



RESEARCH ARTICLE

An annotated checklist of the liverworts and hornworts of Nagaland, India

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Abstract

The present checklist comprises 168 species, including three infraspecific taxa, of liverworts and hornworts belonging to 54 genera and 32 families. It is based on literature reviews and specimen studies from the CAL herbarium. Six taxa are reported for the first time from the State of Nagaland.

Keywords

Marchantiophyta; Anthocerotophyta; Nagaland; India

Introduction

Nagaland, a land-locked state of North East India, is situated between 25°10' - 27°01' N and 93°17' - 95°15'E, nestled amidst the frosty Himalayas. It spans a geographical area of 16,579,00 km² (Fig. 1). The state is characterized by mountain ranges that run from the northeast to the southwest, forming the northern extension of the Arakan Yoma ranges of Myanmar. It shares borders with Manipur to the south, Assam to the west and north, and Arunachal Pradesh to the northeast. Nagaland comprises 12 districts, with altitudes ranging from 194 to 3,841 m. The highest peak, Mount Saramati, stands at 3,841 m. The average temperature lies between 21 to 23°C, with an annual rainfall of 1800 to 2500 mm, primarily from May to September (Fig. 1).

Nagaland's natural vegetation consists of conifers, and tropical evergreens, with variations along an altitudinal gradient. Situated in one of the world's top 25 hotspots, Nagaland's hilly terrain significantly influences its monsoon climate. The state's conducive environmental conditions support a rich growth of bryophytes. While major reports of bryophytes in Nagaland come from the Mokokchung and Kohima districts, there are sparse reports from the Kiphire, Phek, Tuensang, and Zunheboto districts, and Naga Hills. This communication records six species for the first time from Nagaland.

Review of Literature

The taxonomic study of liverworts and hornworts in Nagaland traces back to Váňa (1), who reported *Jungermannia hasskarliana* (Nees) Mitt. and *J. rubripunctata* (S. Hatt.) Amakawa. Subsequently, Srivastava and Asthana (2, 3) reported *Folioceros kashyapii* as a new species from the Chumukedima district of Nagaland. Asthana and Srivastava (4) documented three horn-

