

Taxonomic studies on Bryophytes of Anamudi Shola National Park in the Western Ghats of Kerala

*Thesis submitted to the
UNIVERSITY OF CALICUT
in partial fulfillment for the requirements for the award of the degree of*

Doctor of Philosophy in Botany

by

MUFEEED B.

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Under the guidance of

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THE ZAMORIN'S GURUVAYURAPPAN COLLEGE

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25th September, 2020

CERTIFICATE

This is to certify that the thesis entitled “**Taxonomic studies on Bryophytes of Anamudi Shola National Park in the Western Ghats of Kerala**” is a research work carried out by Mr. Mufeed B., Research Scholar, P.G. & Research Department of Botany, The Zamorin’s Guruvayurappan College, Kozhikode under the supervision and guidance of Dr. Manju C. Nair, Assistant Professor of Botany of this College during the period of 2015-2020.

PRINCIPAL



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(Dr. Manju C. Nair)
Research Guide



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P.G. & Research Department of Botany)

DECLARATION

I hereby declare that the thesis entitled “**Taxonomic studies on Bryophytes of Anamudi Shola National Park in the Western Ghats of Kerala**” is a bonafide record of research work carried out by me at P.G. & Research Department of Botany, The Zamorin’s Guruvayurappan College, Kozhikode, under the guidance of Dr. Manju C. Nair, and no part of this thesis has been previously presented or submitted elsewhere for the award of any degree or diploma or similar title to this or any other University

Place: Z.G. College
Date : 25. 09. 2020

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PLAN OF THE THESIS

The thesis starts with the table of contents and abbreviation used in the text. Then the chapters are divided into seven major sections such as Introduction, Study area, Review of Literature, Materials and Methods, Result & Discussion, Ecology of Bryophytes and Summary & Conclusion appended with Bibliography. A glossary of technical terms for easy use in bryophyte taxonomy is provided as Appendix I. Papers published during the study is included as Appendix II.

Chapter I. Introduction – includes general morphology, importance and ecological characteristic features of Bryophytes along with a brief taxonomic history. Objectives of the present study also included.

Chapter II. Study area – gives a detailed description of Anamudi Shola National Park. Also includes its geography, climate and vegetation along with previous studies. Data is supported with a map.

Chapter III. Review of Literature – includes the Bryophyte studies with special reference to protected areas in India, a summary of Bryofloristic studies with reference to National and some major International works carried out.

Chapter IV. Materials & Methods – describes the methodology adopted for collection, herbarium processing and a general outline on the taxonomic treatment, etc. Methodology adopted for the ecological studies is also described in this section.

Chapter V. Result & Discussion – provides a systematic treatment of Bryophytes of Anamudi Shola National Park, which forms the major part of the thesis and includes description for the order, families, genera and species. Key to orders, families, genera and species were also provided. Each species is described with up to date nomenclature, including basionyms and synonyms, if any, pertaining to India and other parts of the world. The detailed description, diagnostic characters, habitat, distribution, specimen examined, etc. were provided. A note on short discussion is also provided. Authors of plant names are abbreviated based on Brummit and Powell (1992), and IPNI (www.ipni.org). Titles of journals are based on Taxonomic

literature (Stafleu & Cowan, 1976). The species are arranged according to the latest, revised classification by Crandall- Stotler *et al.* (2009), and Goffinet (2012). All the families and genera and species are arranged alphabetically.

Chapter VI. Ecology – Sorensen Similarity Index was worked out using the PAST 4.033.20 software (<http://folk.uio.no/ohammmer/past>) for analyzing the pattern of the general ecology of bryophytes such as diversity of species across major patches of sholas, macrohabitat (major vegetation types), microhabitat and altitudinal zones (1600-2400, with interval of 100 m).

Chapter VII. Summary & Conclusion – A summary of the work is given, highlighting the detail of the contribution by the present study.

A bibliography is given at the end citing all the references mentioned in the text and other relevant references pertaining to taxonomic identifications. A glossary of technical terms is also provided as appendix I for easy recognition of taxonomic terms. Papers published during the study are included in Appendix II.

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ABBREVIATION

Bk	:	Bark of Tree
BM	:	Natural History Museum
BR	:	Biosphere Reserve
BSD	:	Herbarium of Botanical Survey of India, Northern circle, Dehradun.
BSI	:	Botanical Survey of India
CAL	:	Central National Herbarium, Culcutta (CNH)
CALI	:	Calicut University Herbarium
CW	:	Concrete Wall
CR	:	Crevices of Rocks
EGF	:	Evergreen Forest
Ep	:	Epiphyllous
GRL	:	Grass Land
LC	:	Land Cutting
LR	:	Large Rocks
LW	:	Laterite stone wall
LWG	:	Herbarium of NBRI, Lucknow.
MH	:	Madras Herbarium, Botanical Survey of India Southern Circle Coimbatore
mm	:	Millimeter
µm	:	Micrometer
NBRI	:	National Botanical Research Institute
NP	:	National Park
Rt	:	Root of higher plants
SCCN	:	Herbarium of Scott Christian College, Nagarcoil

SEM	:	Scanning Electron Microscope
SLF	:	Shola Forest
ST	:	Stream side
Tr	:	Terrestrial
URL	:	Urban Land
WLS	:	Wildlife Sanctuary
WR	:	Wet rocks
ZGC	:	Zamorin's Guruvayurappan College

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INTRODUCTION

Bryophytes are tiny, tantalizing, aboriginal group of land plants that originated in the Palaeozoic era (Cambrian), 500 million years ago (Morris *et al.* 2018). They endured all this time with their survival nature and distributed the world over from tropics to polar through temperate regions. Tropical rain forests are richer in bryoflora than other geographical regions. More than 18,500 (Geffert *et al.*, 2013, Söderström *et al.*, 2016) species of bryophytes are reported all over the world.

Bryophytes can grow in broad varieties of substrates and habitats. Usually, the bryophytes show a great affinity to water, so they prefer to grow in moist, wet and shaded areas. They can be seen in almost all niches, they fill the habitats which are unsuitable for other plants, therefore constitute an important component of the forest ecosystem. They occur even in the snow vegetation, lakes, deserts, dark caves, exposed rocks as well as high peaks of mountains. They also prefer extremely acidic peat bogs and heavy metal rich soils due to their morphological, anatomical and physiological adaptations (Frahm *et al.*, 2003).

The endurance of bryophytes in extreme habitats, claims a title called ‘resurrection plants’ which means a remarkable capacity to absorb water and they turn to restored. They could come back to life even after frozen for more than 400 years as reported from Teardrop Glacier in the Canadian Arctic (La Farge *et al.*, 2013) or surprisingly more than 1530 years as reported (Roads *et al.*, 2014) from Antarctica. The water is playing an important role in their life cycle.

The bryophytes are nourished by the availability of water, nature of micro-environment and climatic conditions. Due to the favourable climatic conditions, forests are the major habitat of bryophytes. Based on the altitude, micro-climatic conditions and contents of the forest (trees, shrubs, and herbs), the diversity of bryophytes also changes.

The evolution and origin of bryophytes are more similar to those of early embryophytes than are those in any other living plant group (Shaw *et al.*, 2011). The bryophytes include three parallel groups viz., Musci, Hepaticae and Anthocerotae.

Crandall-Stotler (1980) has considered these groups even to be independent phyla. However, all of these three groups possess basically a similar pattern of the life cycle. The life cycle of bryophytes is unique when compared to the rest of the plant groups because they have two distinct alternating phases, the haploid gametophytic phase which is the dominant phase of the life cycle and the diploid sporophytic phase, dependent on the gametophyte for its survival.

Bryophytes play an important role in nutrient cycling, soil formation, providing microhabitat for other plants and animals, promote seed germination and fill the spaces in the habitat. They act as a source of airborne minerals and nutrition for seed plants on their unavailability conditions. The formation of extensive growth of bryophytes in the spaces of habitats can control the water content of much of the surrounding landscape by behaving like a gigantic sponge that absorbs and holds vast quantities of water and influences the water table. They colonize bare rocks, leading ultimately to the initiation of soil formation. This in turn produces a climax community in later through a series of changes, in turn, are important in nutrient cycling in the developing forest vegetation (Schoefield, 2019).

In recent years, bryophytes have been widely used for pollution monitoring and bioremediation. Some bryophyte species are closely associated with particular mineral deposits. For example, *Merceya* sp., *Mielichhoferia elongata* (Hoppe & Hornsch.) Nees & Hornsch. and *M. mielichhoferia* (Funck) Loeske are known as copper mosses because they grow in copper-rich soil. Such species can be used as indicator plants. Bryophytes have also been used to monitor airborne pollution caused by emissions from various sources. Similarly, aquatic bryophytes *Amblystegium riparium* (Hedw.) Schimp., *Fontinalis antipyretica* Hedw., *F. squamosa* Hedw., *Eurhynchium riparioides* (Hedw.) P.W. Richards and *Scapania undulata* (L.) Dumort. are now used to monitor water pollution (Saxena & Harinder, 2004).

A number of bryophytes are known to be rich sources of terpenoids such as sesqui and diterpenoids, and also aromatic compounds. They are very good laboratory specimens to carry out experiments on hybridization, apogamy, apospory and DNA targeting. One of the common moss *Sphagnum* is used as an effective

filtering and adsorption agent for the treatment of wastewater and effluent of factories with acid and toxic discharge containing heavy metals (Ag, Cu, Cd, Hg, Fe, Sb and Pb), and organic substances such as oils, detergents, dyes and micro-organisms (Saxena & Harinder, 2004).

Due to rapid urbanization and pressures inflicted by the growth of the human population and their intense activities, biodiversity is greatly influenced and bryophytes have been observed to be most affected. The conservation of bryophytes is very important in view of their critical role in ecosystem dynamics. They can be conserved by the establishment of moss gardens, protected areas, sacred groves, in-vitro techniques and also by regular monitoring, and periodic collection of data on rare and threatened species.

India is one of the 12 mega biodiversity countries in the world, with each and every state consists of several national parks and reserve forests. The total forest covers 21.54% of the total area of the country, of these a total of 105 National parks and 543 Wildlife sanctuaries are designated (National Wildlife Database, May 2019), providing options for a wide range of flora and fauna, including bryophytes are conserved. In India, 2498 taxa of bryophytes are reported which is 10% of the world taxa. It shows the wealth of the bryoflora in our country (Dandotiya *et al.*, 2011).

India is a tropical country with rich bryophyte diversity. However, many regions remain to be explored in detail, and many bryophyte groups are in need of thorough taxonomic revision meeting international standards. The earliest reference on the bryophytes of India could be traced in the 16th-century work by Van Rhee de (1678-1703). In his monumental work, *Hortus Indicus Malabaricus* mentioned one moss as 'poovan-peda' from the Western Ghats of Kerala. This moss was later found to be *Bryum bicolor* Hedw. by Robinson based on Rhee de's comments (Nicolson *et al.*, 1988). But intention being different, Rhee de's work is not a taxonomic one. During the 17th century two exclusive taxonomic studies on bryophytes were done, Dillenius's *Historia Muscorum* (1741) and Linnaeus's *Species Plantarum* (1753). Thereafter the bryophyte studies in India were accelerated. During the 18th century, many taxonomists made their contributions to Indian bryoflora. It started with the

Musci Nepalensis published in 1808 by Hooker, based on the collection of mosses by Buchanan Hamilton, a Medical officer in the British Embassy. Hooker (1818-1820) described several species for the first time from this region. In 1825, Hooker and Greville made two publications on Indian mosses. Schwägrichen (1811-1842) included some Indian mosses in his supplement to Hedwig's *Species Muscorum*. Thereafter, eminent bryologists like Wallich (1841), Montagne (1842), Griffith (1842, 1843), Gottsche *et al.* (1844), Mitten and Wilson (1857), Mueller (1853-1878), Jaeger (1870-1879), and Brotherus (1898) enriched the Indian bryoflora with their valuable contributions.

The 19th century is considered to be the 'golden era' of bryophytes in India. Various aspects of bryophytes, such as general documentation for the preparation of checklists, floras, and detailed genera or family level treatments were produced during this period. Bryophyte studies are extensively reported from Himalayan and adjacent regions during this period. However, serious studies on the bryophytes of the Western Ghats were not initiated until the mid 19th century. Since, Montagne (1842) and several Europeans till the mid 20th century (about 100 years) carried out explorations in various regions in the Western Ghats, which included sporadic representations from Kerala also. However, compared to the Himalayan and other regions of the country, Western Ghats of Southern India largely remain understudied for bryophytes.

In Southern India, only the Palni hills attracted the earlier workers for systematic exploration of the moss flora. The Western Ghats and west coast of Peninsular India have been recognized as a distinct bryogeographical unit owing to its unique climatic conditions, especially the rainfall. However, only certain regions of this unit like Agumbe-Hulical ranges, Kudremukh, Gerssoppa falls, Coorg and its adjacent areas in the state of Karnataka, have received some attention of earlier bryologists (Alam *et al.*, 2011a & b).

The state of Kerala is the richest in terms of biodiversity in India. Nearly 50 percent of its total area is with forest cover, holding five National Parks and 14 wildlife sanctuaries. Among these, four National parks are situated in the Idukki district. The mountains and annual rainfall provide unique climatic conditions for

bryophyte diversity in these regions. However, considering the estimated diversity of bryophytes, the area has not been subjected to detailed explorations. It had gained some momentum in the last 20 years, with the recording of interesting findings, including novelties. The approach of undertaking intensive studies in biodiversity-rich areas of Kerala proved worthy. Hence, the same is followed in the present study also. Considering the long term values and the benefits, the documentation of the diversity of Protected Areas (PA's), including bryophytes, is significant. The Bryophyte diversity of a Shola National Park, located in the high altitude region of the Western Ghats of Kerala is attempted here. The Shola vegetation of the Western Ghats is aptly referred to as 'Sky Islands of Biodiversity'. These are the peaks of biodiversity rich areas. The myriads of life forms are accumulated here in the hilltops, as there is no place to move further. The sholas are the areas of extraordinary amalgamation of life on the earth with endemism at its peak. More than 20 angiosperm endemics are confined to this area. *Actinodaphne bourdillonii* Gamble, *Ardisia rhomboidea* Wight, *Beilschmiedia wightii* (Nees) Benth. ex J. Hook., *Litsea wightiana* (Nees) Benth. & Hook., *Mahonia leschenaultia* (Wallich ex Wight & Arnott) Takeda, etc. are the endemic plants recorded from Anamudi Shola National Park (Kumar, 2015).

The growth of bryophytes is also at its peak, luxuriantly in almost all the available spaces; from the floor of the forest, trunks, branches to the tip of leaves of trees and shrubs. Here all life forms maintain their uniqueness, from plants to birds, insects and large animals, from their relatives of the lowlands or other vegetation types. They may be varying by one or other features, sometimes by the depth of the colour. The montane habitat, molded by the edaphic and climatic features are thus an ideal place for biologists to cherish the secrets of the diversity of life and evolution. It offers immense opportunity to learn in detail, the innumerable types of life forms, and how they reached the peak of uniqueness. The Anamudi Shola National Park is also not different in holding the uniqueness of Sky Islands.

The Anamudi Shola National Park is situated in the Devikulam Taluk of Idukki district, one of the highest peaks (2440 m) in South India. It consists of three shola forests viz., Mannavan Shola, Pullaradi Shola and Idivara Shola. Of these,

Mannavan Shola is the largest shola in South India with 5.18 km² area. The present study was undertaken with the aim to document the bryophyte richness of these sholas.

Objectives

1. Documentation of the bryophyte flora from different macro and microhabitats of the Anamudi Shola National Park.
2. Studies on the morpho-anatomical features of the Bryophytes of the area.
3. To assess the problems and prospects of conservation of the Bryophytes in the study area.
4. Study the general ecological aspects of the group in the area.
5. Building up of authentic voucher specimens of the taxa collected for the future reference, as deposited in the recognized herbaria.

STUDY AREA

Anamudi Shola National Park is one of the colossal and diversified ecosystems in Kerala. It consists of three pristine sholas viz, Mannavan Shola (5.18 km²), Pullaradi Shola (1.62 km²) and Idivara Shola (0.61 km²), of this Mannavan Shola is the largest shola in South India. Together the extent of the shola is 7.50 km². But according to the SOI topo sheet, settlement and associated farm areas occupy 43.35 km². It is located in the highest hilly regions of the Idukki district in Kerala state. This shola was declared as a National Park in December 2003. It is located on the North-eastern part of the high ranges of Southern Western Ghats. The park is located within 10°10' 0" to 10°12'18" N latitude and 77°09'50" to 77°12'18" E longitude in Devikulam Taluk of Idukki district (Plate 2.01-04).

The elevation of this region ranges from 1600-2440 m. The temperature ranges between 9.5°C (December) to 30°C (April). Average annual rainfall ranges between 2000 to 3000 mm. The climatic condition and annual rainfall of the National Park is favoured (climate is cool most of the year) for the successful growth of plants including bryophytes and pteridophytes.

Legal Boundaries

North: - Starting from Ottakombumala, hill point 2164 m on the southwestern corner of Tirthalar proposed reserve forests, along the southern boundary of the reserve till it reaches the northeastern corner of Mannavan Shola reserve along the northeastern boundary of the said reserve up to Madavarimala, thence northeast along the southern boundary of Idivara Shola reserve passing along hill points 2153, 2104, 2199, 2132, 2127 (Velligirimala).

East: - Starting from hill point at 2127 (Velligirimala) runs along the eastern boundary of Idivara Shola reserved forests and Pullaradi Shola reserved forest till it reaches the southeastern corner of Pullaradi Shola reserved forests adjoining the boundary of Kannan Devan Hills village concession lands.

South: - Starting from the southeastern corner of Pullaradi Shola reserved forests run more or less south along the southern boundary of Pullaradi Shola reserved Forests,

Idivara Shola reserved forest and Mannavan Shola reserved forests adjoining to the Northern Boundary of Kannan Devan Hills Village Concession lands till it reaches Tirthamala.

West: - Starting from Tirthamala runs along the eastern boundary of Mannavan Shola reserved forests till it reaches hill point 2164, Ottakombumala.

Ecological Boundaries

On the northern side, the Park is bordered by the forests of the Marayoor Sandal Division and also a part of Chinnar Wildlife Sanctuary. The eastern side is bordered partly by the Kurinjimala Sanctuary. On the southern and western side are the forests of Kannan Devan Hills and the tea estates. The Park provides ecological connectivity between the Anamalai Tiger Reserve, proposed Palni Hills National Park and the forests of Kannan Devan Hills.

The shola forests adjoining the western boundary of Idivara Shola Reserve Forest of the Park though falling in the jurisdiction of the Marayur Division have not yet been declared as RF and are categorized as revenue lands. The lower portion of this land has recently been identified and surveyed for distribution. Similarly, the forests of Kannan Devan Hills adjoining the southern and western flanks of the Park, though proposed for notification as Reserved Forests remain as revenue lands.

Flora and Fauna:

The Anamudi Shola National Park provides a safe and comfortable shelter to the wild species of flora and fauna. The National Park is underlined by a large number of faunal and floral species. The wildlife includes Elephants, tigers, Spotted Deer, Sambar, Giant Grizzled Squirrel, Hanuman Langur, Panther, Nilgiri Tahr, Gaur, Sloth Bear, Flying Squirrels, etc. The park consists of some of the rarest, endemic plants and species which are not found anywhere else. The area is covered with West Coast Tropical Evergreen, Southern Hilltop Tropical Vegetation found at higher altitudes. Out of 674 species of vascular plants, 598 taxa are flowering plants and 76 are Pteridophytes. Among the 598 angiosperms, 222 (37%) taxa are endemics. This ratio is very high when compared to the national ratio (Kumar, 2015).

The diversity of Pteridophytes is also very high in the national park, and with many unique elements. The population of *Cyathea crinita* Copel., reaching up to 6m height is the richest in and unique character of Mannavan Shola. The occurrence of two rare pteridophytes, viz., *Elaphoglossum stelligerum* Sledge and *Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf in is noteworthy (Kumar, 1997). About 11 species of fungi were also recorded from this shola, of which *Collectotrichum acutatum* turned a new record to Kerala (Kishore Kumar, 2015).

Microhabitats

Anamudi Shola National Park provides a wide range of microclimate to colonize the bryophytes. The bryophytes are playing a key role in ecosystem dynamics. They are the good reason behind the unique climatic condition in Shola forests, where the climate is cool throughout the year. The bryophytes improve the microclimate of the area due to their capacity to hold water in their cells. Usually, the bryophytes are seen as Terrestrial (land cuttings), Lithophytic (rocks), Epiphytic (barks, hanging on branches, on logs), Epiphyllous (growing on leaves), and some of them also seen as associated with ferns and lichens. The distribution of the bryophytes is influenced by several factors. The microclimatic factors like temperature, rainfall, altitude and latitude and microenvironmental factors like shade, humidity and humus play the major roles. The age of soil and its nutrients also influence the growth of the bryophytes. Based on the microclimatic and microenvironmental factors bryophytes form some special habitats such as Epiliths (only on rocks), Xerophytic (able to colonize mobile sand and shows a dormant stage), disturbed sites, calcicoles (rocks and soils containing a high amount of calcium), fire mosses (growing on burned sites, fire ashes deposits a high percentage of potassium, phosphate and magnesium on this soil) and Epixylic (dead logs and woods) (Bahuguna *et al.* 2013).

Tribes of Anamudi Shola National Park

Members of the Muthuvan tribal groups are inhabiting the National Park. They are settled in the Idivara Shola regions of the National park. The two major settlements are Kudallar kudi and Valsapetty kudi. They follow a unique ethnic

culture in their life. Basically, they are educationally undeveloped groups but recently the literacy rate is increasing. They can speak Malayalam and Tamil. However, they maintain a unique language of their own for communication within the community. They are also good farmers, and practice horticulture and slash and burn culture in the reserve forest. They also produce potatoes, beans and other vegetables.

Vegetation

The vegetation comprises mostly Southern sub-tropical hill forests, which gradually transform to the Southern montane wet temperate forests (Champion & Seth, 1968) towards the top (Iddalymotta region). The forest is seen as continuous patches scattered among the grasslands. At lower altitudes (1600 m) the average height of the forest is 20-25 m, with species of *Elaeocarpus tuberculatus* Roxb., *Gordonia obtusa* Wall. ex Wight & Arn., *Persea macrantha* (Nees) Kosterm., etc., while the maximum height of trees with 28-31 m is observed at 1800-1900 m altitude contributed by species of *Syzygium* viz., *S. densiflorum* Wall. ex Wight & Arn., *S. gardneri* Thw., *S. caryophyllatum* (L.) Alston and *S. cumini* (L.) Skeels; *Elaeocarpus glandulosus* Wall. ex Merr., etc. At Iddalymotta regions, the higher reaches of Mannavan Shola at an altitude of 2100-2440 m, the vegetation comprises stunted patchy shola forests i.e., Southern Montane Wet Temperate Forests (Champion & Seth, 1968). Here the trees with an average height of less than 15 m is seen. Most of the grasslands in this region were converted to *Eucalyptus* and Wattle (*Acacia* spp.) plantations. Compared to the low altitude regions, the diversity of angiosperms decreases. However, the diversity of bryophytes was found to increase. The bryophytes are distributed throughout the national park as suitable microclimatic conditions and substratum is available in plenty. The luxuriant growth of hanging mosses is frequently seen in high altitude areas (above 1900 m), compared to low altitude areas. The barks of the plants are covered with several epiphytic species. The growth of thalloid liverworts is usually seen in low altitude areas.

Previous works in the Study area

Anamudi Shola National Park is one of the major hotspots of biodiversity in the Western Ghats of Kerala. The richness of flora and fauna attracted many researchers to this area. There are some former studies conducted in this area other than bryophytes. Kumar (2015) prepared a checklist of the vascular flora of Anamudi Shola National Park. About 674 taxa of vascular plants were recorded; which included 598 taxa of angiosperms and 76 taxa of pteridophytes. Among these 66 species (44 angiosperms and 12 pteridophytes) of vascular plants turned as the first record from the Western Ghats of Kerala. The water use of the grasslands of Mannavan Shola and Eucalyptus plantations was studied by Kallarackal (2010) and indicated the importance of grasslands in the area. Sudhikumar *et al.* (2005) reported 72 species of spiders from the National Park, belonging to 57 genera of 20 families. Among these 15 species are endemic to Western Ghats of Kerala. Mathew *et al.* (2001) prepared a detailed account of the insects of the National Park, composed of about 344 species under 10 orders and 73 families, Of these 11 butterflies are endemic to Western Ghats. The avifauna of the National Park was also studied by Nameer (2001), recording about 76 species belonging to 12 orders and 30 families; of these 9 species are endemics. Most of them inhabit the National Park, but some are migratory birds.

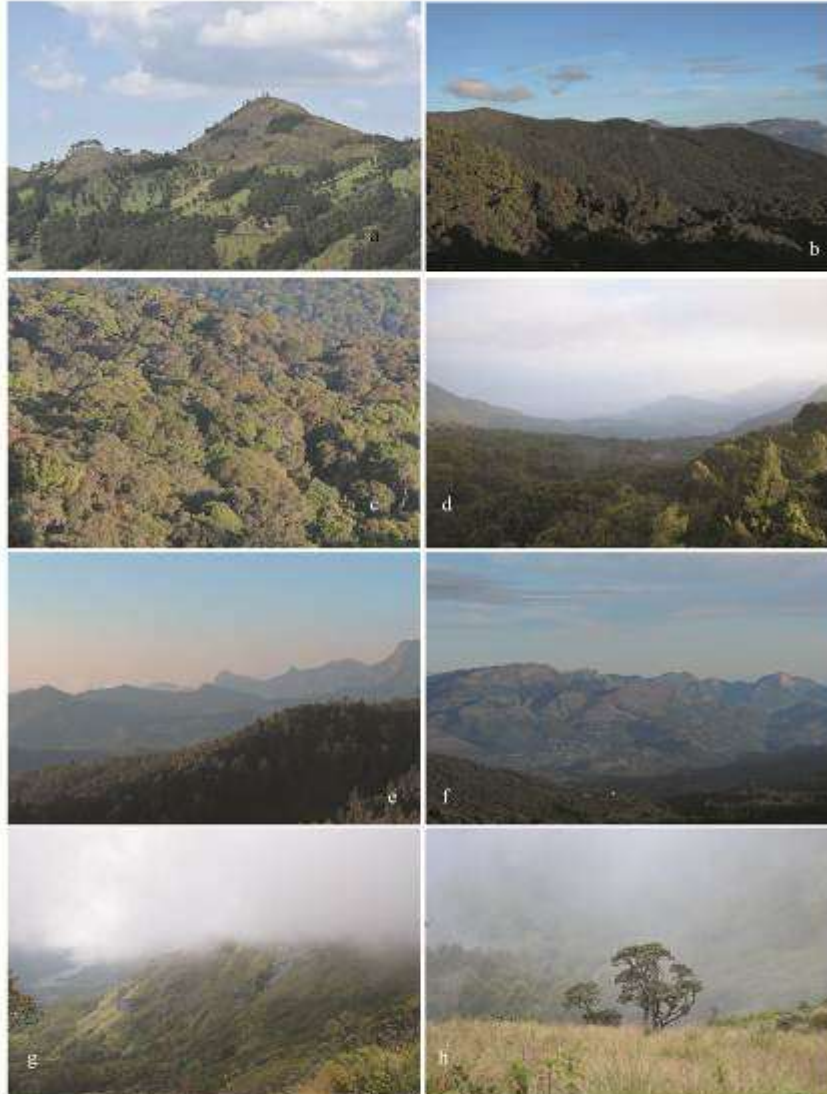


Plate 2, 02: a-h., different macrohabitats in Mannavan Shola forest



Plate 2. 03: a-h., Different macrohabitats in Pullaradi Shola forest

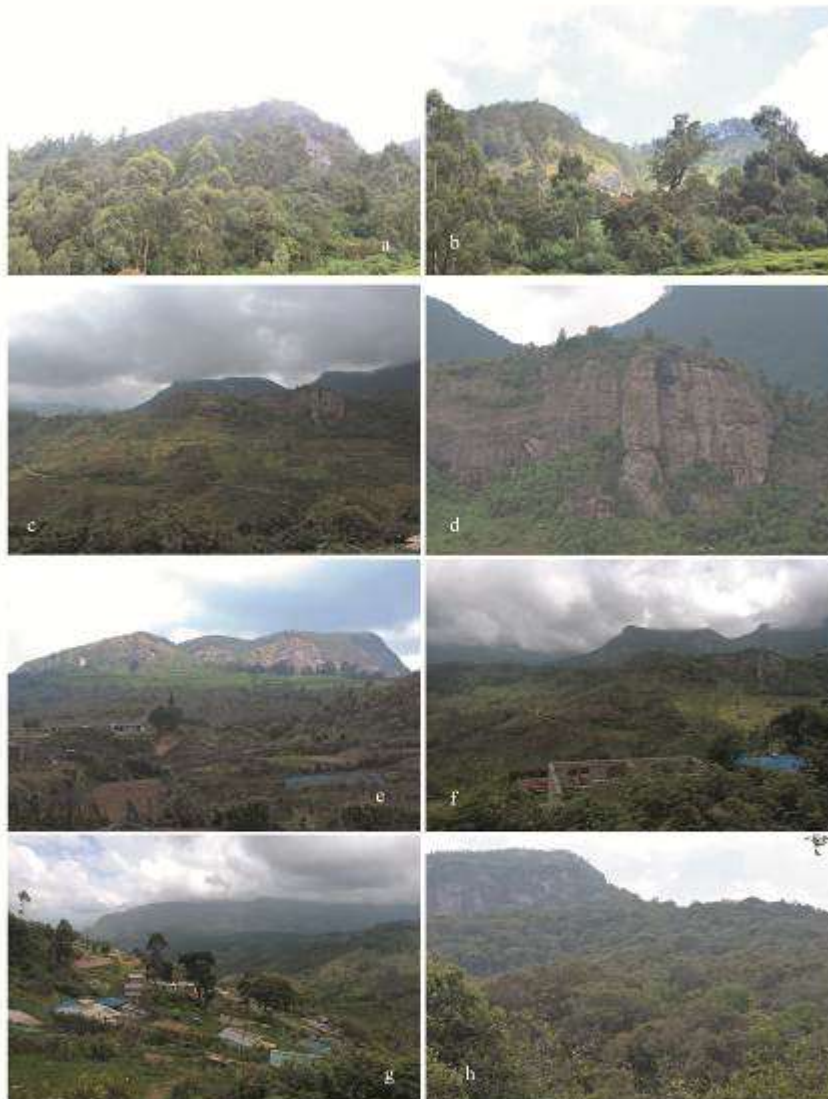


Plate 2. 04: a-h., Different macrohabitats in the Idivaru Shola forest

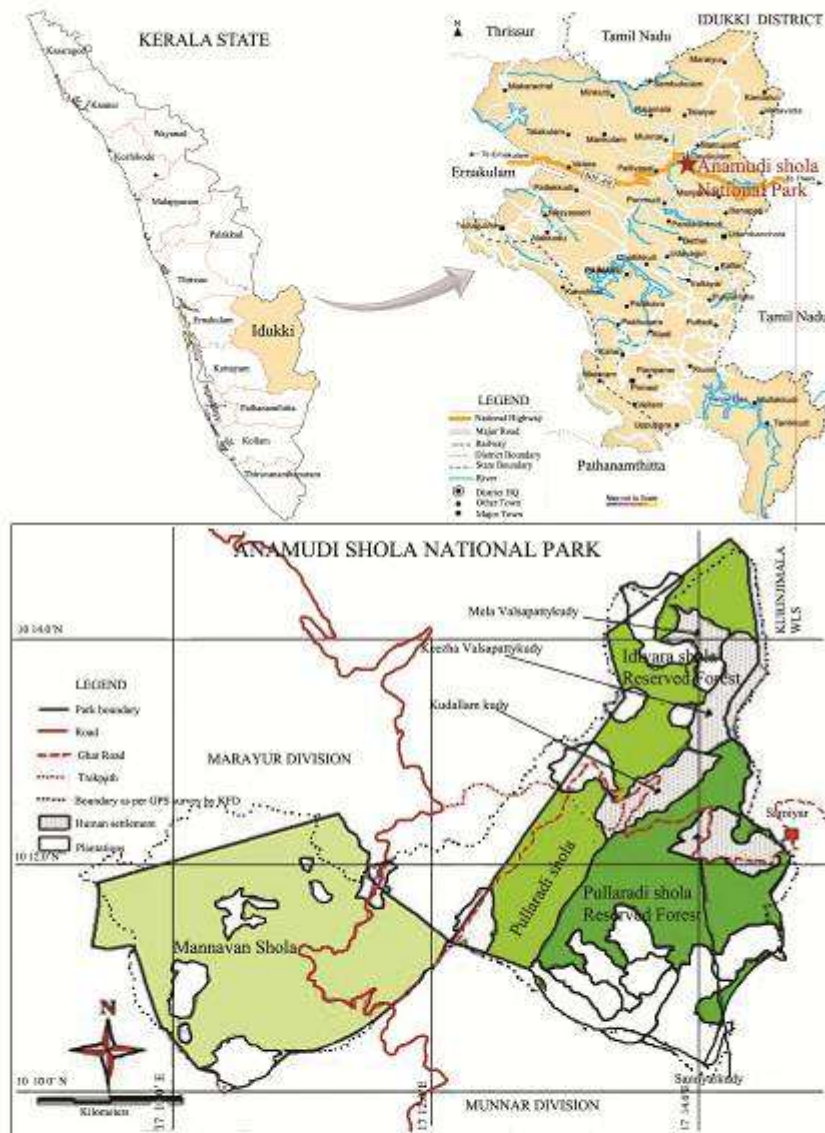


Plate 2. 01: Maps showing location of the study area - the Anamudi Shola National Park in Idukki district of Kerala state.

REVIEW OF LITERATURE

The earliest record on the bryophytes of Southern India in print may be that appeared in the book by van Rheede (1678-1703). In the 12th volume of his monumental work *Hortus Indicus Malabaricus*, illustrative account of one moss was given as 'poovan-peda' (vol.12, t.37, p. 71, 1693). It was later interpreted as *Bryum bicolor* by Robinson based on Rheede's comments (Nicolson *et al.*, 1988). The first taxonomic account on Indian bryophytes is that of Dillenius who included some mosses in his *Historia Muscorum* (1741). It was followed by Linnaeus (1753) who also included some Indian mosses along with higher plants in his *Species Plantarum*. In 1825, Hooker made two publications with Greville in Indian mosses. Schwägrichen (1811-1842) included some species from India in his supplement to Hedwig's *Species Muscorum* (1801). However, serious studies on the bryophytes of the Western Ghats were not initiated until the 19th century. Since Montagne (1842) till the mid 20th century (with a span of about 100 years) several Europeans carried out exploration in various regions on the Western Ghats but with sporadic representation from Kerala. Several new species and new additions were reported from the Western Ghats region of Tamil Nadu and Karnataka by Mitten (1861), Dixon (1921), Chopra (1938), Foreau (1961), Hattori (1974a & b; 1975a-f), etc. but none from Kerala up to the year 2000.

Considering the World scenario of bryophytes, there being a lot of traditional as well as modern taxonomic works carried out. Since the present study is of floristic nature; a review of major works on bryophyte taxonomy is provided. After Dillaneus (1741) and Linnaeus (1753), there were no significant works reported for a long period of time, except for some works of Schwägrichen (1826-27), Jussieu (1836), Montagne (1842) and Brown (1866). During the 19th century, the bryophytes obtained great attraction by several taxonomists and so many works were carried out in different parts of the world.

Bryophyte studies with special reference to protected areas in India

Bryophytes inhabit a wide variety of macrohabitats and microhabitats. The high and low altitude protected areas are some major domains on the earth where the bryophytes thrive well due to the congenial climate. The Indian subcontinent harbors 105 National Parks, 543 Wildlife Sanctuaries, and several Reserve forests. But the studies on bryophytes are limited in these areas. Some major works on the bryophytes of protected areas are provided here.

The first work on the bryophyte studies in protected areas of India started in Silent Valley forests of Kerala by Vohra (1981a). He described *Pogonatum hexagonum* Mitt. from Silent Valley as an endemic moss to India. The area was later declared a National Park in 1984. Subsequently, Vohra (1981b), mentioned about 250 collections of mosses from Mulla-Periyar and its catchment area of the Periyar Tiger Reserve in the Idukki district. Vohra *et al.* (1982) reported 83 species of mosses from the Silent Valley forests. Among these, 43 were epiphytes, 37 grow on soil and rocks, and three species were seen both as epiphytic and epilithic. They also proposed the occurrence of three new species, one in the genus *Pinnatella* and two in *Fissidens* but not described till now. Another interesting finding of them was the recording of the sporophytes of *Handeliobryum setschwanicum* Broth. from the area. Udar and Gupta (1983) described a new species as *Targionia indica* Udar & A. Gupta from different parts of India along with *T. hypophylla* L. They also reported *T. lorbeeriana* Muell. Frib. for the first time from South India.

Udar and Kumar (1985) while studying the family Cephaloziellaceae in South India recorded *Cephaloziella kiaerii* (Austin) Arnell., the sole representative of the genus in South India, from Silent Valley, Munnar and Ponmudi areas of Kerala. Asthana and Srivastava (1986) described a new species of *Folioceros* viz., *F. udarii* Asthana & Srivastava from the Silent Valley National Park in Kerala.

Srivastava and Sharma (2000) enumerated 29 species of Liverworts and Hornworts from the Silent Valley National Park of Kerala. This includes a proposal of a new species as *Taxilejeunea indica* A. Agarwal ex S.C. Srivast. & D. Sharma, but without required description, it is still treated as invalid.

Narayan *et al.* (2001) illustrated, morpho-taxonomic details of eight species of mosses belonging to six genera and six families from Great Himalayan National Park in Himachal Pradesh. The first estimate of the diversity and abundance of the terricolous liverworts from the Indian subcontinent has been made by Negi and Gadgil (2001) in some selected localities of Garhwal Himalayas. They discussed the niche-width and niche overlap of 19 species of terricolous liverworts from 11 selected localities of Garhwal Himalayas for the first time in India with respect to the 2-dimensional resource states of altitudinal gradient and the microhabitat.

Preliminary exploration made by Nair and Madhusoodanan (2001) for bryophytes in the Eravikulam National Park in the Idukki district of Kerala state situated in the high altitude mountainous areas with grassland and shola vegetation, reported 19 species including liverworts and mosses, of which, six species were new records to Kerala. An extended study in the same area by Madhusoodanan *et al.* (2007) reported 115 species including 87 mosses and 28 liverworts. Madhusoodanan and Nair (2004) reported eight species of Pleurocarpous mosses from the Eravikulam National Park, Kerala, of these *Racomitrium orthocarpum* Wils. & Mitt., *Diaphanodon procumbens* (Müll. Hal.) Ren & Card. and *D. blandus* (Harv.) Ren. & Card., were new records for Kerala.

Nair *et al.* (2005) published a book 'Bryophytes of Wayanad in the Western Ghats', the first comprehensive taxonomic treatment on bryophytes from South India. In which Wayanad Wildlife Sanctuary was the main site of collection. This includes a taxonomic account of 171 species and two varieties belonging to 105 genera and 47 families; including two new species viz. *Trichostomum wayanadense* Nair *et al.* and *Amphidium gangulii* Nair *et al.* Many of the species described were new distributional records of phytogeographical significance.

The Bryophyte Flora of Chinnar Wildlife Sanctuary of Idukki district in Kerala was explored for the first time by Nair *et al.* (2006a). They listed 60 taxa including 40 mosses, 19 liverworts and one hornwort. Among these, *Fissidens asperisetus* was a new record for Kerala. Nair *et al.* (2006b) reported *Lejeunea exilis* (Reinw *et al.*) Grolle of Lejeuneaceae for the first time from India based on the specimens collected from Chembra hills of Wayanad district and Eravikulam

National Park of Idukki district in Kerala. Nair *et al.* (2007a) recorded three pleurocarpic mosses from Eravikulam National Park, viz. *Calypothecium wightii* (Mitt.) M. Fleish. of Neckeraceae, *Fabronia schensiana* Müll. Hal. of Fabroniaceae and *Pelekium gratum* (P. Beauv.) Touw. of Thuidiaceae for the first time from Peninsular India.

Nair *et al.* (2007b) reported eleven species of the genus *Philonotis* from Peninsular India such as *P. seriata* Mitt., *P. angusta* Mitt., *P. falcata* (Hook.) Mitt., *P. turneriana* (Schwägr.) Mitt., *P. fontana* (Hedw.) Brid., *P. hastata* (Duby) Wijk & Marg. and *P. mollis* (Dozy & Molk) Mitt., *P. rigida* Brid., *P. secunda* (Dozy & Molk) Bosch & Sande-Lac., *P. thwaitesii* Mitt. and *P. tomentella* Molendo. Among these, *P. seriata* Mitt., *P. angusta* Mitt., *P. turneriana* (Schwägr.) Mitt., were new records for Peninsular India and *P. falcata* (Hook.) Mitt. was a new record from the Kerala state. Most of these species were from different protected areas of Kerala state. *P. angusta* Mitt., *P. turneriana* (Schwägr.) Mitt. and *P. falcata* (Hook.) Mitt. were previously reported only from North east India were found in the Chinnar Wildlife Sanctuary of Idukki district. *P. secunda* (Dozy & Molk.) Bosch & Sande-Lac. and *P. mollis* (Dozy & Molk.) Mitt. were reported from the Eravikulam National Park.

Pócs *et al.* (2007) recorded 33 hepatic taxa collected from the Kerala state by Manju from 2001-2007, of which *Heterocyphus splendens* Lehm. & Lindenb., *Lejeunea eifrigii* Mizut., *L. pellide-virens* S. Hatt., *Leptolejeunea balansae* Steph. and *Mastigolejeunea indica* Steph. were new records for India. Species are previously known from the Himalayas or Khasia mountains such as *Bazzania pearsonii* Steph., *Jubula hutchinsiae* subsp. *javanica* Steph., *Jungermannia truncata* Nees. and *Plagiochila semidecurrens* Lehm. & Lindenb. were recorded for the first time from Peninsular India. Most of the species for this study were collected from Eravikulam National Park. Singh and Singh (2007) reported 12 species of the genus *Plagiochila* from Great Himalayan National Park and its nearby areas in Kulu District, Himachal Pradesh. Of these, *P. sciophila* Nees ex Lindenb. and *P. uniformis* Mitt. show restricted distribution.

The ecological features of the bryophytes of Eravikulam National Park in Kerala was examined by Manju *et al.* (2008b). Microhabitat preferences of 126 taxa

of bryophytes including liverworts, hornworts and mosses were analyzed. The result showed that out of the 126 species about 39% are epiphytes 27% are terrestrial, 12% are saxicolous and about 10% occur both as terrestrial and saxicolous; 6% are epiphytic and saxicolous and 1% is epiphytic and terrestrial and 6% in all forms.

Singh and Singh (2008) explored the diversity of liverworts and hornworts of Great Himalayan National Park. They reported 92 species under 39 genera and 23 families of liverworts, among these 27 species were new records for Himachal Pradesh.

Manju *et al.* (2009a) reported the bryophyte flora of the Aralam Wildlife Sanctuary in the Western Ghats of India, with 16 taxa (89 mosses and 27 liverworts). Among these *Plagiochila singularis* Schiffn. and *Vesicularia dubyana* (Müll. Hal.) Broth. were new for India, 21 species were reported as new for Peninsular India and another 14 species were new for Kerala state. Manju *et al.* (2009b) reported *Jungermannia obliquifolia* (Schiffn) Váňa, as a new record for India, from the wet evergreen forests of Aralam Wildlife Sanctuary in Kannur district of Kerala state. Manju *et al.* (2009c) catalogued bryophyte flora of Agasthyamalai Biosphere Reserve, which includes a total of 90 taxa. Among these 58 species are mosses and 32 liverworts. Among these, 16 species are newly reported for Peninsular India and another 6 species are new records for the Kerala State.

The genus *Lindbergia* Kindb. was reported as a new record of the genus by Manju *et al.* (2009d) with the species *L. koelzii* R.S Williams from Neyyar Wildlife Sanctuary, Kerala state. *Notoscypus pandei* Udar & Kumar, an endemic species of Jungermanniaceae was reported by Manju and Rajesh (2009) from the Kakkayam forests in Kozhikode district and Chandanathode of Wayanad district. Daniels and Daniel (2009a) reported two liverworts as new to India viz., *Cololejeunea distalopapillata* (E.W. Jones) R.M. Schust. and *C. vidaliana* Tixier from the southern Western Ghats. *C. distalopapillata* was collected from Kanyakumari district of Tamil Nadu and one collection of *C. vidaliana* was from Agasthyamalai Biosphere Reserve.

Daniels and Daniel (2009b) reported *Spruceanthus thozetianus* (Gottsche &

F. Muell) B.M. Thiers, an Australian liverwort as new to the bryophyte flora of India collected from Agasthyamalai Biosphere Reserve in the Southern Western Ghats.

Daniels and Mabel (2009) reported two mosses *Calymperes moluccense* Schwägr. and *C. taitense* (Sull.) Mitt. as new record for the mainland of India. The former were earlier known from Indonesia, Sri Lanka and Andaman & Nicobar Island of India and the latter from South East Asia, Oceania and Andaman & Nicobar Island of India.

Alam (2009) studied 29 species of rare and endangered terrestrial Hepaticae of Nilgiri and Palni hills of Tamil Nadu. Singh and Singh (2009) studied the Hepaticae and Anthocerotae of Great Himalayan National Park and its environs. They reported 104 taxa belonging to three orders, 25 families and 42 genera of Hepaticae. Among these 19 species were rare in the study area and certain liverworts viz, *Jungermannia subrubra* Steph., *Geocalyx graveolens* (Schrad.) Nees, *Porella hattorii* Udar & Shaheen, *P. variabilis* (Kashyap & R.S. Chopra) Parihar, *Frullania pariharii* S. Hatt. & Thaithong, *Fossombronina kashyapii* S.C. Srivast. & Udar, *Blasia pusilla* L. and *Sauteria spongiosa* (Kashyap) S. Hatt. are considered as threatened species in Indian bryoflora. They also discussed the topographical and geological features of the study area.

Daniels *et al.* (2010a) described a new genus, *Indopottia* Daniels *et al.* with the species *I. zanderii* Daniels, from the Silent Valley National Park in the family Pottiaceae. Daniels *et al.* (2010b) described a new liverwort *Spruceanthus wiggintonii* Daniels, Kariyappa & P. Daniel, a corticolous species on *Garcinia travancorica* in the evergreen forests of Shankili forest in Kollam district of Kerala and Muthukuzhivayal of Kanyakumari district in Tamil Nadu. But it was synonymised under *Ptychanthus striatus* (Lehm. & Lindenb.) Nees, a common species in Kerala and Tamil Nadu by Wang *et al.* (2014). Kariyappa and Daniels (2010) recorded an African moss as new to India from the Western Ghats of Tamil Nadu. Daniels *et al.* (2010c) rediscovered *Frullania ramuligera* (Nees) Mont., a rare liverwort, based on the collections from Silent Valley National Park of Palakkad district and Shankili forest of Kollam district in Kerala and Kanyakumari district of Tamil Nadu.

Daniels *et al.* (2011c) rediscovered the long lost liverwort *Thysananthus spathulistipus* (Reinw., Blume & Nees) Lindenb. after more than a century from the Shankili reserve forest of Kollam district in Western Ghats. This species was last collected by Decoly and Schaulin Kurseong (1898) from north-east India. Daniels & Raja (2011) reported New Guinean *Thysananthus appendiculatus* Steph. of the family Lejeuneaceae, collected from Silent Valley National Park of Western Ghats as new record for India.

Daniels *et al.* (2011a) added two species *Daltonia angustifolia* Dozy & Molk. and *D. contorta* Müll. Hal. as new to the bryophyte flora of India from Tamil Nadu. This genus was earlier reported only from Himalaya in India. *Daltonia angustifolia* Dozy & Molk. was earlier known from Central Africa, China, Indonesia, Madagascar, Malaya, Nepal, New Guinea, New Zealand, Philippines, Sri Lanka and Vietnam. *D. contorta* was earlier known from Fiji, Hawaii, Indonesia, Malaya, Philippines and Sri Lanka. Daniels *et al.* (2011b) reported the occurrence of the genus *Ochrobryum* Mitt. with *O. kurzianum* Hampe from the Shankili forest in Kollam district of Kerala. It was known earlier from the Garo Hills in Meghalaya and Eastern Ghats of India.

Manju *et al.* (2011a) described *Chiloscyphus chinnarensis* Manju, Rajesh & Madhus. a new autoicous, epiphytic leafy liverwort species from the wet evergreen forests of Chinnar Wildlife Sanctuary of Idukki district of Kerala in the Western Ghats of India. A checklist of the Bryophyte flora of the Parambikulam Tiger Reserve of the Palakkad district in Kerala was reported by Manju and Rajesh (2011). The report includes 58 taxa including 39 mosses, one hornwort and 18 liverworts; of which *Grimmia funalis* (Schwagr.) Bruch. & Schimp. and *Thuidium subdelicatum* (Hampe) Broth. were new for India; *Leucophanes glaucum* (Schwägr.) Mitt. was new for the mainland of India; 10 species were new for Peninsular India and *Schiffneriolejeunea polycarpa* (Nees.) Gradst., *Hypnum imponens* (Hedw.) Boulay, *H. subimponens* subsp. *ulophyllum* Müll. Hal. and *Regmatodon orostegius* Mont. were new records for Kerala state.

Alam *et al.* (2011a) conducted a comprehensive study on the bryophyte flora of Ranthambore National Park in Rajasthan and reported 27 species belonging to 13

genera under 8 families. Nath *et al.* (2011) explored and assessed the family Pottiaceae in central India and reported 8 species from Pachmarhi Biosphere Reserve of Madhya Pradesh. The study results *Hyophila spathulata* (Harv.) A. Jaeger and *Oxystegus tenuirostris* (Hook. & Taylor) A.J.E. Smith were newly reported from central India; *Semibarbula ranuii* Gangulee and *Weissia edentula* Mitt. were new records for Pachmarhi Biosphere Reserve. Deepa *et al.* (2012) reported the Bryophyte diversity of Malabar Wildlife Sanctuary of Kozhikode district in Kerala, with 79 species including 35 liverworts, one hornwort and 43 mosses. Nath *et al.* (2012) described 13 epiphytic mosses belonging to 9 families and 11 genera, among these 5 taxa are from Pachmarhi Biosphere Reserve.

Daniels *et al.* (2012) revised the family Erpodiaceae in India with detailed descriptions, information on habitat, illustration and distribution map. This family consists of three genera *Aulacopilum* Wilson (with *A. beccarii* (Müll. Hal.) Mitt and *A. glaucum* Wilson), *Erpodium* (Brid.) Brid. (with *E. glaziovii* Hampe and *E. mangiferae* Müll. Hal.) and *Solmsiella* Müll. Hal. (with *S. biseriata* (Austin) Steere). Among these, *Aulacopilum beccarii* was reported as new to Asia which was earlier reported from Africa, Australia, Mexico and South America. *Erpodium glaziovii* as a new record to South and Southeast Asia, which was earlier known as distributed in Brazil, Mexico and Yemen. *Aulacopilum glaucum* was reported as new to India, which was earlier reported from Australia, New Zealand, North & South America and Sri Lanka.

Manju *et al.* (2012a) described one new species of pleurocarpic moss, *Aerobryopsis eravikulamensis* Manju & Rajesh from Eravikulam National Park in the Idukki district of Western Ghats. Molecular analysis was also done for comparing it with the related species of *Aerobryopsis* of India.

Manju *et al.* (2012b) reported *Trichosteleum stigmatosum* Mitt. a rare moss of the family Sematophyllaceae from the Silent Valley National Park as a new record for India. Manju and Rajesh (2012) described new species *Symphysodontella madhusoodananii* Manju & Rajesh of Pterobryaceae from the wet evergreen forests of the New Amarambalam Reserve Forest in Malappuram district of Kerala.

Barbhuiya and Singh (2012) reported 25 species of liverworts and one hornwort from the Borail Wildlife Sanctuary of Assam, of which *Frullania berthoumieui* Steph. turned as a new record for India, *Caudalejeunea reniloba* (Gottsche) Steph. as new for North East India and 13 species as new to Assam. Verma *et al.* (2012) conducted a preliminary survey of liverworts and hornworts in the Hoollongapar Gibbon Sanctuary and reported 27 species, of these 17 were new for the sanctuary.

Prajitha *et al.* (2013) reported one pleurocarpic moss *viz.*, *Aerobryopsis wallichii* (Brid.) M. Fleisch. as a new record for India from Silent Valley National Park in the Western Ghats. Alam (2013) studied the metal depositions in *Plagiochasma rupestre* (G. Frost) Steph., distributed in the Ranthambhore National Park in Rajasthan on different seasons, and discussed its potential in pollution control. Alam (2014a) studied the genus *Fossombronia* Raddi in Nilgiri hills and recorded four species *viz.*, *F. cristula* Austin, *F. himalayensis* Kashyap, *F. pusilla* (L.) Dumort. and *F. wondraczekii* (Corda) Dumort. ex Lindb.

Manjula *et al.* (2013a) provided an account of the family *Geocalycaceae* of Kerala. It is represented by 11 species belonging to three genera *viz.*, *Heteroscyphus* Schiffn. (6 spp.), *Chiloscyphus* Corda (3 spp.) and *Lophocolea* (Dumort.) Dumort. (2 spp.). Among these *Chiloscyphus muricatus* (Lehm.) J.J. Engel & R.M. Schust. and *Heteroscyphus bescherelei* (Steph.) S. Hatt., collected from Eravikulam National Park were turned as new records of occurrence for Kerala.

Manjula *et al.* (2013b) presented an account of the genus *Bazzania* Gray of Lepidoziaceae represented in Kerala. It is represented with four species *viz.*, *B. pearsonii* Steph., *B. praerupta* (Reinw. *et al.*) Trev., *B. sumbavensis* (Gott. ex Steph.) Steph. and *B. tridens* (Reinw. *et al.*) Trev. Among these *B. praerupta* (Reinw., Blume & Nees) Nees was reported as a new record for Peninsular India. *Bazzania pearsonii* Steph. was collected from the Eravikulam National Park.

Manju *et al.* (2014) presented a preliminary list of bryophytes of Silent Valley National Park in Kerala. It contains 148 taxa belonging to 109 mosses, 36 liverworts and 3 hornworts. Of which nine species were new records for Peninsular

India, two were new records for India and four species were new records for Kerala. Bansal and Nath (2014) presented an account of the genus *Bryum* Hedw. in Peninsular India. A total of 26 species were recorded, all of them are present in the Western Ghats, and eight species in the Eastern Ghats. *Bryum tuberosum* Mohamed & Damanhuri was included based on the report of Nair *et al.* (2004) from Karnataka State.

Manjula *et al.* (2015a) reported *Fissidens macrosporus* Dixon, a little known species of the Western Ghats as rediscovered after more than 90 years from the Kuruva Island of Wayanad district. Manjula *et al.* (2015b) also reported *Fissidens linearis* var. *obscurirete* (Broth. & Parish) I.G. Stone as a new record for India based on collections from Munnar of Idukki district and Agasthyamalai Biosphere Reserve of Thiruvananthapuram district. Later it was found as a misidentification and corrected to *F. speluncae* Broth. by Manjula *et al.* in Ellis *et al.* 2019. The re-identification was based on the collections also from the Anamudi Shola National Park of Idukki district, Kerala.

Sreebha *et al.* (2015a) examined bryophyte flora of Indira Gandhi National Park in Tamil Nadu and added *Ceratolejeunea belangeriana* (Gottsche) Steph. as new to the Anamalais in the Western Ghats based on the collections from Agasthyamalai Biosphere Reserve. Sreebha *et al.* (2015b) reported *Symphyodon erraticus* (Mitt.) A. Jaeger, as a new distributional record to the moss flora of Western Ghats. Earlier this species was reported from Bhutan, Indonesia, Myanmar, Nepal, Thailand, Sri Lanka and Eastern Himalayas of India. Sreebha *et al.* (2015c) reported two species of leafy liverworts, viz., *Chiloscyphus campanulatus* Steph. and *Heteroscyphus flaccidus* (Mitt.) A. Srivast. & S.C. Srivast., earlier known as endemic to Himalaya, from the Indira Gandhi National Park of Tamil Nadu.

Manju *et al.* (2015a) reported the genus *Calycularia* of Calyculariaceae from the Western Ghats along with the species *Calycularia crispula* Mitt. from high altitude shola forest of the Mathikettan Shola National Park of Idukki district for the first time from Kerala state. Manju *et al.* (2015b) also reported *Aulacopilum beccarii* (Müll. Hal.) Mitt. from the Chinnar Wildlife Sanctuary of Idukki district, as an addition to the moss flora of Kerala. Bahuguna *et al.* (2016) assessed the diversity of

mosses in the Kedarnath Wildlife Sanctuary (KWLS) of Garhwal Himalaya, Uttarakhand. About 113 species of mosses belonging to 65 genera were reported from the sanctuary. Seven species of mosses viz., *Dicranum orthophylloides* Dixon, *Prionidium setschwanicum* (Broth.) Hilp., *Funaria microstoma* Bruch ex Schimp., *Plagiomnium drummondii* (Bruch. & Schimp.) T. Kop., *Aerobryopsis wallichii* (Brid.) Fleisch., *Barbella turgida* Nog. and *Thuidium talongense* Besch. were new records for India. Twelve species of mosses were new to Western Himalaya, which were earlier only reported from Eastern Himalayan region.

Based on the specimen collected from the Nellyampathy hills of Palakkad district in the Western Ghats of Kerala, Bruggeman-Nannenga *et al.* (2016) reported the African species *Fissidens enervis* Sim. as a new record for Asia. Deepa and Manju (2016) reported *Clevea pusilla*, a rare liverwort of Cleveaceae from the Valparai of Tamil Nadu in the Western Ghats after more than 50 years of its earlier collection.

Sreebha *et al.* (2016a) added *Entodontopsis setschwanica* (Broth.) W.R. Buck & Ireland and *Mitthyridium cardotii* (M. Fleisch.) H. Rob. to the moss flora of Peninsular India with description and illustration. *Entodontopsis setschwanica* was earlier known from China, Nepal and Eastern Himalayas of India; while *Mitthyridium cardotii* from Cambodia, Indonesia, Myanmar, Vietnam and Northeast of India.

Sreebha *et al.* (2016b) reported *Wijkia baculifera* (Dixon) H.A. Crum as a new distributional record for Peninsular India from the Indira Gandhi National Park of Tamil Nadu in the Western Ghats of India. It was earlier known from Myanmar and Northeast of India. The authors included a description, an illustration of the species with the key to distinguish the species from *W. surcularis* (Mitt.) H.A. Crum and *W. tanytricha* (Mont.) H.A. Crum the species known under this genus from the Western Ghats.

Sreebha *et al.* (2016c) rediscovered a long-lost moss, *Fissidens serratus* Müll. Hal., from the Indira Gandhi National Park in Anamalais in the Western Ghats

after nearly two centuries. The specimen was earlier collected during 1834 and 1839 by Perrottet in the Nilgiri Hills has been the only Indian representative of this species.

Singh and Singh (2016) reviewed the taxonomy of the epiphyllous liverworts in India, a total of 160 species were reported from Indian bryoflora along with one subspecies and 2 varieties, coming under 23 genera and 8 families. Singh and Singh (2017) provided an account of eight species of *Riccardia* Gray Eastern Himalaya, including two new taxa viz., *R. lachungensis* D. Singh & D.K. Singh and *R. udarii* D. Singh & D.K. Singh. They also reported the sporophytic details of *R. elata* (Steph.) Schiffn. for the first time. *R. levieri* Schiffn. was newly recorded from the state of Sikkim.

Mufeed and Manju (2017) reported *Porella perrottetiana* Trev. from the Anamudi Shola National Park of Idukki district as a new record for Kerala. Manju *et al.* (2017a) described a new species of *Cololejeunea* viz., *C. manilalia* Manju, Chandini & Rajesh, epiphyllous leafy liverworts, from the high altitude, tropical wet evergreen shola forests of the New Amarambalam Reserve forest of the Malappuram district in the Western Ghats of Kerala. This area was declared as the Karimpuzha Wildlife Sanctuary in March 2020. Manju *et al.* (2017b) reported *Physcomitrium immersum* Sull., a very small, rare species having immersed capsule, as a new addition to the Western Ghats from the Peechi-Vazhani Wildlife Sanctuary of Thrissur district of Kerala. Prajitha *et al.* (2017) reported two rare mosses viz., *Bryocrumia vivicolor* (Broth. & Dixon) Buck new to Kerala and *Phyllodon subretusus* (Thwaites & Mitt.) Ochyra & R.R. Ireland new to India from Malabar Wildlife Sanctuary.

Mufeed and Manju (2018) reported a rare liverwort *Gottschelia schizopleura* (Spruce) Grolle, of the family Scapaniaceae from the Anamudi Shola National Park in the Western Ghats of Kerala. Mufeed *et al.* (2018) reported *Colura calyptrifolia* (Hook.) Dumort., a rare epiphytic, leafy liverwort of the family Lejeuneaceae from the Anamudi Shola National Park in the Western Ghats of Idukki district, Kerala.

Gupta *et al.* (2018) presented an illustrated detailed account of the family

Porellaceae in the Govind Wildlife Sanctuary of Uttarakhand with a total of 12 species and infraspecific taxa. All these species were reported for the first time from the area. Daniels *et al.* (2018) published a book on the bryoflora of Indira Gandhi National Park in Anamalai Hills of Western Ghats. It includes descriptions of 217 species with 135 mosses, 81 liverworts and one hornwort. Among these seven species were reported as new for India and several species as new regional records and rediscoveries.

Deepa *et al.* (2019) reported *Wiesnerella* Schiffn. with the species *W. denudata* (Mitt.) Steph. of Wiesnerellaceae, a monotypic family under Marchantiales, as a new genus and species record for Peninsular India from the Anamudi Shola National Park in the Western Ghats of Idukki district, Kerala. Cargill *et al.* (2019) described a new species of the genus *Riccia* as *Riccia sahyadrica* Manju & Cargill, from the Western Ghats of Peechi-Vazhani Wildlife Sanctuary in Thrissur district of Kerala. It showed resemblances with the Australian species *R. caroliniana* Na-Thalang and comes under the section Viridisquamate, a group characterized by the photosynthetic filaments on the undersurface of the thallus.

Manju *et al.* (2019) reported a new species of *Micromitrium* viz., *Micromitrium vazhanicum* Manju, Chandini & Rajesh, a related species to *M. tenerum* (Bruch & Schimp.) Crosby and *M. austinii* Sull. This species was collected from the Peechi-Vazhani Wildlife Sanctuary of Kerala state. It is a tiny moss that grows in temporary ponds and moist muddy soil of the Moist Deciduous Forest of the Sanctuary.

Asthana *et al.* (2019) described a new species as *Cololejeunea lobulopapillata* A.K. Asthana *et al.* from Jakhol in Govind Wild Life Sanctuary in Uttarakhand. It is related to *C. nilgiriensis* G. Asthana & S.C. Srivast. and found growing on leaves of *Porella plumosa* (Mitt.) Parihar.

Daniels and Kariyappa (2019) published a book of the bryoflora of the Agasthyamalai Biosphere Reserve in the Southern Western Ghats which stretches over the borders of Kollam and Thiruvananthapuram Districts in Kerala and Tirunelveli and Kanyakumari Districts in Tamil Nadu. They reported an account of

403 species and 15 intraspecific taxa belonging to 160 genera, 60 families and 16 orders.

Asthana and Sahu (2020) reported a new variety of *Paraleucobryum enerve* (Thed.) Loeske as *P. enerve* var. *secundum* Asthana & Sahu from the Govind Wildlife Sanctuary in Uttarakhand of Western Himalaya. Mufeed and Manju (2020) contributed four species of mosses from the Anamudi Shola National Park as new records to the report of new and national bryophyte records by Ellis et al. (2020). *Didymodon revolutus* (Cardot) R. S. Williams was a new record for India., *Myurium borii* (Dixon) Magill was a new record for the Western Ghats, *Barbella bombycina* (Renauld & Cardot) M. Fleisch. and *Lepidopilidium furcatum* (Thwaites & Mitt.) Broth. were new records for Kerala. Chandini *et al.* (2020) described the genus *Drepanolejeunea* (Spruce) Schiffn. of the family Lejeuneaceae occurring in Kerala with a key to the genus in Western Ghats. Among the six species in Kerala *Drepanolejeunea angustifolia* (Mitt.) Grolle and *D. ternatensis* (Gottsche) Steph. were collected from Anamudi Shola National Park in the Western Ghats; *D. erecta* (Steph.) Mizut., is collected from Schenduruni Wildlife Sanctuary in Kollam district, *D. fleischeri* (Steph.) Grolle & R.L. Zhu and *D. pentadactyla* (Mont.) Steph was collected from Parambikulam Tiger Reserve in Palakkad district.

Manju *et al.* (2020; in press) described a second new species of *Bryocrumia* viz., *Bryocrumia malabarica* Manju, Prajitha, Prakashkumar & W.Z. Ma from the Malabar Wildlife Sanctuary in the Western Ghats of Kerala, similar to the *Bryum vivicolor*, the only known earlier species in the genus *Bryocrumia*. The new species is characterised by closely arranged leaves with distinct tricostate, ovate-rounded to truncate leaves, upper margin of leaf rounded with fine serrations and an inconspicuous central strand in stem cross section.

From this review, it is clear that the bryophyte studies with respect to protected areas in India are very less compared to the vast areas.

Bryo-floristic studies with reference to India

The detailed studies on Indian bryology were started by S.R. Kashyap, the father of Indian Bryology. He (1914) published an article on the West Himalayan

Hepatics. His subsequent publications on various aspects of hepaticology contributed much to the knowledge on Indian liverworts (1914-1932). The publication on *Liverworts of Western Himalayas and Punjab Plain* (1929-1932) includes 161 species, out of which 4 genera and 50 species were new to science. Followed by Kashyap, his students Pande (1936), Bhardwaj (1948, 1950, 1960a & b, 1965a & b, 1971, 1972), Srivastava (1967), Mahabale (1958), Udar (1970, 1976), and others made valuable contributions to Indian Hepaticology.

Kashyap (1915) described two new species of *Anthoceros* viz., *A. erectus* Kashyap and *A. himalayensis* Kashyap (the latter now is called as *Phaeoceros himalayensis* (Kashyap) Prosk.) from the Western Himalayas. Two years later he (1917) discovered another species of *Anthoceros* as *A. chambensis* Kashyap from the Western Himalayas. In 1929 he reduced *A. butleri* under *A. erectus* Kashyap, which is now treated as *Phaeoceros erectus* Kashyap. Kashyap (1917) reported *Aneura indica* Steph. from various parts of the Himalayas, Punjab plains and South India. Kashyap and Pande (1922) described the thallus structure of *Aneura indica* Steph., drawing attention to its extreme variability in different localities. Kashyap and Dutt (1925) described *Notothylas indica* Kashyap from the plains of Uttar Pradesh. Pande and Kashyap (1922) published the life history of *Aneura indica* Steph.

Dixon (1921) published an account on the sporadic collection of 43 species of mosses under 27 genera from the Kanara district of Karnataka. Dixon (1925) studied mosses collected by T.H. Somervell, and described *Grimmia somevellii* Dixon. Varde (1925) described the mosses of South India based on the collection of Foreau from Madura and reported 32 new species of mosses in South India. Noguchi (1958) studied a small collection of mosses from Southern India collected by T.S. Rao and recorded 27 taxa in 15 families.

Gangulee, 'the father of Indian moss' described the mosses of Eastern India in a series of publications. He described the members of the order Fissidentales in 1957, order Dicranales and family Ditrichaceae in 1959, Dicranaceae in 1960 and Leucobryaceae in 1960. Gangulee (1969-1980) made valuable contributions in his series of publications. His work, *Mosses of Eastern India and adjacent regions – A Monograph*, provided a well-illustrated, detailed taxonomic account, and the

distribution map of 990 species of mosses. This book is the first detailed description of mosses and it forms the basic reference manual to study the Indian mosses.

Mahabale (1958) published a paper on the taxonomy of liverworts and mosses. Regeneration on four species of *Atrichum* P. Beauv. have been carried out by Chopra (1960) and gave a preliminary list of mosses from Nainital proper and its nearby localities of Uttarakhand.

Sharma (1971) described the abnormal sex organs in *Pogonatum microstomum* (R.Br.) Brid., during his studies in *Pogonatum* P. Beauv. species. Vohra (1983) examined the suborder Leskineae coming under Hypnobryales of the Himalaya. He has given detailed information of taxonomic features, anatomical features and identification keys of this group.

Gangulee (1985) published a book 'Handbook of Indian mosses' for bryophyte enthusiasts. It consists of 100 species of mosses with detailed illustrations and identifying keys. Rajeevan (1990) examined the bryophytes from the Painavu and Kulamavu regions of the Idukki district in Kerala, as part of his Ph.D. work. It was the first Ph.D. thesis of bryophytes from Kerala. *Bryum tuberosm* Mohammed and Damanhuri earlier known only from the mainland of Peninsular Malaysia (Mohammed & Damanhuri, 1990) was recorded by Nair *et al.* (2004) as a new record to India from the Udupi in Karnataka.

Asthana and Srivastava (1991) made an attempt to clarify the taxonomic status of Hornworts occurring in the Indian subcontinent with the help of electron microscopy. Sporoderm ornamentation was studied using this. They described 34 species belonging to 3 families and 5 genera of hornworts with detailed key, illustration and distribution of each species.

Taxonomic revision of Indian Lepidoziineae has been made by Sharma and Srivastava (1993). The study revealed the presence of Calypogiaceae in the Indian subcontinent. Srivastava and Udar (1975) studied the genus *Fossombronia* Raddi in India with a note on the Indian taxa of Fossombroniaceae, of which six were found in Southern India. Nath and Asthana (1998) reported the diversity and distribution of the genus *Frullania* Raddi in South India, represented by its twelve species with

morphological, vegetative and reproductive characters. Nath *et al.* (2000) explained the significant role of bryophytes in soil management and rock binding based on their critical observations. The study also discussed land conservation, mineral indication, slope formation, erosion prevention, etc. Srivastava and Alam (2002) reported eight species of *Frullania* Raddi from Nilgiri hills of Tamil Nadu with a new record for India, the *Frullania densiloba* Steph., a species with ocelli other than *F. tamarisci* (L.) Dumort. Srivastava and Srivastava (2002) studied the family Geocalycaceae in India and reported 27 taxa belonging to four genera *Chiloscyphus* Corda, *Heteroscyphus* Schiffn., *Lophocolea* (Dumort.) Dumort. and *Geocalyx* Nees. Among the 27 taxa, nine are endemic to India.

Madhusoodanan and Nair (2003) reported *Ricciocarpus natans* (L.) Corda and *Notothylus levieri* Schiffn. ex Steph. from the Western Ghats of Kerala, as new records for South India. A preliminary account on the diversity of the Bryophyte of Kerala with a brief history, its importance and implication of conservation was discussed by Nair and Madhusoodanan (2004).

Srivastava and Alam (2004) reported *Frullania riojaneirensis* Raddi, for the first time from India from Gudalur region of Nilgiri Hills in Tamil Nadu. Lal (2005) presented a checklist of Indian mosses, composed of 1576 taxa distributed over 338 genera belonging to 57 families. Chopra (2005), described different aspects of biology of bryophytes such as ultrastructure, reproductive biology, ecology, morphogenesis, physiology and biochemistry.

Choudhary *et al.* (2006) made an effort to complete the bryoflora of the Gujarat state by providing taxonomic accounts, habitat, ecological zonation and distribution of bryophytes of 67 taxa belonging to 9 orders under 20 families. A preliminary checklist of 53 species of mosses and liverworts of Vellarimala in the Western Ghats of Wayanad district was done by Nair and Madhusoodanan (2006). Long (2006a) prepared a brief note on Himalayan Hepatics, composed of 24 species of leafy hepatics with three Himalayan records and several national and regional records. *Geocalyx lancistipulus* (Steph.) S. Hatt., *Tritomaria quinquedentata* (Huds.) H. Buch and *Tritomaria scitula* (Taylor) Jørg. were new records to Himalaya and *Andrewsianthus ferrugineus* Grolle and *Lophozia decolorans* (Limpr.) Steph. were

new records to India.

Rawat and Srivastava (2007) made an extensive study on the genus *Plagiochila* in Eastern Himalaya, composed of 38 species of two subgenera; including a new species *P. meghalaynsis* Rawat & Srivastava and four species, viz., *P. detecta* Grolle & So, *P. perserrata* Herz., *P. defolians* Grolle & So and *P. hattori* Inoue as new records for India.

Singh and Nath (2007) provided detailed taxonomic accounts of 247 species, under 59 genera of Hepaticae of Khasi and Jaintia Hills in Eastern Himalaya. They described 10 new species along with 166 new additions to the study area.

An account of 130 species under 29 genera of Pottiaceae (Musci) of India was made by Aziz and Vohra (2008). Choudhary *et al.* (2008) studied the bryoflora of North Konkan in Maharashtra, which includes detailed illustrations, taxonomic features, ecological aspects and phytogeographical aspects of 100 species of bryophytes, belonging to 37 genera under 24 families. Pradhan and Joshi (2008) prepared an account of the family Bryaceae of Nepal, composed of 82 taxa including three subspecies and five varieties under seven genera.

Savitha *et al.* (2008) reported *Cololejeunea latilobula* (Herzog) Tixier and *Schiffeneriolejeunea pulopenangensis* (Gott.) Gradst. of Lejeuneaceae as new records for Kerala state based on the collections from the Zamorin's Guruvayurappan College Campus in Kozhikode district. Manju *et al.* (2008) presented a checklist of the bryophytes of Kerala comprising 148 taxa of liverworts, 10 taxa of hornworts and 307 taxa of mosses.

Alam (2009) studied 29 species of rare and endangered terrestrial Hepaticae of Nilgiri and Palni hills of Tamil Nadu. Bhat (2009) studied the mosses of the Western Ghats and the Coastal belt of Karnataka as part of her Ph.D. work. She recorded 188 species under 97 genera and 35 families and includes several new records.

Based on the collection/s from Aralam Wildlife Sanctuary of Kerala, Manju *et al.* (2009e) reported *Groutiella tomentosa* (Hornsch.) Wijk & Margad. of Orthotrichaceae for the first time from Peninsular India. Ramesh and Manju (2009)

provided an account of some ethanobryological aspects in the Western Ghats based on the tribal peoples of the Attappady region of Palakkad district, Kerala. They reported that the Mudugar tribe used *Frullania ericoides* (Nees ex Mart.) Mont. for removal of head lice (*Pediculus humanus* Linn.) and for the nourishment of hair and Irular tribe used *Targionia hypophylla* L. for treatment of scabies, itches and other skin diseases.

Asthana and Shukla (2010) reported *Colura leratii* Steph., an epiphyllous leafy liverwort as a new record for India based on the collection from Agumbe in Karnataka.

A checklist of Bryophytes in India was prepared by Dandotiya *et al.* (2011). Study results 2489 species of bryophytes recorded from India, comprising 1786 species of mosses in 355 genera, 675 species of liverworts in 121 genera and 25 species of hornworts in six genera. But the study also made some mistakes such as double entry, nomenclatural errors, etc. Verma *et al.* (2011) prepared a checklist of mosses in Nilgiri Hills of Tamil Nadu, which includes about 165 species, with 22 new records. A critical revision of Campylopodioideae from India by Frahm (2012) proved that 20 valid species only are valid out of the 70 names known from the region.

Manju *et al.* (2011a) reported *Exormotheca tuberifera* Kasyap, a rare liverwort from Neriamangalam of Ernakulam district Kerala as a new record for Kerala. Manju *et al.* (2011b) recorded 40 species of bryophytes including 24 mosses and 16 liverworts of Kakkavayal reserve forest in the Western Ghats of Kozhikode district, Kerala. This includes four new records of phytogeographical significance to Kerala viz., *Cololejeunea appressa* (Evans) Benedix, *C. follicola* Srivastava & Srivastava, *C. udarii* Asthana & Srivastava and *Pallavicinia himalayensis* Schiffn.

Manju *et al.* (2012a) recorded the different life forms of Bryophyte of the Western Ghats based on their habit structure. Dey and Singh (2012) produced a book on Epiphyllous Liverworts of Eastern Himalaya, containing accounts of 89 taxa under three orders. Manju *et al.* (2012b) discussed the identity of *Riccia fluitans* L. available in India and compared it with the African and European species. They

stated that the species described as *R. fluitans* L. in India is like that of *R. stricta* (Gottsche, Lindenb. & Nees) Perold described from Africa and *R. fluitans* is found only in European countries. Manju *et al.* (2012c) reported 76 species of Lejeuneaceae members from the Western Ghats. Among these three species viz. *Archilejeunea abbreviata* (Mont.) Vanden Berghen, *Otolejeunea semperiana* (Gottsche *et* Steph.) Grolle and *Tuyamaella angulistipa* (Steph.) Schust. & Kachroo were new records for India. One species viz., *Lejeunea cocoes* Mitt., was a new record for Southern India and three species viz., *Archilejeunea minutilobula* Udar & U.S. Awasthi, *Cololejeunea appressa* (A. Evans) Benedix and *C. udarii* G. Asthana & S.C. Srivast. were new records for Kerala. Manju *et al.* (2012) reported *Lejeunea cocoes* Mitt. from the forests of Peruvannamuzhi in Western Ghats of Kerala as a new record for India.

Manju (2013) discussed the current status and conservation aspects of bryophytes in the Western Ghats and stated that there are about 950 species of bryophytes reported and the estimated diversity is 2000 species. Rajesh *et al.* (2013) reported *Symphyodon complantus* Dixon of the family *Symphyodontaceae* as a new record for Kerala from the Thusharagiri hills in Kozhikode district.

Schwarz and Frahm (2013) reported 94 species from the Coorg district in Karnataka, which includes 18 species of liverworts, One species of hornwort and 76 species of mosses. Among these, 27 species of mosses are newly reported for the state of Karnataka and six species are new for Coorg province. One species viz., *Holomitrium javanicum* Dozy & Molk. is reported as new to India.

Daniels and Kariyappa (2013) changed the status of *Cheilolejeunea ceylanica* (Gottsche) R.M. Schust. & Kachroo into *Cheilolejeunea trapezia* var. *ceylanica* (Gottsche) Daniels & Kariyappa. The only tenable character that distinguishes the former and the latter is the presence of vitta in the leaves of the former. Daniels and Daniel (2013) published a book on the bryoflora of the Southernmost Western Ghats. It includes an account of 240 species of bryophytes with 145 mosses, 90 liverworts and 5 hornworts. This work reports three new species and seven new records for India.

Frahm *et al.* (2013) listed the acrocarpic and pleurocarpic mosses from Karnataka state. They listed the species which are already reported from Karnataka. Dey *et al.* (2013) described thirteen species of *Drepanolejeunea* of Marchantiophyta in Eastern Himalayas along with three new records viz., *Drepanolejeunea longii* Grolle & R.L. Zhu, *D. siamensis* (Bischn.) Grolle & R.L. Zhu and *D. tibetana* (P.C. Wu & J.S. Lou) Grolle & R.L. Zhu for Indian Bryoflora. Bahuguna *et al.* (2013) described the diversity of bryophytes, morphological forms and types of habitats in their book with photographs. It explains the ecological aspects of bryophytes inhabit in the area. Singh and Singh (2013) studied the taxonomic status of *Metzgeria macrospora* Kuwah. and compared it with *M. consanguinea* Schiffn.

The family Pottiaceae, one of the dominant acrocarpic moss families of Kerala were reviewed by Vidya *et al.* (2014). They reported 18 species distributed among 13 genera of which *Pottia bryoides* (Dicks.) Mitt., a calcareous rocky species, collected from New Amarambalam Reserve Forest of Malappuram district as a new record for India. Two species viz., *Barbula tenuirostris* Brid. and *Syntrichia fragilis* (Tayl.) Ochyra. were reported as new records for Kerala.

Mufeed *et al.* (2014) presented an account of 32 species of bryophytes of Thusharagiri hills of Kozhikode district. Sandhya Rani *et al.* (2014) presented an account of taxonomic features, distribution, habitat, ecology of 94 species under 67 genera belonging to 36 families of bryophytes of Andhra Pradesh. Aruna and Krishnappa (2014) studied the bryophyte distribution of the mainland of Chikmagalur district in Karnataka and recorded 62 species belonging to 44 genera and 30 families.

Deepa *et al.* (2015) reported *Exormotheca ceylonensis* Major, an endangered liverwort of India, and listed in IUCN threat category from the highly-threatened habitat of Seetharkundu of Palakkad district. Ellis *et al.* (2015) reported several new and noteworthy bryophytes of the world. In this paper, Nair *et al.* from Kerala contributed one species viz. *Syrrhopodon parasiticus* (Brid.) Besch. collected from Kuruva dweep in Wayanad district and reported as new record for India.

Singh and Singh (2015) provided an account of Liverworts and Hornworts of

Himachal Pradesh, and recorded 142 taxa of liverworts and 10 species of hornworts. *Pallavicinia lyellii* (Hook.) Gray, was reported for the first time from Tillarinagar forest, Western Ghats of Kolhapur District in Maharashtra by Lavate *et al.* (2015). Mehta *et al.* (2016) reported eight species of *Fissidens* from different parts of Gujarat, among these three species, were identified up to species level viz., *Fissidens splachnobryoides* Broth., *F. zollingerii* Mont., and *F. xiphoides* M. Fleisch. Manjula *et al.* (2016) described eight species of *Fissidens* from the Eastern Ghats of Andhra Pradesh. Among these, *Fissidens taxifolius* Hedw. and *F. palldinervis* Mitt. were new records for Eastern Ghats and *F. crispulus* Brid. and *F. ceylonensis* Dozy & Molk. were new records for Andhra Pradesh.

Alam *et al.* (2015) prepared a detailed checklist of mosses of Central India composed of 210 valid taxa under 94 genera, and 30 families. Family Pottiaceae were the most abundant one represented by 34 taxa under 19 genera, while genus *Fissidens* was the largest with 26 taxa distributed in the central Indian bryogeographical zone.

Singh (2016) reported two species of the family Lejeuneaceae, viz. *Cololejeunea subocelloides* Mizut. and *Drepanolejeunea laciniata* Qiong He & R.L. Zhu for the first time in Indian bryoflora collected from Sikkim. Jyothilakshmi *et al.* (2016) studied the bryophyte diversity in the Vallikattu Kavu of Kozhikode district and discussed their conservation in the sacred grove. This is the first report of bryophyte in a sacred grove in India. They reported many interesting findings such as *Bryum retusifolium* var. *heterophyllum* Card. ex Gangulee as a new record for Kerala and *Ditrichum tortuloides* Grout. as a new record for Peninsular India. The endemic species *Fissidens kammadensis* Manju *et al.* reported from Kammadam kavu of Kasaragod district and the rare species *Calymperes palisotti* Schwägr. could be collected from this sacred grove.

Manju and Rajesh (2017) published a book on Liverworts of Kerala, which consists of 100 species with several national and regional records. Magdum *et al.* (2017) made a checklist of the mosses of the Western Ghats of Maharashtra, composed of 129 species belonging to 11 orders, 26 families and 59 genera. Manjula *et al.* (2017) reported a new species *Fissidens manilalia* Manjula, Manju & Rajesh

belonging to the subgenus *Aloma* of the family Fissidentaceae from the human influenced habitat in the lowlands of Kerala. It is also compared with the related taxa *F. bogoriensis* M. Fleisch and *F. flabellulus* Thwaites & Mitt. Challenges to the conservation of species in human influenced habitats in India are also discussed. Manju *et al.* (2017) reported *Amblystegium serpens* (Hedw.) Schimp. of the family Amblystegiaceae as a new record for Peninsular India collected from Anakkampoyil of Kozhikode district in Kerala.

Sharma and Bhagat (2017) studied the reproductive biology of *Wiesnerella denudata* (Mitt.) Steph and reported that there is no means of vegetative propagation and reproduction takes place only by sexual mode. This unique reproductive character made it a rare species and they could collect only a single patch during the course of their exploration in ten districts of Jammu and Kashmir. Singh (2018) presented the taxonomic description of four species of *Marchantia* L. namely *M. emarginata* Reinw., Blume & Nees subsp. *emarginata*, *M. linearis* Lehm. & Lindenb, *M. papillata* Raddi subsp. *grossibarba* (steph.) Bischl. and *M. paleaceae* Bertol. subsp. *paleaceae* from Mizoram. Venugopal and Manju (2017) reported the bryophyte diversity of Thamarassery pass (Wayanad pass) in the Western Ghats of Kerala, including eight species of liverworts and 30 species of mosses.

Negi *et al.* (2018) reported antibacterial properties of *Marchantia papillata* Raddi subsp. *grossibarba* (steph.) Bischl. against bacteria *Staphylococcus aureus*. Ellis *et al.* (2019) reported some new bryophyte records of phytogeographical significance from different parts of the world. In this paper bryologists of Kerala also contributed by recording species such as *Fissidens brevinervis* Broth., *F. speluncae* Broth. and *Fissidens viridulus* (Sw.) Wahlenb. *F. brevinervis* is a new record for Northeast India, a species already known from Karnataka in India and corrected the misidentification of *F. linearis* var. *obscurirete* (Broth. & Paris) I.G. Stone, reported by Manjula *et al.* (2015) as *F. speluncae* Broth. *F. speluncae* is a new record for India. *F. viridulus* is reported as a new record for the Western Ghats, collected from Nandhi hills in Karnataka, a species already known from Western Himalayas.

Dixit and Kerketta (2019) recorded 24 species of liverworts from Bilaspur

district, Chattisgarh. They examine the bryophyte distribution in different altitudes and the influence of the bryophyte distribution in different elevations. Thoker and Patel (2019) recorded about 241 taxa of bryophytes belonging to 17 orders, 51 families and 123 genera from Jammu and Kashmir. Among these 20 species were used as medicine for various diseases, such as rheumatism, body aches, antidote, antifungal, wounding and epilepsy, etc.

Manju *et al.* (2019) rediscovered *Oreoweisia brevidens* Herzog after 75 years from the Nandhi hills in Karnataka State. After the type collection by Herzog (1939) from Assam there was no report of this species since then.

Manju *et al.* (2020) provided an overview of the family Calymperaceae occurring in Kerala and recorded five genera viz., *Calymperes* Sw. (8 spp.), *Exostratum* L. T. Ellis (1 sp.; *E. blumii*), *Leucophanes* Brid. (2 spp.; *L. glaucum* and *L. octoblepharioides*), *Octoblepharum* Hedw (1 sp.; *O. albidum* Hedw.) and *Syrrhopodon* Schwägr (5 spp.). Among these *Exostratum* turned as a new genus record and *Syrrhopodon prolifer* Schwägr. was a new species record for Kerala.

Omar *et al.* (2020) provided an account of Mniaceae in India, of which *Orthomnion javense* Koponen from Nandhi hills of Karnataka turned as a new record for India. Earlier it was known from China, Indonesia, Japan, Laos, Papua New Guinea, Philippines and Vietnam. They also reported *O. javense* as a new record for East Nepal. *Plagiomnium insigne* (Mitt.) T. J. Kop. collected from Gulmarg in Jammu and Kashmir and known as badge moss also has been reported for the first time from Asia. It was earlier known from North America.

Singh *et al.* (2020) morphotaxonomically investigated the genus *Colura* (Dumort.) Dumort. in India and recognized eight species in three different bryogeographical regions of the country. Among these, *Colura corynophora* (Nees, Lindenb. & Gottsche) Trevis. is reported as a new record for India. Extended distribution of other species also reported such as *C. leratii* (Steph.) Steph. is added to the Eastern Himalayas, *C. acroloba* (Prantl) Jovet-Ast, *C. ari* (Steph.) Steph. and *C. conica* (Sande Lac.) K.I. Goebel were new to Mizoram, while *C. tenuicornis* (A. Evans) Steph. was a new report to the state of Meghalaya. The earlier report of *C.*

calyptrifolia (Hook.) Dumort. is verified and commented that the report of Mufeed *et al.* (2018) collected from Anamudi Shola National Park is a new record for India.

Manjula and Manju (2020) described the section *Crispidium* (Müll. Hal.) Pursell & Brugg.-Nann. of *Fissidens* Hedw. subgenus *Pachyfissidens* (Müll. Hal.) Kindb. in the Western Ghats, along with a description of a new variety *F. crispulus* var. *nelliampathiae* Manjula & Manju collected from Nelliampathy hills in Palakkad district of Kerala. One species viz., *Fissidens subangustus* Fleisch. is also recorded as the new report for Kerala State. Chandini *et al.* (2020) described the genus *Drepanolejeunea* (Spruce) Schiffn. of the family Lejeuneaceae occurring in Kerala with a key to the genus in the Western Ghats. This study reports a total of six species in Kerala. Among these, *Drepanolejeunea erecta* (Steph.) Mizut. is reported as new to the Western Ghats, *D. fleischeri* (Steph.) Grolle & Zhu, *D. pentadactyla* (Mont.) Steph. and *D. ternatensis* (Gottsche) Steph. are reported as new records for Kerala.

From this review, it is clear that the study of bryophytes is still progressing very well in Kerala compared to other South Indian states. Many interesting findings have been brought to light here. The high diversity of this plant group is indicated by the earlier studies. It also indicates the need for more exploration in unexplored and under explored areas such as reserve forests, sacred groves, sanctuaries, national parks, etc. for getting a better picture of the bryophyte diversity of the area.

Some major International works carried out in Bryophytes

The taxonomic studies on the bryophytes are critically evaluated during the last century in different parts of the world. Jones (1953) described a detailed note on African hepatics which includes the genus *Lophocolea* (Dumort.) Dumort., *Chiloscyphus* Corda and *Leptoscyphus* Mitt. Noguchi (1963) reported 23 species of mosses from the Philippines which were collected by G.E. Edano. Anderson (1963) evaluated the evolutionary status of mosses with several criteria. The study includes, the geographical pattern, cytogenetics, distribution, discontinuity of mosses in different continents leads to a separate position from flowering plants. Thirteen species of *Fissidens* are described and figured from Society Islands (Tahiti, Moorea and Raiatea) along with new species, *F. jaiorum* H. Whittier & H.A. Mill. by

Whittier and Miller (1967). Hattori (1972-76) prepared notes on the Asiatic species of the genus *Frullania* described with illustrations in a series of publications. Mohamed (1979) made an attempt to study the taxonomy of *Bryum billardieri* Schwägr. and compared with *Bryum billardieri* Schwägr. Mohamed (1984) studied the genus *Rhodobryum* (Schimp.) Limpr. with seven species in Asia using the anatomical characters

Ellis (1989) provided an account of fourteen species of *Calymperes* Sw. ex F. Weber that occur in the Indian Peninsula including, Sri Lanka, the Andaman and Nicobar Islands, Westward the Island of Lakshadweep and the Maldives.

