proximally, ending at or before insertion, occasionally scarcely decurrent; vaginant laminae 1/2 leaf length, mostly equal; margin entire but frequently serrulate distally, limbate on all laminae, limbidium approaching apex or terminating a few cells before or partially absent to occasionally absolutely not found, limbidial cells one-three stratoise; costa excurrent to ending as many as six cells before apex, bryoides-type; laminal cells one-stratoise, evident, leioic, frequently scarcely bulging, strong-walled, asymmetrically hexagonal, a few elongate, 6.3-17 µm, occasionally copious in proximal parts of vaginant laminae. Sexual condition: polyoicous; nude antheridia and archegonia often in axils of distal leaves. Sporophytes: one-two per perichaetium; seta: 1.3-11 mm; capsule: theca extrorse, orthic, radially symmetrical to ± inclined, bilaterally symmetrical, 0.3-1.3 mm; peristome bryoides-type; operculum 0.6 mm; calyptra cucullate, leioic to 0.6 mm; spores: 10-22 µm.

Habitat: Soil in moist, shaded sites, stones and rocks (both acidic and basic) in shaded areas, along streams, sometimes inundated, infrequently around bases of trees.

Fissidens diversifolius Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1:140. 1859. [FISSIDENTACEAE]

Plants parvulus, fulvo-prasinus. Stems: fertile foliolar stems generally simple, ca. 3.5 mm long, 1.5 mm wide; axillary pellucid nodules inconspicuous; central strand undifferentiated. Leaves: 5-9 pairs; underside leaves parvulus, squamosus, loosely arranged; upper leaves copious and densely arranged, oblong-ovate, 1.3-1.6 mm×0.3-1.0 mm, acute or obtusely acute at apex; vaginant laminae 2/3-4/5 the leaf length, unequal; margins approximately entire; limbidia of above leaves one-two cells wide on upper half of vaginant laminae, two-three cells wide on lower half; base of dorsal laminae broadly cuneate to orbicular; costa robust, ending with scanty cells underneath apex; cells of apical and dorsal laminae quadrate to asymmetrically hexagonal, 5-12 µm long, leioic, scarcely crasso-muralis; cells of vaginant laminae bigger than those of apical and dorsal laminae, specially toward the proximity of costa. Sexuality: autoicous. Male inflorescences: terminal on dwarf branches. Female inflorescences terminal; setae: 2.4-3.2 mm long. Capsules erect or inclined, symmetrical; urns 0.3-0.7 mm long; opercula conical, ca. 0.3 mm long; spores: 21-33 µm in diameter.

Habitat: Soil or rocks, average 200-500 m elevation.

Fissidens taxifolius Hedw., *Sp. Musc. Frond.* 1801. [FISSIDENTACEAE]

Plants medium-sized, caespitose. Stem: foliolar stems simple, rarely ramified, 5.5-17.5 mm long, 2.1-4.8 mm wide; axillary pellucid nodules undeveloped; cortical stem-cells pusillus and pachy-teichoic, central strand poorly developed. Leaves: in 6-17 pairs, approximately clasping, middle and upper leaves oval-lanceolate, 1.5-3.5×0.4-0.9 mm, acute to mucronate at apex; base of back laminae generally orbicular, occasionally broadly cuneate, vaginant laminae 1/2-3/5 the length of the leaf, moderately unequal; costa robust, percurrent to scarcely excurrent; margins serrulate; cells of apical and dorsal laminae orbicular-hexagonal to hexagonal, 5-13 µm long, tenuimuralis, mammillose, obscure; cells of vaginant laminae shows resemblance with apical and dorsal laminae. Sexuality: dioecous. Female inflorescences lateral; perichaetial leaves: distinguished, tenuiformly lanceolate, ca. 1.5 mm long; archegonia: 365-425 µm long. Setae: 10-18 mm long; capsules horizontal to inclined, asymmetrical, campylar, compressed beneath capsule mouth when xeric; urns ca. 1.5 mm long; exothecial cells rectangular-hexagonal, with crasso-longitudinal and psilo-transverse walls; opercula long rostrulate; peristome teeth 0.55-0.65 mm long, 125-155 µm wide at base, with conspicuous projections on the articulations; spores: 10-19 µm in diameter.

Habitat: Soil, occasionally rocks, 200-500 m elevation.

