

RESEARCH ARTICLE

## Three new additions to the moss flora of Sri Lanka

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**Abstract:** Mosses (Phylum Bryophyta) comprise the most speciose group of bryophytes (liverworts, mosses, hornworts) and consist of about 13,000 species worldwide. Owing to its high level of topographic and climatic heterogeneity, the tropical island of Sri Lanka supports a luxuriant growth of mosses. Compared to other groups of plants in the country, mosses remain as a poorly researched group. Lack of proper taxonomic studies and scarcity of literature sources including locality details hamper further research in the field of bryology. Present study was carried out to explore the diversity of mosses in some selected localities of Sri Lanka. Fresh samples of mosses were collected from different localities including Horton Plains National Park, Lookkandura Conservation Forest, Kanneliya Forest Reserve and Badagamuwa Conservation Forest. Samples were observed for their morphological and anatomical characters using dissecting, compound and scanning electron microscopes. Specimens were identified following recent classification systems, using the most recent taxonomic keys, and monographs. The study identified three species records new to Sri Lanka including *Brachymenium capitulatum* (Mitt.) Kindb., *Ctenidium pinnatum* (Broth. & Paris) Broth. and *Fissidens crassinervis* var. *laxus* (Sull. & Lesq.) A. Eddy. Descriptions of these new species along with photo plates are provided. With the addition of 03 new records the total number of mosses recorded in the island increases from 572 to 575.

**Keywords:** bryophytes; mosses; new species records.


### INTRODUCTION

Sri Lanka (formerly Ceylon) is an island country lying in the Indian Ocean. The island is one of the most diverse regions in South Asia and is recognized as one of the world's biodiversity hotspots along with the Western Ghats of India (Ashton *et al.*, 1997). Owing to its high level of topographic and climatic heterogeneity, Sri Lanka supports a luxuriant growth of a remarkably rich bryophyte (liverworts, mosses, hornworts) flora (Geffert *et al.*, 2013; O'Shea, 2003; Ruklani and Rubasinghe, 2015). In contrast to the well-studied higher plant flora of Sri Lanka, bryophytes are still poorly explored, mainly due to their small size and difficult taxonomy (O'Shea, 2003; Rubasinghe and Long, 2014; Ruklani and Rubasinghe, 2013; Ruklani and Rubasinghe, 2015). According the recent checklists, the island harbours 327 species of liverworts (Long and Rubasinghe, 2014), 560 mosses (O'Shea, 2002) and five Hornworts (Long and Rubasinghe 2014).

Of the three phyla of bryophytes: Marchantiophyta (liverworts), Bryophyta (mosses) and Anthocerotophyta (hornworts), mosses are the most species rich group, including more than 13,000 species worldwide (Crandall-Stotler and Bartholomew-Began 2007; Goffinet *et al.*, 2009). Foundation for studies on mosses in Sri Lanka was laid down during the British colonial period (details in Rubasinghe and Long, 2014). Alexander Moon (1817 – 1825) was the first to collect Sri Lankan bryophytes, and some of his specimens deposited at the Natural History Museum, UK, have not been studied or published yet (O'Shea, 2003; Rubasinghe and Long, 2014). A detailed description of contributions made by early scientists and explorers is given in Rubasinghe and Long (2014). A checklist compiling all the published literature was published by Brian O'Shea (2002). O'Shea's checklist recorded 60 families, 174 genera and 560 species of mosses from Sri Lanka. However, this checklist has not been updated to-date and the country lacks a specimen-based checklist or a Flora of mosses. However, this checklist has not been updated to-date and the country lacks a specimen-based checklist or a Flora of mosses. Therefore, for most of the published taxa of mosses, locality details and descriptions are lacking and more localities still remain underexplored for bryophytes. However, a few contributions to the moss flora have been made since O'Shea's checklist.