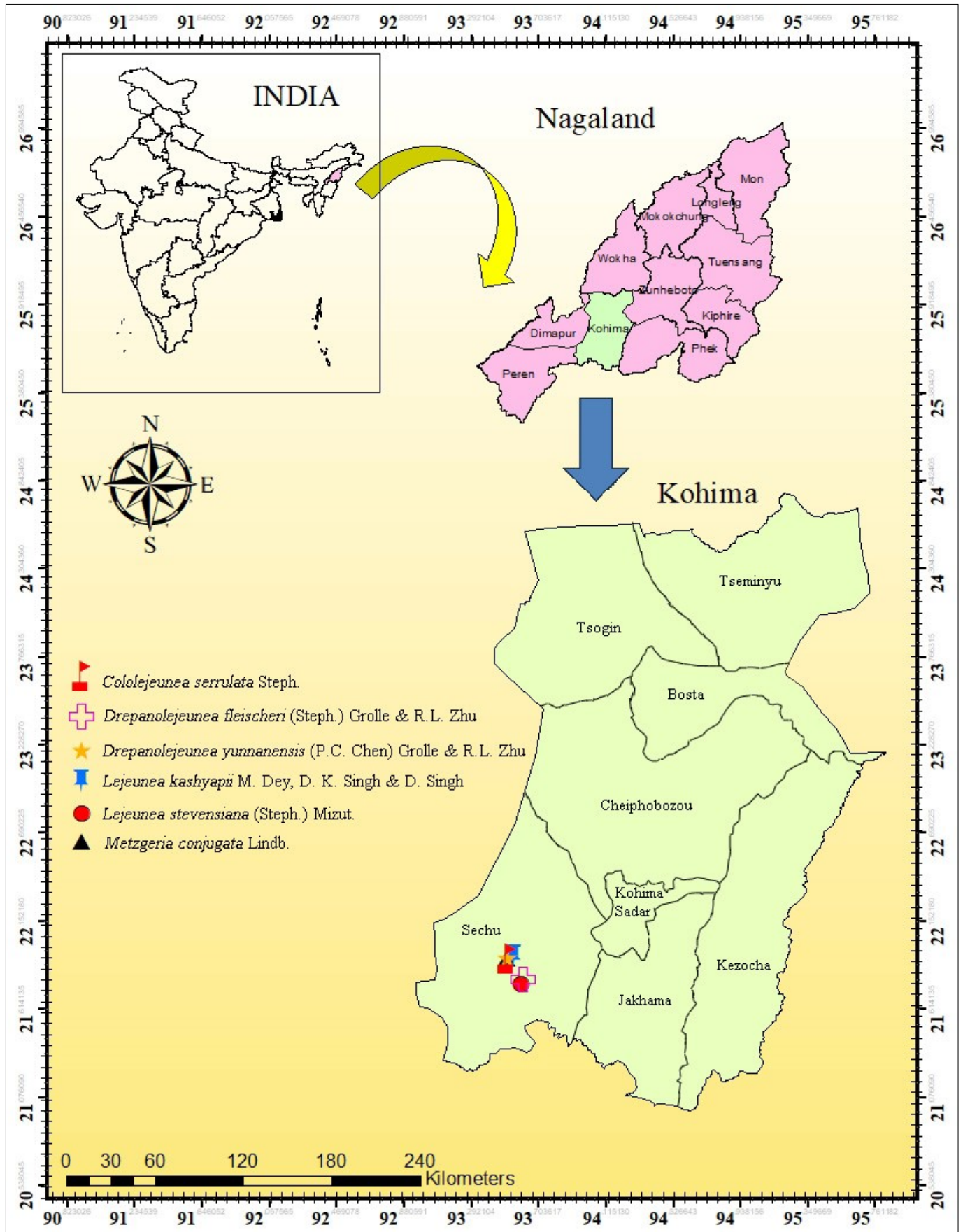


Fig. 1. Distribution Map.

worts species from Mao and Chumukedima districts, namely *Anthoceros bharadwajii* Udar & A.K. Asthana, *A. pandei* Udar & A.K. Asthana and *Folioceros kashyapii* S.C. Srivast. & A.K. Asthana. S.K. Chaturvedi and S. Chaturvedi (5) reported eight liverworts species from Mokokchung and Zunheboto districts of Nagaland. Nath *et al.* (3, 6) enu-

merated three species of *Frullania*: *F. wallichiana* Mitt., *F. ericoides* (Nees) Mont., and *F. muscicola* Steph. var. *muscicola*. Furthermore, S.K. Chaturvedi *et al.* (3, 7) recorded *Fossombronina wondraczekii* (Corda) Dumort. ex Lindb., from the 2nd World War Cemetery in Kohima district. Eshuo and Chaturvedi (3, 8, 9, 10) added several species from

Nagaland, including *Porella obtusata* var. *macroloba* (Steph.) S. Hatt. & M.X. Zhang., six species of *Bazzania*, and *Saccogynidium irregularospinum* C. Gao, T. Cao & M.J. Lai.

Bansal *et al.* (11) have reported two species of *Lejeunea* (*L. cavifolia* Steph. and *L. curviloba* (Ehr.) Lindb., and two species of *Frullania* (*F. walliachana* Mitt. and *F. ericoides* Nees) from the bark of *Thuja orientalis* L. in Mokukchung district. Eshuo *et al.* (3, 12) documented three species of *Scapania* viz. *S. griffithi* Schiffr., *S. ligulata* Steph., and *S. parva* Steph., from various localities in Mokukchung and Kohima districts. Eshuo *et al.* (13) recorded three *Radula* species for the first time in Kohima and Mokukchung districts. Eshuo (14) reported 119 liverwort species and four hornworts species in a Ph.D. thesis entitled “Studies on Liverworts and Hornworts of Kohima and Mokukchung Districts of Nagaland.” Eshuo (15) reported new distributional records of *Herbertus* (3 species) in Nagaland. Additionally, Kumar *et al.* (16) added four species of *Lejeunea* viz. *L. discrete* Lindenb. *L. parva* (S. Hatt.) Mizut., *L. subacuta* Mitt., and *L. princeps* (Steph.) Mizut. from Nagaland. Singh *et al.* (17) have also reported five species of the family Lejeuneaceae from the Kohima district. Sahu *et al.* (18) documented 61 species of liverworts and four species of hornworts.