Funaria hygrometrica Hedwig, *Sp. Musc. Frond.* 172. 1801. [FUNARIACEAE]

Plants 3-12 mm or more, with a basal antheridial ramification, lowly virid to fulvo-viridis; proximally devoid of leaves, distal leaves dense and bulbous, occasionally loosely foliate throughout. Leaves: proximally pumilus, distal leaves 2-5 mm, sharply concave, oblong-ovate to broadly obovate distally, acute to apiculate or pumilo-acuminate, entire or poorly serrulate distally; costa subpercurrent to lowly-excurrent; laminal cells psilo-muralis and inflated distally, hexagonal or oblong-hexagonal becoming much more oblong proximally. Seta: usually (11-)22-45(-85) mm, gracilliform and flexuose, generally

hygroscopic. Capsule: 2-4.5 mm, pyriform, irregular, campylar to orthic, horizontal to pendent or slightly inclined or approximately erect, becoming sulcate when xeric beneath the firmly oblique mouth; annulus revoluble; operculum moderately convex; peristome phaeoic, papillose-striate proximally and papillose distally, strongly trabeculate, becoming appendiculate distally, gives the appearance a lattice by fusion of the tips; endostome segments lance shaped about 2/3 as long as the teeth, flavid, prominently papillose-striate; calyptras cucullate, leioic; spores: generally 10-22 μm , sharply papillose.

Habitat: Bare mineral soil in disturbed habitats, occasionally on wood or gravel; low to high elevations.

Gymnostomiella vernicosa var. *tenerum* (C. Müll. ex Dus.) Arts, J. Bryol. 20:424. 1998. [POTTIACEAE]

Plants perpusillus, 1-4 mm high, prasinus to nigro-prasinus or phaeoic, caespitose. Stems: pumilus, simple, frequently radiculose at the base. Leaves: compressed at xeric condition, erect or widely spreading when moist, obovate to spatulate, rounded at the apex; margins flat, entire beneath, denticulate above middle generally by papillose cells; costa faint, not much conspicuous from laminal cells, psilic, terminating slightly above the leaf middle; upper leaf cells hexagonal, loose, hyaline, psilo-muralis, bluntly papillose; basal cells rectangular, leioic, thin-walled; alar cells inconspicuous. Sexuality: dioecious. Gemmae: frequently in leaf axils. Sporophytes absent.

Habitat: Clay soil and sandstone.

Hyophila involuta (Hooker) A. Jaeger & Sauerbeck, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1871/1872: 354. 1873. [POTTIACEAE]

Plants in lax or dense, prasinus to ferruginous or nigrescent tufts, dull or sometimes with a metallic spot. Stem: glutately foliate, 5-12 (-20) mm high, medial strand strong. Cauline leaves concave when wet, to 1.3-2.2(-2.8) mm, oblong-spatulate to obovate, occasionally with multicellular teeth in distal 1/4, orbicular to orbicular obtuse at the apex, occasionally apiculate; costa robust, conspicuous on back, leioic on the abaxial surface to sometimes horridus at the apex, hydroids lacking; laminal cells near insertion pumilo-rectangular, 2-4.1, strong-walled, pale and fuscus or pellucid, cells 7-10(-13) μm wide, in longitudinal and oblique rows, psilic to crasso-muralis, tumido-mamillose on the adaxial surface, flat on the abaxial. Sexual condition: dioecious. Seta: 6-8 mm, rufus to luteo-cinereous with age. Capsule: erect, 1.4-3.2 mm, tenuiformly cylindric from an inconspicuous neck, annulus clearly distinguished, ruseo-phaeoic, of vesiculose cells, persistent or deciduous; operculum: erect, conical-rostrate, 0.5-0.9 mm; spores: 6-10 μm .

Habitat: Laxly consolidated sedimentary rocks, soft lime stone, rocky river banks, stream sides and bluffs in shaded woods; 0-1050 m.

Leucobryum albidum (P. Beauv) Lindb. Öfvers. Kongl. Vetensk.-Akad. Förh. 20: 403. 1863. [DICRANACEAE]

Plant small, compactly pulvinate patch. Stem: less than 1 cm tall, occasionally 4.5 cm in nutrient rich soil. Leaves: 2-5(-7) mm, limb subtululose, erect to wide-spreading, orthic, apex apiculate, entire, expanding from oblong-obovate sheath, pumilus, more than (occasionally equal to) the length of the sheath; costa in transverse section near base

showing lateral, crassus regions consists mostly of bi(-tri) layers of expanded leucocysts on both sides of the central layer of chlorocysts, and a medial, psilic region consists of one layer of parvulus leucocysts on both sides of the chlorocyst layer; lamina tenuiform, 8-11 cells wide. Specialized asexual reproduction by tiny foliolar gemmae on puny, forked ramification at stem tip or on pseudopodium-like ramification and by caducous leaves with rhizoids at leaf apex. Seta: 7-13 mm, phaeoic to rusus. Capsule: firmly inclined and crispus when dry and empty, occasionally scarcely strumose, 1.3-1.9 mm, rubicund to ferruginous; operculum 1-1.5 mm; peristome teeth erythrean; spores: parvulusly papillose, 10-17 μm .