Bischler-Causse (1989) did a critical revision of the Asiatic and Oceanic species of the genus *Marchantia*. She could recognize nine species of *Marchantia* viz., *M. emarginata* Reinw., Blume & Nees subsp. *emarginata*, *M. geminata* Reinw., Blume & Nees, *M. Hartlessiana* Steph., *M. Linearis* Lehm. & Lindenb., *M. paleaceae* Bertol. subsp. *paleaceae*, *M. Pappeana* Lehm. subsp. *Robusta* (Steph.) Bischl., *M. papillata* Raddi subsp. *Grossibarba* (Steph.) Bischl., *M. polymorpha* subsp. *polymorpha* and *M. subintegra* Mitt. from India. The author synonymised *M. kashyapii* under *M. pappeana* Lehm. subsp. *robusta* (Steph.) Bischl., *M. papulosa* under *M. subintegra* and *M. palmata* under *M. emarginata* Reinw. *et al.* subsp. *emarginata*. Author also studied the European and African taxa of the genus in 1993 and reported six species and five subspecies under two subgenera with detailed taxonomic key and illustrations.

Robinson (1990) examined the evolutionary aspects of Leucobryaceae, which is having eight genera. Mohamed and Robinson (1991) revised the moss families Hookeriaceae (9 genera and 28 species) and Hypoterygiaceae (3 genera and 7 species) in the Malay region.

Hedenäs (1992) published a flora on the pleurocarpous mosses of the Madeira Archipelago, which includes three orders, viz., Isobryales, Hypnobryales and Hookeriales with 46 genera with 88 species and one variety. Buck (1994) made an elaborated study of the largest moss family Meteoriaceae. So (1995) and Zhu and So (1996) evaluated the bryoflora of Hong Kong and recorded 175 species of

mosses and 121 liverworts. Eddy (1996) published a series of books on Malaysian mosses; and the 3rd volume consists of 42 genera coming under 12 families. Pursell (1997) prepared a taxonomic account of the Neotropical *Fissidens* after his monograph of the genus in Neotropics (Pursell, 1994). This addendum reports designation of four lectotypes, *Conomitrium generalium* Müll. Hal., *Diplostichum ulei* Müll. Hal., *Fissidens fossicola* Müll. Hal. and *Fissidens moritzianus* Müll. Hal.

A synoptic taxonomic treatment was provided by Beever (1999) for 24 species and 9 varieties of *Fissidens* of New Zealand. Shaw and Goffinet (2000) published an informative book on Bryophyte biology. This book deals with several aspects and problems in the bryophyte taxonomy. It provided an elaborated account on aspects such as anatomy and classification of Hornworts, morphology and classification of Marchantiophyta, classification of Mosses, origin and phylogenetic relationship of bryophytes, molecular and genetical studies, ecological aspects and role of bryophytes, etc. The classification schemes proposed in this are considered the best in modern times. He and Snider (2000) revised the genus *Symphiodon* Mont. distributed the world over and provided an illustrative account of 15 species including peristome structure and geographical distribution.

So is an eminent bryologist who specialized in liverworts at the Hong Kong Baptist University. Her contributions to bryophyte taxonomy are remarkable. So (2001a) gave a detailed account of the genus *Plagiochila* in China. She collected and worked out more than 5000 specimens from the study area, and reported 80 species with illustrations and taxonomic features. So (2001b) listed 400 species of *Plagiochila* from Australasia and some Island groups of Pacific Ocean and listed them with their original publications and type locality. She has published papers on the taxonomy of the Asian, Australasian and Pacific members of various liverwort genera. So (2002) described seven species of *Porella* L. from Australasia and South Pacific regions. Reese and Pursel (2002) examined the forest floor termite structures in Amazonia and described certain taxa of *Fissidens* which appear to grow on termite structures because of their high organic content.

So (2003) done a revisionary study on the genus *Metzgeria* in Asia and reported 10 species viz., *M. consanguinea* Schiffn., *M. crassipilus* (Lindb.) A. Evans,

M. foliicola Schiffn., *M. furcata* (CL.) Dumort., *M. leptoneura* Spruce, *M. lindbergii* Schiffn., *M. pubescens* (Schränk.) Raddi, *M. robinsonii* Steph., *M. scobina* Mitt., and *M. temperata* Kuwah. Twenty synonyms were proposed and a key to the species in Asia was also provided. Igantov & Ignatova (2003) reported *Brachythecium buchananii* (Hook) A. Jaeger as new for Uzbekistan.

Khatun and Hadiuzzaman (2005) reported *Barbella rutifolia* (Thwait & Mitt.) Broth. and *Pterobryopsis auriculata* Dix. as new records for Bangladesh.

Long (2006a) produced a revision of the genus *Asterella* P. Beauv. in Eurasia. The study includes morphological features of habit, spore tetrads and anatomical characters of 16 species of *Asterella*. Van Zanten (2006) gave a detailed account of the genus *Racopilum* P. Beauv. in Asia, Australasia and Oceania. The study reports eleven species and two varieties including one new species *R. tuibformis* Zanten from Sumatra. The glossary of mosses and other bryophytes by Malcolm and Malcolm (2006) was one of the best. The book gave a detailed illustrated glossary of terms that are used to describe mosses, liverworts and hornworts. Over 530 species of bryophytes are illustrated. Glime (2006) tried to attempt the ecological significance of bryophytes using physiological parameters and highlighted the role of bryophytes in ecosystem processes. Juslén (2006) revised the Asian *Herbertus* Gray, and recorded 12 species.

Long (2006b) did a detailed taxonomic revision of the genus *Asterella* P. Beauv. in Eurasia and gave a detailed account of 16 species with illustrations under five subgenera viz., subgenus *Asterella* with six species, subgenus *Saccatae* (Grolle) D.G. Long with two species, subgenus *Wallichianae* D.G. Long with one species, subgenus *Phragmoblepharis* Grolle with seven species and subgenus *Graciles* D.G. Long with one species.

Seppelt *et al.*, (2007) described the family Ditrichaceae in the flora of North America, with nine genera and 30 species. Pursel (2007) prepared a monograph on the family Fissidentaceae in the Neotropics and adjacent regions. The systematic treatment of Sematophyllaceae in Thailand was done by Pollawatn (2008) and reported 116 species under 24 genus.

Ignatov and Milyutina (2010) had presented a comparative account of molecular phylogenetic analysis with morpho-anatomical features of the genus *Brachythecium* in Russia. They also described a new species, *B. helminthocladum* Ignatov. Atherton *et al.* (2010) published a supportive field guide on mosses and liverworts of Britain and Ireland. The book helps to identify the bryophytes from the field with useful keys, photographs and illustrations. An illustrated guide only for the field identification of mosses and liverworts of the Mediterranean regions with macro photographs of 174 species was done by Frahm (2010).

Pócs and Ninh (2012) reported 36 species of epiphyllous liverworts from the low land areas of the Cát-tiên National Park, Southern Vietnam, including *Colura ornata* K.I. Goebel as a new record for Vietnam. Orgaz *et al.* (2012) revised the genus *Brachythecium* in the Mediterranean region and reported 14 species with detailed illustrations, descriptions and distribution data. Some species were reported as new records for Bosnia-Herzegovina, Cyprus, France and Slovenia and lectotypes for *Brachythecium geheebii* Milde, *Hypnum glareosum* Bruch ex Spruce and *Hypnum mildeanum* Schimp. are designated. Phephu (2013) conducted a taxonomic revision of the family Thuidiaceae in Africa and East African Islands recording 16 species under three genera viz., *Pelekium* Mitt., *Thuidiopsis* (Broth.) M. Fleisch. and *Thuidium* Bruch & Schimp. Bruggeman-Nannenga (2013) revised the subgenus *Fissidens* in Tropical Eastern Africa based on the Tanzanian collections by Tamas Pócs in 1986. She recorded 18 species of *Fissidens* including 14 African endemics and several national and regional records. Hassel *et al.* (2014) reported *Colura calyptrifolia* (Hook.) Dumort. as a new record for Norway and Scandinavia.

Hallingback and Tan (2014) reviewed past and present activities of bryophytes and they also proposed novel strategies and awareness of bryophyte conservation in the future. Shu *et al.* (2015) conducted a detailed study on the rare liverwort *Cheilolejeunea larsenii* Mizut. reported from Africa and Brazil. They also proposed *C. ghatensis* G. Asthana, S.C. Srivast. & A.K. Asthana, an endemic species from India, *C. adnata* var. *autoica* Gradst. & Ilk.-Borg., reported from French Guiana and *C. exinnovata* E.W. Jones from Sierra Leone as synonyms of *C. larsenii* Mizut. Gradstein (2015) provided an illustrative account of 34 species of *Plagiochila* from Brazil. Potemkin *et al.* (2017) reported *Calypogeia azurea* Stotler

& Crotz, a little known leafy liverwort in North-Western European Russia. This species could be collected from the Anamudi Shola National Park during the present study.

A new species of *Metzgeria* Raddi, *M. mizoramensis* Sushil K. Singh & D. Singh was described from Mamit district of Mizoram by Singh and Singh (2018). The species is distinguished by its monoicous sexuality, hairs usually disposed singly along the margin and also scattered on the ventral surface of the thallus, 2-3 rows of epidermal cells of midrib in ventral view and presence of marginal gemmae.

Alonso *et al.* (2018) evaluated the status of *Chionoloma tenuirostre* (Hook. & Taylor) M. Alonso, M.J. Cano & J.A. Jiménez with 10 new synonyms. Sukkharak (2018) revised the liverwort genus *Frullania* in Thailand and recorded 39 species including three new records for Thailand viz., *F. hypoleuca* Nees, *F. ramuligera* (Nees) Mont. and *F. sinuate* Sande Lac.

Ellis *et al.* (2019) reported the extended distribution of 58 species of bryophytes from different parts of the World. It includes national and regional records from India also such as *Mastigolejeunea indica* Steph. from Arunachal Pradesh, Eastern Himalaya collected by Majumdar and Singh. Blockeel *et al.* (2019) reported a rare European moss *Hygrohypnum subeugrium* (Renauld & Cardot) Broth. from Sikkim Himalaya as an extended distribution of this plant other than Europe. Cai *et al.* (2019) studied the molecular phylogeny of the family Thuidiaceae based on the chloroplast and nuclear sequences, confirming that *Thuidium* and *Pelekium* are two different monophyletic groups.

The family Polytrichaceae in Sri Lanka was revised by Wasala and Rubasinghe (2019) and reported two genera and seven species viz. *Atrichum crispulum* Schimp. ex Besch., *Pogonatum aloides* (Hedw.) P. Beauv., *P. marginatum* Mitt., *P. microstomum* (Schwägr.) Brid., *P. neesii* (Müll. Hal.) Dozy, *P. subtortile* (Müll. Hal.) A. Jaeger and *P. urnigerum* (Hedw.) P. Beauv. A detailed description, a taxonomic key and each species was illustrated.

Hodgetts *et al.* (2020) provided a checklist of the current European Bryophyte flora, with a total of 1890 taxa (1390 mosses, 494 Liverworts and 8

Hornworts) including 80 subspecies and 160 varieties. They reported 7 liverworts and 16 mosses as new to Europe and proposed 15 new combinations. Lapshina *et al.* (2020) conducted an extensive study of mosses of the Khulga River basin, Yugra, Russia and recorded 210 species including 56 species as new to Yugra and five species as new to Urals. Putzke (2020) conducted a detailed study of bryophytes and their associates in the South Shetland Islands in Antarctica.

The studies on the ecology of bryophytes in India is very less but Negi and Gadgil (1996, 1997, 2001), Negi (2000), Negi and Upreti (2000), Pinokiyo *et al.* (2008), Bahuguna *et al.* (2014), Upreti and Tandon (2014) and Joshi *et al.* (2016) studied some bryological studies. Glime (2007, 2009, 2018 & 2020) in her series of the online book 'Bryophyte Ecology' discussed the details of ecology of bryophytes, especially in the tropics such as physiological ecology, biological interaction, habitat and role and uses, including the life cycle strategies in different divisions, the fauna associated with bryophyte species, major uses of bryophytes, water relation, light availability, life and growth forms, climate effects, etc. were dealt with in detail.

MATERIALS AND METHODS

The bryophytes grow well in all habitats except in marine water. They inhabit as epiphytes, as lithophytes, terrestrial forms and also in submerged conditions. The specimens for the present study were collected from different microhabitats of the Anamudi Shola National Park in the Western Ghats of Idukki district, Kerala during 2015-2020. The important steps in the taxonomy of bryophytes are collection, preservation of the collected specimens, preparation of herbarium, identification of the collected specimens, preparation of taxonomic description, photo documentation of macro and microhabitats of bryophytes, processing of photos for thesis, naming of the species with up to date nomenclature and finally deposition of voucher specimens in recognized herbaria.

Collection

The first step is the collection of bryophytes from different macro and microhabitats of the study area. Field trips were undertaken with all necessary items required in the field such as field book, sharp-edged knife, scalpel, hand lens, blotting paper (old newspaper), pen or pencil, slip pad, collection bag, trekking shoes, camera and GPS reader. The plants were collected randomly from the study area by observing the morphology, altitude and growth pattern of bryophytes. Plants were scraped out from the substratum with the help of a sharp-edged knife/hoe/shovel. Terrestrial species were collected along with the substratum and the bulk of the soil particles were removed leaving a thin film. Because some species show profuse growth of protonema and tubers. Corticolous and lithophytic species when strongly attached to the substratum were collected with a portion of the bark and rock respectively. The field data were recorded in the field book, such as the locality, date of collection, altitude, latitude, longitude, microhabitat, substratum, associated species, etc. The collected specimens were wrapped in newspaper packets and were brought to the lab. Each specimen was sorted under the microscope. The specimens collected from one area may contain more than one species; hence sub numbers were given by separating the species like 7450a, 7450b, etc. In some cases, the species is dioicous, hence the vegetative and reproductive

plants were sorted out after careful examination and given the same number with sub numbering.

Preservation and herbarium preparation

The methods adopted for preserving bryophytes are very simple as in the case of mosses. The freshly collected specimens were first air-dried in room temperature. If the collection is bulky, a portion of the specimens was kept fresh by keeping in the refrigerator. So that, it can be examined alive, which later may be dried and stored in the same herbarium packets. But in the case of liverworts, the specimens were studied in a fresh state as far as possible. A part of the specimens was dried in air with their substratum and preserved in herbarium packets and a part of the collected specimens was also preserved in wet form. For wet preservation specimens were cleaned well and removed all soil and rock particles. In the case of corticolous species, the thalli were separated from the bark carefully. Cleaned plants were kept in 70% alcohol or 3% formaldehyde taken in 50 ml sample bottles and labeled neatly.

After proper drying, the bryophytes specimens were transferred to brown paper packets of standard size 12.7 cm x 10.16 cm (5 inches x 4 inches). The packets were correctly labeled. The properly labeled packets were deposited in the Zamorin's Guruvayurappan College Herbarium (ZGC) and also in the Calicut University Herbarium (CALI) based on the latest classification system.

Identification

Fresh materials were subjected to study whenever possible and herbarium specimens were used in other cases. The external features of the specimens were studied using Stereo dissection microscopes (Labomed Luxeo 4z and Olympus SZ) and anatomical features by compound microscopes (Labomed LX-400, LX-500 & Olympus CX21iLED). Specimens were treated with 1.5-3% KOH for 30–60 seconds for better clarity and also for studying cellular characteristics such as cell wall thickness, cellular inclusions, papillosity and mamillosity, cell dimensions, etc. The photomicrographs of each species were taken under the compound microscope. The size of the leaves, cells and capsule was measured by using Pixel Pro & Magnus Pro software. Sections of leaves, stem and seta were also taken in possible cases for

detailed studies. Since the plants are very small, the entire plant is continuously sectioned by placing it on a microscopic slide using a normal razor blade under a dissection microscope. The sections thus obtained on the entire slide were observed under a compound microscope and the photographs of the best sections were taken.

Identification of the specimens was done by referring authentic literatures (Bapna & Kachroo, 2000a&b; Bischler-Causse *et al.*, 2005; Bruggeman-Nannenga & Pursell, 1995; Bruggemann-Nannenga, 1997 & 2013; D.K. Singh & S.K. Singh, 2015; Daniels & Daniel, 2013; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019; Dey & Singh, 2012; Eddy, 1988; Gangulee, 1969-80; Iwatsuki & Suzuki, 1995; Li & Iwatsuki, 2001; Long, 2006a & b; Manju & Rajesh, 2017; Nair *et al.*, 2005; Pursell, 2007; Singh *et al.*, 2016; Singh & Nath, 2007; So, 2001; Srivastava & Dixit, 1996). Confirmation of identified taxa were done by referring, protologues, types, authentically identified herbarium specimens from various herbaria and also by consulting with experts from various national and international institutions.

Institutions visited for literature survey and herbarium consultation

The following herbaria were visited for consultation, viz., Calicut University Herbarium (CALI), Malappuram, Kerala; Malabar Botanical Garden & Institute for Plant Sciences (MBGIPS), Kozhikode; Central National Herbarium (CAL), Kolkata and Scott Christian College, Nagercoil (SCCN). Loan specimens procured from Natural History Museum (BM) and Calicut University Herbarium (CALI) were also used for the present study

Taxonomic description

Detailed descriptions and keys were given for family, genus and species. Each species is described with up-to-date nomenclature including basionym and synonyms if any, pertaining to India and other parts of the world as far as possible. A detailed description of species including the morphology and anatomy of gametophyte and sporophyte, discussion on each species including the diagnostic characters, habitat, distribution of the species in world, India and South India and specimens examined on each species are also provided. Authors of plant names are abbreviated based on Brummit and Powell (1992) and the titles of journals are based on Taxonomic literature (Stafleu & Cowan, 1976). The bryophytes are arranged according to the classifications of Crandall-Stotler *et al.* (2009), Goffinet *et*

al. (2009) and Söderström *et al.* (2016).

Photodocumentation

The photographs of the species and their microhabitat were taken using cameras such as Canon Powershot, Nikon Coolpix P520 and Canon D80. The photographs of external features of the specimens were taken by using digital imaging facility attached to the Stereo dissection microscopes (Labomed Luxeo 4z and Olympus SZ) and of anatomical features by a camera attached compound microscopes (Labomed LX-400, LX-500 & Olympus CX21iLED). Each species is described with a photo plate of habit together with details of available characters such as plant morphology, leaves, cells from tip, middle, margin and base, capsule, spores, etc. Photos of microhabitat and habitat were also given on the plate in all available cases.

Measurements used in the Description of species

Terminology and definitions used in this thesis are based on Gangulee (1969-1980), Iwatsuki and Suzuki (1982), Pursell and Bruggeman-Nannenga (2004), Nair *et al.* (2005), Singh and Nath (2007), Pursell (2007), Daniels and Daniel (2013).

Photographs of taxa are based on specimens collected, type and authentically identified specimens from various herbaria which are cited in the specimen examined part of the result.

Except for some, a minimum of four or five individual plants from each collection are used for measurements. The details of these collections are added in the 'specimens examined' part of the description.

For most of the specimens from the study area, a minimum of four or five individual plants from each collection are used for measurements based on the availability of specimens except some which are having a single specimen. The details of these collections are added in the 'specimen/s examined' part of the description.

The length and width of the plant is measured including sporophyte. The length of smaller and the larger among the matured plants are noted to get the range of variation in length.

Normally the leaves towards the apex are larger and the basal is smaller or

reduced. Hence the measurements were made of the middle part of laminal cells are measured from different areas in a single leaf in wet condition. A solution of 1.5-3.0% KOH is used for improving the clarity of the leaves and laminal cells (Koponen, 1970). Only sterile leaves are considered for general cellular measurements.

Capsule length is measured from the neck of the sporophyte to the mouth. Spores are measured from one sporophyte in a collection.

Plant size and growth pattern

Among the species of bryophytes the plant size varies from a minute or stemless plants to large plants. Plants varied from minute leafy liverworts to large thalloid liverworts and small acrocarpic mosses to large hanging pleurocarpic mosses. Plants vary in size from 4 mm to 50 cm long (Plate 4.01).

Leaf

Mosses are usually leaf-like, small to large, costate or ecostate; laminal cells usually vary from tip to base, rarely similar in some species and alar cells may be present or absent.

Based on the nature of growth, Liverworts are usually divided into two; leafy liverworts and thalloid liverworts. Thalloid liverworts are easily identified by their prostrate, dorsio-ventral, without incision nature, size varies from mm small to large up to 15 cm. The thallus is usually thickened by single or multi-layered cells. Dorsal region is photosynthetic and ventral usually meant for storage and anchoring with the help of rhizoids and scales.

Leafy liverworts are usually small (less than 1 mm) to medium sized (10 cm) plants with incisions on their thallus forming a leaf like nature. Under leaves and leaf lobules may be present or absent. Cells are with or without oil bodies (Plate 4.02 & 03).

Gemmae

‘*Gemmae*’ are the multicellular structures that contribute in vegetative multiplication. Some species of thalloid liverworts and mosses like *Calymperes* possess multicellular gemmae.

Sexual Condition

The sexual reproduction for leafy liverworts and mosses is very much alike. The sexual parts are contained in small structures known as antheridia (male) and archegonia (female), which may develop in the same plant or on separate plant bodies, hence the plant may be monoicous or dioicous.

In the thallose liverworts, things are a little different. The antheridia and archegonia are produced on an umbrella-like structure in some of the large liverworts like *Marchantia*, *Dumortiera*, etc. While in other species they are hidden in small pockets on the leaves (Plate 4.04).

Spores

Spore nature is an important identifying character in thalloid liverworts and hornworts. But is less significant in mosses, except for some as the size of the spores may be useful in the delimiting of some species. In most cases, the characters of spores are similar.

Elaters

Elaters are present in liverworts and hornworts. The length and nature of their arrangement of them are key features in the identification of some species, especially in hornworts.

Ecology of Bryophytes in Anamudi Shola National Park

In order to analyse the pattern of distribution, data matrices of bryophytes species in the study area were prepared as four major categories, such as major patches of sholas, macrohabitat (major vegetation types), microhabitat and altitudinal zones (1600-2500, with an interval of 100 m) (Tables 1-3). These data matrices were loaded for Cluster analysis in the PAST 4.033.20 software (<http://folk.uio.no/ohammmer/past>) (June, 2020) Sorensen Similarity Index ($SS = 2a / (2a + b + c)$, where a= number of species common to both sites, b= number of species unique to the first site, and c= number of species unique to the second site) was calculated and Linkage or Similarity dendrograms were prepared following the Unweighted Pair-Group Method with Arithmetic mean (UPGMA), with a bootstrap of 1000.



Plate 4. 01: Different types growth pattern in liverworts, a. *Marchantia polymorpha* L., b. *Wiesnerella demidata* (Mitt.) Steph., c. *Reboulia hemisphaerica* (L.) Raddi, d. *Metzgeria lindbergii* Schiffn., e. *Fossombronia pusilla* (L.) Nees, f. *Dumortiera hirsuta* (Sw.) Nees, g. *Riccardia levieri* Schiffn., h. *Aneura pinguis* (L.) Dumort.



Plate 4. 02: Different types of leaf lobes in leafy liverworts (No scaling). a. *Plicanthus hirtellus* (F. Weber) R.M. Schust., b. *Acanthocoleus yoshinaganus* (S. Hatt.) Kruijt, c. *Porella acutifolia* (Lehm. & Lindenb.) Trevis., d. *Porella madagascarensis* (Nees & Mont.) Trevis., e. *Herbertus aduncus* (Dicks.) Gray. Subsp. *aduncus*, f. *Spruceanthus semirependus* (Nees) Verd., g. *Cheilo-lejeunea xanthocarpa* (Lehm. & Lindenb.) Malombe, h. *Bazzania tridens* (Reinw., Blume et Nees) Trev., i. *Frullania campamilata* Sande, Lac., j. *Plagiochila uniformis* Mitt.



Plate 4. 03: Different types of leaves in mosses (No scaling). a. *Hypopterygium tamariscifolium* (Sw.) Brid. ex Müll. Hal., b. *Thuidium glaucum* (Mitt.) Bosch & Sande Lac., c. *Racomitrium orthocarpum* Wilson ex Mitt., d. *Vesicularia levis* Cardot, e. *Trichopogon serrulatus* (P. Beauv.) M. Fleisch., f. *Lopidium xanthopteris* (Brid.) M. Fleisch., g. *Trichypus bicolor* Reinw. & Hornsch., h. *Brachyvenustum leptophyllum* (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger, i. *Wijkia sareolaris* (Mitt.) H.A. Cram, j. *Didymodon revolutus* (Cardot) R.S. Williams, k. *Eurhynchium hians* (Hedw.) Sande Lac., l. *Rosulabryum billardieri* (Schwaegr.) J.R. Spence, m. *Macrohammum macrocarpum* (Reinw. & Hornsch.) Fleisch., n. *Plagiommium rhynchophorum* (Hook.) T.J. Kop., o. *Macromitrium cf. flexuosum* Mitt., p. *Psychostomum pseudobiquestrum* (Hedw.) J.R. Spence & H.P. Ramsay, q. *Cryptopogon fuscus* (Hook.) M. Menzel, r. *Leucoloma molle* (Müll. Hal.) Mitt., s. *Barbelopsis trichophora* (Mont.) W.R. Buck, t. *Imbricaria alpina* (Huds. ex With.) N. Pedersen, u. *Duthiella declinata* (Mitt.) Zant., v. *Thamtopsis utahensis* (Mont.) W.R. Buck, w. *Plagiobryum argentatum* (Mitt.) Q. Zuo, x. *Hemaliodendron flabellatum* (Sm.) M. Fleisch., y. *Distichopodium nigrescens* var. *sinense* (Broth.) B.C. Tan & H. Rab., z. *Bryum argenteum* Hedw., a1. *Leptopodium furcatum* (Thwaites & Mitt.) Broth., b1. *Schoenobryum concavifolium* (Griff.) Gangulee, c1. *Rhynchostegiella tenella* (Dicks.) Limpr., d1. *Hemaliodendron microdendron* (Mont.) M. Fleisch., e1. *Trichypus bicolor* Reinw. & Hornsch., f1. *Symphiodon erraticus* (Mitt.) A. Jaeger, g1. *Fissidens anomalous* Mont.

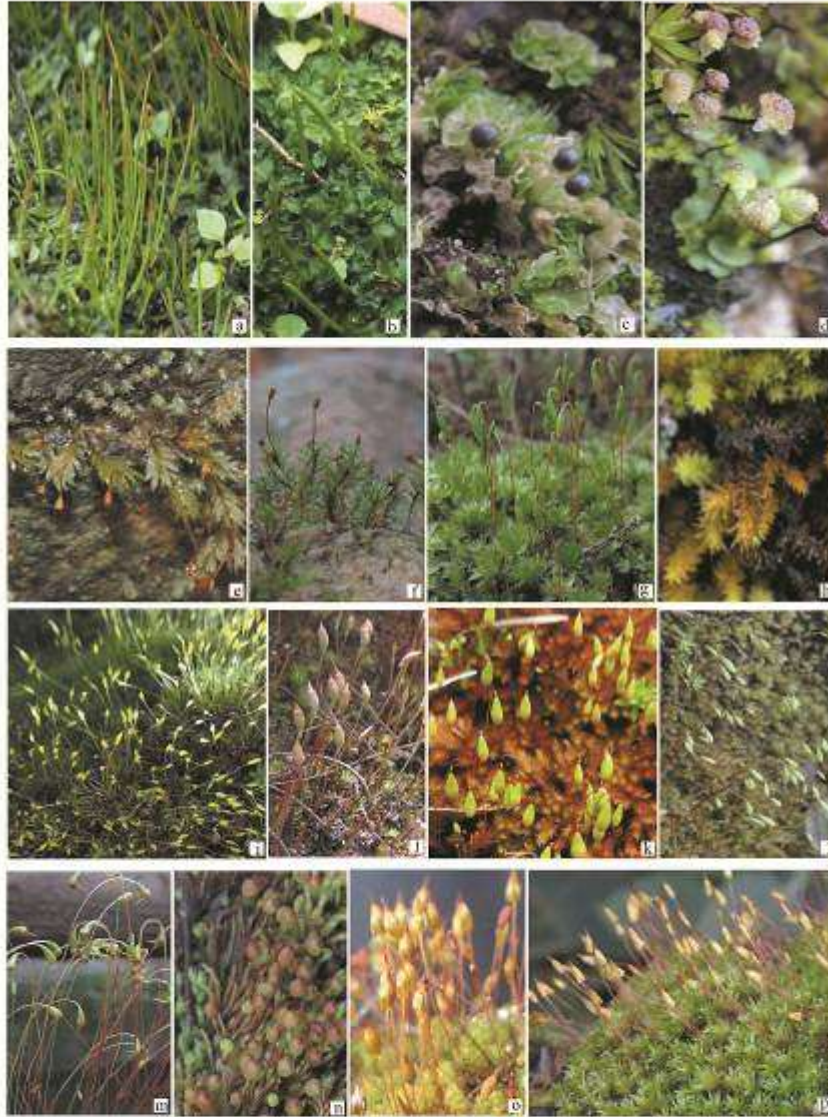


Plate 4. 04. Different types of sporophytes (No scaling). a. *Anthoceros crispulus* (Mont.) Douin, b. *Phaeoceros carolinianus* (Michx.) Prosk., c. *Fossombronia pusillo* (L.) Nees, d. *Asterella leptophylla* (Mont.) Pande, e & f. *Fissidens zollingeri* Mont., g. *Brachymenium leptophyllum* (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger, h. *Schoenobryum concavifolium* (Griff.) Gangulee, i. *Campylopus fragilis* (Brid.) Bruch & Schimp. subsp. *goughii* (Mitt.) J.-P. Frahm, j. *Pogonatum microstomum* (R.Br. ex Schwägr.) Brid., k & l. *Psychostomum pseudotriquetrum* (Hedw.) J.R. Spence & H.P. Ramsay, m. *Funaria hygrometrica* Hedw., n. *Philonotis thwaitesii* Mitt., o & p. *Macromitrium sulcatum* (Hook.) Brid.

RESULT & DISCUSSION

Systematic treatment of Bryophytes of Anamudi Shola National Park

Plants free living, enjoy a wide range of habitats, 1 mm to 50 cm long, thallose, foliose or erect; thalli prostrate, dorsiventral; in foliose form leaves uniseriate, midrib absent; in erect forms leaves uniseriate, midrib present or absent, when present multiseriate; shows alternation of generations, antheridia club shaped, archegonia flask shaped, sporophyte dependant on the gametophyte for nutrition, usually differentiated into foot, seta and capsule, elaters present in liverworts and absent in mosses.

Key to the Phylum

- 1a. Plant body differentiated into root, stem and leaf like structure; sex organ on main stem; sporophytes with well developed foot, seta and capsule **Bryophyta**
- 1b. Plant body thalloid or foliose form; sex organ dorsally on thallus or embedded in thallus tissue; sporophyte not well developed with foot, seta and capsule2
- 2a. Plant body thalloid or foliose; internal tissue of thallus differentiated..... **Marchantiophyta**
- 2b. Plant body thalloid; internal tissue of thallus undifferentiated..... **Anthocerotophyta**

MARCHANTIOPHYTA Stotler & Crand. Stotl.,

Bryoph. Biol. 54, 63. 2000.

The plant body is of two types; thalloid and foliose form, in thalloid form, plant body is dorsi-ventrally flattened, dichotomously branched, ribbon like structures; in foliose form leaves in three rowed with two lateral leaves and one ventral leaf or amphigastria; costa absent; thallus with internal tissue differentiated; scales present in some; rhizoids unicellular or tuberculate type.

Marchantiales Limpr.,

Krypt.-Fl. Schlesien 1: 336. 1876[1877].

Key to the families

- 1a. Male and female receptacle stalked; carpocephalum deeply dissected; epidermal pores compound **Marchantiaceae**

- 1b. Male receptacle sessile or subsessile, female receptacle stalked; carpocephalum not deeply dissected; epidermal pores simple or absent2
- 2a. Epidermal pores absent; receptacles surrounded by elongated bristles; photosynthetic region without air chamber **Dumortieraceae**
- 2b. Epidermal pores simple; receptacles not surrounded by bristles; photosynthetic region with air chambers 3
- 3a. Thallus usually small, up to 4 cm long, assimilatory chambers in several layers ...
..... **Aytoniaceae**
- 3b. Thallus large, 2-8 cm long; assimilatory chambers in single layer4
- 4a. Air pores well elevated; photosynthetic filaments well developed; peduncle with single rhizoidal furrow, carpocephalum conical, lobes shallow
..... **Conocephalaceae**
- 4b. Air pores not much elevated; photosynthetic filaments vestigial; peduncle with 2 rhizoid furrows; carpocephalum discoid, lobes deep**Wiesnerellaceae**

Marchantiaceae Lindl.,

Nat. Syst. Bot. (ed. 2) 412. 1836.

Thallus dichotomously branched with a broad midrib, repeatedly branching by apical innovations, apex notched, emarginated; dorsal layer with or without assimilatory filaments and air pores; gemmae cups present on the dorsal side of the thallus; dorsal layer usually narrow, air chambers in one row, pores barrel shaped; scales in 2 or 3 rows on each side of the midrib, scales appendaged to lingulate; rhizoids tuberculate-smooth; dioicous or monoicous, male and female receptacles long, pedunculate, male receptacle discoid, lobed; female receptacles stellate to disciform, lobed, with 2 valved; capsule oval with short to long pedicel; spores small, tetrahedral; elaters bispiral, long.

Marchantia L.,

Sp. Pl. 1137. 1753.

Thallus dichotomously branched, midrib broad, areolate hexagonal, gemmae globular on the dorsal surface, air chambers in one layer, filaments in the chamber frequently branched, pores barrel shaped, scales in two or three rows on each side of the midrib, rhizoids tuberculate; gemmae more or less biconvex, in some species with globlet shaped, margin shortly bilobed or entire; male receptacle long

peduncled, stellately or palmately lobed, stalk with two rhizoid furrows on the anterior side, female receptacle stellate, with 4-10cm elongated stalk, with two furrows, rhizoids on the anterior side and air chambers on the posterior side; capsule with long seta, spores small, tetrahedral; elaters simple or bispiraled.

Marchantia polymorpha L., Sp. Pl. 1137. 1753; Kashyap, Liverw. W. Himachal. 1: 32-34. 1929; Bischler-Causse, Bryo. Biblio. 45: 45. 1993; Bischler-Causse *et al.* Fl. Neotropica, 226. 2005; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 318. 2007; Chaudhary *et al.*, Bryo. Fl. N. Konkan. 98. 2008; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 5. 2008; D.K. Singh *et al.*, Liverw. & Hornw. India: 194. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 448. 2018. *Jungermannia polymorpha* (L.) Hook. f. & Taylor, London J. Bot. 3: 400. 1844. *Marchantia aquatica* (Nees) Burgeff, Genet. Stud. Marchantia. 32. 1943.

Thallus dark greenish, usually dioicous; formed in overlapping patches, dichotomously branched, 1.5-5 cm long, 0.5-1 cm wide, margin undulate, apex emarginated, incurved when dry; dorsal surface smooth with polygonal areas of black lines along the middle which represent the partition wall of the air chambers below, areolae distinct with a central air pore, pores elevated, barrel shaped, compound, round or oval, surrounded by 3-5 rings of cells; ventral surface brownish with rhizoids and scales, rhizoids dimorphic, scales 3 rows on either side of the mid rib, smaller scale towards margin and larger in the median; thallus differentiated into photosynthetic region above and storage region below, air chambers in single row, photosynthetic filaments branched or unbranched; gemmae cups numerous on dorsal surface of thallus, cup shaped, mouth 2-3 mm wide, tip acuminate; male and female receptacles terminal, stalked, antheridiophore upto 5 cm long, rhizoid furrows two; carpocephalum greenish, discoid, lobes 8, not deeply dissected; archegoniophore 3-6 cm long, covered with scales at the tip, carpocephalum greenish, deeply dissected. sporophyte not observed (Plate 5.01).

Habitat: Terrestrial, on land cuttings and on rocky patch near watercourses in shola forests, evergreen forests and Tea plantations at an altitude above 1800 m.

Discussion: *Marchantia polymorpha* is a widely distributed species in high altitude

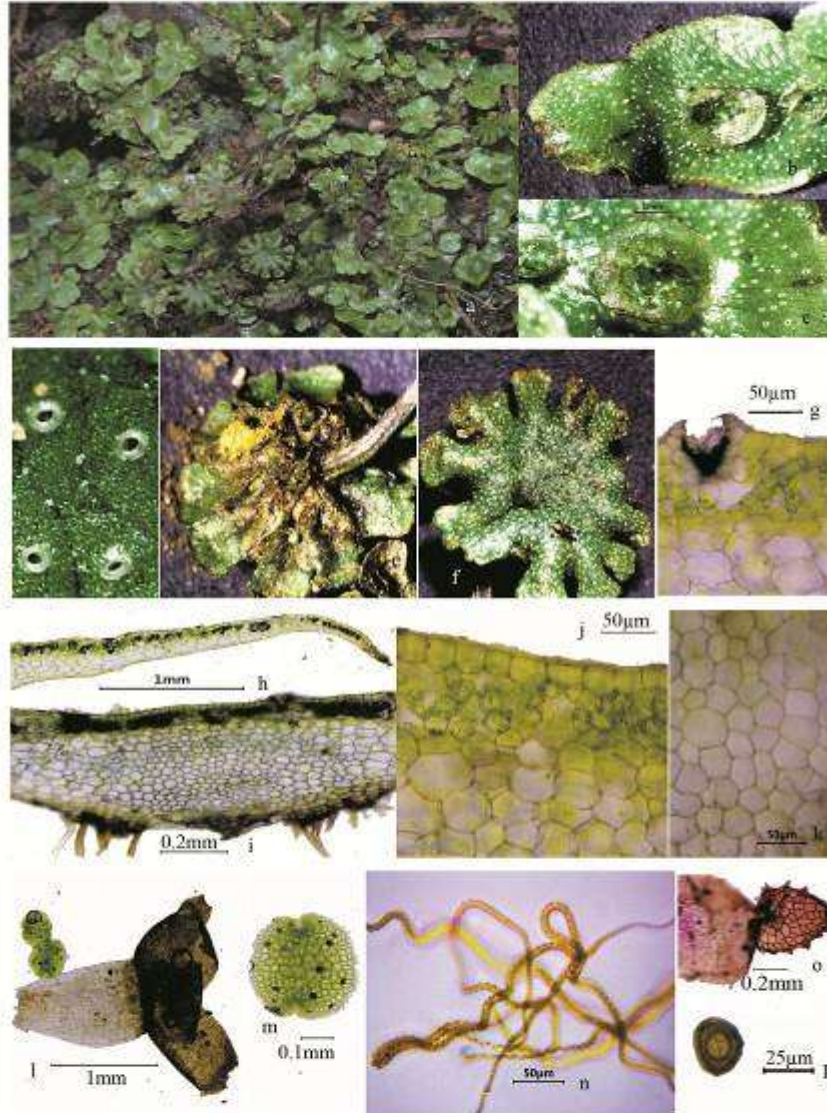


Plate 01: *Marchantia polymorpha* L., a. habit, b&c. thallus with gemmae cup, d. airpore, e&f. male receptacle, g. airpore, h&i. c.s. of thallus, j. epidermal photosynthetic layer, k. storage region, l. cupule, m. gemmae, n. elaters, o. scale, p. spore

areas mainly in the shola forests and evergreen forests. The species has large broad thallus with gemmae all over the surface of the thallus, which helps to identify the species from the field itself. This species is characterized by male and female receptacles with well dissected carpocephalum and ventral scales in three rows on either side of midrib with an ovate or reniform appendage.

Distribution: World: Afghanistan (Frey, 1974), Australia, Israel, Lebanon, Macquarie Is., New Zealand, Pakistan, Syria, Tadzhikistan, Uzbekistan, Vietnam (Bischler-Causse, 1989), Bhutan (Long & Grolle, 1990), China (Piippo, 1990), Europe (Söderström *et al.*, 2007), Indonesia (Söderström *et al.*, 2010), Iran (Akhani & Kürschner, 2004), Iraq (Bischler-Causse, 1989), Japan (Yamada & Iwatsuki, 2006), Korea (Yamada & Choe, 1997), Macronesia (Söderström *et al.*, 2002), Malaysia (Chuah-Petiot, 2011), Nepal (Pradhan & Joshi, 2009), North America (Schuster, 1992a), Papua New Guinea (Bischler-Causse & Piippo, 1991), Philippines (Tan & Engel, 1986), Russia (Konstantinova *et al.*, 2009), Sri Lanka (Abeywickrama & Jansen, 1978), South America (Bischler- Causse *et al.*, 2005), Taiwan (Wang *et al.*, 2011), Turkey (Kürschner & Erdağ, 2005; Ozdemir & Batan, 2017); **India:** Arunachal Pradesh (Rawat & Verma, 2014), Assam (Barukial *et al.*, 2002), Himachal Pradesh (S.K. Singh & D.K. Singh, 2009), Jammu & Kashmir (Langer & Tanwir, 2002), Kerala (Manju *et al.*, 2008; Manju & Rajesh, 2017), Madhya Pradesh (Gautam & Thakur, 1981), Maharashtra (Chaudhary *et al.*, 2008), Meghalaya (A.P. Singh & Nath, 2007), Nagaland (Chaturvedi & Chaturvedi, 2008), Orissa (Alam *et al.*, 2013), Punjab (Bischler- Causse, 1989), Rajasthan (Alam *et al.*, 2011a), Sikkim (D.K. Singh *et al.*, 2016), Tamil Nadu (Chopra, 1938; Daniels, 2010), Uttar Pradesh (Bischler- Causse, 1989), Uttarakhand (A.K. Asthana & Sahu, 2013), West Bengal (Bischler- Causse, 1989).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2300 m) 04.03.2016 *Mufeed 10075*; Pullardi Shola (1805 m) 23.09.2018 *Mufeed 9935* (ZGC).

Other specimen/s examined: India, Tamil Nadu; Ooty Botanical garden (2210m) 28.12.2017, *Deepa* 7529 (ZGC); Kerala, Idukki, Munnar, Chokkanad Tea estate (840m) *Stephen* (CALI 106590!), Himachal Pradesh; Great Himalayan NP (1600m), Singh (BSD 104341!), West Bengal, Darjeeling (Ca 2090m), 09.11. 2003, A.K. Asthana & Sahu (LWG 225509!); Ireland, Rose island, 20.08.1936, W. Turrill (s.n. BM!).

Aytoniaceae Cavers,

New Phytol. 10: 42. 1911.

Thallus monoicous or dioicous, prostrate, thallus irregularly dichotomously branched, simple, medium to large, green to purple-green; dorsal epidermis distinctly divided into polygonal areas in one layer, colorless with trigones; dorsal spores surrounded by 2-5 concentric rings of cells, dorsally pale green to glaucous green and ventrally purple-tinged bordered; oil cells may or may not present; air chambers 2 or more layered in cross-section without assimilatory filaments; ventral scales purple; male and female reproductive structures on dorsal surface; receptacles usually lobed, conical or hemispherical; capsule shortly pedicellate, usually globose or subglobose; spores tetrahedral, reticulate, lamellate, yellowish-brown, with or without winged; elaters short, bi spiral or tri spiral or rarely tetra spiral.

Key to the genera

- 1a. Air pore elevated; female receptacle, terminal, stalked on the main thallus or on ventral branches; male receptacle disciform, reniform or as irregular patch, terminal or subterminal on the main thallus or on small adventitious branches...2
- 1b. Air pore elevated or not; female receptacle dorsal, sessile or stalked; male receptacle always disciform, dorsal, or at the bottom of apical innovations.....***Plagiochasma***
- 2a. Cells surrounding air pore with thin radial walls; male receptacle discoid or with an irregular patch, terminal, subterminal or behind archegoniophore on main thallus or on apical or lateral ventral branches; female receptacle terminal on main thallus or on lateral branches, carpocephalum discoid or inversely saucer-shaped; sporophyte surrounded by hyaline or pigmented pseudoperianth***Asterella***
- 2b. Cells surrounding air pore with thick radial walls; male receptacle discoid or reniform, apical or behind archegoniophore on the main thallus; female receptacle, terminal, carpocephalum hemispherical; pseudoperianth absent***Reboulia***

***Asterella* P. Beauv.,**

Dict. Sci. Nat. 3: 257. 1805 '1804'.

Plants monoicous or dioicous, thallus prostrate, aromatic, thallus fleshy in wet condition turn to leathery on dry; dorsal surface smooth with air pores; ventral surface usually purplish; scales hyaline or purplish on both sides, appendage 1-2, rhizoids smooth or pegged; photosynthetic region aerenchymatous, usually with empty air chambers in many rows, storage region broad in some or highly reduced; male and female receptacles on main thallus; male receptacle terminal, sessile; female receptacle stalked, covered by receptacular scales, carpocephalum 2-6 lobed, stellate, flat or slightly convex dorsally; sporogonium one per involucre, surrounded by pseudoperianth, lobes 5-many, lanceolate, hyaline or pigmented, unistratose, apex fused while young, basal region fused in to a cup; capsule dehiscence by an apical cap, spores 60-120 µm in diameter, iso or anisopolar, ornamentation alveolate or ridged; elaters 1-3 spiral.

Asterella leptophylla (Mont.) Pande, K.P. Srivast. & Sultan Khan ex Grolle, Feddes Rept. 87: 246. 1976; Bapna & Kachroo, Hepatic. India 2: 406. 2000; Long, Rev. Gen. *Asterella* Eurasia. 176. 2006; Manju *et al.*, Checklist Bryo. Kerala, Trop. Bryol. Res. Rep. 7:4. 2008; D.K. Singh *et al.*, Liverw. & Hornw. India. 55. 2016; *Fimbriaria leptophylla* Mont., Ann. Sci. Nat., Bot, Ser. 2, 18: 16. 1842. *F. reticulata* Kashyap, J. Bombay Nat. Hist. Soc. 25: 279. 1917. *Asterella evansii* Kachroo, J. Hattori Bot. Lab 19: 3. 1958. *A. reticulata* (Kashyap) Pande, K.P. Srivast. & Sultan Khan ex Kachroo, J. Hattori Bot. Lab. 19: 4. 1958 *nom. illeg.* *A. kashyapii* Maheshw., Taxon 18: 599. 1969.

Plants thalloid, yellowish green with purple tinge along margin and basal region, aromatic when crushed, delicate, 1.5 cm long, 0.5 cm broad, broadest near apex, dichotomously branched, dorsal surface with irregularly rectangular areas that marks the air chambers; ventral branches common towards the tip of main thallus, heart shaped, thallus margin undulate; ventral surface with rhizoids along midrib and scales in two rows on either side of midrib, smooth or pegged; oil cells scattered; dorsal epidermal cells irregular, 25-40 µm long and 15-35 µm wide; air pores

surrounded by 2-3 rings of 6-8 cells, aperture 25-45 μm in diameter; assimilatory region with air chambers; 1-2 vertical layers along midrib and elongated towards wings; ventral storage region 8-12 cells thick; peduncle purplish; carpocephalum yellowish green or purple, disc like, 3-6 mm in diameter; monoicous (ventral autoicous), spores dark brown, globose and winged, 45-55 μm in diameter, distal face usually reticulated, 3-4 reticulation; proximal face doesn't have primary reticulations, secondary reticulations forms a network, triradiate; elaters 280-320 μm long and 10-12 μm , bispiral (Plate 5.02).

Habitat: Terricolous, grows on land cuttings in association with other mosses like *Eurhynchium hians* (Hedw.) Sande Lac. and *Pogonatum microstomum* (R.Br. ex Schwägr.) Brid. in shola forests at an altitude above 2000 m.

Discussion: *Asterella leptophylla* shows close similarity to *A. khasyana* (Griff.) Grolle, a widely distributed species in Kerala in its thallus morphology, but differ in its sexual condition. *A. leptophylla* is characterized by the ventral autoicous condition in sexuality in which antheridia are formed on small ventral branches formed apically or laterally, whereas in *A. khasyana* it is par autoicous. In *A. leptophylla* epidermal cells with large prominent trigones are seen and the spores are with 3-4 reticulations across the diameter. It is a widely distributed temperate-subtropical Asian species habitat in a wide range of altitudes, from low to high altitudes in different parts of the world, but restricted only in moist forests (Long, 2006b).

Distribution: World: Bhutan (Long & Grolle, 1990), China (Piippo *et al.*, 1997), Indonesia (Söderström *et al.*, 2010), Japan (Long, 2006b), Korea (Yamada & Choe, 1997), Nepal (Pradhan & Joshi, 2009), Pakistan (Furuki *et al.*, 1993), Philippines (Long, 2006b), Russia (Konstantinova *et al.*, 2009), Taiwan (Wang *et al.*, 2011); **India:** Himachal Pradesh (Long, 2006a & b), Jammu & Kashmir (Langer & Tanwir, 2002), Kerala (Madhusudanan *et al.*, 2007; Manju & Rajesh, 2017), Maharashtra (Bagwan & Kore, 2012), Meghalaya (A.P. Singh & Nath, 2007), Sikkim (Long, 2006a), Uttarakhand (A.K. Asthana & Sahu, 2013), West Bengal (Bapna & Kachroo, 2000a).

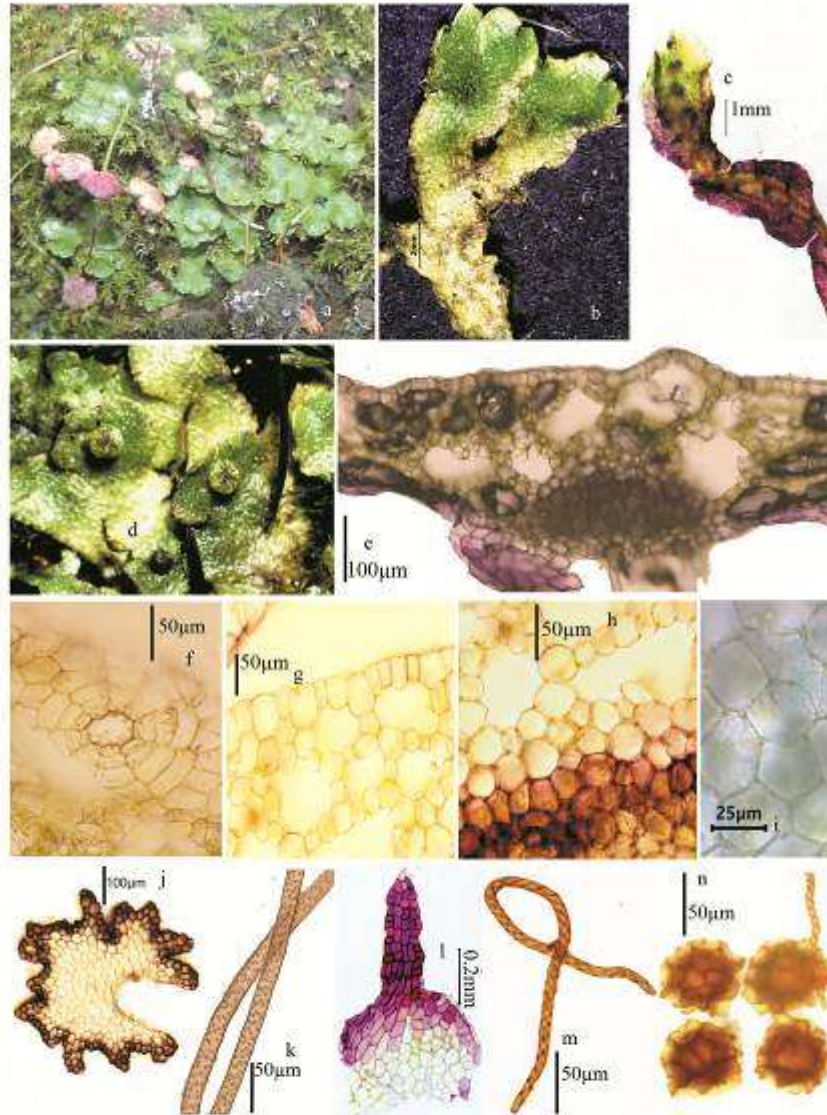


Plate 02: *Asterella leptophylla* (Mont.) Pande, K.P. Srivast. & Sultan Khan ex Grolle, a. habit, b. thallus dorsal, c. thallus ventral, d. receptacle, e. c.s. of thallus, f. airpore, g&h. assimilatory layer, i. storage region, j. c.s. of receptacle, k. pegged rhizoids, l. scale, m. elater, n. spores

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2083 m) 07.11.2017 *Mufeed* 7684; Iddalymotta (2250-2330 m) 22.08.2019 *Mufeed* 9906a; 22.09.2018 *Mufeed* 9554 (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Munnar (720m) 28.09.2017 *Mufeed* 7241; Pallivasal (1245 m), 28.09.2018 *Mufeed* & *Jithu* 9538; Palakkad district, Silent valley NP, Near welcome board (705m), 26.08.2015, *Deepa* & *Manjula* 15586 (ZGC); Parambikulam WLS (850m), 12.10.2006, *Manju* 106804 (CALI!); Uttarakhand; Mussoorie, Sep. 1930, *Chopra* (s.n. BM!).

Plagiochasma Lehm. & Lindenb.,

Nov. Stirp. Pug. 4: 13. 1832.

Monoicous or dioicous; plants seen in overlapping patches or forming mats; thallus leathery; air chambers many layered in cross section; ventral scales in one row on either side of midrib, appendaged, appendages 1-3, marginal papillae may or may not present, if present lanceolate-ovate; assimilatory region with empty air chambers in several layers, storage tissue usually purplish; male receptacle sessile, antheridia formed in cushions, dorsal behind female receptacle or at the bottom of the apical adventitious branch, covered by linear appendicular scales; female receptacle terminal, subsessile or stalked, covered by appendicular scales when young, peduncle without rhizoid furrow, carpocephalum 1-4 lobed, air pores compound; pseudoperianth absent around sporogonium, spores 70-120 µm in diameter, anisopolar, distal face with complete or incomplete reticulations, proximal face with distinct triradiate mark; elaters with or without spiral thickening.

Plagiochasma appendiculatum Lehm. & Lindenb., Nov. Stirp. Pug. 4: 14. 1832; Kashyap, Liverw. W. Himal. 1: 77. 1929; Bapna & Kachroo, Hepatic. India 2: 413. 2000; Chaudhary *et al.*, Bryo. Fl. Gujrat. 31. 2006; A.P. Singh & Nath, Hepat. Hepatic. Khasi Jaintia Hills: 330. 2007; Chaudhary *et al.*, Bryo. Fl. N. Konkan. 91. 2008; Manju *et al.*, Checklist Bryo. Kerala, Trop. Bryol Res. Rep. 7: 6. 2008; Sandhya Rani *et al.*, Bryo. Andhra Pradesh. 48. 2014; D.K. Singh *et al.*, Liverw. & Hornw. India 60-61. 2016; *Antrocephalus polycarpon* Griff., Not. Pl. Asiat. 2: 337. 1849; *Plagiochasma cardotii* Steph., Bull. Soc. Roy. Bot. Belgique 41: 120. 1904.

Plants monoicous; purplish to light green thallus, formed in overlapping large patches; dichotomously branched, 20-40 mm long, 5-8 mm wide, margin usually purple; dorsal surface smooth with elevated air pore, pore aperture 20-22 μm in diameter, surrounded by 6-8 cells, upper epidermal cells polygonal with prominent trigones; ventral surface with rhizoids and scales; ventral scales purplish with one row on either side of midrib; appendage one or two, rotund, base constricted, hyaline to yellowish brown, margin entire; mucilage papillae present; t.s. of thallus 5-6 times as broad as high, upper photosynthetic region with 3-4 vertical layers of small air chambers toward midrib and 2-3 layers along wing, air chambers elongated towards wing; lower storage region compact, 2 times wider than assimilatory tissue, small air chambers present in the upper region of storage tissue, midrib cells pinkish; male and female receptacle on dorsal surface along midrib, male receptacle rotund or horse-shoe shaped, covered by hyaline or pinkish scales when young; archegoniophore 2-7 mm long, covered by hyaline or pinkish scales, scales 0.6×0.1 mm, mucilage papillae present; carpocephalum with 1-5 lobes; spores dark brown, 60-70 μm in diameter, anisopolar, distal face with distinct reticulations, 20-22 μm wide, proximal face with distinct triradiate marks, reticulations absent, winged, wing 10-14 μm broad, margin of wing slightly dentate; elaters light brown, 200-300 μm long, bispiral (Plate 5.03).

Habitat: Terricolous, mostly found on concrete walls of drainages along with *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid and *Plagiomnium rhynchophorum* (Hook.) T.J. Kop in the low altitude area of Anamudi Shola National Park. is also found as dense overlapping patches on soil surface, land cutting and exposed soil shed rocks in high altitudes above 2000 m of the study area.

Discussion: *Plagiochasma appendiculatum* is with very large thallus up to 4 cm long compared to all other species of *Plagiochasma* reported from South India. It is a widely distributed species in the low altitude disturbed areas of Kerala and high altitude forests and it can easily be identified from other species with its single large and rotund ventral scale appendage which is never rotund in other species.

Distribution: World: Afghanistan (Bischler-Causse, 1979), Africa (Wigginton, 2009), Bangladesh (Banu-Fattah, 2001), Bhutan (Long & Grolle, 1990), China

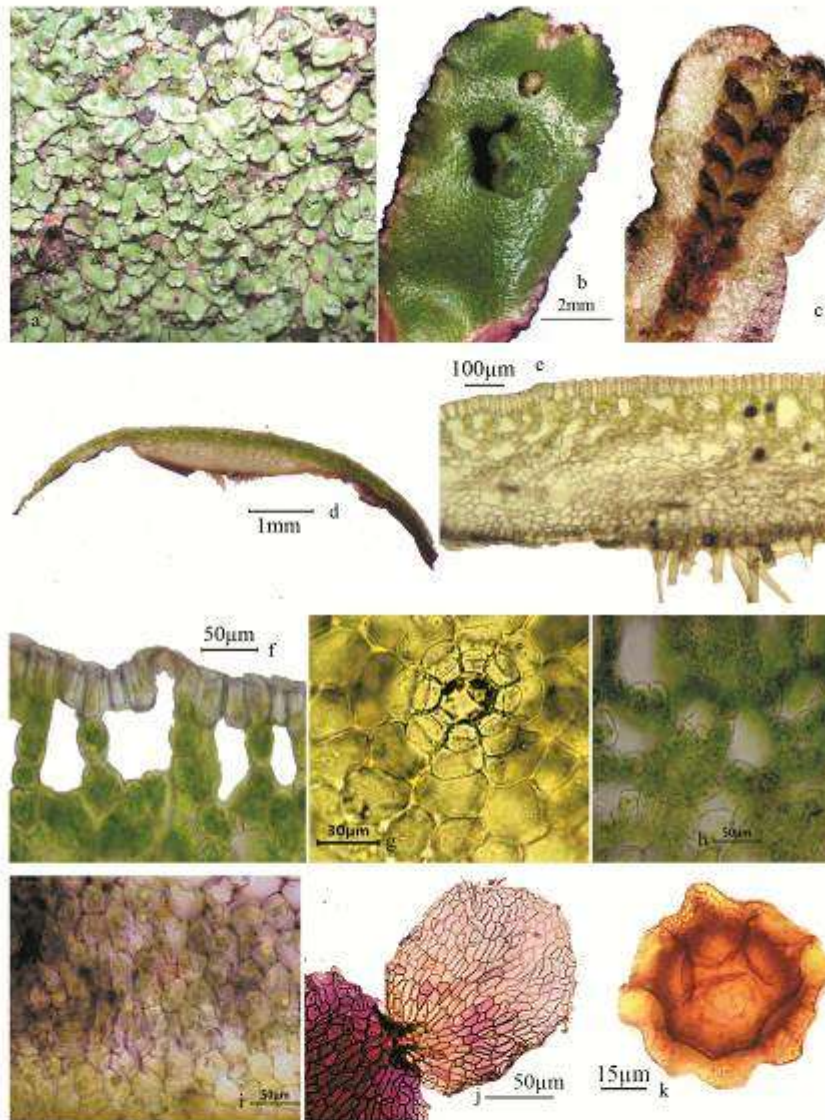


Plate 5. 03: *Plagiochasma appendiculatum* Lehm. & Lindenb., a. habit, b. thallus with receptacle, c. ventral view of thallus with scales, d&e. c.s. of thallus, f. airpore in section of thallus, g. airpore in the surface of thallus, h. epidermal photosynthetic region, i. storage region, j. scale, k. spore

(Piippo, 1990), Europe (Söderström *et al.*, 2007), Indonesia (Gradstein *et al.*, 2005), Myanmar (Bischler-Causse, 1979), Nepal (Pradhan & Joshi, 2009), Pakistan (Kashyap, 1929), Philippines (Tan & Engel, 1986), Taiwan (Wang *et al.*, 2011), Vietnam (Bischler-Causse, 1979), Yemen (Kürschner, 2006); **India:** Andaman Islands (D.K. Singh *et al.*, 2006), Arunachal Pradesh (D.K. Singh, 1996), Assam (Kachroo, 1954; Bischler-Causse, 1979), Chhattisgarh (Nath & Nivedan, 2007), Gujarat (Chaudhary *et al.*, 2006), Himachal Pradesh (S.K. Singh & D.K. Singh, 2009), Jharkhand (Bischler-Causse, 1979), Jammu & Kashmir (Langer & Tanwir, 2002), Maharashtra (Chaudhary *et al.*, 2008), Manipur (D. Singh *et al.*, 2010a), Meghalaya (A.P. Singh & Nath, 2007), Madhya Pradesh (Pande & Srivastava, 1952), Odisha (Alam *et al.*, 2013), Rajasthan (Alam *et al.*, 2011a), Sikkim (Bischler-Causse, 1989), Uttar Pradesh (D.K. Singh & S.K. Singh, 2015), Uttarakhand (Sahu & A.K. Asthana, 2014; S.K. Singh & D.K. Singh, 2007), Telangana; Mahabubnagar (Kalpana *et al.*, 2015), Kerala (Manju *et al.*, 2009), Tamil Nadu (Alam & Srivastava, 2011).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2330 m) 22.08.2019 *Mufeed 9906a*; Mannavan Shola (1600 m) 24.09.2018 *Mufeed 9553* (ZGC).

Other specimen/s examined: India, Kerala, Palakkad district (100 m) 18.08.2012 *Manju 7940*; Tamil Nadu, Kodaikanal (2010 m) 25.10.2015 *Manjula 15789*; Tamil Nadu, Coonoor (1740 m) 22.12.2015 *Deepa & Manjula 15864* (ZGC); Kerala, Thiruvananthapuram, Agasthyamala (1450 m) 15.04.2008 *Manju 106661* (CALI!); Uttarakhand; Mussoorie (ca. 1600 m) September 1930, *Chopra* (187 BM!), Sikkim; Gangtok, 24. 04. 1983, *S. Chandra & Nath* (LWG 203945!), West Bengal; Darjeeling, 21. 04. 1983, *S. Chandra & Nath* (LWG 203917!) Himachal Pradesh; Shimla, 27.10.1980, *S. Chandra & Nath* (LWG 203461!).

***Reboulia* Raddi,**

Opusc. Sci. 2: 357. 1818.

Plants monoicous; yellowish green, older region tinged purple; thallus usually medium to large, dichotomously branched; dorsal surface with single layered epidermis with elevated air pores; ventral surface purplish; scales large with 1 to 4 appendages, in one row on each side of midrib, linear lanceolate to oblong

lanceolate, oil cells and mucilage papillae present; assimilatory region with empty assimilatory chambers present in many rows; male receptacle disc shaped, sessile, terminal or behind the stalk of archegoniophore; female receptacle stalked with rhizoid furrows, receptacle hemispherical or conical, usually 4 lobes, each lobe with single involucre, involucre bilabiate; capsule shortly pedicellate, subglobose; spores tetrahedral, reticulate, lamellate, yellowish brown with or without winged; elaters short and spiral.

Reboulia hemisphaerica (L.) Raddi, Opusc. Sci. 2(6): 357. 1818. Kashyap, Liverw. W. Himal. 1: 72.1929; Bapna & Kachroo, Hepatic. India 2: 410. 2000; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 34. 2005; Bischler-Causse *et al.*, Fl. Neotr. Monog. 207-210. 2005; Manju *et al.*, Trop. Bryol Res. Rep. 7: 6. 2008; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 331. 2007; D.K. Singh *et al.*, Liverw. & Hornw. India. 63-64. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 439. 2018. *Marchantia hemisphaerica* L., Sp. Pl. 1138. 1753. *Grimaldia hemisphaerica* (L.) Lindenb., Nova Acta Acad. Caes. Leop. Carol. Nat. Cur. 14 (106). 1829. *Mindal pangiensis* Kashyap, J. Bombay Nat. Hist. Soc. 24: 346. 1916. *Reboulia hemisphaerica* (L.) Raddi var. *pangiensis* Kashyap, Liverw. W. Himal. 1:74. 1929.

Thallus light to dark greenish, usually with purple margin, dichotomously branched, formed in overlapping patches, upto 1.5 cm long, 0.5-0.6 cm broad; apical notch deep, oblong, obovate or bilobed apex, emarginate; dorsal surface with elevated air pore, epidermal cells polygonal and thick walled with trigones; ventral surface purple, with scales and rhizoids, rhizoids are of both the types, ventral scales dark purple, formed as single row on either side of midrib, appendages elongated and linear; cells rectangular, oil cells scattered, margin crenulate with mucilage papilla; epidermal cells irregular, thick walled with distinct trigone; air pores elevated, aperture 20–35 µm in diameter, surrounded by 4–6 rings of 6–10 cells; assimilatory region with distinct air chambers, 4–5 vertical layers towards midrib, irregular in shape, 2–4 layers and oblong towards wings; storage tissue 10–18 cells thick towards midrib, narrowing towards wings and gradually become absent towards margin, cells in the midrib thick walled and purplish in colour; female receptacle stalked formed at the apical notch, stalk purple in colour, elongated,

10-35 mm long, 0.6-0.7 mm in diameter with a single rhizoid furrow; sporophyte has globose or subglobose capsule, large foot and highly short seta; capsule wall single layered, dehisces by irregularly fragmenting lid; spores dark brown 44–60 µm, tetrahedral, anisoplar, lamellate and winged, distal face with complete reticulations, proximal face with distinct triradiate marking; wing broad 10–13 µm wide, margin dentate; elaters bispiral, 350–400 µm long, rarely branched (Plate 5.04).

Habitat: Terricolous, formed as a dense overlapping patch on soil surface at an altitude above 2000 m. Seen in association with mosses like *Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn., and *Philonotis thwaitesii* Mitt. in shola forests.

Discussion: *Reboulia* Raddi is a monospecific genus of the family *Aytoniaceae* with four subspecies and two varieties (Söderström *et al.*, 2016). The type specimen *Reboulia hemisphaerica* (L.) Raddi is transferred from *Marchantia hemisphaerica* L. by Raddi (1818). Several varieties and species were described by several authors at different times and all these were synonymised among *R. Hemisphaerica*, four subspecies and two varieties which are valid in the genus *Reboulia* Raddi (Söderström *et al.*, 2016). *Reboulia* Raddi can be easily identified from other genera of the family with its hemispherical carpocephalum which is 4-7 lobed. It is distinguished from its allied genus *Plagiochasma* with the terminal position of female receptacle and the peduncle with a single rhizoid furrow, which is absent in the earlier. This species is identified as an indicator of pollution. It has great capability to withstands high drought condition and absorb heavy metals (Frank, 2015)

Distribution: World: Afghanistan (Frey, 1974), Africa (Wigginton, 2009), Australia (McCarthy, 2006), Bhutan (Long & Grolle, 1990), China (Piippo, 1990), Europe (Söderström *et al.*, 2007), Indonesia (Söderström *et al.*, 2010), Iran (Akhani & Kürschner, 2004), Korea (Hong, 1997), Macronesia (Söderström *et al.*, 2002), Nepal (Pradhan & Joshi, 2009), New Caledonia (Thouvenot *et al.*, 2011), North America (Schuster, 1992a), Pakistan (Furuki *et al.*, 1993), Papua New Guinea (Piippo, 1988), Russia (Konstantinova *et al.*, 2009), South America (Bischler-Causse *et al.*, 2005), Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011), Turkey

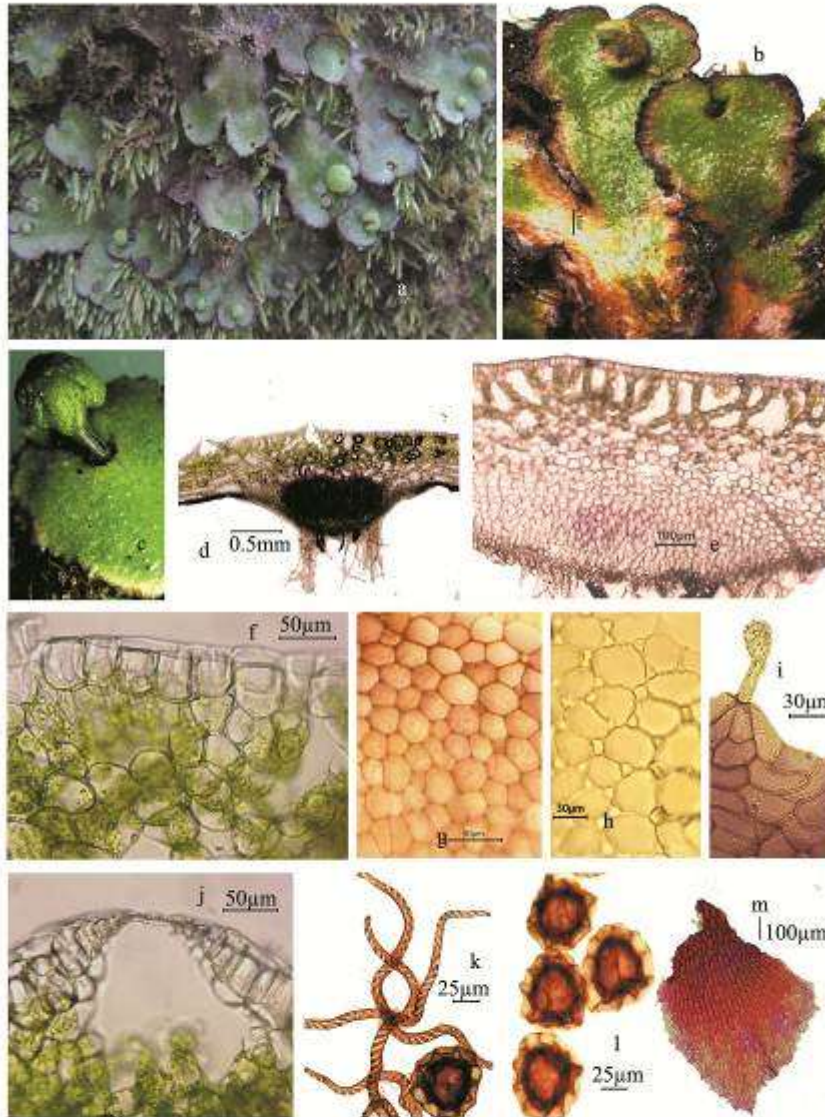


Plate 5. 04: *Reboulia hemisphaerica* (L.) Raddi, a&b. habit, c. female receptacle, d&e. c.s. of thallus, f. photosynthetic region, g. storage region, h. epidermal cells with trigones, i. mucilage papillae, j. t.s. through the airpore, k. elaters, l. spores, m. scale

(Ozdemir & Batan, 2017); **India:** Arunachal Pradesh (D.K. Singh, 1996), Himachal Pradesh (D.K. Singh & S.K. Singh, 2015), Jammu & Kashmir (Langer & Tanwir, 2002), Karnataka; North Kanara (Bapna & Kachroo, 2000b), Kerala (Nair *et al.*, 2005), Madhya Pradesh (Kapoor *et al.*, 2011), Manipur (D. Singh *et al.*, 2010a), Meghalaya (A.P. Singh & Nath, 2007), Odisha (Alam *et al.*, 2013), Punjab (D.K. Singh *et al.*, 2006), Rajasthan (Bapna & Kachroo, 2000b); Sikkim (D.K. Singh *et al.*, 2008), Tamil Nadu (Daniels, 2010), Uttar Pradesh (D.K. Singh & S.K. Singh, 2015), Uttarakhand (Sahu & A.K. Asthana, 2014), West Bengal (Ghosh, 2006).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2200-2350 m) 22.09.2018 *Mufeed 9915b, 9916* (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Kuttikanam (1065m) 24.10.2015 *Manjula 15762* (ZGC); Ichampatty, Chinnar, (1550m), 16.01.2003, *Manju* (87331 CALI!); Munnar (1100m) 24.10.2007 *Gokuldas 106418* (CALI!); Mathikettan Shola National Park, Karipara, 12.03.2014, (1660m), *Rajilesh V.K. 10917* (MBGH!); Wayanad district, Soojipara, (887), *Manju 87085a* (CALI!); Tamil Nadu; Ooty, Coonoor (1720m), 22.12.2015, *Deepa & Manjula 15860* (ZGC).

Conocephalaceae Müll. Frib. Ex Grolle,

J. Bryol. 7(2): 207. 1972.

Thallus dichotomously branched, comparatively large, dorsal surface with elongated polygonal areas with elevated air pores in the middle, margin hyaline; airpores simple, surrounded by 4-6 concentric rings of 6-8 cells; ventral scales large, hyaline or slightly purplish, one row on either side of midrib, appendage single, mucilage papillae present; air chambers in a single row, photosynthetic filaments vestigial; male receptacle terminal, sessile, discoid, unlobed; dioicous, female receptacle stalked, carpocephalum conical, not deeply lobed, pseudoperianth absent, peduncle with single rhizoid furrow, involucre tubular, 7-8 per receptacle, each bear single sporogonium; capsule wall unistratose, cells with annular thickening, dehiscence by splitting into 4-8 valves; spores with lamellate ornamentation; elaters 2-4 spiral.

***Conocephalum* Hill,**

Gen. Nat. Hist. (ed. 2) 2: 118. 1773.

Dioicous; thallus comparatively large, dichotomously branched, dorsal surface with elongated polygonal areas with elevated air pores in the middle, margin hyaline; airpores simple, surrounded by 4-6 concentric rings of 6-8 cells; ventral scales large, hyaline or slightly purplish, one row on either side of midrib, appendage single, mucilage papillae present; air chambers in single row, photosynthetic filaments vestigial; male receptacle terminal, sessile, discoid, unlobed; female receptacle stalked, carpocephalum conical, not deeply lobed, pseudoperianth absent, peduncle with single rhizoid furrow, involucre tubular, 7-8 per receptacle, each bear single sporogonium; capsule wall unistratose, cells with annular thickening, dehiscence by splitting into 4-8 valves; spores with lamellate ornamentation; elaters 2-4 spiral.

Conocephalum conicum (L.) Dumort., Comment. Bot. 115.1822; Bapna & Kachroo, Hepatic. India 2: 399. 2000; Manju *et al.*, Trop. Bryol Res. Rep. 7: 4. 2008; D.K. Singh *et al.*, Liverw. & Hornw. India. 192. 2016; Manju & Rajesh, Liverw. Kerala vol.1. 2017. *Marchantia conica* L., Sp. Pl. 1138. 1753.

Thallus dioicous; bright greenish, glossy, large, up to 8cm long, 1cm broad, dichotomously branched, margin undulating translucent, leathery, membranous; dorsal surface flat; mid dorsal line shallow, polygonal areas that represent the lower air chambers very prominent, in the middle of each polygonal areas air pore present; pore simple, well elevated over thallus surface, aperture 35-40 µm in diameter, surrounded by 4-5 rings of 6-8 cells; ventral surface pale green, midrib prominent covered by rhizoids; ventral scales large in one row on either side of midrib more towards apex not overlapping, appendage single, purplish, 0.3 mm long, 0.35-0.45 mm in maximum width, slightly, constricted towards base, margin slightly crenulated, with many mucilage papillae, basal body broad, 0.7-0.9 mm wide, slightly bulged towards one side, hyaline, cells in the bulged region polygonal, rest of the cells rectangular, elongated, margin densely covered by mucilage papillae; epidermal cells pentagonal to hexagonal, 33-50 µm long and 31-40 µm wide, thin walled, trigones absent; storage region parenchymatous, cells polygonal, 10-15 cells

high towards midrib, gradually narrowing towards margin; male receptacle disciform, subsessile, near the apex, slightly raised on a short stalk, antheridia scattered in the disc, receptacle conical or dome shaped, immersed in thallus while young, pedunculate after fertilization, surrounded by receptacular scales while young, peduncle hyaline; purplish colour at the base; 1.5-2 cm long rhizoid furrow single, carpocephalum conical, not deeply lobed pseudoperianth absent, sporophyte 2 to 5, involucre bilipped, capsule globose, capsule wall single layered except at top, cells with annular thickening, seta long; spores green while young and yellowish brown at maturity, globose to elliptical, 35-48 μm in diameter, 26 $\times$ 35 – 33 $\times$ 40 μm when elliptical; ornamentation lamellate, lamellae forms reticulate pattern; elaters fluently fusiform, trispiral, 200-270 μm long (Plate 5.05).

Habitat: Terricolous; formed as loose patches at an altitude above 2000 m mostly on land cuttings in shola forests where water drips regularly and also found among soil in Tea plantations.

Discussion: *Conocephalum conicum* (L.) Dumort. is the widely distributed species and developmental studies were conducted in this species Szweykowski *et al.* (2005). The peculiar character of *Conocephalum conicum* is the conical shaped carpocephalum of female receptacle. It is also characterized by the light green thallus which is large upto 8cm long and more than 1 cm broad, dorsal surface with distinct polygonal areas with large and well elevated epidermal pores. Ventral scales are large of almost 1 mm wide with wavy margin and numerous slime papillae.

Distribution: World: Afghanistan (Frey, 1974), Bhutan (Long & Grolle, 1990), China (Piippo, 1990), Europe (Söderström *et al.*, 2007), Iran (Akhani & Kürschner, 2004), Japan (Yamada & Iwatsuki, 2006), Korea (Yamada & Choe, 1997), Nepal (Hattori, 1975a; Pradhan & Joshi, 2009), Macronesia (Söderström *et al.*, 2002), North America (Schuster, 1992), Pakistan (Furuki *et al.*, 1993), Russia (Konstantinova *et al.*, 2009), Taiwan (Wang *et al.*, 2011), Turkey (Kürschner & Erdağ, 2005, Ozdemir & Batan, 2017); **India:** Arunachal Pradesh (D.K. Singh, 1996), Himachal Pradesh (D.K. Singh & S.K. Singh, 2015), Jammu & Kashmir (Langer & Tanwir, 2002), Kerala (Madhusoodnan *et al.*, 2007; Manju *et al.*, 2008), Manipur (D. Singh *et al.*, 2010a); Orissa (Alam *et al.*, 2013), Sikkim (D.K. Singh *et*



Plate 5.05: *Conocephalum conicum* (L.) Dumort., a. thallus, b. t.s. of thallus through margin, c. t.s. of air pore, d. photosynthetic region, e. dorsal epidermis, f. storage region, g. scale margin, h. air pore, i. scale, j. spores, k&l. spores enlarged, m. elater

al., 2008), Uttarakhand (Bir, 1970), West Bengal (Ghosh, 2006).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2100m) 04.03.2016 *Mufeed 10050*; Mannavan Shola (2050m) 24.03.2016 *Mufeed 15946* (ZGC).

Other specimen/s examined: India, Arunachal Pradesh; Mehao WLS, 20.02.2006, Das & Dey (39019 CAL!), West Bengal; Singalila NP (2696m), 03.11.2003, A.K. Asthana & Sahu (LWG 224383!, 224389!), West Bengal, Darjeeling (2377m), 08. 11. 2003, A.K. Asthana & Sahu (LWG 225468!), Japan, Miyazaki (100m), 10.01.1946, S. Hattori (35 BM!).

Wiesnerellaceae Inoue,

Ill. Jap.Hepat.2: 192. 1976.

Thallus large, up to 3cm long and 1cm broad; polygonal areas on dorsal surface indistinct, airpore simple, scales in two rows, appendage single; photosynthetic region with rudimentary photosynthetic filaments, storage region broad, parenchymatous; antheridia in dorsal terminal cushion, female receptacle stalked, peduncle with two rhizoid furrows, carpocephalum not deeply lobed, pseudoperianth absent, capsule dehiscence by 4-6 irregular valves.

Note: *Wiesnerellaceae* Inoue, are monotypic family under the order Marchantiales with a single species *Wiesnerella denudata* (Mitt.) Steph. (Crandall-Stotler *et al.*, 2009). The genus *Wiesnerella* was first described by Schiffner in 1896 with a single species *W. javanica* Schiffn. under the family Marchantiaceae. But, Mitten (1861) described a species *Dumortiera denudata* Mitt. from East Himalaya (Borovichev & Bakalin, 2014) which was transferred to the genus *Wiesnerella* by Stephani (1899) and synonymised it with *Wiesnerella javanica* (Mitt.) Steph. and proposed a new combination *Wiesnerella denudata* (Mitt.) Steph. (Inoue & Shimamura, 1981).

Since it is a monotypic family the genus characters are similar to the family characters.

Wiesnerella denudata (Mitt.) Steph., Sp. Hepat. 1: 154. 1899; Bapna & Kachroo, Hepatic. India 2: 439. 2000; D.K. Singh *et al.*, Liverw. & Hornw. India 276. 2016; Deepa *et al.*, Lindbergia 42: 2. 2019. *Dumortiera denudata* Mitt., J. Proc. Linn. Soc.

5: 125. 1860. *Wiesnerella javanica* Schiffn., Oesterreich. Bot. Zeit. 46: 87. 1896. *W. fasciaria* C.Gao & K.C. Chang, Act. Bot. Yunnan 3: 390. 1981.

Plants monoicous; thallus light greenish, 2-4 cm long and 7-10 mm broad, spreading, dichotomously branched, margin undulate, dorsal surface with shallow polygonal areas which represents the air chambers inside, each air chamber opens out through airpore, pores simple and elevated above thallus surface, 33-38 μm wide, surrounded by 4-5 rings of 8-10 cells; dorsal epidermis unistratose of thin walled polygonal, sub isodiametric parenchyma cells with granulate oil bodies, 54-78 μm long and 25-35 μm wide, trigones absent; anatomically divided in to upper narrow photosynthetic region and lower broad storage region, photosynthetic region with unistratose photosynthetic chambers which contain rudimentary photosynthetic filaments of one or two cells high, photosynthetic cells 19-21 μm long and 13-16 μm wide; storage region broad, parenchymatous; rhizoids of both tuberculate and smooth walled types aggregated along the mid rib; ventral scales hyaline, delicate with a single appendage, one row on either side of the mid rib, scale appendage semi circular, hyaline in young thallus and purplish in older ones, mucilaginous papillae present along the margin of the scales, margin irregular; male receptacle subsessile, cushion like and covered by hyaline scales, formed at the tip of thallus or from behind the stalk of female receptacle; female receptacle terminal, raised, formed in a notch at the apex of thallus, peduncle hyaline, 2-3 cm long, 1 mm diameter with two rhizoid furrows, carpocephalum greenish, convex, deeply lobed with 4-6 lobes, each lobe contain a single sporophyte, pseudoperianth absent; capsule blackish dehisces through longitudinal valves; spores dark brownish, spherical, surrounded by an undulating membrane with reticulate ornamentation, 27.5-30.4 μm in diameter (without wing), wing 6.5-8 μm wide; elaters golden brown, bi spiral, 300-350 μm long (Plate 5.06).

Habitat: Terricolous, grows as dense overlapping patch on wet rocks and on roots of higher plants near stream side along with *Dumortiera hirsuta* (Sw.) Nees, *Thuidium glaucinum* (Mitt.) Bosch & Sande Lac. and *Fissidens taxifolius* Hedw. in shola forests.

Discussion: This is a monotypic genus with a single species *W. denudata*. Even



Plate 5. 06: *Wiesnerella denudata* (Mitt.) Steph., a. plant habit, b. habit with sporophyte, c. thallus with female receptacle, d. female receptacle e. receptacle with sporophyte side view, f. receptacle with sporophyte ventral view, g. t.s. of thallus, h. epidermal cells, i. sporophyte, j. air pore t.s. k. airpore, l. scale, m. peduncle c.s. n. peduncle o. elater with spore, p. spores

though it was earlier reported from Sikkim, Himachal Pradesh and Jammu & Kashmir its occurrence in South India is based on the present collection. Deepa *et al.* (2019) given a detailed description of the species and reported it as new record for South India based on the collection from Anamudi Shola National Park. This species may be mistaken for *Dumortiera* due to its similar habit. This species has large and broad thallus with an undulating margin like that of *Conocephalum conicum* (L.) Dumort. and *Dumortiera hirsuta* (Sw.) Nees. It differs from *Dumortiera* Nees only in its colour when it is sterile. Thallus of *Dumortiera* is semi translucent dark green to grey coloured which is light green in *Wiesnerella*. When it produces reproductive structures it can be distinguishable. In *Dumortiera* male and female receptacles are covered by elongated hairs which is absent in *Wiesnerella*. But internally the thallus shows much variation. In *Dumortiera*, dorsal surface doesn't bear reticulations and photosynthetic filaments, but in *Wiesnerella* reticulations and photosynthetic filaments are present. Sometimes it can be mistaken for *Conocephalum* also, but the photosynthetic filaments are 1-3 cells long with uppermost cell elongated in *Conocephalum* but only vestigial with one or rarely two cells long in *Wiesnerella*.

Distribution: World: China (Koponen *et al.*, 2000), Indonesia (Campbell, 1918), Japan, Korean Peninsula, Russia (Borovichev & Bakalin, 2014), Nepal (Pradhan & Joshi, 2009), Papua New Guinea (Piippo, 1990); **India:** Himachal Pradesh (Bir & Chopra, 1972), Jammu & Kashmir (Sharma & Bhagat, 2017; Kashyap, 1929; S.K. Singh & D.K. Singh, 2010), Kerala (Deepa *et al.*, 2019), Sikkim (D.K. Singh *et al.*, 2008).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1850-1900 m) 14.07.2017 *Mufeed* 7205; Mannavan Shola 09.11.2017 *Mufeed* 7450; Pullaradi Shola (1850 m) 23.09.2018 *Mufeed* 9940 (ZGC).

Dumortieraceae D.G. Long,

Edinburgh J. Bot. 63(2–3): 260. 2006.

Monoicous or dioicous; dark greenish thallus formed in dense overlapping patches as mats in comparatively less illuminated areas along streamside or on wet rocks; dorsal surface smooth, airpores absent; air chambers absent or vestigial; ventral surface covered by bristles, ventral scales in two rows, unappendaged, hyaline and

delicate; sex organs formed on stalked receptacles; bristles present densely around the carpocephalum, peduncle with 2 rhizoid furrows; involucre tubular, pseudoperianth absent; seta short, capsule wall single layered, cells with annular thickening, dehiscence of capsule by the splitting of a wall into irregular longitudinal valves; spores comparatively smaller with muricate ornamentation; elaters long and 2-3 spiral.

Since it is a monotypic family the genus characters are similar to family characters.

Dumortiera hirsuta (Sw.) Nees, in Reinwardt, Blume & Nees, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 410. 1824; Kashyap, Liverw. W. Himal. 1: 42-43. 1929; Bapna & Kachroo, Hepatic. India 2: 440. 2000; Manju *et al.*, Trop. Bryol Res. Rep. 7: 4. 2008 & Arch. Bryol. 42: 3. 2009 & Taiwan 54: 61. 2009; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk. 377. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 276. 2013; Sandhya Rani *et al.*, Bryo. Andhra Pradesh. 54-55. 2014; D.K. Singh *et al.*, Liverw. Hornw. India: 78. 2016; Manju & Rajesh, Liverw. Kerala vol. 1. 2017; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.:459. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 612. 2019. *Marchantia hirsuta* Sw., Prodr, 145. 1788. *M. irrigua* Wilson, in Hooker, Brit. Fl. 2: 106. 1833. *Hygrophila nepalensis* Taylor, Trans. Linn. Soc. 17: 392. 1835. *Hygrophila irrigua* (Wilson) Taylor, in J. Mackay, Fl. Hibern. 2: 54. 1836. *Dumortiera irrigua* (Wilson) Nees. Naturgesch. Eur. Leberm. 4: 159. 1838. *D. nepalensis* (Taylor) Nees., Naturgesch. Eur. Leberm, 4: 169. 1838. *D. hirsuta* var. *angustior* Gottsche, and fo. *Depauperata* Gottsche, Lindenb. & Nees, Syn. Hepat. 544. 1846. *D. hirsuta* var. *intermedia* Gottsche, Lindenb. & Nees, Syn. Hepat. 544. 1846. *D. hirsuta* var. *laticornis* Gottsche, Lindenb. & Nees, Syn. Hepat. 544. 1846. *D. hirsuta* var. *irrigua* (Wilson) Spruce, Trans. & Proc. Bot. Soc. Edinburgh 15: 566. 1885. *D. hirsuta* var. *trichopus* Spruce, Trans. & Proc. Bot. Soc. Edinburgh 15: 567. 1885. *D. hirsuta* var. *brasiliensis* Schiffn., in Schiffner & Arnell. Oesterr. Akad. Wiss., Math-Naturwiss. KI. Denkschr. 111: 8. 1964.

Thallus semi translucent dark green to grey coloured, usually in large overlapping patches; thallus large, 3-10 cm long and 0.8-1.5 cm wide, margin undulate or wavy, dichotomously branched, prominent midrib; dorsal surface

smooth or papillate, air pore absent; ventral surface has scales all over, mid rib covered by rhizoids; ventral scales delicate, hyaline and membranous; t.s of thallus differentiated in to photosynthetic and storage region, photosynthetic region constituted by upper 2-3 layers of cells, upper most layer forms the epidermis, cells thin walled comparatively small, 12-23 μm long and 11-15 μm wide in cross section; cells in the storage region polygonal, larger, towards mid rib thick walled and smaller with oil bodies, largest in wings; sex organs dorsal and apical; male receptacle discoid, densely covered with bristles, peduncle short, 0.3-0.4 mm long, 0.8-1 mm in diameter; female receptacle apical, sessile when young, carpocephalum discoid slightly convex dorsally, densely covered with bristles, shallowly 6-10 lobed, peduncle elongated 2-4 cm long and 0.9-1.5 mm in diameter hyaline margin wavy in cross section, rhizoid furrows 2; spores hemispherical, 20-28 μm in diameter, isopolar, ornamentation muricate; elaters dark brown, 2 (-3) spiral, 0.4-0.6 mm long, 7-9 μm wide towards middle (Plate 5.07).