Materials and Methods

The newly recorded species were collected from Kohima, Dzukou Valley (Dzulardi, Khonoma) (Supplementary Table 1), during March, 2017 and November, 2023. Plant samples were dried in blotting paper for 5-6 days and preserved in brown paper packets. The distribution and habitats of all species are provided in Supplementary Table 1. Specimens were deposited in the Central National Herbarium, Howrah (CAL) of the Botanical Survey of India. A detailed morphological study of the taxon was conducted using a LEICA microscope (LEICA S8AP0) fitted with a LEICA Digital Camera LEICA DFC550 and operated by LEICA Imaging Software (LAS Version 4.4.0 [Build: 454]). For the distribution map, we used ArcGIS 10.2.2 software, Version 10.2.2.3552.

Synopsis of the Checklist

The present checklist is the result of the authors' detailed review of the literature and specimens studied in the CAL herbarium. Liverwort taxa at the rank of genus and above are treated in the checklist according to the classification proposed by Crandall-Stotler *et al.* (19) in 2009 and Söderström *et al.* (20) in 2016, with some modifications. Hornwort taxa have been arranged following Duff *et al.* in 2007 (21). The names of the species in the checklist are arranged alphabetically.

Floristic analysis

In total, 168 taxa, including three infraspecific taxa, have been reported from Nagaland (Supplementary Table 1). The Marchantiophyta, or group of liverworts, comprises 162 species, including three infraspecific taxa, belonging to 30 families and 51 genera (Table 2 & Fig. 2). On the other hand, the Anthocerotophyta contains 6 species belonging

to 2 families and 3 genera (Table 2 & Fig. 2). The number of infraspecific taxa recognized within a genus is indicated in

Table 2. Conspectus liverworts and hornworts of Nagaland.

Orders	Families	Genera	Species (including infraspecific taxa)
Marchantiophyta			
Marchantiales	8	11	22 (1)
Pelliales	1	1	1
Fossombroniales	2	2	3
Pallaviciniales	1	1	2
Metzgeriales	2	2	11
Porellales	6	17	53 (2)
Jungermanniales	10	17	67
Anthocerotophyta			
Anthocerotales	1	2	3
Notothyladales	1	1	3
Total	32	54	165 (3)

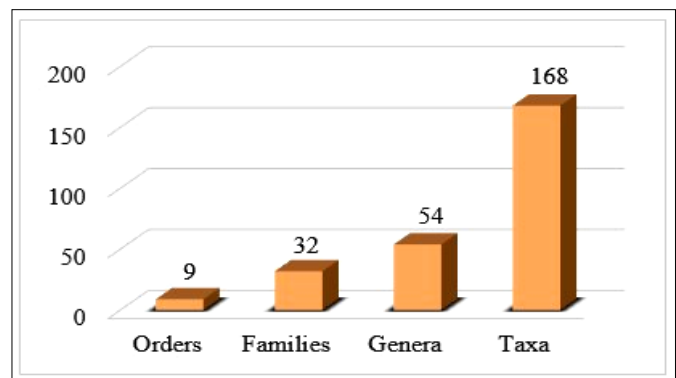


Fig. 2. Orders, families, genera, and taxa of liverworts and hornworts in Nagaland.

brackets next to the number of species for each genus.

The family Lejeuneaceae emerges as the largest family of liverworts in the state, with 37 species, followed by Plagiochilaceae (19 spp.), Lepidoziaceae (11 spp.), Frullaniaceae (08 spp.), Lophocoleaceae (08 spp.), Ricciaceae (07 spp.), Metzgeriaceae (06 spp.), Scapaniaceae (06 spp.), Solenostomataceae (06 spp.), and Porellaceae (05 spp.) (Fig. 3). Similarly, the genus *Plagiochila* stands out as the largest, with 18 spp., followed by *Lejeunea* (12 spp.), *Frullania* (08 spp.), *Bazzania* (07 spp.), *Heteroscyphus* (06 spp.), *Metzgeria* (06 spp.), *Riccia* (06 spp.), *Solenostoma*