Habitat: Moist humus, sandy soil, rotting logs and stumps, tree bases, hardwood trees, pine and palms, forests, bogs, and swamps; low to moderate elevations.

Leucobryum glaucum (Hedwig) Ångström in E.M. Fries, Summa Veg. Scand. 1: 94. 1845. [DICRANACEAE]

Plants procerus, compact pulvinate. Stem: 1-13.5 cm, occasionally breviform. Leaves: 3-8 mm, limb concave to subtululose, erect or erect-spreading, occasionally falcate-secund, apex acute or apiculate, normally \pm serrulate at the tip, spreading from oblong-obovate sheath, 1-2(-4) times the length of sheath; costa in transverse section near base showing lateral, crasso zone consists mostly of bi-tri(-tetra) layers of copious leucocysts on both sides of the central layer of chlorocysts and a central, psilo-zone composed of one layer of puny leucocysts adaxial to and bi-layers abaxial to the chlorocysts (or vice versa), sometimes with only one layer of leucocysts on both sides of the chlorocysts; lamina tenuiform, five-eleven cells wide. Specialized asexual reproduction by bunches of tiny caducous leaf-like gemmae at stem tip and by folia with rhizoids at apex. Seta: 7-17 mm, rubicund. Capsule: firmly inclined and campylar when xeric and empty, generally strumose, 1.4-2.2 mm, rubrus to ferruginous; operculum 1.4-2.2 mm; peristome teeth deeply reddish; spores: approximately leioic to acutely papillose, 12-17 μm .

Habitat: Humus, soil, rotting logs and stumps, tree bases, and rock ledges, forests, bogs, and swamps; low to high elevations (0-1800 m).

Macromitrium richardii Schwägrichen, Spec. Musc. Suppl. 2(2): 70. 173. 1826. [ORTHOTRICHACEAE]

Plant pusillus in dense mats. Branches 0.5-1 cm; branch leaves firmly crispulus and inrolled at xeric condition, lanceolate to ligulate-lanceolate, 0.6-1.9 mm, deeply acute, obtuse, or obtusely apiculate; distal laminal cells 6-12 μm wide, asymmetrically hexagonal to orbicular-elliptic, swollen at mid leaf, grading to papillose-bulging at tip; basal laminal cells rectangled to elongate-linear. Perichaetial leaves show resemblance to the cauline. Calyptra: mitrate, nude, or with few trichomes ensheathing entire capsule; spores: 21-33 μm , glutately papillose.

Habitat: Branches and trunks of trees; low elevations.

Marchantia linearis Lehm. & Lindenb, Nov. Stirp. Pug. 4: 8. 1832. [MARCHANTIACEAE]

Plant dichotomously ramified with conspicuous midrib, nigro-prasinus, dorsiventrally campestral, psilic, 25 \times 8 mm, with adventitious ventral shoots, midrib tenuiform, evident, nigrous, entire on margin, scarcely concave-emarginated at apex, pores abundant, tiny, raised with hexa superimposed

concentric rings with tetra or penta cells in each ring, 2-3 cells above epidermis level. Dorsal surface: areolate, unilayered, epidermal cell achlorophyllous, doliform. Scales: in two rows on each side, median scales fixed along decurrent base; appendages minute, orbicular or lanceolate, dentate on margin, acute-acuminate at apex; laminar scales ligulate. Rhizoids: smooth or tuberculate. Gemmae: cups are present on dorsal surface, numerous, globoid, vitreous. Reproductive structures not seen.

Habitat: Near streams and shady areas.