Habitat: Terricolous or rupicolous, formed as dense patch on wet soil covered rocks, large wet rocks, along with other mosses such as *Fissidens anomalus* Mont., *Plagiomnium rhynchophorum* (Hook.) T.J. Kop., *Vesicularia levieri* Cardot, *Wiesnerella denudata* (Mitt.) Steph. etc. in evergreen and shola forests at an altitude above 1800 m.

Discussion: The genus *Dumortiera* Nees was established by Reinwardt *et al.* (1824) by transferring *Marchantia hirsuta* Sw. to *D. hirsuta* (Sw.) Nees. Several species have been reported in *Dumortiera* Nees since then (Forrest *et al.*, 2011), but Söderström *et al.* (2016) recognized only a single highly variable species and two subspecies, viz., *D. hirsuta* (Sw.) Nees transferred from *Marchantia hirsuta* Sw. (Swartz, 1788; Reinwardt *et al.*, 1824) and *Dumortiera hirsuta* subsp. *nepalensis* (Taylor) R. M. Schust. transferred from *Hygrophila nepalensis* Taylor (Schuster, 1992) and *Dumortiera hirsuta* subsp. *tatunoi* Horik. (Horikawa, 1951) described from Japan. *Dumortiera hirsuta* (Sw.) Nees is characterized by the semi translucent dark green to grey coloured thallus. Air chambers or air canals are completely absent in the thallus. Upper 2-3 layers of dorsal tissue are photosynthetic and the ventral surface of the thallus has hyaline hairs, receptacles are covered by long bristles.



Plate 5. 07: *Dumortiera hirsuta* (Sw.) Nees. a. habit with sporophyte, b. habit without sporophyte, c&d. receptacle, e. papillae on thallus margin, f. c.s. of thallus, g. storage region, h. c.s. of receptacle, i. elater, j&k. spores

Distribution: World: Africa (Wigginton, 2009), Australia (McCarthy, 2006), Bangladesh (Banu-Fattah, 2001), Bhutan (Long & Grolle, 1990), China (Piippo, 1990), Europe (Söderström *et al.*, 2007), Hawaii (Staples & Imada, 2006), Indonesia (Söderström *et al.*, 2010), Iran (Akhani & Kürschner, 2004), Japan (Yamada & Iwatsuki, 2006), Korea (Yamada & Choe, 1997), Macronesia (Söderström *et al.*, 2002), Nepal (Hattori, 1975a), New Zealand (Glenny, 1998), North America (Schuster, 1992), Papua New Guinea (Piippo, 1991), Sri Lanka (Long & Rubasinghe, 2014), South America (Bischler-Causse *et al.*, 2005), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008); **India:** Andhra Pradesh (Sandhya Rani *et al.*, 2014), Arunachal Pradesh (D. K. Singh, 1996), Assam (Barbhuiya & Singh, 2012), Goa (Phatak *et al.*, 2007), Himachal Pradesh (S.K. Singh & D.K. Singh, 2009), Jammu & Kashmir (Langer & Tanwir, 2002), Kerala (Nair *et al.*, 2006; Manju *et al.*, 2008; Manju & Rajesh, 2017), Madhya Pradesh (A.K. Asthana & Nath, 2007), Manipur (D. Singh *et al.*, 2010a), Meghalaya (A.P. Singh & Nath, 2007), Nagaland (Chaturvedi & Chaturvedi, 2008), Orissa (Dash & Saxena, 2009), Sikkim (D.K. Singh *et al.*, 2008), Tamil Nadu; (Daniels, 2010), Uttarakhand (Gaur & Nautiyal, 1981, S.K. Singh & D.K. Singh, 2002), West Bengal (Hattori, 1966).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola, Jandamala (1950 m) 09.11.2017 *Mufeed* 7480; Mannavan Shola (1850-1870 m) 07.02.2018 *Mufeed* 7295, 7296 (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Marayoor (1029m), 07.02.2015, *Mufeed* 16045 (ZGC); Marayoor (1029m), 07.02.2015, *Mufeed* 16046 (ZGC); Marayoor (1029m) 05.02.2014 *Mufeed* 1003, 1005 (ZGC); Mathikettan Shola (1620m) 27.11.2014 *Rajilesh* 3926 (ZGC); Mathikettan Shola National Park, Chundel (1300 m), 09.04.2013, *Rajilesh* V.K. 9451 (MBGH!); Palakkad district, Nelliampathi (1139 m), 24.09.2015, *Maya* 15693, 15699 (ZGC), Parambikulam TR (1530 m), 12.10.2006, *Manju* 106806 (CALI!); West Bengal, Darjeeling (2407 m), 08.11.2003, *Asthana & Sahu* (LWG 225458!), Bangladesh, Cox's Bazar, J, Sinclair (3180 BM!).

Fossombroniales Schljakov,

Bot. Zhurn. (Moscow & Leningrad) 57(4): 500. 1972.

Fossombroniaceae Hazsl.,

Magyar Bir. Moh-fl. 20, 36. 1885.

Plants very delicate, small, yellowish to greenish, thallus ruffled, prostrate to procumbent; leaves lobed, uniseriate, margin wavy, possess slime papillae; sporophyte differentiated in to foot, seta and capsule, capsule globose, seta usually short, spores numerous, rounded, yellowish brown.

Fossombronia Raddi,

Jungermanniogr. Etrusca 29. 1818.

Plants prostrate, green to yellowish green, obliquely arranged, delicate thallus found in open soil as patches; stem simple, distally flattened with or without apical tubers; rhizoids usually hyaline; leaves quadrate to subquadrate, broad on top, gradually decreases and narrow on base, usually broader than long, succubus, obliquely arranged in either sides; leaves usually form a single papillae at tip; cells thin walled, filled with chloroplast in fresh, absent in dry thallus; monoicous or dioicous.

Fossombronia pusilla (L.) Nees, Naturgesch. Eur. Leberm. 3: 319. 1838; K.P. Srivast. & Udar, Nova Hedwigia, 26: 808. 1975; Alam, *Frahmia* 7: 2. 2014; D.K. Singh *et al*, Bot. Surv. India. 82. 2016. *Jungermannia pusilla* L., Sp. Pl. 2: 1136. 1753. *Maurocenius pusillus* (L.) Gray, Nat. Arr. Brit. Pl. 1: 687. 1821. *Codonia pusilla* (L.) Dumort., Comment. Bot. 111. 1822.

Plants usually green to pale green, very delicate, tufted, thallus up to 10 mm long; stem prostrate, fleshy, internal cells of the stem parenchymatous, thin-walled; leaves simple, oblong-quadrate or quadrate to reniform, leaf apex broader and narrow at base, 1.56 mm long and 1.20 mm wide, imbricate, obliquely inserted, margin entire, strongly undulate and irregularly lobed to angulate; apical marginal cells rectangular to quadrate, usually form a single papillae, marginal cells 19-42×26-64 µm, median leaf cells thin-walled, pentagonal to hexagonal, 110-134×36-57 µm; basal cells long, rectangular, 148-193×34-54 µm; rhizoids slightly pinkish, scattered along the

ventral surface of the plant; oil bodies very small, spherical to ellipsoidal, 18-35 per cell, slightly bluish; sporophyte erect, arising from the tip of the plant, seta short, 1-3 mm long, capsule spherical, dark brown, green when young; spores reddish to dark brown, 38-40 μm diameter, distal face irregularly lamellate, 5-7 lamellae, project as 12-19 spines around the margin of each spore, lamellae are almost parallel, elaters yellowish brown, 145-155 μm long, mostly bispiral (Plate 5.08 & 09).

Habitat: Lithophytic, on rock filled land cuttings along with *Pogonatum microstomum* (R.Br. ex Schwägr.) Brid. and *Asterella leptophylla* (Mont.) Pande, K.P. Srivast. & Sultan Khan ex Grolle in the shola forests along the line of grassland at an altitude above 2000 m.

Discussion: *Fossombronia pusilla* is a dioicous species. Morphologically it is closely related to *F. himalayensis* Kashyap and *F. wondraczekii* (Corda) Dumort. ex Lindb. but differs significantly in sporoderm architecture (Srivastava & Udar, 1975; 1979). The distal face of the spores of *F. pusilla* are irregularly lamellate with 5-7 lamellae and project as 12-19 spines around the margin of each spore. But in *F. himalayensis* the distal face of the spore is with high and thick lamellae usually broken and irregularly disposed of, forked towards the margin and form a single reticulation. In *F. wondraczekii* distal face of the spore is high and thick, usually parallel lamellae, sometimes anastomosing to form 1-2 reticulations, with prominent perispore and conspicuous spines at the equator. *F. pusilla* was first reported from India by Srivastava & Udar (1975) from Nilgiri hills in Tamil Nadu and Alam (2014a) relocated the same from Nilgiri hills. The present collection from Anamudi Shola National Park of Western Ghats extends its distribution to Kerala.

Distribution: World: Archipelago, Australia, China, Japan, Malay, Taiwan (Scott, 1985; Krayesky *et al.*, 2005; Katagiri & Furuki, 2012); Azores, Chile, Macaronesia, North and South Africa (Schuster, 1992a; Paton, 1999; Damscholt, 2002; Söderström *et al.*, 2002); Russia (Borovichev & Bakalin, 2017), Turkey (Kürschner & Erdağ, 2005); **India:** Kerala (present collection), Meghalaya (S.K. Singh & Kumar, 2013; Singh *et al.*, 2016), Tamil Nadu (Alam, 2014a; Daniels, 2010; Srivastava & Udar, 1975), Uttarakhand (S.K. Singh & D.K. Singh 2007; D.K. Singh *et al.*, 2016).

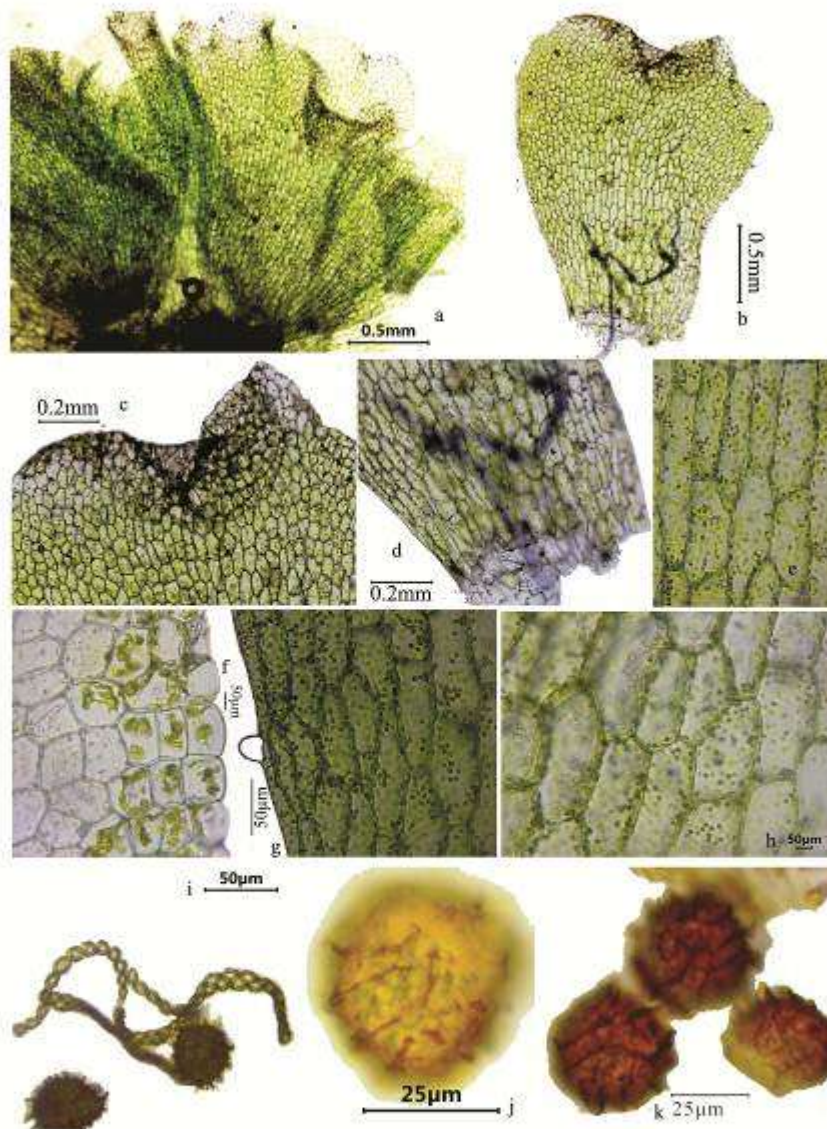


Plate 5.08: *Fossombronina pusilla* (L.) Nees, a. single thallus, b. leaf, c. leaf apex, d. leaf base, e. cells at middle, f. cells at margin, g. marginal cells with single papillae, h. cells showing oil bodies, i. spores and elaters, j&k. spores

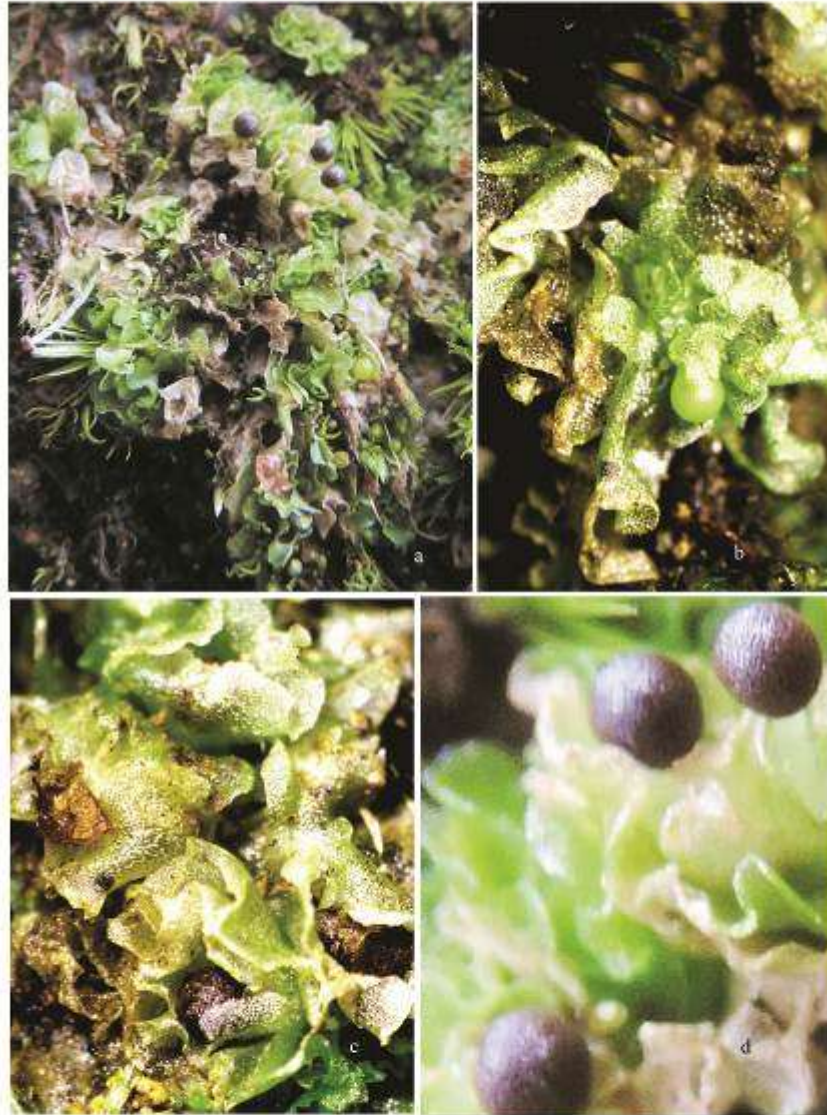


Plate 5. 09: *Fossombronia pusilla* (L.) Nees, different views of the habit, a&c. habit with mature sporophyte, b. habit with young sporophyte, d. mature sporophyte

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100-2350 m) 22.09.2018 *Mufeed* 9914; 27.09.2018 *Mufeed* 9892 (ZGC).

Pallaviciniales W. Frey & M. Stech,
Nova Hedwigia 81: 64. 2005.

Pallaviciniaceae Mig.,
Krypt.-Fl. Deutschl., Moose 423. 1904.

Plants thallose, creeping, prostrate, usually delicate or thick, forked at tip; margin entire or wavy, mid rib with central strand, thickened or pitted cells; lamina one celled thick, wide, cells hexagonal, apex obtuse, broad to lanceolate, rhizoids numerous in the midrib region; monoicous or dioicous.

Pallavicinia S.Gray.,
Nat. Arr. Brit. Pl. 1: 679, 775. 1821.

Plants thallose, prostrate, linear, midrib conspicuous, wing narrow to broad with undulate margin; rhizoids on either side of the midrib or on the midrib region; hairy along the margin of wing and costa, straight or slightly curved; antheridia on dorsal surface in receptacle, surrounded by involucre; capsule oblong-cylindrical; spores spherical, reddish-brown, reticulate; elaters 2-3 spiralled.

Pallavicinia ambigua (Mitt.) Steph., Mém. Herb. Boissier 11: 7. 1900; A.P. Singh & Nath, Hepat. Hepatic. Khasi Jaintia Hills 303. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7:4. 2008; D.K. Singh *et al.*, Liverw. Hornw. India 202. 2016; Manju & Rajesh, Bryo. Kerala. Liverw. 1: 49. 2017. *Steetzia ambigua* Mitt., J. Proc. Linn. Soc., Bot. 5: 123. 1861. *Pallavicinia fistulosa* Steph., Sp. Hepat. 6: 63. 1917. *Symphyogyna philippinensis* Steph., Sp. Hepat. 6: 69. 1917. *Pallavicinia nigricans* Herzog, Memoranda Soc. Fauna Fl. Fenn. 26: 39. 1951.

Plants thalloid, ribbon like, simple or branched, prostrate, yellowish green or dark greenish, up to 5 cm long and 10 mm wide; rhizoids arise only in the midrib region, forking of the thallus is caused by a vertical division in the apical cell, forking may have a limited or unlimited growth depending upon the availability of sunlight and moisture content; midrib of cells usually 9 or 10 cells thick and it suddenly passes

into one cell thick towards margin, cells thin walled, polygonal, the central conducting cells thick walled, small, 12-14 µm, polygonal, marginal cells 20-30 µm, median cells 30-45 µm; plants collected with young sporophyte, the young sporophyte is oblong cylindrical and greenish, spores not matured (Plate 5.10).

Habitat: On wet rocks and wetland cuttings where water drips regularly in partially shady areas of shola forests above 2200 m.

Discussion: *Pallavicinia ambigua* was first reported from Khasi hills in India as *Steetzia ambigua* Mitt. Stephani (1900) re-examined this species on the basis of the collections made by Hooker from Khasi hills and included under the genus *Pallavicinia* S. Grey. The first report of this species is from Kerala is by Kachroo (1956). Later Manju *et al.* (2009) collected from Agasthyimalai Biosphere reserve. This species is characterized by ribbon like prostrate thallus up to 5cm long and the cells across the midrib are 9 or 10 cells wide.

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994);

India: Eastern Himalaya, Meghalaya (A.P. Singh & Nath, 2007), Kerala (Manju *et al.*, 2009; Manju & Rajesh, 2017).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2300 m) 27.09.2018 *Mufeed 9888* (ZGC).

Metzgeriales Rosenv.,
Sporeplanterne 278. 1913.

Key to the families

- 1a. Plants thin, dichotomously branched, bristle-like hairs present all over the thallus **Metzgeriaceae**
- 1b. Plants moderately thick, irregularly branched, hairs absent **Aneuraceae**

Metzgeriaceae H. Klinggr.,
Höh. Crypt. Preuss. 10. 1858.

Plants thalloid, yellowish green, thallus narrow, thin, prostrate, erect or pendant and flattened, either irregularly or dichotomously branched; lamina unistratose, apex truncate or obtuse, margins bearing bristle-like hairs; costa well defined, with large epidermal cells, bristle-like hairs present on thallus margins, ventral surface of costa

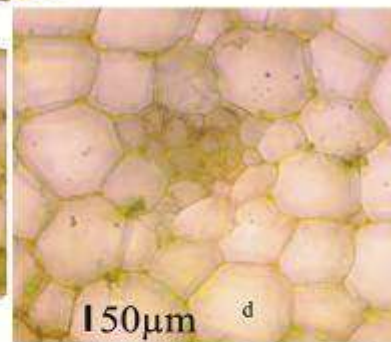


Plate 5. 10: *Pallavicinia ambigua* (Mitt.) Steph., a. habit, b. c.s. of thallus, c. cells at middle, d. cells at center, e. cells at margin, f. young sporophyte

and surface of thallus; oil bodies absent or very small, homogeneous; ventral scales absent, asexual reproduction by gemmae; dioicous or monoicous; specialized male and female branches on very short branchlets, scattered along the ventral side of the costa, antheridia inside a globose sac, archegonia hidden under a thallus flap, sporophyte surrounded by fleshy, hairy calyptra, capsule spherical to ovoid, splitting into four valves when mature, walls 1–2-stratose, elaters single-spiralled, attached to elatophore at valve apices; spores small, minutely papillose.

***Metzgeria* Raddi,**

Jungermanniogr. Etrusca. 34. 1818.

Plants thalloid, yellowish green to pale green, thin and flattened, dichotomously branched; lamina unistratose, apex truncate or obtuse, margins bearing bristle like hairs; costa well defined; mucilage hairs short or long on thallus margins and ventral surface of costa and surface of thallus, ventral scales absent; asexually reproduce by gemmae; dioicous or monoicous.

Key to the species

1a. Mucilage hairs long and straight arise from margin of the wing and ventral surface of the mid rib ***Metzgeria lindbergii***

1b. Mucilage hairs short and straight, arise from the margin of the wing ***Metzgeria* sp.**

Metzgeria lindbergii Schiffn., Denkschr. Kaiserl. Akad. Wiss., Wien Math.-Naturwiss. Kl. 67: 182. 1898; A.P. Singh & Nath, Hepat. Hepatic. Khasi Jaintia Hills 307. 2007. *Metzgeria pectinata* Steph., Sp. Hepat. 6: 58. 1917. *Metzgeria himalayensis* Kashyap, J. Bombay Nat. Hist. Soc. 26: 280. 1917. *Metzgeria saxbyi* Pearson, Ann. Cryptog. Exot. 4: 70. 1931. *Metzgeria oceanica* Kuwah., J. Hattori Bot. Lab. 23: 22. f. 9: a–h. 1960. *Metzgeria assamica* S.C. Srivast., J. Indian Bot. Soc. 55: 194. f. 1–17. 1976. *Metzgeria minuta* Kuwah., J. Hattori Bot. Lab. 31: 166. 1968. *Metzgeria conjugata* subsp. *japonica* (S. Hatt.) Kuwah., J. Hattori Bot. Lab. 20: 135. 1958. *Metzgeria fukuokana* Kuwah., J. Jap. Bot. 53: 264. f. 1–21. 1978. *Metzgeria minor* (Schiffn.) Kuwah., J. Jap. Bot. 53: 269. 1978.

Plants pale green, 10 mm long and 0.9 mm wide, prostrate, delicate, thin, dichotomously branched, slightly convex at apex, obtuse with many hairs,

adventitious shoots present; midrib distinct; gemmae usually present on the marginal regions; mucilage hairs long and straight, arise from margin of the wing and ventral surface of the midrib; cells usually polygonal, thin walled; cells at apex marginal cells comparatively small, 23–30 µm long and 30–40 µm wide; median cell large, 40–55 µm across; reproductive structures not seen (Plate 5.11).

Habitat: Epiphytic, on barks of large trees in shola forests.

Discussion: Kashyap (1917) described *Metzgeria himalayensis* Kashyap from Western Himalayas and thereafter this species is represented in bryoflora of India by this name. Srivastava (1976) reported another new species *M. assamica* S.C. Srivast. from Assam. So (2003) in her revision on the genus *Metzgeria* in Asia synonymised *M. assamica* under *M. lindbergii* Schiffn. He & Jia (2019) treated these two species under *M. lindbergii* Schiffn. This species was earlier recorded only from Tamil Nadu in South India. Hence the present collection from Anamudi Shola National Park is a new record for Kerala. This species is characterized by very delicate and thin thallus with a distinct midrib, long mucilage hairs which arise from margin of the wing and ventral surface of the midrib.

Distribution: World: Australia, Bhutan, China, Indonesia, Japan, Malaysia, Nepal, Philippines, Sri Lanka (So, 2003; He & Jia, 2019), Columbia (Ellis *et al.*, 2019);

India: Assam (Srivastava, 1976 as *M. assamica*), Himachal Pradesh (S.K. Singh & D.K. Singh, 2010), Kerala (Present collection), Manipur (D. Singh *et al.*, 2010a), Meghalaya (A.P. Singh & Nath, 2007 as *M. assamica* & 2007 as *M. conjugate* subsp. *japonica*), Odisha (Mishra *et al.*, 2016), Sikkim (D.K. Singh *et al.*, 2008), Tamil Nadu (Foreau, 1961; Srivastava & Udar, 1975; Daniels, 2010), Western Himalaya (Kashyap, 1917 as *M. himalayensis*).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1945-2100 m) 07.02.2018 *Mufeed* 9844; 26.09.2018, *Mufeed* 13349 (ZGC).

***Metzgeria* sp.**

Plants pale green, 5-10 mm long, 0.9 mm wide, prostrate, very delicate, thin, dichotomously branched, slightly convex at the apex, obtuse; midrib distinct;

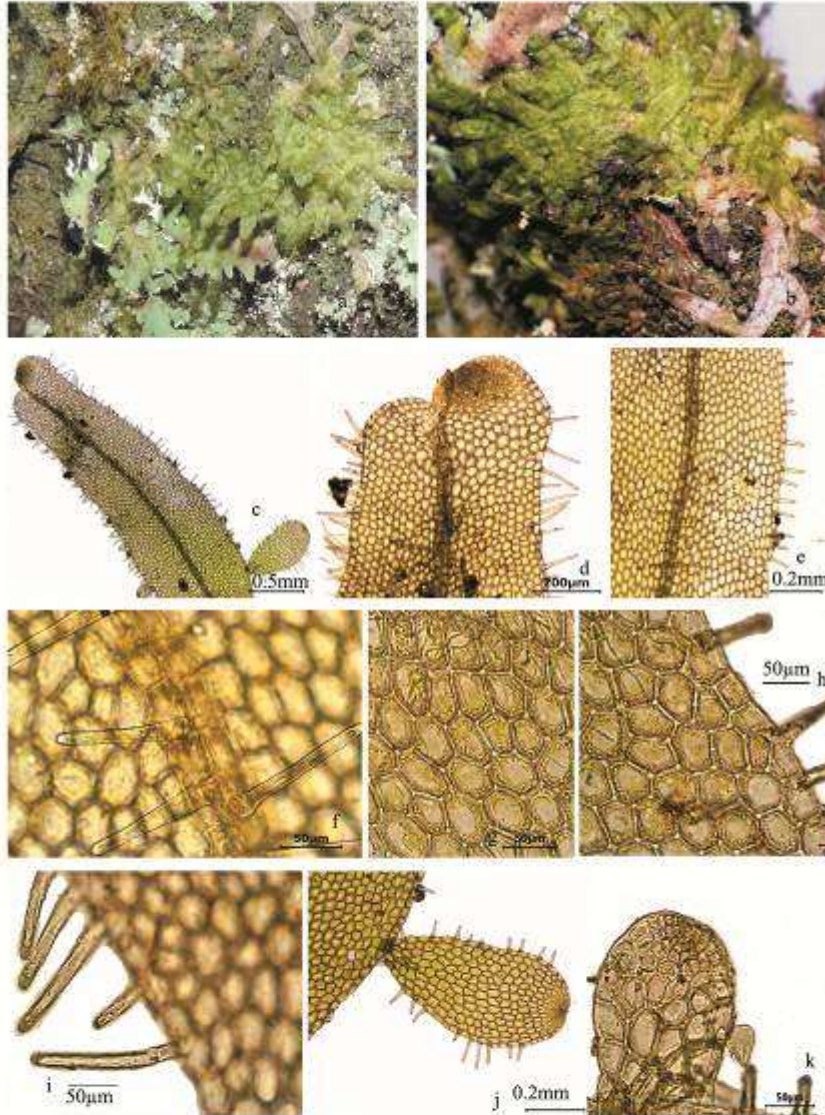


Plate 5. 11: *Metzgeria lindbergii* Schiffn., a&b. habit, c. single thallus, d. tip of thallus, e. thallus margin, f. spines on costa, g. middle cells, h. marginal cells, i. thallus outgrowth, j&k. new propagules

mucilage hairs short and straight, arise from margin of the wing usually from the middle; cells usually polygonal, thin walled, cells at apical margin comparatively small, 30-35 µm long 30-32 µm wide; median cells 25-35 µm across; gemmae and reproductive structures not observed (Plate 5.12).

Note: The species is collected from the Wattle plantation on the Iddalymotta region. Due to the cutting of woods and fire line works the habitat may destroy. The additional collection was not getting further clarification.

Habitat: Epiphytic, on barks of shola tree.

Discussion: Plants prostrate and delicate, dichotomously branched thallus, mucilage hairs short and arise from the marginal wings. Without the sporophyte it is very difficult to confirm most of the species of *Metzgeria*. The vegetative characters are different from the species already reported from India. Hence this collection is not confirmed up to species at this time. Further investigation is needed to fix its identity.

Distribution: Kerala (Present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2300 m) 22.09.2018 *Mufeed* 9919 (ZGC).

Aneuraceae H. Klinggr.,
Höh. Crypt. Preuss. 11. 1858.

Plants pale green to darkish green, prostrate, small or medium sized, delicate, moderately thick, fleshy, pinnately or irregularly branched, apex obtuse, margin smooth or entire; rhizoids usually absent or rare in some; thallus convex below and plain above, 3-8 cells thick in the middle and 1-2 cells thick wide at the margins; laminal cells usually polygonal with or without trigones, oil bodies present; dioicous or autoicous.

Key to the genera

- 1a. Plants fleshy, bright green, pinnately branched ***Aneura***
- 1b. Plants delicate, pale to deep green, irregularly branched ***Riccardia***

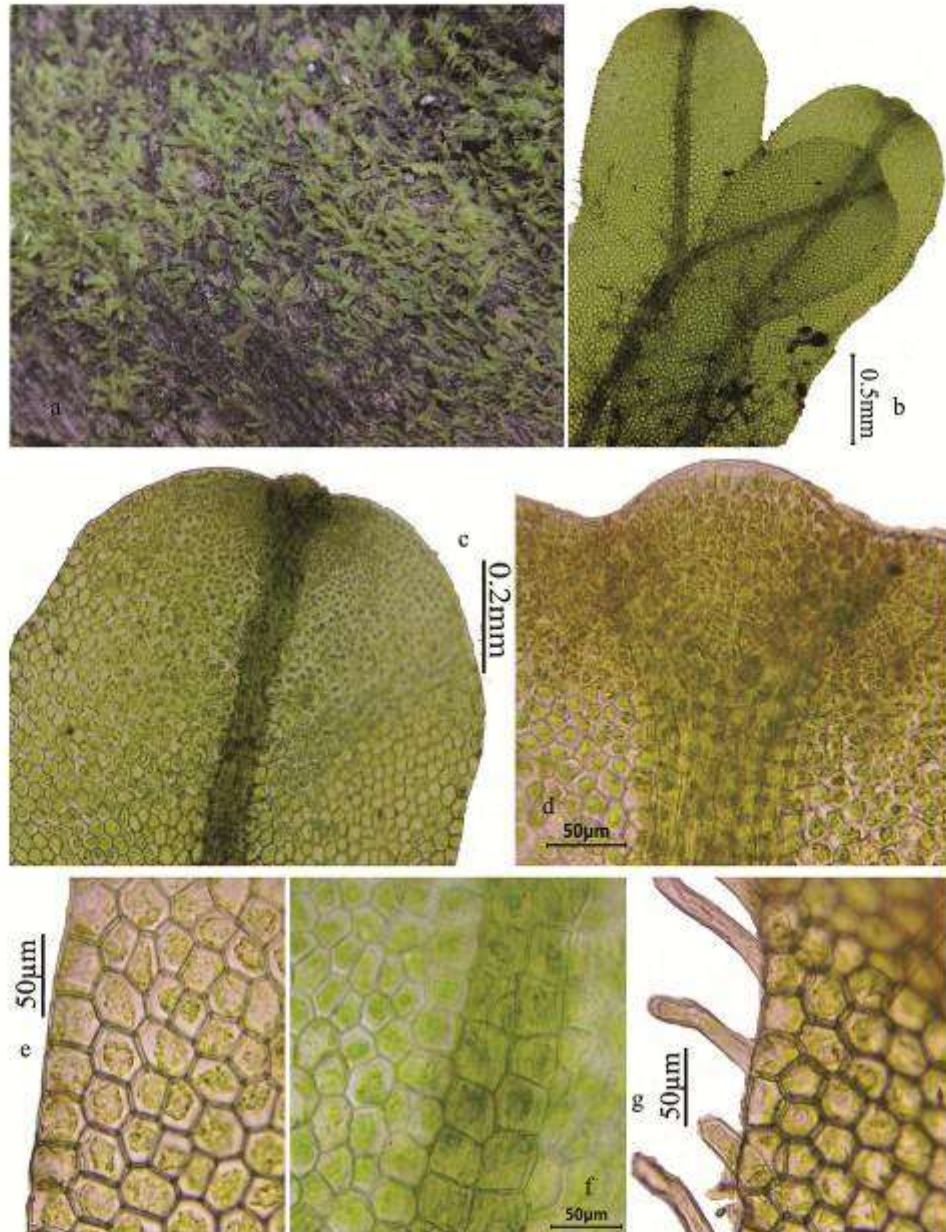


Plate 5. 12: *Metzgeria* sp., a&b. habit, c. leaf apex, d. cells at notch, e. cells at margin, f. nerve cells, g. mucilage hairs.

***Aneura* Dumort.,**
Comment. Bot. 115. 1822.

Thallus prostrate, closely attached to substrate, fleshy, bright green, robust. 2-4 mm long, ligulate, apex rounded; branching simple, oil bodies in cells numerous, cells thick towards middle, thallus gradually becoming thinner toward undulate or plicate margins; rhizoids restricted to median ventral surface; dioicous; male branches with 2-4 irregular rows of antheridia; female branches rudimentary with archegonia sessile and hidden in deep lateral notch, archegonia in 2 or more rows; seta thick, capsule valves with thickenings along longitudinal walls of epidermal cells on both adaxial and abaxial surfaces; spores 18-27 µm diameter.

***Aneura pinguis* (L.) Dumort.**, Syll. Jungerm. Europ. 86. 1831; Chopra, Proc. Indian Acad. Sci. Sect. B7: 243. 1938; S.C. Srivast. & Udar, Biol. Mem. 1: 144. 1976; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 14. 1994; Bapna & Kachroo, Hepatic. India 2: 358. 2000; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 3. 2008; Daniels, Arch. Bryol. 65: 8. 2010; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 274. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 253. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 49. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 432. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 580. 2019. *Jungermannia pinguis* L., Sp. Pl. 2: 1136. 1753. *Riccardia pinguis* (L.) Gray, Nat. Arr. Brit. Pl. 1: 684. 1821. *Metzgeria pinguis* (L.) Corda, Naturalientausch 12: 654. 1829. *Aneura pinguis* var. *angustior* (Hook.) Dumort., Syll. Jungerm. Europ. 86. 1831. *Gymnomitrion pingue* (L.) Huebener, Hepaticol. Germ. 41. 1834. *Aneura sessilis* (Spreng.) Gottsche, Lindenb. & Nees, Syn. Hepat. (fasc. 4): 495. 1846. *Riccardia fuscovirens* Lindb., Musci Scand. 5. 1879. *Riccardia pinguis* var. *tenuis* Nees ex Schiffn., Consp. Hepat. Arch. Ind. 56. 1898. *R. viridissima* Schiffn., Denkschr. Kaiserl. Akad. Wiss., Wien Math.-Naturwiss. Kl. 67: 176. 1898. *Aneura viridissima* (Schiffn.) Steph., Sp. Hepat. 1: 273. 1899. *Aneura laurentiana* Steph., Sp. Hepat. 6: 32. 1917. *Riccardia blasioides* Horik., J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 1: 197. f. 1. 1933. *R. indica* Pandé & K.P. Srivast., J. Indian Bot. Soc. 37: 417. 1958 (*inval*).

Plants prostrate, in patches, bright green, fleshy, robust, axis plane to slightly concave, simple, lingulate to sublinear, 15-20 mm long 5-7 mm wide, apices rounded, margins entire, undulate to somewhat crisped or lobed; pinnately or sparsely branched, often short, sometimes long, irregularly furcate; dorsal epidermal cells barrel shaped, thin-walled, 35-55 μm long 20-35 μm wide; ventral epidermal cells 45-70 μm long 20-35 μm wide; median cells large, polygonal, 45-55 μm long and 45-70 μm wide; oil bodies found in all cells, numerous, spherical to subspherical or ovoid, faintly granular, inconspicuous, colourless, scattered; cross section of thallus plano-convex with wings weakly recurved, 7-12 cells thick, gradually becoming thinner laterally, epidermal cells chlorophyllose, shallower than internal, cells hyaline, but not forming a distinctive layer; rhizoids restricted to ventral median area, 20-25 μm wide; dioicous; male plant somewhat smaller than female plants, antheridial branches lateral, forms as continuation of thallus margin, antheridial chambers irregularly arranged, antheridia subglobular; female plant with archegonial branches, archegonia in rows; calyptra clavate, large, 10 mm long and 2 mm wide; seta long, capsule oblong ovoid, darkish, with 4 valves; spores dark brown, papillose, 20 μm in diameter, elaters with single spiral band, brownish red, tapering at the ends, 140 μm long and 10 μm wide (Plate 5.13).

Habitat: Epiphytic, mostly found on decayed woods and logs in shola forest above 1800 m.

Discussion: It is a very rare species in the study area. Thallus shows slimy appearance during monsoon season and is found on rotten wood. It is characterized by prostrate fleshy bright green thallus, usually 7–12 cells thick, pinnately or sparsely branched, dioicous; calyptra clavate, seta long and capsule oblong ovoid.

Distribution: World: Africa (Perold, 2001), China (Pippo, 1990), Japan (Furuki & Mizutani, 1994), Russia (Konstantinova, 1992); **India:** Assam (Barbhuiya & Singh, 2012), Chattisgarh (Dixit & Kerketta, 2019), Himachal Pradesh (D.K. Singh & S.K. Singh, 2015), Kerala (Daniels & Kariyappa, 2019; Madhusoodanan *et al.*, 2007; Venugopal & Manju, 2017), Odisha (Mishra *et al.*, 2016), Sikkim, West Bengal, Punjab, Rajasthan, Madhya Pradesh, Maharashtra (Barbhuiya & Singh, 2012), Tamil Nadu (Daniels, 2010).

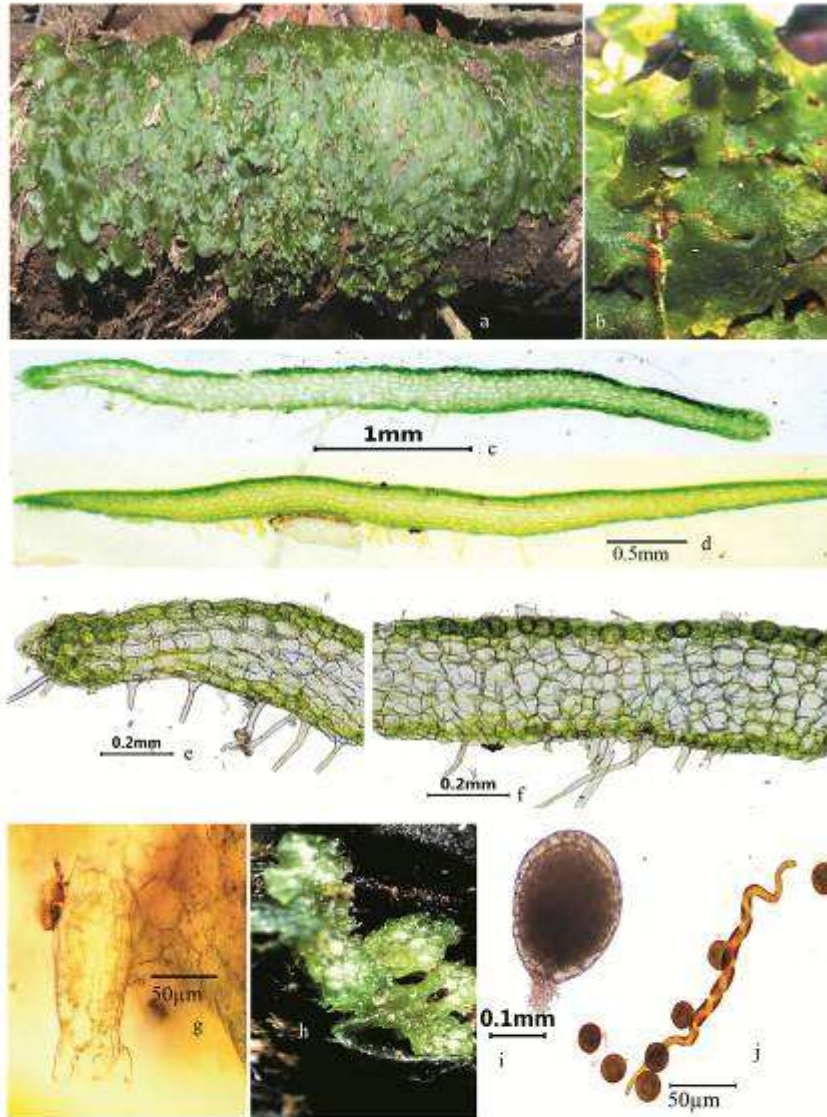


Plate 5. 13: *Aneura pinguis* (L.) Dumort., a. habit, b. habit with sporophyte, c&d. t.s. of thallus, e. t.s. of thallus margin at tip, f. t.s. of thallus at middle, g. fertile structure at margin, h. gemmae cup, i. gemmae, j. elater and spores

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (1900-2300 m) 07.02.2018 *Mufeed* 1797, 23.09.2018 *Mufeed* 9946, 26.09.2018 *Mufeed* 9991 (ZGC).

***Riccardia* Gray,**

Nat. Arr. Brit. Pl. 1: 683. 1821.

Thallus narrow, delicate, irregularly or pinnately branched, branches slender with broad, emarginate or obtuse apex, margin entire or crenulate; rhizoids scarce; oil bodies present in the epidermal cells, spherical to ovoid or elliptical, simple, homogenous or granular, 1-5 per cell; main axis rounded or biconvex, 4-15 cells thick in the middle with multistratose wing becoming 1-4 cells wide and unistratose at the margins, cells thin walled; monoecious or dioicous, antheridial branches once or twice branched, archegonial branches short, sometimes elongated and branched like antheridial branches, calyptra cylindrical or clavate; seta elongated; capsule blackish-brown, ovoid or slightly cylindrical, dehiscing by 4 equal valves; spores spherical or globose, pale yellow or brown, 11-29 μm diagonally; elaters unispiraled, broad in the middle, sometimes branched.

Riccardia levieri Schiffn., Osterr. Bot. Zeitschr. 49: 130. 1899; K.P.Srivast., J. Indian Bot. Soc. 39: 538. 1960; S.C.Srivast & Udar, Biol. Mem. 1: 132. 1976; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 35. 1994; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 59. 2000; Bapna & Kachroo, Hepatic. India 2: 354. 2000; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 574. 2001; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 43. 2005; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 313. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 6. 2008; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 277. 2009; Alam & K.P.Srivast., Nelumbo 103. 2009. Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 253. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 51. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 334. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 582. 2019.

Plants pale to deep green, prostrate, 20 mm long and 1 mm wide, delicate, fleshy, irregularly branched, apices obtuse, margin smooth, entire; rhizoids rare; main axis convex below, slightly plain above, 3-5 cells thick in the middle, 1-2 cells wide at

the margins; wing multistratose, gradually thin towards margin; laminal cells polygonal, thin walled, non trigonous; oil bodies few in number and scattered, dark; reproductive structures not seen (Plate 5.14).

Habitat: On rocks, usually grow as mats on moist and shady rocks, crevices of rocks and stones near streams above 1800 m in shola forests, grasslands and tea plantations.

Discussion: This is a very common species in the riparian habitat of all types of forests in South India. It is characterized by thallus 3-5 cells thick in the middle, main axis convex below and wings multistratose, gradually become thin towards margin.

Distribution: India: Andhra Pradesh (Basha *et al.*, 2015), Chattisgarh (Dixit & Kerketta, 2019), Himachal Pradesh, Uttarakhand (D.K. Singh & S.K. Singh, 2015), Meghalaya, Sikkim, West Bengal (A.P. Singh & Nath, 2007; D. Singh & D.K. Singh, 2017), Karnataka (Schwarz, 2013), Kerala (Daniels & Kariyappa, 2019; Srivastava & Sharma, 2000; Nair and Madhusoodanan, 2001, Manju & Rajesh, 2009), Odisha ((Mishra *et al.*, 2016), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013; Daniels & Kariyappa, 2019; Sharma & Alam, 2011).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2310 m) 22.09.2018 *Mufeed* 9930; Mannavan Shola (1900 m) 24.09.2018 *Mufeed* 9969 (ZGC).

Other Specimen/s examined: India, Kerala, Wayanad district, Kurichiad range, Chikkanji (920 m) *Manju* 84540 (CALI!); Tamil Nadu, Nilgiri Hills (2250 m) 10.10.2000 *H.C. Gangulee* 12634 (CAL!).

Porellales Schljakov.

Bot. Zhurn. (Moscow & Leningrad 57(4): 505. 1972.

Key to the families

- 1a. Underleaves absent **Radulaceae**
- 1b. Underleaves present 2
- 2a. Plants medium to large, robust, up to 8 cm long, archegonium 5-30 per gynoecium **Porellaceae**
- 2b. Plants small to medium sized, 0.5-30 mm long, archegonium 1 (-2) or many 3



Plate 5. 14: *Riccardia levieri* Schiffn., a&b. habit, c. thallus enlarged view, d. t.s. of thallus, e. t.s. of thallus middle layer, f&g. cells with oil bodies

3a. Plants very small, 0.5 to 20 mm long, leaf lobule sac like, attached with lobes
..... **Lejeuneaceae**

3b. Plants medium sized, 10-30 mm long, leaf lobule helmet shaped, free from lobes
..... **Frullaniaceae**

Frullaniaceae Lorch,

Krypt.-Fl. Anf. 6: 174. 1914.

Plants usually medium sized, up to 15cm long, reddish brown, green to brownish black, rarely small, prostrate, pinnately branched, subfloral innovations absent; leaves incubous, strongly bilobed, dorsal lobes of leaf much larger than the ventral lobes, inflated, usually helmet shaped, saccate, being connected by a small stalk; stylus present or absent; small ventral lobes lying free from the stem, lobes margin entire, rarely dentate; cells thick walled, trigones prominent; oil bodies spherical, elliptical or oval, long fusiform, 2 to many per cell, with minute, rarely large globules; underleaves bilobed or rarely unlobed, entire; monoicous or dioicous, antheridia axillary, globose on uniseriate stalk; female inflorescence terminal or on lateral branch with archegonia 2 to many, female bracts 2-5 pairs, perianth mostly flattened dorsally, usually with 3-5 keeled, mouth small with a beak; seta short, capsule spherical, spores oblong to orbicular or spherical.

Frullania Raddi,

Jungermannogr. Etrusca 9. 1818.

Plants medium sized, green to reddish brown or black; prostrate, pinnately branched; leaves imbricate, incubous, plants dioicous or monoicous, robust or slender, flaccid or rigid, bipinnately branched or irregularly pinnately branched; lobes distant, contiguous or imbricate, widely spreading or convex with recurved apex, ovate, obovate, oblong or orbicular, apex rounded, obtuse, acuminate, mucronate or acute, dorsal base truncate, cordate or auriculate, margins entire or undulate; cells thin walled or thick walled, trigones confluent or nodulose; ocelli absent or present, 7–24 per lobe; stem lobules covered or uncovered by underleaves, distant, contiguous or imbricate, attached to stem by stalk-like base or connate to lobes, appressed, parallel, incumbent, oblique, apex acute, obtuse, rounded or truncate, mouth hemifold, rounded or truncate; styli filiform, foliaceous or triangular, underleaves distant, contiguous or imbricate, obovate, oblong, spatulate, trapezoid, reniform or

orbicular, entire or retuse, sinus acute, apiculate, obtuse or rounded, base cuneate or auriculate, margins entire or undulate, incurved, recurved or straight; dioicous or monoicous, male inflorescence usually terminal on short lateral branches, female inflorescence terminal or lateral, perianth tri or pluri keeled, mouth small, forming a beak, seta short, capsule spherical, spores oblong to orbicular or spherical.

Key to the species

- 1a. Leaf lobes with ocelli *F. tamarisci*
- 1b. Leaf lobes without ocelli 2
- 2a. Dorsal base of leaf lobes cordate, lobules campanulate *F. campanulata*
- 2b. Dorsal base of leaf cordate to auriculate, lobules saccate 3
- 3a. Styli filiform or triangular *F. muscicola*
- 3b. Styli foliaceous *F. polyptera*

Frullania campanulata Sande. Lac., Nederl. Kruidk. Arch. 3: 422. 1854; Chopra, Proc. India Acad. Sci. B7: 248.1938 & J. Indian Bot. Soc. 22: 249. 1943; Kachroo, Bull. Bot. Surv. India 12: 230. 1970; Udar & Nath, Int. Quart, J. Pl. Sci. Res. 6: 73. 1979; Nath & A.K. Asthana, J. Hattori Bot. Lab. 85: 77. 1998; Bapna & Kachroo, Hepatic. India 2: 167. 2000; S.C. Srivast. & A. Alam, J. Bombay Nat. Hist. Soc. 99: 237. 2002; Daniels, Arch. Bryol. 65: 15. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 169. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 84. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 312. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 396. 2019.

Plants reddish to brownish red, up to 15 mm long and 1.3–1.7 mm wide including lobes; leaves pinnate, ovate, entire with obtuse apex, 1 mm long and 0.7-0.8 mm wide; lobules campanulate, longer than broad, parallel to stem, sometimes obliquely oriented with rounded vertex and wide constricted mouth, 0.3 mm long and 0.55 mm wide; underleaves small, longer than broad or as broad as long, angulate on both sides, 0.4 mm long and 0.3 mm wide, bifid, lobes triangular, subacute, entire margin often with 1 or 2 obtuse projection teeth; female bracts and bracteoles entire; perianth 2/3 exserted, pyriform, 4-keeled, smooth surface, dioicous (Plate 5.15).

Habitat: Terricolous on large rocks and logs in a brownish red color in shola forest.

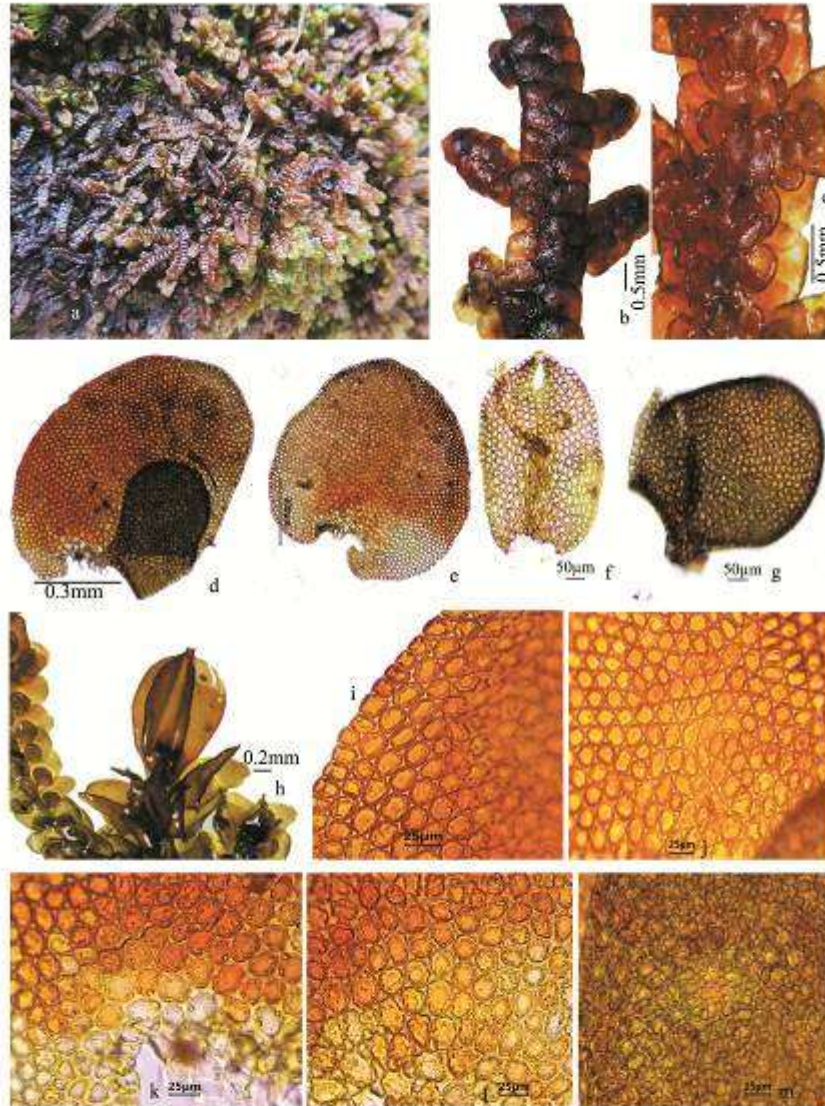


Plate 5. 15: *Frullania campanulata* Sande Lac., a. habit, b. thallus dorsal view, c. thallus ventral view with underleaves, d. leaf with leaf lobule, e. leaf lobe, f. underleaf, g. leaf lobule, h. reproductive branch with perianth, i. leaf marginal cells, j. leaf middle cells, k&l. leaf basal cells, m. leaf lobule cells

Discussion: Nath and Asthana (1998) reported and described *F. campanulata* from Tamil Nadu, but the size of the plant is large compared to the present collection. The present collection is a new record for Kerala. It is characterized by brownish red thallus with ovate leaves, ocelli absent in lobes, lobules campanulate and the perianth 4-5 keeled and pyriform.

Distribution: World: Sri Lanka (Long & Rubasinghe, 2014); **India:** Karnataka (Schwarz, 2013), Kerala (present collection), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013; Daniels & Kariyappa, 2019; Nath & A.K. Asthana, 1998).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola, Jandamala (2017 m) 09.11.2017 *Mufeed 7460* (ZGC).

Frullania muscicola Steph., Hedwigia 33: 146. 1894 & Sp. Hepat, 4: 444. 1910; Verd. in Handel-Mazzetti, Symb. Sinic. 5139. 1930; Kashyap, Liv. W. Himalaya Punjab Pl. 2: 14. 1932; Chopra, J. Indian Bot. Soc. 22: 249. 1943; Inoue, J. Jap. Bot. 36: 187. 1961; Kachroo, Bull. Bot. Surv. India 12: 229. 1970; Udar & Nath, Int. Quart. J. Pl. Sci. Res. 6: 74. 1979; S. Hatt. & P.J. Lin. J. Jap. Bot. 59: 139. 1985; Nath & A.K. Asthana, J. Hattori Bot. Lab. 85: 75. 1998; Bapna & Kachroo, Hepatic. India 2: 175. 2000; Narayan *et al.*, Indian J. For. 24: 275. 2001; S.C. Srivast. & A. Alam, J. Bombay Nat. Hist. Soc. 99: 237. 2002; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 63. 2005; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 201. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 4. 2008; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 212. 2009; Daniels, Arch. Bryol. 65: 17. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 173. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 90. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 319. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 408. 2019. *Frullania dilatata* auct. non (L.) Dumort. in Mitt., J. Proc. Linn. Soc. Sr 2, 3: 302. 1891. *F. truncatifolia*. Steph. & Yoshin., Bot. Mag. Tokyo 17: 38. 1903. *F. purpurascens* Steph., Sp. Hepat. 4:523. 1910. *F. fauriana* var. *yoshinagana* S. Hatt., Bull. Tokyo Sci. Mus. 11:55. 1944.

Plants robust, flaccid, irregularly pinnately branched, brownish green or reddish black; stem with leaves 0.8–1.5 mm wide, stem lobes imbricate, convex with strongly recurved apex, orbicular, 0.7–0.85 mm long and 0.7–0.8 mm wide, apex

obtuse-rounded, dorsal base cordate to auriculate, margins entire; marginal cells, thin walled, slightly rectangular, 16-21 μm long and 16-18 μm wide; median cells 20-26 μm long and 10-18 μm wide, walls thin, trigones nodulose; basal cells 26-38 μm long and 20-28 μm wide, walls thin, trigones nodulose; ocelli absent; oil bodies 4-9 per cell, globose to ellipsoid, 5-15 μm long and 5 μm wide, consisting of a few to numerous, indistinct globules; leaf lobules partly covered by underleaves, saccate, distant, parallel to oblique attached to stem, cucullate, longer than wide, entire, apex rounded, mouth obliquely truncate, widely opened, ventral portion slightly parallel to dorsal portion, without beaks; styli filiform, in a row of 5-7 cells; underleaves distant, flat, obovate, 0.2 mm long and 0.15 mm wide, bilobed, sinus acute, base cuneate, margins entire (Plate 5.16).

Habitat: Epiphytic, on logs and branches in shola forest at an altitude between 1800-2200 m.

Discussion: *Frullania muscicola* is a very common Asiatic species and widely distributed in India and Kerala. From Kerala, it is previously reported by Nath and A.K. Asthana (1998) and Nair *et al.* (2005) from Wayanad district.

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994), Korea, Manchuria, Mongolia, and Nepal (Nair *et al.*, 2005); **India:** Kerala (Nair *et al.*, 2005; Nath and A.K. Asthana, 1998), Meghalaya (A.P. Singh & Nath, 2008), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola, (1800-1900 m) 12.07.2017 *Mufeed 7303, 7337b*; Pullaradi Shola Jandamala (2050 m) 09.11.2017 *Mufeed 7476* (ZGC).

Other specimen/s examined: India, Himachal Pradesh, Kullu (2400 m) 27.05.2002 S.K. Singh 99709 (BSD!).

Frullania polyptera Taylor, London J. Bot. 5: 401. 1846; Mitten J. Proc. Linn. Soc., Bot. 5: 119. 1861; Steph., Sp. Hepat. 4: 439. 1910; Kachroo, Bull. Bot. Surv. India 12: 230. 1970; Udar & Nath, Curr. Sci. 40: 638. 1971; S. Hatt., J. Hattori Bot. Lab. 38: 210. 1974; 44: 546. 1978; Bapna & Kachroo, Hepatic. India 2: 178. 2000; Daniels, Arch. Bryol. 65: 17. 2010; D.K. Singh *et al.*, Liverw. Hornw. India: 93. 2016. *Frullania pyriflora* Steph., Sp. Hepat. 4: 443. 1910. *F. gollani* Steph., Sp.

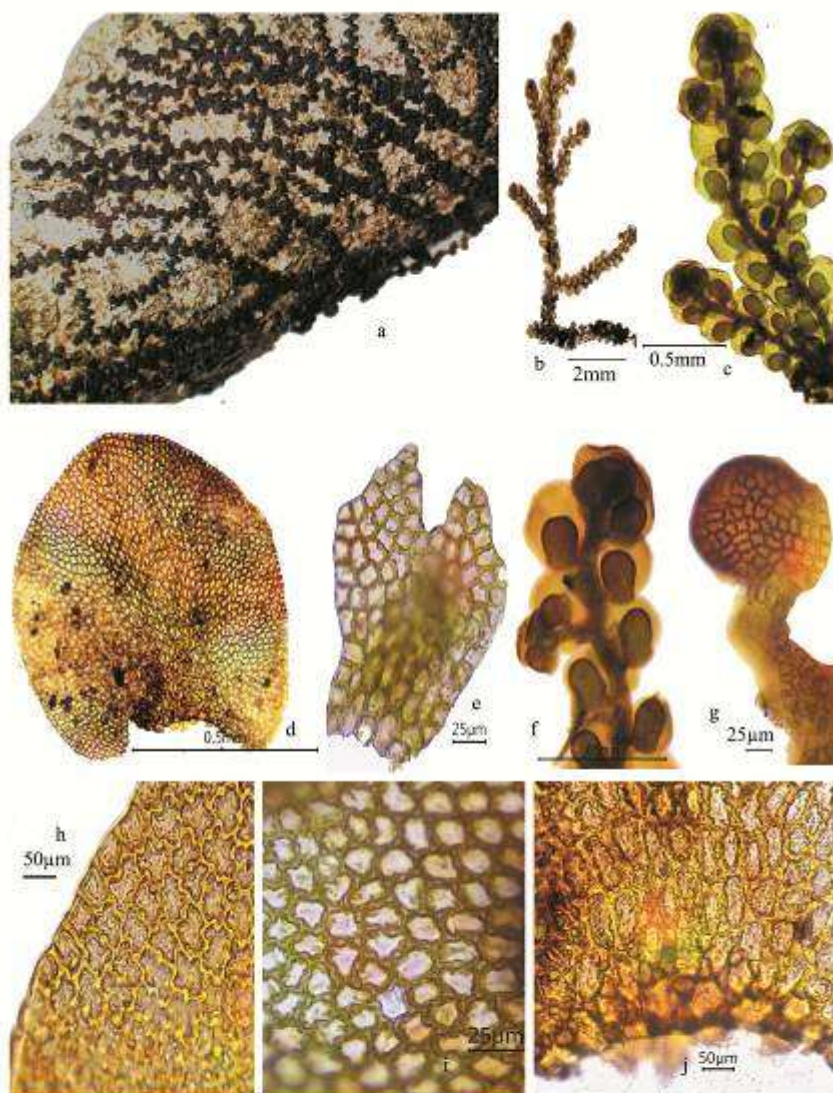


Plate 5. 16: *Frullania musicola* Steph., a&b. habit, c. habit enlarged, d. leaf, e. underleaf, f&g. leaf lobule, h. leaf marginal cells, i. leaf middle cells, j. leaf basal cells

Hepat. 4: 445. 1910.

Plants flaccid, slender, dark reddish brown when fresh and blackish when dry, 1.5–5 cm long, stems creeping, bipinnately to tripinnately branched; leaves imbricate, ovate-orbicular, widely spreading, 0.45–0.55 mm long and 0.30–0.40 mm wide, entire at margin, apex rounded, dorsal base cordate to auriculate; cells rounded-quadrangle, walls thick, trigones nodulose; marginal cells 5–11 μm long 4–8 μm ; median cells 8–20 μm long 6–12 μm wide, internodular thickenings present; basal cells 10–33 μm long 8–24 μm wide, with a few large red-coloured cells at extreme base; ocelli absent; styli foliaceous; oil bodies not seen; lobules uncovered by underleaves, distant, attached to stem by stalk like base, saccate, longer than wide, apex acute, mouth obliquely truncate; underleaves flat, distant, 0.12–0.18 mm long 0.95–0.14 mm wide, obovate to spatulate, 2-lobed; reproductive structures not observed (Plate 5.17).

Habitat: Corticolous on shola tree.

Discussion: *F. polyptera* Taylor is earlier reported from different localities of Tamil Nadu in India. The present collection is a new record for Kerala. This species is closely related to *F. muscicola* Steph. However, *F. muscicola* differs by the presence of filiform styli.

Distribution: World: Nepal (Hattori, 1977d; Taylor, 1846), Thailand (Hattori, 1978; Sukkharak, 2018), Thailand, Malaysia (Hattori *et al.*, 1978b); **India:** Kerala (present collection), Tamil Nadu (Hattori, 1974; Mitten, 1861; Udar & Nath, 1971; Daniels, 2010; Daniels & Kariyappa, 2019).

Specimen/s examined: Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2150 m) 22.09.2018 *Mufeed 9909* (ZGC).

***Frullania tamarisci* (L.) Dumort.,** Rec. Obs. Jungerm. Tournay 13. 1835; Steph., Sp. J. Hattori Bot. Lab. 85: 68. 1998; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 1: 65–67. 2005. *Jungermannia tamarisci* L., Sp. Pl. 1134. 1753.

Plants greenish brown to dark black or reddish brown, vary in size, up to 20 mm long and 1.2 mm wide including lobes; leaf lobe ovate, strongly concave with acute or apiculate or entire apex; ocelli present, 1 or 2 rows, 10–20 cells long, ocelli absent in some lobes; lobule saccate, subparallel to the stem, lobule connected with a small stalk; underleaves longer than wide, usually with 1 or 2 marginal teeth, 0.2 mm long

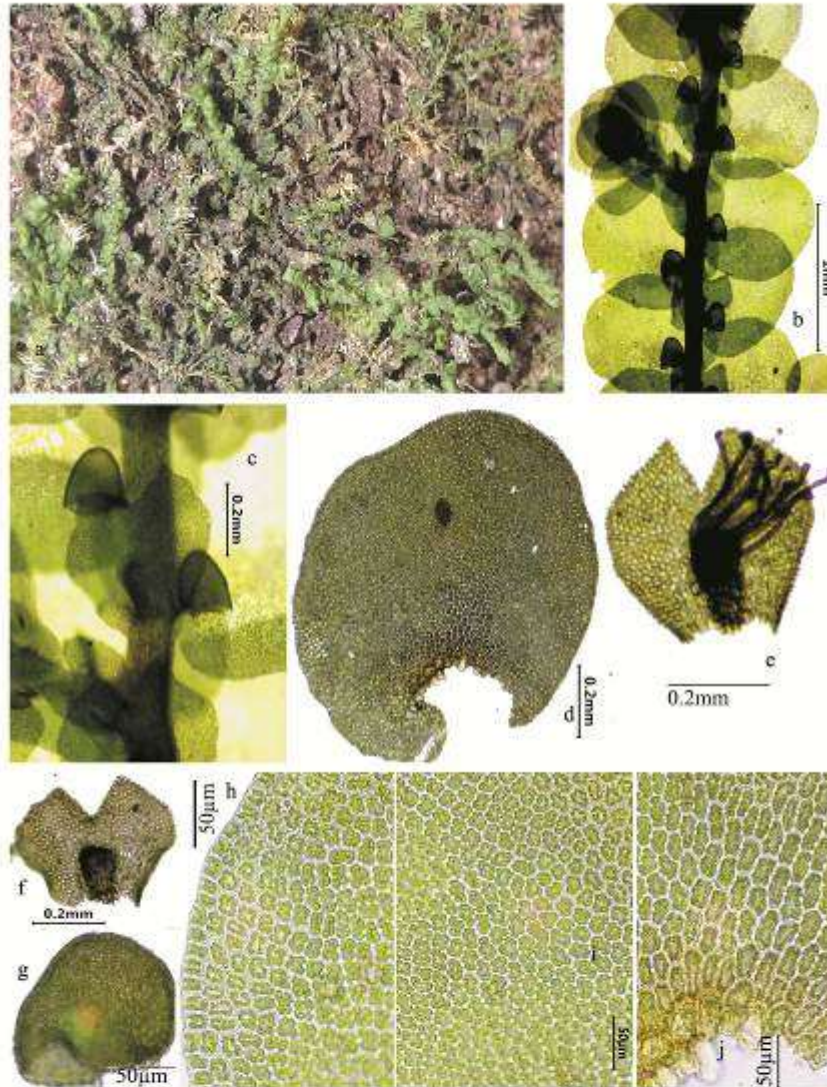


Plate 5. 17: *Frullania polyptera* Taylor, a&b. habit, c. lobules and underleaves arrangement, d. leaf, e&f. underleaves, g. leaf lobule, h. cells at margin, i. cells at middle, j. cells at base

and 0.4 mm wide; laminal cells usually homogenous, cell walls thickened with large nodulose trigones at base, 40–70-(100) μm long 20 -30 μm wide; dioicous; perianth oblong, strongly 3 keeled, rostrum prominent (Plate 5.18).

Habitat: Epiphytic on barks or branches of large trees.

Discussion: *Frullania tamarisci* is a widely distributed species in South India. Nath and Asthana (1998) reported this species from Idukki and Wayanad district of Kerala.

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994); **India:** Kerala (Nair *et al.*, 2005), Tamil Nadu (Nath & Asthana, 1998).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2100 m) 14.07.2017 *Mufeed 7512c*; Iddalymotta (2150 m) 22.09.2018 *Mufeed 9905* (ZGC).

Lejeuneaceae Cavers,

New Phytol. 9: 291, 1910. nom. conserv.

Plants green, pale yellowish, brown, black or whitish, never red; pinnate, dichotomous or irregularly branched, leafy, very small to medium sized, 0.5-20 mm long, prostrate, vegetative branches *Lejeunea*-type sometimes *Frullania*-type, rarely *Radula*-type; leaves alternate, incubous, bilobed; leaf lobules distinctly saccate, perpendicular to the axis, inflated to elongate; underleaves present or absent, undivided or bifid; rhizoids in tufts from underleaf bases; bracts, bracteoles and perianth prominent, perianth usually with a beak; capsule globose, spores isodiametrical or elongate, multicellular, with or without rosettes, elaters mono or bispiral, attached to the capsule valves.

Note: Lejeuneaceae are the largest family of liverworts with more than 1000 species distributed among 74 currently accepted genera in the world (Gradstein, 2013; Söderström *et al.*, 2016; Zhu *et al.*, 2019). About 30 genera are recorded from India, of which six genera viz., *Acanthocoleus*, *Cheilolejeunea*, *Lejeunea*, *Microlejeunea*, *Spruceanthus*, *Drepanolejeunea* and *Colura* occur in the present study area.

Key to the genera

1a. Underleaves undivided..... 2

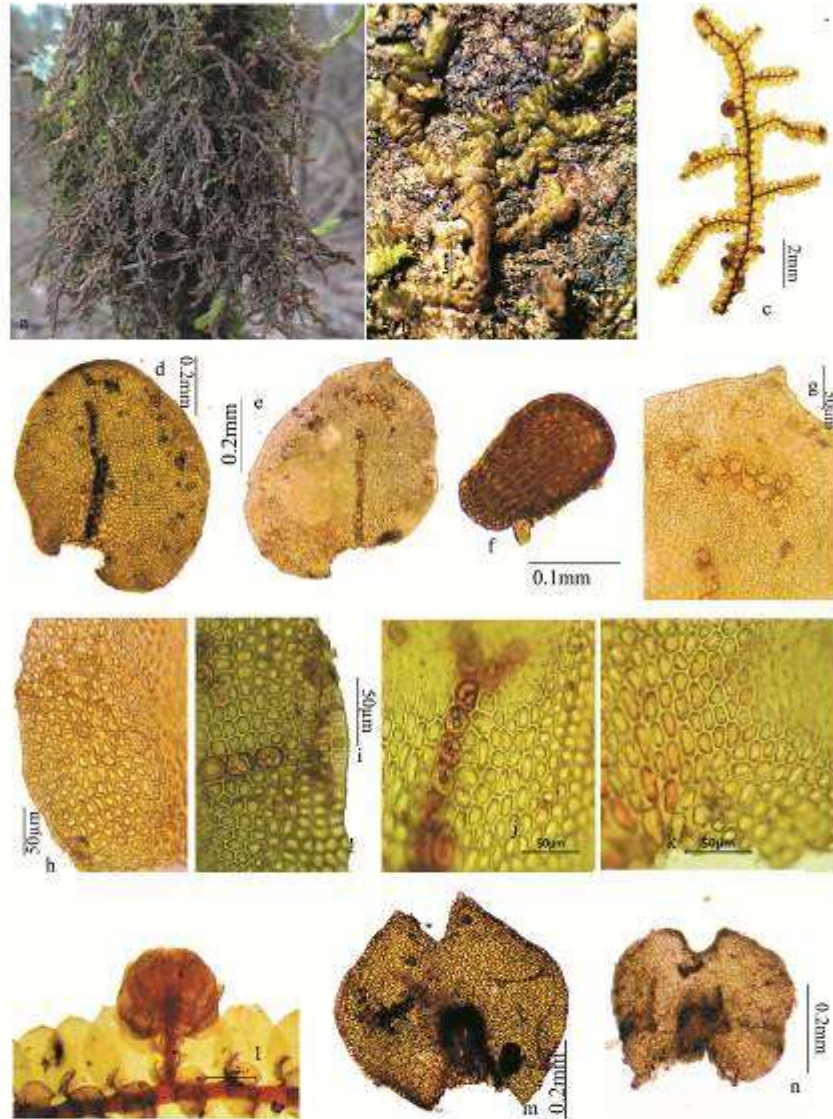


Plate 5. 18: *Frullania tamarisci* (L.) Dumort., a&b. habit, c. single plant, d&e. leaf showing ocelli, f. leaf lobule, g. leaf apex, h&i. leaf margin, j. enlarged view of ocelli, k. leaf basal cells, l. reproductive branch, m&n. underleaves,

- 1b. Underleaves divided, mostly bifid 3
- 2a. Plants large, 6-9 cm, leaf lobe margin dentate, cells with large, prominent trigones and intermediate thickenings ***Spruceanthus***
- 2b. Plants up to 2 cm long, leaf lobe margin entire, cells without or slightly intermediate thickenings and trigones ***Acanthocoleus***
- 3a. Leaves distantly arranged on stem 4
- 3b. Leaves contiguous to imbricate on stem 6
- 4a. Ocelli present on the leaf lobes, leaf lobules smaller than leaf lobes5
- 4b. Ocelli absent on the leaf cells, long beaked leaf lobules, formed as fusiform sac, twice as lobe length ***Colura***
- 5a. Underleaves deeply inserted, sinus wide, leaf lobule having one single curved apical cell on teeth, leaf lobes linear lanceolate, apex acuminate... ***Drepanolejeunea***
- 5b. Underleaves not deeply inserted, sinus not wide, teeth of leaf lobule without any curved cells, leaf lobes ovate, obtuse at apex ***Microlejeunea***
- 6a. Oil bodies large coarsely segmented ***Cheilolejeunea***
- 6b. Oil bodies smooth, rarely segmented and in to small granule types.... ***Lejeunea***

***Acanthocoleus* Schust.,**

Bull. Torrey Bot. Club 97: 339. 1970

Plants small to medium sized, creeping, irregularly branched, vegetative branches short or long; stems flaccid, ventral merophytes dorsal cortical cells arranged in straight longitudinal rows, stem in cross section composed of 9-17 cortical cells surrounding 12-65 medullary cells; leaves incubous, with a larger dorsal lobe and a smaller ventral lobule, laxly to rather densely imbricated, when wet widely spreading and erect-patent, when dry wrapped around the stem, leaf lobe ovate to nearly rotundate, margin entire to toothed with 1-8 teeth, the apex rounded, acute to shortly acuminate, the apical region plane to incurved, postical margin plane, the keel smooth, straight to rounded; leaf lobule $1/4$ - $1/3$ as long and $1/4$ - $2/5$ as wide as the lobe, reduced, ovate-rectangular, the basal part inflated, the upper part plane, the free margin proximally lying against the lobe, distally not lying against the lobe, with two teeth; underleaves imbricated, larger, suborbicular, the margin plane or recurved, the apex widely rounded, the margin entire, the insertion cuneate to subtransverse, underleaf base at the rhizoid disc tristratose in logitudinal section; monoicous, androecia located below the gynoecium with unmodified bracts, mature

perianth immersed or emergent.

Acanthocoleus yoshinaganus (S. Hatt.) Kruijt, Bryophyt. Biblioth. 36: 105. 1988; Bapna & Kachroo, Hepat. In India 2: 328. 2000. *Lopholejeunea subfusca* (Nees) Steph. var. *yoshinagna* S. Hatt., Bot. Mag. Tokyo 58: 38. 1944. *Lopholejeunea yoshinagna* (Hatt.) Hatt., J. Hattori Bot. Lab. 8:33. 1952. *Dicranolejeunea yoshinagana* (S. Hatt.) Mizut., J. Hattori Bot. Lab. 24: 174. 1961; Udar & Awasthi, Geophytology 12(1): 122-124. 1982; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007.

Plants yellowish brown, dark brown to black when dry, dry leaves wrapped around the stem, when wet leaves spreading, branched, *Lejeunea* type, stem in cross section, cortical cells 10-14, medullary cells 15-55 cells; rhizoids, light-brown, the rhizoidal disc attachment extending to the first basal cells of underleaf; leaf lobe ovate, 0.8 mm long and 0.6 mm wide, imbricate, apex rounded to acute, margin entire; leaf cells isodimetrical, penta-heptagonal, marginal cells 14-16 µm long and 8-12 µm wide, cells at middle 18-22 µm long and 10-14 µm wide, cells at base 30-35 µm long and 12-18 µm wide; trigones small or absent, observed in basal cells only, oil bodies small, numerous; leaf lobule 0.30 mm long and 0.20 mm wide, inflated, 1/3 as long as leaf lobe, 2 teeth, first tooth 1-2 celled, the second tooth 1-2 celled or often reduced to a mere protruding marginal cell, free margin 3-6 cells long, keel arched; underleaves 0.35 mm long and 0.50 mm wide, not imbricate, rounded, 2-3 times wide as stem, cells iso-diametrical at the margin to somewhat elongated at the base; vegetative and sexual reproductive structures not observed in the present collection (Plate 5.19).

Habitat: Epiphytic on main tree trunk of shola trees.

Discussion: This species is treated under *Dicranolejeunea yoshinagana* (S. Hatt.) Mizut. by several authors. From India, the species was reported by Udar & Awasthi (1982) as *D. yoshinagna*. In the monograph of the genera *Dicranolejeunea* and *Acanthocoleus* clarify the misapplied names (Udar & Awasthi, 1988). After that many authors regretfully treated this species under *Acanthocoleus*. Zhu & Gradstein (2005) excluded the placement of *A. yoshinaganus* under *Lopholejeunea subfusca*

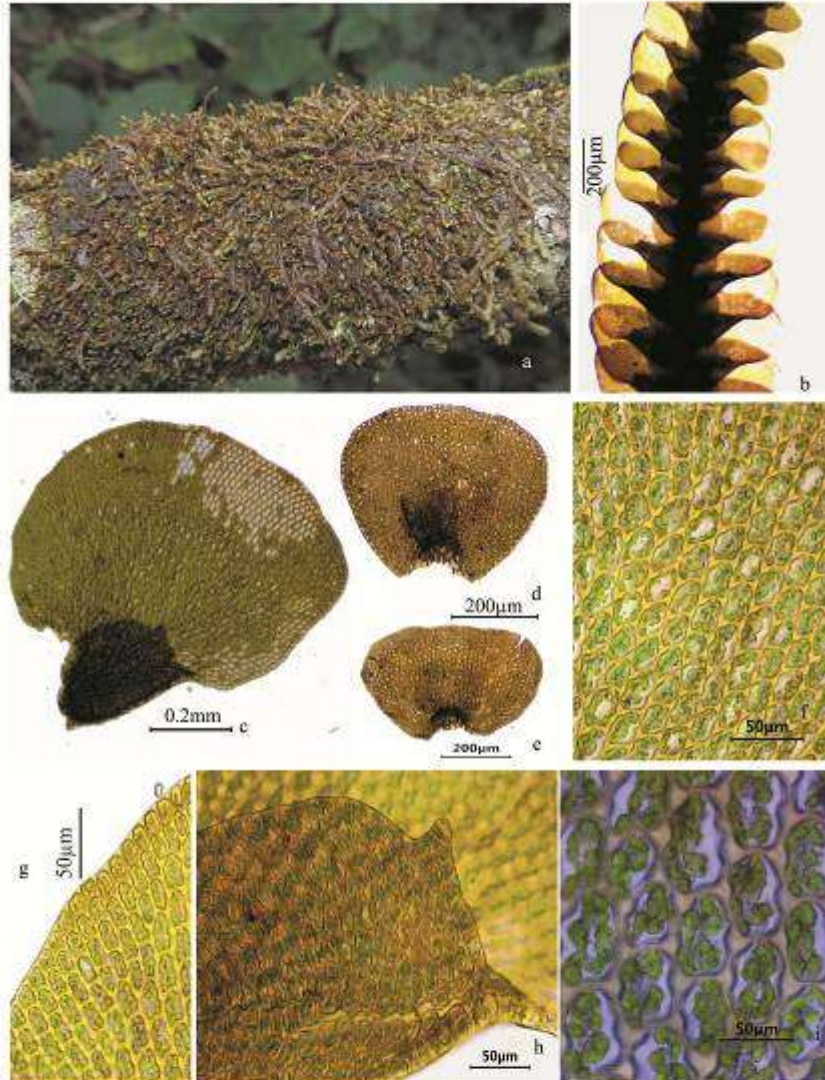


Plate 5. 19: *Acanthocoleus yoshinaganus* (S. Hatt.) Kruijt, a. habit, b. single plant, c. leaf, d&e. underleaf, f. leaf cells, g. leaf marginal cells, h. leaf lobule, i. laminal cells enlarged

var. *yoshinagana* S. Hatt. Bapna & Kachroo (2000b) reported this species from Karnataka in South India. Hence the present collection is a new distributional record to Kerala. This species is characterized by yellowish brown plants with ovate leaf lobes, toothed inflated leaf lobules and the under leaves are rounded to quadrate.

Distribution: World: Japan, Korea (Kruijt, 1988); **India:** Karnataka (Bapna & Kachroo, 2000b), Kerala (present collection), Meghalaya (A.P. Singh & Nath, 2007).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1800 m) 24.09.2018 *Mufeed* 9965 (ZGC).

Cheilolejeunea (Spruce) Schiffn.,
1(3): 124. 1895.

Plants light green to yellowish-green, creeping, loosely to tightly appressed to the substrate, irregularly to densely branched; leaves orbicular to oblong-ovate, imbricate in some with round slightly incurved apex; leaf lobule small, ovate with 1 or 2 celled, angular tooth at apex; underleaves small, orbicular, distant to imbricate, 2-lobed, not deeply bilobed, 2-3 times as wide as the stem; oil bodies 2-3 per leaf cell, in some only one, elliptical or spherical of the grape-cluster type; cells at middle thin walled with small to large trigones with intermediate thickenings; monoicous or dioicous, male inflorescence terminal or on lateral branches, bracts imbricate, female inflorescence on elongated branches with 1 or 2 subfloral innovations, bracts and bracteoles similar to leaves, unequally bifid, lobe oblong-ovate, entire, perianth 4 or 5 keeled; capsule globular to elongated; elaters few, 150-250 µm long, spiral bands slender; spores rounded, 50-70 µm long and 30-40 µm wide.

Key to the species

- 1a. Underleaves bilobed, sinus deeply inserted, lobule margin free2
- 1b. Underleaves rounded, slightly sinus at apex, lobule inrolled to ventral margin
..... ***C. xanhocarpa***
- 2a. Leaves loosely imbricate-distant, apex acute and incurved, leaf lobule 1/3-1/4
the length of the lobe ***C. subopaca***
- 2b. Leaves imbricate, apex obtuse, leaf lobule large, ½ the length of the

lobe..... *C. udarii*

Cheilolejeunea subopaca (Mitt.) Mizut., J. Hattori Bot. Lab. 26: 183.1963; Mitt., J. Proc. Linn. Soc. Bot. 5: 116. 1861 (as *Lejeunea subopaca*); Herzog, Ann. Bryol. 12:85. 1939 (as *Strepsilejeunea papillata*); Manju & Madhusudhanan, Indian J. Forest. 29 (2): 191-196. 2006; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007. *Lejeunea subopaca* Mitt., J. Proc. Linn. Soc., Bot. 5: 116. 1861. *Strepsilejeunea papillata* Herzog, Ann. Bryol. 12: 85. 1939. *Euosmolejeunea papillata* Herzog, Ark. Bot. ser. 2, 3: 57. 1953. *Strepsilejeunea papillata* (Herzog) R.M. Schust. & Kachroo in Kachroo & R.M. Schust., J. Linn. Soc., Bot. 56: 510. 1961.

Plants yellowish green to yellowish brown, 3-5x1.2 mm including leaves, branches prominent, stem c.s. with 7 cortical cells, 12 thickwalled medullary cells; leaves loosely imbricate-distant, lobe convex, ovate triangular, 0.9mm long and 0.56mm wide; apex acute and incurved, margin slightly crenate, dorsal margin arched, ventral margin slightly incurved or nearly straight, marginal cells, 12-17 µm long 12-22 µm wide, median cells 15-30 µm in diameter, basal cells 45-55 µm long and 20-30 µm wide, trigones well developed; leaf lobule small, 0.23 mm long and 0.20 mm wide, inflated, constricted at apex, the free margin crenulate, first tooth indistinct, second tooth 1-3 celled triangular and curved towards the keel, keel slightly arched or nearly flat; underleaves distant, subtransversely inserted, about twice as wide as the stem, orbicular 0.43 mm long and 0.40 mm wide, bilobed to 1/3 of their length, margin entire, reproductive structures are not observed (Plate 5.20).

Habitat: Epiphytic, on bark of the shola tree trunk.

Discussion: The species was originally described as *Lejeunea subopaca* Mitt. from Eastern Himalayas by Mitten (1861) and Mizutani (1963) and transferred to the genus *Cheilolejeunea*. The species is characterised by imbricate-distant leaves, leaf lobes ovate, apex acute and incurved.

Distribution: World: Bhutan, China (Ye & Zhu, 2010), Nepal (Pradhan & Joshi, 2009), Sri Lanka (Long & Rubasinghe, 2014); **India:** Arunachal Pradesh (Singh, et

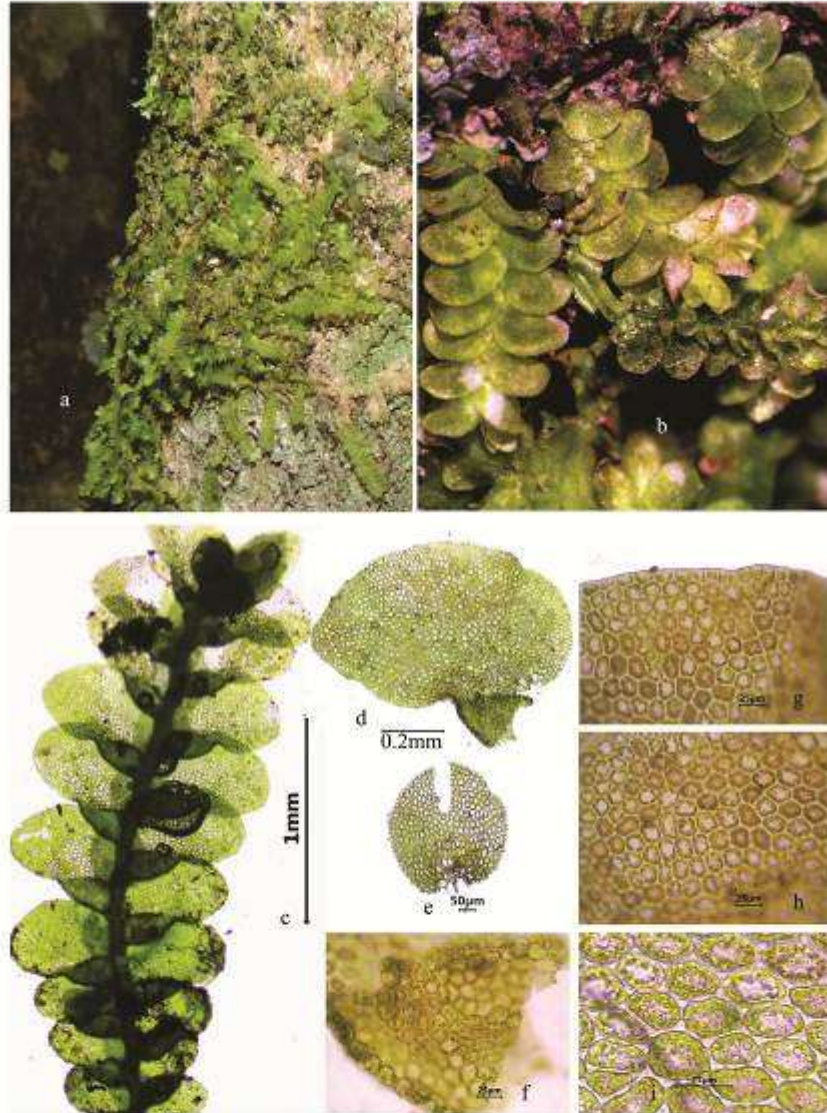


Plate 5. 20: *Cheilolejeunea subopaca* (Mitt.) Mizut., a&b. habit, c. ventral view of branch, d. leaf with lobule, e. under leaf, f. lobule cells, g. leaf marginal cells, h. leaf middle cells, i. leaf basal cells

al., 2015), Kerala (Nair & Madhusudanan, 2006, Manju *et al.*, 2012), Meghalaya (Mitten, 1861; Mizutani, 1963), Sikkim, West Bengal (Hattori, 1966; A.K. Asthana *et al.*, 1995).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (1945 m) 07.02.2018 *Mufeed 9864* (ZGC).

Cheilolejeunea udarii G. Asthana, S. C. Srivat. & A.K. Asthana, *Lindbergia* 20:142. 1995.

Plants yellowish green, stem 12-15 mm long, 0.50-1.19 mm wide including leaves, stem c.s. with 7-8 cortical cells, 13-15 thick walled medullary cells; leaves imbricate, obliquely spreading, leaf lobe convex, ovate triangular, 0.42-0.6 mm long and 0.3-0.5 mm wide, apex obtuse, strongly incurved, margin entire, dorsal margin arched, ventral margin nearly straight or incurved at middle, marginal cells 9-12 μ m, median cells 16.5-25 μ m long and 12-15 μ m wide; basal cells 22.5-27.6 μ m long and 10-18 μ m wide, trigones present; leaf lobule large, $\frac{1}{2}$ the length of the lobe, 0.15-0.42 mm long and 0.09-0.2 mm wide, inflated, constricted at apex, the free margin incurved, the first tooth indistinct, second tooth triangular, 1-3 celled, keel arched; underleaves distant, 3-4 times wide as stem, orbicular, 0.24-0.3 mm, bilobed to $\frac{1}{2}$ of their length, margin entire (Plate 5.21).

Habitat: Epiphytic, on barks of the large trees in shola forest.