Benito Tan (2005) reported 05 new species of mosses based on a collection made at Hantana Ridge and Loolecondra Tea Estate: *Acroporium secundum* (Reinw. & Hornsch.) Flesich., *Gammiella koningsbergeri* (Fleisch.) B.C. Tan & Y. Jia, *Hageniella micans* (Mitt.) B.C. Tan & Y. Jia, *Pinnatella foreauana* Thér. & P. dela Varde, and *Sematophyllum phoeniceum* (Müll. Hal.) M. Fleisch. Seven new species were reported by Ruklani & Rubasinghe (2013) from the Central Province: *Anomobryum lanatum* (P. Beauv.) J.R. Spence & H.P. Ramsay, *Bryum argenteum* var. *lanatum* (P.Beauv.) Hampe, *Pohlia wahlenbergii* (F. Weber & D. Mohr) A.L. Andrews, *Bartramia brevifolia* Brid., *Dicranum scoparium* Hedw., *Macromitrium mauritianum* Schwägr. and *Sematophyllum demissum* (Wilson) Mitt. These reports highlight the necessity of proper systematic studies on the moss flora of the country.

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## MATERIALS AND METHODS

A series of taxonomic surveys were conducted at different geographic localities in Sri Lanka including Horton Plains National Park, Loolkandura Conservation Forest, Kanneliya Forest Reserve and Badagamuwa Conservation Forest. Fresh samples of mosses were collected and thoroughly surveyed for morphological and anatomical characters. Specimens were identified using taxonomic keys, descriptions and monographs and authenticated using type descriptions and/or specimens. Voucher specimens were prepared and deposited at the National Herbarium Peradeniya (PDA).

## RESULTS

Three species records new to Sri Lanka were identified during the survey including: *Brachymenium capitulatum* (Mitt.) Kindb. and *Ctenidium pinnatum* (Broth. & Paris) Broth and *Fissidens crassinervis* var. *laxus* (Sull. & Lesq.) A. Eddy. Taxonomic descriptions along with details of ecology and distribution are provided for each newly recorded species.

1. *Brachymenium capitulatum* (Mitt.) Kindb., Enumeratio Bryinearum Exoticarum, Supplementum Primum: 86. 1889  $\equiv$  *Bryum capitulatum* Mitt., Journal of the Linnean Society, Botany 22: 306. 1886. Type-Tanzania. Kilimanjaro, *Hannington s.n.* (S). (Fig. 1).

Description- Plants small, up to 10mm high, in somewhat loose tufts greenish above, brownish towards the base. Rhizoids reddish. Stem erect, with leaves densely arranged at apex, fewer below. Leaves capitulate, larger at apex, flexuous, appressed when dry, spreading when moist, ovate-spathulate, acuminate, 4-5