Marchantia polymorpha L. Sp. Pl. 1137 1753. [MARCHANTIACEAE]

Plant dichotomously branched, 2-9 cm long, 1-7 cm across, and up to 1.7 mm in thickness, prostrate on the ground, occasionally clambering over adpositus thalli, individual lobes 8-16 mm across, adpositus lobes mingle together at their bases, thallus becomes psilic toward its margins, margins leioic, undulate, and edentate overall; tips of the lobes are notched. Upper surface: thallus nitid-irid and glabrous, turned pale purpureous at maturity along the margins, faintly indented into pusillo linear-rectangular, rectangular, or rhomboidal sections; each and every section has a tiny leucoish air chamber with a single doliform pore, minute pores always remain open, at intervals along the center of each lobe solitary gemma cups are present. Gemma cups: orbicular membranous rims having crenate margin, shallow circular pan shape, individual gemmae ca 1 mm across, viridis, and more or less oval in shape. Lower surface: underside of the thallus bears scales and two types of rhizoids; scales are arranged in three rows on each side of the thallus; long filiform rhizoids anchor the thallus to the substrate and hold it in place, while pumilo acicular rhizoids absorb water from the substrate to keep the thallus hydrated. Sexuality: dioecious. Antheridiophores: on fully developed male plants, antheridiophores arise from the thallus lobes; about 1-4 cm tall; antheridiophores similar to campestrial umbrellas in overall form, consisting of hexa-octa spore-bearing lobes that radiate outward from the apex of a nude stalk, spore-bearing elliptic-oblong, cinero-prasinus or purpuro-prasinus, verrucose, glabrous, and interconnected by a pellucid membrane along their margins, stalk of the antheridiophore is porraceous to purpuro-irid, terete, and glabrous. Archegoniophores: on mature female plants, they develop from the thallus lobes; ca 4-7.5 cm tall; these resemble palm trees with tenuiformly drooping fronds in overall form, consisting of eight-eleven ovary lobes that radiate outward and downward from the apex of a nude stalk; the ovary lobes oblongiform and viridis above with downwardly campylar margins; ovaries attached to the beneath of these lobes, stalk of the archegoniophore is light viridis to purpuro-irid, terete, and glabrous.

Habitat: It is found in wet areas of limestone and sandstone cliffs, mud at entrances to caves, shaded rocks along streams, wet depressions in woods, sandy ground below rocky overhangs in canyons, bottoms of shaded ravines, sandy soil along rivers, drier areas of peat bogs, hillside seeps, lowly drained areas of fields, and greenhouses.

Meteriopsis reclinata (C.Muell.) Fleish. in Broth, in Nat. Pfl, 1 (3): 826. 1906. [METEORIOCEAE]

Plants stout, luteo-irid above, phaeic below; principal stem creeping, 10 cm long; secondary branches pendulous, asymmetrical, pinnately ramified. Leaves: dense, ovate-

lanceolate, cordate, with sheathing base, licate, broad base gradually tenuiformly down into an aristate tip, 1.8×1.2 mm wide, cells elongated rhomboidal, 0.04×0.01 mm at apex, basal cells elongated, rectangular-quadrate, pellucid, 0.04×0.01mm, margin sharply denticulate at tip, mildly at base; costa single, occupied nearly half of the leaf.

Habitat: Grows on rock in the form of tufts.

Metzgeria furcata (L.) Dumort., Recueil Observ. Jungerm., 26.1835. [METZGERIACEAE]

Plants luteo-irid; thallus linear, dichotomously ramified, ramification intercalary; midrib gracilliform, conspicuous, consists of a layer of hyaline cells, 1-3 cm long, 0.5-1.3 mm wide, margins flat, wing (7)12-19 cells wide from midrib to margin, dorsally costa bears two epidermal cells and two-three cells ventrally; laminal cells 24-40×34-50 mm; marginal hairs dispersed, usually solitary, occasionally paired, 80-130(200) mm long, certain sectors frequently naked, ventral surface occasionally comose. Sexual condition: dioecious, sexual organs on heavily reduced ventral branches. Gemmae: generally linear on margin of thallus, campestrial, emerging from margin of thallus, with straight hairs 100-160 mm long. Male ramification: globose, acinate. Female ramification: broadly obovate, hispid, 200-550 mm. Calyptra: carnate, pyriform, capsule oblong-ovate, tetra valved.

Habitat: Grows on rock and rocky soil in the form of tufts.

Neckera pennata Hedwig, Sp. Musc. Frond. 200. 1801. [NECKERACEAE]

Plants 4-12 cm. Stem: bears branches or lacking or few, attenuate; paraphyllia scarce to lacking. Stem leaves: (medial) oblong-ovate, wavy, 2-4(-6)×1.3-1.7 mm; margins denticulate to entire proximally, serrulate at apex; apex acute to broadly acute; ecostate or doubly costate, nanus; alar cells asymmetrically pumilo-quadrate; basal laminal cells rectangular, 50-62×6-10 μm; distal medial cells oblong-linear, (22-)43-55×2-5 μm; apical cells oblong-rhombic, (14-)32-37×(2-)4-6 μm. Sexual condition: autoicous. Seta: 0.2 cm. Capsule: plunged.