Discussion: *Cheilolejeunea udarii* is an endemic species to South India. The type locality of *C. udarii* is from Dodabetta peak in Ootacamund of Tamil Nadu described by A.K. Asthana *et al.* (1995). After the first description there is no report of this species and the present collection from Anamudi Shola National Park of Idukki district report its rediscovery after 25 years from South India. The present collection is a new record for Kerala also. This species is characterized by ovate triangular leaves, obtuse apices, lobules that are $\frac{1}{2}^{\text{th}}$ of the lobe size and which are not covered by underleaves.

Distribution: World: India; Kerala (present collection), Tamil Nadu (A.K. Asthana *et al.*, 1995).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park,

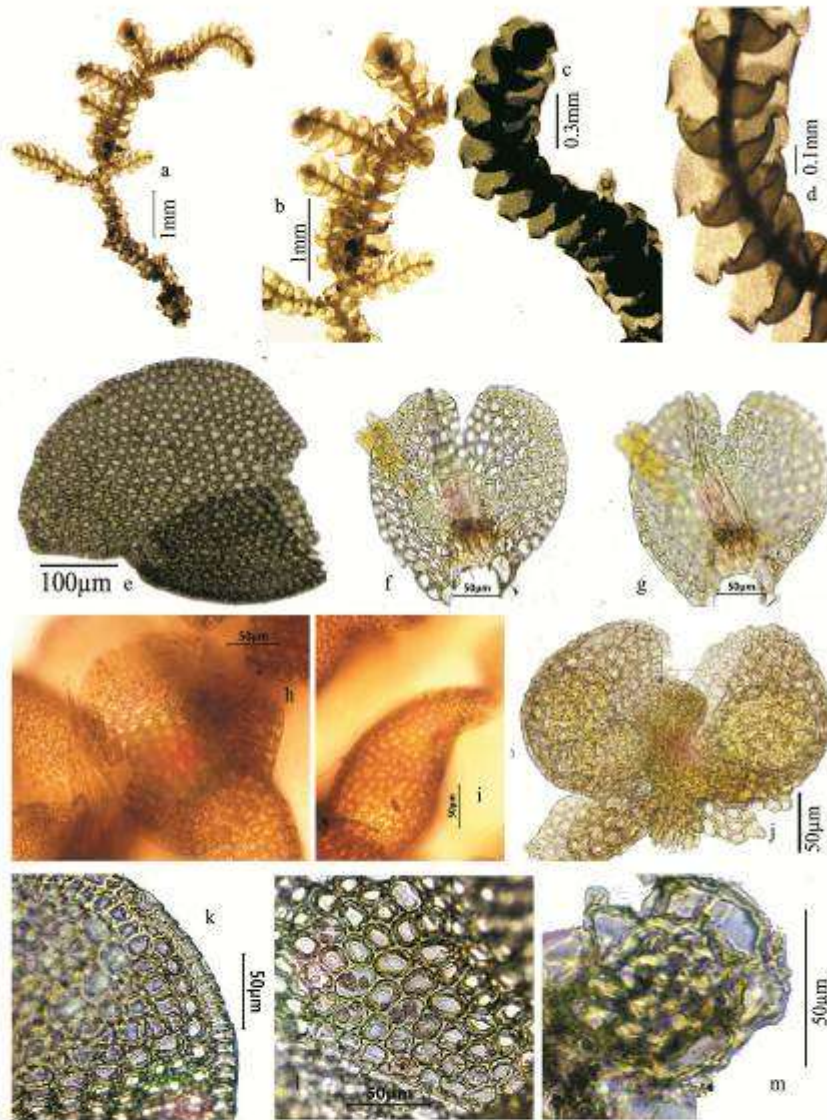


Plate 5. 21: *Cheilolejeunea udarii* G. Asthana, S. C. Srivat. & A.K. Asthana, a&b. habit, c&d. single thallus, e. underleaf arrangement, f. leaf lobule, g. male bract, h. marginal cells, i. median cells, j. c.s. of stem

Pullaradi Shola (2200 m) 04.03.2016 Mufeed 7303 (ZGC).

Cheilolejeunea xanthocarpa (Lehm. & Lindenb.) Malombe, Acta Bot. Hung. 51: 326. 2009; D.K. Singh *et al.*, Liverw. Hornw. India: 119. 2016. *Jungermannia xanthocarpa* Lehm. & Lindenb. in Lehm., Nov. Stirp. Pug. 5: 8. 1833. *Lejeunea xanthocarpa* (Lehm. & Lindenb.) Lehm. & Lindenb., Syn. Hepat. 330. 1845. *Archilejeunea xanthocarpa* (Lehm. & Lindenb.) Steph., Hedwigia 29(3): 134. 1890. *Archilejeunea pabstii* Steph., Hedwigia 34(1): 61. 1895. *Leucolejeunea xanthocarpa* (Lehm. & Lindenb.) A. Evans, Torreyia 7: 229. 1907. *Acrolejeunea fuscescens* Gola, Ann. Bot. (Rome) 6: 275. 1912; Udar & Awasthi, Proc. Indian Natl. Sci. Acad. 49 B: 25. 1983; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007; Daniels & Daniel, Bryofl. S. W. Ghats. India: 147. 2013.

Plant robust, green, brownish in herbarium, branched, *Lejeunea* type, stem in cross section with 12-15 cortical cells and small medullary cells, thick walled, trigones distinct; leaves imbricate, widely spreading, lobe orbicular-ovate, 1.2 mm long and 1 mm wide, apex rounded, margin entire, dorsal margin convex, ventral margin highly involute up to apex, cells with distinct trigones and intermediate nodular thickenings, marginal cells 10-14 µm long and 10-13 µm wide, median cells 20-32 µm in diameter, basal cells 30-40 µm long and 20 µm wide; lobule ovate rectangular, 1 mm long and 0.25 mm wide, inrolled into ventral margin, tooth of lobule visible only after flattening of the ventral margin of leaf lobe, first tooth reduced, second tooth one celled; underleaves rounded, slightly sinus at apex, 0.35 mm long and 0.60 mm wide, broad at apex, rounded to cordate at base, margin entire (Plate 5.22).

Habitat: Epiphytic on bark of trees in shola forest and in grassland area.

Discussion: *Cheilolejeunea xanthocarpa* was previously treated under *Leucolejeunea xanthocarpa* (Lehm. & Lindenb.) A. Evans. There are so many nomenclatural confusions related to this placement. The reason for the placement is mainly due to the undivided underleaves of this species. Wilson *et al.* (2007) based on molecular phylogeny proposed that all *Leucolejeunea* species should be moved to *Cheilolejeunea* based on the chloroplast genome analysis. After that Malombe

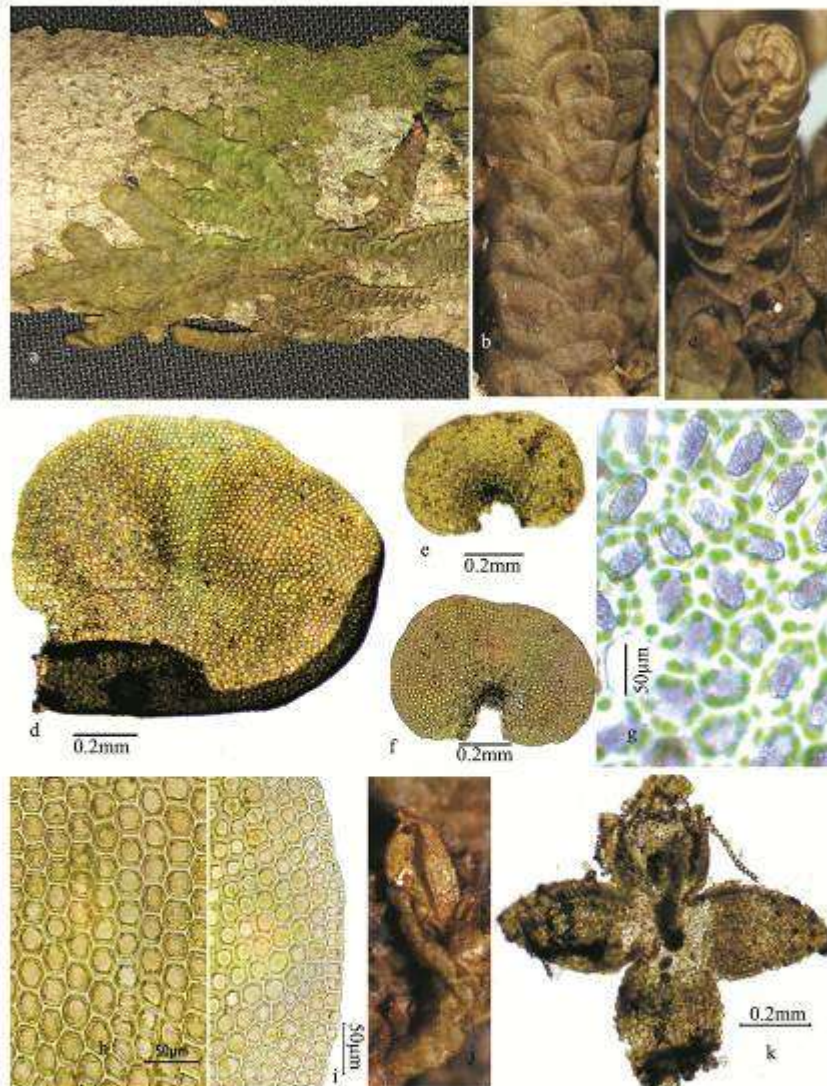


Plate 5. 22: *Cheilolejeunea xanthocarpa* (Lehm. & Lindenb.) Malombe, a. habit, b. thallus dorsal view, c. thallus ventral view with underleaves, d. leaf with lobule, e&f. underleaves, g. oil bodies in median cells, h. leaf middle cells, i. leaf marginal cells, j. capsule, k. capsule wall opened with elaters

(2009) in his studies on African *Cheilolejeunea* proposed *Leucolejeunea* as a new synonym under *Cheilolejeunea*, but he doesn't make any details of the type of *Leucolejeunea*. Ye & Zhu (2010) clarified all taxonomical issues regarding this and treated *Leucolejeunea* as a new synonym for *Cheilolejeunea*. However there are no other evident characters either from morphology or molecular for supporting this placement. This species is characterized by widely spreading orbicular ovate leaf lobes and ovate rectangular lobule, rounded underleaves and slightly sinus at apex.

Distribution: World: Africa (Wigginton, 2009), Australia (McCarthy 2006), China (Pippo, 1990), Cambodia (Tixier, 1983), Japan (Yamada & Iwatsuki, 2006), Indonesia (Söderström *et al.*, 2010), Malaysia (Chuah-Petiot, 2011), Macronesia (Miller, 1960), North America, South America (Schuster, 1980), New Caledonia (Thouvenot *et al.*, 2011), Papua New Guinea (Grolle & Piippo, 1984), Philippines (Tan & Engel, 1986), Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008) [All reports based on the species *Leucolejeunea xanthocarpa*]; **India:** Kerala (Udar & Awasthi, 1983), Meghlaya (A.P. Singh & Nath, 2007), Tamil Nadu (Udar & Awasthi, 1983, Daniels, 2010; Daniels & Daniel, 2013) [All reports based on the species *Leucolejeunea xanthocarpa*].

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2320 m) 03.03.2016 *Mufeed 10016*; Mannavan Shola (2100 m) 03.03.2016 *Mufeed 10026a* (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nigiri Hills (2600-2660 m) 08.10.2000 S.C. Srivastava *et al.*, 12445 (LWU)

Colura (Dumort.) Dumort.,
Recueil Observ. Jungerm. 12. 1835.

Plants small, usually green to yellowish green, branching irregular, stem composed of seven cortical cells surrounding 3 medullary cells; species of *Colura* are typically recognized by their leaf morphology; the presence of lobules forming an apical sac with an aperture mechanism consisting of a valve and a hinge, this sac varies greatly in sizes and shapes, and may function a water retention and in some species as zoophagy, lobed, upper margin of dorsal lobe arched, entire, straight at point of

dorsal attachment, not overlapping, ventral margin of dorsal lobe almost straight in many species; lobules long, twice as lobe length in majority of species, strongly inflated forming a fusiform sac with a narrow beak-like prolongation at the tip, free margin involute, strongly valved at the mouth of the sac; underleaves deeply bilobed with divergent lobes, gemmae present on the beak like prolongation of the lobules, discoid; monoicous or dioicous.

Colura calyptrifolia (Hook.) Dumort., Recueil Observ. Jungerm.: 12. 1835; Mufeed *et al.*, Nelumbo 60(2): 148. 2018; S.K.Sing *et al.*, Cryptogamie Bryologie, 41(10): 116. 2020. *Jungermannia calyptrifolia* Hook., Brit. Jungermann. pl. 43: 1–13. 1813. *Lejeunea calyptrifolia* (Hook.) Spreng., Syst. Veg., 4(1): 234. 1827. *Colurolejeunea calyptrifolia* (Hook.) Schiffn., Hepat. Engl.-Prantl. 121. 1893. *Colura bulbosa* Herzog, Nat. Hist. Juan Fernandez 2: 751. f. 14: g–k. 1942.

Plants erect, small, up to 6 mm long, 1.3 mm wide including leaves, yellowish green, brownish when dry, branching irregular; stem 90-100 µm in diameter, composed of seven cortical cells surrounding 3 medullary cells; leaves 0.3-0.38 mm long and 0.2 -0.24 mm wide, up to 1.25 mm long including lobular beak, diverging from stem at an angle of approximately 85⁰, contiguous, erect spreading, upper margin of dorsal lobe arched, entire, straight at point of dorsal attachment, not overlapping, ventral margin of dorsal lobe almost straight, pointed, ending with one cell, incurved at tip to the dorsal margin; cells of leaf lobes rectangular to hexagonal, thin-walled without trigons and intermediate thickening, median cells 14-36 µm long and 9-23 µm wide, basal cells larger, 31-70 µm long and 20-40 µm wide, lobules 0.9-1.25 mm long, twice as lobe length, strongly inflated forming a fusiform sac, with a narrow beak-like prolongation at the tip, free margin involute strongly valve at the mouth of the sac, ovate to short-ligulate, composed of rectangular thin walled cells 16-25.2 µm long and 10-30 µm wide, border cells hyaline; underleaves deeply bilobed with divergent lobes, lobes 0.16-0.22 mm long, with apex terminating in a single cell, lobes 4-6 cells broad at base, cells of under leaves 16.2-28.78 µm in size, trigones and intermediate thickenings absent; gemmae present on the beak like prolongation of the lobule, 1-3 in number, discoid, 65-85 µm in diameter, about 20-22 celled, margin entire. Plants collected were sterile (Plate 5.23).

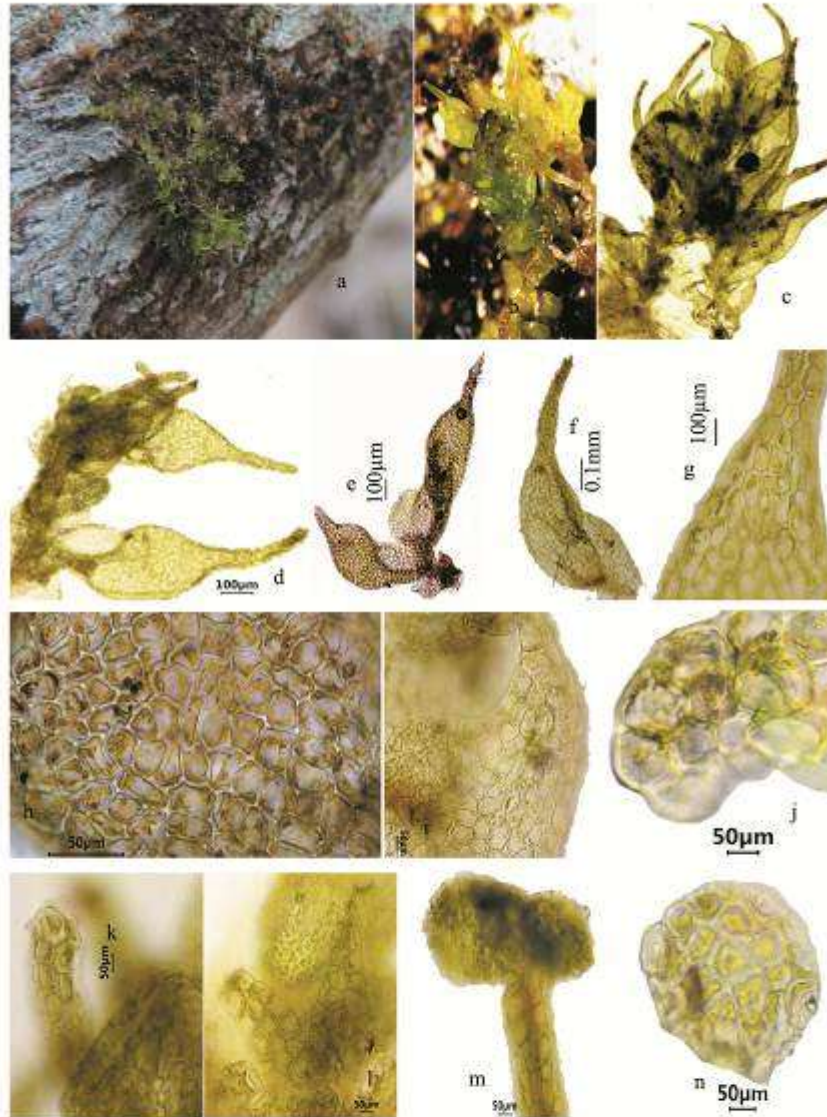


Plate 5. 23: *Colura calyptrifolia* (Hook.) Dumort., a,b&c. habit, d. leaf attached to the stem, e & f. leaves, g. cells at apex, h. lobule cells, i. leaf cells, j. c.s. of stem, k. leaf tip, l. underleaf, m. gemmae at lobule, n. gemmae

Habitat: Corticolous growing on the bark of trees in the moist shady areas of montane wet temperate forest locally known as shola forest along with *Cheilolejeunea xanhocarpa* (Lehm. & Lindenb.) Malombe and *Parmelia* genus of lichens.

Discussion: The discovery of *C. calyptrifolia* from Anamudi Shola reports the occurrence of genus *Colura* in Kerala and a new record to Western Ghats (Mufeed *et al.*, 2018). This species was reported from Asia by Lal (1977) from Tiger Hills of Darjeeling in Eastern Himalaya. As per the recent survey on Indian *Colura* by S.K. Singh *et al.*, (2020), that the previous report of *C. calyptrifolia* from Eastern Himalayas was a misidentification. The occurrence of *C. calyptrifolia* in Arunachal Pradesh and West Bengal is dubious as there is no trace of specimens at CAL or ASSAM that can substantiate the report. Hence the report of Mufeed *et al.* (2018) is a new distributional record of this species to India. *Colura* is a highly distinctive genus with long beaked sac like leaf lobule and presence of valve, gemmae are rounded on the tip, and internally the cells are without trigones and intermediate nodular thickening with thin-walled cells.

Distribution: World: Chile, Taiwan, Ireland, Europe (Hassel *et al.*, 2014); Central & South Africa (Dualien county, Dominica, Venezuela, Tanzania, Uganda and Malawi Island (Porley, 1997; Yang, 2013), Sri Lanka (Long & Rubasinghe, 2014); **India:** Kerala (Mufeed *et al.*, 2018; S.K. Singh *et al.*, 2020).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2300m) 08.11.2017, Mufeed 7462; 06.02.2018 Mufeed 9867b; 22.09.2018 Mufeed 9987 (ZGC).

Drepanolejeunea (Spruce) Steph.,
Hedwigia 30(5): 202, 209. 1891.

Plants very minute, usually yellowish-green to light green, occasionally brownish, delicate; stems spreading, irregularly branched, closely adnate, slender, formed of 7 to 8 rows of cortical cells surrounding 3 to 4 rows of medullary cells, cortical cells larger than medullary; rhizoids frequent, form a distinct rhizoid-initial disc at underleaf bases; leaves flat or slightly convex, distant to contiguous usually widely

spreading, lobes typically strongly asymmetrical, ovate-pointed to lanceolate, margins free, a strong tendency to be crenulated or variously dentate, cells with ocelli; lobule ovate to ovate rectangular, inflated, apex marked by a strong, elongate, falcate or hooked 1-celled apical tooth; underleaves small, remote, inserted on 2 rows of cortical cells, strongly transverse, fundamentally obtrapezoidal, formed of cells of subequal size, bilobed, the lobes strongly divergent, sinus shallow and broad, usually crescentic to obtuse, lobes slender, filiform 2-4 cells long and 1-4 cells wide at base, separated typically by only 2 cells and 2 cells at each side below the lobes; usually dioicous, inflorescence typically on a short lateral branch, producing one subfloral innovation, perianth terete, below more or less 5-keeled above, keels usually produced outward as discrete, often variously winged, dentate or armed horns or crests, beak distinct, seta with 12 epidermal and 4 internal cell rows, auriculate, androecia with bracteoles at base only.

Key to the species

- 1a. Leaf margin serrated with 2 to 3 celled 1 or 2 tooth, apex involuted, leaves caduceus ***D. ternatensis***
- 1b. Leaf margin serrated without teeth, apex acute, not involuted, leaves not caduceus ***D. angustifolia***

Drepanolejeunea angustifolia (Mitt.) Grolle, J. Jap. Bot. 40: 206. 1965; Udar & U.S. Awasthi, J. Hattori Bot. Lab. 53: 420. 1982; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 4. 2008; Daniels, Arch. Bryol. 65. 2010; Manju *et al.*, Act. Biol. Plant. Agri. 2: 132. 2012; Daniels & Daniel, Bryofl. S. W. Ghats. India: 147. 2013; Dey & D.K. Singh, Epiphyll. Liverw. E. Himal.: 216. 2012; Dey *et al.*, Trop. Bryol. 35: 15. 2013; D.K. Singh *et al.*, Liverw. & Hornw. India, 134: 2016; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 485. 2019. *Jungermannia tenuis* Reinw., Blume & Nees, Nova Acta Acad. Caes. Leop.- Carol. German. Nat. Cur. 12: 226. 1824. *Lejeunea angustifolia* Mitt., J. Proc. Linn. Soc., Bot. 5: 116. 1861. *Drepanolejeunea tenuis* (Reinw., Blume & Nees) Schiffn., Consp. Hepat. Arch. Ind. 280. 1898; Mizutani, J. Hattori Bot. Lab. 26: 172. 1963; Udar & Awasthi, J. Hattori Bot. Lab. 53: 420. 1982. *Physocolea angustifolia* (Mitt.) Steph., Sp. Hepat. 5: 887. 1916. *Drepanolejeunea longifolia* A.P. Singh & Nath, Hepat. Khasi Jaintia Hills: E. Himal.

248. 2007.

Plants pale green when fresh and brownish when dry, 4-10×0.31-0.35 mm including leaves, branched; stem in transverse section with 7 cortical cells, 10-15×12-14 µm, 4 medullary cells, 4-8×6-9 µm diagonally, ventral merophytes 2 cells wide; rhizoids present at the base of underleaves, numerous, tufted, hyaline; rhizoidal disc absent; leaves distant, diverging from stem at an angle of 30-40°; leaf lobe linear-lanceolate, erect-spreading, 0.28-0.30×0.09-0.13 mm; apex acute, ending in a single cell; margin slightly serrulate, arched dorsally, straight ventrally; cells at margin polygonal, 11-23 µm; median cells rounded to polygonal, 20-25×10-13 µm; basal cells hexagonal, polygonal, 18-20×10-15 µm; trigones and intermediate nodular thickenings absent; cells smooth; oil bodies and ocelli not seen; leaf lobule inflated, ½ as long as leaf lobe, ovate, 0.10-0.16×0.10-0.11 mm, bilobed; first tooth unicellular, elongate, curved; second tooth indistinct; free lateral margin bordered by 4 linear cells; keel arched; underleaves distant, small, as wide as stem, bilobed, sinus V-shaped, 0.04-0.08 × 0.06-0.07 mm; lobes uniseriate, 2-3 cells long, 2 cells wide at base; reproductive structures not seen (Plate 5.24).

Habitat: Epiphytic on bark of shola tree trunk.

Discussion: The first report of *Drepanolejeunea* from India is by the description of *D. angustifolia* (Mitt.) Grolle as *Lejeunea angustifolia* Mitt. from Sikkim (Mitten, 1861). From Western Ghats the genus was first described by Udar & Awasthi (1982) from Tamil Nadu with *D. angustifolia* (Mitt.) Grolle. and *D. ternatensis* as *D. ternatensis* var. *lancispina*. *D. angustifolia* (Mitt.) Grolle is earlier reported from Kerala (Manju *et al.*, 2012). This species is characterized by its very small epiphytic plants with light green colour, distantly placed linear lanceolate leaves, inflated leaf lobule ½ as long as the leaf lobe and the bilobed underleaves with ‘v’ shaped sinus.

Distribution: **World;** Bhutan (Long & Grolle, 1990), China (Piippo, 1990), Japan (Yamada & Iwatsuki, 2006), Malaysia (D.K. Singh *et al.*, 2016), Nepal (Pradhan & Joshi, 2009), Papua New Guinea (Grolle & Piippo, 1984), Philippines (Tan & Engel, 1986); **India;** Andaman (D.K. Singh *et al.*, 2006a; Dey *et al.*, 2013), Arunachal Pradesh (Rawat & Varma, 2014), Kerala (Manju *et al.*, 2008, 2012, present



Plate 5. 24: *Drepanolejeunea angustifolia* (Mitt.) Grolle, a. habit, b. single plant, c&d. habit enlarged view, e. leaf, f. underleaf, g. leaf lobule, h. leaf tip cells, i. c.s. of stem

Collection), Meghalaya (A.P. Singh & Nath 2007), Sikkim (Mitten, 1861 as *L. angustifolia*, Dey & D.K. Singh, 2012), West Bengal (Udar & U.S. Awasthi, 1982 & Mizutani, 1963 as *D. tenuis*, Dey & D.K. Singh 2012), Tamil Nadu (Udar & U.S. Awasthi, 1982).

Specimen/s examined: India, Kerala, Idukki, Anamudishola NP, Iddalymotta (2200 m) 03.03.2016 *Mufeed 9972*; 25.09.2018, *Mufeed 10018* (ZGC).

Other specimen/s examined: India, Kerala, Idukki, Eravikulam NP, Amarshola (2000 m) *Manju 80241/b* (CALI!).

Drepanolejeunea ternatensis (Gottsche) Steph., *Hedwigia* 28: 169. 1889; Daniels, *Arch. Bryo* 65: 13. 2010; Daniels & Daniel, *Bryofl. S. W. Ghats. India*: 147. 2013; Daniels & Kariyappa, *Bryofl. Agasthyamalai Bio. Res.*: 490. 2019. *Lejeunea ternatensis* Gottsche in Gottsche *et al.*, *Syn. Hepat.* 346. 1845. *Drepanolejeunea ternatensis* (Gottsche) Steph. var. *lancispina* Herzog, *Ann. Bryol.* 12: 119. 1939; Udar & Awasthi, *J. Hattori Bot. Lab.* 53: 430 1982; A.K. Asthana & S.C. Srivastava, *Pl. Sci. Today* 2 (4): 185. 2015.

Plant light green, brown when dried, small, $1.15\text{-}3 \times 0.23\text{-}0.28$ mm including leaves, deeply appressed to the substratum; branching irregular, rhizoids few, hyaline; ventral merophytes two cells wide; stem c.s. with 7 cortical cells and 3 medullary cells; leaves distant, diverging from stem at $35\text{-}40^\circ$ angle, caducous, linear lanceolate, $0.24\text{-}0.3 \times 0.10\text{-}0.12$ mm, margin falcate, dorsal margin convex, irregularly toothed, tooth with 1-2 celled, ventral margin arched, serrated, apex acuminate, uniseriate at extreme tip, 4-6 cells long, curled towards dorsal margin, $19\text{-}20 \times 7\text{-}9$ μm , marginal cells papillate, rounded–quadrate, $23\text{-}31 \times 14\text{-}15$ μm , basal cells of toothed margin of leaf lobe elongated, 36.74×76.88 μm , basal and median cells quadrate to rounded, $20\text{-}40 \times 15\text{-}20$ μm , trigones and intermediate thickenings are present throughout the cells; leaf lobule inflated, ovate $0.05\text{-}0.1 \times 0.04\text{-}0.10$ mm, ovate, involute at margin, first tooth distinct, second one indistinct; underleaves bilobed, $0.05\text{-}0.07 \times 0.03\text{-}0.04$ mm, sinus as wide as stem, 3 cells long, 0.04 mm long, attached with two lateral cells on each side, 6 marginal cells encircling the stem attachment area, cells circular, polygonal, 9-14 μm ; androecia not seen, perianth is present on short lateral innovation, lobes toothed, 2-3 cells long, margin serrated, cells 29-34 μm , perianth lobe up to 0.35 mm long, male and other

asexual reproductive structures are not seen (Plate 5.25).

Habitat: Epiphytic on bark of trees in evergreen forests.

Discussion: The first report of *D. ternatensis* from India is by Udar & Awasthi (1982) from Tamil Nadu as *D. ternatensis* var. *lancispina*. Söderström *et al.* (2010) synonymised this variety under *D. ternatensis* because of the similar characters shared by this species. Later, Daniels & Daniel (2013) described *D. ternatensis* (Gottsche) Steph. from Nilgiri hills of Tamil Nadu. Based on the present collection Chandini *et al.* (2020) reported this species as new record for Kerala. This species is characterized by caducouse, linear lanceolate leaves, lobes with dorsal margin convex, toothed, irregular, tooth with 1-2 celled, ventral margin arched, serrated, apex acuminate, uniseriate at extreme tip, 4-6 cells long and curled towards dorsal margin.

Distribution: **World;** Australia (McCarthy, 2006), Africa (Wigginton, 2009), China (Zhu & So, 2001), Japan (Yamada & Iwatsuki, 2006), Fiji, Indonesia (Söderström *et al.*, 2011), Papua New Guinea (Grolle & Piippo, 1984), Philippines (Tan & Engel, 1986), Taiwan (Wang *et al.*, 2011), New Caledonia (Thouvenot *et al.*, 2011), Malaysia (Chuah-Petiot, 2011 as *D. ternatensis* var. *lancispina*); **India:** Kerala (present collection), Tamil Nadu (Udar & U.S.Awasthi, 1982), Doddabetta (Udar & U.S.Awasthi, 1982 as *D. ternatensis* var. *lancispina*), Kanyakumari, Upper Kodaiyar (Daniels & Daniel, 2013), Palni Hills, Kodikanal, Coasan road (A.K. Asthana & A.Srivasthava, 2015 as *D. ternatensis* var. *lancispina*).

Specimen/s examined: India, Kerala, Idukki, Anamudi Shola National Park, Mannavan Shola (1697 m 10°12'21"N 77°11'09"E) Manju, A.C. 10227 (ZGC).

Lejeunea Lib.,

Ann. Gen. Sci. Phys. 6: 373, 1820.

Plants 0.6–1.5 mm wide, pale to bright green and yellowish, sometimes glossy, in loose mats, loosely attached to the substratum; rhizoids few, arise from underleaf bases; regularly to irregularly pinnately branched, branching of *Lejeunea*-type, cross section with 6–10 outer and 12–35 inner cell rows, outer cells larger, ventral merophyte 2 cells wide; leaves contiguous to imbricate, lobe convex, slightly to strongly curved to ventral side, lobule nearly plane to involute inward, with two

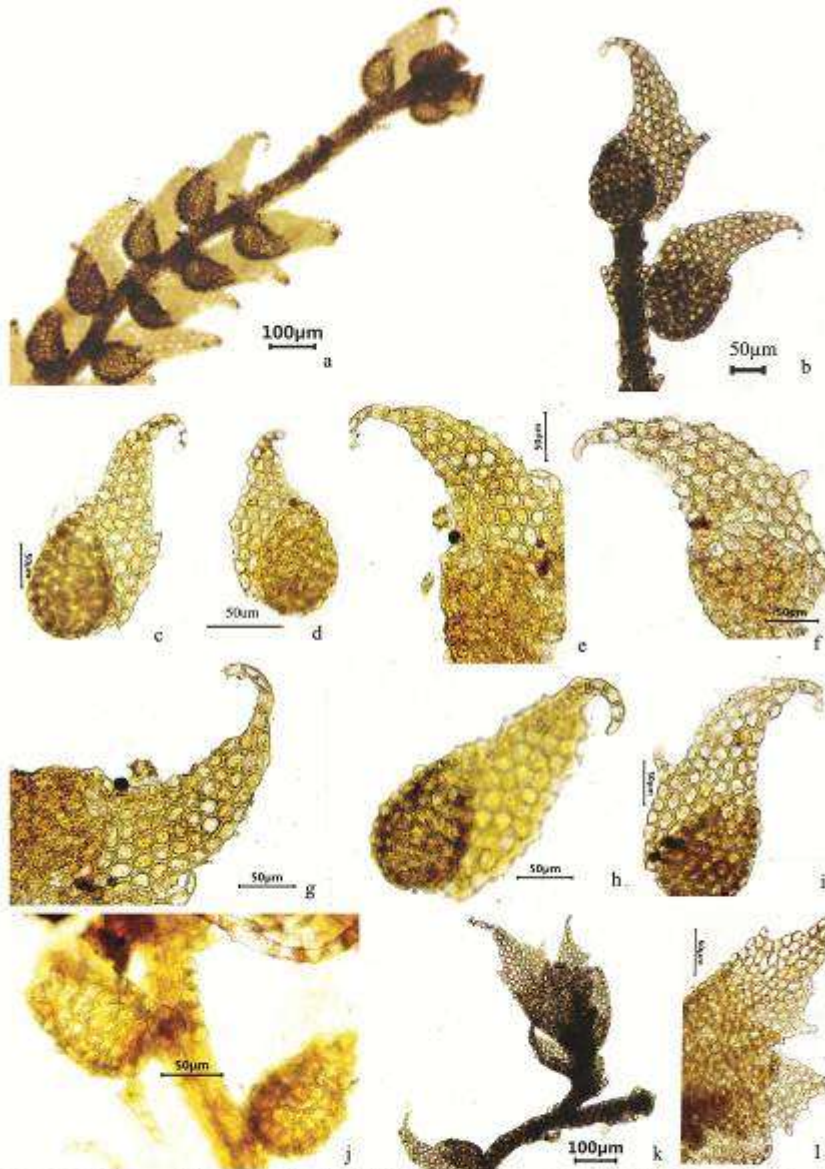


Plate 5. 25: *Drepanolejeunea ternatensis* (Gottsche) Steph., a. a portion of plant with cauducos leaves, b. leaf arrangement, c, d, e, f & g. different leaf lobes, h. leaf lobule and involute leaf apex, i. single leaf. j. stem with underleaf, k. perianth, l. perianth enlarged view

teeth, the first tooth larger than the second, slime papilla near proximal base of the first tooth; cells in the leaf lobe middle thin to somewhat thickened walls, intermediate thickenings present, oil bodies small, more than 5 per cell; underleaves, bilobed, lobes acute to obtuse; mostly autoicous; perianth on branches, with Radula-type branching, distinctly (4–)5-keeled, somewhat beaked.

Key to the species

- 1a. Underleaves arranged closely *L. flava*
- 1b. Underleaves distant 2
- 2a. leaf lobules about 1/3 of the length of the lobes, apex constricted, inflated, first tooth unicellular, rounded, second tooth indistinct *L. cocoes*
- 2b. leaf lobule inflated, 1/4–1/5 as long as the lobe, triangular ovate, bidentate, first tooth small, unicellular, second tooth obsolete *L. subacuta*

Lejeunea cocoes Mitt., J. Proc. Linn. Soc. Bot. 5: 114. 1861; A.P. Singh and Nath, Curr. trends bryology, 367. 2007; A.P. Singh & Nath, Hep. Khasi and Jaintia hills, 264 .2007; Manju *et al.*, Acta Bot. Hung. 54(3-4). 341. 2012.

Plants pale green; prostrate on bark, 7–10 mm long and 0.4–0.6 mm wide including leaves, branching irregular, primary branches up to 4 mm long and 0.30–0.45 mm wide including leaves stem 0.06 × 0.08–0.09 mm in diameter, 4 celled across, cortical cells in 6 longitudinal rows, 16.5–24.0 mm × 26.7–30.5 mm, thin walled, medullary cells in 5 longitudinal rows, slightly thick walled, cortical cells larger than medullary cells, 10.0–13.5 mm × 15.0–16.5 mm; rhizoids numerous, leaves distant, suberect, ovate, slightly convex, 0.35–0.46 mm long, 0.20–0.25 mm wide, apex obtuse to rotundate, margin entire, marginal cells of leaf lobe thin walled, 10–12 mm × 20–25 mm, rectangular, slightly trigonous; median cells hexagonal with minute trigonous, 17–23 mm × 30–32 mm, basal cells elongate, thin walled, 22–28 mm × 27.5–35.0 mm, hexagonal, trigonous, trigones small, leaf lobules about 1/3 of the length of the lobes, apex constricted, inflated, first tooth unicellular, rounded, second tooth indistinct; underleaves very distant, bifid, as wide as stem, 0.08–0.10 mm long, 0.08–0.09 mm wide, apex bilobed to about half the length, each lobe 3–4 celled long, lobes with dull toothed margins; perianth with 5 keels (Plate 5.26).

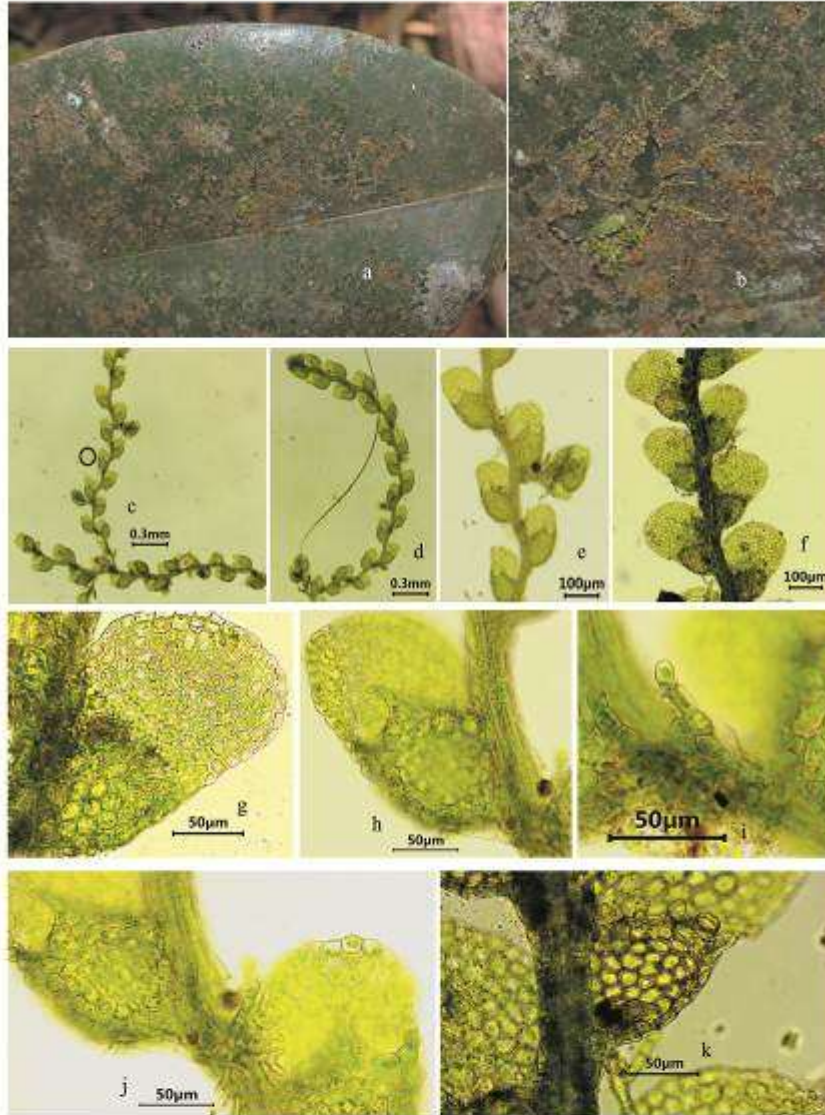


Plate 5. 26: *Lejeunea cocoes* Mitt., a&b. epiphyllous habit, c&d. single plant, e&f. ventral portion showing leaf arrangement, g&h. leaf lobule and its arrangement on stem, i. underleaf, j. leaf lobule, k. lobule tip

Habitat: Epiphytic on barks of large trees.

Discussion: *Lejeunea cocoes* Mitt. is the only epiphyllous species collected from the low altitude shola trees of the study area. Previously reported from Kerala by Manju *et al.* (2012) from Kozhikode district.

Distribution: Kerala (Manju *et al.*, 2012), Meghalaya (A.P. Singh & Nath, 2007).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1800 m) 14.04.2019 *Mufeed 15613* (ZGC).

Lejeunea flava (Sw.) Nees, Naturagesch. Eur. Leberm. 3: 277.1838; Chopra, Proc. Ind. Acad. Sci. 7: 250. 1938; Joshi *et al.*, Ad. Plant Sci. 2: 169-177. 1989; N.S. Parihar *et al.*, Hepat. & Anthocerot. India: 25. 1994; Bapna & Kachroo, Hepatic. India 2: 238. 2000; Srivasthava & Sharma, Naut. Comm. Vol. Rec. trends. Bot. Res. 70. 2000; S.K. Singh & D.K. Singh, Geophytology 32: 115. 2004 & Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 228. 2009; Pócs *et al.*, Acta Bot. Hung. 49: 127. 2007; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7:5. 2008; Manju *et al.*, Acta Biol. Plant. Agriensis 2:134. 2012; Dey & D.K. Singh, Epiphyll. Liverw. E. Himal.: 216. 2012; D.K. Singh *et al.*, Liverw. & Hornw. India: 134: 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 377. 2018. *Jungermannia flava* Sw., Prodr. 144. 1788. *Lejeunea thymifolia* Nees, Syn. Hepat.: 372. 1845. *Eulejeunea flava* (Swartz) Schiffn. in Engl. & Prantl. Nat. Pflanzenfam. 1(3): 122. 1895.

Plants green, light brown when dry, branches *Lejeunea* type, 6-8 mm long and 1 mm wide including leaves; stem c.s. with 7 cortical cells, 14-17 medullary cells; leaf lobes imbricate, ovate-oblong, apex narrowly rounded, leaf margin entire, 0.6 mm long and 0.4 mm wide; leaf cells smaller at leaf margin, 8-10 µm long and 18-20 µm wide, rounded, irregularly quadrate to rectangular towards the leaf margin, median cells 23-27 µm in diameter, basal cells 32-38 µm, trigones well developed, intermediate thickenings present and not prominent; leaf lobule inflated, 0.15 mm long and 0.22 mm wide, 1/4-1/5 length of the lobe, keel straight, free margin incurved, first tooth one celled, second tooth 1-2 cells long along the keel; underleaves bilobed, covering the lobule, large 4-5 times wider than stem, 0.44 mm

long and 0.48 mm wide, imbricate, contiguous, orbicular, lobes $\frac{1}{2}$ of underleaf length, sinus narrow, acute to obtuse, margin entire, underleaf attached to the stem by 4 superior central cells; reproductive structure not observed (Plate 5.27).

Habitat: Epiphytic on branches and main trunk along with *Hookeria acutifolia* Hook. & Grev. seen in all altitudinal ranges in shola forests and Tea plantations.

Discussion: *Lejeunea flava* is a widely distributed species in Kerala. It is characterized by small lengthy plant with up to 8 cm long, leaf lobule $\frac{1}{4}$ th the length of the leaf lobe, underleaves bilobed, large and imbricate with narrow sinus and c.s of stem with 7 cortical cells and 14-17 medullary cells.

Distribution: World: Africa (Wigginton, 2009), Australia (McCarthy, 2006), Bhutan (Long & Grolle, 1990), Cambodia (Tixier, 1979), China (Piippo, 1990), Europe (Ros *et al.*, 2007), Fiji (Söderström *et al.*, 2011), Indonesia (Söderström *et al.*, 2010), Japan (Yamada & Iwatsuki, 2006), Korea (Yamada & Choe, 1997), Macronesia (Miller, 1960), Malaysia (Chuah-Petiot, 2011), Nepal (Pradhan & Joshi, 2009), New Zealand (Glenny, 1998), North America (Stotler & Crandall- Stotler, 1977), Papua New Guinea (Grolle & Piippo, 1984), Philippines (Tan & Engel, 1986), Samoa (Grolle & Schultze-Motel, 1972), South America (Yano, 1984), Singapore (Piippo *et al.*, 2002), Sri Lanka (Long & Rubasinha, 2014), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008), Vietnam (Pócs, 1965); **India:** Andaman (Chavan, 2010), Arunachal Pradesh (Dey & D.K. Singh, 2012; D.K. Singh *et al.*, 2016), Assam (D.K. Singh, 1996), Himachal Pradesh (Kumar & Anand, 1990), Kerala (Daniels & Kariyappa, 2019; S.C. Srivastava & Sharma, 2000, Manju *et al.*, 2012), Manipur (D.K. Singh *et al.*, 2010, Dey & D.K. Singh, 2012), Meghalaya, Sikkim (Mizutani, 1971), Tamil Nadu (Chopra, 1938; Daniels, 2010; Daniels & Kariyappa, 2019), West Bengal (Dey & D.K. Singh, 2012).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2350 m) 12.07.2017 *Mufeed* 7302; Mannavan Shola (1700 m) 14.07.2017 *Mufeed* 9970; Idivara Shola (2100 m) 25.03.2016 *Mufeed* 10010 (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills (2600-2660 m) 08.10.2000 S.C. Srivastava *et al.*, 12445 (LWU)

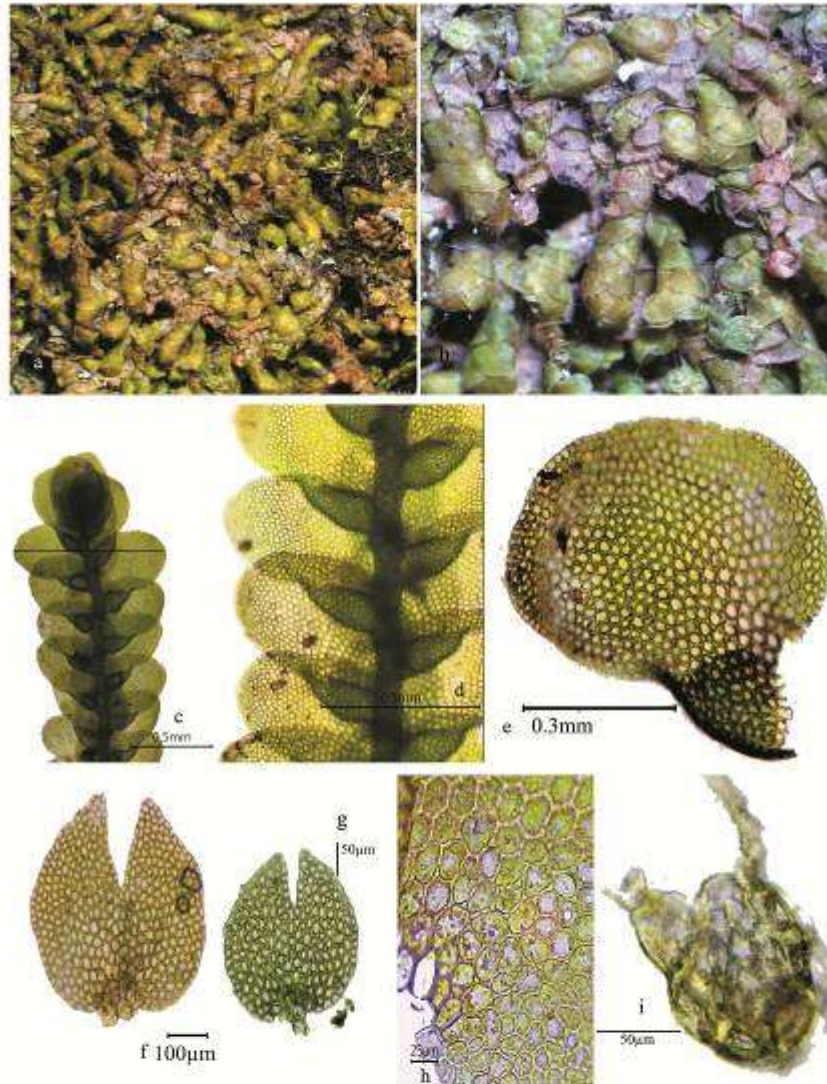


Plate 5. 27: *Lejeunea flava* (Sw.) Nees, a&b. habit, c&d. ventral view of branch, d. leaf showing leaf lobule, f&g. underleaves, h. basal cells, i. c.s. of stem

Lejeunea subacuta Mitt., J. Proc. Linn. Soc., Bot. 5: 113. 1861; R.L. Zhu & M. L. So in Ann. Bot. Fennici 36: 224. 1999; Manju *et al.*, Acta Biol. Plant. Agriensis 2: 135. 2012; Dey & Singh, Epiphyll. Liverw. E. Himal.: 216. 2012; Singh *et al.*, Liverw. Hornw. India, 149: 2016.

Plants light green to yellowish, 8mm long, 0.9-1 mm wide including leaves, c.s of stem 6-7 large cortical cells, 5-8 small medullary cells; rhizoids hyaline, numerous; leaves distant, contiguous, widely to slightly obliquely spreading, lobe oblong ovate 0.6 mm long and 0.4 mm wide, apex obtuse, rarely sub acute, margin entire, dorsal margin arched, ventral margin nearly straight; leaf cells at margin sub quadrate, rectangular, 10-16 μ m long and 10 μ m wide, median cells hexagonal, 24 μ m long and 14 μ m wide, basal leaf cells elongated, polygonal, 30 μ m long and 15 μ m wide; oilbodies not seen; leaf lobule inflated, 1/4-1/5 as long as the lobe, triangular ovate, 0.13 mm long and 0.10mm wide, bidentate, first tooth small, unicellular, second tooth obsolete, hyaline papilla present at the proximal side of first tooth, keel nearly straight; underleaves distant, 2-3 times wide as stem, oval to sub orbicular, 0.3×0.2 mm longer than wide, bilobed to ½ of underleaf length, margin entire, sinus narrow, wide, reproductive structures not observed (Plate 5.28).

Habitat: Epiphytic, on barks and branches of wattle.

Discussion: *Lejeunea subacuta* Mitt. is previously from Kozhikode and Thrissur district of Kerala. It is characterized by oblong ovate leaf lobes, triangular ovate inflated, leaf lobule, 1/4-1/5 as long as the leaf lobe, oval-sub orbicular under leaves, bilobed to ½ of underleaf of length with entire margin.

Distribution: World: China (Piippo, 1990), Nepal (Pradhan & Joshi, 2009), Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011); **India:** Kerala (Manju *et al.*, 2012), Megalaya (Mitten, 1861), Sikkim, West Bengal (Dey & D.K. Singh, 2012, D.K. Singh *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100 m) 7.11.2017 Mufeed 7401 (ZGC).

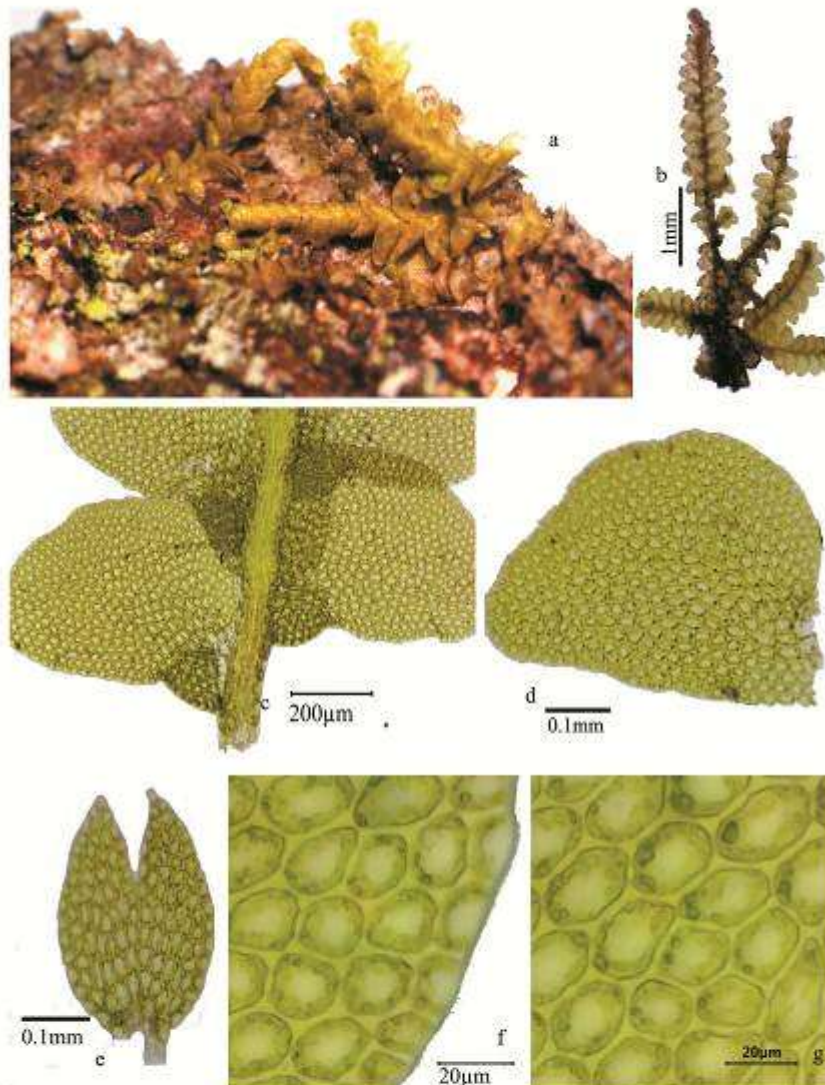


Plate 5. 28: *Lejeunea subacuta* Mitt., a. habit, b. single plant, c. leaf arrangement, d. leaf, e. underleaf, f. marginal cells, g. median cells

Microlejeunea (Spruce) Steph.,
Hedwigia 27 (2): 61. 1888.

Plants dioicous, small size, strong shoots 0.16-0.5 mm, stem 30-50 µm in diameter; leaves distant, leaf lobe ovate, commonly have basal ocelli, obtuse at apex; lobule large, inflated, with strongly arched keel, circular mouth with curved apical tooth and incurved free margin; small underleaves little wider than stem, a third to a half the length of adjacent leaves, deeply bifid with nearly parallel lobes stem with three medullary cells in cross section; Inflated pyriform 5-carinate perianth, female bracts with a long, usually more or less winged keel, the lobules only shortly free, male bracts usually more or less winged on the keel.

Microlejeunea punctiformis (Taylor) Steph., Hedwigia 29: 90. 1890; Chopra, J. Indian Bot. Soc. 22: 249. 1943; D.K. Singh *et al.*, Phytotaxonomy 6:101. 2006; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007; Dey *et al.*, Indian J. Forest. 32: 677. 2009; Dey & D.K. Singh, Epiphyll. Liverw. E. Himal.: 352. 2012; Manju *et al.*, Acta Biol. Plant. Agriensis 2: 125-145. 2012; Verma *et al.*, Polish. Bot. J. 58 (2): 525-537. 2013; D.K. Singh *et al.*, Liverw. & Hornw. India, 162: 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 404. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 529. 2019. *Lejeunea punctiformis* Taylor, London J. Bot. 5: 398, 1846; Kachroo, Bull. Bot. Surv. India 12: 238. 1970; N.S. Parihar *et al.*, Hepat. & Anthocerot. India: 25. 1994; Bapna & Kachroo, Hepatic. India 2: 242. 2000; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 262. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7:5. 2008; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 208. 2013. *Lejeunea gracillima* Mitt., J. Proc. Linn. Soc., Bot. 5: 115. 1861. *Microlejeunea gracillima* (Mitt.) Carr. & Pears, Proc. Linn. Soc. N. S. Wales Ser. 2, 2: 1040. 1888.

Plants small, delicate, soft, pale green to yellowish green, 2-4 mm long, 0.2-0.3 mm wide including leaves; rhizoids colourless, branching *Lejeunea* type; leaves distant, lobes convex, ovate, obtuse at apex, 0.18 mm long and 0.12 mm wide; leaf cells polygonal, 15-20 µm in diameter; lobule convex well developed, ovate at apex, about 3/4th the length of leaf lobe, 0.14 mm long and 0.10 mm wide, 2 teeth, first

tooth larger, 1 celled, second tooth smaller, obtuse, one celled, oil bodies granulate, small, spherical to fusiform; underleaves distant, as wide as stem, bilobed, divided by V-shaped sinus, $\frac{1}{2}$ of underleaf length; reproductive structures are not seen (Plate 5.29).

Habitat: Epiphytic on tree bark and seen as epiphyllous on the surface of leaf lobe of *Cheilolejeunea xanhocarpa* (Lehm. & Lindenb.) Malombe in the shola forest above 2000 m.

Discussion: Several authors included the genus *Microlejeunea* Steph. under *Lejeunea* Lib. Based on the recent molecular work Dong *et al.* (2013) given the status of *Microlejeunea* as a separate genus. In India, most of the authors considered the genus as *Microlejeunea*. *M. punctiformis* is an Asian taxon and the species is easily identifiable by its small size, distant leaves and large lobules and regular under leaves. From the study area the plants observed on the leaf lobe of *Cheilolejeunea xanhocarpa* (Lehm. & Lindenb.) Malombe. Chandini & Manju (2018) treated this species under *Lejeunea punctiformis* Taylor based on the present collection.

Distribution: World: Australia (McCarthy, 2005), Bhutan (Long & Grolle, 1990), China, Vietnam (Zhu & So, 2001), Nepal (Pradhan & Joshi, 2009), Singapore (Piippo *et al.*, 2002), Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008); **India:** Arunachal Pradesh (Dey & D.K. Singh, 2012), Assam (Verma *et al.*, 2012), Kerala (Manju *et al.*, 2012, Manju & Rajesh, 2017; Daniels & Kariyappa, 2019), Meghalaya (A.P. Singh & Nath, 2007), Manipur (D.K. Singh *et al.*, 2010), Sikkim (Zhu & Long, 2003, Dey & D.K. Singh, 2012), Tamil Nadu (Daniels & Daniel, 2013; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019), West Bengal (Dey & D.K. Singh, 2012).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100-2350m) 03.03.2016 *Mufeed 10026b*; 25.09.2018 *Mufeed 9970* (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Eravikulam National Park (2200m) 27.11.2001, *Manju & Saju 80373b* (CALI!).

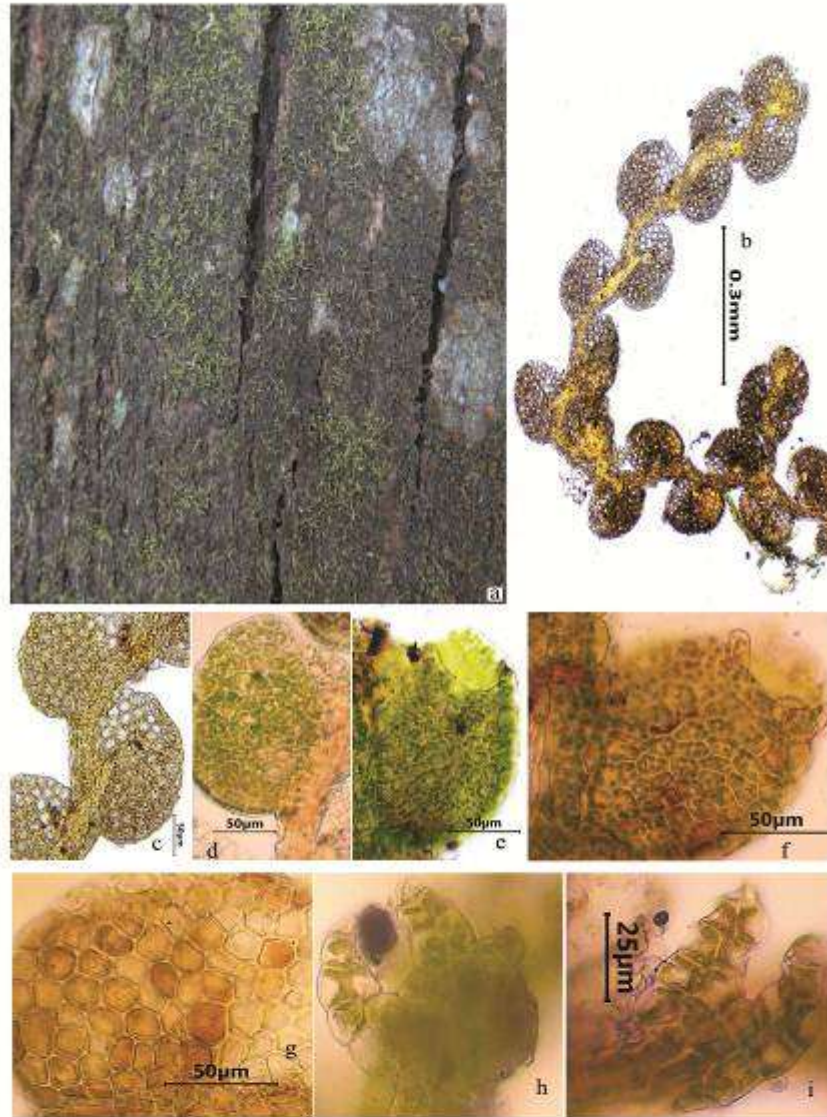


Plate 5. 29: *Microlejeunea punctiformis* (Taylor) Steph., a. habit, b. single plant, c. leaf arrangement, d. leaf, e & f. leaf lobule, g. leaf lobule cells, h & i. underleaf

***Spruceanthus* Verd.,**
Ann. Bryol. Suppl. 4: 151. 1934.

Plants large, robust, yellowish-green, irregularly branched; leaves widely spreading, incubous, lobe ovate-oblong, margin dentate to entire, apex acute, rarely obtuse; cells isodiametric, thick walled with intermediate nodular thickenings, triangular-radiate trigones distinct; oil bodies numerous, minute, 20-40 per cell, homogenous, hyaline; lobules small with 1-3 teeth; underleaves orbicular, entire or with dentate margin, 2 times as broad as stem, plicate at base; male inflorescence on terminal or on short lateral branches, with 1 or 2 subfloral innovations, bracteoles present; female inflorescence terminal on main branch, bract margin spinose, apex acute, bracteole margin entire or dentate, perianth 5-10 keeled; seta 2-4 mm long; capsule globular; spores varies in shape, globular to elongate, with minute papillae and spines; elaters brown, 1 or 2 spiral bands.

Spruceanthus semirepandus (Nees) Verd., Ann. Bryol. Suppl. 4: 153; Chopra, J. Indian Bot. Soc. 22: 250. 1943; Hattori, Fl. East. Himalaya: 532. 1966; Udar & U.S. Awasthi, J. Indian Bot. Soc. 61: 183. 1982; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 37. 1994; Bapna & Kachroo, Hepatic. India 2: 315. 2000; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 75. 2005; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 249. 2007; Manju *et al.*, Taiwania 54(1): 63. 2009; Manju *et al.*, Acta Biol. Plant. Agriensis 2:139. 2012; Daniels & Daniel, Bryofl. S.-most W. Ghats: 233. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 168. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 410. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 541. 2019. *Jungermannia semirepanda* Nees, Hepat. Jav. 39. 1830. *Lejeunea semirepanda* (Nees) Nees & Mont., Ann. Sci. Nat. Bot. (ser.2) 5: 59.1836. *Ptychanthus semirepanda* (Nees) Nees, Naturgesch. Eur. Leberm. 3: 212. 1838. *Phragmicoma semirepnda* (Nees) Gottsche in Gottsche *et al.*, Syn. Hepat. 302. 1845. *Marchesinia semirepanda* (Nees) Kuntze, Revis. Gen. Pl. Pars II: 837. 1891. *Thysanthus semirepandus* (Nees) Schiffn., Osterr. Bot. Z. 49: 205. 1899. *Marchesinia gigantea* Steph., Sp. Hepat. 5: 154. 1912. *Thysananthus rotundistipulus* Steph., Sp. Hepat. 6: 566. 1924.

Plant large, 6-9 cm long, robust, dark green when fresh, brown when dry, stem c.s.

with 26-28 thick walled cortical cells, 60 small medullary cells, branching *Lejeunea* type; leaf lobe imbricate, widely spreading, lobe obliquely ovate, 2 mm long and 1.8 mm wide; apex apiculate or acute, margin entire or dentate towards apex, ventral margin usually incurved, dorsal margin slightly arched and auriculate at base, lobe cell walls thickened, trigones large, radiate, intermediate thickenings frequent, marginal cells subquadrate, 13-15 µm long and 9-12 µm wide, median cells hexagonal, 35-40 µm long and 20-25 µm wide, basal cells elongated, 55-75 µm long and 20-25 µm wide; lobule ovate, 1/5-1/4 as long as the lobule, inflated, free lateral margin usually incurved, apex obliquely truncate, 1-3 unicellular teeth; underleaves densely imbricate, appressed to stem, sub orbicular, 0.75 mm long and 0.67 mm wide, 3 to 4 times wide as stem, apex rounded to truncate, margin entire or dentate (Plate 5.30).

Habitat: Epiphytic, usually seen on the exposed roots of the shola trees at an altitude above 2000 m.

Discussion: *Spruceanthus semirepandus* is a widely distributed species mostly found in the high altitude sholas and evergreen forests. Compared to other Lejeuneaceae members *Spruceanthus semirepandus* is large robust plants with 6-9cm long, c.s. of stem with 26-28 thick walled cortical cells, 60 small medullary cells and the leaf lobes obliquely ovate with dentate apex.

Distribution: World; Bhutan (Long & Grolle, 1990), Cambodia, Laos, Vietnam (Tixier, 1967, 1983), Indonesia (Söderström *et al.*, 2010), Japan (Yamada & Iwatsuki, 2006), Malaysia (Chuah-Petiot, 2011), Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008); **India:** Arunachal Pradesh (Singh, 1996, Rawat & Verma, 2014), Kerala (Nair *et al.*, 2005, Manju *et al.*, 2009, Manju *et al.*, 2012; Daniels & Kariyappa, 2019), Manipur (Singh *et al.*, 2010), Sikkim (Udar & U.S. Awasthi, 1982, D.K. Singh *et al.*, 2008), Tamil Nadu (Daniels, 2010, Daniels & Daniel, 2013; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019), West Bengal (Hattori, 1996, Udar & U.S. Awasthi, 1982), Western Himalaya (S.N. Srivastava *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2150 m) 25.09.2018 *Mufeed* 9982 (ZGC).

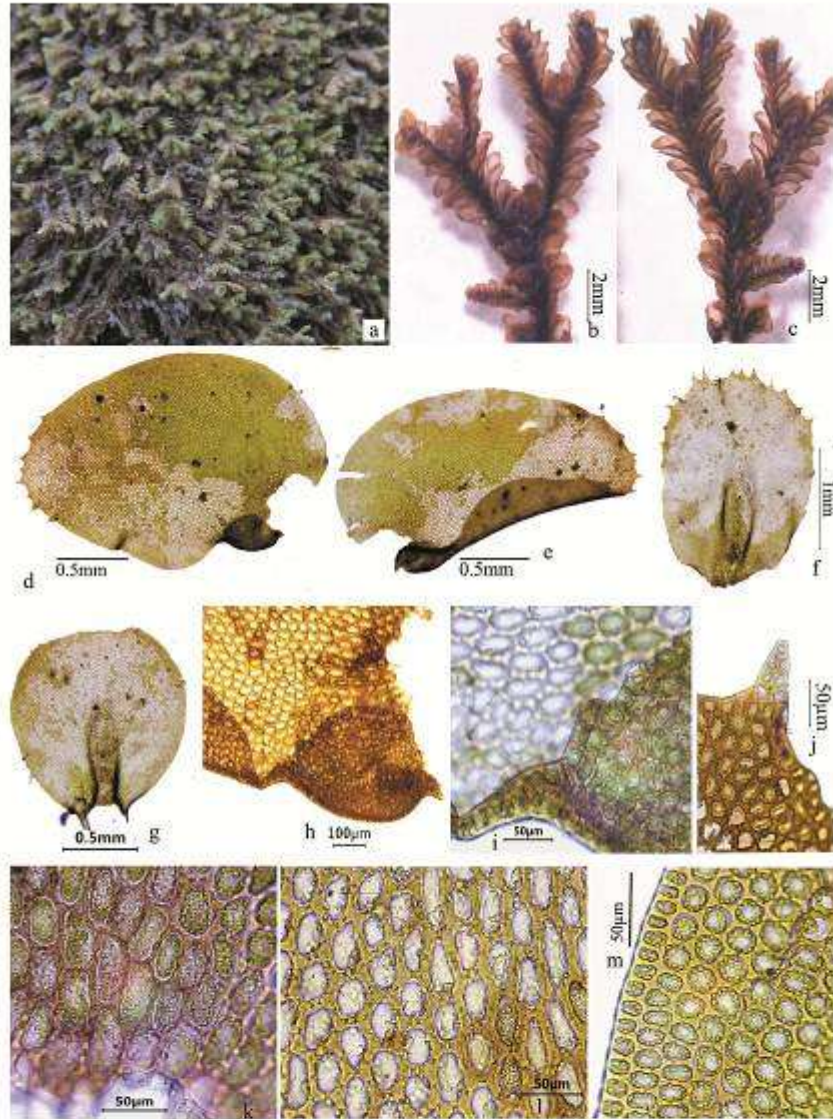


Plate 5. 30: *Spruceanthus semirepandus* (Nees) Verd., a. habit, b. branch dorsal view, c. branch ventral view, d&e. leaf, f. perianth, g. underleaf, h. leaf lobule, i. lobule tip, j. leaf spine, k. leaf basal cells, l. leaf middle cells, m. leaf marginal cells.

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1380-1775 m) *Manju C.N. 120260, 120282a, 120395 (CALI!)*.

Porellaceae Cavers,

New Phytol. 9: 292. 1910.

Plants robust, up to 30cm long, prostrate to suberect to loosely flocculent to pendulous, olive green to brown, shiny, 1-3 pinnately branched, branching frullania type; leaves ovate to lanceolate, entire to dentate, obliquely inserted; lobules parallel and contiguous to stem, usually free from lobes; underleaves large or rarely emarginate at apex, teeth may or may not present; dioicous, male and female inflorescence normally on small lateral branches, archegonia 5-30, androecia spicate, 8-12 pairs of bracts; sporophyte with the foot, seta and capsule; elaters with 1-2 spiral, spores usually verrucose.

***Porella* L.,**

Sp. Pl. 2: 1106. 1753.

Plants usually medium-sized to large, up to 8cm long and 1cm wide with leaves, 1-2 pinnately branched, rarely tripinnate, somewhat glossy, arising from a creeping rhizome; rhizoids at basal part of shoot; leaf lobes oblong-ovate, margins entire to variously dentate, apex rounded to acuminate, leaf lobules oblong to ovate, bases often appendiculate; underleaves lingulate to oblong-ovate, apex rounded or subacute; leaf cells with distinct trigones; oil bodies small, homogeneous, and numerous per cell; dioicous, androecia on short lateral branches, short spicate, bracts in 3-5(-10) pairs, antheridia one per bract; gynoecia on short lateral branches, bract-lobes, lobules and bracteoles often larger than leaf lobes, lobules and underleaves respectively; perianth cupulate, obovoid, short cylindrical or pyriform, mouth narrow or wide, minutely dentate or laciniate; capsule spherical, 4-valved, spores globose, echinate, elaters bispiral.

Key to the species

- 1a. Plants more than 30 mm long with oblong ovate lobes; lobes usually toothed ... 2
- 1b. Plants up to 20 mm long with ovate lobes; lobes smooth, teeth absent *P. madagascariensis*
- 2a. Underleaves with few teeth, 1 (-2-4) teeth 3

- 2b. Underleaves with many teeth, 15-18 teeth***P. perrottetaina***
 3a. Leaf lobules lanceolate to ovate, apex slightly undulate***P. acutifolia***
 3b. Leaf lobules lanceolate or lingulate, apex acuminate or obtuse.....
***P. campylophylla***

Porella acutifolia (Lehm. & Lindenb.) Trevis., Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat. 4: 408. 1877; Bapna & Kachroo, Hepatic. India 2: 149. 2000; Nair *et al.*, Bryo. Wayanad W. Ghat. 59. 2005. *Madotheca acutifolia* Lehm. & Lindenb., Syn. Hepat. 266. 1845. *Porella hawaiiensis* A.Evans., Trans. Conn. Acad. Arts. 8: 254. 1891. *Madotheca lancifolia* Steph., Sp. Hepat. 4: 305. 1910. *M. stracheyana* Gottsche ex Steph., Ibid. 4: 308. 1916. *M. elbertii* Steph., Ibid. 6: 520. 1924. *Porella lancifolia* (Steph.) Grolle, J. Hattori Bot. Lab. 28: 51. 1965.

Plants yellowish green or dark green, up to 60 mm long and 5 mm wide, irregularly bi to tripinnately branched, branches obliquely spreading; leaves imbricate, oblong-ovate, 1-2 mm long and 0.7-0.9 mm wide, margin entire, apex rarely subacute to acuminate, sometimes 1-2(-3) toothed, rarely obtuse; marginal cells of leaf subquadrate, 12-17 µm long and 17-22 µm wide, median cells polygonal, 17-21 µm long and 27-35 µm wide, basal cells elongated polygonal, 32-52 µm long and 22-26 µm wide; trigones triangular; lobules lanceolate-ovate, 0.75 mm long and 0.35 mm wide, margin entire, slightly undulate, apex obtuse; underleaves orbicular, triangular or oblong, 0.80 mm long and 0.50 mm wide, margin entire or with 2-3 teeth near base, apex acute to obtuse; reproductive structures not seen (Plate 5.31).

Habitat: Epiphytic, on barks of large trees in shola forest.

Discussion: In India this species was first described by Gottsche *et al.* (1844) from Madras Peninsula under the name *Madotheca acutifolia* Lehm. & Linden. Later, Stephani (1910), Kashyap (1932) and Chopra (1943) listed this species from South India and Western Himalayas. *Porella acutifolia* (Lehm. & Lindenb.) Trevis. is characterized by bi-tripinnate plants with oblong ovate leaves, leaves usually 1-3 toothed, lobules lanceolate ovate with entire margin and underleaves triangular with 2-3 teeth near base.

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994), Philippines, Sri Lanka, Java (Hattori, 1969); **India:** Assam, Meghalaya (A.P. Singh

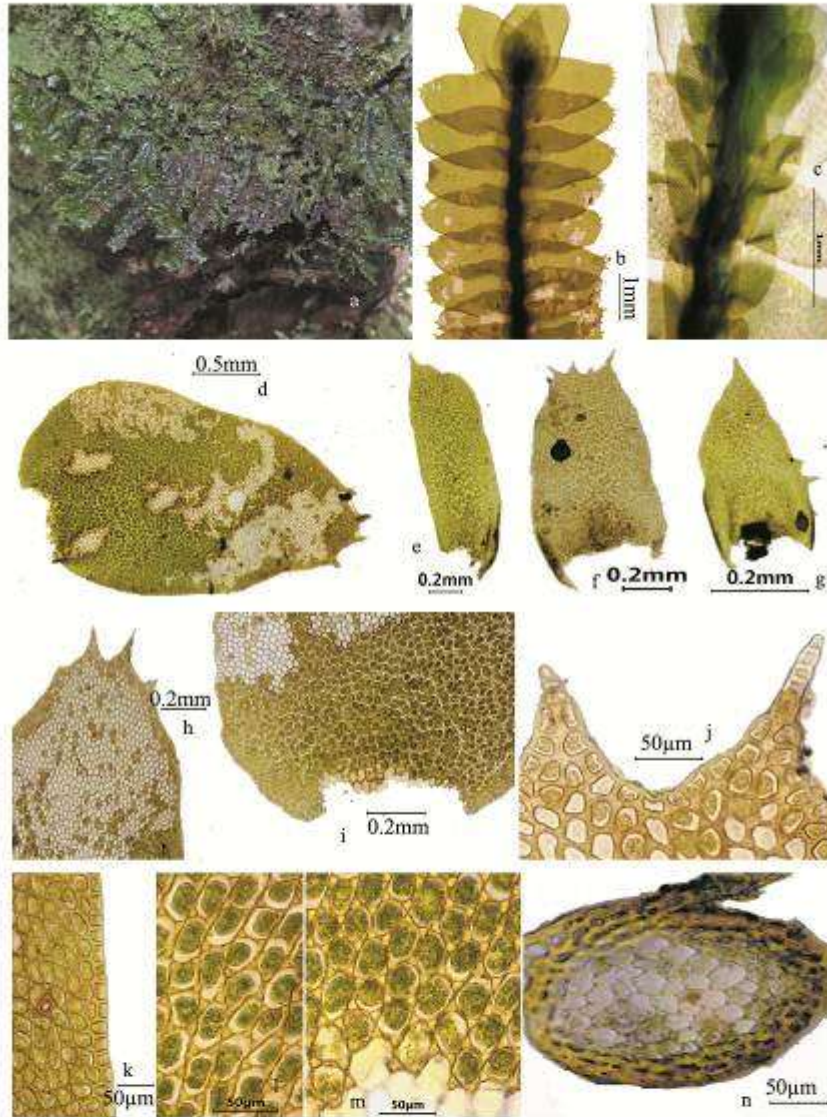


Plate 5. 31: *Porella acutifolia* (Lehm. & Lindenb.) Trevis., a. habit, b. dorsal region, c. ventral region with lateral leaves, d. leaf, e. leaf lobule, f&g. underleaves, h. leaf apex, i. leaf base, j. leaf tip cells, k. leaf margin, l. leaf cells at middle, m. leaf cells at base, n. c.s of stem

& Nath, 2007), Kerala (Nair *et al.*, 2005 & 2006), Western Himalayas (Kashyap, 1932), Tamil Nadu (Chopra, 1943; Gottsche *et al.*, 1844; Daniels, 2010), Western Himalayas (Kashyap, 1932).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2010-2400m) 24.03.2016 *Mufeed 1000, 10007a* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1380 m) *Manju C.N. 99670* (CALI!); Tamil Nadu, Nigiri Hills (2660 m) 08. 10. 2000 S.C. *Srivastava et al.*, 12504 (LWU!)

Porella campylophylla (Lehm. & Lindenb.) Trevis., Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat. 4: 408. 1877; Hattori, J. Hattori Bot. lab. 44: 101. 1978; Shaheen & S.C. Srivast., Geophytology 19: 34. 1989; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 33. 1994; Bapna & Kachroo, Hepatic. India 2: 152. 2000; Nair *et al.*, Bryo. Wayanad W. Ghat. 61. 2005; Pócs *et al.*, Acta Bot. Hung. 49: 126. 2007; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 172. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 6. 2008; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 167. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 243. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 226. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 429. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 567. 2019. *Jungermannia campylophylla* Lehm. & Lindenb. in Lehm., Nov. Stirp. Pug. 6: 40. 1834. *Madotheca campylophylla* (Lehm. & Lindenb.) Gottsche *et al.*, Syn. Hepat. 265. 1845. *Jungermannia neckeroides* Griff., Not. Pl. Asiat. 2: 313. 1849. *Madotheca ptychantha* Mitt., J. Proc. Linn. Soc. London 5: 108. 1861. *M. gollanii* Steph., Sp. Hepat. 4: 304. 1910. *M. indica* Steph., *Ibid.* 6: 524. 1924. *M. madurensis* Steph., *Ibid.* 6: 525. 1924. *M. denticulata* Kashyap, Liv. W. Himalaya Punjab Pl. 2: 332. 1932; Chopra, J. Indian Bot. Soc. 22: 248. 1943. *Porella plumosa* (Mitt.) Inoue var. *gollanii* (Steph.) Pócs, J. Hattori Bot. Lab. 31: 79. 1968. *P. gollanii* (Steph.) S. Hatt. & Mizut., Dansk. Bot. Arkiv. 27(1): 95. 1969. *P. ptychantha* (Mitt.) S. Hatt., J. Hattori Bot. Lab. 34: 426. 1970.

Plants light green to brownish green, 40-70 mm long, 3-5 mm wide with leaves, pinnately branched; stem in cross section 14-20 cells across, cortical cells in 2-4

rows, thick-walled, medullary cells thin-walled; leaves incubous, densely imbricate; leaf lobes usually ovate to oblong-ovate, 2-2.8 mm long and 1.6 mm wide, apex sub-truncate, rounded, obtuse or acute, usually with 3-8 sharp teeth, occasionally entire; marginal cells thick walled, 20-32 μm long and 23-30 μm wide, middle leaf cells polygonal, 32-48 μm long and 15-25 μm wide, trigones nodulose-bulging; leaf lobules lanceolate or ligulate, 1.35 mm long and 0.6 mm wide, apex obtuse, acuminate or sometimes slightly notched, often with 1-4 small teeth, base longly decurrent, narrowly incurved, usually entire, few branches with very small leaf lobules; underleaves oblong-ovate, 1.4 mm long and 0.9 mm wide, apex obtuse, truncate or sometimes acute, with 1-4 small teeth, base longly decurrent, narrowly incurved, entire or sometimes crispate or irregularly laciniate; reproductive structures not seen (Plate 5.32).

Habitat: Epiphytic, on exposed roots and bark of large trees.

Discussion: *Porella campylophylla* (Lehm. & Lindenb.) Trevis. was first recorded by Stephani (1910) from Himalayan region under the name *Madotheca campylophylla* (Lehm & Lindenb.) Lehm. Kashyap (1932) listed this species from Western Himalaya and Eastern Himalaya. From South India the species is reported by Chopra (1943). It is a widely distributed species in the high altitude shola forests of Kerala and is characterized by its pinnately branched brownish green plants with oblong leaves, acute apex or toothed lobes, lobule margin entire and apex obtuse and underleaves with 1-4 small teeth.

Distribution: World: China (Pippo, 1990), Nepal, Myanmar, Vietnam (Stephani, 1910); **India:** Assam, Meghalaya, West Bengal, Tamil Nadu (Hattori, 1969), Kerala (Nair *et al.*, 2005 & 2006; Nair & Madhusoodanan 2006; Pócs *et al.*, 2007), Sikkim (Kashyap, 1932),.

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1980 m) 09.11.2017 *Mufeed* 7454; Pullaradi Shola (2010 m) 23.09.2018 *Mufeed* 9945 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Muthanga range, Keeradamkolli (758 m) *Manju C.N.* 84516, Chembra hills (1360m) *Manju C.N.*

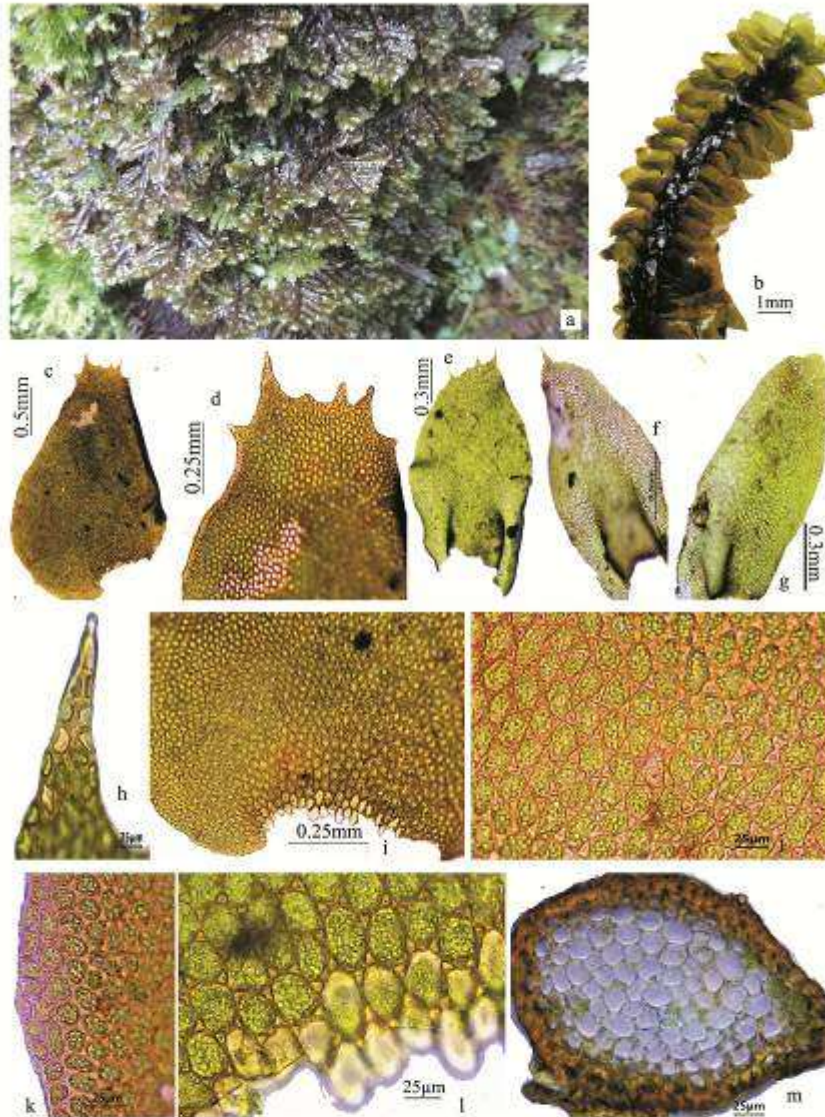


Plate 5. 32: *Porella campylophylla* (Lehm. & Lindenb.) Trevis., a. habit, b. branch, c. leaf, d. leaf apex, e&f. underleaves, g. leaf lobule, h. cell at extreme tip of spine, i. leaf base, j. leaf cells at middle, k. leaf margin, l. leaf basal cells, m. c.s. of stem

120391 (CALI!).

Porella madagascariensis (Nees & Mont.) Trevis., Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat. 4: 407. 1877; S.K. Singh & D.K. Singh, Geophytology 36: 97. 2006; Gupta *et al.*, Hattoria 9: 22. 2018. *Lejeunea madagascariensis* Nees & Mont., Ann. Sci. Nat., Bot., sér. 2, 5: 57. 1836. *Madotheca madagascariensis* (Nees & Mont.) Nees & Mont., Syn. Hepat. 272. 1845.

Plants light green to olive green, old parts brown, 20 mm long and 2.5 mm wide, bipinnately branched; lobes imbricate, ovate, 1-1.2 mm long and 0.9 mm wide at base; margin entire, apex rounded, base slightly decurrent; marginal cells of leaf quadrate to subquadrate, 16-19 x 20-25 µm, median cells hexagonal to spherical, 20-30 µm diagonally, basal cells slightly elongated, polygonal, 35-55 x 15-20 µm; trigones nodulose; leaf lobules lanceolate, 0.4 mm long and 0.2 mm wide, broad at base, margin entire or sometimes 1-2 toothed, apex obtuse or rounded; underleaves triangular to sub rectangular, 0.3 mm long and 0.2 mm wide, margin entire, acute or shallowly bilobed at apex; reproductive structures not seen (Plate 5.33).

Habitat: Epiphytic, on base of shola tree trunk associated with *Homaliodendron microdendron* (Mont.) M. Fleisch.

Discussion: *Porella madagascariensis* (Nees & Mont.) Trevis. was first reported from the Nilghiri hills by Montagne (1842) as *Madotheca nilghiriensis* (Nees & Mont.) Nees & Mont. Gupta *et al.* (2018) recently described this species from Govind WLS of Uttarakhand in India. The present collection from Anamudi Shola National Park is a new record for Kerala. It is characterized by its leaf lobes ovate and rounded at apex, cells rounded to hexagonal with nodulose trigones at base, lobules lanceolate with rounded apex and underleaves sub-rectangular with bilobed apex.

Distribution: World: Africa (Grolle, 1995), China (Pippo, 1990), Vietnam (Shu *et al.*, 2017); **India:** Kerala (present collection), Tamil Nadu (Verma *et al.*, 2013), Uttarakhand (Gupta *et al.*, 2018).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2100 m) 12.07.2017 *Mufeed 7341c*; Idivara Shola (1990 m)

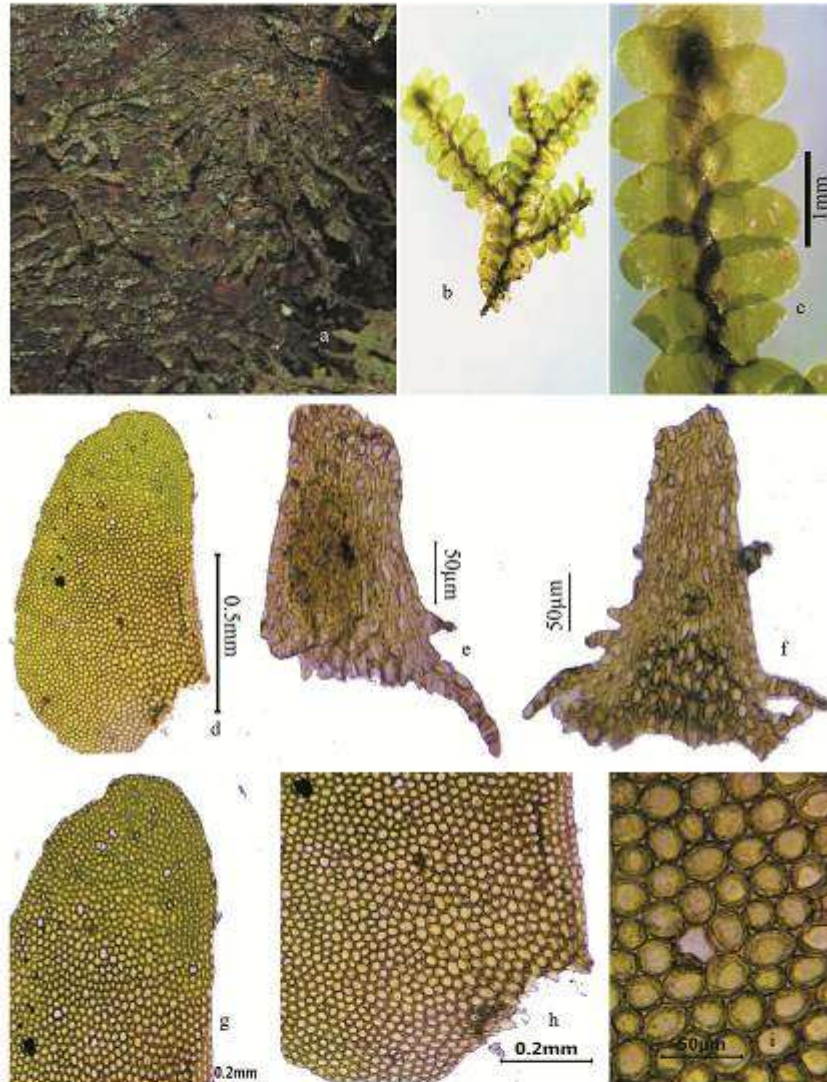


Plate 5. 33: *Porella madagascariensis* (Nees & Mont.) Trevis., a. habit, b. single thallus, c. thallus arrangement on stem dorsal view, d. leaf, e. leaf lobule, f. underleaf, g. leaf apex, h. leaf base, i. leaf cells

27.09.2018 *Mufeed* 9886 (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills (2200 m) 09.10.2000 S.C. Srivastava *et al.*, 12545, 12559 (LWU!).