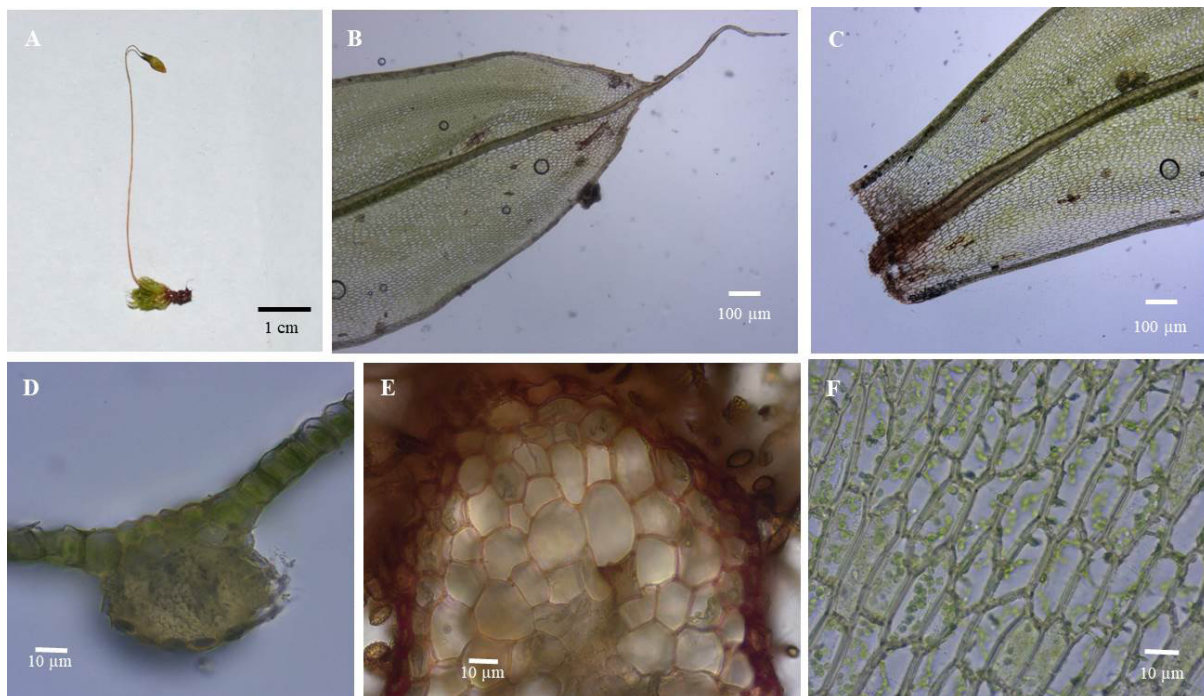
mm long; margin recurved at base, plane and serrate at apex, marginal cells 1-3 rows, narrow, hyaline; costae excurrent ending in long awns; median leaf cells rectangular to hexagonal, 35-50  $\mu$ m long, thin-walled, cells at leaf base rectangular. Setae erect, twisted, 30-35  $\mu$ m long. Capsule yellowish, ovoid to oblong, up to 4.0 mm long, mouth narrow. Spores papillose, 10-14  $\mu$ m in diameter.

Specimens examined- Sri Lanka, Central Province, Nuwara Eliya District, Horton Plains National Park, 06°50.63280'N, 080°48.87120'E, 1958 m. 6 January 2018, *Herath & Rubasinghe 041-18HRSR* (PDA).

Taxonomic note-Eight species of *Brachymenium* are recorded from Sri Lanka: *B. acuminatum* Harv. in Hook., *B. exile* (Dozy & Molk.) Bosch & Sande Lac., *B. glaucum* A.Jaeger, *B. longicolle* Thér., *B. nepalense* Hook. in Schwaegr., *B. nietneri* (Müll.Hal.) A.Jaeger, *B. systylium* (Müll.Hal.) A.Jaeger, and *B. walkeri* Broth. (O'Shea, 2002). *Brachymenium capitulatum* can be easily distinguished from the other species by its distinctly bordered leaf margin and well-developed stereid cells of leaf costae.

Habitat-on rotten tree trunks.

Distribution-The species is also reported from China, Bhutan, Nepal, India (Sikkim), Papua New Guinea, and Africa (Bansal *et al.*, 2011; Blockeel *et al.*, 2006; Müller and Schäfer-Verwimp, 1999) and here from Horton Plains National Park, Sri Lanka.



**Figure 1:** *Brachymenium capitulatum* A-Habit, B-Leaf apex with excurrent costa, C-Leaf base, D-Leaf cross section, E-Stem cross section, F-Median cells of the leaf.

2. *Ctenidium pinnatum* (Broth. & Paris) Broth., Die Natürlichen Pflanzenfamilien I(3): 1073. 1908 ≡ *Stereodon pinnatus* Broth. & Paris, Bulletin de l'Herbier Boissier, sér. 2(2): 991. 1902. Type- Japan. Liou Kiou (Ryukyu Is.) Faurie 1325. (P) (Fig. 2).

**Description**-Plants small, soft, glossy, yellowish green. Stem prostrate, 2.5–3.0 cm long, pinnately, densely branched; branches curved, 6–7 mm long. Stem leaves erect-spreading or curved, 0.8–1.0 mm long, broadly ovate-lanceolate, gradually acuminate, cordate at base; margins serrulate; costae absent; median leaf cells 30–35 μm long, prorate, smooth; alar cells shortly rectangular to rectangular, alar cells not distinctly differentiated; branch leaves flattened, slightly falcate, 0.6–0.8 mm long, ovate-lanceolate, shortly acuminate. Sporophytes not seen.

