

## SHORT COMMUNICATION

# A Preliminary Survey of Bryophytes in the Central Province of Sri Lanka

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## ABSTRACT

Bryophytes possess a key position in land plant evolution and hold the link between green algal ancestors and vascular plants. Bryophytes comprise the most diverse and species rich group of land plants after flowering plants. The most recent classification includes bryophytes in three phyla: Marchantiophyta (liverworts), Bryophyta (mosses) and Anthocerotophyta (hornworts). Bryophyte flora of Sri Lanka is poorly researched and does not contribute much to its biodiversity figures. Therefore, a preliminary survey was carried out in the Central Province of Sri Lanka to aid future bryological research in the country. This on-going survey has identified 15 liverworts, 27 mosses and 2 hornworts, with 12 new species records in Sri Lanka.

**Key words:** bryophytes, Marchantiophyta, Bryophyta, Anthocerotophyta, phylogeny, classification

## INTRODUCTION

Bryophytes (commonly referred to as ‘mosses’) are frequently found in damp shady places, along riverbanks, edges of ponds and lakes, on tree trunks and even on manmade habitats like roofs and walls. These tend to form tufts or close mats. They do not produce flowers, seeds or fruits and also do not possess a proper vascular system composed of a xylem and phloem. After flowering plants, bryophytes are the most diverse and species-rich lineage of embryophytes (Mishler, 2001; Renzaglia *et al.*, 2007; Wellman and Gray, 2000). This diverse group is also referred to as non-vascular land plants or non-vascular embryophytes. Extant bryophytes comprise more than 15,000 described species worldwide (Beike and Rensing, 2010; Vanderpoorten and Goffinet, 2009).

Traditionally, ‘bryophytes’ included three morphologically distinct groups based on the type of gametophyte; *i.e.*, liverworts, mosses and hornworts. According to the most recent classification scheme proposed by Crandall-Stotler *et al.* (2009), the three groups of bryophytes (liverworts, mosses and hornworts) are recognized as three phyla; Bryophyta (mosses), Marchantiophyta (liverworts) and Anthocerotophyta (hornworts), based on both

morphological and molecular data. As the only extant group of land plants with a dominant gametophytic generation, they share many fundamental structural features and display unifying and innovative reproductive characters. Therefore, despite their paraphyletic position, the three phyla are still frequently categorized together in a single group, the ‘Bryophytes’ (Crandall-Stotler, 1980; Schofield, 1985). Further, bryophytes lack a proper cuticle or roots, the uptake of water is mainly from the ambient humidity. Therefore, more than any other organism, bryophytes are highly sensitive to climate change. Due to deforestation and climatic changes over the years, the bryophyte flora of the world may have changed drastically and many endemics may have gone extinct. However, no proper records are currently available, especially in developing countries like Sri Lanka.

Explorations on the Sri Lankan bryophyte flora began in the 19<sup>th</sup> Century and many contributions to the field were made mainly by British bryologists and explorers including George Gardner (1812 – 1849), G. H. K. Thwaites (1812 – 1882), W. Mitten (1819 – 1906), and C. C. Townsend (O’Shea, 2003 and references therein). All major publications on Sri Lankan bryophytes up to date are based on the collections made by Gardner and Thwaites and few sporadic

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collections made afterwards. The existing checklists on bryophytes up to date are limited (Abeywickrama and Jansen, 1978; O'Shea, 2003) and do not represent the entire group. The literature-based checklist produced by Abeywickrama and Jansen (1978) included all the taxa known to have published at the time: 174 genera and 569 species of mosses, 60 genera and 183 species of liverworts and 03 genera and 06 species of hornworts. An updated checklist was published by O'Shea (2002) with 560 moss species. A literature-based study by O'Shea (2003) recorded a high endemism (11%) for mosses. However, no accurate evaluation or study has been carried out so far to check the endemism of liverworts and hornworts.