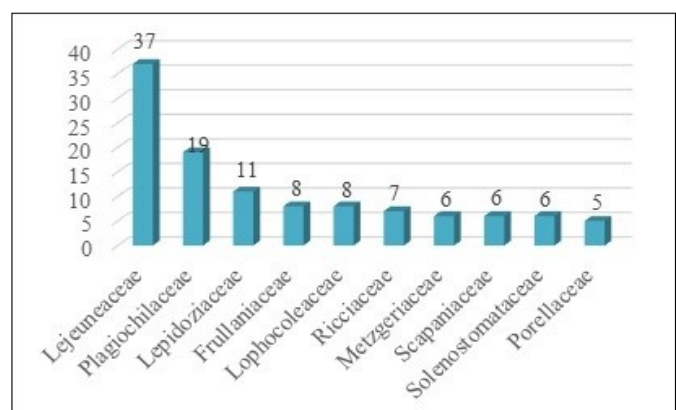


Fig. 3. Prolific families of liverworts and hornworts in Nagaland.

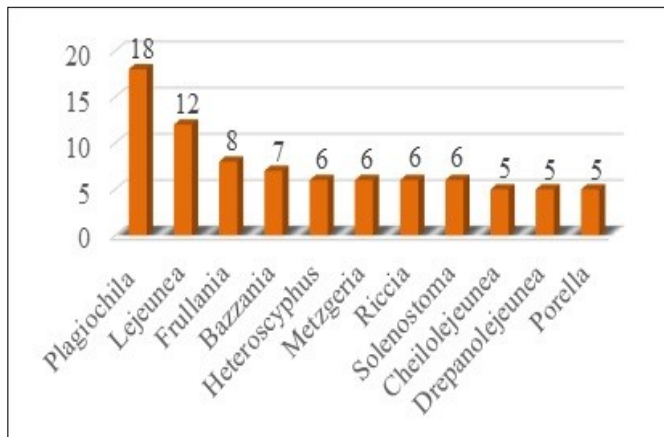


Fig. 4. Prolific genera of liverworts and hornworts in Nagaland.

(06 spp.), *Cheilolejeunea* (05 spp.), *Drepanolejeunea* (05 spp.), and *Porella* (05 spp.) (Fig. 4).

Furthermore, the habitat-wise distribution of all taxa was described using a Venn diagram (Fig. 5). Out of the total 168 taxa of liverworts and hornworts recorded from Nagaland, 100 taxa (59.5%) are terrestrial, 53 (31.5%) are corticolous, and 48 taxa (28.5%) are epiphyllous. Among these, 81, 23, and 29 taxa are exclusively confined to their respective habitats in the state (Fig. 5). Additionally, 16 taxa of liverworts were found growing both as terrestrial and corticolous, 04 taxa occur in both terrestrial and epiphyllous, while, 15 taxa occur in both corticolous and epiphyllous habitats. *Plagiochila nepalensis* Lindenb. was found in terrestrial, corticolous, and epiphyllous. Addition-

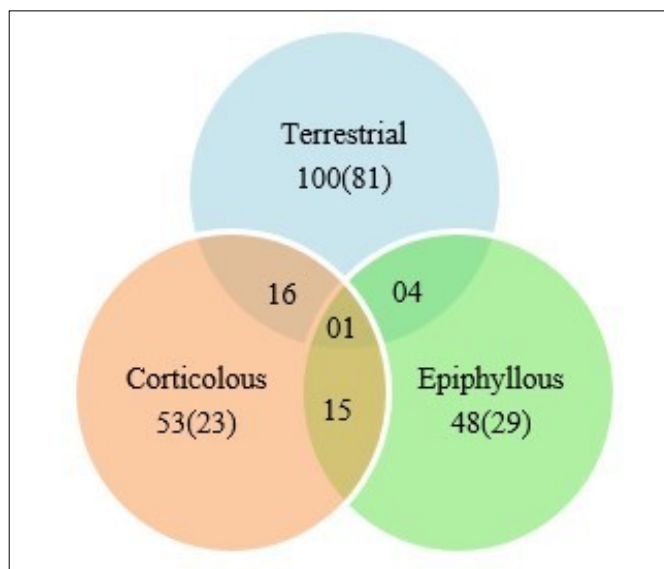


Fig. 5. Habitat-wise distribution of liverworts and hornworts.

ally, *Riccia carposnatans* (L.) Corda is the only aquatic liverwort known from Nagaland.