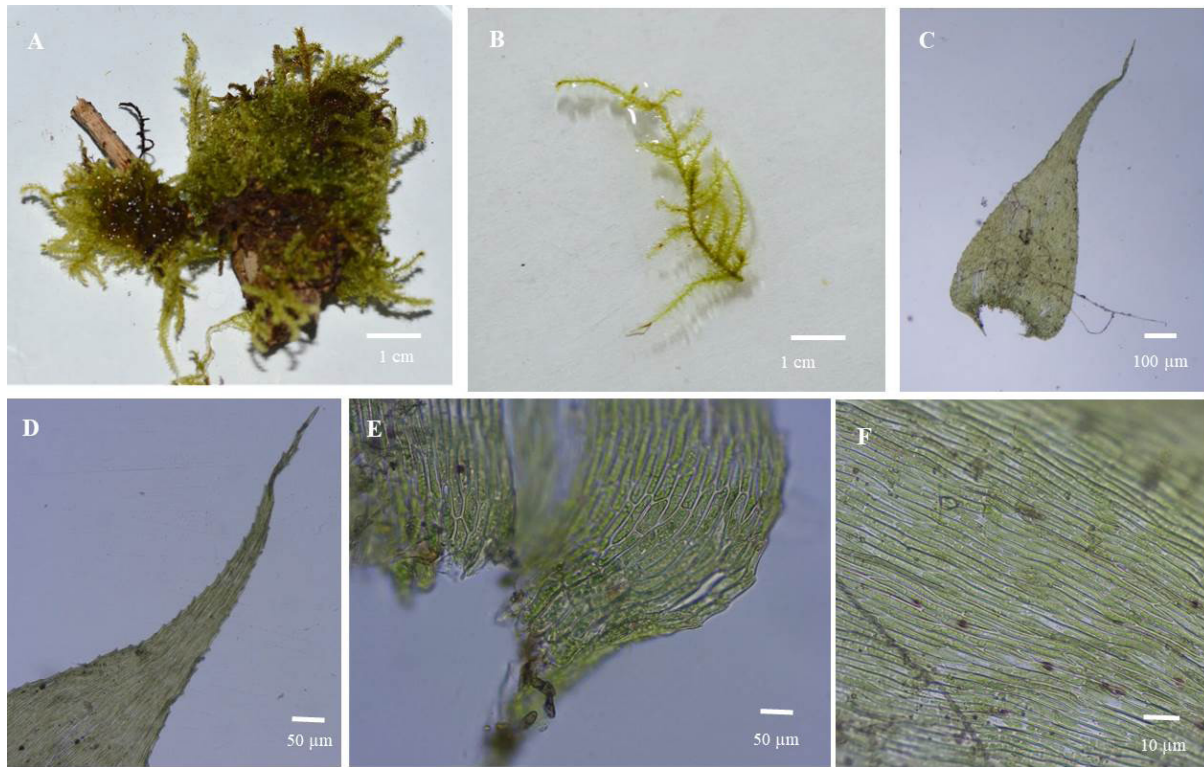
**Specimens examined**-Sri Lanka, Central Province, Nuwara Eliya District, Horton Plains National Park, 06°47.05320'N, 080°47.87220'E, 2106 m. 6 January

2018, Herath & Rubasinghe 042-18HRSR (PDA).

**Habitat**-On rotten wood

**Taxonomic Note**-O'Shea (2002) recorded two species of *Ctenidium*: *C. ceylanicum* Cardot ex M.Fleisch. and *C. lychnites* (Mitt.) Broth. *Ctenidium pinnatum* is distinct in its small nature, dense pinnate branching of the stem, and gradually acuminate, falcate stem leaves.