Since the available checklists do not include earlier synonyms for taxon names or their original publications, several taxa are listed under more than one name while some taxon names are no longer accepted (O'Shea, 2003). Apart from the few sporadic collections, no proper explorations or systematic studies on Sri Lankan bryophytes have been carried out. Therefore, there is a great need for field explorations and well documented collections, based on the updated recent classifications. However, a major impediment for such explorations is that much of the existing literature and checklists are old and the collections are scattered in herbaria in several continents. These highlight the importance of systematic field explorations, subsequent taxonomic identification and documentation of bryophytes of the country. Therefore, a preliminary survey of bryophytes in the Central Province was undertaken with the view of initiating systematic bryological studies in Sri Lanka.

## MATERIALS AND METHODS

The preliminary survey of bryophytes was carried out in Kandy and Nuwara Eliya Districts of the Central Province of Sri Lanka. Samples were collected from different habitats including natural forests, agro-forests, urban ecosystems and road sides and stored in paper packets as described by Schofield (1985). The collected specimens were surveyed for vegetative (gametophytic), reproductive and sporophytic characters including macroscopic and anatomical

characters, using a hand lens, light microscope and a stereomicroscope. Taxa were identified up to the generic/specific level using taxonomic keys produced for different geographic regions of the world, based on the most recent classification systems of Crandall-Stotler *et al.* (2009) for liverworts, Goffinet *et al.* (2009) for mosses and Renzaglia *et al.* (2009) for hornworts.

## RESULTS AND DISCUSSION

In the present survey, a total of 44 bryophytes were identified to their species/generic level, which included 15 liverworts, 27 mosses and 2 hornwort species. The details of species identified in each group are listed below (Boxes 1, 2 and 3). Recent changes in taxonomic circumscriptions of familial, generic and/or specific ranks are described in the list where necessary as 'notes'.

Ten families were encountered under the Phylum Marchantiophyta (liverworts): 6 complex thalloid families: Aytoniaceae (2), Cyathodiaceae (2), Dumortieraceae (1), Exormotheceae (1), Lunulariaceae (1), Marchantiaceae (3); two simple thalloid families: Metzgeriaceae (1), Pallaviciniaceae (1); and 2 leafy liverwort families: Jungermanniaceae (2) and Plagiochilaceae (1) (Box 1).

Sixteen moss families were identified under the Phylum Bryophyta: Bryaceae (4), Bartramiaceae (1), Dicranaceae (1), Fissidentaceae (2), Funariaceae (1), Hypnaceae (2), Leucobryaceae (3), Myuriaceae (1), Neckeraceae (2), Orthotrichaceae (2), Plagiotheceaceae (1), Polytrichaceae (3), Pottiaceae (1), Pterobryaceae (1), Rhizogoniaceae (1), Sematophyllaceae (1) (Box 2). Phylum Anthocerotophyta (hornworts) included 2 families: Notothyladaceae (1) and Anthocerotaceae (1) (Box 3).

Results of the current study revealed 12 new species records in Sri Lanka which include 2 complex thalloid liverworts, 1 leafy liverwort, 1 simple thalloid liverwort and 10 mosses. The new species records are indicated with a *delta* ( $\Delta$ ) mark (Boxes 1, 2 and 3). The newly recorded species are currently being examined further to describe their taxonomic and biogeographic affinities.

**Box 1.** List of Liverworts identified during the on-going survey (The new species records are indicated with a ‘ $\Delta$ ’ mark).

**Liverworts: Phylum Marchantiophyta Stotler & Crand.-Stotl.**

**Family Aytoniaceae Cavers**

*Plagiochasma rupestre* (J. R. & G. Forst.) Steph. Sp. Hepat. 1: 80. (1898).

*Reboulia hemisphaerica* (L.) Raddi Opusc. Sci. 2(6): 357. (1818).

**Family Cyathodiaceae Stotler & Crand.-Stotl.**

$\Delta$ *Cyathodium foetidissimum* Schiffn. Kaiserl. Akad. Wiss. Wien., Math.-Naturwiss. Kl., Anz. 67: 154. (1898).

*Cyathodium smaragdinum* Schiffn. ex Keissl. Ann. Naturhist. Mus. Wien. 36: 84. (1909).

Note: The genus *Cyathodium* Kunze, earlier included in the family Targioniaceae is now included in the monogeneric family Cyathodiaceae (Stotler *et al.*, 2009).