The present communication reports six species of liverworts for the first time from Nagaland, viz., *Cololejeunea serrulata* Steph., *Drepanolejeunea fleischeri* (Steph.) Grolle & R.L. Zhu, *D. yunnanensis* (P.C. Chen) Grolle & R.L. Zhu, *Lejeunea kashyapii* M. Dey, D.K. Singh & D. Singh, *L. stevensiana* (Steph.) Mizut. and *Metzgeria conjugata* Lindb. (Fig. 6). This checklist is based on scanty bryological excursions conducted in 2017 and 2023, as well as literature up to date. It is anticipated that the checklist will un-

dergo significant alterations once the documentation of liverworts and hornworts is completed.

Unique characteristic of the identified species

Cololejeunea serrulata Steph.

It is characterized by sub-elliptical leaf lobes with rounded apices and irregularly serrulate margins. The leaf cells are thin-walled with minute and indistinct trigones, lacking intermediate thickenings. Additionally, they have oblong-ovate, inflated, bidentate leaf lobules, which are approximately 1/3 to 2/5 as long as the leaf lobe. The first tooth consists of two cells in length and one cell in width, while the second tooth is either one or two-celled or indistinct.

Drepanolejeunea fleischeri (Steph.) Grolle & R.L. Zhu

It is characterized by oblong ovate to ovate leaf lobes with acute apices and irregularly denticulate margins. Usually one, rarely two ocelli cells are present at the base. The leaf cells are slightly thick-walled with small or indistinct trigones, lacking intermediate thickenings. Additionally, they featured ovate, inflated leaf lobule, approximately 1/3 as long as the leaf lobe, with the free lateral margin bordered by 8–13 sub-quadrate to rectangular cells. The underleaves are 3/4 bilobed with very widely spreading, nearly horizontal, linear-lanceolate lobes, which are 7–9 cells long and 2 cells wide at the base, becoming 2–4 cells uniseriate at the apex.

Drepanolejeunea yunnanensis (P.C. Chen) Grolle & R.L. Zhu

These plants are characterized by oblong ovate, slightly falcate leaf lobes with acute apices and serrate margin. Usually, two ocelli cells are present at the base. The leaf cells are slightly thick-walled with small or indistinct trigones, lacking intermediate thickenings. Additionally, they feature oblong ovate, inflated leaf lobule, approximately 2/5 as long as the leaf lobe, with the free lateral margin bordered by 8–10 rectangular cells. The underleaves are 3/4 bilobed with very widely spreading, nearly horizontal, linear-lanceolate lobes, which are 7–9 cells long and 2–3 cells wide at base, becoming 2–4 cells uniseriate at the apex.

Lejeunea kashyapii M. Dey, D.K. Singh & D. Singh

It is characterized by more or less sub-orbicular leaves with ventral lobe 1/4–1/3 of its length. The first tooth is 1–3 cells long and 1–2 cells wide at base, while the second tooth is indistinct. Additionally, the underleaves are reniform, always broader than long.

Lejeunea stevensiana (Steph.) Mizut.

It is characterized by triangular-ovate leaf lobes with usually apiculate apices. Nodulose trigones and subnodulose intermediate thickenings are frequent in the leaf cells. Additionally, they have a punctate cuticle and inflated structures, approximately 1/6–1/4 as long as leaf lobe. The underleaves are 2.5–3.5 times as wide as the stem, with a cordate base.

Metzgeria conjugata Lindb.

It is characterized by being monoicous, with 2–4 rows of epidermal cells of the midrib visible in ventral view. Hairs



Fig. 6. Photomicrographs plate. **A.** *Colelejeunea serrulata* Steph. **B.** *Drepanolejeunea fleischeri* (Steph.) Grolle & R.L. Zhu, **C.** *D. yunnanensis* (P.C. Chen) Grolle & R.L. Zhu, **D.** *Lejeunea kashyapii* M. Dey, D.K. Singh & D. Singh, **E.** *L. stevensiana* (Steph.) Mizut. and **F.** *Metzgeria conjugata* Lindb.

are present in pairs or sometimes singly along the margins and also scattered on the ventral surface of the thallus. Additionally, hairs are present on the surface and midrib of the androecial branches.

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Authors' contributions

DS participated in the plant collection and identification process, while SNA and MP contributed to plant dissections, analysis, photomicrographs plate preparation, map preparation, and drafting the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

Supplementary data

Supplementary Table 1. List of the species of liverworts and hornworts

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