Porella perrottetiana (Mont.) Trevis., Mem. Reale 1st Lombardo Sci. Ser. 3 Cl. Sci. Mat. 4: 408 1877; Mufeed & Manju, Acta Bot. Hung. 59 (1-2): 270. 2017. *Madotheca perrottetiana* Mont., Ann. Sci. Nat. Bot., sér. 2. 18: 15. 1842.

Plants pale greenish to brownish green, branching pseudo-dichotomous, branches short; stem 4-6 cm long, 2-3 mm wide including leaves, creeping or ascending; branches 3-3.5 mm long, leaf lobes opposite, 6-8 mm long, imbricate to ovate oblong, apex narrow, 5-6 spines; spines unequal, not parallel, spines with single cell in lateral side, apical spines with 8 or 9 long cells of 39-42 μm long and 17-20 μm wide, basal cells with 2-4(5) rows of rhomboidal cells, mid laminal cells more or less spherical, 80-95 μm diagonally, mid basal cells rectangular, 40-48 μm long and 21-28 μm wide; trigones prominent at basal cells; leaf lobules attached to leaf lobe at the extreme base, ligulate-ovate lanceolate with narrow apex; 1.15-1.30 mm long and 45-50 mm wide, spines very few in lobule compared to underleaf, apical spine 0.20-0.30 mm long; oil bodies over 25 per leaf cell, homogenous, spherical, 4-6 μm in diameter; underleaves 1.5-1.7 mm long and 0.30-0.35 mm wide, broader than stem, 1.50-1.65 mm long including spines, 15-18 number of spines present throughout the margin, spines 0.13-0.65 mm long; spines present at tip with 0.6-0.7 mm long (Plate 5.34).

Habitat: Creeping on the bark of trees and on the branches it is drooping, rarely grows on rock cliffs in evergreen and shola forests at an altitudinal range of 1600-2200 m.

Discussion: *Porella perrottetiana* (Mont.) Trevis. is first collected from Nielgheri Hills in Tamil Nadu (Montagne, 1842). After Montagne's report this species was collected by several authors from different areas of Tamil Nadu, such as Kotagiri and Shembaganur (Chopra, 1938). All known under *Madotheca perrottetiana* Mont. This species was also collected from Ootacamund and Kodaikanal (Hattori, 1967c) and Dodabetta (Hattori, 1969). Hattori (1976c) synonymised *Madotheca*

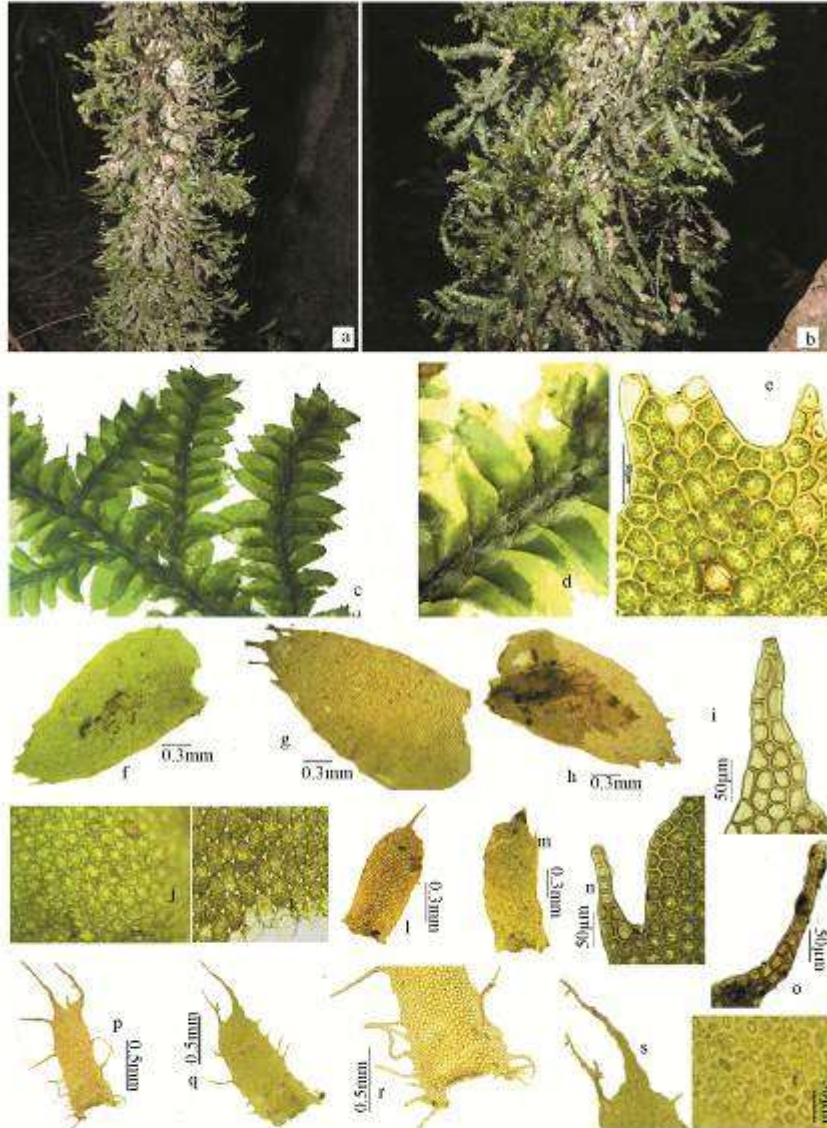


Plate 5.34: *Porella peristotiana* (Mont.) Trevis., a&b. habit, c. habit dorsal view, d. branch ventral view, e. leaf spine, f&g. leaf, h. leaf lobule attached to lobe, i. leaf tip cells, j. median cells, k. basal cells, l & m. underleaf, n. leaf spine, o. leaf lobe spine, p&q. leaf lobes, r. leaf lobe base, s. leaf lobe tip, t. leaf lobe cells

perrottetiana under *Porella perrottetiana*. Later, Udar and Shaheen (1983) reported this species from Nilgiris and Ootacamund in Tamil Nadu. Daniels (2010) listed this species based on earlier collections. Mufeed & Manju (2017) reported this species as a new record for Kerala based on the collection from Anamudi Shola National Park. It is characterized by the large plants with short branches, leaf lobes ovate oblong with narrow apex usually with 5-6 spines, leaf lobules ligulate ovate, lanceolate with narrow apex and underleaf with numerous spines.

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994); **India:** Kerala (Mufeed & Manju, 2017), Tamil Nadu (Daniels, 2010; Hattori, 1969; Udar & Shaheen, 1983).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000-2200 m) 03.03.2016 *Mufeed 10038*; 12.07.2017 *Mufeed 7352a*; Mannavan Shola (1600-1700 m) 14.07.2017 *Mufeed 7536, 7542 (ZGC)*.

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills (2200 m) 09.10.2000 *S.C. Srivastava et al., 12545, 12559 (LWU!)*.

Radulaceae Müll. Frib.,
Lebermoose 1: 404. 1909.

Plants small, medium or large, yellowish green to brownish; stem irregularly pinnately or bipinnately branched or dichotomously branched, prostrate, epiphytic or saxicolous; stem c.s. shows 5-15 cells across; leaves alternate, widely or obliquely spreading, ovate, obovate often more or less falcate, apex rounded, obtuse or subacute, margin usually entire, dorsal base arched; cells thin or thick walled, with or without trigones; lobules widely spreading, oblique, quadrate, ovate, orbicular or rectangular; rhizoids pale brown to brown; asexual reproduction by gemmae; dioicous or monoicous.

Radula Dumort.

Comm. Bot. 112. 1822 & Rec. d'obs. 14. 1835.

Plants yellowish-green, irregularly branched, branches prostrate or erect; leaves incubous, usually ovate or falcate, with a broadly rounded anterior margin; lobule rectangular, persistent; underleaves absent; androecia terminal on the main stem,

bracts imbricate, in several pairs; gynoecia terminal, usually on the stem or main branch, female bracts 1-4 pairs.

Radula acuta Mitt., Fl. Vit. 410. 1871. *Radula acuta* var. *subintegra* Steph., Hedwigia 23: 156. 1884. *R. mucronata* Steph., Hedwigia 23: 114. 1884. *R. apiculata* Sande Lac. ex Steph., Hedwigia 23: 150. 1884. *R. paucidens* Steph. ex Castle, Rev. Bryol. Lichenol. 30: 39. 1961.

Plants small, leafy, up to 1 cm long, 0.20 mm wide, rarely branched, saxicolous; leaf apiculate or subacute, 0.9 mm long and 0.6 mm wide; leaf lobe loosely imbricate, widely spreading, slightly concave, dorsal base slightly covering the stem; lobules subquadrate, $\frac{1}{3}$ rd of the leaf length, 0.35 μ m long and 0.28 μ m wide; laminal cells pentagonal or hexagonal with trigones, 24-34 μ m diagonally; marginal cells quadrangular, 15-17 μ m long and 20-25 μ m wide; apex acute, usually ends with a single cell, 26 μ m long and 21 μ m wide; reproductive structures not observed (Plate 5.35).

Habitat: Saxicolous, on crevices of large rocks, on small rocks and land cuttings.

Discussion: *Radula acuta* Mitt. is a rare species in the study area. From India this species was earlier reported only from Arunachal Pradesh and Andaman & Nicobar Islands (Majumdar *et al.*, 2012). Hence the present collection is a new record for Peninsular India. It is a small saxicolous plant that grows up to 1 cm long, rarely branched, leaf cells apiculate and the cells usually with trigones.

Distribution: World: China (Piippo, 1990), Fiji (So, 2006), Indonesia (Yamada, 1979), Japan (Yamada & Iwatsuki, 2006), Malaysia (Chuah-Petiot, 2011), New Caledonia (Thouvenot *et al.*, 2011), Pacific Isles, South Pacific (So, 2006), Papua New Guinea (Yamada & Piippo, 1989), Philippines, Samoa (Yamada, 1979; Tan & Engel, 1986), Tahiti (So, 2006), Taiwan (Wang *et al.*, 2011), Thailand (Yamada, 1979, Lai *et al.*, 2008); **India:** Arunachal Pradesh, Andaman & Nicobar Islands (Majumdar *et al.*, 2012), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1705 m) 14.07.2017 *Mufeed 7513b* (ZGC).

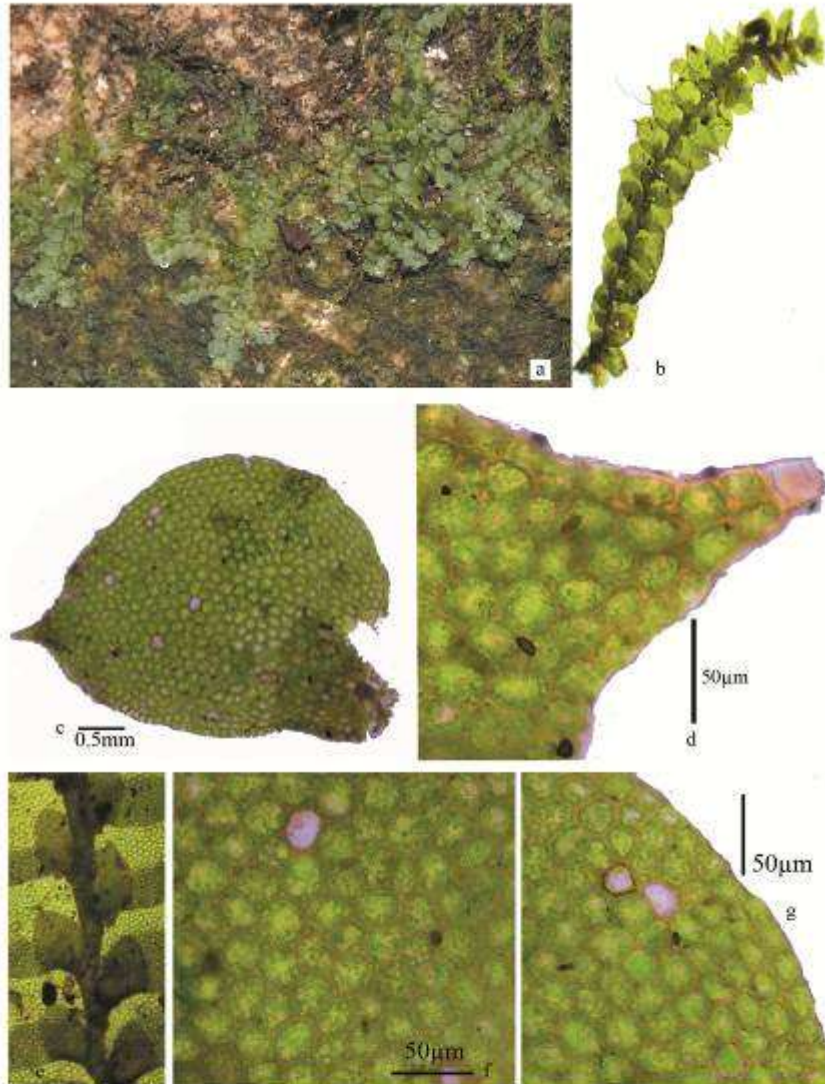


Plate 5.35: *Radula acuta* Mitt., a. habit, b. thalus dorsal view, c. leaf, d. leaf tip cells, e. leaf with leaf lobule, f. leaf cells, g. leaf marginal cells

Jungermanniales H. Klinggr.

Höh. Crypt. Preuss. 10. 1858.

Key to the families:

- 1a. Leaves arranged incubously 2
- 1b. Leaves arranged saccubously 3
- 2a. Oil bodies few to many ... 4
- 2b. Oil bodies usually absent ... **Herbertaceae**
- 3a. Underleaves usually absent or vestigial 5
- 3b. Underleaves small to large, bilobed 6
- 4a. Lobes with smooth cuticle, irregularly dentate at apex **Lepidoziaceae**
- 4b. Lobes without cuticle, minutely bidentate at apex **Calypogeiaceae**
- 5a. Leaves opposite or alternate; margin usually dentate **Plagiochilaceae**
- 5b. Leaves usually opposite; margin smooth or entire 7
- 6a. Trigones nodulose and bulging **Notoscyphaceae**
- 6b. Trigones minute or absent 8
- 7a. Marginal cells usually differentiated, thin walled, entire **Solenostomataceae**
- 7b. Marginal cells undifferentiated, entire or spinose 9
- 8a. Plants very small, brownish or reddish; leaves distant and deeply bifid; cells usually thick walled **Cephaloziellaceae**
- 8b. Plants medium size; whitish or yellowish; leaves bidentate or bifid; cells usually thin walled **Lophocoleaceae**
- 7a. Lobes usually unequal and obliquely inserted; dorsal lobes larger than ventral lobe ... **Scapaniaceae**
- 7b. Lobes opposite, equal, dorsally connate, undivided **Southbyaceae**

Southbyaceae Váňa, Crand.-Stotl., Stotler & D.G. Long,

Nova Hedwig. 95(1–2): 184. 2012.

Plants prostrate, small to medium sized; rhizoids hyaline to brownish, clustered; leaves succubous, opposite, dorsally connate, undivided, with the margins entire; filamentous to lanceolate; laminal cells thin walled, trigones minute or absent, cells smooth to papillose or striose; underleaves absent or minute and lanceolate; rhizoids scattered; branches lateral, *Plagiochila* or *Frullania*-type; androecia and gynoecia on the main axes; sporophytes enclosed by a short calyptra and hollow marsupium, perianth at the top of the marsupium, bilabiate, hidden by the inner bracts, or absent;

capsule ellipsoidal to long cylindric, with the wall 2-stratose; gemmae formed from the abaxial surface of the leaves, 1- to 2-celled.

***Gongylanthus* Nees,**

Naturgesch. Eur. Leberm. 2: 405. 1836.

Plants small to medium, whitish green; rhizoids hyaline and forming clusters; leaves succubous, opposite, barely connate on the dorsal and ventral margins; leaf semicircular, the upper margin of leaf rolled inwards, then looks like a concave leaf; underleaves absent; cells rounded-hexagonal to rectangular, marginal leaf cells slightly smaller than mid-leaf cells; cell walls thin without or with small trigones; oil bodies numerous, homogenous and colourless; dioicous, male reproductive structures produce on the short stalks, female structure similar to the leaves, archegonia born at the apex, after archegonia mature a marsupium is commonly produced.

Gongylanthus himalayensis Grolle, Khumbu Himal 1(4): 285. f. 7. 1966. *G. indicus* S.C. Srivast. & P.K. Verma, Indian J. Forest. 28: 201. 2005; Daniels, Arch. Bryol. 18. 2010.

Plants silver-white or white-green, up to 7 mm long, prostrate and slightly arcuate sideways; gregarious, growing on land cuttings; leaves imbricate and opposite, semicircular, the upper margin rolled inwards to form a concave appearance; underleaves absent, rhizoids pale brown in fascicles from the ventral leaf bases; laminal cells rounded-hexagonal to rectangular, marginal leaf cells slightly smaller than mid-leaf cells, marginal cells 20-30 µm long and 20-25 µm wide, cells at middle, spherical, 30-55 µm in diameter, cell walls thin with small trigones; oil bodies numerous, 0-14 per cell, small, approximately the same size as the chloroplasts, homogeneous and colourless; gemmae rounded usually with a notch; sporophytes not seen (Plate 5.36).

Habitat: Terricolous, on land cuttings in shola forest.

Discussion: S.C. Srivastava & Verma (2005) reported *Gongylanthus indicus* from Nilgiri Hills in Tamil Nadu. Daniels (2010) also listed this species based on the original description from Tamil Nadu. But, Váňa, *et al.* (2012) synonymised this

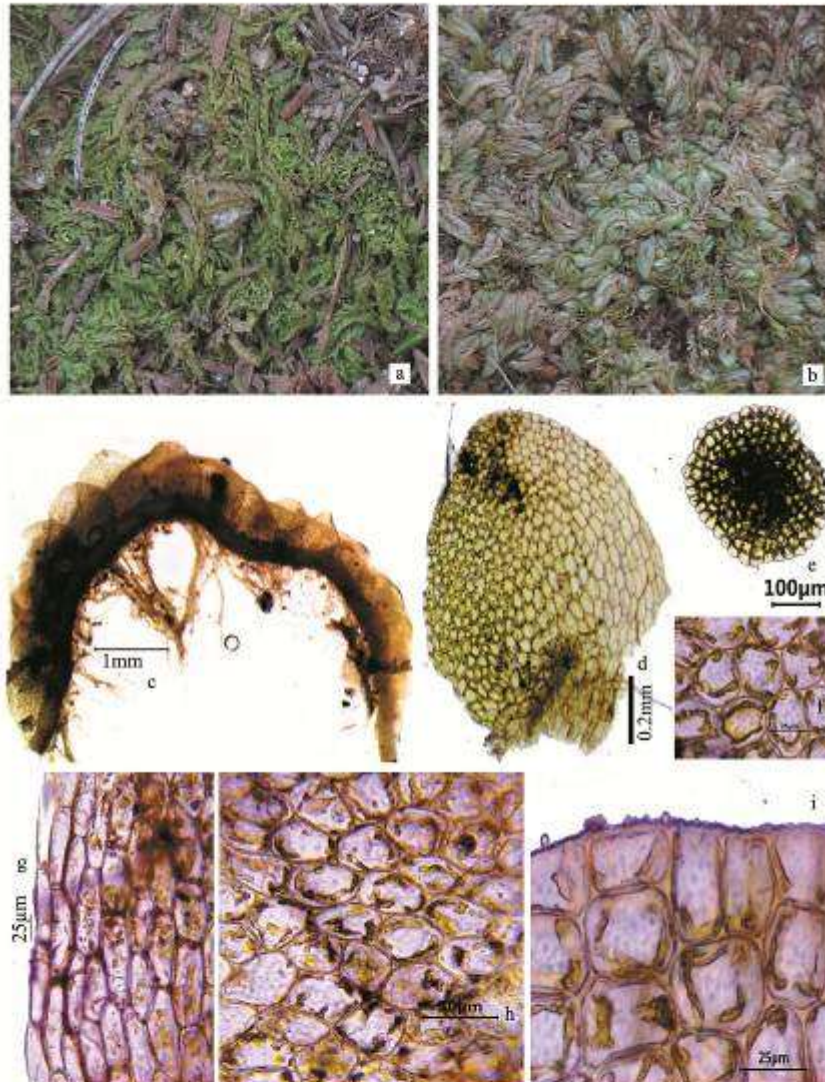


Plate 5.36: *Gongylanthus himalayensis* Grolle., a&b. habit, c. single plant, d. leaf, e. gemmae, f. trigones, g. basal marginal cells, h. middle cells, i. apical cells

species under *G. himalayensis*, the species reported by Grolle from Western Himalayas. Long (1979) reported this species from Eastern Himalayas also. The present collection is an extended distribution and new record to Kerala.

Distribution: World: Bhutan, China, Nepal (Long, 1979), Vietnam (Grolle, 1987); **India:** Assam (Bapna & Kachroo, 2000), Kerala (Present collection), Tamil Nadu (Daniels, 2010; Srivastava & Verma, 2005).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (1830-1850 m) 22.09.2018 *Mufeed* 9920, 9933 (ZGC).

***Calypogeiaceae* Arnell,**
Skand. Fl. 2(a): 189. 1928.

Plants pale green to whitish green to bluish green, prostrate, sparsely branched, branching usually postical; stem undifferentiated, cortical cells smaller than the medullary cells; rhizoids absent or abundant; leaves incubous, horizontally oriented, moderately imbricate, obliquely inserted, ovate to ovate elliptical, ovate triangular, slightly convex, rounded and entire at apex or minutely bidentate; underleaves medium to large, bilobed to suborbicular or ovate and entire; cells usually thin walled with trigones, pellucid or smooth; oil bodies many, botryoidal or coarsely segmented; asexual reproduction by means of 1-2 celled gemmae; autoicous or rarely dioicous.

***Calypogeia* Raddi,**
Ungermannogr. Etrusca 31. 1818.

Plants usually pale green to whitish green or bluish green; rhizoids abundant, arises under the base of underleaf; stem not differentiated; leaves incubous, ovate to ovate elliptical to ovate triangulate, slightly convex, apex rounded or entire or minutely bidentate; underleaves varying from bifid to retuse to unlobed; cells thin walled with trigones, smooth or finely verrucose; oil bodies finely botryoidal to coarsely segmented, 2-13 per cell; asexually reproduce by gemmae, 1-2 celled; monoicous or rarely dioicous; male branches small with 1-2(-3) antheridium in each branches; gynoecia sessile, developing a cylindrical, pale, pendulous, subterranean rhizoidous marsupium.

Calypogeia azurea Stotler & Crotz, Taxon 32: 74. 1983; Sharma, D. and S.C. Srivastava, Bryophyto. Bibliotheca. 47: 1-353. 1993. *C. trichomanis* (L.) Corda, Naturalientausch 12: 653. 1829, *auct. plur. non*; Mitt., J. Proc. Linn. Soc., Bot 5: 106. 1861; Chopra, J. Indian Bot. Soc. 22: 245. 1943. *C. gollanii* Steph. Ex Bonner, Index Hepat. 3: 491. 1963.

Plants greyish green, yellowish green when dried, 8-12 mm long and 1.3-2 mm wide, simple to minute ventral intercalary branches; leaves imbricate, ovate to cordate with wide at near the base, subacute to obtuse, exceptionally a few leaves emarginate at the apex, 0.60 mm long and 0.45 mm wide; underleaves bilobed, with (2)3–6 tiers of cells from the base of sinus to the rhizoid-initial zone, 0.06 mm long and 0.12 mm wide, lobes acute or subacute; lateral margins entire or with solitary angulations; cells of underleaves sub-isodiametric or partly elongated; leaf cells almost not differentiated near the margins and at the base, thin walled, without distinct trigones; apical cells sub-isodiametric, 20-30 µm long and 15-30 µm wide, marginal cells 15-25 µm long and 30-45 µm wide, median cells sub-isodiametric, 30-50 µm long and 20-30 µm wide; oil bodies blue or deep blue, 2-5 per cells, large segments, 2-5 µm each; reproductive structures not observed (Plate 5.37).

Habitat: Epiphytic, on barks and logs of large trees, along with *Leucobryum juniperoideum* (Brid.) Müll. Hal. and *Chiloscyphus muricatus* (Lehm.) J.J. Engel & R.M. Schust. in shola forest.

Discussion: Stotler and Crotz (1983) have synonymised *Calypogeia trichomanis sensu* K. Muller in to *C. azurea* Stotler et Crotz which has limited occurrence in Europe and North America. When oil bodies absent it may be confused with several species such as *C. muelleriana*, *C. suecica*, *C. fissa* or juvenile thallus of *C. neesiana* and *C. integristipula* with bilobed underleaves. It is characterized by the very delicate small plants with distinctive deep blue oil bodies usually 2–5 oil bodies per cell.

Distribution: World: Japan (Furuki & Mizutani, 1994), Europe (Potemkin *et al.*, 2017), Korea (Papp, 2008), Russia (Konstantinova *et al.*, 1992), Taiwan (Wang *et al.*, 2011), Turkey (Gökler, 1998; Gökler *et al.*, 2000); **India:** Kerala (present

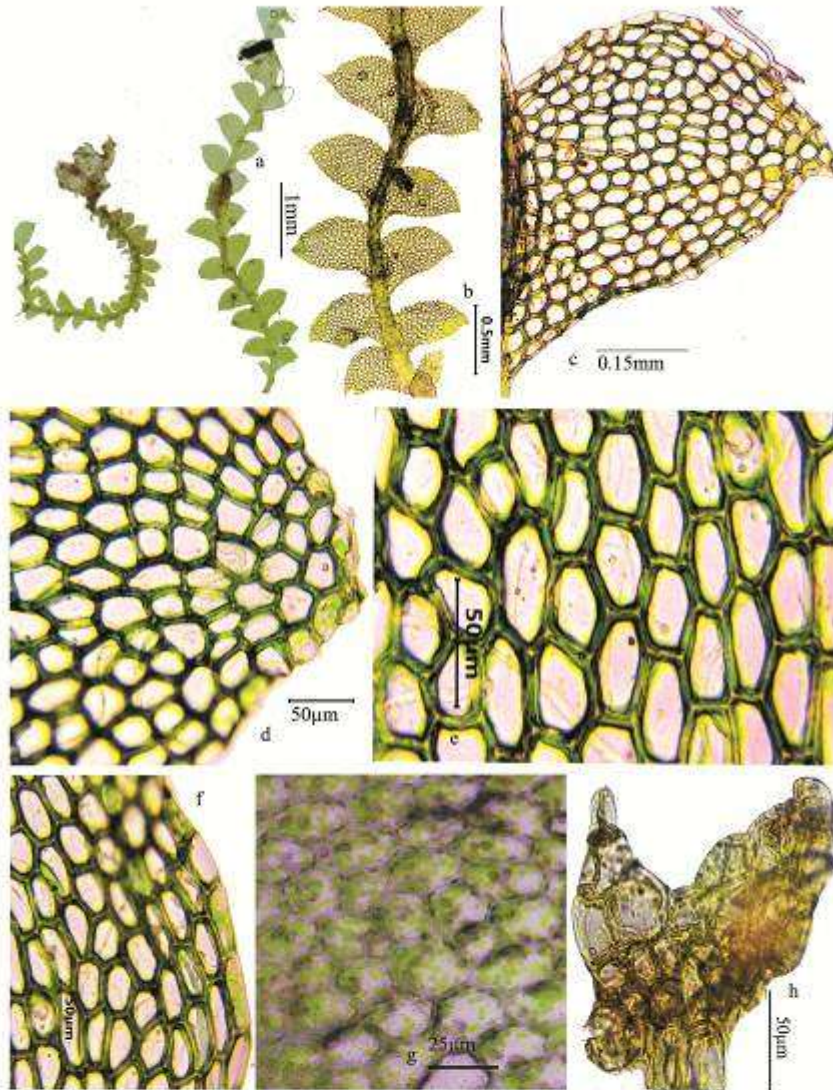


Plate 5. 37: *Calypogeia azurea* Stotler & Crotz., a. habit, b. leaf arrangement on stem, c. leaf, d. leaf apex, e. leaf cells, f. leaf margin, g. oil bodies, h. under leaf

collection), Madhya Pradesh, Sikkim, Tamil Nadu (D.K. Singh *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 14.07.2017 *Mufeed 7512c* (ZGC).

Cephaloziellaceae Douin,

Mém. Soc. Bot. France 29: 5. 1920.

Plants small, usually not visible in the field with naked eye, brownish to reddish or dull green; leaves succubous, small and distant, widely patent, deeply bifid, margin entire or dentate; lobes typically narrow and 9 cells wide at base; laminal cells usually small and thick walled; cuticle smooth or papillose; oil bodies spherical to ovoid, nearly homogeneous; underleaves very small or reduced to slime papillae or absent; rhizoids colourless, scattered; asexually reproduce by 2-celled gemmae; plants autoicous or dioicous.

Cylindrocolea R.M. Schust.,

Bull. Natl. Sci. Mus. 12(3): 666. 1969.

Plants green to reddish brown or deep brown to blackish, delicate and creeping; branching exclusively intercalary; leaves small, distant, transversely oriented, dorsally inserted midline of the stem, uniformly bilobed; lobes divaricate, triangular, lanceolate, narrow, entire or dentate at margin; cells small, non collenchymatous, thin walled to equally thickened; cuticle smooth to coarsely verrucose; oil bodies small, spherical to ovoid, 3-9 per cell; underleaves small or absent; asexual reproduction by means of 2 celled ovoid to subspherical gemmae; dioicous or monoicous.

Cylindrocolea kiaeri (Austin) Váňa, Phytotaxa 112(1): 2. 2013. *Jungermannia kiaeri* Austin, Bull. Torrey Bot. Club 6: 18. 1875. *Cephalozia kiaeri* (Austin) Pearson, Skr. Vidensk.-Selsk. Christiania, Math.-Naturvidensk. Kl. 1887(9): 8, 1887. *C. minutissima* Kiaer & Pearson, Forh. Vidensk.-Selsk. Kristiania 1892(14): 7. 1893. *C. lilae* C.M.Cooke, Trans. Connecticut Acad. Arts 12: 36, 1904. *C. willisana* Steph., Sp. Hepat. 3: 306. 1908. *Cephaloziella kiaeri* (Austin) Douin, Mém. Soc. Bot. France 29: 69. 1920; Udar & A. Kumar Geophytology 15(2): 141. 1985; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 55. 2005; Daniels & Kariyappa, Bryofl.

Agasthyamalai Bio. Res.: 379. 2019. *C. minutifolia* Horik., J. Sci. Hiroshima Univ., Ser. B., Div. 2, Bot. 2: 175, 1934.

Plants pale greenish to brownish or reddish, very small, delicate, up to 15 mm long, branching simple; rhizoids few at base of the stem; leaves distant, contiguous, small, deeply bilobed, lobes subequal, $135-150 \times 105-110 \mu\text{m}$ including lobes; laminal cells rectangular, thin walled, cells at apex acute, ends with single cells, $8-13 \times 5-10 \mu\text{m}$, cells at base, $12 \times 7 \mu\text{m}$; underleaves absent; sporophytes not seen (Plate 5.38).

Habitat: On land cuttings in tea plantation, evergreen and shola forests found in all altitudinal ranges and in some areas it is mixed with *Lophocolea bidentata* (L.) Dumort.

Discussion: From India this species was earlier reported in different names. From North east A.P. Singh & Nath (2007) reported this species as *Cephaloziella willisana* Steph. Udar & Kumar (1985) listed this species from Wayanad, Palakkad, Thiruvananthapuram and Idukki district of Kerala as *Cephaloziella kiaeri*. Nair *et al.* (2005), also reported this species as *Cephaloziella kiaeri* from Wayanad district. Váňa *et al.* (2013) proposed a new combination *Cylindrocolea kiaeri* for *Jungermannia kiaeri* Austin there by making *Cephaloziella kiaeri* (Austin) Dourin. a synonym for the former. *Cephaloziella willisana* (Steph.) N. Kitag. also synonymised under *Cylindrocolea kiaeri* by Váňa *et al.* (2013). D.K. Singh *et al.* (2016) followed this. But some recent reports such as in Daniels & Kariyappa (2019) they have followed *Cephaloziella kiaeri*. This species is a common low and high altitude area of Kerala. It is characterized by small delicate linear plants with deeply bilobed leaves.

Distribution: World: Africa (Grolle, 1995), China (Pippo, 1990) Japan (Furuki & Mizutani, 1994), Sri Lanka (O'Shea, 2002); **India:** Karnataka (Schwarz & Frahm, 2013), Kerala (Udar & Kumar, 1985; Nair *et al.*, 2005; Manju *et al.*, 2009a as *Cephaloziella kierii*), Meghalaya (A.P. Singh & Nath, 2007 as *Cephaloziella willisana*), Tamil Nadu (Udar & Kumar, 1985, Daniels & Daniel, 2013; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019 as *Cephaloziella kierii*).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park,



Plate 5. 38: *Cylindrocolea kiaeri* (Austin) Vana, a,b&c. habit, d. leaf arrangement, e&f, leaf arrangement, g. leaf cells, h. leaf.

Mannavan Shola (1650-2410 m) 24.03.2016 *Mufeed* 10002c; 14.07.2017 *Mufeed* 7545, 7572 (ZGC).

Other specimen/s examined: India, Kerala, Thrissur, Peechi-vazhani Wildlife Sanctuary, Peechi dam area (82 m) *Chandini & Mufeed* 10486 (ZGC); Tamil Nadu, Ootakkamund (2100 m) 10.10.2000 S.C. *Srivastava* 12655 (LWU!).

Herbertaceae Müll. Frib. ex Fulford & Hatcher,

Bryologist 61: 284. 1958.

Plants usually epiphytic, ascending or pendulous, simple, sparsely branched, brownish green or reddish green when moist; stem small to large, usually rigid and brittle, branching intercalary; leaves distant, incubously inserted, bifid, strongly falcate, concave at base and with canaliculate lobes, lobes generally curved, acute to acuminate, narrowly triangular lanceolate; underleaves similar to leaves or little smaller, bifid; leaf cells collenchymatous with trigones, thick walled, cells dimorphic, median basal group of cells extremely elongated than other cells; oil bodies usually absent; dioicous, perianth lobed.

Herbertus Gray,

Nat. Arr. Brit. Pl. 1: 705–706. 1821.

Plants small to medium, green, brown or yellowish brown, dark when dry; leaves distant, incubously inserted, bifid, strongly falcate, concave at base with canaliculate lobes, lobes acute to acuminate, narrowly triangular lanceolate, straight and almost symmetrical; underleaves similar to leaves or smaller, bifid; leaf cells collenchymatous with trigones, thick walled, cells dimorphic, median basal group of cells extremely elongated than other cells; dioicous, perianth lobed.

Herbertus aduncus (Dicks.) Gray, subsp. *aduncus*, Nat. Arr. Brit. Pl. 1: 705. 1821 (*Herbertia adunca*); Manju *et al.*, Trop. Bryol. Res. Rep. 7: 4. 2008; D.K. Singh *et al.*, Liverw. Hornw. India: 100. 2016; Rawat *et al.*, *Frahmia* 14: 1-17. 2017. *Jungermannia adunca* Dicks., Pl. Crypt. Brit. fasc. 3: 12. 1793. *Schisma aduncum* (Dicks.) Dumort., Syll. Jungerm. Europe: 77. 1831. *Herbertus stramineus* (Dumort.) Trevis., Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat. 4(13): 397. 1877. *H. dicranus* (Taylor ex Gottsche, Lindenb. & Nees) Trevis., Mem. Reale Ist. Lombardo

Sci., Ser. 3, Cl. Sci. Mat. 4: 397. 1877. *H. delavayi* (Steph.) Steph., Hedwigia 34(1): 43. 1895. *H. longifissus* Steph., Hedwigia 34: 44. 1895. *Schisma pusillum* Steph., Spec. Hep. 6: 361. 1922. *Schisma fragile* Steph., Spec. Hep. 6: 359. 1922. *Schisma gracile* Steph., Spec. Hep. 6: 359. 1922 (non *Schisma gracile* Mont., Ann. Sci. Nat. 19: 254. 1843.). *Herbertus* ('*Herberta*') *minor* Horik., J. Sci. Hiroshima Univ., ser. B., div. 2, 2: 211. 1934. *H. remotiusculifolius* ('*Herberta remotiusculifolia*') Horik., J. Sci. Hiroshima Univ. ser. b, div. 2, 2: 209. 1934. *H. pusillus* ('*Herberta pusilla*') (Steph.) S. Hatt., Bull. Tokyo Sci. Mus. 11: 8. 1944. *H. sakuraii* f. *pusillus* ('*Herberta sakuraii* f. *pusilla*') (Steph.) S. Hatt., J. Hattori Bot. Lab. 2: 6. 1947. *Herbertus sakuraii* f. *remotiusculifolius* ('*Herberta sakuraii* f. *remotiusculifolia*') (Horik.) S. Hatt., J. Hattori Bot. Lab. 2: 6. 1947. *H. sakuraii* subsp. *sakuraii* auct. non (Warnst.) S. Hatt.: Schuster in Rev. Bryol. Lichénol. 26: 132. 1957. *Sendtnera adunca* (Dicks.) Gottsche & Rabenh. in Rabenhorst, Hep. Eur. (Exsicc.) n. 210. 1962. *Herbertus aduncus* subsp. *schusteri* (H.A. Mill. & E.B. Scott) H.A. Mill., Nova Hedwigia 4: 366. 1962. *H.* ('*Herberta*') *fragilis* (Steph.) H.A. Mill., J. Hattori Bot. Lab. 28: 311. 1965. *H. kurzii* (Steph.) H.A. Mill., J. Hattori Bot. Lab. 28: 320. 1965. *H. borealis* Crundw., Trans. Brit. Bryol. Soc. 6(1): 41. 1970. *H. buchii* Juslén, Ann. Bot. Fenn. 43: 416. 2006. *H. norenius* D.G. Long, D. Bell & H.H. Blom, Molec. Ecol. Resources 12(1): 44. 2012.

Plants robust, size very variable from small to medium sized, green, brown or yellowish brown, dark and brittle when dry, up to 8 cm long, intercalary branching pattern; leaves imbricate, erect, distant, incubously inserted, bifid, strongly falcate, concave at base with canaliculate lobes, lobes generally curved, acute to acuminate, narrowly triangular lanceolate, straight and almost symmetrical, leaf 1-2 mm long and 0.3–0.7 mm wide near base; 8-24 cells wide at lobe base, gradually decrease the number of cells towards apex, lobe apex acute, with 2-4 uniseriate cells, leaf margin usually plane, slime papillae few and sessile if present; vitta not very strong, extending to 2/5–4/5 of lobe, vitta cells 10-18, basal cells 30-40 µm long and 15-20 µm wide, median cells 20-30 µm long and 15 µm wide, cells at apex 20-30 µm long and 20 µm wide, usually with triangular trigones; underleaves similar to leaves, smaller and symmetrical, plants collected were sterile (Plate 5.39).



Plate 5. 39: *Herbertus aduncus* (Dicks.) Gray subsp. *aduncus*, a. habit, b. leaf c. leaf apex, d. leaf tip cells, e. leaf base, f. leaf cells, g. leaf margin, h. leaf basal cells i. c.s. of stem

Habitat: Epiphytic, upper part of bark of the Pines.

Discussion: The *Herbertus aduncus* (Dicks.) Gray, subsp. *aduncus* is very rare in the study area, but it is a high altitude shola species previously reported from Kerala by Manju *et al.* (2008). It is characterized by the large plants with intercalary branching patterns, brittle when dry, usually bifid leaves, symmetrical with a strong falcate nature, leaf lobes long and narrow, uniseriate at apex and the underleaves similar to the leaves with slight size difference.

Distribution: World: Canada, China, Japan, South Korea, Bhutan, Nepal, United States (Juslén, 2006), Hong Kong (So & Zhu, 1996); **India:** Arunachal Pradesh (Rawat *et al.*, 2017), Kerala (Nair & Madhusoodanan, 2006; Manju *et al.*, 2008), Manipur (Singh *et al.*, 2010), Meghalaya (A.P. Singh & Nath, 2007), Sikkim (Juslén, 2006).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100-2210 m) 25.09.2018, *Mufeed 9977, 9980b* (ZGC).

Solenostomataceae Stotler & Crand.-Stotl.

Edinburgh J. Bot. 66(1): 190. 2009.

Plants medium pale green to purplish; leaves succubous, undivided or shallowly bilobed, with the margins entire; underleaves usually absent; rhizoids scattered; branches lateral, of the Frullania- or Plagiochila-type; androecia and gynoecia on leading axes; sporophytes enclosed by a shoot calyptra and stem perigynium–perianth complex, sometimes with incipient marsupium development; perianths often reduced, terete below, pluriplicate above, with the mouth gradually contracted, rarely beaked; capsules subspheroidal to ovoid or shortly ellipsoidal, with the wall 2(to 4)-stratose, with the innermost wall cells rectangular, with semiannular thickenings; gemmae absent

Solenostoma Mitt.,

J. Linn. Soc., Bot. 8: 51. 1864.

Plants medium sized, usually 0.75-2.90 mm wide, pale green or purplish or vinaceous tinged on ventral side; rhizoids usually tinged; purplish pigmentation usually at the leaf base; stem terete, slightly elliptical, usually with 1- 2(3-4) layers

of cortical cells differentiated with medullary cells, often with intercalary flagella; rhizoids generally inserted near the postical base; leaves rotundate to ovate, varying due to as wide as long shape, broad at base; laminal cells thin walled with minute to often somewhat bulging trigones, isodiametric; cuticle verruculose to striolate; oil bodies granular, papillate; perianth ovoid narrowed in aconical fashion distally and contracted to a slender mouth, not beaked, unistratose; perigynium distinct, shortly tubular, developed from the height of perianth above it, with 2-3 pairs of bracts; elaters bispiral.

Solenostoma hyalinum (Lyell) Mitt., Nat. Hist. Azores 319. 1870; Singh & Nath, Hep. Khas. Jain. Hill. E. Himalay. 1:101. 2007 as *Jungermannia hyalina*. *Jungermannia hyalina* Lyell Brit. Jungermann. 63. 1816[1814]. *J. schmideliana* Huebener, Hepaticol. Germ 99. 1834. *Jungermannia biformis* Austin, Proc. Acad. Nat. Sci. Philadelphia 21: 220. 1869[1870]. *Aplozia hyalina* (Lyell) Dumort. Bull. Soc. Roy. Bot. Belgique 13: 58. 1874. *Eucalyx hyalina* (Lyell) F. Lees, London Cat. Brit. Moss. Hepat. (ed. 2): 25. 1881. *Mesophylla hyalina* (Lyell) Corb., Rev. Bryol. 31: 13. 1904. *Nardia biformis* (Austin) Lindb., Acta Soc. Sci. Fenn. 10: 530. 1875. *N. hyalina* (Lyell) Carrington, Brit. Hepat. 35. 1874. *N. muelleriana* Schiffn., Oesterr. Bot. Z. 54: 128. 1904. *Plectocolea hyalina* (Lyell) Mitt., Trans. Linn. Soc. London, Bot. 3(3): 198. 1891. *Solenostoma hyalinum* var. *heteromorphum* (Gottsche & Rabenh.) R.M. Schust., Hepat. Anthocerotae N. Amer. 2: 1003. 1969. *S. ontariense* R.M. Schust., Hepat. Anthocerotae N. Amer. 2: 1004. 1969. *Southbya biformis* (Austin) Austin, Hepat. Bor.-Amer. Exsicc. 9: 26. 1873. *S. hyalina* (Lyell) Husn., Hepaticol. Gall. 16. 1875.

Plants up to 3 mm long 0.8 mm wide including leaves, pale green, prostrate, simple; rhizoids purple, long, through stem; leaves imbricate, obliquely inserted, decurrent dorsally, widely spreading, orbicular to subobovate, 0.52 mm long and 0.58 mm wide; marginal cells thin walled, 24- 30 µm long and 15-30 µm wide; slightly trigonous; median cells thin walled, 25-40 µm in diameter, trigones nodulose; basal cells thin walled, 35-50 µm in diameter, nodulose trigonous; cuticle smooth, minutely verrucose (Plate 5.40).

Habitat: Terricolous, on land cuttings above 2200 m in shola forest.

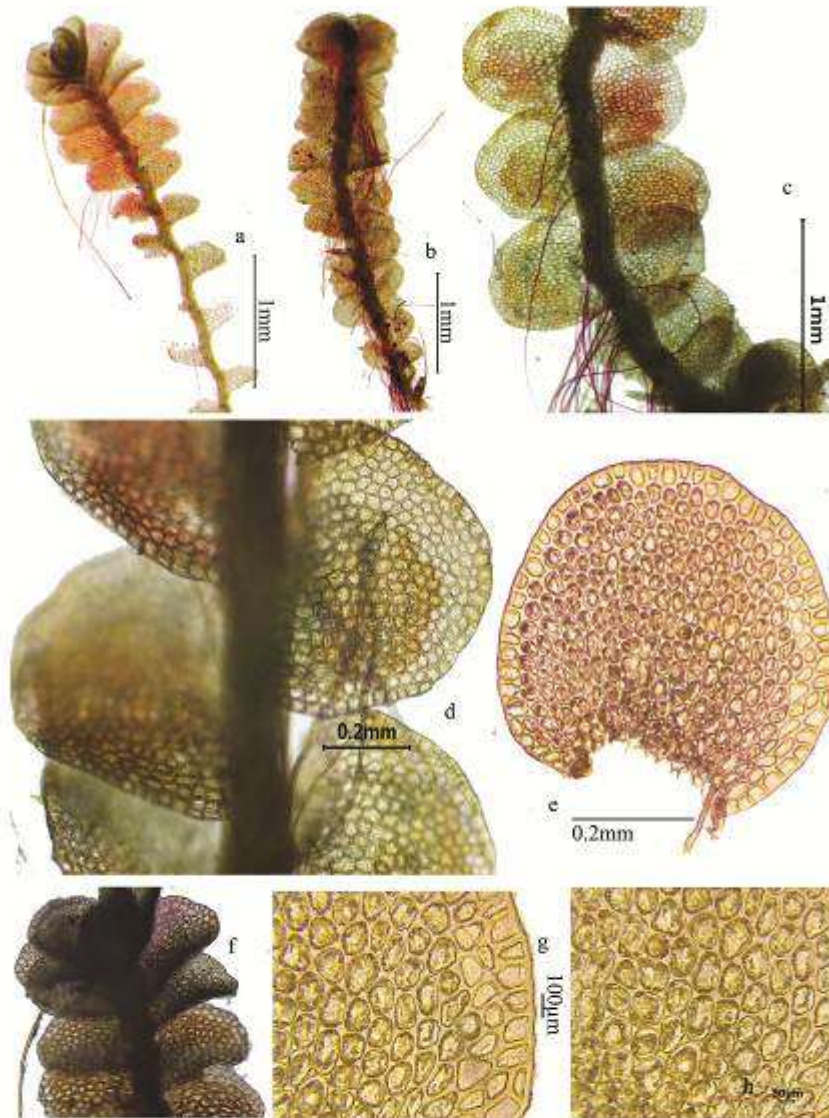


Plate 5. 40: *Solenostoma hyalinum* (Lycell) Mitt., a&b. habit, c. rhizoids with thallus, d. leaf arrangement, e. leaf, f. thallus apex, g. marginal cells, h. cells middle

Discussion: *Solenostoma* which was considered as subgenus of *Jungermannia* is resolved in a different lineage and consider as a new family Solenostomataceae by (Stotler *et al.*, 2009) and raised the subgenus status of *Solenostoma* to genus status. Hattori (1971) described *Jungermannia hyaline* Lyell from Nepal. A.P. Singh and Nath (2007) reported *J. hyalina* from Jaintia hills of Meghalaya. Here as per Stotler & Crand–Stotl. (2009) we have considered *Solenostoma* as a genus.

Distribution: **India:** Kerala (present collection), Meghalaya (A.P. Singh & Nath, 2007).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2400 m) 03.03.2016 *Mufeed 10002b* (ZGC).

Lepidoziaceae Limpr.

Krypt.-Fl. Schlesien 1(2): 310. 1877.

Plants prostrate, erect or procumbent forming patches, yellowish green or olive green, pseudodichotomously branched; rhizoids on leaf bases; all leaves in same size, usually incubously arranged, lobed or dentate; underleaves large, lobed or dentate; cells slightly thick walled with trigones; cuticle smooth or weakly papillose; oil bodies homogenous; asexual reproduction is absent; monoicous or dioicous.

Bazzania S.F. Gray,

Nat. Arr. Brit. Pl. 1: 704. 1821.

Plants medium to robust, olive green to yellow, branching of two types, lateral and pseudodichotomous from ventral half; stem cylindrical, cortical and medullary cells thick walled; rhizoids on leafy branches from underleaf bases; leaves incubous, alternate subopposite, distant, imbricate, ovate-rectangular or ovate-lanceolate, antical base cordate, apex usually 2-3 dentate; margin entire or crenulated, rarely serrate or spinose dentate near base; leaf cells quadrate hexagonal, larger at base, trigonous, cuticle smooth verruculose; oil bodies 2-6 per cell, homogenous; underleaves large, transversely inserted, distant, imbricate, quadrate-orbicular, sometimes cordate at base, entire or 2-4 toothed or lobed; asexually reproduce by caduceus leaves.

Bazzania tridens (Reinw., Blume *et* Nees) Trev., Mem. R. Instit. Lombardo Ser. 3,

4: 415. 1877. D.Sharma. & S.C. Srivast., Bryophyt. Biblioth. 47: 121. 1993; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 16. 1994; Bapna & Kachroo, Hepatic. India 1: 286. 2000; Pócs *et al.*, Act. Bot. Hun. 49(1-2): 121-129. 2007; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 33. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7:3. 2008 & Taiwania 54: 62. 2009; Daniels, Arch. Bryol. 65: 10. 2010; Barbhuiya & S.K. Singh, Arch. Bryol. 134: 2. 2012; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 237. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 176. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 415. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 554. 2019. *Jungermannia tridens* Reinw., Blume & Nees, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 228. 1825. *Mastigobryum tridens* (Reinw., Blume & Nees) Nees, Syn. Hepat. (fasc. 2): 227. 1845. *Bazzania albicans* Steph., Hedwigia 32: 204. 1893. *B. sinensis* Gottsche ex Steph., Hedwigia 25: 208. 1886. *Mastigobryum formosae* Steph., Bull. Herb. Boissier, sér. 2, 8(11): 842. 1908.

Plants small to medium, pale green, olive or brownish in colour with cutinised nature, up to 17 mm long, 3 mm wide including leaves; leaves imbricate, widely spreading, ovate or oblong, 1.10 mm long and 0.50 mm at base, apex 3 toothed, 0.30 mm wide, teeth triangular, small, 1 or 2 cells long, sinus lunate; laminal cells thick walled, slightly trigonous, 11-30 µm long and 20-25 µm wide; marginal cells non trigonous, 12-24 µm long and 10-15 µm wide; underleaves distant contiguous, hyaline, appressed, subquadrate, thin walled, 0.45-0.56 mm long and 0.40-0.47 mm wide, margin entire, transversely inserted; reproductive structures not seen (Plate 5.41).

Habitat: Usually seen at the base or the buttresses of the tree trunks on wet terrestrial habitats, associated with *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk. and *Wijkia surcularis* (Mitt.) H.A. Crum. in shola forests.

Discussion: *Bazzania tridens* is a common high altitude species in Kerala, usually seen at an altitude above 1600m. Manju *et al.* (2007) recorded *B. tridens* from Munnar region of Idukki district as a new record for Kerala. This species is characterized by the plants usually shiny in exposed areas and slightly dull when



Plate 5. 41: *Bazzania tridens* (Reinw., Blume & Nees) Trevis. a. habit, b. leaf, c. leaf tip cells, d. leaf middle cells, e. leaf margin, f. leaf basal cells, g. under leaf, h. c.s. of stem

growing in shady areas, leaves widely spreading with three toothed at apex and underleaves usually subquadrate.

Distribution: World: Bhutan (Long & Grolle, 1990), China (Pippo, 1990), Indonesia (Meijer, 1960), Korea (Yamada & Choe, 1997), Nepal (Pradhan, 2013), Thailand (Lai *et al.*, 2008), Sri Lanka (Long & Rubasinghe, 2014), Japan (Mizutani, 2000); **India:** Assam (Barbhuiya & S.K. Singh, 2012), Kerala (Manju & Rajesh, 2017; Nair *et al.*, 2005; Daniels & Kariyappa, 2019), Manipur (D. Singh *et al.*, 2010a), Meghalaya, West Bengal (A.P. Singh & Nath, 2007), Sikkim (D.K. Singh *et al.*, 2008), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi shola (2100 m) 12.07.2017 *Mufeed 7316b*; Iddalymotta (2200-2210 m) 25.09.2018 *Mufeed 9977, 9980b* (ZGC).

Lophocoleaceae H. Klinggr.,

Fl. Gén. Belgique, Bryoph. 1(2): 208. 1956.

Plants whitish or yellowish to dull green, small to robust, delicate, prostrate, anisophyllous; stem without hyalodermis, cortical cells usually thin walled and not differentiated or differentiated in some; rhizoids arise from base of the under leaves; leaves succubously inserted, usually bifid or bidentate often becoming unlobed, alternate, subopposite or opposite; cells usually undifferentiated, thin walled, trigones absent or present; oil bodies present, 1-12 per cell, oval, oblong to elliptical; underleaves free or united at the base of the leaves, shortly bilobed or entire, usually with one tooth on both sides of the margin; asexual reproduction by means of gemmae or by regeneration of the other plant parts; dioicous or monoicous; sporophytes composed of foot, seta and capsule, capsule ovoid or spherical, spores light brown, slightly granular; elaters bispiral.

Key to the genera

- 1a. Plants light green to brownish, usually with subopposite leaves 2
- 1b. Plants yellowish green with alternate lobes **Lophocolea**
- 2a. Underleaves distant, free, oblong ovate to triangulate, sinus not deeply inserted

- *Chiloscyphus*
 2b. Underleaves contiguous, reniform cordate to rounded, sinus deeply inserted
 *Heteroscyphus*

***Chiloscyphus* Corda,**

Naturalientausch 12: 651. 1829.

Plants prostrate, light green to light brown, branching laterally; leaves slightly to closely imbricate or even distant, alternate to subopposite, ovate-oblong, subquadrate, rectangular to orbicular, entire at margins, apex entire or rarely dentate with small teeth; cells usually thin walled, sometimes slightly thick walled, trigones usually absent or very small, triradiate; underleaves distant, free, oblong ovate or triangulate, bilobed; lobes parallel with narrow to broad sinus, usually with one tooth on one or both sides; monoicous; androecia usually on main branches; gynoecia terminal on very short lateral branches; perianth without subfloral innovations, obovate to broadly campanulate, tri-plicate.

Chiloscyphus campanulatus Steph., Sp. Hepat. 3: 208. 1907; Kashyap, Liverw. W. Himal. 2: 64. 1932; A. Srivast. & S.C. Srivast., Indian Geocalyc.: 44. 2002; S.K. Singh & D.K. Singh, Cryptog. Bryol. 28: 255. 2007 & Hepat. Anthocerot. Gt. Himal. Natl. Pk.: 89. 2009.

Plants up to 5 cm long, 1.5-1.7 mm wide, prostrate, greenish; leaves closely imbricate, alternate, flat, ovate-oblong, sometimes subquadrate to slightly rectangular, entire, obtuse, 0.6-0.7 mm long and 0.5-0.6 mm wide; truncate-rotundate or retuse at apex; cells thin-walled, with minute, triradiate trigones; marginal cells towards apex 18-24 µm long and 18-20 µm wide, quadrate to rounded-quadrate or subquadrate; median cells 24-30 µm in diameter, rounded; basal cells 20-34 µm long and 14-30 µm wide, polygonal; oil bodies 2-5 per cell, 12-20 µm long and 8-10 µm wide, fusiform to elongate-ovoid, granular-segmented; underleaves free, 0.19 mm long and 0.27 mm wide, oblong, 2-lobed; lobes parallel to slightly diverging, with a narrow sinus and a hyaline papilla at apex, single toothed on either side, teeth 3 or 4-celled, with a hyaline papilla at apex; stem 7-9 celled across, cells homogenous, 20-35 µm, thin-walled, minutely thickened at corners; rhizoids clustered at underleaf base; sporophyte not observed (Plate 5.42).

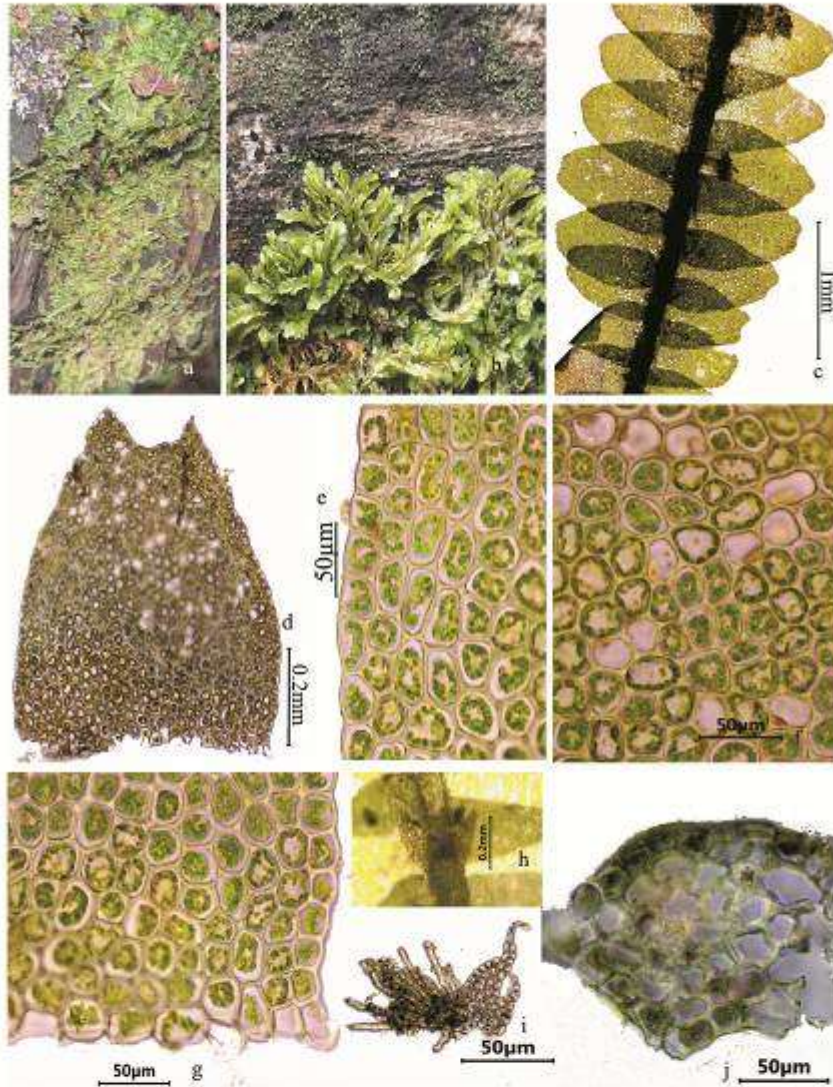


Plate 5, 42: *Chiloscyphus campanulatus* Steph., a&b. habit, c. single plant, d. leaf, e. leaf marginal cells, f. leaf middle cells, g. leaf basal cells, h & i. underleaves with rhizoids, j. c.s. of stem

Habitat: Terrestrial, growing on moist land cuttings or on wet rocks in shady places or on a thin film of soil over rocky patch exposed to sunlight.

Discussion: *Chiloscyphus campanulatus* Steph. is an endemic species to India and earlier reported from Tamil Nadu in South India. The present collection is a new record for Kerala. The plant usually grows above 1500 m altitude. It is characterized by prostrate and delicate thallus with alternate, ovate-oblong, entire leaves, bilobed underleaves free and single toothed on either side.

Distribution: India: Assam (Bhattacharyya *et al.*, 2011), Himachal Pradesh, Uttarakhand (S.K. Singh & D.K. Singh, 2009), Jammu & Kashmir (A. Srivastava & S.C. Srivastava, 2002), Kerala (present collection), Tamil Nadu (Daniels 2010, Sreebha *et al.*, 2015c).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (1880 m) 23.09.2018 Mufeed 9941, 9943 (ZGC).

***Heteroscyphus* Schiffn.,**

Oesterr. Bot. Z. 60: 171. 1910.

Plants light green to brownish green, small to medium sized, prostrate, delicate; leaves loosely or closely imbricate or subopposite, ovate, oblong, orbicular to ovate rectangular, entire at margins, sometimes with acute tooth or without tooth at tip; laminal cells undifferentiated, thin walled, trigones small to large; underleaves free or united at the base of leaves, reniform, cordate, rectangular to rounded, deeply bilobed; rhizoids in bunch at underleaf base; dioicous, androecium usually on short intercalary branches, gynoecium terminal or on intercalary branches, perianth obovate, broadly campanulate, capsule globose to ovoid, spores light brown, spinulose, elaters slender 2-3 spiral, hyaline.

Key to the species

- 1a. Leaves alternate, quadrate-rectangular, pluridentate; underleaves distant, free or united, lanceolate, deeply bilobed, lobes divergent with broad sinus .. ***H. argutus***
- 1b. Leaves opposite, ovate oblong, cordate in appearance, larger than wide; underleaves orbicular to reniform, bifid, sinus v-shaped ***H. perfoliatus***

Heteroscyphus argutus (Reinw., Blume & Nees) Schiffn., Oesterr. Bot. Z. 60: 172. 1910; Kachroo, Bull. Bot. Surv. India 12: 186. 1970; S.C. Srivast. & A. Srivast.,

Lindbergia 15: 201. 1989; Bapna & Kachroo, Hepatic. India 2: 62. 2000; A. Srivast. & S.C. Srivast., Indian Geocalycac.: 122. 2002; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 48. 2005; Daniels, Arch. Bryol. 65: 18. 2010; Manjula *et al.*, Arch. Bryol. 176: 3. 2013; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 177. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 183. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 330. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 428. 2019. *Jungermannia arguta* Reinw., Blume & Nees, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 206. 1825. *Chiloscyphus argutus* (Reinw., Blume & Nees) Nees, Syn. Hepat. 183. 1845; Chopra, Proc. Indian Acad. Sci. Sect. B7: 246. 1938 & J. Indian Bot. Soc. 22: 249. 1943. *Heteroscyphus cubans* (Taylor) Schiffn., Oesterr. Bot. Z. 60: 172. 1910. *Lophocolea arguta* (Reinw., Blume & Nees) Nees & Mont., Voy. Amér. Mérid., Bot. 7(2): 79. 1839.

Plants lithophytic, medium sized, dark green, 20-30 mm long 2-3 mm wide including leaves, irregularly laterally branched; leaves succubous or rarely distant, alternate, quadrate to rectangular, 1.3 mm long and 1 mm at base, margin entire, apex almost equally broad as the base, usually pluridentate with 6-8 tooth; teeth usually 2-3(-4) or 6 cells long and 1 or 2 cells wide; cells usually differentiated, quadrate hexagonal, 2 layers towards apex and margin usually with thick walls, cells without trigones; cells at margin 22-35 µm long and 15-20 µm wide, thick walled, median cells 25-50 µm long and 27-35 µm wide, basal cells 35-50 µm long and 28-45 µm wide; underleaves distant, free or united very narrowly with leaves on one side at their base, small, 0.30 x 0.50 mm, deeply bilobed, lobes divergent with broad sinus, lobes lanceolate, usually with one tooth on both lateral margins, tooth 2-3 cells long 1 or 2 cells wide at base, thin walled; rhizoids in bunch at underleaf bases (Plate 5.43).

Habitat: Terrestrial, usually seen on land cuttings along with *Vesicularia levieri* Cardot and *Fissidens taxifolius* Hedw. in shola forest.

Discussion: *Heteroscyphus argutus* is a widely distributed species from low to high altitude areas. It is characterized by pluridentate leaves, leaves usually longer than wide and the underleaves deeply bilobed with broad sinus.



Plate 5. 43: *Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn., a. habit, b. leaf arrangement on the stem, c. leaf, d. leaf apex, e. cells of leaf spine, f. leaf basal cells, g. leaf marginal cells, h. underleaf, i. c.s. of stem

Distribution: World: China (Pippo, 1990), Japan (Furuki & Mizutani, 1994); **India:** Kerala (Manjula *et al.*, 2013; Nair *et al.*, 2005), Meghalaya (A.P. Sing and Nath, 2007), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2250 m) 04.03.2016 *Mufeed 10068*; Pullaradi Shola (2190 m) 26.09.2018 *Mufeed 9998* (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills (1990 m) 11. 10. 2000 *S.C. Srivastava et al.*, 12848 (LWU!).

Heteroscyphus perfoliatus (Mont.) Schiffn., Oesterr. Bot. Z. 60: 171. 1910; A. Srivast. & S.C. Srivast., Indian Geocalycac.: 89. 2002; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 755. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7:4. 2008; Daniels, Arch. Bryol. 65: 18. 2010; Manjula *et al.*, Arch. Bryol. 176: 5. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 187. 2016. *Lophocolea perfoliata* Mont. Ann. Sci. Nat., Bot., sér. 2, 18: 12. 1842. *Chiloscyphus perfoliatus* (Mont.) Nees, Syn. Hepat. 172. 1845.

Plants small, laterally compressed, light green-yellow or brownish at maturity, delicate, prostrate, closely appressed with substratum, up to 30×3 mm including leaves; leaves succubous, squarrose, closely imbricate, opposite, entire, ovate oblong, occasionally cordate in appearance, base broader, apex narrowed, obtuse, leaves longer than wide, 1.45 mm long and 1 mm wide; marginal cells regular to nodulose, trigones; underleaves large, orbicular to reniform, wider than the stem, closely imbricate, connate with the adjoining lateral leaves at the base, bifid, 0.45-0.90 mm; sinus v-shaped; rhizoids hyaline, long, arising from below the under leaves in bunches; reproductive structure not observed (Plate 5.44).

Habitat: Lithophytic, seen on small and large rocks where water drips regularly in shola forest.

Discussion: Mitten (1861) first reported *Heteroscyphus perfoliatus* (Mont.) Schiffn. from Nilgiri mountains in South India as *Chiloscyphus perfoliatus* (Mont.) Nees. Later several taxonomists (Schiffner, 1910; Bonner, 1966; Chopra, 1943, S.K. Singh & D.K. Singh, 2002) were also reported this species from different parts of India.

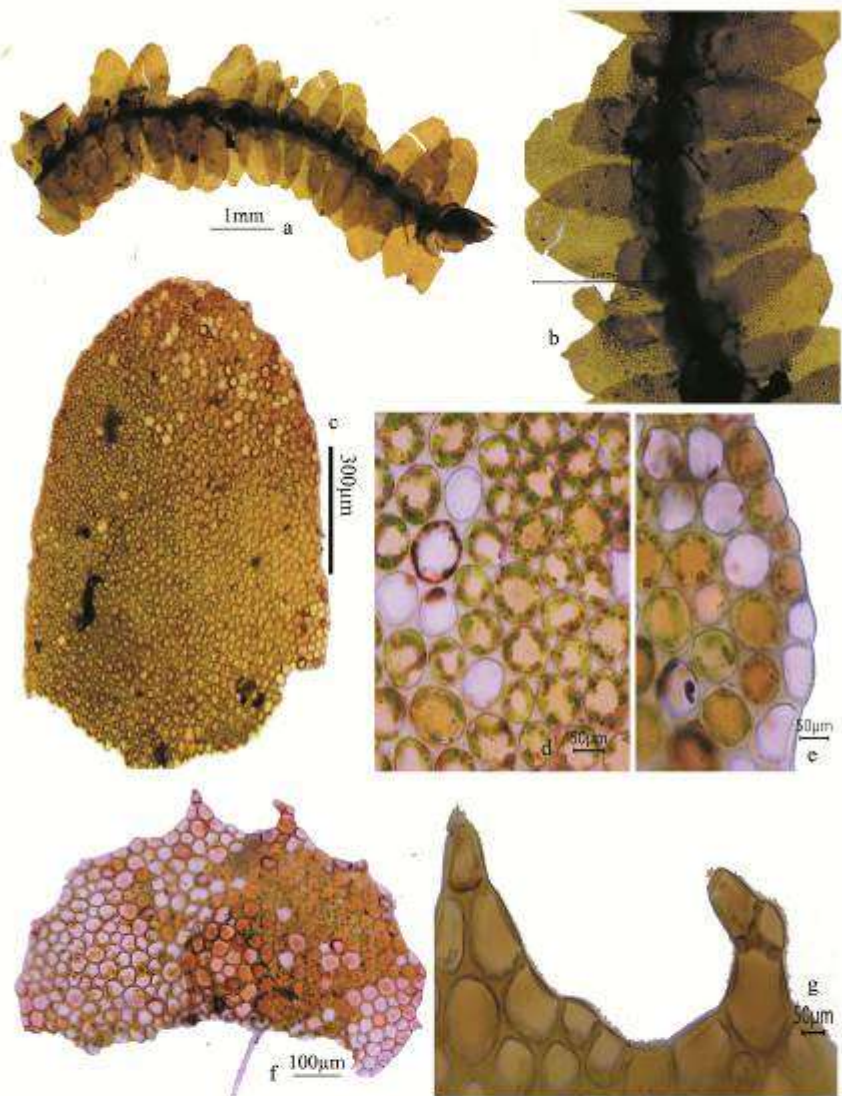


Plate 5. 44: *Heteroscyphus perfoliatus* (Mont.) Schiffn., a. habit, b. ventral surface of thallus-enlarged view, c. leaf, d. leaf cells, e. leaf marginal cells, f. under leaf, g. under leaf apical cells

This species is characterized by delicate plants with broad leaves, underleaves large, bifid and sinus v-shaped.

Distribution: World: Nepal, Sri Lanka (Long & Rubasinghe, 2014); **India:** Kerala (Manjula *et al.*, 2013), Meghalaya (S.K. Singh & D.K. Singh, 2002), Tamil Nadu (Montagne, 1842; Mitten, 1861 as *Chiloscyphus perfoliatus*), West Bengal (Chopra, 1943).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (1900 m) 12.07.2017 *Mufeed 7319b* (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Vaguvarai, Eravikulam National Park (1850 m) 19.09.2001, *Manju CN, 80194* (CALI!).

Lophocolea (Dumort.) Dumort.,
Recueil Observ. Jungerm. 17. 1835.

Plants yellowish green to light green, sparingly branched, prostrate, delicate, branches lateral or intercalary; stem usually undifferentiated, rarely outer layers relatively thick walled; leaves closely imbricate or distant, alternate, ovate to oblong, quadrate or rectangular, usually entire at margins, rarely toothed; apex acute, retuse or obtuse; cells thin walled, with or without trigones; underleaves remote, free or narrowly united at base with leaves, usually deeply bilobed; dioicous or monoicous, male and female inflorescence terminal or intercalary on main branches or lateral branches, perianth oblong or campanulate, usually triplicate; capsule ovoid or dark brown, spores granulate, elaters bispiral.

Key to the species

- 1a. Leaf surface spinulose ***L. muricatus***
- 1b. Leaf surface smooth 2
- 2a. Plants large up to 50 mm long, leaves deeply bilobed; stem 9-10 cells across.....
..... ***L. bidentata***
- 2b. Plants small up to 5 mm long, leaves minutely lobed; stem 5-6 cells across
..... ***L. minor***

Lophocolea bidentata (L.) Dumort., Recueil Observ. Jungerm. 17. 1835; Manjula *et al.*, Arch. Bryol. 176: 5. 2013. *Jungermannia bidentata* L., Sp. Pl. 1132. 1753. *Lophocolea bidentata* fo. *cuspidata* Nees, Naturgesch. Eur. Leberm. 2: 327. 1836. *L.*

coadunata (Sw.) Mont., Voy. Amér. Mérid., Bot. 76. 1839. *L. cuspidata* (Nees) Limpr., Hedwigia 15(2): 18. 1876. *L. longispica* Steph., Bull. Soc. Roy. Bot. Belgique 31: 116. 1892. *L. setacea* Steph. Hedwigia 31: 125. 1892. *L. scott-elliottii* Steph., Bull. Herb. Boissier, sér. 2, 7(4): 308. 1907. *Leptoscyphus stephensiae* Sim, Trans. Roy. Soc. South Africa 15(1): 105. 1926. *Chiloscyphus coadunatus* (Sw.) J.J. Engel & R.M. Schust., Nova Hedwigia 39: 413. 1984. *C. cuspidatus* (Nees) J.J. Engel & R.M. Schust., Nova Hedwigia 39: 413. 1984. *C. latifolius* (Nees) J.J. Engel & R.M. Schust., Nova Hedwigia 39: 418. 1984. *C. coadunatus* var. *rivularis* (Raddi) Frisvoll, Elvebakk, Flatberg & Økland, NINA 4: 93. 1995.

Plants pale green to yellowish-green, epiphytic, appressed, up to 50 × 2 mm including leaves, branching simple; leaves subopposite, slightly imbricate, apex broad, shortly bilobed, obliquely inserted, quadrate oblong, 1.1-1.3 mm long and 1 mm wide; apex broad, sinus lunate, lobes acute or acuminate; laminal cells pentagonal or hexagonal except at tip, apical cells 30 µm long and 20 µm wide; median and basal cells, 25-40 µm diagonally; underleaves small, 0.45 mm long and 0.30 mm wide, distant as or more wide as the stem, deeply bilobed, lobes narrowed at apex, 5-8 mm long and 2 mm wide at base; rhizoids hyaline, in small tufts from base of the under leaves; stem 9-10 cells across, cells not differentiated (Plate 5.45).

Habitat: Epiphytic and Terrestrial, usually seen on decayed woods and land cuttings, it is associated with *Cylindrocolea kiaeri* (Austin) Váňa in shola, evergreen and grassland in all altitudinal ranges.

Discussion: *Lophocolea bidentata* (L.) Dumort. is a widely distributed species and was first described and named by Linnaeus (1753). Later, Stephani (1906) described from Asia, Europe and America. In India *L. bidentata* listed from different regions, such as Western Himalayas by Kashyap (1932), Sikkim and South India by Chopra (1943) and Srivastava and Srivastava (2002) reported from Sikkim, West Bengal, Uttar Pradesh and South India. This species is characterized by its delicate plants with subopposite leaves, leaves usually quadrate oblong and shortly bilobed, underleaves deeply bilobed, lobes 5-8 cells long, 2 cells wide and the stem cells 9-10 cells across.

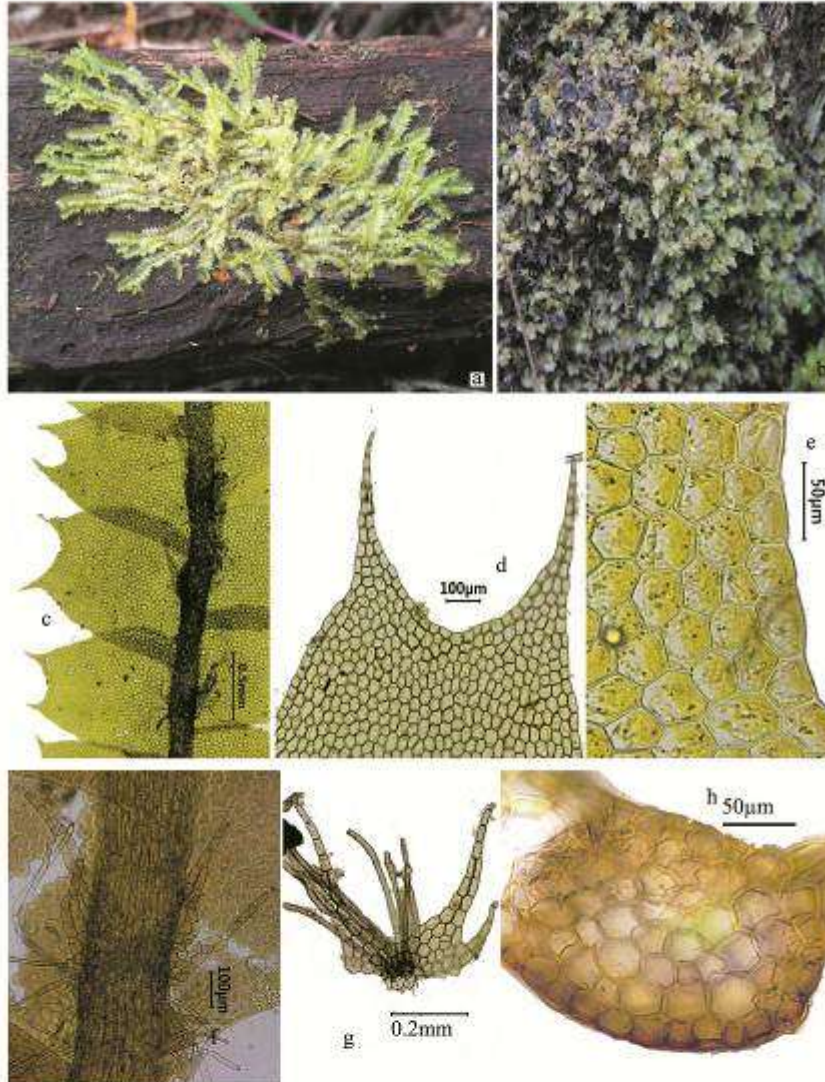


Plate 5. 45: *Lophocolea bidentata* (L.) Dumort., a&b. habit, c. leaves, d. leaf tip cells, e. leaf marginal cells, f&g. under leaves, h. c.s. of stem

Distribution: World: America, Europe (Järvinen, 1976), Korea (Yamada & Choe, 1997), Nepal (Pradhan & Joshi, 2015), Sri Lanka (Long & Rubasinghe, 2014); **India:** Kerala (Manjula *et al.*, 2013), Meghalaya (A.P. Singh & Nath, 2007), Sikkim, Western Himalayas, West Bengal (Chopra, 1943; Kashyap, 1932; A. Srivasatava & S.C. Srivastava, 2002), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1800 m) 14.07.2017 *Mufeed* 7501; Iddalymotta (1600-2200 m) 22.09.2018 *Mufeed* 9913, 9923, 9925; 25.09.2018 *Mufeed* 9976; Pullaradi Shola (2220 m) 26.09.2018 *Mufeed* 9997 (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nigiri Hills (2250 m) 08. 10. 2000 S.C. Srivastava *et al.*, 12362 (LWU).

Lophocolea minor Nees, Naturgesch. Eur. Leberm. 2: 330. 1836; A. Hameed, J. Bombay Nat. Hist. Soc. 43: 197.1942; A. Srivast. & S.C. Srivast., Indian Geocalycac.: 177. 2002; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 71. 2007; S.K. Singh & D.K. Singh, Hepat. Anthocerot. Gt. Himal. Natl. Pk. 108. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 180. 2013; Manjula *et al.*, Arch. Bryol. 176: 5. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 190. 2016; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 433. 2019. *Chiloscyphus minor* (Nees) J.J. Engel & R.M. Schust., Nova Hedwigia 39(3–4): 419. 1984.

Thallus yellowish -green, small, main stem creeping, branching irregular, simple, up to 5 mm long, 1.1 mm wide including leaves; leaves alternate, slightly imbricate to distant, quadrate to sub-rectangular, minutely bilobed, 0.40 mm long and 0.35 mm wide in basal leaves, leaves smaller towards apex, margins entire, apex bilobed, sinus sub-lunate, lobes broadly triangular, 3 cells long; apical cells minute, 18-64 µm long and 10-14 µm wide, median cells pentagonal or hexagonal, 37-57 µm long and 36-46 µm wide, basal cells large, 55-75 µm long and 35-45 µm wide, cells are thin walled without trigones except at base with minutely trigones; rhizoids long, hyaline in small tufts from the base of under leaves; stem sub-cylindrical, 5-6 cells across, cortical cells larger and medullary cells comparatively smaller; underleaves small, 0.11 × 0.18 mm, distant, deeply bilobed, lobes narrow, lanceolate, 3 cells long

with 1 or 2 cell long tooth on the outer side (Plate 5.46).

Habitat: Plants usually grow on wet soil surfaces and on roots of higher plants along with *Cylindrocolea kiaeri* (Austin) Váňa in evergreen forest at low altitude areas.

Discussion: *Lophocolea minor* Nees was first described by Stephani (1906) in “*Species Hepaticarum*” from Asia, Europe and America. Kashyap (1932) listed this species from Western Himalayas, later Chopra (1943) and Parihar *et al.* (1994) also listed this species from Western Himalayas. They commented that the plant is usually recognized by its gemmiferous leaf margin but in the present collection could not locate gemmae. It is characterized by its very delicate yellowish green small plants with minutely lobed leaves, lobes usually 3 celled, underleaves small and deeply bilobed with 3 cells long and the lobes with 1 or 2 cells long tooth on outer side.

Distribution: World: America, Asia, China, Japan, Siberia, Korea, Thailand (Lai *et al.*, 2008), Finland (Jarvinen, 1976); **India:** Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Uttar Pradesh (D.K. Singh & S.K. Singh, 2012), Eastern Himalayas, Meghalaya, (A.P. Singh & Nath, 2007), Kerala (Manjula *et al.*, 2013).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1690m) 24.09.2018 *Mufeed 9950b* (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nigiri Hills (1900 m) 11. 10. 2000 *S.C. Srivastava et al.*, 12816A (LWU).

Lophocolea muricata (Lehm.) Nees, Syn. Hepat. 169. 1845; Bapna & Kachroo, Hepatic. India 2: 71. 2000; A. Srivast. & S.C. Srivast., Indian Geocalyc.: 162. 2002; D.K. Singh *et al.*, Liverw. Hornw. India: 190. 2016; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 435. 2019. *Jungermannia muricata* Lehm., Linnaea 4: 363. 1829. *Chiloscyphus muricatus* (Lehm.) J.J. Engel & R.M. Schust., Nova Hedwigia 39: 419. 1984 [1985]; Manjula *et al.*, Arch. Bryol. 176: 2. 2013.

Plants very small, up to 12 mm long and 0.7-1 mm wide including leaves, plants pale green, lateral, overlapping; leaves alternate, longer than wide, bilobed, base broader, spinulose from base to apex, leaf size variable from top to bottom, top leaves 0.30-0.35 mm long and 0.20 mm wide, middle leaves 0.33-0.35 mm long and

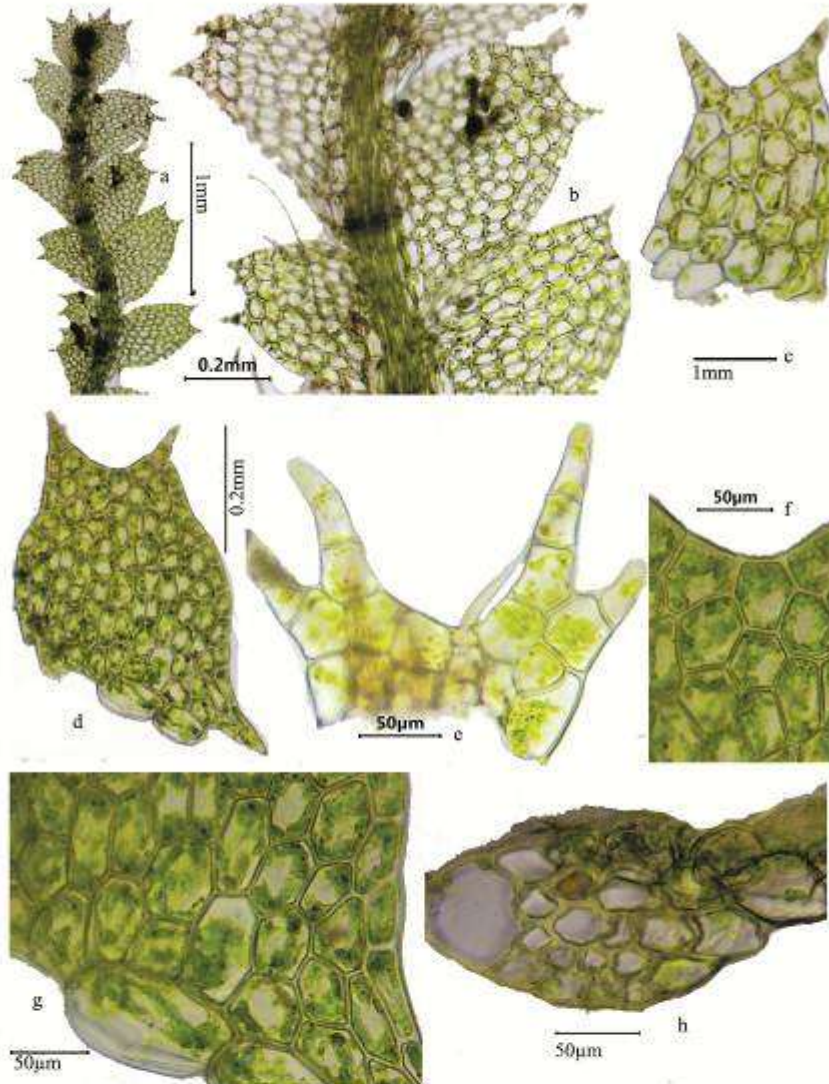


Plate 5.46: *Lophocolea minor* Nees, a&b. habit, c&d. leaves, e. underleaf, f. cells at apex, g. cells at base, h. c.s. of stem

0.31-0.34 mm wide, basal leaves 0.29-0.38 mm long and 0.26-0.35 mm wide; cells rectangular without intercellular spaces, 9-11 μm long and 11-14 μm wide at tip, middle cells 11-14 μm long and 11-16 μm wide, basal cells 9-11 μm long and 11-14 μm wide; spines numerous, 2-4 series of cells, single cell at tip; underleaves deeply bilobed, each lobe again divided into one or two small lobes; upper 2-3 single cells, 0.11-0.95 μm wide at base; rhizoids restricted to the base of underleaves (Plate 5.47).

Habitat: Usually seen on logs, in twigs and branches, growing along with the patches of *Calypogeia azurea* Stotler & Crotz and *Leucobryum juniperoideum* (Brid.) Müll. Hal. in shola forest.

Discussion: From India *Lophocolea muricata* was earlier reported from Tamil Nadu and Kerala only, A. Srivastava and S.C. Srivastava (2002) reported this species from Palni Hills of Tamil Nadu and Manjula *et al.* (2013) reported from Malappuram district of Kerala as *Chiloscyphus muricatus*. These are small epiphytic plants with bilobed spinulose leaves, underleaves deeply bilobed and again divided into one small lobe.

Distribution: **World;** Brazil (Frozza, 2010), China (Pippo, 1990); **India:** Kerala (Manjula *et al.*, 2013 as *Chiloscyphus muricatus*), Tamil Nadu (A. Srivastava and S.C. Srivastava, 2002; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 14.07.2017 *Mufeed 7512b* (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nigiri Hills (2660 m) 08. 10. 2000 S.C. Srivastava *et al.*, 12504 (LWU).

Notoscyphaceae Crand.-Stotl.,

Váňa & Stotler Syst. Bot. 40(1): 38. 2015.

Plants delicate, seen in prostrate patches, light or yellowish green, occasionally brownish or even reddish, dorsally or ventrally or laterally compressed; stem rarely to frequently branched; leaves succubous, closely imbricate, alternate, sub-opposite to opposite, ovate-oblong, rectangular, semicircular to triangular, apex either entire, bilobed or dentate with 1 to many small dentitions, cells uniformly thin walled or

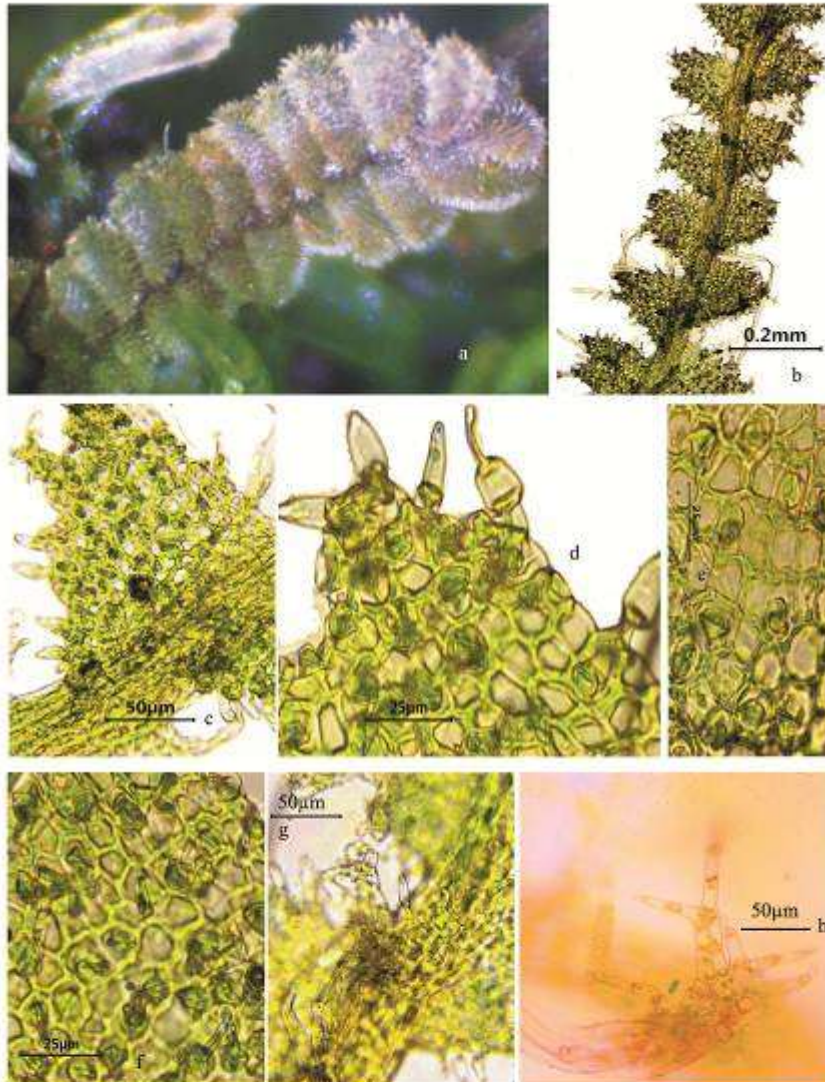


Plate 5. 47: *Lophocolea muricata* (Lehm.) Nees a. habit, b. leaf arrangement on the stem, c. leaf, d. leaf tip, e. leaf cells at middle, f. cells with papillae, g&h. underleaves

thick walled towards the outer margin, polygonal, with or without minute to distinct triradiate to nodulose bulging trigones; oil bodies several; underleaves well developed, distant or slightly to closely imbricate, free or united, small to large, usually shortly to deeply bilobed at apex; rhizoids usually in tufts at underleaf bases.