Habitat: Base and trunks of trees, boulders.

Octoblepharum albidum Hedw., Sp. Musc. Frond. 50. 1801. [DICRANACEAE]

Plants parvus, 4-11 mm high, cinero-prasinus, approximately glossy, in laxly or glutately caespitose and pulvinate. Stems: pumilus, moderately cladate; medial strand lacking. Leaves: erect-patent to campylar spreading, 4-7 mm long, campestrial, ammentiform to ligulate from an oblong-ovate base, apiculate at the apex; pellucid lamina cells puny, visible only on two sides of costa at the leaf base; margins entire, with tiny serration at the leaf apex; costa broad and thick, covering almost the entire upper lamina, convex on abaxial side in cross section, costal leucocysts bi-penta layers on adaxial side, uni-tetra layers on abaxial side, supporting a nearly medially positioned chlorocyst layer, chlorocysts in cross section triangular in the upper parts of leaves, quadrangular at the leaf base. Sexual condition: autoecious. Setae: ca. 4-5 mm long, fulvid, leioic; capsules erect, cylindriciform; peristome teeth eight, luteus, lanceolate with a broad base, stria present vertically; opercula long rostrate, with an oblique beak; calyptrae: cucullate, leioic, entire at the base; spores: absent.

Habitat: Tree trunk.

Pheoceros laevis (L.) Prosk. subsp. *laevis* Prosk., Rapp and Comm. VIII Congr Intern. Bot., Paris 14-16. 69. 1954. [ANTHOCEROTACEAE]

Plants dioecious; thallus spongy, merulo-prasinus, dorsiventral, dichotomously ramified, dorsal surface smooth, dioecious, male thallus up to 8 mm wide, deeply lobed at apex, female thallus flabelliform, long and cladate, deeply lobed, margin undulating, up to 20 mm long, and 17 mm wide at apex; antheridia on the dorsal surface; archaegonia embedded in the thallus; sporangia with central columella; spores luteo-virid, pseudoelaters light yellow, frequently ramified and thin walled, composed of 1-4 cells.

Habitat: Grows near the streams in forest.

Physcomitrium pyriforme (Hedw.) Hampe, Linnaea. 11: 80. 1837. [FUNARIACEAE]

Plants olivaceous or fulvo-viridis. Stems: 0.3-14(-24) cm. Leaves: obovate to ovate-lanceolate, distal leaves 2-6 mm; margins dentate, occasionally approximately leioic distally; percurrent to sometimes lowly-excurrent. Specialized asexual reproduction: lacking. Seta: (1-)5-14(-30) mm. Capsule: extrorse, 1-4 mm, globoid-pyriform at juvenescence, more diversified in shape at maturity, urceolate to pyriform; neck pumilus, conspicuous; exothecial cells asymmetrically hexagonal; suboral cells consisting of five-seventeen rows of rectangular cells; spores: (25-)45-60(-92) μm , papillose.

Habitat: Wet soil in disturbed places; low to high elevations.

Plagiochasma appendiculatum Lehm. et Lindenb. in Lehm., Nov. Minus, Cogn. Stirp. Pug. 4:14.1832. [AYTONIACEAE]

Plants purpuro-prasinus, crassus, 21 \times 7 mm, dichotomously ramified, sometimes with adventitious ventral shoots in bulky patches. Lobes: oblong-ovate, serpentine margins with violet edge, midrib inevident, devoid of gemmae; upper epidermal cells many-angled, walls psilic or crassus. Epidermal pores copious, moderately to highly raised over surface covered by tri-tetra concentric rings of hexa-deca cells each; air chambers empty in bi-penta layers wide in middle of thallus; ventral surface generally purpureus, scales purple, in one row on each side of the midrib, broadly mentee with one-two appendages, raching half way to margin, bent over apex; appendages pellucid, grandiform, entire, orbicular-ovate, obtuse, firmly tenuiformly plicate at base, occasionally luteus or roseus. Sexuality: monoecious. Male receptacle orbicular, reniform or soleate in the middle of the thallus; antheridia 11-20 in clusters, 0.3 mm, oblong, clavate, with a short stalk. Pores simple, ensheathed by pellucid scales, partially purple or rosy tinged, tetra-octa cells wide, with rounded or obtuse apex. Female receptacle: in the middle of the thallus, penta-ennea lobed. Scales: hyaline or partially tinged with rubrus or violaceous orbicular or obtuse apex, margin papillate; archaegoniophore 0.8 mm long or sessile, involucre one-five, luteus, rufus or fuscus. Capsule: globose, phaeoic with a prominent lid, elaters with two-three spirals, 0.4-0.7 mm long, spores light phaeoic, merulo-flavus, proximal and distal faces regularly alveolar, 2-3 reticulations, wing entire or slightly lobed, finely punctuate.