**Distribution**- *Ctenidium pinnatum* is also reported from China, Japan, Taiwan and Vietnam (Zhang *et al.*, 2016; Higuchi, Yao and Lin, 2012) and here from Horton Plains National Park, Sri Lanka.



**Figure 2:** *Ctenidium pinnatum* A) Habit of the plant B) A branch showing pinnate branching pattern C) Stem leaf D) Acuminate leaf apex E) Leaf base F) Leaf lamina cells.

3. *Fissidens crassinervis* Lac. var. *laxus* (Sull. & Lesq.) A. Eddy, A Handbook of Malesian Mosses 1: 70. 1988  $\equiv$  *Fissidens laxus* Sull. & Lesq. Proceedings of the American Academy of Arts and Sciences 4: 276. 1859. Type-Hong Kong (G) (Fig. 3).

Description-Plants small, brownish green, variable in size, up to 4 mm tall. Stem ovoid, central strand absent in cross section. Leaves small, narrow, linear-lanceolate, bluntly acuminate, 1.0–1.2 mm long; costa strong, reddish brown, disappearing below apex; margin weakly crenulate; vaginant lamina less than half leaf length.

Sporophytes not seen. Seta terminal, sporophytes not common (Eddy, 1988).

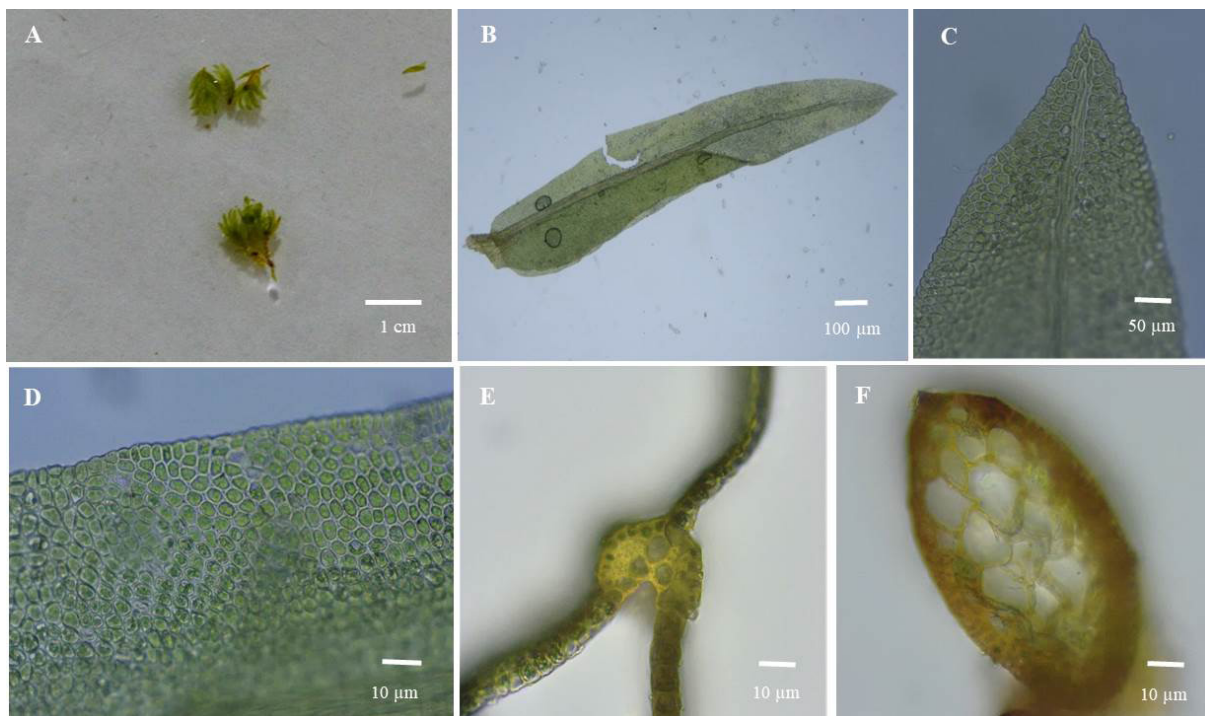
Specimens examined-Sri Lanka, Southern Province, Galle District, Kanneliya Forest Reserve, 06°19.04220'N, 080°18.97860'E, 38 m. 20 January, 2018. Herath & Rubasinghe 071-18HRSR (PDA).