***Notoscyphus* Mitt.,**

Fl. Vit. 407. 1873.

Plant yellowish green, prostrate; stem sparsely or irregularly branched, 7 cells wide, cells thick walled; rhizoids hyaline; leaves succubous, imbricate, ovate, sub quadrate, apex truncate or rounded or obtuse; leaf cells polygonal, thick walled with large nodulose trigones; under leaves prominent, large, ovate-oblong, bifid, lobes uniseriate towards apex.

Notoscyphus lutescens Schiffn., Denkschr. Kaiserl. Akad. Wiss., Wien Math.-Naturwiss. Kl. 67: 192. 1898. *Jungermannia lutescens* Lehm. & Lindenb., Nov. Stirp. Pug. 4: 16. 1832. *J. belangeriana* Lehm. & Lindenb., Nov. Stirp. Pug. 5: 4. 1833. *Gymnomitrion belangerianum* (Lehm. & Lindenb.) Gottsche, Syn. Hepat. 4. 1844. *Jungermannia bolanderi* (Austin) Austin, Bull. Torrey Bot. Club 5(4): 17. 1874. *Notoscyphus belangerianus* (Lehm. & Lindenb.) Mitt., J. Linn. Soc., Bot. 16: 189. 1877. *Cephalozia borbonica* (Steph.) Besch., Fl. Réunion 9. 1895. *C. ligulata* (Steph.) Besch., 9. 1895. *Alicularia notoscyphoides* (Schiffn.) Steph., Fl. Réunion 9. 1895; Steph., Sp. Hepat. 2: 44. 1901. *Notoscyphus paroicus* Schiffn., Denkschr. Kaiserl. Akad. Wiss., Wien Math.-Naturwiss. Kl. 67: 192. 1898; Manju & Rajesh, Bryo. Kerala, Liverw. vol. 1. 79. 2017; Daniels *et al.*, Pl. Sci. Today 5(2): 81. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 436. 2019. *Notoscyphus jackii* (Steph.) Steph., Bull. Herb. Boissier, sér. 2, 1: 175. 1901. *N. congoanus* Steph., Sp. Hepat. 6: 78. 1917. *Calypogeia minutistipula* Steph., Sp. Hepat. 6: 449. 1924. *Notoscyphus natalensis* Sim, Trans. Roy. Soc. South Africa 15: 95. 1926.

Plants forming a light yellowish green loose weft, 15-20 mm long and 1.2 mm wide including leaves, prostrate, branching infrequent, ventral intercalary; stem cylindrical to sub cylindrical, medullary cells and cortical cells not differentiated; rhizoids usually produced in groups at or near underleaf bases or occasionally scattered on stem; leaves imbricate, simple, alternate, succubous, oblong-ovate, apex

obtuse, 0.55 mm long and 0.45 mm wide, subtransversely inserted, margin entire to slightly bifid; marginal cells thick walled with prominent trigones, 20-45 μm long and 20-35 μm wide, median cells thick walled with trigones, 30-40 (-55) μm in diameter, basal cells thick walled with large nodulose bulging trigones, 30-60 μm in diameter; underleaves free, small, 30-40 μm long and 20-25 μm wide, bifid, sinus deep, lobes large, subequal, acuminate, erect, lobes 6-8 cells long and 2 cells wide at base, apex uniseriate, 4-6 cells high (Plate 5.48).

Habitat: Epiphytic, on bark of large trees in evergreen forest in low altitude areas.

Discussion: It is a widely distributed species in South India and reported earlier from Kerala, Karnataka and Tamil Nadu as *Notoscyphus paroicus* Schiffn. Staples & Imada (2007), treated *Notoscyphus paroicus* under *N. lutescens* Schiffn. D.K. Singh *et al.* (2016) treated *N. lutescens* and *N. paroicus* as separate species under Geocalycaceae. There is controversy regarding the placement of this genus. First *Notoscyphus* placed under the family Jungermanniaceae and Shaw *et al.* (2015) placed it in Geocalycaceae. Molecular evidence shows that *Notoscyphus* should be placed in its own family, so it is replaced from Geocalycaceae into Notoscyphaceae (Shaw *et al.*, 2015). Here followed Staples & Imada (2007) and Shaw *et al.* (2015). This species is characterized by the prostrate epiphytic plants with ovate alternate leaves which are succubous, underleaves small with deep sinus and 4-6 uniseriate cells present in each lobes.

Distribution: World: Africa (Wiggington, 2009), Australia (McCarthy, 2006), China (Pippo, 1990), Hawaii (Staples & Imada, 2006), Indonesia (Söderström *et al.*, 2010), Malaysia (Chuah-petiot, 2011), Philippines (Tang & Engel, 1986), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al.*, 2008); **India:** Karnataka (Udar and Kumar, 1981b), Kerala (Daniels & Kariyappa, 2019; Manju *et al.*, 2014; Manju & Rajesh, 2017), Meghalaya (A.P. Singh & Nath, 2007), Tamil Nadu (Daniels *et al.*, 2018; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1650 m) 14.07.2017 *Mufeed* 7532 (ZGC).

Other specimen/s examined: India, Kerala, Kozhikode District, Malabar Wildlife Sanctuary: Peruvannamuzhi: Chenkottakkolli (260-420m), 12.01.15, *Prajitha*

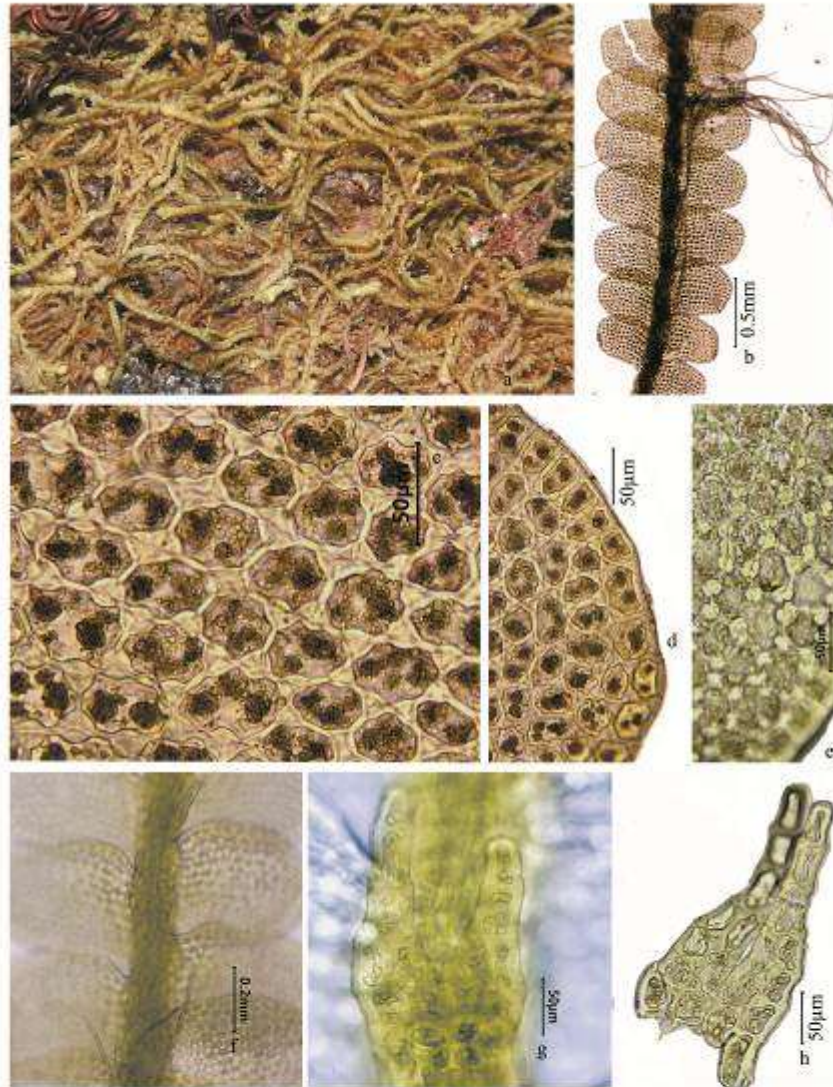


Plate 5. 48: *Notoscyphus lutescens* (Lehm. & Lindenb.) Mitt., a. habit, b. branch ventral view, c. leaf middle cells, d. leaf marginal cells, e. intercellular thickening (trigones), f. underleaves arrangement, g&h. underleaves

13503; 11.09.14, *Prajitha 14128* (MBGH).

Plagiochilaceae Müll. Frib.,

Leberm. Eur. 877. 1956.

Plants robust, greenish to blackish green, main stem prostrate, branches erect to drooping, branching lateral, intercalary; rhizoids few; leaves succubous, alternate or opposite, margin entire or toothed; underleaves vestigial or absent; dioicous, male inflorescence on main axis or on short branches, female inflorescence with one or two subfloral innovations, capsule ovoid, spores 15-30 µm diagonally, elaters one or bi spiral.

Plagiochila (Dumort.) Dumort.,

Recueil Observ. Jungerm. 14. 1835.

Plants usually have a creeping rhizome, strongly adherent to tree trunks and rock surfaces; rhizomes usually have numerous rhizoids; shoots arise directly from the substrate, simple or sparingly branched; leaves of most species are oblong ovate, quadrate or deeply lobed, most leaf margins are toothed to varying degrees, dorsal margin usually convex; laminal cells vary in size, isodiametric or hexagonal with or without trigones, cell walls may be moderately thick, all species possess smooth cuticle; underleaves absent or vestigial, small, filiform; asexually reproduce by fragmenting leaves, propagules or by flagelliform branches; dioicous, male plants usually small in size compared to the female; spores usually small, 15-20 µm in diameter.

Key to the species

- 1a. Plants usually yellowish green to olive green or deep brown; leaf cells with large trigones 2
- 1b. Plants usually greenish brown; leaf cells with small trigones ***P. sciophila***
- 2a. Marginal teeth of leaf present from apex to ventral margin throughout; distal parts of shoots usually with terminal branches ***P. arbuscula***
- 2b. Marginal teeth of leaf mostly restricted to apex; shoots usually simple..... 3
- 3a. Stem surface without paraphyllia ***P. fruticosa***
- 3b. Stem surface with 1-2 (-3) entire-margined and/or dentate paraphyllia at some dorsal leaf bases 4
- 4a. Leaves oblong-ovate, persistent ***P. durelii***

- 4b. Leaves (orbicular-) oblong-ovate, fragmenting5
 5a. Plants dichotomously branched; leaves remote to contiguous, apex of leaf distinctly bilobed; marginal teeth 5-8 per leaf ***P. junghuhniana***
 5b. Plants 1 or 2 times pinnately branched; leaves moderately imbricate, apex often rounded, occasionally bidentate; marginal teeth 10-18 per leaf.... 6
 6a. Leaf with more than 15 teeth at margin ... ***P. uniformis***
 6b. Leaf with 8-10 teeth at margin ***P. indica***

Plagiochila arbuscula (Brid. ex Lehm. & Lindenb.) Lindenb., Sp. Hepat. 1: 23. 1839; M.L. So, Syst. Bot. Monogr. 60: 103. 2001; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal. 203. 2007; Nair *et al.*, Geophytology, 35(1&2). 40. 2005; Manju & Rajesh, Bryo. Kerala, Liverw. vol. 1. 66. 2017. *Jungermannia arbuscula* Brid. ex Lehm. & Lindenb., Nov. Stirp. Pug. 4: 63. 1832. *Plagiochila belangeriana* Lindenb., Sp. Hepat. 109. pl. 19. 1840. *P. ferdinandi-muelleri* Steph., Bull. Herb. Boissier, sér. 2, 4: 777. 1904. *P. australis* Steph., Sp. Hepat. 6: 126. 1917. *P. fuscorufa* Steph., Sp. Hepat. 6: 158. 1918. *P. plicatula* Steph., Sp. Hepat. 6: 201. 1921. *P. yuwandakensis* Horik., Bot. Mag. (Tokyo) 49: 50. f. 1: 2. 1935. *P. bilabiata* Herzog, Hedwigia 78: 227. 1938.

Plants usually up to 10 cm long, yellowish green to olive green or dark brown, slightly glossy, arising oblique from a creeping rhizome, highly dichotomously branched, distal parts of shoots usually with terminal branches, stem yellowish brown; rhizoids numerous; leaves moderately imbricate, oblong to ovate, 1.75 mm long and 1.30 mm wide, widest near the base, dorsal margin almost straight, entire, base long, decurrent, apex irregularly spinose, marginal teeth of leaf present from apex to ventral margin throughout, base slightly ampliate, decurrent, teeth 5 or 6 per leaf, teeth apex 3 cells long, 3-4 cells in a uniseriate row; cells with large trigones, cells at tip acute, 20 µm long and 15 µm wide, cells at middle rounded, 20-30 µm in diameter, marginal cells thickened, ovoid, 11-35 µm in diameter, cells at base elliptical, 28–40 µm; underleaves vestigial, paraphyllia absent; asexual propagules rarely seen; sporophyte not observed (Plate 5.49).

Habitat: Epiphytic plants usually hanging on tree trunks along with *Campylopus subulatus* Schimp. ex Milde and *Brachymenium leptophyllum* (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger. in evergreen and shola forest.

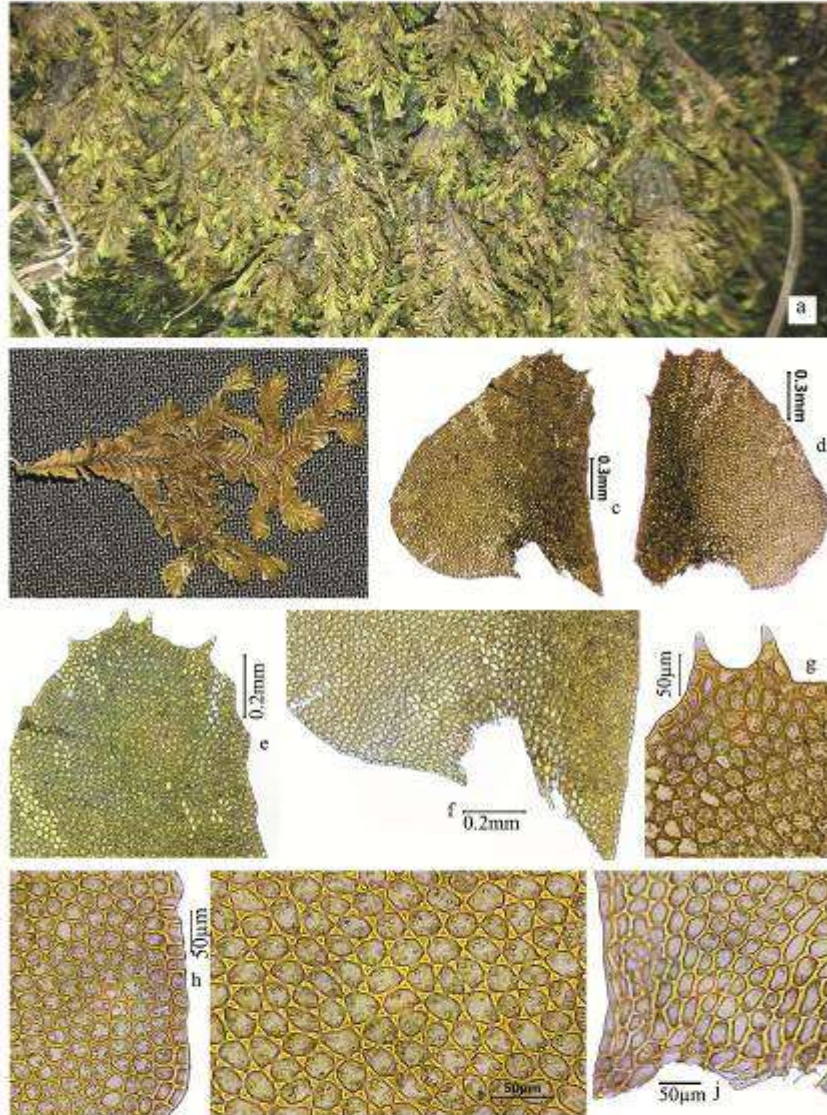


Plate 5. 49: *Plagiochila arbuscula* (Brid. ex Lehm. & Lindenb.) Lindenb., a. habit, b. single plant, c&d. leaves, e. leaf apex, f. leaf base, g. leaf spine showing cells, h. leaf marginal cells, i. leaf middle cells, j. leaf basal cells

Discussion: *Plagiochila arbuscula* has a wide distribution in East and Southeast Asia and ranges from Japan to Australia. The weakly developed plant is often confused with *P. flexuosa* Mitt. (So, 2001). It is a high altitude species reported only from Kerala in South India. It is characterized by marginal teeth of leaf present from apex to ventral margin throughout and the distal parts of shoots usually with terminal branches, underleaves vestigial and paraphyllia absent.

Distribution: World: Australia, Fiji, Indonesia, New Caledonia, Papua New Guinea, Philippines, Thailand, Japan, Tahiti, Solomon Islands (So, 2011); **India:** Kerala (Manju & Rajesh, 2017; Nair *et al.*, 2005)

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600-1700 m) 14.07.2017 *Mufeed* 7382b, 7543; Iddalymotta (2250 m) 22.09.2018 *Mufeed* 9931 (ZGC).

Plagiochila durelii Schiffn. subsp. ***durelii*** Oesterr. Bot. Z. 49: 131. 1899; M.L. So, Syst. Bot. Monogr. 60: 39. 2001; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal. 1: 60. 2007. *P. bhutanensis* Schiffn., Osterr. Bot. Z. 49: 130. 1899. *P. ferruginea* Steph., Bull. Herb. Boissier, ser. 2 3: 879. 1903. *P. thomsonii* Steph., Bull. Herb. Boissier, ser. 2. 3: 887. 1903. *P. subpropinqua* Schiffner ex Steph., Sp. Hepat. 6: 211. 1930. *P. alata* Inoue, Bull. Natl. Sci. Mus., Tokyo 8: 383. 1965. *P. harae* Inoue, in Hara, Fl. E. Himalaya 1: 517. 1967.

Plants in loose patches, up to 5 cm long, light brown, not glossy, moderately branched to highly branched; presence of flagella, arising from base of shoot; creeping rhizome absent; leaves moderately imbricate, horizontally spreading, oblong-ovate, persistent, 1.8-2 mm long and 1.3-1.5 mm at base, dorsal margin slightly recurved, base long decurrent, with 3-4 uniseriate teeth at distal end, apex broadly rounded, 5-6 teeth, ventral margin arched, marginal teeth variable in number; cells usually round or elliptical, moderately thickened with prominent trigones, apical cells 15-25 µm, median cells 20-35 µm; basal cells 25-35 µm; underleaves vestigial; paraphyllia lamelliform, entire-margined or dentate, (1-) 2-3 per dorsal leaf base at some sectors of shoot, sometimes absent; male plants not seen, female plants bears gynoeceium terminal on main shoot, with 1-2 innovations,

bracts more broadly ovate and densely toothed than stem leaves; spores not seen (Plate 5.50).

Habitat: Epiphytic, on exposed roots of tree trunks at base of shola trees.

Discussion: The paraphyllia of this species show wide variations, based on this character So (2001) erected many subspecies. The present one is *P. durelii* subsp. *durelii* which shows lamelliform paraphyllia with dentate margin, (1-) 2-3 per dorsal leaf base at some sectors of shoot and in some leaf base it is absent. Uniyal (2011) listed this species as *Plagiochila durelii*, reported earlier from Himachal Pradesh, it is a typological error.

Distribution: World: Bhutan, China, Nepal, Thailand (So, 2001); **India:** Himachal Pradesh (Singh, D.K. & Singh, S.K., 2008), Kerala (present collection), Sikkim (So, 2001), Uttaranchal (Rawat & S.C. Srivastava, 2007), West Bengal Meghalaya,.

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100-2150 m) 15.07.2017 *Mufeed 7612b*; 25.09.2018 *Mufeed 9974* (ZGC).

Plagiochila fruticosa Mitt., J. Proc. Linn. Soc., Bot. 5: 94. 1861; M.L. So, Syst. Bot. Monogr. 60: 66. 2001; Nair *et al.*, Geophytology 35: 42. 2005; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal.1: 96. 2007. *P. bipinnata* Steph., Sp. Hepat. 6: 131. 1918. *P. tosana* Steph., Sp. Hepat. 6: 227. 1921.

Plants up to 8 cm long, shoots simple, olive green, glossy, arising from a long creeping rhizome; rhizoids only on creeping rhizomes; stem leaves ovate rectangular, 1.25 x 0.7 mm, more wide near base; branch leaves 1 × 0.5 mm, dorsal margin straight, slightly recurved, entire, base decurrent, teeth mostly restricted to apex, apex truncate with 3-5 teeth; teeth 6-8 per leaf; underleaves vestigial, paraphyllia absent; laminal cells at apex 20-25 × 10-12 µm, cells at middle rounded to quadrate, 18-30 µm diagonally, cells at base 20-30 × 15-20 µm, trigones small, intermediate thickening sometimes present, cuticle smooth; reproductive structures not observed (Plate 5.51).

Habitat: Epiphytic plants usually found on the decayed woods and on branches of evergreen trees.

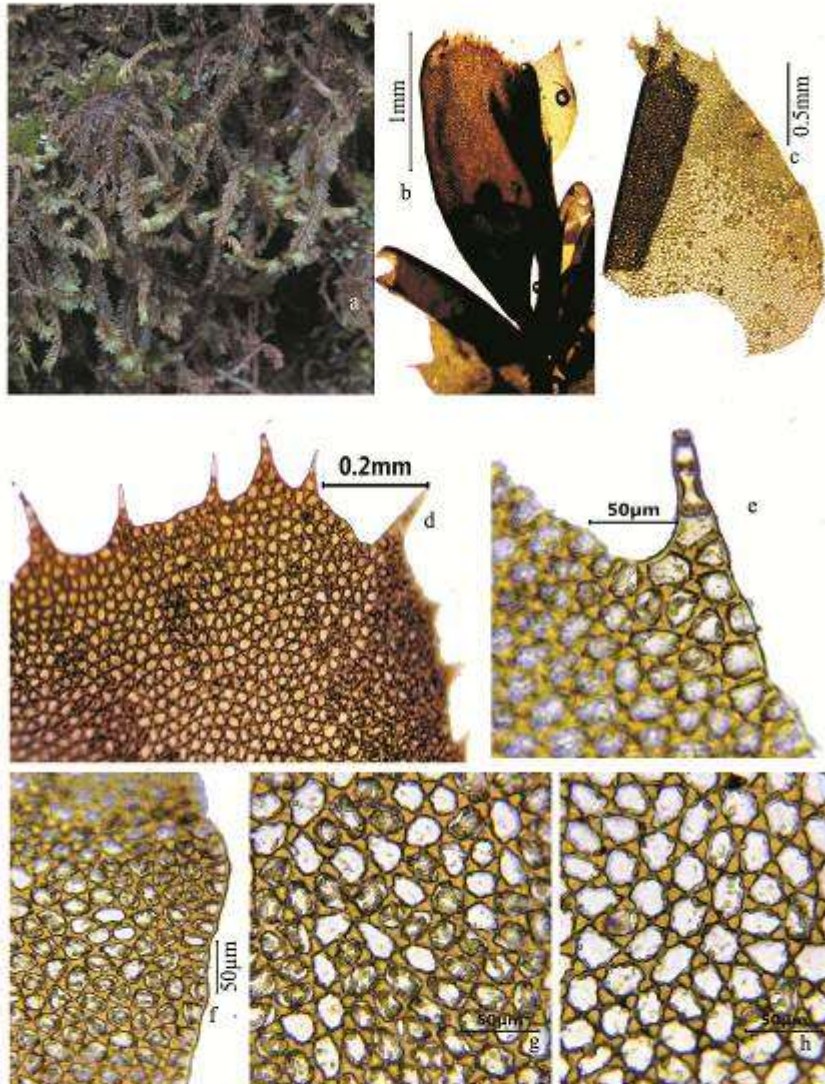


Plate 5. 50: *Plagiochila dorelii* Schiffn., a. habit, b. fertile branch, c. leaf, d. leaf tip, e. leaf spine, f. marginal cells, g. median cells, h. basal cells



Plate 5.51: *Plagiochila fruticosa* Mitt., a. habit, b. ventral view, c. dorsal view, d. leaf arrangement, e&f. leaf, g. leaf apex, h. leaf cells at extreme tip, i. leaf marginal cells, j. leaf cells at middle

Discussion: *Plagiochila fruticosa* Mitt. resembles *P. frondescens* (Nees) Lindenb. in its morphology, it differs only in its smaller leaf size and subquadrate leaf cells. Hence, the earlier reports of *P. fruticosa* were originally labelled as *P. frondescens* (Nees) Lindenb. (So, 2001). It is a widely distributed species in high altitude evergreen and shola forests of Kerala. *Plagiochila fruticosa* Mitt. is characterized by the absence of paraphyllia on its stem surface, simple shoots and the teeth in the leaf lobe restricted only to apex.

Distribution: World: Bhutan, China, Japan, Nepal, Philippines, Vietnam, Thailand, (So, 2001); **India:** Eastern Himalayas, Meghalaya (A.P. Singh & Nath, 2007), Kerala (Nair *et al.*, 2005; Manju & Rajesh, 2017).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1605-1650 m) 14.07.2017 *Mufeed* 7556; 25.09.2018 *Mufeed* 7581b (ZGC).

Plagiochila indica Mitt. ex Steph. Bull. Herb. Boissier, sér. 2, 3: 532. 1903; So & Grolle, J. Bryol. 23: 126. 2001; Pócs *et al.*, Acta Bot. Hung. 49(1-2): 126. 2007; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal. 1: 183. 2007.

Plants medium-sized, highly branched, shoots 50-70×1.8-2.5 mm, light brown, creeping rhizome not seen, stem surface exposed; leaves oblong-ovate, contiguous to slightly imbricate, 1.8-2 mm long and 1.2 mm wide, dorsal leaf margin strongly revolute, base moderate to long decurrent, almost entire, apex broadly rounded, dentate, ventral margin distinctly arched, base not ampliate; marginal teeth small, 8-10 in number per leaf, 1-2 cells long, 1-2 cells wide at base, terminal cells acuminate, subapical and median cells 25-35 µm, basal cells 30-35 µm diameter, not forming a vita, trigones medium-sized, walls thin throughout, cuticle smooth; underleaves vestigial, paraphyllia absent; asexual reproduction by propagules on ventral surface of mature leaves; sporophyte not seen (Plate 5.52).

Habitat: Epiphytic, on base of the trunk in shola forest at an altitude above 2200 m.

Discussion: The type material of *Plagiochila indica* was from Nilgherry hills in Tamil Nadu collected by Hooker and deposited in New York Botanical Garden. It is a rare species reported only from few localities. This species is characterized by its

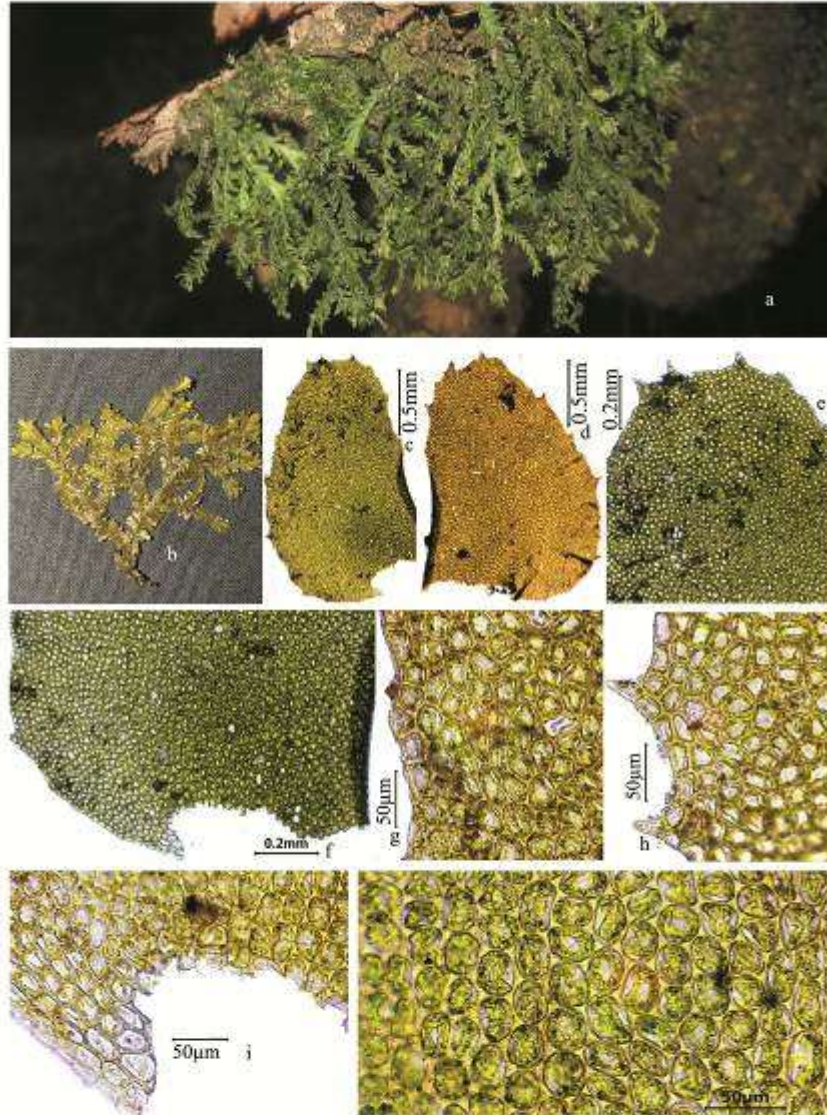


Plate 5. 52: *Plagiochila indica* Mitt. ex Steph., a. habit, b. single plant, c&d. leaf, e. leaf apex, f. leaf base, g. leaf marginal cells, h. leaf spine, i. leaf basal cells, j. leaf middle cells

medium sized, highly branched plants with 8-10 small teeth on the leaf apex and absence of paraphyllia.

Distribution: World: Thailand (Inoue, 1974; So & Grolle, 2001); **India:** Kerala (Pócs *et al.*, 2007), Sikkim, West Bengal (Rawat & S.C. Srivastava, 2007), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2440 m) 22.09.2018 *Mufeed* 9927 (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Kattumala (2220 m) *Manju C.N.* 80266a (CALI!); Tamil Nadu, Nigiri Hills (2660 m) 08.10.2000 *S.C. Srivastava et al.*, 12504 (LWU!).

Plagiochila junghuhniana Sande Lac., Ned. Kruidk. Arch. 3: 416. 1855; M.L. So, Syst. Bot. Monogr. 60: 151. 2001; Verma & Srivastava, J. Bombay. Nat. Hist. Soc, 105(2), 236. 2008; Verma *et al.*, Polish Bot. J. 58(2), 530. 2013. *P. massalongoana* Schiffner, Denkschr, Kaiserl. Akad. Wiss., Math.–Natur- wiss. Kl. 70: 175. 1990. *P. daviesiana* Steph., Bull. Herb. Boissier, ser. 2, 2: 105. 1902; Sp. Hepat. 2: 285. 1902. *P. vescoana* Steph., Bull. Herb. Boissier, ser. 2, 2: 108. 1902. *P. berkeleyana* Gottsche ex Steph., Sp. Hepat. 6:129. 1918. *P. pulchra* Steph., Sp. Hep. 6: 192.1921. *P. tinctoria* Herzog, Hedwigia 78: 230. 1938. *P. lagunensis* Inoue, Bull. Natl. Sci. Musc., Tokyo, ser. B, 5: 31. 1979.

Plants 4 cm long, dichotomously branched, branches terminal, creeping rhizome not seen, rhizoids infrequent, only at basal part of shoots; leaves contiguous to remote, slightly imbricate, horizontally spreading, linearly oblong ovate, 2.20 mm long and 1.2 mm wide, widest at base, dorsal margin almost straight, slightly recurved, entire, base moderately decurrent, apex distinctly bilobed, sinus wide, lobes 8 or 9 cells long and 3-5 cells wide, ventral margin arched, hardly decurrent, with 5-8 spinose teeth, teeth 5-10 per leaf; apical cells acute, 24 µm long and 16 µm wide; subapical cells 16 µm long and 22 µm wide; median and basal cells somewhat large, 35-55 µm long and 15-20 µm wide; trigones usually small, walls thin; underleaves vestigial; paraphyllia absent; asexual reproduction by propagules from ventral leaf surface, propagules usually form profusely; sporophyte not seen (Plate 5.53).

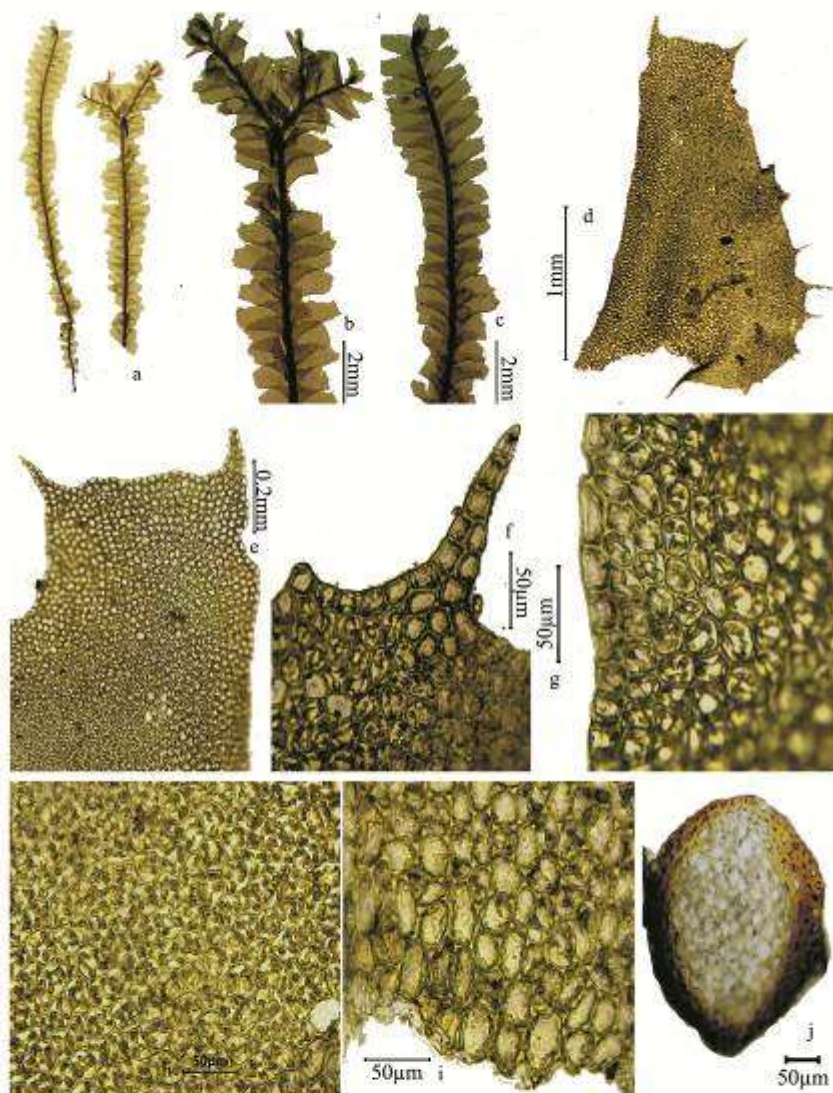


Plate 5. 53: *Plagiochila junghuhniana* Sande Lac., a. habit, b. enlarged view of dorsal region, c. enlarged view of ventral region, d. leaf, e. leaf apex, f. leaf spine, g. marginal cells, h. leaf middle cells, i. leaf basal cells, j. c.s. of stem

Habitat: Seen on rotten logs in evergreen forests.

Discussion: This species can be easily separated from other species by its few marginal teeth on the leaf and the frequent presence of propagules. So (2001) commented that this species is rather common in South East Asia and Melanesia. This species was earlier recorded from Tamil Nadu in South India. The present collection is a new record for Kerala.

Distribution: World: Borneo, China, Indonesia, Java, New Caledonia, Papua New Guinea, Philippines, Sumatra, Sulawesi, Thailand, Vietnam (So, 2001); **India:** Kerala (present collection), Tamil Nadu (Daniels, 2010), Western Himalayas, Darjeeling, Sikkim (Rawat & S.C. Srivastava, 2007; Dandotiya *et al.*, 2011).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2160 m) 25.03.2016 *Mufeed 10053* (ZGC).

Plagiochila sciophila Nees ex Lindenb., Sp. Hepat. fasc. 2–4: 100. 1840; Chopra, J. Indian Bot. Soc. 22: 244. 1943; N.S. Parihar *et al.*, Hepat. & Anthocerot. India 32. 1994; Bapna & Kachroo, Hepatic. India 2: 110. 2000; M.L. So Syst. Bot. Monogr. 60: 112. 2001; Nair *et al.*, Geophytology, 35: 43. 2005; D. Singh & D.K. Singh, Indian J. Forest 29: 458.2006; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal. 116. 2007; Dey & D.K. Singh, Epiphyll. Liverw. E. Himal.: 388.2012; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 242. 2013; D.K. Singh *et al.*, Liverw. Hornw. India: 220. 2016; Rajilesh *et al.*, Annals of Plant Science 7.1: 1946-1948. 2018 (as *P. magna*); Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 562. 2019. *Plagiochila orientalis* Taylor, London J. Bot. 5: 261. 1846. *P. ciliata* Gottsche, Ann. Sci. Nat., Bot., ser. 4, 8:334. 1857. *P. acanthophylla* Gottsche, Bot. Zeitung (Berlin) 16, Beil. 37, 38. 1858. *P. japonica* Sande-Lac., Ann. Mus. Bot. Lugduno-Batavum 1: 290.1864. *P. sockawana* Steph., Bull. Herb. Boissier, ser. 2, 2: 120.1903. *P. flavovirens* Steph., Sp. hepat. 6: 156. 1918. *P. trochantha* Schiffn. ex Steph., Sp. Hepat. 6: 226. 1921. *P. vygensis* Steph., Sp. hepat. 6: 237. 1921. *P. acanthophylla* subsp. *ciliigera* (R.M. Schust.) R.M. Schust., Hepat. Anthocerotae N. Amer.) 4: 435. 1980.

Plants in loose tufts, up to 6 cm long, green or greenish brown, arising from a long

creeping rhizome, highly branched; rhizoids usually scanty on ventral side of the stem; leaves contiguous, horizontally spreading, oblong-ovate, 1.5-1.7 mm long and 1 mm wide at the base, dorsal margin straight, slightly recurved, entire, base short decurrent, not reaching stem mid line, apex irregularly spinosely toothed, sometimes with two large teeth; teeth variable in number, from a few to 15 per leaf, mostly ciliate spinose, 5 or 6 cells long; cells with small trigones, cells at apex acute, $23 \times 13 \mu\text{m}$; subapical cells $20\text{-}30 \mu\text{m}$ diagonally; cells at median $20\text{-}40 \mu\text{m}$, cells at base $25\text{-}35 \mu\text{m}$, marginal cells usually long and barrel shaped, $35\text{-}60 \times 15 \mu\text{m}$; underleaves usually vestigial; paraphyllia absent; asexually reproduce by propagules, arising laterally from the stem; reproductive structure not observed (Plate 5.54).

Habitat: Epiphytic, on the bark of large trees in shola forest above 2200 m.

Discussion: *Plagiochila sciophila* Nees ex Lindenb. is a very complex species in terms of morphological plasticity. Hence *P. sciophila* is treated repeatedly as new species from different parts of Asia after the first description from Nepal by Lindenberg (1840). So (2001) in his monograph almost clarified and worked out all the synonyms of *P. sciophila*. Rajilesh *et al.* (2018) reported this species as *Plagiochila magna* Inoue from Mathikettan shola National Park of Kerala. The species is characterized by its highly branched greenish brown plants, leaf apex irregularly spinosely toothed and the cells with small trigones.

Distribution: World: Bhutan, China, Japan, Korea, Malaysia, Melanesia, Nepal, Philippines, Pakistan, Thailand, Vietnam (So, 2001); **India:** Himachal Pradesh, West Bengal, (D.K. Singh & S.K. Singh, 2007), Jammu & Kashmir (So, 2001), Kerala (Daniels & Kariyappa, 2019; Rajilesh *et al.*, 2018), Meghalaya (A.P. Singh & Nath, 2007), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2140-2160 m) 12.07.2017 *Mufeed* 7301a; 26.09.2018 *Mufeed* 9992; Mannavan Shola (1700 m) 14.07.2017 *Mufeed* 7543 (ZGC).

Plagiochila uniformis Mitt., J. Proc. Linn. Soc., Bot. 5: 98. 1861; K.K. Rawat & S.C. Srivast., Gen. *Plagiochila* E. Himal. 1: 195. 2007.

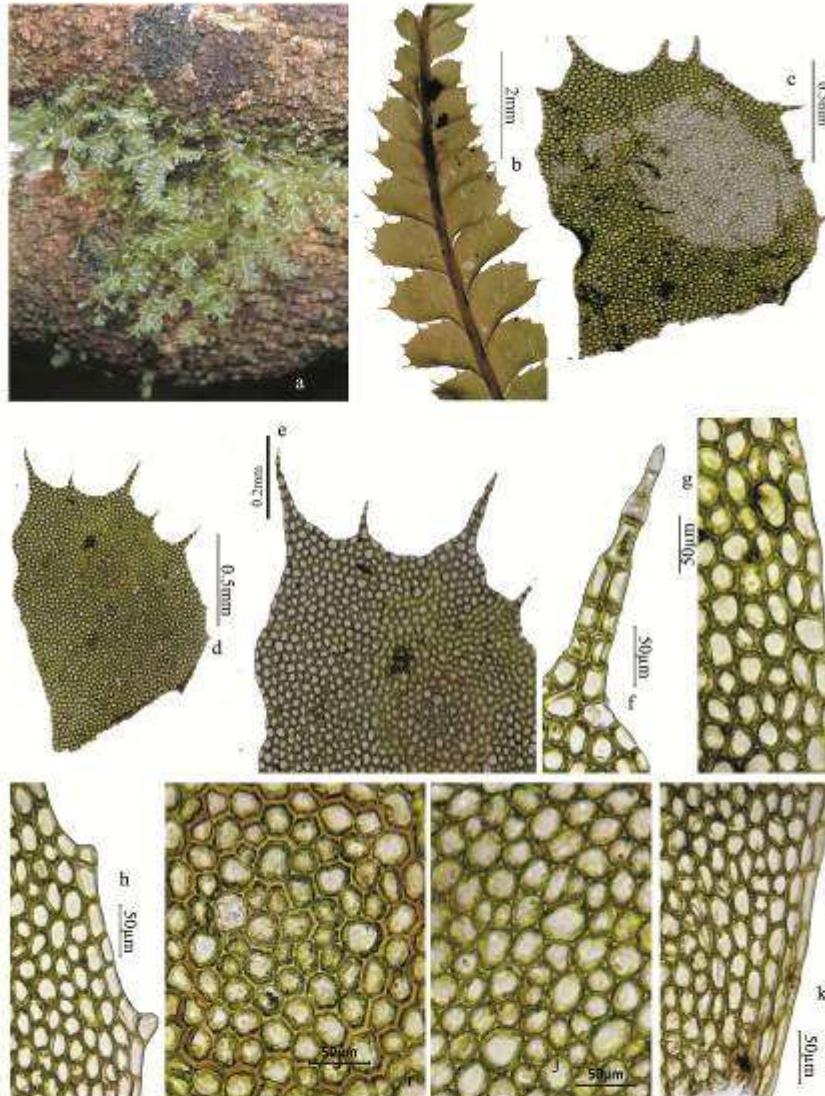


Plate 5. 54: *Plagiochila sciophila* Nees ex Lindenb., a. habit, b. single plant, c&d. leaf, e. leaf apex, f. cells of leaf spine, g&h. leaf margin base, i&j. leaf cells middle, k. basal cells

Plants green or yellowish green, 1 or 2 times pinnately branched, medium to large; leaves oblong, moderately imbricate, leaf apex often rounded, 2 mm long and 1.5 mm wide, ventral margin never ampiliate; marginal cell wall thickened, nontrigonus, 30-40 μm long and 12-14 μm wide; apical cells, acute, 18 μm long and 16 μm wide; sub apical cells, round to quadrate, 15- 30 μm in diameter; median cells rounded, trigones small, 20-30 μm ; basal cells 25-45 μm , trigones prominent; marginal teeth more than 15; teeth usually single celled all over the margin, 5 or 6 tooth at apex; asexually reproduce by propagules; sporophytes not seen (Plate 5.55).

Habitat: Epiphytic species usually found on the exposed roots of shola trees.

Discussion: *Plagiochila uniformis* Mitt. was first described by Mitten (1861) from Khasia mountains in Assam. This species was also reported by A.P. Singh and Nath (2007) from Western Himalayas on the basis of the collection made by J.D. Hooker and T. Thomson. The species is characterized by 1 or 2 times pinnately branched plants and the leaves moderately imbricate with more than 15 teeth on the margin of leaf lobe.

Distribution: India: The species is endemic to India. Distributed in Assam, Manipur, Meghalaya, West Bengal, Himachal Pradesh, Uttarakhand (Rawat & S.C. Srivastava, 2007), Uttarakhand (A.P. Singh & Nath, 2007). The present collection is a new record for South India.

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola, Jandamala (1950 m) 23.09.2018 *Mufeed* 9939 (ZGC).

Scapaniaceae Kold. Rosenv. Schust.,

Amer. Midl. Nat. 49(2):428, 1953.

Plants generally small to medium, yellowish or brownish or reddish to purplish, up to 5 cm long, stem dark brown, branching lateral or intercalary; rhizoids numerous, scattered; leaves dorsally or succubously obliquely inserted, unequally bilobed or equal in some; dorsal lobes larger and $1/3^{\text{rd}}$ time larger than the ventral lobe, ventral lobes slightly larger with folded keels and many marginal teeth; laminal cells usually papillose or weakly papillose; oil bodies 2-12 per cell; underleaves absent; asexual reproduction by gemmae; dioicous; perianth dorsiventrally flattened, mouth wide and truncate; spores papillose, elaters bispiral.

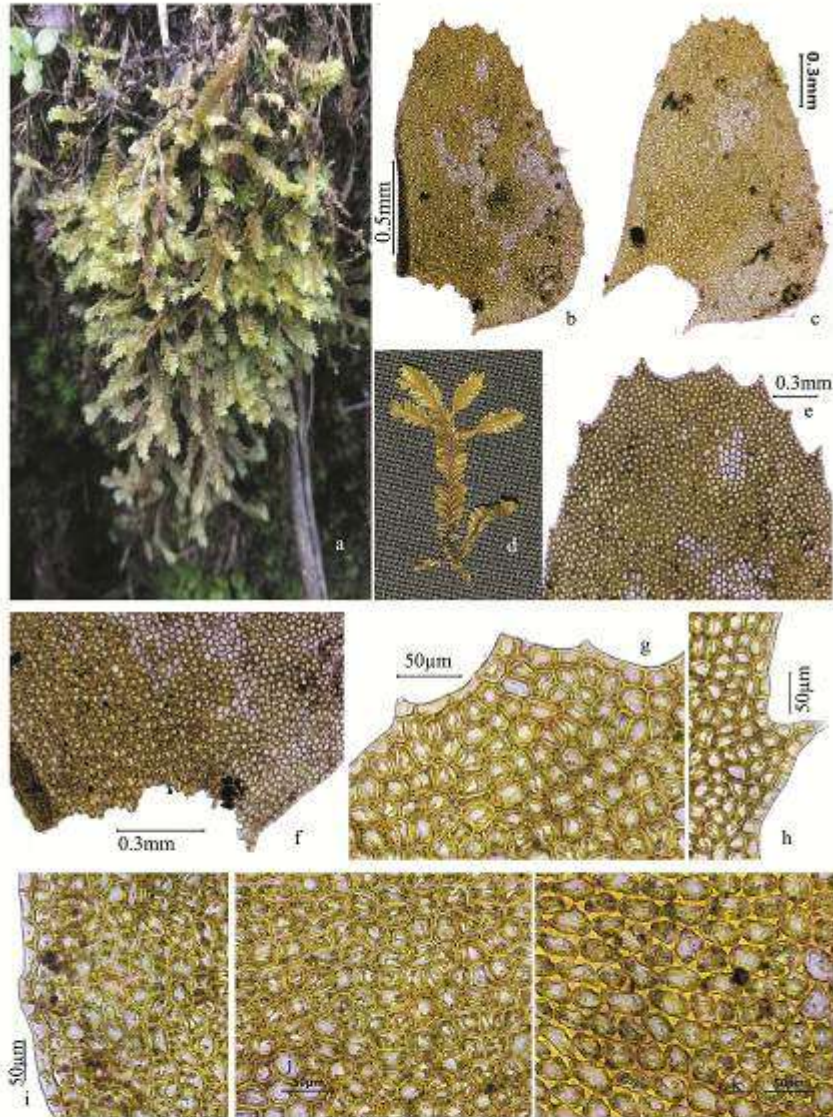


Plate 5. 55: *Plagiochila uniformis* Mitt., a. habit, b&c. leaf, d. single plant, e. leaf apex with spines, f. leaf base, g. leaf tip cells, h. leaf marginal spine, i. leaf marginal cells, j. leaf middle cells, k. leaf basal cells

Key to the genera

- 1a. Plants yellowish to reddish brown; leaves deeply 2-3 lobed, canaliculated and falcate; underleaves usually large same as leaves; oil bodies many ***Plicanthus***
- 1b. Plants reddish to dark green or brownish red; leaves ovate to oblong, narrowly to broad ovate; underleaves and oil bodies usually absent ***Gottschelia***

Gottschelia Grolle,

J. Hattori Bot. Lab. 31: 13. 1968.

Plants robust, reddish to dark green or brownish red, rigid, suberect, branches rare; leaves contiguous, entire, succubous, scale like, ovate to oblong, narrowly to broad ovate, more or less transversely inserted, interlocking dorsally, apex obtuse, margin incurved; cells thick walled with bulging trigones, more prominent in posterior part of the leaves, sometimes with intermediate nodular thickening in cell walls; oil bodies absent, underleaves absent; dioicous; perianth long or short cylindric.

Gottschelia schizopleura (Spruce) Grolle, J. Hattori Bot. Lab. 31: 16. 1968; Udar *et* Kumar, J. Indian Bot. Soc. 61: 250. 1982; *Jungermannia schizopleura* Spruce, Trans. Proc. Bot. Soc. Edinberg 15: 577. 1885; *Anastrophyllum cucullifolium* Steph., Spec. Hepat. 6: 104 (1917); *Jamesoniella microphylla* (Nees) Schiffn., in Pande and Singh, Bull. Bot. Soc. Univ. Saugar 11: 1. 1959.

Plants greenish to reddish brown, compact, 20-30 mm long, rigid, suberect; stem erect, smooth, 160-170 µm in diameter, branching lateral, cortical region 2-3 layered thick, cells deep brown, 8-12 µm long and 10-18 µm wide, medullary cells hyaline, cells 18-24 µm, thin walled; rhizoids very few at the base of the stem; leaves alternate, obliquely inserted, succubus, ventral margin overlap the entire stem, ovate to oblong, interlocks dorsally, upper leaves large, 0.7 mm long and 0.8 mm wide, basal smaller cells with 0.3-0.4 mm diagonally, apex obtuse, leaf margin smooth, incurved, marginal cells 14-20 µm, flat or incurved, median cells 20 µm long and 26 µm wide, basal cells distinct, 26-36 µm, thin to thick walled with prominent bulging trigones, intermediate nodular thickening present, oil bodies numerous per cell; underleaves absent, reproductive structures not observed (Plate 5.56).

Habitat: Terricolous, grows on moist soil, shady land cuttings and also on rocky

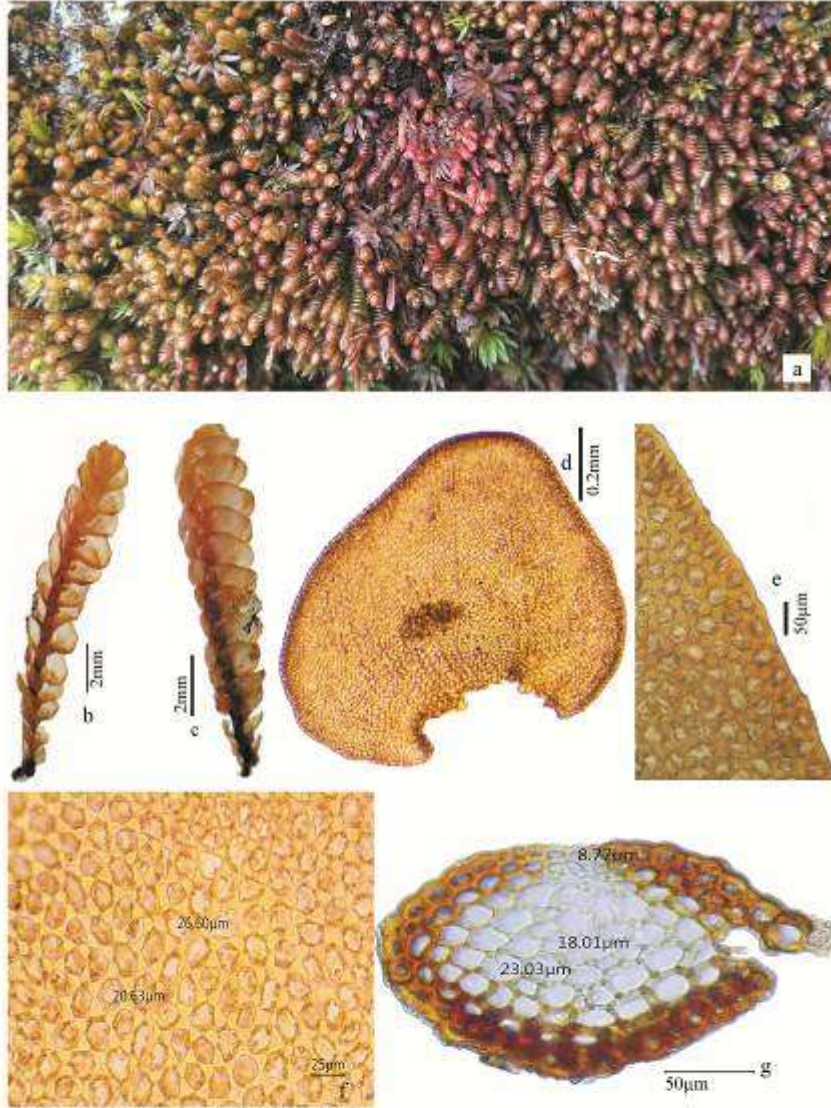


Plate 5: 56: *Gottschelia schizopleura* (Spruce) Grolle a. habit, b. ventral thallus, c. dorsal thallus, d. leaf, e. marginal cells, f. median cells, g. c.s. of stem

patches along with *Campylopus schmidii* (Müll. Hal.) A. Jaeger in shola forests in low and high altitude areas.

Discussion: This species was instituted as *Jungermannia schizopleura* by Spruce (1884-1885) and later described under the name of *Anastrophyllum cucullifolium* St. by Stephani (1917), and as *Jamesoniella microphylla* (Nees) Schiffn. by Pande and V.K. Singh (1959). Finally Grolle (1968) resolved the taxonomic ambiguity and validated the species as *Gottschelia schizopleura* (Spruce) Grolle. Udar & Kumar (1982) reported this species from Avalanche in Tamil Nadu. Mufeed & Manju (2018) reported this collection as a new record for Kerala. This species is characterized by reddish brown fleshy thallus, leaves ovate to oblong, obliquely inserted, succubous, usually large leaves at top and gradually decreases the size at base and the under leaves are absent.

Distribution: World: Africa (Spruce, 1884), China (Pippo, 1990), Celebes, Indonesia (Gradstein *et al.*, 2005), Malaysia (Liu *et al.*, 2009), Papua New Guinea (Vána & Piippo, 1989), Philippines (Logatoc *et al.*, 2019), Sri Lanka (Long & Rubasinghe, 2014), Taiwan, (Wang *et al.*, 2011); **India:** Kerala (Mufeed & Manju, 2018), Tamil Nadu (Alam, 2014; Udar & Kumar, 1982).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2400 m) 24.03.2016 Mufeed 10003; Mannavan Shola (1700 m) 14.07.2017 Mufeed 7545a (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills (2200 m) 09.10.2000 S.C. Srivastava *et al.*, 12557, 12538 (LWU!)

Plicanthus R.M. Schust.,

Nova Hedwigia 74(3–4): 484–494, f. 5–7. 2002.

Plants yellowish or reddish brown, robust, rigid when dry, simple or sparingly branched, erect or loosely pendulous, branching laterally ventral; rhizoids very few; leaves imbricate, transversely inserted, deeply 2-3 lobed, lobes canaliculated, often falcate; usually armed at base with teeth; lobes equal or unequal; underleaves large, similar to lateral leaves, deeply lobed; cells small, trigonous, with thickened walls; oil bodies several per cells; dioicous; androecium intercalary, similar to leaves;

gynoecium with single subfloral innovations; perianth large, long, inflated cylindrical, pluriplicate.

Key to the species

- 1a. Plants usually 2(-3) lobed, rarely 1 or few teeth at base ***P. birmensis***
1b. Plants 3 lobed, usually many teeth present; ventral lobes having more teeth than dorsal ***P. hirtellus***

Plicanthus birmensis (Steph.) R.M. Schust., Beih. Nova Hedwigia 119: 223. 2002. *Chandonanthus birmensis* Steph., Bull. Soc. Roy. Bot. Belgique 38: 43. 1899; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 56. 2005; A.P. Singh & Nath, Hepatic. Khasi Jaintia Hills: 1: 88. 2007. *Chandonanthus hirtellus* var. *birmensis* (Steph.) S. Hatt., Fl. E. Himalaya 508. 1966. *Temnoma birmense* (Steph.) S. Hatt., J. Hattori Bot. Lab. 7: 46. 1952.

Plants small, yellow to brownish, 6-8 mm long and 2.10 mm wide including leaves, erect or procumbent, rarely branched; rhizoids colourless and restricted in to the base of the stem; leaves contiguous to imbricate, yellowish brown, obliquely inserted, 0.80-0.90 mm long 0.66 mm wide, usually 2 lobed or rarely 3 lobed, lobes ovate oblong with acuminate apex, sinus descending; dorsal lobe larger, ventral lobes smaller, rarely 1 or few small teeth at base; cells at apex thick walled, 2 cells at tip uniseriate; apical cells, 20-22 µm long and 13 µm wide; median cells thick walled, 12-22 µm in diameter; basal cells slightly thick walled, trigonous, 22-30 µm long and 14-18 µm wide; underleaves bifid, 20 mm long and 0.15 mm wide, sinus deep, lobes oblong to lanceolate with acute apex, margins with 1-2 small teeth; stem circular in outline, cortical cells 1-2 layered, thick walled and tinted, 15-25 µm in diameter; medullary cells thin walled, 13-23 µm in diameter; reproductive structures not seen (Plate 5.57).

Habitat: Epiphytic, on barks in association with *Lopholejeunea subfusca* (Nees) Schiffn. and *Cylindrocolea kiaeri* (Austin) Váňa.

Discussion: Schuster (2002) proposed the combination *Plicanthus birmensis* (Steph.) R.M. Schust. considering *Chandonanthus birmensis* Steph. as basionym. Many have followed *Chandonanthus birmensis* as valid name, but D.K. Singh *et al.*

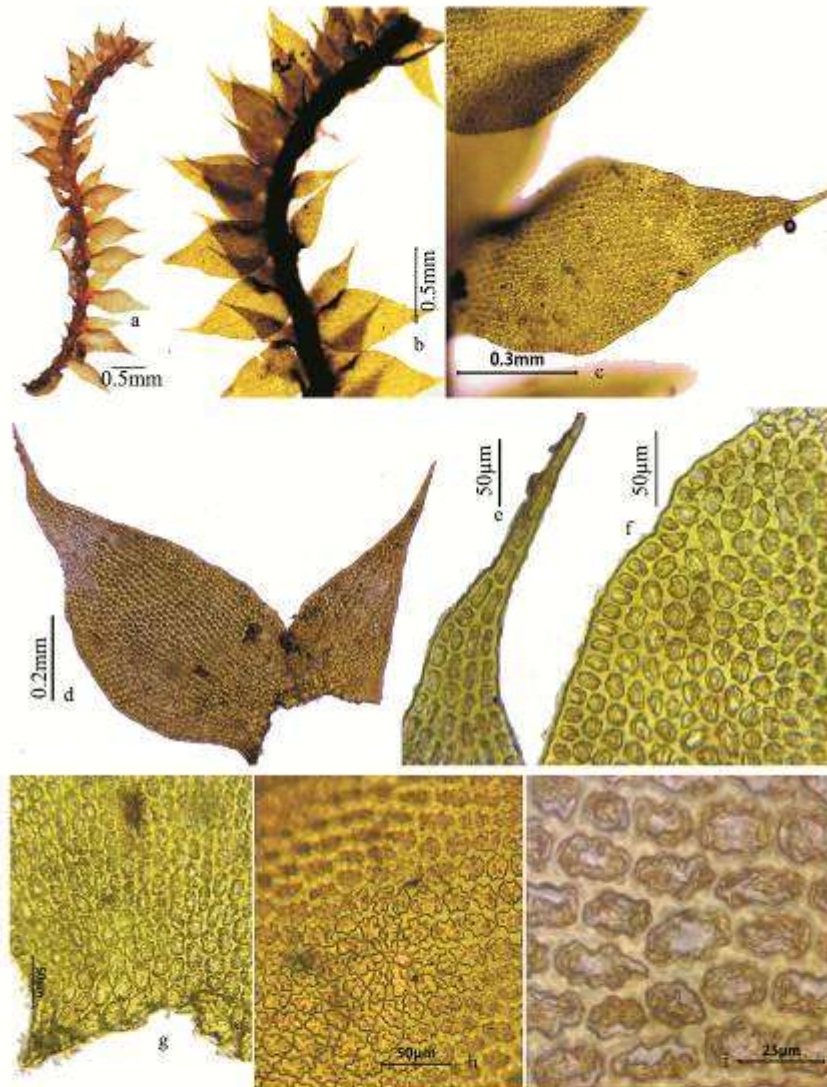


Plate 5. 57: *Plicanthus birmensis* (Steph.) R.M. Schust., a&b. habit, c&d. leaves, e. leaf tip cells, f. leaf marginal cells, g. leaf basal cells, h. leaf middle cells, i. cells enlarged

(2016) followed *Plicanthus birmensis*. Chopra (1943), Udar and Kumar (1982) and Parihar *et al.* (1992) also listed this species from different areas as *Chandonanthus birmensis*. This species is characterised by yellowish brown plants with obliquely inserted 2 or rarely 3 lobed leaves and the lobes ovate oblong with acuminate apex and descending sinus.

Distribution: World: Africa, Japan, Myanmar, Java (Stephani, 1909); **India:** Kerala (Manju *et al.*, 2008), Meghalaya (A.P. Singh & Nath, 2007), Sikkim (Chopra, 1943).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1650 m) 14.07.2017 *Mufeed 7514c* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1380-1740 m) *Manju C.N.* 99605, 120400 (CALI!)

Plicanthus hirtellus (F. Weber) R.M. Schust., *Nova Hedwigia* 74: 492. 2002; Stephani, *Sp. Hepat.* 3: 643.1909; Udar & Kumar, *Geophytology* 12: 63. 1982; Bapna & Kachroo, *Hepatic India* 2: 4. 2000; A.P. Singh & Nath, *Hepatic. Khasi Jaintia Hills*: 88-90. 2007; Daniels & Kariyappa, *Bryofl. Agasthyamalai Bio. Res.*: 379. 2019 (as *Chandonanthus hirtellus*). *Jungermannia hirtella* F. Weber, *Hist. Musc. Hepat. Prodr.* 50. 1815. *Anthelia hirtella* (F. Weber) Steph., *Rev. Bryol.* 18(4): 56. 1891. *Chandonanthus hirtellus* (F. Weber) Mitt., *J. Linn. Soc., Bot.* 22: 321. 1886. *C. perloi* Gola, *Mem. Reale Accad. Sci. Torino, ser. 2* 65: 7. 1914. *Mastigophora madagassa* Steph. *Sp. Hepat.* 4: 40. 1909.

Plants large, reddish yellow to brownish, brittle when dry, compact, filiform, erect, branching limited; rhizoids colourless and confined to the base of the stem; leaves contiguous to imbricate at apex, oblique, 3 lobed, lobes ovate to oblong usually with acuminate apex, sinus descending up to the base; dorsal lobes larger, median and ventral lobes comparatively smaller, ventral lobes having more teeth than the median lobes; leaf apical cells 4, thick walled, uniseriate, 20-25 µm long and 7-9 µm wide, median cells 12-14 µm, marginal cells thick walled, 7 µm long and 13-15 µm wide, basal cells also thick walled, trigonous, 27-30 µm long and 13-18 µm wide; underleaves bifid, 0.70 mm long and 0.45 mm at base, sinus deep, descending up to the base; reproductive structures not seen (Plate 5.58).

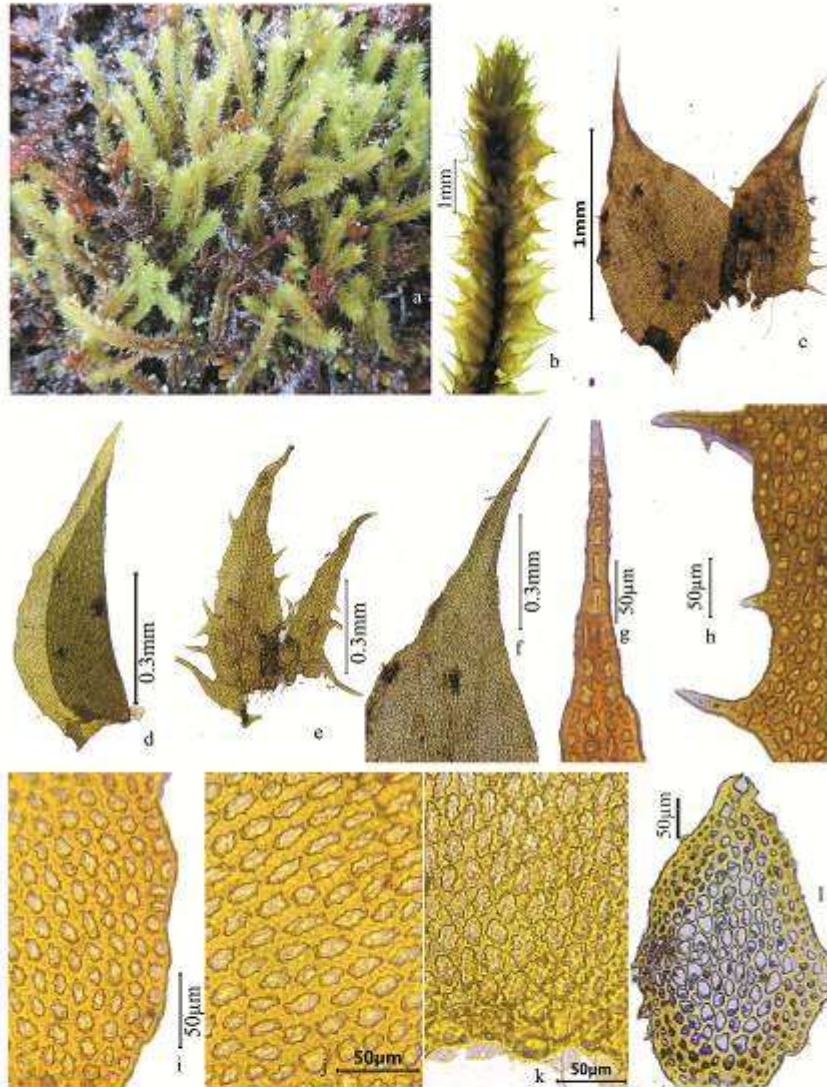


Plate 5. 58: *Plicanthes hirtellus* (F. Weber) R.M. Schust., a. habit, b. branch showing leaf arrangement, c&d. leaves, e. underleaf, f. leaf apex, g. leaf tip cells, h. leaf basal spine, i. leaf marginal cells, j. leaf middle cells, k. leaf basal cells, l. c.s. of stem

Habitat: Plants grow on soil, in association with *Pogonatum neesii* (Müll. Hal.) Dozy and *Frullania tamarisci* (L.) Dumort.

Discussion: Schuster (2002) proposed the combination *Plicanthus hirtellus* (F.Weber) R.M. Schust. for *Jungermannia hirtella* F.Weber thereby making *Chandonanthus hirtellus* (F. Weber) Mitt. a synonym of the former which D.K. Singh *et al.* (2016) followed. But, still many have following *Chandonanthus hirtellus* without considering *Plicanthus hirtellus*. Compared to *Plcanthus birmensis*, *P. hirtellus* is large plants and both the species mostly found in high altitude shola forests.

Distribution: World: Australia, Africa (Figuieredo *et al.*, 2010), Japan, Sri Lanka (Long & Rubasinghe, 2014), Taiwan (Wang *et al.*, 2011); **India:** Kerala, Tamil Nadu (Daniels & Kariyappa, 2019), Meghalaya, Sikkim (A.P. Singh & Nath, 2007).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000 m) 14.07.2017 *Mufeed* 7545, 7567; Iddalymotta (2200 m) 14.07.2017 *Mufeed* 9983; Pullaradi Shola (1900 m) 14.07.2017 *Mufeed* 7446 (ZGC).

ANTHOCEROTOPHYTA Rothm.ex Stotler & Crand. Stotler.,
Bryologist 80 (3): 425. 1977.

The plant body is thalloid form, flattened, lobed; rhizoides hyaline, unicellular; thallus without internal tissue differentiation, pyrenoid present in each cells; capsule horn like, erect.

Anthocerotales Limpr.,
Krypt.-Fl. Schlesien 1(2): 345. 1877.

Anthocerotaceae Dumort.,
Anal. Fam. Pl. 68–69. 1829.

Plants thalloid, prostrate with large cavities, filled with mucilage; epidermal cells chlorophyllose, usually 1 to 4 chloroplasts per cell; *Nostoc* colonies presents throughout the thallus; rhizoids on ventral surface of the thallus; monoicous or dioicous; antheridia 4-5 per cavity with a jacket regularly arranged in four tiers of cells; involucre erect and cylindrical; sporophyte having foot with a defined

placenta, needle-shape, elongated and erect capsule; stomata present in epidermis of capsule; columella typically composed of 16 cells; sporogenous layer 1–2 cells thick, pseudoelaters short and thin-walled, 1–many celled, spores brownish, dark-brown to blackish, with a defined trilete mark, ornamentation spinose or lamellate.

Anthoceros (P.Micheli) L. *emend.* Prosk.,
Bull. Torrey Bot. Club 78(4): 346. 1951.

Plants spongy, thalloid, lobed, suberect, isolated or in rosette of variable morphological forms, margins deeply dissected, internally with 1-3 layers of mucilage chambers; upper epidermal layer with one sub-spherical or stellate chloroplast per cell, pyrenoid present in the central region, composite; monoicous or dioicous, androecia intercalary, arranged along median line or throughout; capsule erect, bivalved, dehiscing longitudinally from apex to base, spores brown to dark brown; pseudoelaters 1-4 (-5) celled.

Anthoceros crispulus (Mont.) Douin, Rev. Bryol. 32: 27. 1905; A.K. Asthana & S.C. Srivast. Pl. Sci. Tod. 97: 385. 1987; A.K. Asthana & S.C.Srivast., Bryophyt. Bibl. 42: 30. 1991; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 69. 2000; Nair *et al.*, Bryo. Wayanad, W. Ghats 80. 2005; S.K. Singh, Geophytology, 42(2): 164. 2013. *A. punctatus* L., Sp. Pl. 2: 1139. 1753. *A. punctatus* var. *crispulus* Mont., in Webber & Berthelot, Hist. Ins. Can. Bot. 2(4): 64. 1840. *A. meeboldii* Steph., Sp. Hepat. 5:1004. 1916. *Folioceros pandei* Udar & Shaheen, Geophytology 12: 78-80. 1982.

Plants green, thalli spongy, radially arranged in form of rosette, up to 2 cm in diameter, dorsal surface covered with radially oriented lamellate outgrowths; involucre narrow and long up to 5 mm; upper epidermal layer with one sub-spherical chloroplast per cell, two pyrenoids per cell in the central region of chloroplast; monoicous, antheridial chamber showing 1 or 2 antheridia, archegonia immersed on the thallus; stomata usually seen in epidermal layers of spore wall, inner layer lining the cells of capsule wall with occasional irregular thickening bands; spores dark-brown, 31-40 µm in diameter with distinct proximal and distal faces, the surface is usually reticulate on all faces; while numerous spines arise from the distal face, spines acute to sub-acute with adhering tendency; elaters light-

brown, up to 3-celled, 100-110 µm long and 15 µm wide, sometimes branched (Plate 5.59).

Habitat: Terricolous, seen mostly in moist land cuttings and on soil along with several mosses at an altitude above 2000 m in grasslands.

Discussion: *Anthoceros crispulus* (Mont.) Douin is a widely distributed species in India from low to high altitude areas. In India, the species was first reported by S.K. Pande and Ahmad (1944) from Lucknow. Later, A.K. Asthana & S.C. Srivasatava (1991) extended the distribution of this taxon, to Nilgiri hills of South India. This species was first reported from Kerala by Stephani (1916) as *A. meeboldii* Steph. (A.K. Asthana & S.C. Srivasatava (1991). During recent years it is reported from different localities of Kerala from low altitudes of Kozhikode district to high altitudes of Idukki district. This species is characterized by its spongy thallus arranged in the form of rosette, two pyrenoids in the chloroplast of epidermal cells and the sporophyte is narrow and cylindrical with stomata on spore wall.

Distribution: World: China (Peng & Zhu, 2013), Europe, Indonesia, Japan, Java, Nepal, North America, South America, Yunnan (Hasegawa, 1984), Hong Kong (Zhao *et al.*, 2002), Taiwan (Piippo, 1990); **India:** Karnataka (Frahm, 2013), Kerala (Nair *et al.*, 2005; Manju *et al.*, 2008; Manju & Rajsh, 2009), Uttar Pradesh (S.K.Pande & Ahmad, 1944; S.K. Singh, 2013), Tamil Nadu (S.C. Srivastava & A.K. Asthana, 1987; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2190-2350 m) 22.09.2018 *Mufeed* 9917,9922; Pullaradi Shola (2300 m) 27.09.2018 *Mufeed* 9887 (ZGC).

Other specimen/s examined: India, Kerala, Wayanand district, Periya (920 m) *Manju* 80116 (CALI!); Tamil Nadu, Oottakkamund (2100 m) 10.10.2000 S.C. *Srivastava* 12687 (LWU!).

Notothyladales Hyvönen & Piippo,
J. Hattori Bot. Lab. 74: 117. 1993.

Notothyladaceae Müll. Frib. ex Prosk.,
Phytomorphology 10: 10. 1960.

Plants prostrate, orbicular-suborbicular, dichotomously branched, forming isolated-confluent rosettes; lobes laciniate; thalli ecostate, solid, 9 or 10 cell layers thick,



Plate 5. 59: *Anthoceros crispulus* (Mont.) Douin a & b. habit, c. single thallus, d & e. elaters, f. antheridium, g. c.s. of thallus, h. epidermal cells, i. c.s. of spore, j. spore, k. spore enlarged

dorsal surface smooth, sometimes ridged or lamellate; dorsal epidermal cells rectangular to polygonal, pyrenoid one per chloroplast or absent; *Nostoc* colonies occur irregularly on ventral side; monoicous or dioicous.

***Phaeoceros* Prosk.,**

Bull. Torrey Bot. Club 78(4): 346–347. 1951.

Thallus smooth and solid, yellow green to dark green, small to medium sized, irregularly branched, biconvex to planoconcave to concave-convex; *Nostoc* colonies scattered through ventral half of thallus, appearing as dark dots; rhizoids ventral, hyaline, or pale brown, tubers present in some species; monoicous or dioicous; irregularly arranged jacket cells of the antheridia; spores yellow to bright yellow, pseudoelaters thin walled, frequently branched.

Phaeoceros carolinianus (Michx.) Prosk., Bull. Torrey Bot. Club 78: 347. 1951; A.K. Asthana & S.C.Srivast., Bryophyt. Bibl. 42: 125. 1991; S.K. Singh & D.K. Singh, Cryptog. Bryol. 28: 254. 2007 & Hepat. Anthocerot. Gt. Himal. Natl. Pk.:408.2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 160. 2013; D.K. Singh *et al.*, Liverw. & Hornw. India: 283. 2016. *Anthoceros carolinianus* Michx., Fl. Bor.-Amer. 2: 280. 1803. *A. callistictus* Spruce, Trans. & Proc. Bot. Soc. Edinburgh 15: 576. 1885. *A. communis* Steph., Bull. Herb. Boissier 5: 86. 1897. *A. ecklonii* Steph., Sp. Hepat. 5: 978. 1916. *A. tenuissimus* Steph., Hedwigia 32: 145. 1893. *A. usambarensis* Steph., Denkschr. Kaiserl. Akad. Wiss., Wien Math.-Naturwiss. Kl. 88: 733. 1913. *Phaeoceros communis* (Steph.) Schiffn. & Pande in Pande & K.P. Srivast., J. Indian Bot. Soc. 31: 346. 1952. *P. laevis* subsp. *carolinianus* (Michx.) Prosk., Rapp. Comm., VIII Congr. Int. Bot. 69. 1954. *P. jackii* (Steph.) Bapna, Univ. Udaipur Res. Stud. 3: 138. 1965. *P. gollani* (Steph.) Bapna, J. Indian Bot. Soc. 56: 84. 1977. *P. tenax* (Steph.) Udar & D.K. Singh, *ibid.* *P. cataractarum* (Steph.) Udar & D.K. Singh, *ibid.* *P. esquirolii* (Steph.) Udar & D.K. Singh, Geophytology 11: 257. 1981.

Monoicous, thallus small to medium in size, ribbon like, forming rosettes, patches or mats, furcate to irregularly branched, thallus solid, 8–10 cells thick in transverse section, cells compact, usually biconvex to concave-convex; dorsal epidermal cells quadrate to hexagonal, 20-35 × 30-50 µm, internal cells 24-58 × 20-50 µm; rhizoids

ventral, pitted, hyaline, or pale brown; involucre erect, conical to cylindrical, up to 6 mm long, contracted at the mouth; androecial chambers on female thallus, 3-5 antheridia per chamber, capsule up to 80 mm long, exerted, opening by two valves becoming twisted when dried, well-developed columella, becoming yellow and then dark brown with age from the apex down; assimilative layer 4-5 cells thick and sporogenous layer of two rows of spores, stomata present in the capsule wall, spores yellowish green with papillate sporoderm, rounded-tetrahedral, equatorial, 42-48 μm diagonally; pseudoelaters short and stumpy, thin walled, up to 5 cells in length, frequently branched, 112-188 x 10 μm wide, pale brown (Plate 5.60 & 61).

Habitat: Terrestrial, usually growing on land cuttings along with *Pogonatum neesii* (Müll. Hal.) Dozy and *Philonotis falcata* (Hook.) Mitt. in grasslands.

Discussion: *Phaeoceros carolinianus* is a widely distributed and common species worldwide (Hässel de Menéndez, 1987; Schuster 1992). In India also it is very common but the species was reported by most of the authors under *Phaeoceros laevis* subsp. *carolinianus*. *P. carolinianus* is closely related to *Phaeoceros laevis* (L.) Prosk. another common species of *Phaeoceros* in its thallus morphology. But they differ in nature of sexuality, the sexual character and spore patterns distinguish these two species. *P. laevis* is a dioicous species and spores are usually densely impregnated with minute papillae and pseudoelaters are branched, but *P. carolinianus* is a monoicous species and the spores are bright yellowish green with papillate sporoderm and the pseudoelaters are short and stumpy (A.K. Asthana & S.C. Srivastava, 1991). This species was earlier reported from Tamil Nadu in South India by A.K. Asthana & S.C. Srivastava (1991). Later, Daniels (2010) reported this species from Kanyakumari district of Tamil Nadu. This species was not reported from Kerala earlier. Hence the present collection is a new record of occurrence to Kerala.

Distribution: World: Australia (Cargill & Fuhrer, 2008), Japan (Furuki & Mizutani, 1994), Russia (Konstantinova *et al.*, 1992); **India:** Arunachal Pradesh, Meghalaya, Manipur, Rajasthan, Sikkim, Uttarakhand, Uttar Pradesh, West Bengal (A.K. Asthana & S.C. Srivastava, 1991; D.K. Singh *et al.*, 2016), Himachal Pradesh (S.K. Singh & D.K. Singh, 2010), Kerala (present collection), Madhya Pradesh (A.K. Asthana & S.C. Srivastava, 1991; A.K. Asthana & Gupta, 2015), Maharashtra

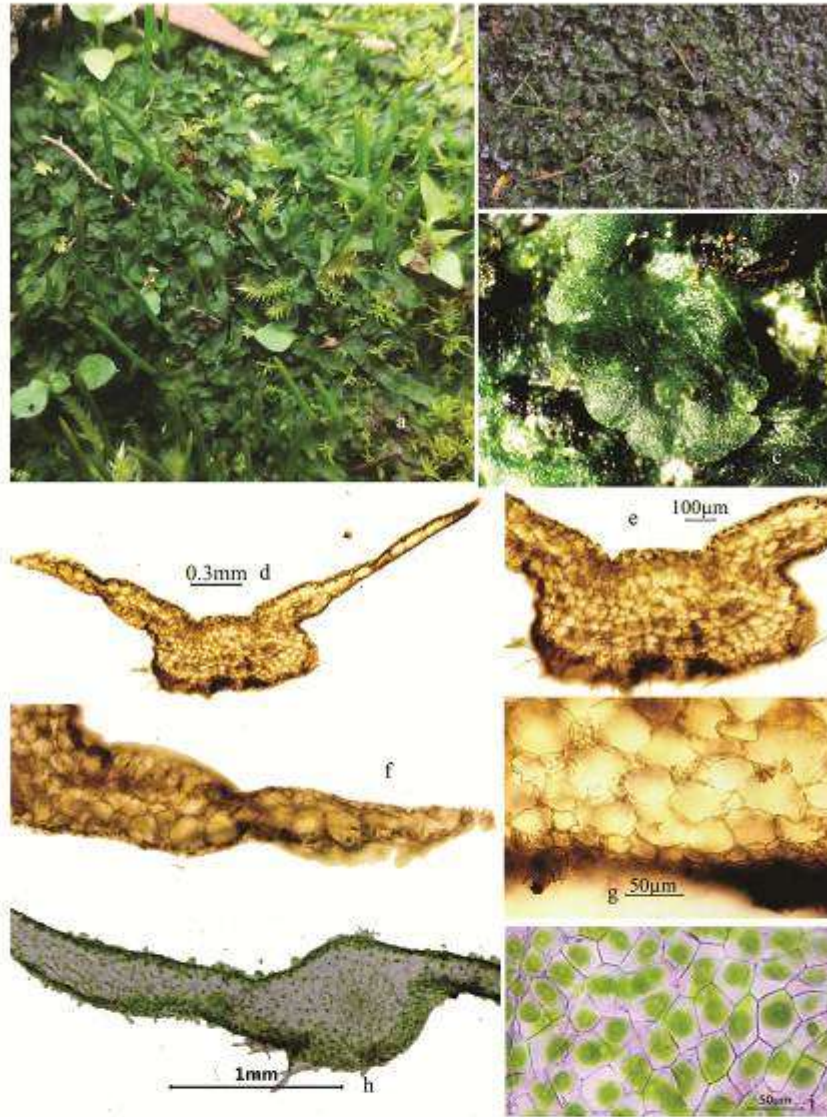


Plate 5. 60: *Phaeoceros carolinianus* (Michx.) Prosk. a&b. habit, c. enlarged view of single thallus, d&h. c.s. of thallus, e&g. enlarged view of central region, f. margin of thallus enlarged, i. epidermal cells

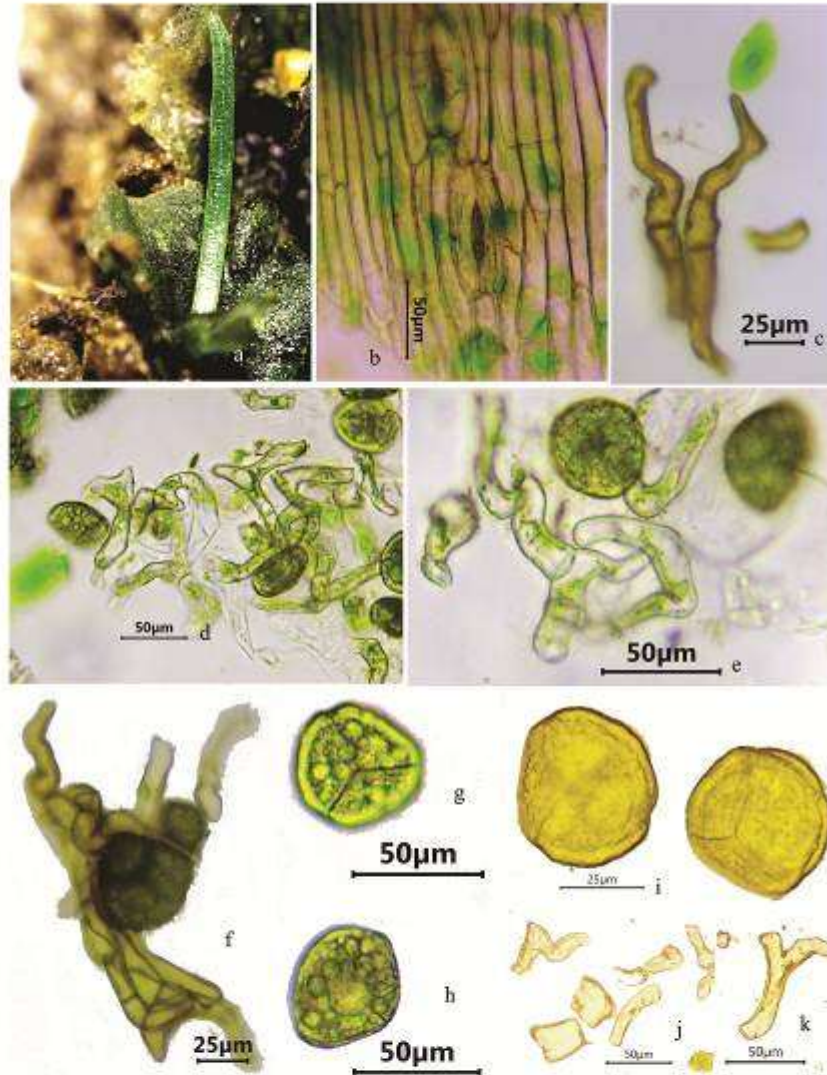


Plate 5. 61: *Phaeoceros carolinianus* (Michx.) Prosk. a. single thallus with sporophyte, b. stomata on the sporophyte wall, c-k. different views of the spores and elaters.

(Chaudhary *et al.*, 2008), Odisha (Dash & Saxena, 2009), Tamil Nadu (A.K. Asthana & S.C. Srivastava, 1991; Daniels, 2010; Daniels & Daniel, 2013) (All collections based on *P. laevis* subsp. *carolinianus*).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 24.09.2018 *Mufeed* 9963 (ZGC).

BRYOPHYTA Schimp.,

Handb. Paleophyt.1. 1879.

Plants foliose, leaves usually many ranked, spirally arranged, rarely distichous, costate or ecostate, laminar cells isodiametric to linearly elongated; seta short or long; capsules vary in shape with mouth, operculum and peristome teeth. Mosses are the most diversified group of bryophytes. Gametophyte is either erect or prostrate, branched or not, midrib prominent, single or double, rhizoids multicellular and branched; sporophyte differentiated into foot, seta and capsule.

Polytrichales Cavers,

New Phytologist 10(1–2): 31. 1911.

Polytrichaceae Schwägr.,

Sp. Musc. Frond. 1. 1830.

Plants erect, stiff, up to 15 cm high, usually unbranched; leaves lamellose, lingulate to linear lanceolate, base broader, differentiated into a sheathing proximal and a spreading distal part, microphyllous in basal regions of the stem, teeth on the back of the leaves, fully or partially; costa single, strong, percurrent; dioicous or autoicous; seta long, capsule erect or inclined, peristome single rowed, teeth 32-64.

Pogonatum P. Beauv.,

Mag. Encycl. 9(5[19]): 329. 1804.

Plants greenish, dark blackish when dry, erect, varying in size, often tall and showy, 2-10cm or more high, stem innovating from creeping underground rhizome, occasionally branched above; leaves large, not bordered, sharply toothed on top; costa broad, sometimes toothed but not lamellate at the back, entire or crenulated along the upper margin, sheathing lamina at base of leaf, attached to stem; seta long, erect, capsule erect or suberect, grooved when dry, peristome teeth 32, one rowed,

rarely 16, calyptra hairy, covers the entire capsule.

Key to the species

- 1a. Plants tall, up to 50 mm high, apical cells of lamellae ends with bottled shape..
..... ***P. microstomum***
- 1b. Plants medium sized, up to 30 mm high, apical cells of lamellae ends with
depressed ***P. neesii***

Pogonatum microstomum (R.Br. ex Schwägr.) Brid., Bryol. Univ. 2: 745. 1827; Bruehl, Rec. Bot. Surv. India 13(1): 117. 1931; Gangulee, Mosses E. India & Adj. Reg. 1(1): 143. 1969; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 94. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 16. 2008; Daniels, Arch. Bryol. 79. 2010. *Polytrichum microstomum* R.Br. ex Schwägr., Sp. Musc. Frond., Suppl. 2 2(1): 10. pl. 154. 1826. *Pogonatum longicollum* P.C. Chen & T.L. Wan, Gen. Musc. Sin. 2: 304. 1978. *P. macrocarpon* Broth., Symb. Sin. 4: 135. 1929. *P. minutum* Brid., Bryol. Univ. 2: 127. 1827. *Polytrichum clavatum* Dozy & Molk., Pl. Jungh. 3: 326. 1854. *Pogonatum mirabile* Horik., Bot. Mag. (Tokyo) 49: 671. 26. 1935. *P. paucidens* Besch., Rev. Bryol. 18: 89. 1891; *P. subclavatum* Dixon, Ann. Bryol. 12: 56. 1939.