**Family Dumortieraceae D. G. Long**

*Dumortiera hirsuta* (Sw.) Nees Fl. Bras. Enum. Pl. 1: 307. (1833).

Note: The single genus *Dumortiera* has been traditionally placed in Wiesnerellaceae or Marchantiaceae. However, according to molecular phylogeny by Forrest *et al.*, (2006), it is not closely related to either family. The genus is now included in its own family Dumortieraceae due to the presence of several unique features that differ from all other Marchantiales (Long, 2006).

**Family Exormotheceae Müll. Frib. ex Grolle**

*Exormotheca ceylonensis* Meijer J. Hatt. Bot. Lab. 16: 72 f-l. (1956).

**Family Lunulariaceae H. Klinggr.**

*Lunularia cruciata* (L.) Dumort. ex Lindb. Not. Sällsk. Fauna Fl. Fenn. Förh. 116. (1822).

Note: The family Lunulariaceae was formerly included in the Order Marchantiales. It is now treated under the Order Lunulariales D. G. Long, which is well supported by molecular data and its unique morphological characters.

**Family Marchantiaceae Lindl.**

*Marchantia amboinensis* Mont. & Nees Ann. Sci. Nat., Bot., sér. 2, 9: 43. (1838).

$\Delta$ *Marchantia paleacea* Bertol. Opusc. Sci. 1: 242. (1817).

*Marchantia palmata* Reinw. Nees & Blume Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. (1825).

**Family Jungermanniaceae Rchb.**

*Jungermannia hasskarliana* (Nees) Mitt. J. Proc. Linn. Soc., Bot. 5: 90. 1860[1861].

$\Delta$ *Jungermannia obovata* Nees Naturgesch. Eur. Leberm. 1: 279, 332. 1833[1833].

**Family Plagiochilaceae Müll. Frib. & Herzog**

*Plagiochila spinulosa* (Dicks.) Dumort. Recueil. Observ. Jungerm. 15. (1835).

**Family Metzgeriaceae H. Klinggr.**

*Metzgeria furcata* (L.) Corda Naturalientausch 12: 654. (1829).

**Family Pallaviciniaceae Mig.**

*Pallavicinia lyellii* (Hook.) Gray. Nat. Arr. Brit. Pl. 1: 685, 775. (1821).

**Box 2.** List of Mosses identified during the ongoing survey (The new species records are indicated with a ‘ $\Delta$ ’ mark).

**Mosses: Phylum Bryophyta Schimp.**

**Family Bryaceae Schwägr.**

$\Delta$ *Anomobryum lanatum* (P. Beauv.) J.R. Spence & H.P. Ramsay *Telopea* 9: 785. (2002).

$\Delta$ *Bryum argenteum* var. *lanatum* (P.Beauv.) Hampe *Linnaea* 13: 44 (1839).

*Bryum capillare* Hedw. *Sp. Musc. Frond.* 182. (1801).

$\Delta$ *Pohlia wahlenbergii* (F. Weber & D. Mohr) A.L. Andrews *Moss Fl. N. Amer.* 2(3): 203. (1935).

**Family Bartramiaceae Schwägr.**

$\Delta$ *Bartramia brevifolia* Brid. *Bryol. Univ.* 2: 737. (1827).

**Family Dicranaceae Schimp.**

$\Delta$ *Dicranum scoparium* Hedw. *Sp. Musc. Frond.* 126. (1801).

**Family Fissidentaceae Schimp.**

*Fissidens elegans* Brid. *Muscol. Recent. Suppl.* 1: 167 (1806).

*Fissidens bryoides* Hedw. *Sp. Musc. Frond.* 153. (1801).

**Family Funariaceae Schwägr.**

$\Delta$ *Physomitrium* (Brid.) Brid. *Bryol. Univ.* 2: 815. (1827).

Note: The species identified during this survey is not previously recorded from Sri Lanka and should be further verified by comparison with authentically named voucher specimens or types.