Habitat: Terrestrial, moist and dry places, rocks in moist deciduous forests with *Targionia hypophylla*.

Plagiomnium ellipticum (Bridel) T.J. Koponen, Ann. Bot. Fenn. 8: 367. 1971. [MNIACEAE]

Plants in dense mats. Erect stems of 2-6 cm, not dendroid; sterile stems to 13 cm. Leaves: prasinus to luteo-prasinus, campylar and contorted at xeric condition, platyform when moist, broadly elliptic, ovate, orbicular, or oblong-elliptic, (1-)3-5(-9) mm; base not decurrent or occasionally slight-decurrent; margins poorly to slightly dentate distally or to 3/4 leaf length, occasionally to near base, frequently entire on sterile stems, teeth bluntly, of 1 (or 2) cells; apex broadly perbicular, obtuse, or rarely truncate or retuse, generally tenuiformly mucronate or cuspidate, cusp bent to side, occasionally dentate; costa percurrent or excurrent; medial laminal cells elongate or rarely \pm isodiametric, (30-)45-60(-85) μm , conspicuously pumilus near margins, frequently less than 1/2 size, in longitudinal and \pm diagonal rows, not to weakly, occasionally strongly, collenchymatous, walls pitted, pits rarely inevident or absent; marginal cells pumiloliner or rhomboidal, sometimes linear in larger leaves, in 2-4 rows. Sexual condition: dioecious. Seta 1(-3), yellow to ferrugineous, 1.7-4.6 cm. Capsule: pensile, cylindrical or oblong-cylindric, 3-6 mm, neck indistinct; operculum conic-apiculate; spores: 24-30 μm .

Habitat: Peat or humus in open bogs, fens, wet meadows and forests, swamps, shores of rivers and lakes; low elevations.

Racopilum cuspidigerum (Schwaegr.) Aongstr. in Ofvers. Foerh. Kongl. Svenska Vetensk.- Akad. 29: 10. 1872. [RACOPILACEAE]

Plants luteo-viridis above, luteo-phaeoic below, many fine rhizoids on stem and matured portion of branches; branches pinnate, up to 2.5 cm long. Leaves: aristate, ca 2.2 mm long and 0.65 mm wide, arista 0.35 mm, oblong-ovate, leaf cells parenchymatous with intercellular spaces, hexagonal-rhomboidal at the apex, 0.03 \times 0.01mm, basal cells quadrate-rectangular-hexagonal, 0.02 \times 0.01 mm, margin entire below, strongly dentate at the top up to half portion. Costa: conspicuous, luteo-phaeoic, excurrent in the arista.

Habitat: Common on soil over rocks, road sides, rock crevices of waterfalls, near water streams of the forest, base of the stem.

Reboulia hemisphaerica (L.) Raddi, Opusc. Sci. Bologna. 2: 357. [AYTONIACEAE]

Plants with approximately crenulate, serpentine margins. Thalli: 2-5 \times 0.4-0.9 cm, elongate, moderately widened distally; epidermis persistent, leioic; air pores and areolation inconspicuous; epidermal cells 45-52 \times 30-36 μm with tiny bulging trigones; air pores covered by 3-5 concentric rings of 6-8 cells each; ventral scales with decolorate margins and dispersed oleocytes; appendages 2-3 per scale, linear and capilliform, 2-3 cells wide, ending in 1-3 single cells. Sexual condition: paroecious (occasionally polyoicous, but generally with few paroicous thalli in the mat; androecia nephriiform to lunate or reduced and chevroniform, positioned 1-10 mm posterior to the base of the gynoecial stalk; gynoecium in apical notch, stalk 1.5-3.5 cm, purpureus; carpocephalum porraceous, with air pores in the upper portion, tetra-penta lobed beneath, each lobe directed downward, the slit widening to form a rotund opening as the sporophyte spreads. Sporophyte: capsule pale porraceous; spores: fulvid., 65-80 μm ; elaters 250-350 \times 10-12 μm , 2-3 spiraled.

Habitat: Soil over rock that is commonly but not exclusively calcareous, habitats that are at least periodically moist, temperate areas; subcosmopolitan.