Habitat-On a thalloid liverwort, *Riccia* sp.

Taxonomic Note-O'Shea (2002) recorded 36 species and 02 varieties under *Fissidens*: *F. angustiusculus* Dixon & P.de la Varde, *F. angustus* Thwaites & Mitt., *F. anomalus* Mont., *F. antrophyi* Müll.Hal., *F. axilliflorus* Thwaites & Mitt., *F. beckettii* Mitt., *F. ceylonensis*

Dozy & Molk., *F. crassinervis* Sande Lac., *F. crispulus* Brid., *F. curvatoxiphioides* Dixon & P.de la Varde, *F. curvatus* Hornsch., *F. dentatolimbatus* Dixon, *F. discolor* Wilson ex Mitt., *F. firmus* Mitt., *F. flaccidus* Mitt., *F. fuscoviridis* Thwaites & Mitt., *F. gardneri* Mitt., *F. gedehensis* M.Fleisch., *F. incertus* Thér. & P.de la Varde, *F. karwarensis* Dixon, *F. lateralis* Broth., *F. macrosporoides* Dixon & P.de la Varde, *F. macrosporus* Dixon, *F. minutus* Thwaites & Mitt., *F. nanocarpus* Müll. Hal., *nom. nud.*, *F. nobilis* Griff., *F. plumula* Thwaites & Mitt., *F. schmidii* Müll.Hal., *F. serratus* Müll.Hal., *F. socialis* Müll.Hal., *F. speluncae* Broth., *F. subobscurus* Paris, *F. thwaitesii* Paris, *F. virens* Thwaites & Mitt., *F. walkeri* Broth., *F. zollingeri* Mont. *F. ceylonensis* var. *simplex* M.Fleisch., and *F. pellucidus* var. *pellucidus* Hornsch. The new record, *F. crassinervis* var. *crassinervis* is loosely related to *F. crassinervis* var. *crassinervis*. However, reddish-brown plants, deep reddish brown costae and narrow, tapering leaves of *F. crassinervis* var. *crassinervis* readily separates it from much green coloured *F. crassinervis* var. *laxus*.

Distribution-The species is also reported from India, Japan and Malesia (Suleiman and Edwards, 2002) and here from Kanneliya Forest Reserve, Sri Lanka.



**Figure 3:** *Fissidens crassinervis* var. *laxus* A) Habit of the plant B) Leaf C) Bluntly acute leaf apex, D-Leaf lamina cells, E) Leaf cross section F) Cross section of stem.

## DISCUSSION AND CONCLUSION

The four selected localities explored during the study revealed a considerable diversity of mosses including 23 families, 46 genera and 63 species. Calymperaceae, Fissidentaceae, Leucobryaceae, Meteororiaceae, Neckeraceae, Bryaceae, Dicranaceae, Thuidiaceae and Sematophyllaceae were the commonly encountered families during study. Horton Plains National Park comprised the highest species diversity and luxuriant growth of mosses while Badagamuwa conservation Forest showed the least species diversity and sparse growth of mosses. Deforestation, clearance of roadsides and climate change are main threats to the moss flora of Sri Lanka. Although Sri Lanka harbors a high diversity of bryophytes, there is no specimen based checklist nor a “Flora” for bryophytes of Sri Lanka. Therefore, documents describing their morphology, identification methods, distribution patterns, locality and phonological details lacking for most groups of bryophytes including mosses. This scarcity of information and expertise in the field prevent further research carried out on this important group of plants within the country. Also, due to the same reason, it is a barrier to identify the important sites for bryophyte conservation. The study emphasizes the importance of identification and documentation of the existing bryophyte flora of the country so that necessary conservation measures could be implemented to conserve the existing taxa before they are disappeared from the country.

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