**Family Hypnaceae Schimp.**

$\Delta$ *Pseudotaxiphyllum* Z. Iwats. *J. Hatt. Bot. Lab.* 63:448 – 450. (1987).

*Taxiphyllum taxirameum* (Mitten) M. Fleisch. *Musci Fl. Buitenzorg.* 4: 1435. (1922).

**Family Leucobryaceae Schimp.**

*Campylopus flexuosus* (Hedw.) Brid. *Muscol. Recent. Suppl.* 4:71 (1819).

*Campylopus schmidii* (Müll. Hal.) Jaeg. *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1870-71: 439. (1872).

*Leucobryum chlorophyllosum* Müll. Hal. *Syn. Musc. Frond.* 2: 535. (1851).

**Family Myuriaceae M. Fleisch.**

*Myurium rufescens* (Reinw. & Hornsch.) M. Fleisch. *Musci Buitenzorg* 3:672. (1908).

**Family Neckeraceae Schimp.**

*Homali dendron flabellatum* (Sm.) M. Fleisch. *Hedwigia* 45: 74. (1906).

*Circulifolium exiguum* (Bosch & Sande Lac.) S.Olsson, Enroth & D.Quandt. *Org. Divers. Evol.* 10(2): 120 (2010).

**Family Orthotrichaceae Arn.**

*Macromitrium japonicum* Dozy & Molck. *Ann. Sci. Nat., Bot., sér.* 3(2): 311. (1844).

$\Delta$ *Macromitrium mauritianum* Schwägr. *Sp. Musc. Frond., Suppl.* 2 (2): 127. pl.189. (1827). (Figure 1).

**Family Plagiotheciaceae (Broth.) M. Fleisch.**

*Plagiothecium latebricola* Schimp. *Bryol. Eur.* 5:184 (1851).

**Family Polytrichaceae Schwägr.**

*Pogonatum aloides* (Hedw.) P. Beauv. *Prodr. Aethéogam.* 84. (1805).

*Pogonatum microstomum* (R. Br. ex Schwägr.) Brid. *Bryol. Univ.* 2: 745. (1827).

*Pogonatum urnigerum* (Hedw.) P. Beauv. *Prodr. Aethéogam.* 84. (1805).

**Family Pottiaceae Schimp.**

*Trichostomum crispulum* Bruch *Flora* 12: 395. (1829).

**Box 2 contd.****Family Pterobryaceae Kindb.**

*Symphysodontella involuta* (Thwaites & Mitt.) M. Fleisch. Musci Fl. Buitenzorg 4: 1674 (1923).

**Family Rhizogoniaceae Broth.**

*Pyrrhobryum spiniforme* (Hedw.) Mitt. J. Linn. Soc., Bot. 10: 174. (1868).

**Family Sematophyllaceae Broth.**

<sup>Δ</sup>*Sematophyllum demissum* (Wilson) Mitt. Journal of the Linnean Society, Botany 8: 5. (1864).



**Figure 1.** *Macromitrium mauritianum* Schwägr. The species is recorded from the Agalega Islands, Madagascar, Tanzania, Mauritius, Réunion Island and is fairly common in East African Islands. The species is not previously recorded from Sri Lanka. The blunt leaf apices with excurrent costa and smooth, elongate basal cells with curved lumina are quite distinctive of the species (Wilbraham and Ellis, 2010; Wilbraham, 2008).

**Box 3.** List of Hornworts identified during the ongoing survey**Hornworts: Phylum Anthocerotophyta Rothm. ex Stotler & Crand.-Stotler****Family Notothyladaceae (Milde) Müll. Frib. ex Prosk.**

*Phaeoceros* Prosk.

Note: The genus *Phaeoceros* which was earlier included in the family Anthocerotaceae is now placed in the family Notothyladaceae based on molecular phylogenies, detailed morphological and ultrastructural analyses (Renzaglia *et al.*, 2009).

**Family Anthocerotaceae (Gray) Dumort. corr. Trevis. emend. Hässel.**

*Anthoceros* L.