Rhodobryum roseum (Hedw.) Limpr. Laubm. Deutschl. 3: 444. 1892. [BRYACEAE]

Plants 1-4 cm tall, frequently cladate by gracilliform sub-apical innovations. Stem leaves: 3-9 mm, relatively scarce in rosettes, 17-23; margins revolute to about mid leaf or less, apex acute; costa diversified, from sub-percurrent to percurrent, with tenuiform apiculus, to low-excurrent into a gracilliform capillo-puncta on central rosette leaves, in cross section with parvus stereid band, not reaching dorsal epidermal layer because of a layer of intervening psilomuralis cells; distal and central laminal cells hexagonal, 24-36×50-82 µm, proximal cells longer, to 100 µm, rectangular. Inner perichaetial leaves: with costa fluctuating, from sub-percurrent to percurrent or excurrent into a short, leioic to poorly denticulate capillo-puncta. Spores: 15-22 µm.

Habitat: Humus rich soil, and litter in coastal shrub-lands or occasionally forests; 0-300 m.

Riccardia multifida (L.) Gray, Nat. Arr. Brit. Pl. 1: 684 1821. [ANEURACEAE]

Plants fulvo-prasinus, ramification diverse, 1-1.5 cm×0.5-1.2 mm, margin entire, rarely crenulate; superficial cells psilo-muralis, polygonal; oleo bodies solitary, ovoid; principal axis biconvex in cross section, 4-6 cells thick in the middle, wing 3 cells thick and ultimate branch unistratose. Sexual condition: monoecious, antheridial branches gracilliform, embedded, globose; archegonial ramification pumilus, archegonia dorsal.

Habitat: Moist soil and rocks covered with soil near waterfalls and water streams.

Riccia fluitans L. Sp. Pl. 1139 1753. [RICCIACEAE]

Plants monoecious; thallus: terrestrial, flavo-viridis, 30-55 mm long, 1.3 mm broad, many times dichotomously ramified, segments divergent, linear, apex emarginate or truncate, aerosaccus. Rhizoid: numerous, ventral scales parvus, confined beneath the apex, aero-cavities prominent. Spores: phaeo-luteus, translucent.

Habitat: Terrestrial marshy places, near streams in deciduous forest.

Targionia hypophylla L. Sp. Pl. 1136.1756. [TARGIONIACEAE]

Plants dioecious; thallus prasinus, simple, psilic, little bit delicate, occasionally dichotomously divided in close clusters or clasping, linear-oblong, 6-10 mm long, 3-4 mm wide, frequently with adventitious ventral shoots, attached to soil only at their base, margin entire, areolae distinct, epidermal cells penta-sexa angled, cell walls moderately thickened and cells slightly trigonus, air chambers prominent, containing green filaments under the pore, pellucid with scarce chloroplasts, pores simple, evident, scarcely raised with tetra concentric ring of six cells each. Rhizoids: numerous, arising from the midrib, ventral scales purpureus, in one row on each side of the midrib, broadly triangular, subulate at apex. Antheridia: clustered on the disc of the dwarf ventral shoots, involucre vitreus, appendages lacking, purpureus, subglobose, keeled having penta-hexa archaegonia, several cells thick throughout in its basal part forming air chambers without filaments, merulo-

nigrescent to purpule, margin entire or scarcely denticulate. Sporophyte: operculated by bivalve, spherical involucre, capsule wall unilayered with annular and spiral fascia, spores tetrahedral, merulo-phaeoic, devoid of wings, all faces minutely reticulate, 62×65 µm in diam, elaters 7-8 µm wide and 140 µm long with bimerulo-spiral fascias throughout.

Habitat: Terrestrial, common as pure patches on moist and dry soil, rock surfaces on exposed slopes in moist and dry deciduous forest associated with ferns.

Taxiphyllum cuspidifolium (Cardot) Z. Iwatsuki, J. Hattori Bot. Lab. 28: 220. 1965. [HYPNACEAE]

Plants in gracilliform mats, merulius to luteo-viridis, with an oleic droplets when wet. Stem: 1-4 cm, 1-4 mm wide, prostrate, frequently radiculose ventrally. Leaves: laxly imbricate, normally concave, leioic, symmetric, 1.0-2.8×0.5-1.2 mm, ovate to broadly ovate-lanceolate, acuminate or nematiform-acuminate, frequently twisted at apex, margins campetrial, serrulate to dentate exceeding middle leaf, proximally denticulate to entire; costa nanna and double, one ramification extending 1/3-1/2 length of leaf, occasionally absent; cells leioic; median cells 75-125×7-15 µm; alar cells 13-46×10-24 µm, quadrate to rectangular, in two-several rows with five-twelve cells in marginal row. Sexual condition: dioecious. Perichaetia: grandiform, abundant, bracts lanceolate to ovate-lanceolate, acuminate to deeply acuminate. Perigonia and sporophytes: not reported.