Plants tall, 50-70 mm long, green, robust, tufted; stem erect, unbranched, reddish brown, basal part densely covered with rhizoids and scale leaves; leaves spirally arranged, upper leaves stiff, 9-11 mm long and 1-2 mm wide; basal leaves very small, upto 3 mm long, incurved when dry; apex acute, leaf sheaths well developed; cells at sheathing area long, rectangular becoming shorter and thick walled at the middle, apical cells rounded to slightly quadrate, 24-26 µm diagonally, leaf marginal cells rectangular, small, 9 µm long and 11 µm wide; basal cells quadrate to pentagonal, cells at near base, 13-37 µm long and 12-19 µm wide; gradually elongated at the extreme base, 10-17 µm long and 35-67 µm wide; costa percurrent, pairs of tooth on abaxial side of the costa; margin dentate at top, hyaline, thin walled, basal marginal cells forms an hair like appendages; leaf lamellae numerous, arranged compactly in ventral face, 4 or 5 cells high; tip cells thin walled, much larger and divided into a two flask shaped forks; seta 1cm long; capsule erect or sub erect, reddish brown, up to 2.5 mm long and 1 mm diameter (Plate 5.62 & 63).

Habitat: Mostly lithophytic, the specimen harbors on rocky patches, on crevices of rocks and on land cuttings in shola forests along with *Pogonatum neesii* (Müll. Hal.)

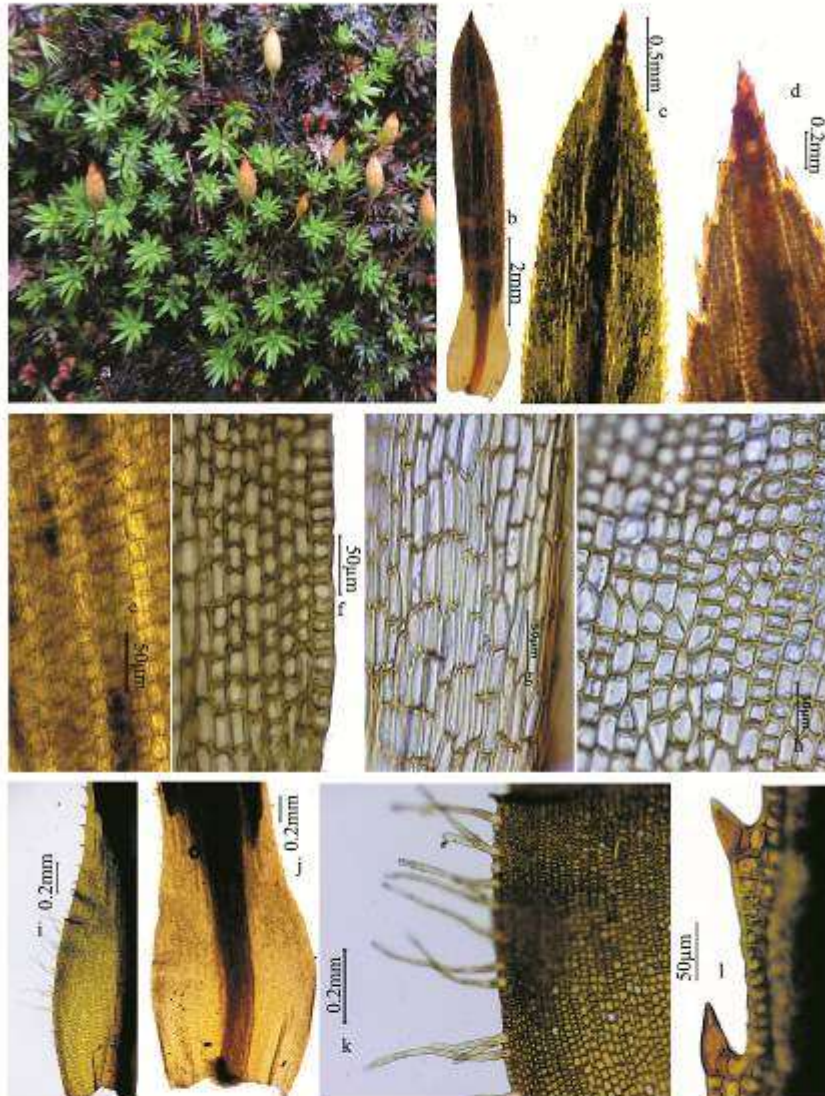


Plate 5. 62: *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid., a. habit, b. leaf, c&d. leaf apex, e. leaf middle cells, f. leaf margin, g&h. cells near base, i&j. leaf sheathing base, k. marginal cells with hairy outgrowth, l. leaf marginal spine

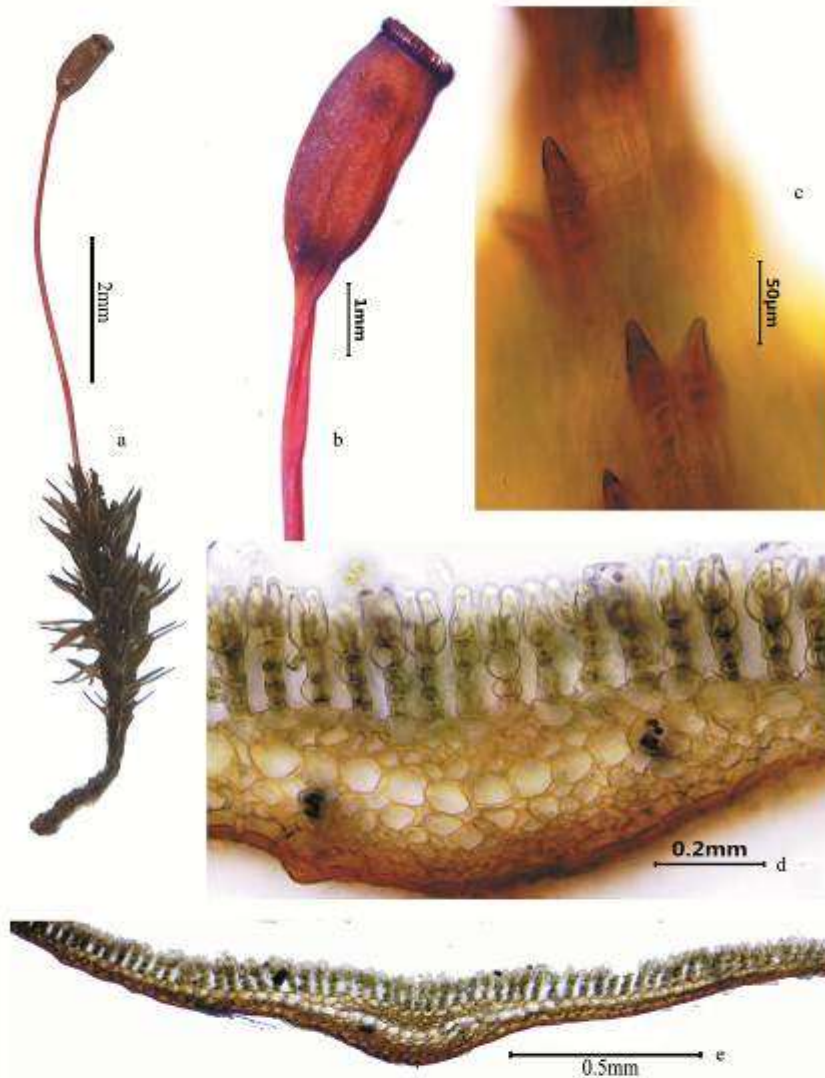


Plate 5. 63: *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid., a. habit with sporophyte, b. capsule, c. lamellae spine, d&e. c.s. of stem

Dozy and *Gottschelia schizoplura* (Spruce) Grolle.

Discussion: *Pogonatum microstomum* is a South-East Asiatic species. It is a common species in high altitude mountains of Kerala, earlier reported from Wayanad district by Nair *et al.* (2005). Gangulee (1969) also reported this species from Eastern Himalayas. This species is characterized by tall plants with attractively greenish or olive green in color and the c.s. of leaf lamellae shows two flask shaped forks at the tip of epidermal cells. Aruna & Krishnappa (2018) studied the antimicrobial properties of *P. microstomum* recently from Karnataka.

Distribution: World: China (Wang & Luo, 1994), Philippines (Tan & Iwatsuki, 1991), Sri Lanka (Wasala & Rubasinghe, 2019), Taiwan (Hyvönen & Lai, 1991); **India:** Eastern Himalayas (Gangulee, 1969), Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2005; Madhusoodanan *et al.*, 2007), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Mannavan Shola, Anamudi Shola National Park (1776 m) 02.08.2015 *Mufeed 13327* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad, Periya (940m) *Manju C.N. 99614*; Chembra hills (1420 m) *Manju C.N. 120397* (CALI!).

Pogonatum neesii (Müll. Hal.) Dozy, Ned. Kruidk. Arch. 4(1): 75. 1856; Bruehl, Rec. Bot. Surv. India 13(1): 118. 1931; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 16. 2008; Daniels, Arch. Bryol. 65: 79. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 12. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 18. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 21. 2019. *Polytrichum neesii* Müll. Hal., Syn. Musc. Frond. 2: 563. 1851. *Pogonatum aloides* (Hedw.) P. Beauv. forma *neesii* (Müll. Hal.) Gangulee, Mosses E. India & Adj. Reg. 1(1): 103. 1969; Dabhade, Moss. Khandala: 47. 1998; Nair *et al.*, Geophytology 36 (1 & 2): 10. 2006.

Plants small, up to 30 mm long, greenish, turn to dark brown when dry; stem simple, usually unbranched, leaves closely arranged in upper part, distally arranged scale leaves at base; leaves lanceolate, up to 6-8 mm long and 1 mm wide, apex sharply acute, serrated, slightly sheathing margin, wider hyaline base; costa shortly excurrent, toothed at top back; lamellae numerous, covering almost entire ventral surface of leaf, 5 cells high, end cell slightly larger, flat and notched at top; apical

cells rounded to quadrate, 11-19 µm, basal cells rectangular, 7-12 µm long and 11-25 µm wide; sporophyte usually longer than plant size, seta long, straight, up to 30 mm, capsule straight, smooth, ribbed when dry, up to 5 x 1.5 mm, exothelial cells with minute projection in one side (Plate 5.64).

Habitat: Terrestrial, on land cuttings of truck paths, usually associated with *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid., *Plicanthus hirtellus* (F. Weber) R.M. Schust. and *Gottschelia schizoplura* (Spruce) Grolle in shola forests.

Discussion: The species is described as *Pogonatum aloides* fo. *neesii* (Müll. Hal.) Gangulee by Gangulee (1969), in his work Mosses of Eastern India, by considering a very close species of *Pogonatum aloides*. It was earlier reported from Chinnar Wildlife Sanctuary of Idukki district in Kerala (Nair *et al.*, 2006). This species is characterized by usually small in size, leaves are crumpled or curled when dry, well developed lamellae, covering the ventral surface of the leaf and the ends of the lamellae flat and notched at top.

Distribution: World: Australia, Papua New Guinea, New Zealand (Ramsay, 1997), China (Hyvönen & Koponen, 2019), Nepal (Gangulee, 1969), Borneo, Celebes, Indonesia, Java, Malaysia, Philippines, Sumatra (Hyvönen, 1989), Sri Lanka (Wasala & Rubasinghe, 2019), Thailand (Sukkharak & Chantanaorrapint, 2014), Vietnam, Russia (Akatova & Ignatova, 2000); **India:** Eastern Hiamalayas (Gangulee 1969), Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2006), Madhya Pradesh (Alam, 2015), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1950-2400 m) 02.08.2015 *Mufeed 10028*; 01.03.2016 *Mufeed 10002a* (ZGC).

Other Specimen/s examined: India, Kerala, Idukki district, Chinnar WLS, Way to Olikkudi (1650 m) *Manju C.N. 87406* (CALI!).

Timmiales Ochyra,
Biodiversity of Poland 3: 102. 2003.
Timmiaceae Schimp.,
Coroll. Bryol. Eur. 87. 1856.

Plants tall and robust resembling the members of Polytrichaceae, leaf with a

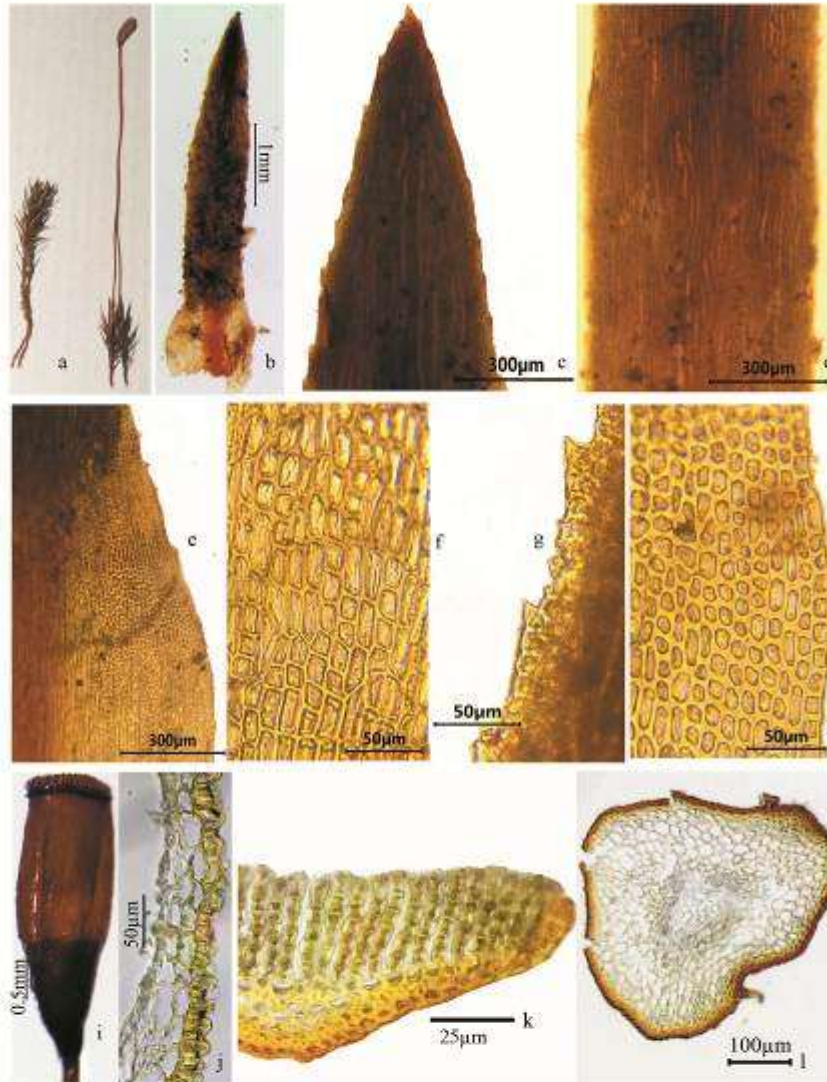


Plate 5. 64: *Pogonatum neesii* (Müll. Hal.) Dozy, a. habit, b. leaf, c. leaf apex, d. leaf middle, e. cells near base, f. cells near middle, g. leaf marginal cells at lamina, h. leaf cells at sheathing base, i. capsule, j. c.s. of capsule wall, k. c.s. of leaf, l. c.s. of stem

sheathing base, leaf lamina with serrate margins but lack the very wide costa, c.s of leaf shows longitudinal lamellae, the cells on the upper surface show mamilllose development; capsule symmetrical, elliptical oblong with a tapering apophysis, usually inclined or horizontal, lightly furrowed when dry.

Timmia Hedw.,

Sp. Musc. Frond. 176. 1801.

Timmiaceae are a monogeneric family with the genus *Timmia*, including four species worldwide (Budke & Goffinet, 2006). Hence the family characters and genus characters are similar.

Timmia megapolitana Hedw., Sp. Musc. Frond. 176. 1801; Gangulee, Mosses E. India & Adj. Reg. 1974. *Mnium megapolitanum* (Hedw.) J.F. Gmel. ex P. Beauv., Mém. Soc. Linn. Paris 1: 465. 1823. *Orthopyxis megapolitana* (Hedw.) P. Beauv., Prodr. Aethéogam. 79. 1805. *Grevillea serratum* L.C. Beck & E mmons, Amer. J. Sci. Arts 11: 183. pl. 1: a–3. 1826. *Timmia bavarica* Hessel., De Timmia 19. f. 3. 1822. *Timmia cucullata* Michx., Fl. Bor.-Amer. 2: 304. 1803.

Plants yellowish green, brownish below, erect, forming dense to loose tufts; stem erect, up to 1-2 cm long, unbranched; leaves gradually reduced the size towards base, upper leaves about 5 mm long, 1 mm wide at base, more widely spaced below and interspersed with papillose rhizoids, leaf apex acute, leaves flexuous or crisped when dry, usually with a sheathing base and a lamina with serrate margin, slightly wavy, toothed from apex of leaf to a little down the base, sheath clear or pale yellowish; costa strong, sub-percurrent; laminal cells round to hexagonal, 7-14 µm, cells at base smooth, thin walled, rectangular, 50-75 µm long and 12-14 µm wide; marginal cells forming spines, 10–20 × 10 µm; sporophytes not seen (Plate 5.65).

Habitat: Lithophytic and also terrestrial, on soil patches and crevices of rocks. Associated species are *Hymenostylium recurvirostrum* (Hedw.) Dixon and *Ctenidium lychnites* (Mitt.) Broth. in shola forest at lower elevation.

Discussion: *Timmia megapolitana* Hedw. is commonly found on calcareous soil, during the present study also it is collected from rocky patch. Maniselvan & Kumar (2000) reported this species from Tamil Nadu as *Timmia cucullata* Michx. Abramov

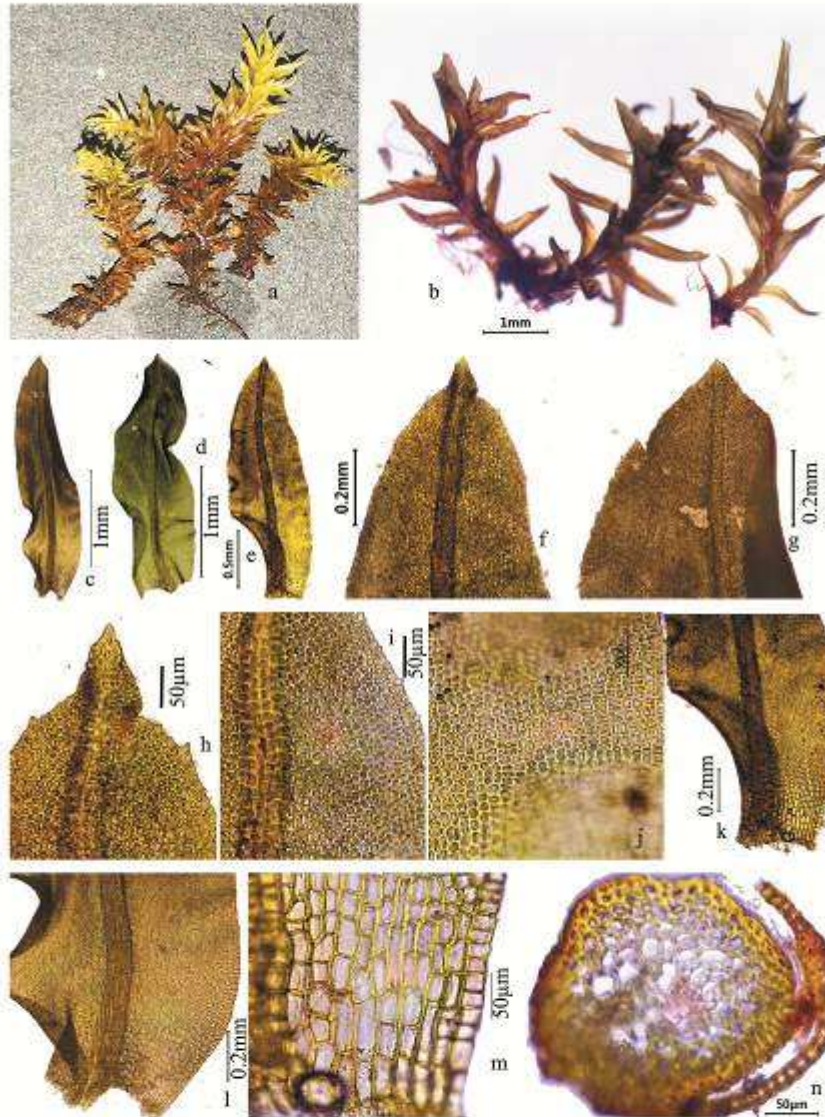


Plate 5. 65: *Timmia megapolitana* Hedw., a&b. habit, c,d&e. leaves, f&g. leaf tip, h. leaf tip cells, i. cells near apex, j. leaf cells middle, k&l. leaf base, m. leaf basal cells, n. c.s. of stem

& Abramova (1983) has synonymised this species under *T. megapolitana*. The present collection from Anamudi Shola National Park is a new record for Kerala. It is a distinct species in the genus characterized by the plants with yellowish green above and brownish below, leaves usually with a distinct sheathing base and serrate leaf margin at apex.

Distribution: World: Bhutan (Long, 1994), China (Zhao & Han, 1999), Europe, North America (Holzinger, 1920), Japan (Noguchi & Iwatzuki, 1989); **India:** Jammu & Kashmir (Thoker & Patel, 2019), Kerala (present collection), Punjab (Rawat *et al.*, 2015), Uttaranchal (Kumar & Singh, 2002), Tamil Nadu (Maniselvan & Kumar, 2000; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1772 m) 02.08.2015 *Mufeed 13330b* (ZGC).

Funariales M. Fleisch.,
Hedwigia 61(4): 393–394. 1920.

Funariaceae Schwägr.,
Sp. Musc. Frond. 43. 1830.

Plants acrocarpic, yellowish green, very small and medium sized, usually seen in terrestrial habitats and also seen in disturbed areas of forests; leaves broad at top and size reduce at base; costa percurrent or slightly excurrent; apex acuminate, margin usually entire at base and slightly wavy at apex; cells smooth, thin walled, usually large, rhomboidal at apex and rectangular at basal regions; capsule ovoid to pyriform, erect or inclined; peristome 16 toothed.

Key to the genera

- 1a. Capsule mostly symmetric and erect; peristome rudimentary or absent ***Entosthodon***
- 1b. Capsule asymmetric and inclined to horizontal; peristome deeply inserted, single or double ***Funaria***

Entosthodon Schwägr.,
Sp. Musc. Frond., Suppl. 2 1: 44. 1823.

Plants greenish, usually growing in open clusters, associated with grasses, very

small, up to 10 mm long including sporophyte; stem small, bears small leaves at base and large rosette at top; leaves ovate-lanceolate to oblong-lanceolate, 5.5 x 1.5 mm, margin usually dentate at apex; costa ending below the apex; cells thin walled, chlorophyllose, hexagonal to rhomboidal at apex and margin, cells at base rectangular; seta erect, reddish brown, capsule usually erect, symmetric.

Entosthodon wichurae M. Fleisch., Musci Buitenzorg 2: 481. 1904; Gangulee, Mosses E. India & Adj. Reg. 2(4): 853. 1974; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 571. 2001; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 119. 2005; Manju & Rajesh, Acta Bot. Hung. 51(3-4): 331. 2009; Manju *et al.*, Taiwania 54(1): 61. 2009. *Brachymenium cagnii* G. Negri, Ann. Bot. (Rome) 7: 167. 1908. *Entosthodon brassii* E.B. Bartram, Lloydia 5: 258. 1942. *E. contortus* E.B. Bartram, Lloydia 5: 259. 1942. *E. lutschianus* Müll. Hal., Index Bryol. Suppl. 141. 1900. *Funaria lutschiana* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 62A(9): 15. 1921. *Physcomitrium kiusiense* Sakurai, Bot. Mag. (Tokyo) 46: 738. 1932.

Plants yellowish green, small, up to 10 mm long, unbranched; stem short with small leaves below and large leaves of rosette on top, crumbled when dry; leaves lanceolate, 5.5 mm long and 1.5 mm wide at middle, narrow base and acute tip; costa ending below the apex; laminal cells thin walled, large rectangular near vein, shorter near margin, marginal cells slightly serrate near the tip; apical cells rhomboidal, 100-105 µm long and 8-12 µm wide, basal cells 95-165 µm long and 35-45 µm wide, marginal cells elongate rhomboidal, 165 µm long and 16 µm wide, cells near costa smaller, rectangular, 57-77 µm long and 20-25 µm wide; seta apical, erect; capsule erect, 2x1.4 mm, symmetrical; spores large, rounded, 20 µm diagonally, reddish brown, rough (Plate 5.66).

Habitat: Lithophytic, seen in land cuttings, large rocks and stones near streams and open grasslands.

Discussion: A South-East Asiatic species, mostly found in the high altitude temperate forests. In India, Gangulee (1974) reported this species from Eastern Himalayas. In Kerala it is a very common species in the grasslands along shola forests of high altitude mountains. The present collection from Anamudi Shola National Park shows large size of plants compared to other ones. It is characterized by small plants up to 10 mm long, usually sporophytes are larger than gametophytes

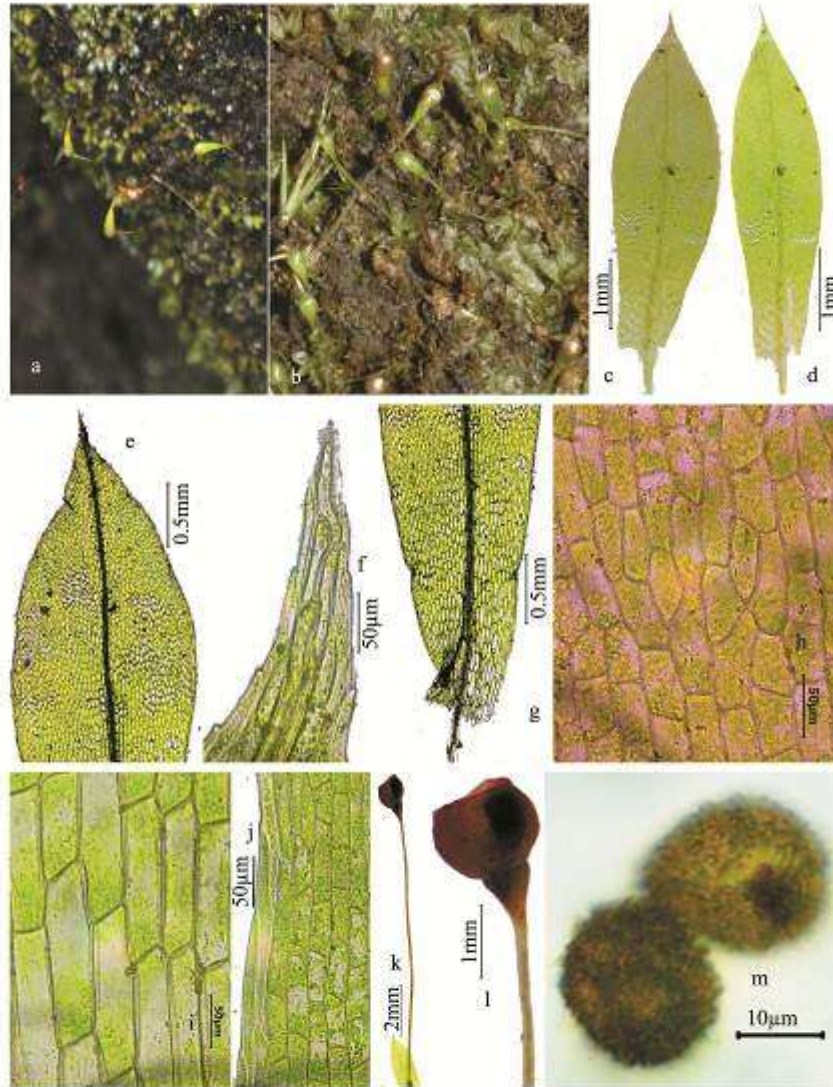


Plate 5. 66: *Entosthodon wichurae* M. Fleisch., a&b. habit, c&d. leaves, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf middle cells, i. leaf basal cells, j. leaf marginal cells, k&l. sporophyte, m. spores

and symmetric capsule with rough spores.

Distribution: World: Indonesia (Ho *et al.*, 2006), Philippines (Tan & Iwatzuki, 1991), Sri Lanka (O'Shea, 2002), Uganda (O'Shea, 2006); **India:** Kerala (Nair *et al.*, 2005; Manju *et al.*, 2009), Meghalaya, Uttar Pradesh (Gangulee, 1974; Sahu & Asthana, 2015), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2000 m) 02.08.2015 *Mufeed 13370* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1120-1450m) *Manju C.N. 120247, 120291* (CALI).

***Funaria* Hedw.,**

Sp. Musc. Frond. 172. 1801.

Plants usually yellowish green, acrocarpic, inhabit in loose tufts; leaves broad or more concave and leaves at top forms a conspicuous rosette; costa percurrent or shortly excurrent; cells almost same from top to bottom, thin walled, rectangular to hexagonal, large cells near costa and base, cells reduced in size at margin and tip; sporophyte usually long, yellowish or orange, seta erect, capsule asymmetric, slightly pendulous to drooping at maturity; spores rounded, medium sized.

***Funaria hygrometrica* Hedw.,** Sp. Musc. Frond. 172. 1801; Dixon, J. Bot. 47: 158. 1909 & J. Bombay Nat. Hist. Soc. 39: 778. 1937; Bruehl, Rec. Bot. Surv. India 13(1): 46. 1931; Gangulee, Mosses E. India & Adj. Reg. 2(4): 856. 1974; Chopra, Taxon Indian Moss. 185. 1975; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 120. 2005; Chaudhary *et al.*, Bryoph. Fl. Gujarat 98. 2006 & Bryoph. Fl. N. Konkan 151. 2008; Manju *et al.*, Arch. Bryol. 42: 7. 2009; Daniels, Arch. Bryol. 65: 59. 2010; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 119. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 135. 2019. *Mnium hygrometricum* (Hedw.) With., Syst. Arr. Brit. Pl. (ed. 4) 3: 787. 1801. *Koehltreutera hygrometrica* (Hedw.) Grindel, Bot. Taschenb. 317. 1803. *Funaria calvescens* Schwägr., Sp. Musc. Frond., Suppl. 1 2: 77, pl. 65. 1816. *F. angustifolia* Brid., Muscol. Recent. Suppl. 3: 71. 1817. *Strephedium hygrometricum* (Hedw.) P. Beauv., Nomencl. Bot. 2: 406. 1824. *Funaria androgyna* Brid., Bryol. Univ. 2: 58. 1827. *F. ramificans* Brid., Bryol. Univ. 2: 738. 1827. *F. campylopus* Brid., Bryol. Univ. 2: 739. 1827. *F. connivens* Müll.

Hal., Bot. Zeitung (Berlin) 13: 747. 1855. *F. gracilescens* Schimp. ex Müll. Hal., Bot. Zeitung (Berlin) 16: 154. 1858. *F. convoluta* Hampe, Linnaea 30: 455. 1860. *F. marginata* Kindb., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 7(9): 79. 1883. *F. lonchopelma* Müll. Hal., Hedwigia 38: 61. 1899; *F. megapoda* Müll. Hal., Bull. Herb. Boissier 5: 175. 1897. *F. globicarpa* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 161. 1898. *Fontinalis hygrometrica* (Hedw.) P. Syd., Bot. Jahresber. 32(1): 528. 1905.

Plants yellowish green, small, usually unbranched, up to 1.5 cm long including sporophyte; leaves usually two types, the leaves larger at top forming rosette, lower leaves small and scale like, larger leaves concave, oblong ovate, erect spreading, curled and shrunk when dry, lower leaves 1.7 mm long and 0.7 mm wide, leaf margin entire, apex acuminate; costa strong, excurrent; leaf cells thin walled, rectangular to hexagonal, elongated at base, reduce size at apex and margin; cells at base 122-138 µm long and 30-44 µm wide, cells at margin 30-33 µm long and 43-53 µm wide and cells at tip 45- 60 µm long and 25-30 µm wide; seta erect, usually bending, capsule horizontal to pendulous, yellowish orange, asymmetrical, ±2 mm long and 1 mm wide; spores small, 10 µm diagonally (Plate 5.67).

Habitat: Lithophytic and Terrestrial. Widely distributed in land cuttings, large rocky patch, on small rocks and on concrete walls of water tanks in the shola forest and grasslands at altitude above 2000 m. Associated species are *Pogonatum microstomum* (R.Br. ex Schwägr.) Brid. and *Bryum argenteum* Hedw.

Discussion: *Funaria hygrometrica* is a widely distributed species and several authors reported several varieties of this species (Tropicos.org). Gangulee (1974) described *Funaria hygrometrica* and *F. hygrometrica* var. *calvescens* from Eastern Himalayas. He stated that *F. hygrometrica* is the only species seen in Eastern India, and all other species from India are minor or major variants of this species. Recently Bhattacharya *et al.* (2017) validated the differences of gametophytes and sporophytes in three distinct population of *F. hygrometrica* and states that the altitude and environmental factors change the gametophytic as well as sporophytic characters of this species. The specimens collected from different localities of Kerala also support this statement.

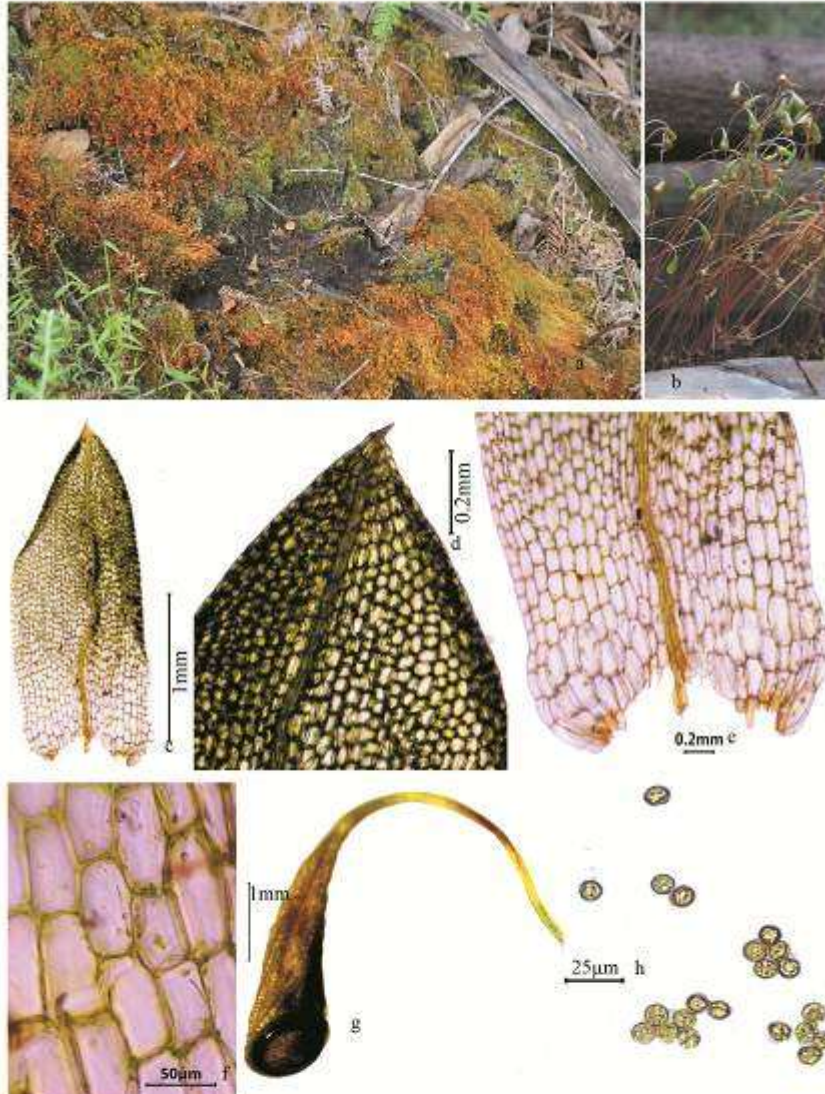


Plate 5. 67: *Funaria hygrometrica* Hedw., a. mature habit, b. plant with sporophyte, c. leaf, d. leaf apex, e. leaf base, f. leaf basal cells enlarged, g. mature capsule, i. spores

Distribution: World: China (Redfearn Jr., 1986), Columbia (Waard & Florschütz, 1979), Egypt (Saadawi & Badawi, 1977), Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2005), Philippines (Tan & Iwatzuki, 1991), Sri Lanka (O'Shea, 2002), Thailand (Sukkharak & Chantanaorrapint, 2014); **India:** Assam (Robinson, 1964), Gujarat (Chaudhary *et al.*, 2006), Himachal Pradesh (Choyal & Sharma, 2011), Jharkhand (Gangulee, 1974), Maharashtra (Magdum *et al.*, 2017), Odisha (Mishra *et al.*, 2016), Rajasthan (Alam *et al.*, 2014), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2200-2400 m) 22.09.2018 *Mufeed 9903b, 9908* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Hair PinPoint (550m) *Manju C.N. 80115a* (CALI!).

Dicranales M. Fleisch.,
Hedwigia 61(4): 392. 1920.

Key to the families

- 1a. Vaginant lamina usually present on the basal portion of the leaves **Fissidentaceae**
- 1b. Vaginant lamina absent 2
- 2a. Costa strong, less than $1/3^{\text{rd}}$ of the base width **Ditrichaceae**
- 2b. Costa narrow to broad, usually more than $1/3^{\text{rd}}$ of the base width 3
- 3a. Plants whitish green; alar cells not differentiated **Leucobryaceae**
- 3b. Plants yellowish green to brownish green; alar cells prominent **Dicranaceae**

Fissidentaceae Schimp.,
Coroll. Bryol. Eur. 96. 1856.

Plants pale to dark green, usually terrestrial, epiphytic or corticolous, erect or slightly decumbent, tufted, or forming dense mats; stem unbranched or rarely branched; rhizoids basal and axillary; leaves distichous, pinnately arranged on stems, firmly attached to the stem, vaginant lamina usually present on the basal portion of cauline leaves, shape may vary, rounded or narrowed to the costa; costa usually well developed, ending far below apex to excurrent; margin entire to serrate or denticulate, marginal cells usually slightly differ from inner laminal cells, often differentiated into a limbidium on vaginant laminae, limbidial cells single layer to

multi-layered, usually prosenchymatous, yellowish or colourless; laminal cells usually unistratose, small, rounded, quadrate or irregular in shape, mamilllose or papillose; monoicous, rarely dioicous; sporophytes usually one per perichaetium, rarely 2, light green or yellow when young, darken when matured, orange or reddish, spores usually green, finely papillose or smooth.

***Fissidens* Hedw.,**

Sp. Musc. Frond. 152. 1801.

Plants terrestrial or epiphytic, stem without central strand, leaves soft, narrowly bordered with lax thin walled cells; laminal cells small, round or quadrate, mamilllose or papillose; limbidium on vaginanal laminae, total or partial or absent; cells unistratose or multistratose; costa percurrent or excurrent; monoicous or rarely dioicous.

Key to the species

- 1a. Plants small to medium sized, up to 10 mm long 2
- 1b. Plants large, up to 30-40 mm long ***F. anomalus***
- 2a. Limbidium present 3
- 2b. Limbidium absent 4
- 3a. Vegetative plant has 7-17 pairs of leaves; hyaline nodule absent ***F. speluncaae***
- 3b. Vegetative plant has 2-7 pairs of leaves; hyaline nodules differentiated
..... ***F. zollingeri***
- 4a. Dorsal lamina base rounded to wedge shaped; costa ending 2-5 cells below apex
..... ***F. crispulus***
- 4b. Dorsal laminal base rounded; costal cells ends at apex ***F. taxifolius***

Fissidens anomalus Mont., Ann. Sci. Nat., Bot., 2 17: 252. 1842; Müll. Hal., Bot. Zeitung (Berlin) 11: 19. 1853; Broth., Rec. Bot. Surv. India 1(12): 314. 1899; Foreau, J. Madras Univ. 2: 242. 1930; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 773. 1937; Gangulee, Mosses E. India & Adj. Reg. 1(2): 555. f. 265. 1971; Chopra & S.S. Kumar, Moss. W. Himal.: 56: 1981; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 571. 2001; Madhusoodanan *et al.*, Curr. Trends Bryol. 261. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 12. 2008 & Taiwan 54: 63. 2009; Daniels, Arch. Bryol. 65: 54. 2010; Daniels & Daniel, Bryo.

South. W. Ghat. 36. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 62. 2019. *Fissidens cryptotheca* Dozy & Molk., Pl. Jungh. 314. 1854. *F. neckeroides* Griff., Culcutta J.Nat. Hist. 2: 504. 1842. *F. schiffneri* Baumgartner & Dixon, Ann. Nat. Hist. Mus. Wien 59: 67. 1953.

Plants large, light green coloured when exposed to sunlight and turn to dull green in shady areas, 30-40 mm long and 4 mm wide, branched or unbranched, rhizoids brown, smooth; leaves arranged in pairs, densely arranged towards tip, lanceolate, apex acuminate, 4-4.5 mm long and 1-1.2 mm wide, margin serrate, limbidium absent; vaginant lamina longer than wide, reaching $\frac{3}{4}$ of the leaf length, uniseriate, base broad; costa prominent, distinct, reaching 4 or 5 cells below apex; laminal cells rounded or irregularly polygonal, mamilllose, leaf bordered by a light coloured band of 2-4 rows of smooth, pale coloured cells, vaginant laminal cells 7-13 μ m long and 7-14 μ m wide, dorsal laminal cells, 6.5-13 μ m long and 7-14 μ m wide; reproductive structures are not seen (Plate 5.68).

Habitat: This species is found only on shola forests at an altitude above 1500 m. Found on bark and exposed roots of shola trees along with lichen and lithophytic near riverine areas. On rocks it is associated with *Plagiomnium rhynchophorum* (Hook.) T.J. Kop., *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal. and *Thuidium glaucinum* (Mitt.) Bosch & Sande Lac in wet areas.

Discussion: *F. anomalus* Mont. is a very large species compared to other *Fissidens* species reported from Western Ghats and it is mostly distributed in the shola forests of high altitude regions. Western Ghats specimen shows up to 20 pairs of leaves but Li & Iwatsuki (2001) reported 53 pairs of leaves in the vegetative form. It is internally characterized by a distinct margin of smooth cells, inner laminal cells mamilllose and with elongated juxta costal cells.

Distribution: World: China (Redfearn Jr. & Wu, 1986), Indonesia, Java, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam, Yunan (Li & Iwatsuki, 2001), Philippines (Tan & Iwatsuki, 1991); **India:** Eastern Himalaya (Asthana & Srivastava, 2015), Karnataka (Frahm *et al.*, 2013), Kerala (Madhusoodanan *et al.*, 2007, Manju *et al.*, 2008; 2009), Tamil Nadu (Daniels & Daniel, 2013; Daniels & Kariyappa, 2019),

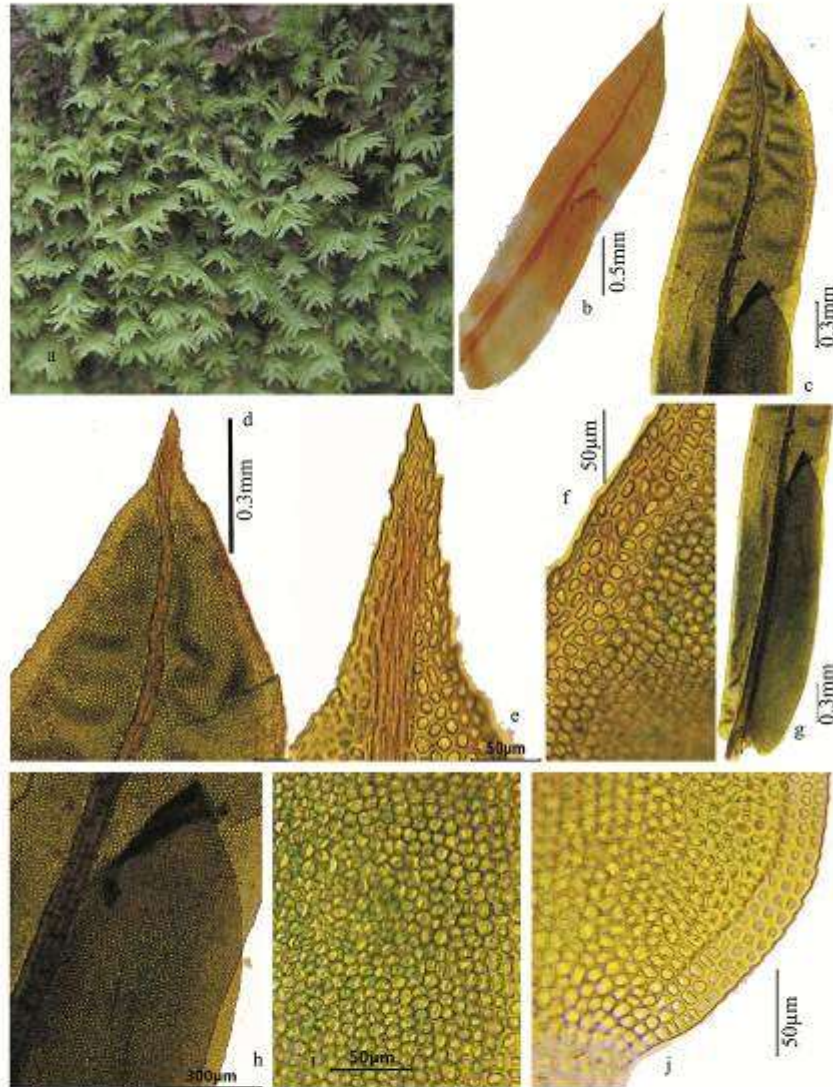


Plate 5. 68: *Fissidens anomalus* Mont., a. habit, b. leaf, c. leaf apex, d. leaf tip, e. leaf tip cells, f. leaf margin, g. vaginant lamina, h. vaginal lamina tip, i. leaf middle cells, j. leaf basal cells

Western Himalaya (Gangulee, 1971).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2050-2400 m) 07.11.2017 *Mufeed* 7405; 22.09.2018 *Mufeed* 9910; Mannavan Shola (1650 m) 14.07.2017 *Mufeed* 7511; Pullaradi Shola (2100 m) 27.09.2018 *Mufeed* 9889 (ZGC).

Other specimen/s examined: India, Kerala, Idukki district, Eravikulam NP (Neerar, Kattumala, 2010m) 22.09.2001 *Manju* 80204 (CALI!); Munnar, Kattumala (2100m) 27.09.2001, *Manju* C.N. 80254 (CALI!); Mathikettan Shola NP (1200 m) 20.03.2014 *Rajilesh*, V.K. 1024 (ZGC!); Malappuram district, New Amarambalam RF (1050 m) *K.P. Rajesh* 111857b (ZGC!); Kannur district, Aralam WLS, Ambalappara, (1400 m) *K.P. Rajesh* 106683 (CALI!); Palakkad district, Parambikulam WLS (1250 m) 12.10.2006, *Manju* C.N. 106822 (CALI!); Sri Lanka, *Thwaites*, 133. (BM!).

Fissidens crispulus Brid., Musc. Rec. suppl. 4: 187. 1819. var. ***crispulus***; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Foreau, J. Madras Univ. 2: 243. 1930 & J. Bombay Nat. Hist. Soc. 61: 224. 1964; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 398. 1982; Iwatsuki & Mohamed, J. Hattori Bot. Lab. 62: 353. 1987; Chaudhary & Deora. Moss Fl. Rajasthan 38. 1993; Brugg.-Nann., J. Hattori Bot. Lab. 81: 155. 1997; Li & Iwatsuki, Moss Fl. China 2: 25. 2001; Lal, Checklist Ind. Moss.: 63. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 105. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Manju, *et al.*, Trop. Bryol. Res. Rep. 7. 2008b; Daniels, Arch. Bryol. 65: 54. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 52: 2013; Schwarz, *Frahmia* 158: 24. 2014b; Diop *et al.*, J. Bryol. 2. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 69. 2019. *Fissidens zippelianus* Dozy & Molk., Zoll. Syst. Verz. 29. 1854; Dixon, J. Indian Bot. 2: 180. 1921. *F. incrassatus* Sull. & Lesq., Proc. Amer. Acad. Arts Sci. 4: 276. 1859. *F. auriculatus* Müll. Hal., Linnaea 37: 166. 1872; Daniels & Kariyappa, Curr. Sci. 93(7): 978. 2007. *F. sakourae* Paris & Broth., Bull. Herb. Boissier, ser. 2, 2: 921. 1902. *F. salcifolius* Sak., Bot. Mag. Tokyo 47: 741. 1933. *F. osadae* Sak., Bryologist 39: 5, pl. II. 1936. *F. pepuensis* P.C. Chen, Sunyatsenia 6(2): 189, 31. 1941. *F. sylvaticus* var. *zippelianus* (Dozy & Molk.) Gangulee, Mosses E.

India & Adj. Reg. 2: 537. 1971.

Plants growing in mats, light green; stem with central strand, 2 or 3 rows of marginal small, thick walled cells and one or two rows of inner large thin walled cells, 4-8 mm long and 1-3 mm wide, rhizoids smooth, reddish brown, axillary hyaline nodules differentiated, 8-15 pairs of leaves, branched or unbranched; leaves of vegetative stem lanceolate, tip acute, margin crenulate towards tip, 1-1.7 mm long and 0.2-0.4 mm wide, 4 or 5 times long as wide; limbidium absent; vaginant laminae slightly opened or closed, unistratose, 0.16-0.20 μm wide at base, vaginant laminae basal cells slightly elongated, reaching $\pm 1/2$ apical leaf length; dorsal lamina base rounded to wedge-shaped, normally not decurrent, but slightly decurrent in some leaves, 5-7 cell wide, apical lamina and dorsal lamina unistratose; costa prominent, ending 2-5 cells below leaf apex, bryoides type; mid dorsal laminal cells slightly convex with conical mammillae, 11.30-12.63 μm ; mid vaginant laminal cells plane, rectangular, 10.90-13.5 μm long and 10-11.5 μm wide; gemmae not found; plants dioicous (Plate 5.69).

Habitat: Terricolous, usually on soil patches and on land cuttings in shola forest.

Discussion: This species is the most common member of Fissidentaceae in Western Ghats in all altitudinal ranges and found on all types of macrohabitat and microhabitat. Its tolerance is very high compared to other species and it can habituate in a wide range of terrestrial, aquatic and epiphytic habitats such as, soil, land cuttings, wet and dry rocks, tree base, roots of higher plants, laterite stones, cement wall, decayed matters and water flowing rocks along with other bryophytes and other lower plant groups such as ferns. It can be confused with *F. taxifolius* Hedw. which, however, is easily distinguished by the lack of axillary hyaline nodules. *F. crispulus* Brid. is well characterised by its large, hyaline axillary nodules, lanceolate to narrowly lanceolate, elimbate leaves with acute to mucronate leaf apex, mamilllose laminal cells and closed or slightly open vaginant laminae.

Distribution: World: China, East Nepal, Japan, Sri Lanka, Malaysia, Myanmar, Philippines, Thailand (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001), Madagascar, Reunion, Singapore, Bioko, Cameroon, Central African Republic, Comoros,



Plate 5. 69: *Fissidens crispulus* Brid., a. habit, b. single plant, c. leaf, d&e. leaf apex, f. leaf base, g. leaf marginal cells, h. sheathing lamina tip, i. vaginant lamina cells, j. dorsal lamina basal cells, k. cells at upper half with papillae

Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ivory Coast, Kenya, Malawi, Mauritius, Nigeria, Rodrigues, Rwanda, Seychelles, Sierra Leone, Sudan, Tanzania, Togo, Zambia, Zimbabwe (O'Shea, 2006); **India:** Andaman & Nicobar Islands, Andhra Pradesh, Assam, Darjeeling, Khasia Hills, Bihar, Chhotanagpur, West Bengal, Orissa (Gangulee, 1971; Lal, 2005), Karnataka (Montagne, 1842; Schwarz, 2014), Kerala (Manjula & Manju, 2016; Nair *et al.*, 2005), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013; Foreau, 1930, 1961).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1776 m) 02.08.2015 *Mufeed 13331* (ZGC).

Other specimen/s examined: India, Kerala; Malappuram district, Canoli plot, Nilambur, (40 m) 24.07.2014 *Manjula 671* (ZGC), Calicut University campus (Botanical garden) 18.07.2014 *Manju C.N. 1165a* (CALI!); Kozhikode district, Marippuzha (637 m) 18.07.2013 *Manjula, K.M. 612b, 614* (ZGC).

Fissidens speluncae Broth., Hedwigia 50: 124. 1910; Manjula *et al.*, Acta Bot. Hung. 57(1-2): 165–168. 2015 (as *F. linearis* var. *obscuriretis* (Broth. & Paris) I.G. Stone); Ellis *et al.*, J. Bryol. 41(2): 182. 2019.

Plants medium sized 2-6 mm long and 1-2 mm wide including leaves, tip curls in herbarium, 7-17 pairs of alternate leaves more crowded towards tip, usually unbranched with yellowish green coloured stem, stem 0.12-0.13 mm in diameter, central strand lacking; rhizoids brown, smooth; hyaline nodules absent; leaves lanceolate, 0.8-1.5 × 0.20-0.30 mm, 4 times long as wide, leaf margin not entire due to projections of marginal cells, acute leaf apex and ends in a single costal cell; limbidium on vaginant laminae, four or five rows at vaginant laminae base, reaching the insertion; vaginant laminae open, unequal and reaching 1/2 or 2/3 of apical lamina, 0.12-0.15 mm wide at base, unistratose; dorsal lamina base rounded, dorsal lamina and apical lamina unistratose; costa prominent, yellowish green coloured, slightly excurrent; quadrate to irregularly hexagonal and compactly arranged laminal cells, pluripapillose, 4-6 papillae in each cells of vaginant laminal cells, four or five papillae in apical and dorsal laminal cells, juxta costal cells not differentiated, tip cells ± 20 µm long and 5 µm wide, middorsal laminal cells 7-8 µm long and 4-6.5

µm wide, mid vaginant laminal cells 9-15 µm long and 6-12 µm wide; gemmae not found; plants dioicous, perigonia terminal, plants 2.5-3.5 mm long and 1.2-1.8 mm wide, perigonal leaves 0.80-0.95 mm long, antheridia 0.17-0.21 mm long; perichaetia terminal, plants 4.6-5.6 mm long and 1.4-1.7 mm wide, perichaetial leaves 1.2-1.5 mm long, up to 10 rows of limbidium present at base of apical lamina and vaginant laminae base, archegonia 0.19-0.21 mm; sporophyte not found (Plate 5.70).

Habitat: On soil and land cuttings in shola forests along with *Floribundaria walkeri* Broth.

Discussion: Manjula *et al.* (2015) reported this species erroneously as *F. linearis* var. *obscuriretis* (Broth. & Paris) I.G.Stone, a new record for Kerala, based on the sterile collection. Ellis *et al.* (2019) corrected as *F. speluncae* and is reported as a new record for India. It is a very rare species distributed in limited areas. *F. speluncae* Broth. is characterised by lanceolate leaves with an acute apex, a slightly excurrent costa, 4–6 papillae on cells of the vaginant lamina, and a prominent limbidium at the base of its perichaetial leaves. It can be confused with *F. ceylonensis* Dozy & Molk. which, however has intramarginal limbidium and oblong leaves.

Distribution: World: Sri Lanka (type); **India:** Kerala (Ellis *et al.*, 2019; Manjula *et al.*, 2015).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2000 m) 12.07.2017 *Mufeed 7324b*; Mannavan Shola (1700 m) 24.09.2018 *Mufeed 9965* (ZGC).

Other specimen/s examined: India, Kerala, Thiruvananthapuram district, Agasthyamalai Biosphere Reserve (1300 m) 12.12.2013 *Rajilesh 732a* (ZGC); Malappuram district, Canoli plot, Nilambur (50 m) 24.07.14 *Manjula 671a* (ZGC), Idukki district, Way to Munnar from Marayoor, Munnar Udumalpet road (1168 m) 05.02.2014 *Manjula 996* (ZGC).

Fissidens taxifolius Hedw., Sp. Musc. Frond. 1801; Foreau, J. Madras Univ. 2: 243. 1930 & J. Bombay Nat. Hist. Soc. 61: 224. 1964 & J. Bombay Nat. Hist. Soc. 58:

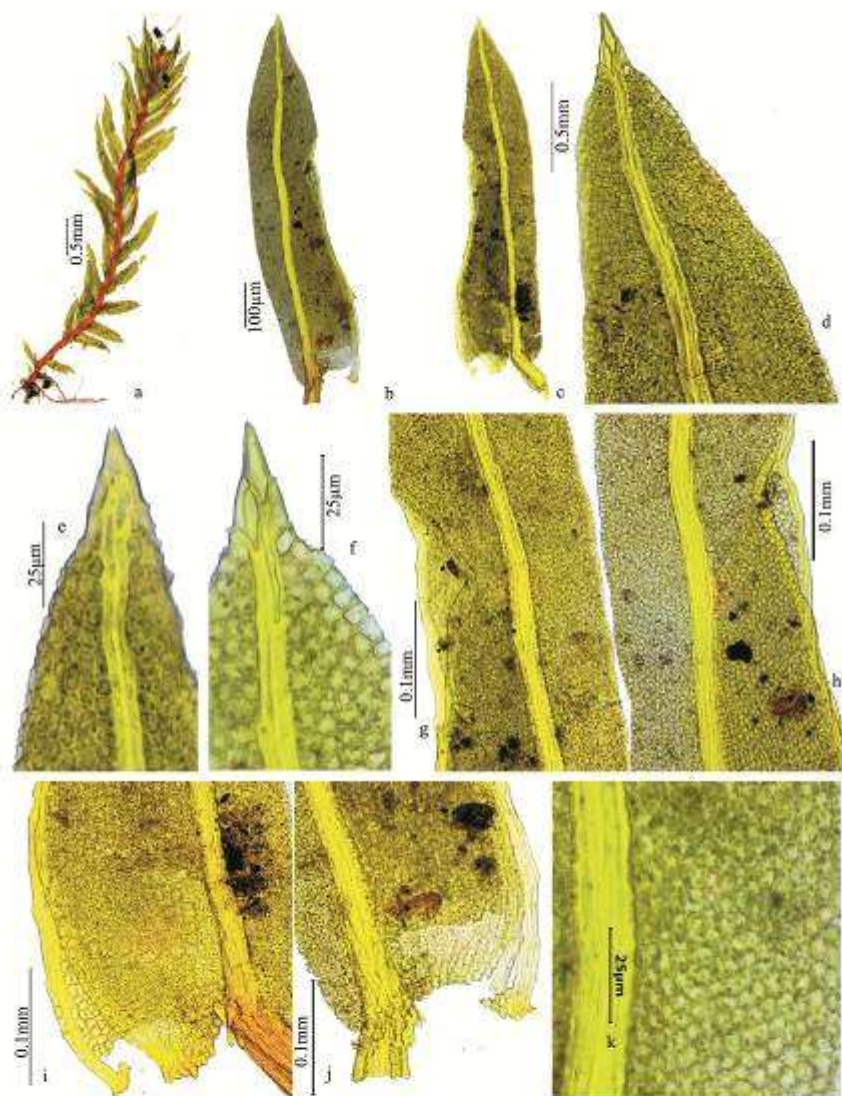


Plate 5. 70: *Fissidens speluncae* Broth., a. single plant, b&c. leaf, d. leaf tip, e&f. leaf tip cells, g&h. vaginant laminae, i&j. leaf basal cells with limbidium, k. leaf cells

16. 1961; Bartram, Fieldiana: Botany 25: 22. 1949; Gangulee, Mosses E. India & Adj. Reg. 1: 544. F. 259. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 413. 1982; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986; Lal, Checklist Indian Moss. 63. 2005; Pursell, Fissidentaceae Fl. Neo. Mono. 101; 29. 2007; Daniels & Daniel, Bryofl. South. W. Ghats. 49. 2013. *Dicranum taxifolium* (Hedw.) F. Weber & D. Mohr., Index Musc. Pl. Crypt. 2. 1803. *Skitophyllum taxifolium* (Hedw.) Bach., Pyl., J. Bot. Agric. 4: 166. 1814. *Schistophyllum taxifolium* (Hedw.) Brid., Bryol. Univ. 2: 693. 1827. *Fissidens sylvaticus* Griff., Calcutta J. Nat. Hist. 2: 507. 1842. *F. circinalis* Mitt., J. Proc. Linn. Soc. Bot. 1(Suppl.): 138. 1859. *F. pallidicaulis* Mitt., Nat. Hist. Azores 314. 1870. *F. angustus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 322. 1873. *F. terminiflorus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 322. 1873. *F. subobscurus* Paris, Index Byol.: 487. 1896. *F. lutescens* Broth., Rec. Bot. Surv. India 1(12): 315. 1899. *F. adelphinus* var. *submucronatus* Card., Bull. Herb. Boiss. Sér. 2, 7: 716. 1907. *F. angustiusculus* Dixon & P. de la Varde, Arch. Bot. Bull. Mens. 1: 163. 1927. *F. nipponensis* Sak., Bot. Mag. Tokyo 47: 743. 1933. *F. okinawaensis* Bartr., Bryologist 50: 160, f. c-e. 1947. *F. clebschii* Steere, Bryologist 53: 129. f. 1-8. 1950. *F. taxifolius* var. *acutifolius* Nog., J. Hattori Bot. Lab. 8: 70. 1952. *F. pallidulus* Hampe ex Gangulee, Bull. Bot. Soc. Beng. 11: 82. 1957.

Plants medium sized, bright green when fresh, axillary hyaline nodules absent; rhizoids smooth, brownish; stem gregarious, 4-7 mm long and 2-2.5 mm wide, 8-13 pairs of leaves, light green, central strand differentiated; leaves lanceolate to lingulate, margin serrate throughout, apex mostly apiculate or mucronate; limbidium absent; vaginant laminae reaching 1/2 of apical lamina, slightly open, minor lamina apex ends in between margin and costa, margin serrate, uniseriate; dorsal lamina base rounded, not decurrent, slightly depressed near insertion in some leaves, apical lamina and dorsal lamina uniseriate; costa stout, ending in a short apiculus or costal cells ends at apex; laminal cells irregularly polygonal or slightly rounded, multilayered, mid vaginant laminal cells 11-14 µm long and 10-14.5 µm wide, mid dorsal laminal cells convex, 13.5-17 µm long and 6.7-8 µm wide, vaginant laminal cells at base near costa 13-23 µm long and 4-9 µm wide; gemmae

not found (Plate 5.71).

Habitat: Growing as terrestrial and on large rocks and land cuttings as mats in shola forest.

Discussion: Gangulee (1971) considered *Fissidens taxifolius* Hedw. as *F. sylvaticus* and considering its high variability proposed four varieties under *F. sylvaticus*. But *F. sylvaticus* is synonymised under *F. taxifolius* along with three varieties. One variety is kept under *F. crispulus* Brid. Daniels & Daniel (2013) has validly published these varieties under *F. taxifolius*. *F. taxifolius* is characterised by lanceolate to oblong lanceolate leaves, costa shortly excurrent in apiculus, highly mamilllose laminal cells. This species is closely related to *F. crispulus* Brid. in the mamilllose laminal cells and elimbate leaf but differs in the undifferentiated axillary hyaline nodule, excurrent costa and more broad leaves. Manjula (2018) reported this species as new record for Kerala.

Distribution: World: Alabama, Arizona, Arkansas, Brazil, California, Canada, Caribbean, Chile, China, Delaware, Florida, Georgia, Guatemala, Hawaiian, Honduras, Kansas, Kentucky, Louisiana, Madagascar, Maine, Massachusetts, Mexico, Michigan, Mississippi, Missouri, Nebraska, Nepal, New Hampshire, New Jersey, New York, New Zealand, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Philippines, Sri Lanka; South Carolina, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsin (Redfearn Jr. & Wu, 1986; Tan & Iwatsuki, 1991; Li & Iwatsuki, 2001; Müller & Pursell, 2003; Pursell, 1994, 2007); **India:** Assam, Bihar, Sikkim, West Bengal (as *F. sylvaticus* var. *auriculatus*) (Gangulee, 1971), Karnataka (Schwarz, 2014), Kerala (present collection), Madhya Pradesh, Maharashtra, Uttar Pradesh, (as *F. angustiusculus* Dixon & P. de la Varde), Tamil Nadu (as *F. angustiusculus* Dixon & P. de la Varde) (Bruehl, 1931; Daniels & Daniel, 2013; Dixon & Potier de la Varde, 1927; Foreau, 1930, 1961).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2200-2250 m) 04.03.2016 *Mufeed* 10056, 10062; Jandamala (1940 m) 09.11.2017 *Mufeed* 7459; Mannavan Shola (2000 m) 24.09.2018 *Mufeed* 9955 (ZGC).

Other specimen/s examined: India, Kerala; Palakkad district, Nelliampathy

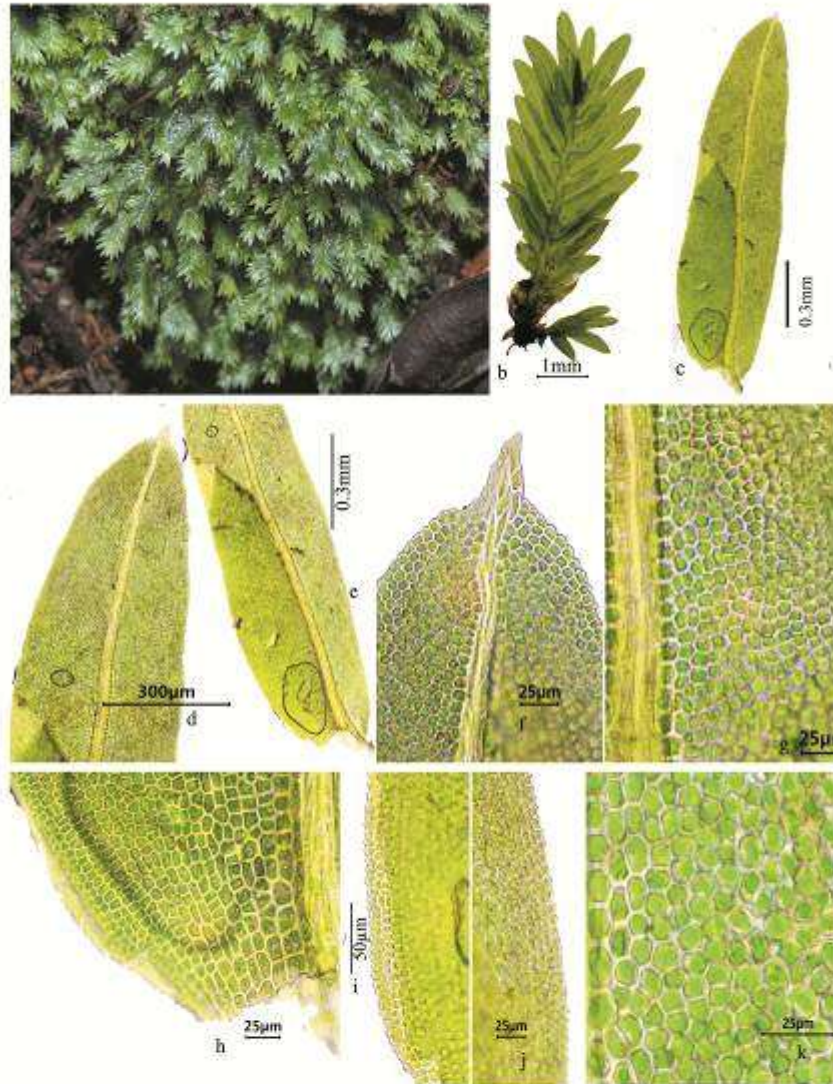


Plate 5. 71: *Fissidens taxifolius* Hedw., a. habit, b. single plant, c. leaf, d. leaf apex, e. vaginant lamina, f. leaf tip cells, g. leaf middle cells, h. leaf basal cells on the vaginant laminae, i. leaf base showing sheathing laminae, j. dorsal lamina margin k. leaf cells showing mamillae

(900m), 12.07.2014, *Manjula*, K.M. 1139a (ZGC); Tamil Nadu, Palni hills, 28.12.1926, *Foreau* (511 BM!); Maharashtra, Mahabaleshwar (868m) 10.11.2016 *Manjula* 16201 (ZGC); Nepal, (Sanghu Downs), 17.02.1962, A.H. Norkett (9912) (BM!).

Fissidens zollingeri Mont., Ann. Sci. Nat., Bot., sér.34: 114. 1845; Dixon, J. Indian Bot. 2: 177. 1921; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Bruehl, Rec. Bot. Surv. India 13(1): 17. 1931; Wadhwa, M.V.M. Patrika 4: 91. 1969; Gangulee, Mosses E. India & Adj. Reg. 1(2): 478. 1971; Iwatsuki & Suzuki, J. Hattori Lab. 51: 367. 1982; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986; Iwatsuki & Mohamed, J. Hattori Bot. Lab. 62: 342. 1987; Brugg.-Nann. & Berendsen, J. Hattori Bot. Lab. 68: 205. 1990; Dabhade, Moss. Khandala: 138. 1998; Lal, Checklist Indian Moss. 64. 2005; Li & Iwatsuki, Moss Fl. China 2: 66. 2001; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 108. 2005; Chaudhary *et al.*, Bryoph. Fl. Gujarat: 72. 2006 & Bryoph. Fl. N. Konkan: 246. 2008; Daniels & Kariyappa, Curr. Sci. 93(7): 981. 2007; Pursell, Fl. Neotrop. Monogr. 101: 225. 2007; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b; Brugg.-Nann. & Arts, J. Bryol. 32: 204. 2010; Daniels, Archive Bryol. 65: 57. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 53. 2013; Sandhya Rani *et al.*, Bryo. Andhra Pradesh. 132. 2014; Brugg.-Nann., Lindbergia 39: 33–34. 2016; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 85. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 97. 2019. *Fissidens kegelianus* Müll. Hal., Syn. Musc. Frond. 1: 49. 1848. *F. pseudo-bryoides* Schlieph., Bot. Zeitung (Berlin) 13: 424. 1855. *F. vogelianus* Mitt., Tras. Linn. Soc. London 23: 54. 5 f. 10. 1860. *F. clavipes* Sull., Proc. Am. Acad. Arts 5: 275. 1861 [1862]. *F. monandrus* Mitt., J. Linn. Soc. Bot. 12: 598. 1869. *F. macrophyllus* Welw. & Duby, Mém. Soc. Phys. Genève 21: 223. 1872. *Conomitrium caripens* Hampe & Müll. Hal., Linnaea 38: 574. 1874. *Fissidens trinitensis* Hampe ex A. Jaeger, Ber. Thätigk. St. gallischen Naturewiss. Ges. 1874-75: 123. 1876. *F. balansaeanus* Besch., Mém. Soc. Sci. Nat. Cherbourg 21: 260. 1877. *F. balansaeanus* var. *limosus* Besch., Mem. Soc. Sci. Nat. Cherbourg 21: 261. 1877. *Conomitrium subpalmatum* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn. Ser. 3. 9: 273. 1877 [1878]. *Fissidens obsoletidens* Müll. Hal. ex Besch., Ann. Sci. Nat. Bot. sér. 6, 9: 332. 1880.

F. platy-bryoides Müll. Hal., Fl. 69: 505. 1886. *F. stenocarpus* Müll. Hal., Rev. Bryol. 14:57. 1887. *F. crassicollis* Besch., Rev. Bryol. 18: 50. 1891. *F. flexifrons* Besch., Rev. Bryol. 18: 50. 1891. *Conomitrium bengalense* Hampe in Müll. Hal., Linnaea 39: 364. 1896. *Fissidens bengalensis* Par., Index Bryol.: 461. 1896. *F. coorgensis* Broth., Rec. Bot. Surv. India 1(12): 316. 1899; Schwarz, Frahmia 158: 6. 2014. *F. xiphoides* M. Fleisch., Hedwigia 38 (Beibl.): 125. 1899; Chaudhary *et al.*, Bryoph. Fl. Gujarat: 70. 2006. *F. gracilis* Schimp. ex E.S. Almon, Ann. Bot. 13: 126. 1899. *F. tijucae* Broth., Hedwigia 38 (Beibl.): 59. 1899. *F. acutissimus* Müll. Hal., Gen. Musc. Frond. 57. 1900. *F. mararyensis* Broth. Hedwigia 45: 265. 1906. *F. brachycaulon* Broth. in Mildbr., Wiss. Ergebn. Deut. Zentr.-Afr. Exped., Bot. 2: 143. 11 f. 143. 1910. *F. tenuisetus* Cardot, Rev. Bryol. 35: 64. 1908. *F. jujuiensis* Broth., Ark Bot. 15: 2. 1917.

Plants small, simple, light green; central strand weak to lacking, vegetative stem 6-8 mm long and 3-4.5 mm wide including leaves, vegetative plant with 2-7 pairs of leaves; rhizoids reddish, smooth; axillary hyaline nodules differentiated; leaves lax, oblong-lanceolate, rarely linear lanceolate, upper leaves larger, 1.5-3 mm long and 0.3-0.5 mm wide, tip acute to slightly acuminate, margin entire; limbidium present on all laminae, 5-7 rows at vaginant laminae base, 3-5 rows at apical lamina base, one or two rows towards the apex of leaves; vaginant laminae reaching 1/2 – 3/4 of leaf length, slightly open or closed, 0.10-0.15 mm wide at base, a small curve on the apical lamina where vaginant laminae ends, unistratose; dorsal lamina narrows towards base, joins to the leaf insertion, not decurrent, 2-4 cells wide, dorsal and apical lamina unistratose; costa prominent, yellow to slightly orange, slightly excurrent apex, cuspidate, bryoides type; mid dorsal laminal cells plane, 7-9 µm long and 4-8 µm wide, mid vaginant laminal cells plane or slightly convex, 8-12.5 µm long and 5-6 µm wide, juxta costal cells elongated, 27-29 µm long and 10-15.5 µm wide; sporophyte inclined, seta 4-6 mm, capsule symmetrical, 0.75-1 mm long and 0.25-0.35 mm wide, 21-24 files of exothecial cells with thickened corners, peristome bryoides type, tooth base 28.5-33 µm, 0.17-0.25 mm long; operculum rostrate; spores 8.2-11.5 µm diagonally (Plate 5.72).

Habitat: Terricolous, on land cuttings, crevices of rocks and on small rocks in shola forest.

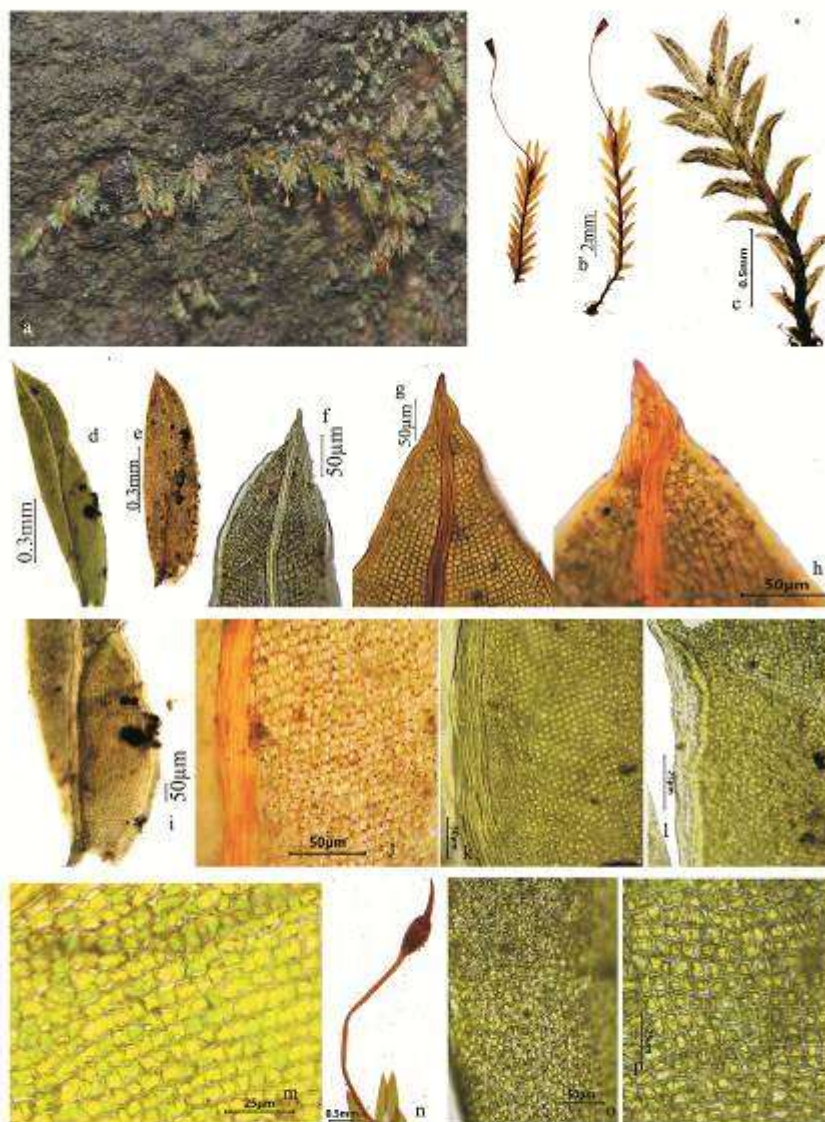


Plate 5. 72: *Fissidens zollingeri* Mont. a. habit, b. single plant with sporophyte, c. vegetative plant, d&e. leaf, f-h. leaf apex sowing cells, i. vaginant laminae, j. leaf cells near costa, k. limbidium on vaginant laminae, l. sheathing lamina tip, m. leaf cells mamillae, n. sporophyte, o & p. laminal cells

Discussion: *F. zollingeri* Mont. shows wide variations in morphological characters based on the microhabitat, and shows resemblance and variations with several species. Hence some authors considered some species as separate from *F. zollingeri* and some considered some species under synonym of *F. zollingeri*. Gangulee (1971) treated *F. xiphoides* Fleisch. and *F. zollingeri* Mont. as separate with a slight variation in the large and wide leaves with two rowed limbidium at apex, but this species is synonymised under *F. zollingeri* by Iwatsuki (1991). Daniels and Daniel (2013) and Daniels & Kariyappa (2019) considered *F. biformis* Mitt. as a synonym of *F. zollingeri* Mont. But these two species have variations like linearly lanceolate leaves with papillose laminal cells and narrowly acute leaf apex of *F. biformis* Mitt. Hence, Manjula (2018) treated these two species as separate. Dabhade (1998) and Chaudhary *et al.* (2008) listed this species as *F. xiphoides* Fleisch. from Maharashtra.

Distribution: World: Central Vietnam, Fiji, Java, Malay, Myanmar, North Vietnam, New Guinea, Philippines, Sri Lanka, Sumatra, Samoa, Tahiti; west-central tropical Africa (Benin, Cameroon, Democratic Republic of the Congo, Central African Republic, Gabon, Guinea, Nigeria); East tropical Africa (Kenya, Tanzania, Uganda); south tropical Africa (Angola); and Western Indian Ocean (Comoro islands, La Re´union, Madagascar, Rodriguez, Seychelles) (Bruggeman-Nannenga & Berendsen, 1990; Iwatsuki & Suzuki, 1982; Iwatsuki & Mohamed, 1987; Li & Iwatsuki, 2001; Pursell, 2007; Bruggeman-Nannenga & Arts, 2010); **India:** Andaman Islands, West Bengal (Gangulee, 1971; Mohamed *et al.*, 1986; Lal, 2005), Gujarat, Uttar Pradesh (Sandhya Rani *et al.*, 2014; Wadhwa, 1969), Goa (Magdum *et al.*, 2017), Karnataka (Schwarz, 2014), Kerala (Manju *et al.*, 2008b; Nair *et al.*, 2005; Daniels & Kariyappa, 2019), Madhya Pradesh, Maharashtra (Chaudhary *et al.*, 2006, 2008; Dabhade, 1998), Tamil Nadu (Daniels, 2003, 2010; Daniels & Daniel, 2013; Foreau, 1930, 1961; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2000-2100 m) 04.03.2016 *Mufeed 10052*; 02.07.2017 *Mufeed 7459*; Mannavan Shola (2000 m) 24.09.2018 *Mufeed 9953, 9957* (ZGC).

Ditrichaceae Limpr.,

Laubm. Deutschl. 1: 482. 1887.

Plants small to medium-sized, gregarious or loosely to densely tufted, stem erect, simple with central strand, leaves mostly lanceolate, acuminate or subulate, straight or somewhat curved, rarely sheathing at base; costa single, well developed, percurrent to excurrent; lamina cells smooth, basal cells elongate, narrower towards the margins, those of basal angles not differentiated or forming a marginal border, distal cells isodiametric or short-rectangular to elongate, walls firm; dioicous, autoicous or synoicous; seta short to elongate, yellow to orange, reddish brown, brown, or reddish purple, capsule immersed to emergent and subglobose to long-exserted, cylindric, erect to inclined or pendulous, often curved or asymmetric.

Ceratodon Brid.,

Bryol. Univ. 1:480. 1836,

Plants acrocarpous, lower part of stem densely covered in reddish rhizoids; leaves ovate to linear-lanceolate, acuminate, margin recurved, variably dentate to serrate near apex or entire; costa excurrent; cells at base rectangular, at middle quadrate to isodiametric, smooth and unistratose; dioicous; seta yellow to red, capsule ellipsoid to cylindrical, calyptra cuculate, annulus usually with a membranous border, spores papillose, sub-spherical.

Ceratodon purpureus (Hedw.) Brid., Bryol. Univ. 1: 480. 1826; Gangulee, Mosses E. India & Adj. Reg.1(2): 204-209. 1971. *Dicranum purpureum* Hedw., Sp. Musc. Frond. 136. 36. 1801. *Mnium purpureum* (Hedw.) With., Syst. Arr. Brit. Pl. (ed. 4) 3: 786. 1801. *Tortula saussuriana* P. Beauv. Prodr. Aethéogam. 93. 1805. *Didymodon purpureus* (Hedw.) Hook. & Taylor, Muscol. Brit. 65. 20. 1818. *Barbula saussuriana* (P. Beauv.) Brid. Muscol. Recent. Suppl. 4: 94. 1819. *Trichostomum purpureum* (Hedw.) De Not., Syllab. Musc. 189. 1838. *Ceratodon antarcticus* Cardot, Rev. Bryol. 27: 43. 1900. *C. grossiretis* Cardot, Bull. Herb. Boissier, sér. 2, 6: 4. 1906. *C. minutifolius* Cardot, Compt. Rend. Hebd. Séances Acad. Sci. 153: 602. 1911. *C. purpurascens* (Hedw.) Jenn., Man. Mosses W. Pennsylvania 57. 1913. *Leskeella cuspidata* J.J. Amann & Meyl., Bull. Soc. Vaud. Sci. Nat. 57: 133. 3. 1930. *Meesia kenya* P. de la Varde, Ark. Bot., n.s. 3: 129. f. 22. 1955. *Ceratodon*

validus (Cardot) Horik. & Ando, Hikobia 3: 278. 1963.

Plants green, reddish or brown, ± 70 mm long, forming short turfs; stem robust, stiff, crowded, slender with distant, lax, flexuose leaves; leaves ovate-lanceolate to linear-lanceolate, 1.3 mm long and 0.35 mm wide at base, loosely contorted to appressed when dry, recurved and slightly twisted when moist, margin recurved to just below apex, usually dentate near apex or entire; costa usually percurrent or excurrent; perichaetial leaves broadly ovate, narrowing above, apex obtuse or shortly acuminate, margin entire or slightly crenulated, laminal cells at base quadrangular, $10\text{--}18 \times 10\text{--}12 \mu\text{m}$, cells at middle $6\text{--}12 \times 9 \mu\text{m}$, seta purple, occasionally yellow, 14 mm long, capsule inclined to horizontal at maturity, elliptical-oblong to cylindrical, 1.5×0.5 mm, operculum short conical to long rostrate; spores not observed (Plate 5.73).

Habitat: On cement walls, usually seen on disturbed areas of the sholas, collected from Mannavan Shola check post region.

Discussion: The genus *Ceratodon* Brid. was not reported from Kerala. Hence the present collection along with the species *C. purpureus* (Hedw.) Brid. is a new record for Kerala. Burley and Pritchard (1990) commented that is an exceptionally polymorphic and cosmopolitan species, the morphological characters may greatly vary in different geographical zones. This species is characterized by the leaves usually concave with percurrent or excurrent costa and the margin of the leaf is usually recurved when moist.

Distribution: World: Austria, China, Europe, Germany, Greenland, Hawaii, Iceland, Japan, Scandinavia, British Isles, the Caucasus, S.W. Asia, Korea, USSR, Switzerland, United States (Burley & Pritchard, 1990); **India:** Delhi (Chopra & Kanta, 1966), Eastern Himalaya (Gangulee, 1971), Kerala (present collection), Tamil Nadu (Foreau, 1930, 1961; Gangulee, 1971; Daniels, 2010), Uttar Pradesh (Sahu & Asthana, 2015).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900 m) 03.03.2016 *Mufeed 10017* (ZGC).

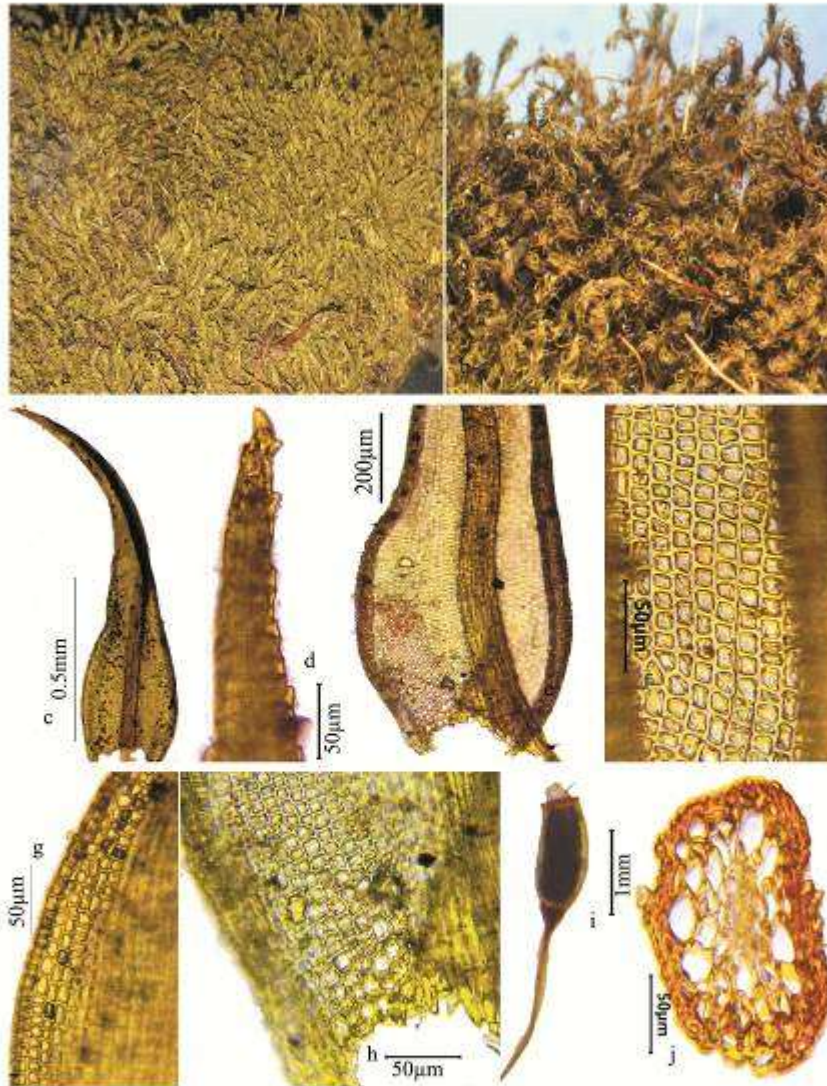


Plate 5. 73: *Ceratodon purpureus* (Hedw.) Brid., a&b. habit, c. leaf, d. leaf tip cells, e. leaf basal portion, f. leaf middle cells, g. leaf marginal cells, h. leaf basal cells, i. sporophyte, j. c.s. of stem

Dicranaceae Schimp.

Coroll. Bryol. Eur. 11. 1856.

Plants erect, stem often tomentose; leaves mostly narrow, lanceolate, occasionally falcate or falcate-secund, with a single, narrow to broad costa, with or without rhizoids at the base, sometimes ending in a hyaline, occasionally toothed apex, costa in cross section with or without stereid bands, leaf cells usually smooth, sometimes mamilllose, or rarely with a single papilla on one or both sides, proximally, papillose distally.

Key to the genera

- 1a. Leaf without distinct border, costa broad, upper leaf cells smaller, smooth 2
- 1b. Leaf with distinct border, costa narrow, upper lamina cells obscure, incrassate.....
..... ***Leucoloma***
- 2a. Plants small with ovate lanceolate leaves; margin entire, serrate or serrulate;
costa ending below apex ***Aongstroemia***
- 2b. Plants medium to large lanceolate to ovate lanceolate leaves; margin often plane
or incurved; costa percurrent to excurrent ***Campylopus***

***Aongstroemia* Bruch & Schimp.,**

Bryol. Eur. 1: 169. 1846.

Plants usually small, in loose or dense tufts, or growing by separate shoots, pale-green, golden-green or yellowish brown; stems erect, simple or slightly branched; leaves imbricate, symmetric or asymmetric, ovate, ovate-lanceolate or shortly lingulate, obtuse, broadly acute or acuminate, concave; margin entire, undulate, serrate or serrulate; lamina unistratose; costa strong, smooth, ending below apex; median laminal cells narrow hexagonal to rhomboidal, thick-walled, at margins narrower and thin-walled; basal cells rounded-quadrate, irregularly narrow rectangular or short rectangular; dioicous; seta 1-1.5 cm, straight, red; capsule erect, symmetric, ovate red-brown; peristome teeth divided in distal half or undivided, vertically striolate to almost smooth proximally, papillose to smooth distally.