## CONCLUSION

The current survey revealed 15 liverworts, 27 mosses and 2 hornworts, with 12 new species records in Sri Lanka. This highlights the importance of implementing conservation measures to protect the rich bryophyte flora of the country. The survey is continued with repeated field explorations to collect and identify more species. Further studies on characterization of species and verification of their geographical distribution and status are also being conducted. The lack of a 'Bryophyte Flora' or any established classification system/taxonomic keys for genera and species of liverworts, mosses and hornworts of Sri Lanka is a major impediment to conduct research on bryophyte flora of the country and therefore, systematic updates and a classification system for the Sri Lankan bryophyte flora need to be developed.

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## REFERENCES

- Abeywickrama, B.A. and Jansen, M.A.B. (1978). *A check list of the mosses of Sri Lanka*. UNESCO: Man and the Biosphere National Committee for Sri Lanka **2**: 1-25.
- Beike, A. K. and Rensing, S. A. (2010). The *Physcomitrella patens* genome – a first stepping stone towards understanding bryophyte and land plant evolution. *Tropical Bryology* **31**: 43–50.
- Crandall-Stotler, B. (1980). Morphogenetic designs and a theory of bryophyte origins and divergence. *Bio Science* **30**(9): 580–585.
- Crandall-Stotler, B. J., Stotler, R. E. and Long, D. G. (2009). Phylogeny and classification of the Marchantiophyta. *Edinburgh Journal of Botany* **66**: 1–44.
- Forrest, L. L., Davis, E. C., Long, D. G., Crandall-Stotler, B. J., Clark, A. and Hollingsworth, M. L. (2006). Unraveling the evolutionary history of the liverworts (Marchantiophyta): multiple taxa, genomes and analyses. *The Bryologist* **109**: 303–334.
- Goffinet, B., Buck, W. R. and Shaw, A. J. (2009). Morphology, anatomy, and classification of the Bryophyta. In: B. Goffinet and A. J. Shaw (eds.). *Bryophyte Biology*. 2<sup>nd</sup> edition. Cambridge University Press.
- Long, D. G. (2006). New higher taxa of complex thalloid liverworts (Marchantiophyta - Marchantiopsida). *Edinburgh Journal of Botany* **63**: 257–262.
- Mishler, B. D. (2001). The biology of bryophytes: Bryophytes aren't just small tracheophytes. *American Journal of Botany* **88**(11): 2129–2131.
- O'Shea, B. (2002). Checklist of the mosses of Sri Lanka. *Journal of Hattori Botanical Laboratory* **92**: 125–164.
- O'Shea, B. J. (2003). Biogeographical relationships of the mosses of Sri Lanka. *Journal of Hattori Botanical Laboratory* **93**: 293–304.
- Renzaglia, K. S., Schuette, S., Duff, R. J., Ligrone, R., Shaw, A. J., Mishler, B. D. and Duckett, J. G. (2007). Bryophyte phylogeny: advancing the molecular and morphological frontiers. *The Bryologist* **110**(2): 179–213.
- Renzaglia, K. S., Villarreal, J. C. and Duff, R. J. (2009). New insights into morphology, anatomy, and systematic of hornworts. In: B. Goffinet and A. J. Shaw (eds.). *Bryophyte Biology*. 2<sup>nd</sup> edition. Cambridge University Press.
- Schofield, W. B. (1985). *Introduction to Bryology*. Macmillan, New York.
- Vanderpoorten, A. and Goffinet, B. (2009). *Introduction to Bryophyte Biology*. Cambridge University Press. Cambridge, UK.
- Wellman, C. H. and Gray, J. (2000). The microfossil record of early land plants. *Philosophical Transactions: Biological Sciences* **355**(1398): 717–732.
- Wilbraham, J. & Ellis, L. (2010). Further taxonomic studies on the family Calymperaceae (Musci) and Orthotrichaceae (Musci) in the bryoflora of Réunion Island, with notes on taxa from other islands in the western Indian Ocean. *Cryptogamie, Bryologie* **31**(1): 31 – 66.
- Wilbraham, J. (2008). *The moss family Orthotrichaceae on Réunion Island*. Unpublished presentation given at the International Seminar 'Bryophytes of the Mascarenes taxonomic workshop held at the University of La Réunion.