Habitat: Calcareous soil and rock, rarely over exposed tree roots.

Tortula atrovirens (Smith) Lindb., Ofve. af Forhan: Kongl. Svenska Vetens-Akad. 21(4):234. 1864; *Grimmia atrovirens* Sm., Engl. Bot. 28: 2015. 1809. [POTTIACEAE]

Plants pusillus, 3-6 mm high, merulo-prasinus above, phaeo-viridis below, caespitose. Stem: erect, simple, occasionally asymmetrically ramified, radiculose beneath. Leaves: contorted-campylar or lowly crisped at xeric condition, expanding when wet, oblong-ligulate or oblong-ovate, scarcely concave, 0.4-0.7×0.1-0.3 mm, orbicular-obtuse or mucronate at apex; margins firmly broadly crispulus, entire; costa robust, rubro-phaeoic, excurrent as a mucro or a tiny awn, ventral side of upper costa operculated by a copious pad of inflated, papillose cells; upper leaf cells orbicular-quadrate to hexagonal, 8-12 µm in diameter, psilic - slightly crasso-muralis, each cell ensheathed by bi-tetra C-shaped papillae; basal cells keenly differentiated, pumilo-rectangular, pellucid, leioic. Sexual condition: autoecious. Setae: 2-7 mm long; capsules erect, luteo-phaeoic, cylindrical, 1.2-1.7 mm long; peristome teeth erect, unequally linear-lanceolate, heavily papillose, with low basal membrane; opercula conical-rostrate, with a long, blunty beak; spores: 13-24 µm in diameter, scarcely papillose.

Habitat: Rocks or thin soil over rocks in dry places.

Trematodon ambiguus (Hedw.) Hornsch., Fl. 2: 88. 1819. [BRUCHIACEAE]

Plants perpusillus, 5-8 mm high, fulvo-prasinus, gregarious or dispersed. Stem: erect, generally simple. Leaves: 2-4 mm long, erect or rarely contorted when dry, erect-spreading when wet, oblong, colliding at base, suddenly tapered from the shoulder to a long-awned, blunt apex; margins flat,

entire; costa firm, filling the entire acumen, leioic on the dorsal surface; leaf cells at the shoulder asymmetrically pumilo-rectangular to rhombic, 13-27×5-9 µm, rather crasso-muralis; basal cells tenuiformly long-rectangular, 40-95×8-14 µm, rather psilo-muralis, loose, with many tenuiform cells (4-6 µm wide) near the margins. Sexual condition: autoecious. Perichaetial leaves: closely related to the upper stem leaves. Setae: straight, 15-20 mm long, luteus. Capsules: inclined, urns nana-cylindrical, 1.3-2.0 mm long, neck 1.2-2.0 mm long, strumose at base; opercula long-rostrate; Annuli properly developed, deciduous, revoluble; stomata superficial; peristome teeth rubicund, linear-lanceolate, vertically striate proximally to the tips, sharply papillose at the tips; spores: 25-30 µm in diameter, luteus, firmly papillose.

Habitat: Calcareous soil and rock.

5. Conclusion

Biodiversity is regarded as the essential property characteristic of an ecosystem or biotic community. In the present investigation, species diversity and richness as well as the functional diversity was extensively studied. Understanding the diversity patterns and community structure of bryophytes will help integrate nature conservation at multiple biotic group levels. They occur widely in the global terrestrial ecosystem, often as dominants in the floor layer of the moist tropical and subtropical broad-leaved forest biomes. However, bryophytes appear to have been neglected in many ecological studies, where only vascular plants or even woody plants were investigated such as in the emerging fields of community ecology to explore the role of ecological processes and biotic diversity in maintaining ecosystem function. Until now, little has been known about the diversity patterns of bryophytes, their spatial heterogeneity, their role in forest community assembly, and their biotic and abiotic interactions to maintain the ecosystem function as a whole. Field observations at regular intervals could reveal that the disturbances and threat to the bryodiversity of this region is associated with many human activities like expansion of agricultural land, the construction of road, destruction of forests, execution of unplanned developmental activities; and habitat destruction through over exploitation of resources, shifting cultivation and other anthropogenic interference have resulted in a detrimental effect with regards to the gradual depletion of the resources in the area. Therefore, serious attentions and efforts are required to save these valuable bryoflora of this region.

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7. References

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