Aongstroemia orientalis Mitt., Trans. Linn. Soc. London, Bot., ser. 2. 3: 154. 1891.
Anomobryum uncinifolium Broth., Philippine J. Sci. 5: 146. 1909. *Aongstroemia uncinifolia* (Broth.) Broth., Nat. Pflanzenfam. ed. 2, 10: 179. 1924.

Plants small, 4-6 mm long, shiny, yellow to yellowish green, in loose tufts; stems slender, julaceous, erect or ascending, simple or slightly branched at the tip; leaves oval to oblong, strongly clasping at base, leaf 0.7 mm long and 0.3 mm wide, tip acute, sharply bent to one side at the tips; margins slightly serrulate above, entire below; costa strong, ending near the apex or percurrent; upper cells rounded-quadrangle, 10-15 µm long and 6 µm wide; lower cells rectangular, 15-18 µm long and 8 µm wide; plants collected were sterile (Plate 5.74).

Habitat: Terrestrial, on land cuttings along with *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid.

Discussion: *Aongstroemia orientalis* Mitt. is a very rare species in the study area. It looks like an acrocarpic moss, but the main stem is creeping and is characterized by the oval to oblong leaves and the leaf tip sharply bent to one side at the tips. This species was reported only from Himalayas in India and hence the present collection is a new record for Peninsular India.

Distribution: World: Borneo (Iwatsuki, 1972), Brazil (Forzza, 2010), China (Redfearn Jr. & Wu, 1986), Japan, Russia, Mexico, Central and South America (Crum & Buck, 1990), Myanmar, Indonesia, Philippines (Tan & Iwatsuki, 1991); **India:** Kerala (present collection), Western Himalayas (Alam, 2013b).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park Iddalymotta (2150 m) 25.09.2018 *Mufeed 9981* (ZGC).

***Campylopus* Brid.,**

Muscol. Recent. Suppl. 4: 71. 1819[1818].

Plants small, medium or large to very vigorous, often strong and sturdy, colour varies from green yellowish to reddish brown, usually in dense tufts, stem erect, usually simple or branched; leaves erect, lanceolate to ovate lanceolate, usually gradually narrowed subtubulose apex, margin often plane or incurved, always serrulate or denticulate at the extreme tip; costa broad, often occupying ½ or more the basal region, percurrent to long excurrent or sometimes hyaline; usually stereid bands forms either adaxial surface for providing mechanical support, rarely without stereid cells in transverse section; apical cells quadrangle to rhomboidal or rectangular

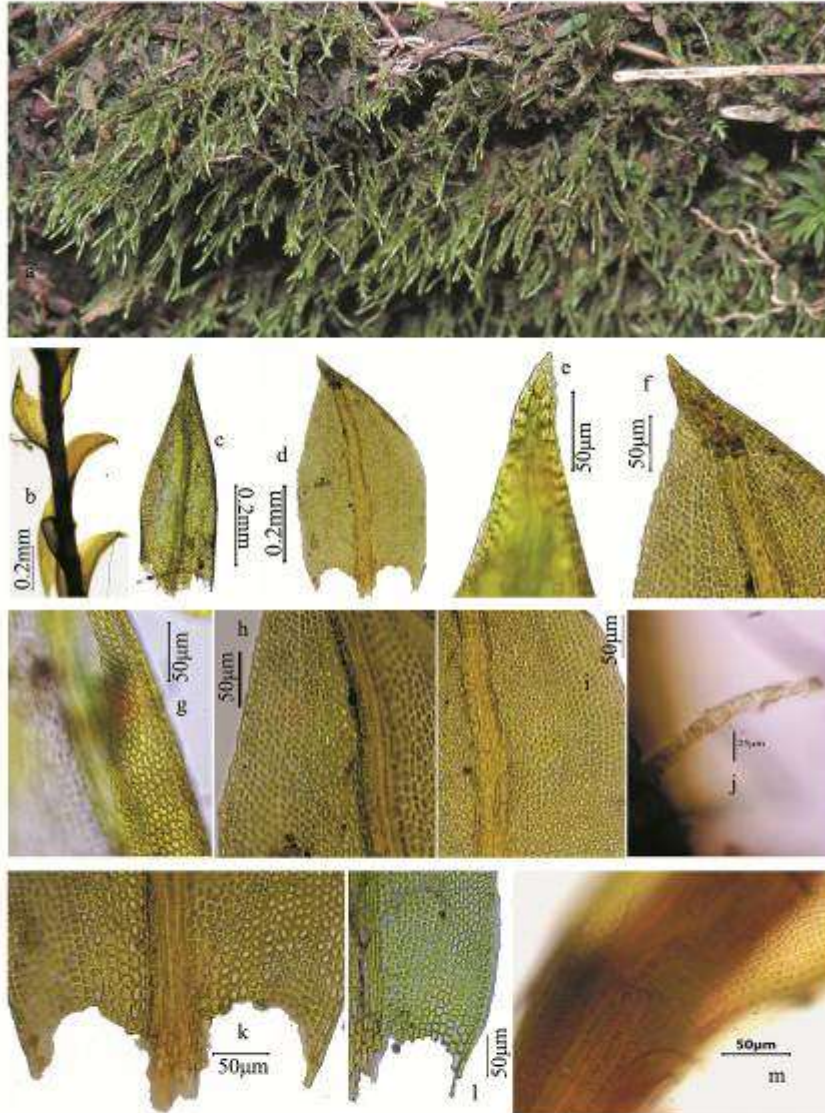


Plate 5. 74: *Aongstroemia orientalis* Mitt., a. habit, b. single plant, c&d. leaves, e. leaf tip cells, f. cells at apex, g&h. apex marginal cells, i. cells at middle, j. paraphyllia, k&l. basal cells, m. leaf attachment

incrassate, lower cells rectangular to rhomboidal or linear, narrower towards the margins, sometimes forms hyaline border; alar cells prominent, inflated, extending to the costa; dioicous, setae elongate, capsule erect or curved, ovoid to ellipsoid, furrowed when dry, peristome teeth 16, calyptrae cucullate, often fringed at base, spores spherical, yellow to brown.

The genus *Campylopus* is a very complex one, this may be due to the dioicous nature and sexual dimorphism that occurs in several species. This may lead to difficulties if only female plants occur at one locality, or if only female tufts have been collected. Some species have different types of leaves with different size and areolation along a single stem. Extreme basal leaves forming small rosettes, stem leaves different and apical leaves forms comal tufts. Also, sterile and fertile plants have different leaf forms and aerolation, especially of the involucre leaves around the perichaetia. From India about 20 species have been reported by Gangulee (1971). But most of them are synonymised under different names (Frahm, 1984; 1994). Considering all these difficulties from the present study area collected eight different collections, but here included only five species which shows a marked difference in all characters.

Key to the species

- 1a. Plants whitish green, short branches in the upper part of the stem *C. fragilis* subsp. *goughii*
- 1b. Plants yellowish green to brownish, branches if present large 2
- 2a. Costa $\frac{1}{2}$ of leaf length, with ventral hyalocysts and dorsal lamellae 1-3 cells high ... *C. pilifer*
- 2b. Costa $\frac{1}{3}$ of leaf length, hyalocyst at centre 3
- 3a. Plants dichotomously branched, leaf tip cells hyaline *C. schmidii*
- 3b. Plants not dichotomously branched, leaf tip cells not hyaline 4
- 4a. Stereids small on dorsal side *C. subulatus*
- 4b. Stereids present on both the ventral and dorsal regions *C. ericoides*

Campylopus ericoides (Griff.) A. Jaeger., Ber. Thätigk. St. Gallischen Naturwiss. Ges.: 424. 1872; Bruehl, Rec. Bot. Surv. India 13(1): 23. 1931; Gangulee, Mosses E. India & Adj. Reg. 1(2): 296. 1971; J.-P. Frahm, J. Hattori Bot. Lab. 140. 1992; Daniels, Arch. Bryol. 65: 45. 2010; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 98.

2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 10. 2008; Arch. Bryol. 42: 6. 2009; Taiwania 54: 64. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 14. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 21. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 25. 2019. *Dicranum ericoides* Griff., Calcutta J. Nat. Hist. 2: 499. 1842. *Campylopus erythrognaphalus* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges.: 439. 1872. *Dicranum erythrognaphalon* Müll. Hal., Bot. Zeitung (Berlin) 11: 37. 1853. *Campylopus involutus* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges.: 418. 1872; Gangulee, Mosses E. India & Adj. Reg. 1(2): 307. 1971; Manju *et al.*, Taiwania 54: 64. 2009. *Dicranum involutum* Müll. Hal., Bot. Zeitung (Berlin) 11: 37. 1853. *Campylopus tenuinervis* M. Fleisch., Musci Buitenzorg 1: 120. 1904.

Plants light green to yellowish brown, in dense tufts, medium sized, 20-50 mm long, not dichotomously branched; stem reddish, erect, hairy, comal tufts small, radiculose at base; c.s. of stem oval to quadrate, with larger cortical cells, medullary cells smaller thick walled, concentrated at middle, prominent; leaves straight, ± 5 mm long, flexuose when dry, erect when moist, lanceolate, radiculose at leaf base, gradually narrowed to a grooved subula, margin inflexed, wavy at upper half; costa pale yellowish brown, placing $1/3$ the leaf base width, excurrent, with stereid bands on both sides; upper cells obliquely rectangular or oval, 22-30 μm long and 7 μm wide, thick walled, leaf marginal cells narrow, thin walled, 36 μm long and 4 μm wide; alar cells weakly developed, incrassate, basal cells tinged with yellowish brown, long rectangular cells, 20-75 μm long and 10-12 μm wide; sporophyte not observed (Plate 5.75).

Habitat: Terricolous, on land cuttings and on wet and dry rocky patches in open grasslands and shola forest.

Discussion: *Campylopus* is a genus that is found only in the high altitude grass lands along with shola forests. This is a widely distributed species in the high altitude regions of Kerala. Gangulee (1971) described *C. ericoides* and *C. involutus* from Eastern Himalayas. But, Frahm (1994) synonymized *C. involutus* under *C. ericoides*. It is characterized by the broad costa occupying $1/3$ of the leaf base and the stereids present on both the ventral and dorsal regions.

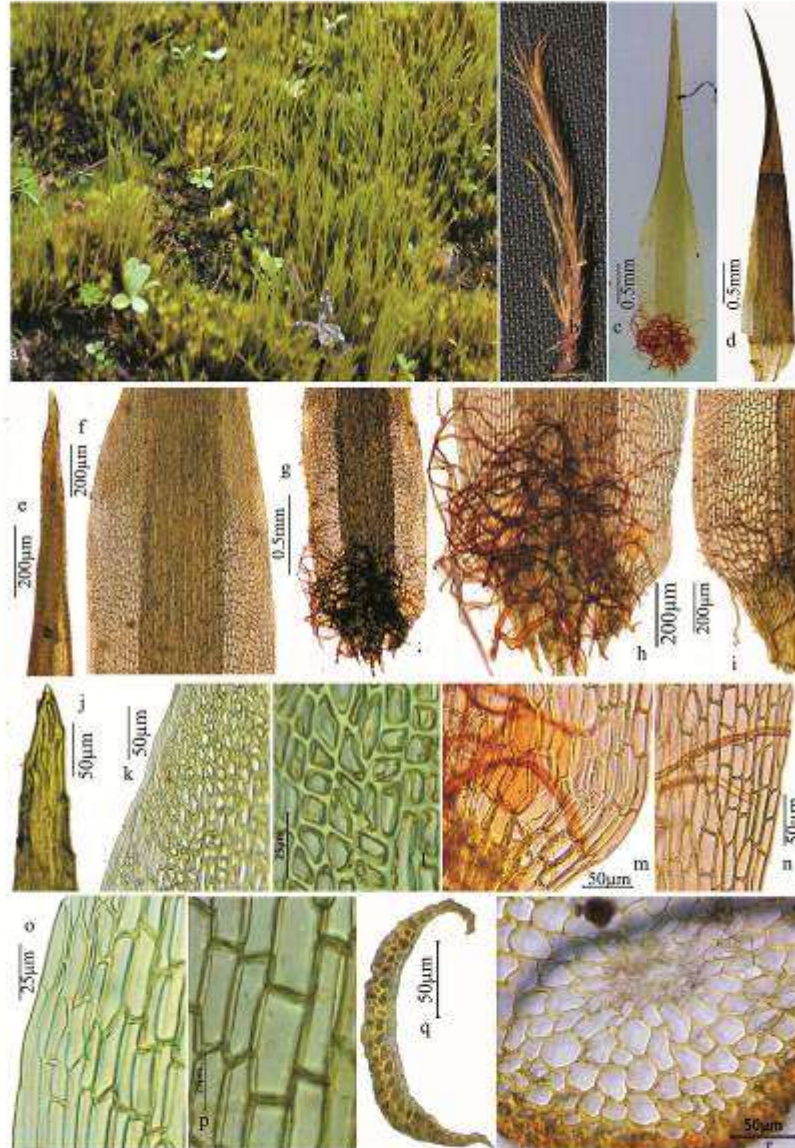


Plate 5. 75: *Campylopus ericoides* (Griff.) A. Jaeger, a. habit, b. single plant, c&d. leaf, e. leaf apex, f. leaf middle, g&h. leaf base with rhizoids, i. basal cells, j. leaf tip cells, k. leaf marginal cells, l. leaf cells enlarged, m. alar cells, n&o. cells near base margin, p. basal cells enlarged, q. c.s. of leaf, r. c.s. of stem

Distribution: World: Australia (Frahm, 1994), China (Frahm, 1992), Philippines (Tan & Iwatsuki, 1991), Java, Nepal (Gangulee, 1971), Sri Lanka (O'Shea, 2002), Thailand, Vietnam (Ninh, 1993); **India:** Assam, West Bengal (Gangulee, 1971), Karnataka (Frahm *et al.*, 2013), Kerala (Nair *et al.*, 2005), Madhya Pradesh (Gupta *et al.*, 2016), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013, Daniels *et al.*, 2018, Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1850-2000 m) 02.08.2015 *Mufeed 13308b*, 13317; 14.07.2017 *Mufeed 7374*, 7576; Pullaradi Shola (2400 m) 26.09.2018 *Mufeed 10000* (ZGC).

Campylopus fragilis (Brid.) Bruch & Schimp. subsp. ***goughii*** (Mitt.) J.-P. Frahm, Trop. Bryol. 4: 61. 1991; Gangulee, Mosses E. India & Adj. Reg. 278, 287, 295. 1971 (as *C. subfragilis*, *C. subgracilis* & as *C. fragilis*); Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 15. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 25. 2019. *Dicranum goughii* Mitt., Musc. Ind. Or.:17. 1859. *Campylopus goughii* (Mitt.) A. Jaeger ,Ber. S. Gall. Naturw. Ges., 1870-71: 424. 1872; Broth., Rec. Bot. Surv. India 1(12): 312. 1899; Foreau, J. Madras Univ. 2: 244. 1930; Bruehl, Rec. Bot. Surv. India 13(1): 23. 1931; Gangulee, Mosses E. India & Adj. Reg. 283; 1971; J. Lal, Checklist Indian Moss.: 39. 2005. *C. nietneri* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 423 (Gen. Sp. Musc. 1: 136). 1872. *Dicranum nietneri* Müll. Hal., Linnaea 36: 35. 1869.

Plants usually in loose tufts, pale whitish-green, radiculose; stem brown, up to 2 mm long, short branches in the upper part of the stem; leaves up to 2.8 mm long 0.4 mm wide at base, flexuose in the apex, more flexuose when dry, lanceolate, extending into a long canaliculated subula, margin inflexed except at base, extreme tip serrulate; alar cells not bulging out, formed of few cells not much inflated, orange yellow in colour and distinct from yellowish brown costa; basal laminal cells pale, irregularly rectangular, 25-35 µm long 5 µm wide, cells at apex smaller, rhomboid to elongate, incrassate, 15 µm long and 5 µm wide, cells at upper part light brown like cells of costa; seta long up to 8 mm, capsule ovoid, slightly nodding at the tip, urn region separated from the epidermal cells, 2 mm long, 0.5 mm wide, operculum long beak like, calyptra small, covering only half portion when mature, spores spherical, yellowish green, 15 µm diagonally (Plate 5.76).

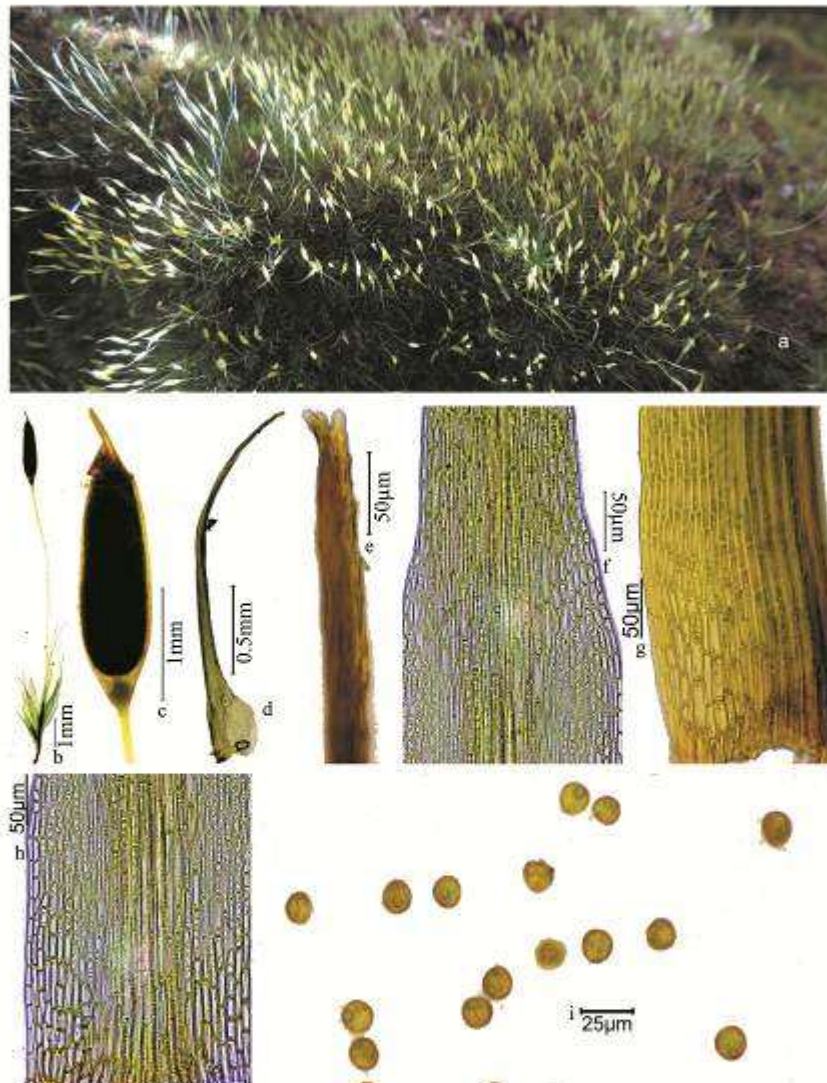


Plate 5. 76: *Campylopus fragilis* (Brid.) Bruch & Schimp. subsp. *goughii* (Mitt.) J.-P. Frahm, a. habit, b. single plant with sporophyte, c. capsule, d. leaf, e. leaf extreme tip, f. leaf middle cells, g&h. leaf basal cells, i. spores

Habitat: Terricolous, on land cuttings in grassland and border of shola forest.

Discussion: The Indian species reported by Gangulee (1971) as *C. subfragilis* Ren. & Card. was synonymised with *C. fragilis* (Brid.) B.S.G. by Frahm (1987) and he (2012) commented that the Indian records from Darjeeling, Palni hills and Shembaganur are probably belonging to *C. fragilis* ssp. *goughii* in India. Also *C. subgracilis* Renauld & Cardot ex Gangulee reported by Gangulee (1971) also synonymised with *C. fragilis* (Brid.) Bruch & Schimp. ssp. *goughii* (Mitt.) J.P. Frahm. All these species illustrated in Gangulee (1971) looks similar. Manju & Rajesh (2012) reported this species as *Campylopus fragilis*. Daniels & Kariyappa (2019) reported this species as *Campylopus subfragilis*. The characters are almost similar to *C. fragilis* ssp. *Goughii*, but there is no illustration to compare. This species is characterized by its whitish green plants, short branches in the upper part of the stem which looks like a pencil and the structure of sporophyte is peculiar.

Distribution: **World:** China, Bhutan Nepal, Sri Lanka (Frahm, 1987); **India:** Darjeeling, Sikkim, West Bengal, Khasi Hills (Gangulee, 1971), Karnataka (Frahm *et al.*, 2013), Kerala (Manju & Rajesh, 2012), Madhya Pradesh (Gupta *et al.*, 2016), Western Himalaya, Kumaon, Kashmir (Dandotiya *et al.*, 2011), Tamil Nadu (Daniels & Kariyappa, 2019; Foreau, 1930, 1961; Gangulee, 1971).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2240 m) 22.09.2018 *Mufeed* 9902 (ZGC).

Campylopus pilifer Brid., Muscol. Recent. Suppl. 4: 72. 1819; Foreau, J. Madras Univ. Sect. B. 2: 8. 1930 & J. Bombay Nat. Hist. Soc. 58: 17. 1961 (as *C. polytrichoides* & as *C. introflexus*); Gangulee, Mosses E. India & Adj. Reg. 303. 1971 (as *C. introflexus*). *C. polytrichoides* De Not., Syll. Musc. 222, 1838. *C. introflexus* (Hedw.) Brid., Mant. Musc. 72. 1819. *C. ericetorum* (Mitt.) A. Jaeger, Ber. S. Gall. Naturw. Ges. 1877-78: 386. 1880. *C. tricolor* (Müll. Hal.) A. Jaeger, Ber. S. Gall. Naturw. Ges. 1870-71: 437, 1872. *C. acrocaulon* (Müll. Hal.) Paris, Index Bryol. 238. 1894. *C. angustifolius* Warnst., Hedwigia 57: 81. f. 16. 1915. *C. arbogastii* Renauld & Cardot, Rev. Bot. Bull. Mens. 9: 289. 1891. *C. bessonii* Renauld & Cardot, Rev. Bot. Bull. Mens. 9: 397. 1891. *C. cinchonae* Paris,

Index Bryol. Suppl. 90. 1900. *C. erectus* (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 89. 1869. *C. griseolus* (Müll. Hal.) Paris, Index Bryol. Suppl. 92. 1900.

Plants yellow-green to dark green, mostly seen in shade, 10 mm long, in loose tufts; stems dark blackish, stiff, equally foliate from base to apex; c.s. of stem with small and large cortical cells and medullary cells indistinct; leaves linear lanceolate, ending in a serrate, hyaline hairpoint; upper laminal cells oval to rhomboid, incrassate, 18-25x5-9 µm; alar cells weak, basal marginal laminal cells thin-walled, hyaline, 16-18x5 µm; cells near costa at base rectangular, coloured, 40-50 x 8 µm; costa 1/2 of the leaf width, in cross-section with ventral hyalocysts and dorsal lamellae 1-3 cells high; sporophyte usually long, capsule oval shaped, furrowed, narrow mouthed, 2x0.5 mm, calyptra bell shaped with frilled base covering the capsule, operculum beak shaped, beak long, spores papillose, 15x20 µm (Plate 5.77).

Habitat: On large rocks along with lichen and *Rosulabryum wightii* (Mitt.) J.R. Spence in partially shady areas of sholas and grasslands.

Discussion: *Campylopus pilifer* Brid. is reported from India as *C. introflexus* (Hedw.) Brid. by Gangulee (1971). It is synonymised under *C. pilifer* by Mites (1994). But, Frahm (2012) commented that *C. introflexus* is a Sub Antarctic species, introduced along the West coast of North America and in Europe. He also commented that *Campylopus pilifer* is misapplied in India, where it does not occur. The illustration in Gangulee (1971) shows a plant with erect hairpoints, whereas the type specimen of *C. introflexus* has reflexed ones. Frahm (2012) also commented that due to the lack of an illustration of the transverse section of the costa it cannot be decided whether Gangulee's figure belongs to *C. pilifer* or more probable to *C. schmidii*. This species was earlier reported from Tamil Nadu by Foreau (1930) as *C. pilifer* and as *C. introflexus* and as *C. polytrichoides* by Foreau (1961). The present collection from Anamudi Shola National Park shows similarity with *C. pilifer* in its cross section of costa which is described by Frahm (1984). Manju & Rajesh (2012) reported this species from Kerala as *C. pilifer*.

Distribution: A widely distributed species. **World:** Africa, Central and South

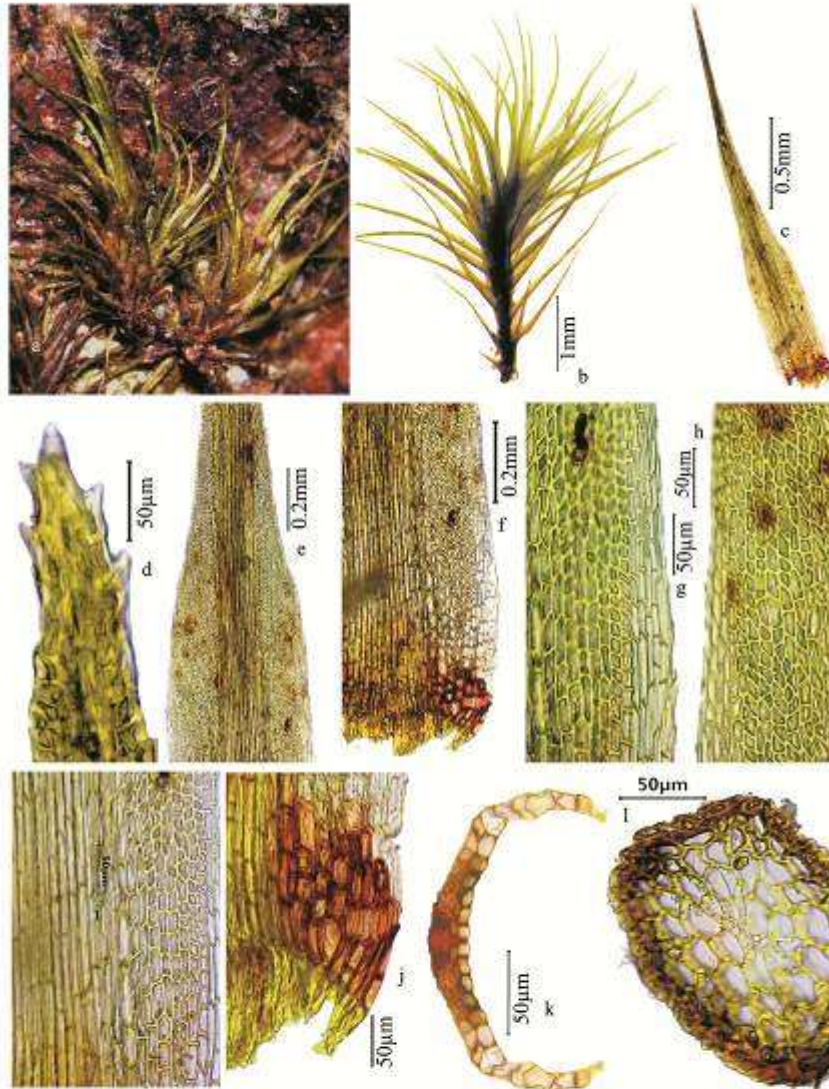


Plate 5. 77: *Campylopus pilifer* Brid., a&b. habit, c. leaf, d. leaf tip, e. leaf apex, f. leaf base, g. leaf middle marginal cells, h. leaf cells at middle, i. cells near base, j. alar cells, k. c.s. of leaf, l. c.s. of stem

America, Southern North America, South West Europe, Sri Lanka (Frahm, 1984); **India:** Kerala (Manju & Rajesh, 2012), Tamil Nadu (Foreau, 1930; 1961; Gangulee, 1971).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2240 m) 22.09.2018 *Mufeed 9902* (ZGC).

Campylopus schmidii (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 439 (Gen. Sp. Musc. 1: 143). 1872; Manju *et al.*, Acta Biol. Plant. Agr. 3: 81. 2014. *Dicranum schmidii* Müll. Hal., Bot. Zeitung (Berlin) 11: 37. 1853. *D. nodiflorum* Müll. Hal., *ibid.* 38. 1853. *Campylopus aureus* Bosch & Sande Lac, Bryol. Jav. 1: 80. 67. 1858. *C. subtricolor* Lorentz, Moosstudien 159. 1864. *C. nodiflorus* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 440. 1872. *C. chryseolus* Müll. Hal. ex Besch., Ann. Sci. Nat., Bot., sér. 6, 9: 325. 1880. *C. ripicola* Besch., Ann. Sci. Nat., Bot., sér. 6, 9: 326. 1880. *C. calvus* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 33(2): 111. 1895. *C. deciduus* Renauld & Cardot., Bull. Soc. Roy. Bot. Belgique. 33(2): 111. 1895. *C. merapicola* Müll. Hal., Gen. Musc. Frond. 266. 1900. *C. herzogii* Broth., Hedwigia 50: 122. 1910. *C. robbinsii* E.B. Bartram, Rev. Bryol. Lichénol. 30: 187. 1962.

Plants dioicous, glossy, yellowish green to golden brown, in cushion like tufts, up to 60 mm long, perichaetial leaves in comal tufts, usually dichotomously branched; c.s. of stem with cortical and medullary cells, cortex with small 3-4 layers of thick walled cells, medullary cells large and thin walled, 8-10 layers across, central strand present; leaves with hyaline hair-points, apex pointed, erect, lanceolate, 3-6 mm long, leaf margin flat with 3-4 layers of hyaline cells from upper region of alar cells to middle region; costa strong covering 2/3 of the leaf base, excurrent into a stiff apex, ending in hyaline, denticulate tip; sterioids on ventral surface, regularly ribbed at back; alar cells prominent, reddish brown, not much bulging, rectangular, 3-4 rows, 40-60 x 15-18 µm; leaf tip cells long, hyaline, 65 x 10-12 µm, middle cells rhomboid and incrassate, 40 x 10 µm, basal cells rectangular, 60 x 10 µm, becoming narrower near the margin; seta flexuous, up to 1cm long, capsule oval shaped, furrowed, narrow mouthed, 2.3 mm long and 1 mm wide, calyptra bell shaped with

frilled base covering the capsule, operculum beak shaped, beak long, spores papillose, $15 \times 20 \mu\text{m}$ (Plate 5.78).

Habitat: On rocky patch in open land cuttings mostly among grasslands.

Discussion: *C. schmidii* (Müll. Hal.) A. Jaeger is earlier reported from grassland shola of Silent Valley National Park and Eravikulam National Park in Kerala. It is characterized by dichotomously branched plants, up to 60 mm long, sterieds on dorsal side, leaf tip cells hyaline, alar cells not much bulged, seta flexuous and calyptra bell shaped with frills.

Distribution: World: Africa (Frahm *et al.*, 2004), Australia (Frahm, 1994a), China, Papua New Guinea, Japan, Taiwan (Frahm *et al.*, 2004), Philippines (Tan & Iwatsuki, 1991), Sri Lanka (O'Shea, 2002), United States (Norris and Shevock, 2004); **India:** Himalaya (Asthana and Sahu, 2015), Karnataka (Frahm *et al.*, 2013; Schwarz & Frahm, 2013), Kerala (Vohra *et al.*, 1982; Nair & Madhusoodanan 2006; Manju & Rajesh, 2012; Manju *et al.*, 2014), Maharashtra (Magdum *et al.*, 2017), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2220 m) 22.09.2018 *Mufeed 9903* (ZGC).

Campylopus subulatus Schimp. ex Milde, Bot. Zeitung (Berlin) 20: 460. 1862. Gangulee, Mosses E. India & Adj. 1(2): 279. 1971; *Dicranum gracile* Mitt., J. Proc. Linn. Soc., Bot. Suppl. 1: 17. 1859. *Dicranum latinerve* Mitt., *ibid.* *Campylopus schwarzii* Schimp., Musci Eur. Nov. 1. pl. 1. 1864; *C. gracilis* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 427 (Gen. Sp. Musc. 1: 131). 1872; Gangulee, Mosses E. India & Adj. 306. 1971. *C. latinervis* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 426. (Gen. Sp. Musc. 1: 130). 1872.

Plants yellowish green, up to 8mm long, stem blackish, not dichotomously branched, upper leaves larger forming tufts; leaves lanceolate, yellowish green, 3 mm long and 0.4mm wide, leaf margin flat, serrated at tip, costa $\frac{3}{4}$ of leaf width, leaf upper cells irregularly rounded to elongate, 13-18 μm long and 7-9 μm wide, middle marginal cells, hyaline, elongate, 21-28 μm long and 5-8 μm wide; alar cells

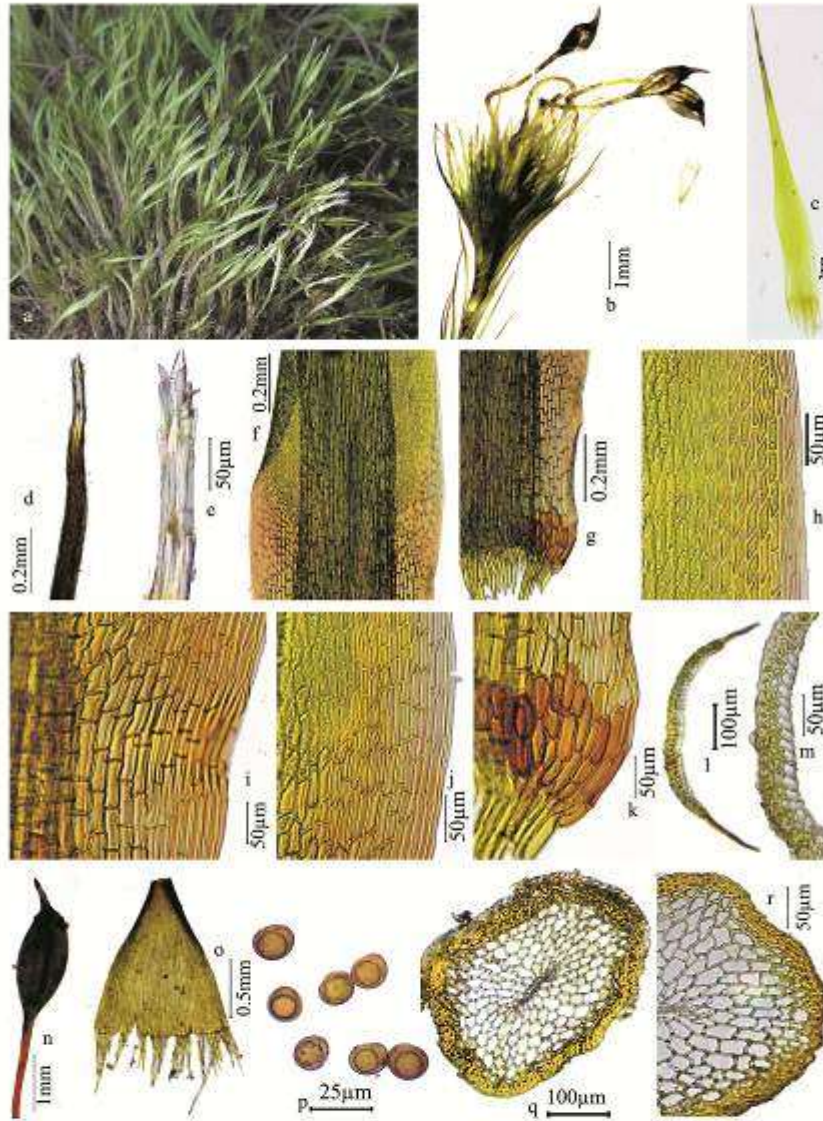


Plate 5. 78: *Campylopus schmidii* (Müll. Hal.) A. Jaeger, a. habit, b. habit with sporophyte, c. leaf, d&e. leaf tip, f. middle region, g. basal region, h. marginal cells, i. cells near base, j. cells near middle margin, k. alar cells, l&m. c.s. of leaf, n. sporophyte, o. calyptra, p. spores, q&s. c.s. of stem

not bulging, brownish, above alar cells near costa very small cells, 25-45 µm long and 13-18 µm wide, towards margin hyaline elongate cells; c.s. of leaf with single layer of large ventral hyalocyst and dorsal small stereids; c.s. of stem without central strand, cortical cells large, thin to thick walled, medullary cells inconspicuous; sporophyte not observed (Plate 5.79).

Habitat: Terrestrial, on rock filled land cuttings and on soil in shady areas of grassland and margin of shola forest at an altitude above 2200 m.

Discussion: Gangulee (1971) described *Campylopus subulatus* Schimp. ex Milde, *C. gracilis* (Mitt.) A. Jaeger, *C. schwarzii* Schimp. and *C. latinervis* (Mitt.) A. Jaeger from different localities of Eastern Himalayas and adjacent regions. Frahm (1992 & 1994) synonymised all these species under *C. subulatus*. Since the plant shows much variation in the morphological characters and leaf characters in a single species. Costa character is very specific for identification. Gangulee (1971) provided character of lamellae in *C. schwarzii* only. The present collection shows similarity with *C. schwarzii* in its large ventral hyalocyst and dorsal small stereids.

Distribution: World: China, East Nepal, Myanmar, Thailand (Gangulee, 1971);

India: Kerala (Nair & Madhusoodanan 2006; Manju & Rajesh, 2012), Sikkim, Manipur, Western Himalaya (Gangulee, 1971).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600 m) 14.07.2017 *Mufeed 7519* (ZGC).

***Leucoloma* Brid.,**

Bryologia Universa 2: 218. 1827.

Plants dioicous; moderate sized, soft, pale green, shiny, epiphytic plants without central strand; stem reddish or blackish in colour, usually branched with very few rhizoids; leaves densely covered by straight to falcate, tapered to a very long subulate acumen from an ovate lanceolate base, margin entire except at the apex, leaf border wider near the leaf base; costa narrow, excurrent; cells small, subquadrate to rectangular, lamina bordered by narrow, hyaline cells, upper cells highly papillose and obscure, alar differentiated, hyaline or reddish brown, quadrate to rectangular, thick walled; setae erect, elongate, capsule cylindric, smooth,

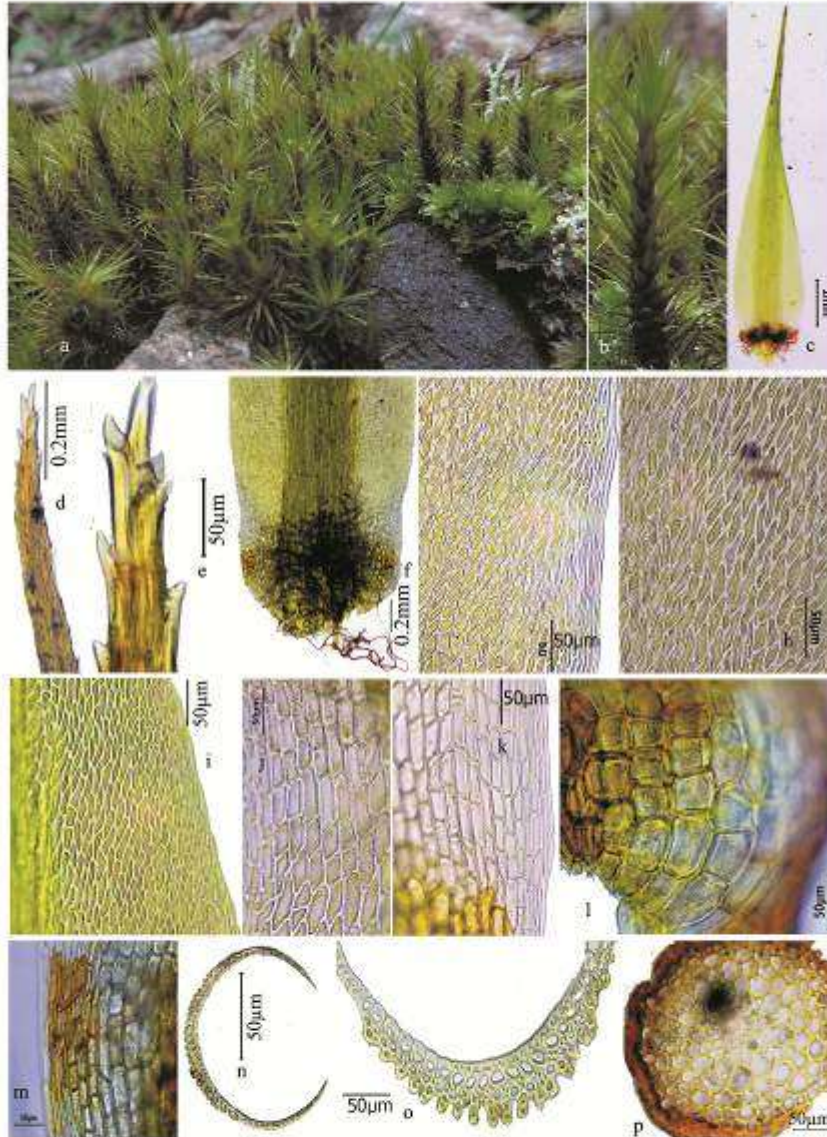


Plate 5. 79: *Campylopus subulatus* Schimp. ex Milde a. habit, b. single plant, c. leaf, d&e. leaf tip, f. leaf base with rhizoides, g. leaf margin near base, h. leaf cells at middle, i. leaf margin near tip, j&k. cells near base, l. alar cells, m. basal cells near costa, n&o. c.s. of stem, p. c.s. of stem

peristome teeth linear, calyptrae cucullate, entire at base, spores papillose.

Leucoloma molle (Müll. Hal.) Mitt., J. Proc. Linn. Soc., Bot., Suppl.1: 13. 1859; Foreau, J. Madras Univ. Sect. B. 2: 198. 1930 & J. Bombay Nat. Hist. Soc. 58: 19. 1961; Bruehl, Rec. Bot. Surv. India 13(1): 30. 1931; Gangulee, Mosses E. India & Adj. Reg. 1(2): 409. 1971; Chopra, Taxon Indian Moss. 86. 1975. *Dicranum molle* Müll. Hal., Syn. Musc. Frond. 1: 354. 1848. *D. insigne* Müll. Hal., Linnaea 36: 33. 1869. *Leucoloma subintegrum* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 33: 93. 1891. *L. limbatulum* Besch., Bull. Soc. Bot. France 45: 54. 1898. *L. novae-guineae* Paris, Index Bryol. Suppl. 223. 1900. *L. pallidicaule* Paris, Index Bryol. Suppl. 233. 1900. *L. molle* var. *longipilum* M. Fleisch., Musci Buitenzorg 1: 124. 1904. *L. kanakense* Broth. & Paris, Öfvers. Finska Vetensk.-Soc. Förh. 48(15): 4. 1907. *L. hawaiiense* Broth., Bernice P. Bishop Mus. Bull. 40: 9. 2 f. 6. 1927.

Plants pale green or whitish green, large, up to 5 cm long, in loose tufts, stem erect or branched, central strand absent; leaves widely erect spreading when moist, slightly flexuose, usually falcate when dry, margin involute above, bordered by a single row of elongated cells at the apex, 15-18 rows at the middle, up to 20 rows near the base; costa narrow, long, excurrent, cells narrow rounded at apex, 30-35 x 7 µm, median cells subquadrate to rounded rectangular, 10-14 µm long and 6 µm wide, minutely papillose, basal cells rectangular, 20 x 30 µm, smooth; alar cells quadrate to short rectangular, 34-44 x 15-18 µm, brownish, thick walled; c.s of stem rounded, outer most 2-3 layers of cells thick walled and inner layers thin walled and presence of large lumen; sporophytes not seen (Plate 5.80).

Habitat: On rocky patches in shola forests.

Discussion: *Leucoloma molle* (Müll. Hal.) Mitt. was earlier reported from Tamil Nadu in South India and not reported from Kerala. Hence the present collection is a new record for Kerala. It is characterized by the plants seen in loose tufts without a central strand, margin of leaf bordered by elongated cells and number of layers increase from top to bottom.

Distribution: World: China (Redfearn Jr., 1990), Hong Kong (So & Yip, 1995), Malaysia (Ho & Tan, 2002), Philippines (Alcala, 2019), Sri Lanka (Tan, 2005),

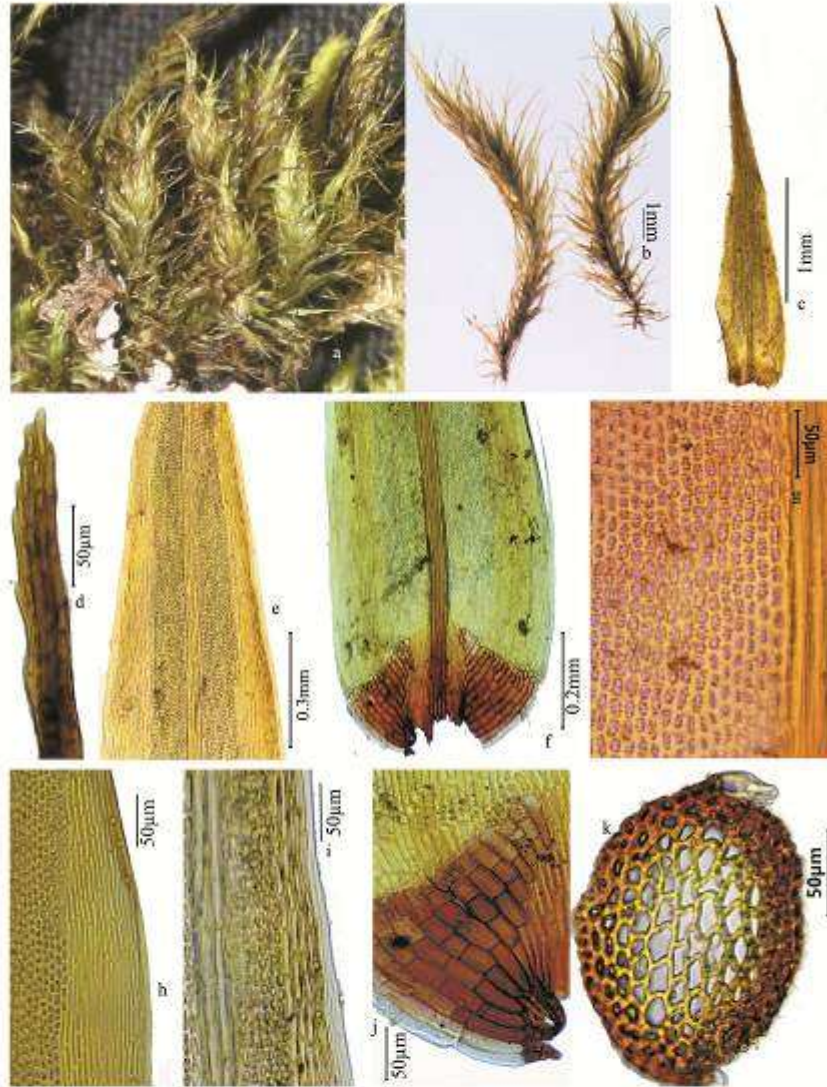


Plate 5. 80: *Leucoloma molle* (Müll. Hal.) Mitt., a&b. habit, c. leaf, d. leaf tip cells, e. leaf middle region showing hyaline cells at margin, f. leaf base, g. leaf middle cells, h. hyaline basal leaf marginal cells, i. upper leaf margin, j. alar cells, k. c.s. of stem

Taiwan (Lin, 1981); **India:** Kerala (present collection), Tamil Nadu (Foreau, 1930, 1961; Chopra, 1975; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1950 m) 02.08.2015 *Mufeed 13313* (ZGC).

Other specimen/s examined: India, Tamil Nadu, Nilgiri Hills *H.C. Gangulee 858* (CAL!).

Leucobryaceae Schimp.

Coroll. Bryol. Eur., 19. 1856.

Plants robust, whitish green to pale green, rarely branched; leaves form leucocysts and chlorocysts on margin, the median region is arranged with chlorocyst bordered on both sides of the leaves by one or more layers of leucocysts; costa broad or thin; alar cells usually absent; seta erect, capsule erect or pendulous, peristome 8 or 16, calyptra cucullate.

Leucobryum Hampe,

Linnaea 13: 42. 1839.

Plants whitish or pale green in dense cushions or patches; usually colonise in logs and barks of large trees, brittle when dry; leaves long, elliptic, falcate when moist, appressed when dry; costa very broad, occupying the whole width of the leaves except some marginal areas, margin hyaline, 2 to many layers are seen, entire.

Key to the species

- 1a. Plants whitish green with leaves up to ± 3 mm long; leaves gradually narrowed to subtubulous apex ***L. aduncum***
- 1b. Plants yellowish or whitish green with leaves up to 7 mm long; leaves gradually form a canaliculated apex ***L. juniperoideum***

Leucobryum aduncum Dozy & Molk., Plantae Junghuhnianae 3: 319. 1854; Bruehl, Rec. Bot. Surv. India 13(1): 30. 1931; Gangulee, Mosses E. India & Adj. Reg. 1(2): 428. 1969; Chopra, Taxon Indian Moss. 90. 1975; Daniels, Arch. Bryol. 65: 67. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 23. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 39. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 42. 2019. *L. brachyphyllum* Hampe ex Müll. Hal., Linnaea

17: 317. 1843. *L. conocladon* Besch., Ann. Sci. Nat., Bot., sér. 5, 18: 202. 1873. *L. francii* Cardot & Thér., Diagn. Esp. Var. Nouv. Mouss. 2. 1910. *L. pentastichum* Dozy & Molk., Pl. Jungh. 3: 319. 1854. *L. scalare* Müll. Hal. ex M. Fleisch., Musci Buitenzorg 1: 143. 1904. *L. serrifolium* Broth. & Paris, Öfvers. Finska Vetensk.-Soc. Förh. 51A(17): 9. 1909.

Plants small to medium sized, up to 1-2 cm long, whitish green in dense tufts; stems erect, branched, central strand absent; leaves 3.4 mm long and 0.94 mm wide at base, lanceolate, gradually narrowed to subtubulose apex, often with rhizoids, ovate to elliptic base, marginal cells hyaline, narrowly rectangular to linear, 1-2 rows on the upper part of the leaves, 4-6 rows on the base; c.s. of lamina shows costal leucocysts 2-3 layered, enclosing a layer of median chlorocysts through the leaves, laminal cells ranges 40-102 × 26-38 µm; sporophytes not seen (Plate 5.81).

Habitat: Epiphytic on logs and trunks of shola trees and evergreen trees.

Discussion: *Leucobryum aduncum* Dozy & Molk. is a widely distributed species in Tamil Nadu but not yet reported from Kerala. Daniels & Kariyappa (2019) reported this species as new record for Kerala from Kollam and Thiruvananthapuram district. It is characterized by its whitish green plants, stems without central strand and leaves gradually narrowed to subtubulose apex.

Distribution: World: China (Gao, 1983), Indonesia (Gradstein & Culmsee, 2010), Malaysia (Suleiman & Edwards, 2002), Philippines (Tan & Iwatsuki, 1991), Sri Lanka (O'Shea, 2002), Thailand (Dixon 1932); **India:** Kerala (Daniels & Kariyappa, 2019), Tamil Nadu (Daniels, 2003; Foreau, 1930, 1961; Biju and Daniels 2017; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1670-1850 m) 02.08.2015 *Mufeed 13308*; 14.07.2017 *Mufeed 7535* (ZGC).

Other specimen/s examined: Nepal, Eastern Himalayas Feb.–Apr. 1900 *H.C. Gangulee B.L. 2115* (CAL).

Leucobryum juniperoideum (Brid.) Müll. Hal., Linnaea 18: 689. 1845; Gangulee, Mosses E. India & Adj. Reg. 1(2): 420. 1969; Daniels & Daniel, Indian J. For. 26:

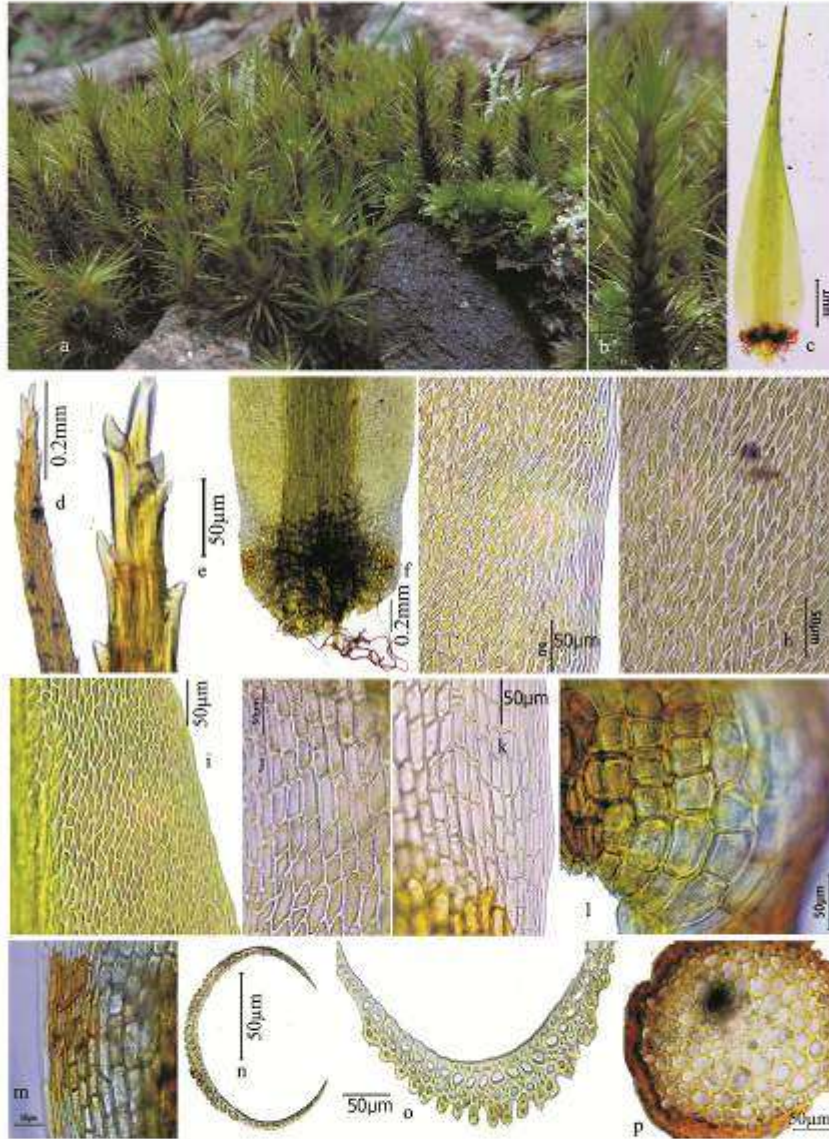


Plate 5. 79: *Campylopus subulatus* Schimp. ex Milde a. habit, b. single plant, c. leaf, d&e. leaf tip, f. leaf base with rhizoides, g. leaf margin near base, h. leaf cells at middle, i. leaf margin near tip, j&k. cells near base, l. alar cells, m. basal cells near costa, n&o. c.s. of stem, p. c.s. of stem

392. 2003; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 100. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 14. 2008; Taiwania 54: 64. 2009; Daniels, Arch. Bryol. 65: 68. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 26. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 42. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 48. 2019. *Dicranum juniperoideum* Brid., Bryol. Univ. 1: 409. 1826. *Leucobryum neilgherrense* Müll. Hal., Botanische Zeitung (Berlin) 12: 556. 1854. *L. holleanum* Dozy & Molk., Bryol. Jav. 1: 17. 1855. *L. triviale* Müll. Hal., Linnaea 36: 30. 1869. *L. retractum* Besch., Ann. Sci. Nat. Bot., sér. 7, 17: 334. 1893. *Ochrobryum japonicum* Besch., J. Bot. (Morot) 11: 151. 1897. *Leucobryum altiusculum* Besch., J. Bot. (Morot) 12: 285. 1898. *L. brevicaule* Besch., J. Bot. (Morot) 12: 285. 1898. *L. ferriei* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 28. 1905. *L. neilgherrense* var. *minus* Cardot, Beih. Bot. Centralbl. Abt. 2; 19(2): 97. 1905. *L. angustissimum* Broth., Symb. Sin. 4: 28. 1929.

Plants whitish or yellowish green, up to 2.5 cm high, found on decayed woods and tree trunks forming dense tufts with branched or with single stem; leaves erect spreading, ± 7 mm long and 1 mm wide, base broad, gradually form a narrow, ovate, canaliculated, cucullate, apiculate apex; costa wide, smooth; c.s of leaf shows one layer of 4 angled chlorocysts between two layers of leucocysts at the top and multi-layered leucocysts at base; apical cells rectangular, 55 μ m long and 37 μ m wide, median cells rectangular, 53-70 μ m long and 38 μ m wide, basal cells elongate, rectangular, marginal cells elongate, 2-3 layered, narrow, 94-114 μ m long and 22 μ m wide; sporophytes not seen (Plate 5.82).

Habitat: Epiphytic, on barks and logs along with *Calypogeia azurea* Stotler & Crotz and *Chiloscyphus muricatus* (Lehm.) J.J. Engel & R.M. Schust

Discussion: *Leucobryum juniperoideum* (Brid.) Müll. Hal. is a widely distributed species in the high altitude evergreen and shola forests. Müller (1854) described a new species *Leucobryum neilgherrense* Müll. Hal. from Nilghiri hills in Tamil Nadu. Breuhl (1931), Potier de la Varde (1922), Foreau (1930, 1961) and Gangulee (1971) reported this species from Tamil Nadu. Gangulee (1971) described both species with minor variation from Eastern Himalayas. But, Yamaguchi (1993) synonymized *L. neilgherrense* under *L. juniperoideum*. It is characterized by whitish plants up to 2.5cm, leaves smooth on back and the leaf lamina cells rectangular except at the marginal region.

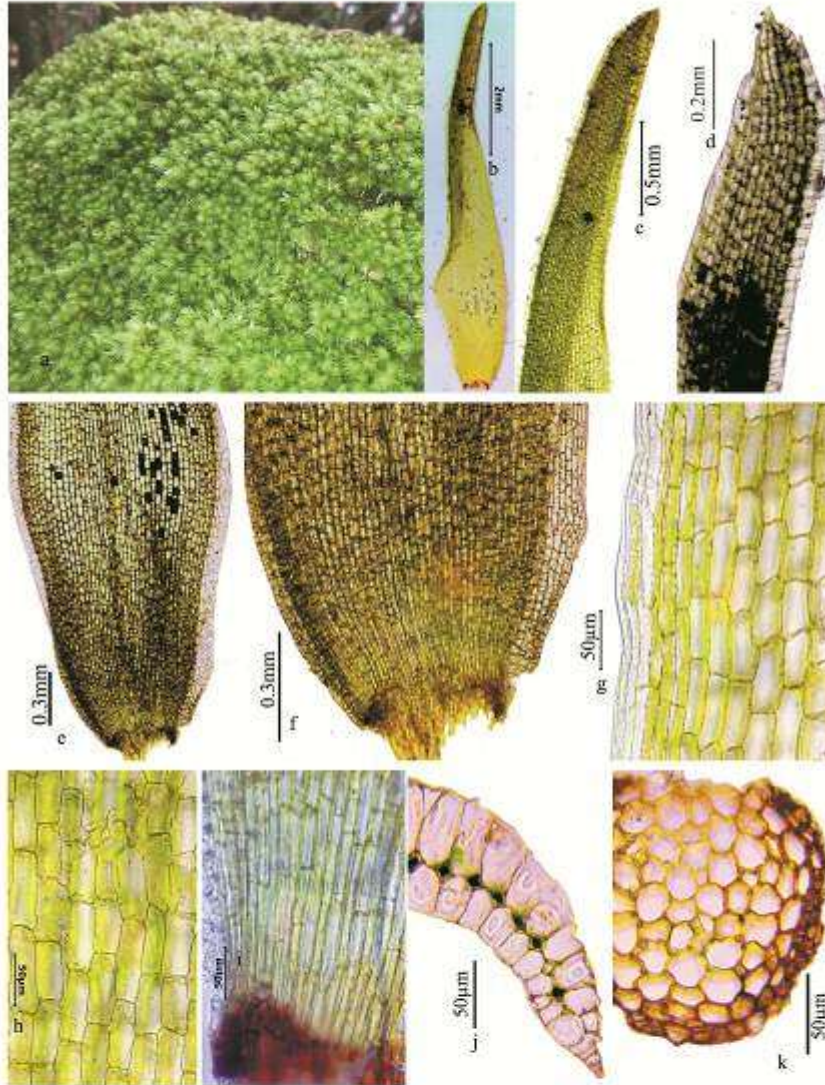


Plate 5. 82: *Leucobryum juniperoideum* (Brid.) Müll. Hal., a. habit, b. leaf, c. leaf apex, d. leaf tip cells, e. leaf base, f. leaf base enlarged view, g. leaf middle margin, h. middle cells, i. basal cells, j. c.s. of leaf, k. c.s. of stem

Distribution: World: Bhutan (Gangulee 1971), Borneo, Burma, China, Fiji, Japan, Java, Korea, Nepal, Philippines, Sri Lanka, Sumatra, Thailand, Vietnam (Karczmarz, 1981); **India:** Assam, Manipur, Darjeeling, West Bengal (Gangulee, 1971), Kerala (Nair *et al.*, 2005; Manju & Rajesh, 2012; Daniels & Kariyappa, 2019), Tamil Nadu (Breuhl, 1931; Foreau, 1930, 1961; Gangulee 1971; Daniels & Daniel, 2013; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700-1942 m) 02.08.2015 *Mufeed 13311*; 14.07.2017 *Mufeed 7512* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Ponkuzhi (900m) *Manju C.N. 84371, 84381*, Muthanga range, Mankolli (893m) *Manju C.N. 84520* (CALI!)

Pottiales M. Fleisch.,

Hedwigia 61: 392. 1920.

Pottiaceae Hampe,

Bot. Zeitung (Berlin) 11(18): 329. 1853.

Plants usually loosely caespitose, green above and brown below, irregularly branching or unbranched; stem usually short or several centimetres long; leaves appressed and contorted when dry, ovoid to lanceolate, margin usually recurved below, entire or dentate above; apex rounded-obtuse to more commonly narrowly acute; base usually ovate to oblong, sheathing at base; costa ending below the apex or awned; laminal cells at apex subquadrate or rarely rectangular; in most of the genus papillae present on the upper laminal cells, basal cells differentiated, clear and smooth; seta long and erect, capsule erect, cylindrical to ovate cylindric, operculum conic rostrate, calyptra cucullate.

Key to the genera

- 1a. Leaves lanceolate to linear lanceolate; basal cells thin walled and elongated..... *Hymenostylium*
- 1b. Leaves ovate to ovate-lanceolate, basal cells thick walled and quadrangular *Didymodon*

***Didymodon* Hedw.,**
Sp. Musc. Frond. 104. 1801.

Plants usually in loose to dense tufts, green to olive green when young, greenish brown to reddish or brown to blackish when mature; stem erect, simple or branched; leaves ovate to ovate-lanceolate, or lanceolate which are erectopate to squarrose when moist, appressed when dry, generally keeled; apex rounded, obtuse, acute or acuminate; margin weakly to strongly decurrent, entire or papillose, unistratose, not apiculate; costa ending below the apex or percurrent or excurrent with generally one layer of guide cells, generally with ventral stereids; upper and middle laminal cells without papillae or with one to three simple or bifurcate papillae per cell; seta yellowish or reddish brown; capsule erect or lightly inclined, oblong, ovoid or elliptical; spores smooth.

Didymodon revolutus (Cardot) R.S. Williams, The Bryologist 16: 25. 1925; Ellis *et al.*, J. Bryol. 42(2): 197. 2020. *Husnotiella revoluta* Cardot, Rev. Bryol. 36: 71. 1909. *Trichostomopsis revoluta* (Cardot) R.H. Zander, Framew. Post-Phylogenet. Syst. P. 93. 2013. *Husnotiella revoluta* Cardot, Rev. Bryol. 36: 71. 1909. *H. palmeri* Cardot, Rev. Bryol. 37: 121. 1910. *H. revoluta* var. *palmeri* (Cardot) E.B. Bartram, The Bryologist 29: 45. 1926.

Plants in loose turfs, light green to brown, 2 mm long, stem central strand differentiated; leaves imbricate when dry, erect to patent when moist, concave, ovate to elliptic, lingulate, 1.4 mm long and 0.6 mm wide at base, apex rounded, margin entire, plane in the lower part, papillose-crenulate, recurved to revolute to near apex, unistratose or bistratose in patches; costa 0.1 mm wide at leaf base, ending below apex, strongly spurred above midleaf, dorsal cells of costa in upper middle of leaf elongate to quadrate or shortly rectangular, papillose or smooth, transverse section of leaf base elliptic, with 3–4 guide cells in one layer, without ventral stereids, 1(2) layers of dorsal stereids, papillose, dorsal surface of cells differentiated, papillose, upper and middle laminal cells rounded to subquadrate, sometimes shortly rectangular, 8–10 µm long and 15–20 µm wide, lightly thick-walled, with 1–4 simple or bifurcate papillae per cell; basal cells quadrate to rectangular, 10–12 µm long and 30–35 µm wide, generally lightly thick-walled, smooth; sporophyte not observed (Plate 5.83).

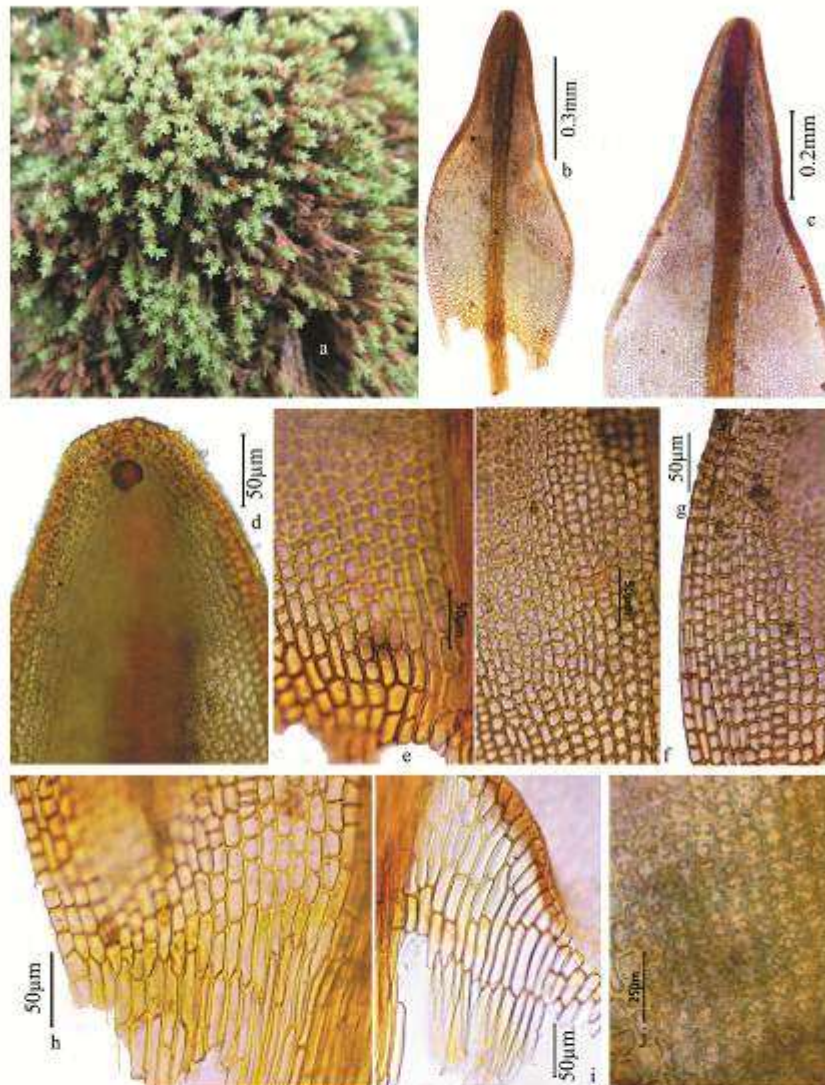


Plate 5. 83: *Didymodon revolutus* (Cardot) R. S. Williams a. habit, b. leaf, c. leaf apex, d. leaf tip enlarged, e. cells near base, f. cells at middle, g. cells at margin, h&i. cells at base, j. upper lamina cells

Habitat: Terrestrial, on land cuttings in shola forest.

Discussion: *Didymodon revolutus* (Cardot) R.S. Williams was reported as a new species to the Asian flora by Jiménez *et al.* (2003) collected from Yemen. This species was not reported from India, hence the present collection is a new record for India. Based on the present collection Ellis *et al.* (2020) reported this species as new record for India. It is characterized by ovate to elliptic or lingulate leaves, apex rounded, costa spurred above mid leaf and ending far below apex, guide cells in one layer, without ventral stereids, 1(2) layers of dorsal stereids and ventral epidermis with a pad of cells.

Distribution: World: Cape Verde (Cano, 2016), Mexico (Zander, 1994), U.S.A. (Redfearn Jr., 1983), Yemen (Jiménez *et al.*, 2003); **India:** Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola, Jandamala (1950 m) 09.11.2017 *Mufeed 7480* (ZGC).

Hymenostylium Brid.,
Bryol. Univ. 2: 81. 1827.

Plants growing in turfs or cushions, often flagellate, green-glossy, light brown below; stem often branched; leaves distant on stem, appressed-incurved, sometimes twisted or lax when dry, spreading, occasionally squarrose when moist, lanceolate or linear-lanceolate, up to 3.5 mm in length, upper lamina keeled, margin plane to broadly recurved one or both sides, entire or rarely serrulate near apex by projecting cell walls, rarely bistratose in patches along margins or medially; apex acute, occasionally obtuse or rounded, base oval or rectangular, occasionally narrowly decurrent; costa often stout, percurrent or more usually excurrent; upper laminal cells usually heterogeneous in size and shape, quadrate to rectangular or rhomboidal, walls thin-walled to trigonous, often porose.

Hymenostylium recurvirostrum (Hedw.) Dixon, Rev. Bryol. Lichénol. 6: 96. 1933; Pande & Singh, Pl. Sc. 97(1): 77. 1987; Sollman, Trop. Briol. 26: 83. 2005; Vidya *et al.*, Act. Bio. Pl. Agr. 43-72. 2015; Rawat *et al.*, Pl. Sci. Today 2(4): 154-158. 2015. *Anoectangium patagonicum* Cardot & Broth., Kongl. Svenska Vetensk. Acad.

Handl., 63(10): 30. 1923. *A. sordidum* Mitt., J. Linn. Soc., Bot. 12: 176. 1869. *Bryum verticillatum* With., Syst. Arr. Brit. Pl. (ed. 4) 3: 804. 1801. *Cynodontium asperellum* Stirt., Ann. Scott. Nat. Hist. 15(58): 106. 1906. *Gymnostomum atroviride* Griff., Calcutta J. Nat. Hist. 2: 479. 1842. *G. brevisetum* Nees & Hornsch., Bryol. Germ. 1: 164. 10 f. 21. 1823. *G. globosum* Hornsch., Flora 8: 79. 1825. *G. kunzeanum* (Müll. Hal.) Paris, Index Bryol. 545. 1896. *G. longirostre* Kunze ex Müll. Hal., Bot. Zeitung (Berlin) 5: 827. 1847. *G. pomiforme* Nees & Hornsch., Bryol. Germ. 1: 158. 10 f. 15. 1823. *G. recurvirostrum* Hedw., Sp. Musc. Frond. 33. 1801. *G. venezuelense* (Müll. Hal.) Paris, Index Bryol. 549. 1896. *G. xanthocarpum* Hook., Musci Exot. 2: 153. 1819. *Pottia xanthocarpa* (Hook.) Müll. Hal., Syn. Musc. Frond. 1: 563. 1849. *P. kunzeana* Müll. Hal., Fl. Chil. 7: 198. 1850. *Weissia longirostris* Mitt., J. Linn. Soc., Bot. 12: 134. 1869. *Hymenostylium contextum* Herzog, Biblioth. Bot. 87: 29. 1916. *H. kunzeanum* (Müll. Hal.) Müll. Hal., Gen. Musc. Frond. 396. 1900. *H. longirostre* Broth., Nat. Pflanzenfam. I(3): 389. 1902. *H. longopulvinatum* Dusén, Ark. Bot. 6(8): 7. 1906. *Hyophila laxitexta* J. Froehl. ex Imam & Ghabbour, Bot. Not. 125: 521. 1972.

Plants small to medium-sized, grow in dense, extensive tufts, green and glossy above, brownish below and moderately radiculose with branches; rhizoids smooth, brown, stem up to 2cm tall, slender and fragile, simple or sparingly branched, reddish-brown, smooth or scabrous; leaves appressed to stem, weakly contorted or curled when dry, erecto-patent to patent when wet, oblong-lanceolate, 5.7 mm long and 0.6 mm wide, keeled and not or slightly decurrent base which is sometimes slightly expanded, becoming gradually acuminate and acute at the apex; leaf margins unistratose, recurved on one side from the middle to the lower side, papillose-crenulate above, entire below or papillose-crenulate nearly throughout, often projecting above the base; costa relatively broad, ending 3–5 cells below the apex to percurrent; distal and median laminal cells quadrate, short-rectangular to oblate, 6-10 μm long and 5-8 μm wide, moderately thick-walled and often collenchymatous, slightly bulging on both surfaces, usually with 1–3 rows, conical papillae scattered over the lamina, or sometimes without papillae, basal cells mostly enlarged, elongated smooth, typically sturdy, rectangular, 25-40 x 8-12 μm , hyaline

and thick-walled; sporophyte not seen (Plate 5.84).

Habitat: Epiphytic, on barks of shola trees in altitudinal ranges.

Discussion: The species rather common in high altitude mountains, the plant shows some leaf variation all around the world. Leaf shape variation present in the apical parts, ranges from broad or blunt to acuminate apex. The specimen from Wayanad District (Nair *et al.*, 2005), shows variation from the present collection in the broad apex of leaf. This species is characterized by the leaves with recurved margins on one side, papillae of the laminal cells usually simple and scattered except at base and the basal cells are rectangular and hyaline.

Distribution: World: Bhutan, Nepal (Gangulee, 1972), China (Redfearn Jr., 1986), Iraq (Agnew & Vondracek, 1975), Mongolia (Abramov & Abramova, 1983), Papua New Guinea (Norris & Koponen, 1989), South Africa (Magil & Leistner, 1981), United States (Weber, 1973); **India:** Delhi (Chopra & Kanta, 1966), Kerala (Vidya *et al.*, 2005), Madhya Pradesh (Alam *et al.*, 2015), Maharashtra (Magdum *et al.*, 2017), Punjab (Lal, 2005), Rajasthan (Bapna & Choudhary, 1989), Sikkim, Western Himalaya (Gangulee, 1972), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700-2300 m) 02.08.2015 *Mufeed* 13330a; 03.04.2016 *Mufeed* 10015; 14.07.2017 *Mufeed* 7566 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Soojippara (760 m) Manju C.N. & K.P.Rajesh 87084 (CALI!).

Bryales Limpr.,

Krypt.-Fl. Schlesien 1(1): 55. 1876.

Notes: Order Bryales includes seven families viz., Catoscopiaceae Broth., Pulchrinodaceae D. Quandt, Bryaceae Schwägr., Phylloprepariaceae Crosby, Pseudoditrichaceae Steere & Z. Iwats., Mniaceae Schwägr. and Leptostomataceae Schwägr. (Goffinet *et al.*, 2008). Later, detailed work by Spence (2014) considered the family Bryaceae as a heterogenous family and concluded that Bryaceae consists of two relatively distinct families, with type Bryaceae sister to Leptostomataceae, and the Rhodobryaceae sister to the Mniaceae/Roellobryaceae clade. In the more recent

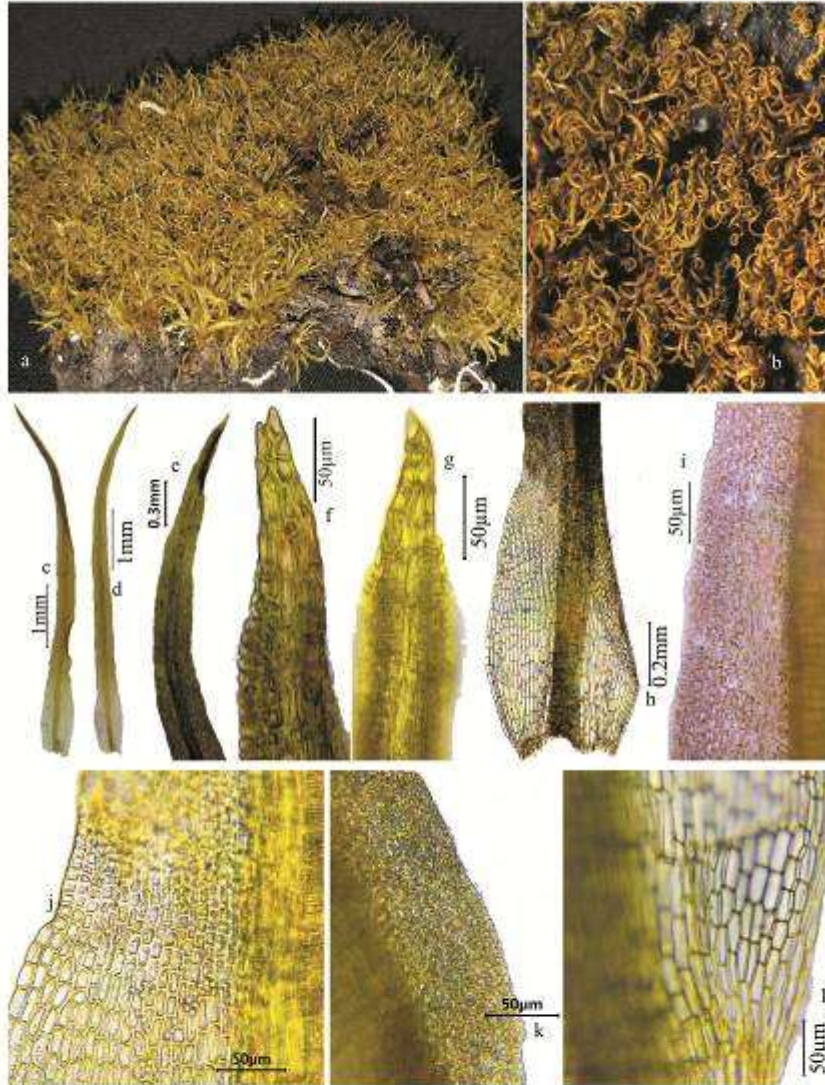


Plate 5, 84; *Hymenostylium recurvirostrum* (Hedw.) Dixon; a. habit, b. dry habit, c&d. leaf, e. leaf apex, f&g. leaf tip cells, h. leaf base, i. cells at middle, j. cells near base, k. cells near tip, i. basal cells enlarged view

study by Spence and Ramsay (2019) using molecular and morphological characters, the members included in Rhodobryaceae are retained in Bryaceae. The present study followed the classification system of Goffinet *et al.* (2008) with the modification of Spence and Ramsay (2019) for the order Bryales. Among the seven families two families viz., Bryaceae and Mniaceae are represented in the present study area.

Key to the families

- 1a. Stem erect, often with subfloral innovations, radiculose at base; costa varies from short not reaching the apex to percurrent or excurrent into a short to long awn **Bryaceae**
- 1b. Stem erect or creeping, simple, mostly branched, with rhizoids all around; costa ending below the apex, shortly excurrent **Mniaceae**

Bryaceae Schwägr.,

Wild., Sp. Pl. ed. 4, 5(2): 47. 1830.

As per Spence (2014) the family Bryaceae included nine genera world wide *Acidodontium* Schwägr., *Anomobryum* Schimp., *Bryum* Hedw., *Gemmabryum* J.R. Spence & H.P. Ramsay, *Haplodontium* Hampe, *Imbriobryum* Pedersen, *Leptostomopsis* (Müll. Hal. ex Brotherus) J.R. Spence & H.P. Ramsay, *Ochiobryum* J.R. Spence & H.P. Ramsay and *Osculatia* De Not. The latest revised keys by Spence and Ramsay (2019) included all the genera included under Rhodobryaceae (Spence, 2014) were incorporated to Bryaceae and the family now includes 14 genera incorporating *Brachymenium* Schwägr., *Mniobryoides* Hoermann, *Plagiobryoides* J.R. Spence, *Plagiobryum* Lindb., *Ptychostomum* Hornsch., *Rhodobryum* (Schimp.) Limpr. and *Rosulabryum* J.R. Spence. Among these six genera viz., *Bryum* Hedw., *Imbriobryum* Pedersen, *Brachymenium* Schwägr., *Ptychostomum* Hornsch., *Rosulabryum* J.R. Spence and *Rhodobryum* (Schimp.) Limpr. are distributed in the present study area.

Plants dioicous, rarely monoicous; mostly tufted, 1-12 cm long, usually green or yellowish, sometimes reddish green or silvery, size varies from very short to medium sized, usually tufted, habitat grows in terrestrial lands and rocks, sometimes epiphytic seen on trunks; stem erect, radiculose, often with subfloral innovations; leaves thin, lanceolate, at lower half small and distantly placed, upper half larger

usually forming comal tufts, shrunk when dry, leaf margins vary from smooth to finely serrulate, serrate or denticulate distally; costa varies from short (not reaching the apex), to percurrent or excurrent into a short to long awn; cells near leaf base quadrate to rectangular, except basal marginal cells are rhomboid to hexagonal; seta long, smooth, capsule pendulous, erect in some, calyptra narrow, cucullate, smooth.

Key to the genera

- 1a. Main stem erect, no underground rhizomatous growth, leaf marginal serration simple 2
- 1b. Main stem creeping with underground rhizomatous growth, leaf margin sharply serrated **Rhodobryum**
- 2a. Plant small with slender to evenly foliate stem, often julaceous, plants mostly yellowish dark or yellowish green and silvery green 3
- 2b. Plants large, not julaceous, plants green in early season and reddish purple in summer 4
- 3a. Leaves with weak costa, distal laminal cells elongate, proximal cells quadrate **Bryum**
- 3b. Leaves with strong costa, laminal cells rhomboid 5
- 4a. Rhizoidal tubers present **Imbricabryum**
- 4b. Rhizoidal tubers absent **Ptychostomum**
- 5a. Capsule erect or sub erect ... **Brachymenium**
- 5b. Capsule inclined **Rosulabryum**

***Brachymenium* Schwägr.,**

Sp. Musc. Frond., Suppl. Secund. (1,2): 131–134, pl. 135. 1824.

Plants small to medium sized, tufted, dark green to golden green; stem erect, rosulate with numerous subfloral innovations; leaves spreading, acuminate when moist, leaves imbricate to spirally twisted around stem when dry; costa short to long excurrent; leaf cells smooth, usually rhomboidal, basal cells large, rectangular; alar cells same as near the juxta costal cells; capsule erect and long, spores smooth or papillose, brown or tan in colour.

Brachymenium leptophyllum (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger, Ber. Thaetigk. St. Gallischen Naturwiss. Ges. 1873–74: 111 (Gen. Sp. Musc. 1: 573). 1875; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 9. 2008; Arch. Bryol. 42: 5. 2009. *Bryum leptophyllum* Bruch & Schimp. ex Müll. Hal., Syn. Musc. Frond.

1: 273. 1848; *Brachymenium corticola* Mitt. ex Ochi, Hikobia 4: 11. 1964; *B. longicolle* Thér., Bull. Soc. Bot. Genève, 26: 85. 1936; Gangulee, Mosses E. India & Adj. Reg. 2(4): 936. 1974. *B. variable* Dixon, Smithsonian Misc. Collect. 69(8): 2. 1. 1918; *B. recurvatum* Broth. & P. de la Varde, Bull. Soc. Bot. France 72: 795. 1925.

Plants medium sized, 2-3 cm high, yellowish green above, dark brownish below, not glossy; stems short, erect with 4-6 branches; leaves appressed or irregularly flexuous when dry, oblong ovate, 3-4 mm long, margin nearly entire, narrowly recurved below the apex, bordered by 1-3 rows of differentiated elongated hyaline cells; costa excurrent, median leaf cells hexagonal, 42-45 µm long and 10-12 µm wide, basal cells rectangular, 56-60 µm long and 20-24 µm wide; sporophyte long, capsule nearly erect or inclined, pyriform, mouth small, neck narrowed, spores spherical, brownish, 35-48 µm in diameter (Plate 5.85).

Habitat: Lithophytic and terrestrial species seen on rocky patches and land cuttings in compact form in shola forest.

Discussion: *Brachymenium leptophyllum* is a common high altitude mountain taxa in South India. Gangulee (1974) described this species from India as *B. longicolle*. From Kerala this species was reported as *B. leptophyllum*. It is yellowish green, medium sized plant with oblong ovate leaves having 1-3 rows of differentiated marginal elongated cells and the cells are rhomboid except at base.

Distribution: World: Africa (O'Shea, 2006), China (Li *et al.*, 2007), Nepal (Pradhan and Joshi, 2008); **India:** Karnataka (Schwarz & Frahm, 2013), Kerala (Manju *et al.*, 2008; Manju *et al.*, 2009; Manju & Rajesh, 2013), Sikkim, Manipur (Gangulee, 1974), Tamil Nadu (Maniselvan & Kumar 2000).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700-1900 m) 02.08.2015 *Mufeed 13301*; 14.07.2017 *Mufeed 7525, 7578* (ZGC).

Other specimen/s examined: Sikkim., Ther., No: (24/7)14-2, (CAL!).

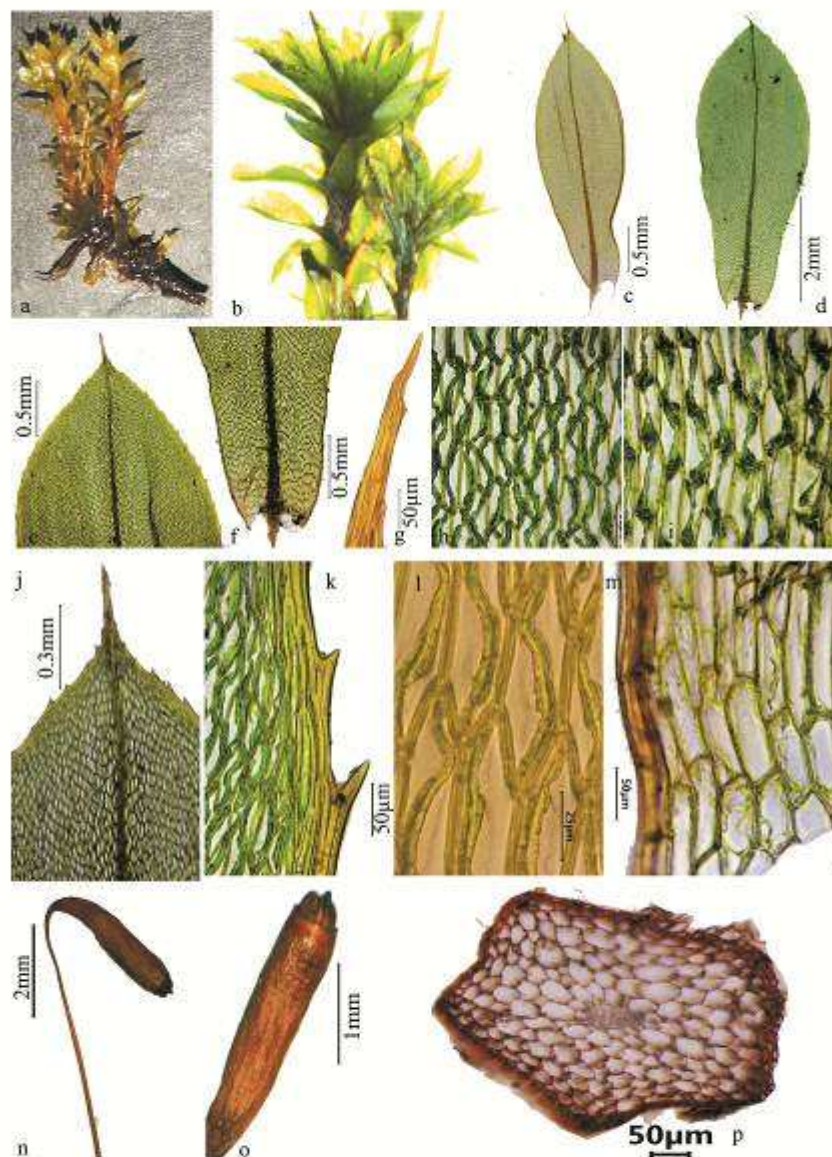


Plate 5. 85: *Brachymenium leptophyllum* (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger, a. single plant, b. habit enlarged, c&d. leaf, e. leaf apex, f. leaf base, g. leaf tip cells, h&i. leaf cells, j. leaf tip cells, k. leaf marginal cells, l. leaf cells enlarged, m. leaf basal cells, n. sporophyte, o. capsule, p. c.s. of stem

***Bryum* Hedw.,**
Sp. Musc. 178. 1801.

Plants usually short, up to 2 cm high; pure white, silver green, yellow, yellowish green and green with red tints; stem julaceous or gemmiform; leaves usually shorter, 1.5 mm long, ovate-lanceolate, base not decurrent; apex broadly rounded to acute; costa percurrent or excurrent; alar cells usually absent or somewhat differentiated in juxta costal region; sporophytes seen on tip of the plant, seta long twisted when dry, capsule inclined to pendent, ovate or clavate to pyriform, spores finely papillose, pale brown or yellow brown in colour.

***Bryum argenteum* Hedw.,** Sp. Musc. Frond. 181. 1801; Broth., Rec. Bot. Surv. India 1(12): 320. 1899; P.Bruehl, Rec. Bot. Surv. India 13(1): 52.1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 779. 1937; Foreau, J. Madras Univ. Sec. B. 2: 249. 1930; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 126. 2005; Chaudhary *et al.*, Bryoph. Fl. N. Konkan 173. 2008; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 9. 2008; Arch. Bryol. 42: 5. 2009; Daniels, Arch. Bryol. 65: 40. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 86. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 146. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 158. 2019. *Argyrobryum argenteum* (Hedw.) Kindb., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 7(9): 78. 1883. *Hypnum argenteum* (Hedw.) F. Weber & D. Mohr, Index Mus. Pl. Crypt. 3. 1893. *Mnium argenteum* (Hedw.) Hoffm. ex P. Beauv., Prodr. Aethéogam. 74. 1805. *Anomobryum alpinum* M. Zang & X.J. Li, Bryofl. Xizang, 164. f. 71: 1. 1985. *Brachymenium argenteoides* Dixon, Notes Roy. Bot. Gard. Edinburgh. 19(95): 289. 1938. *Mnium lanatum* P. Beauv., Prodr. Aethéogam. 75. 1805. *Bryum tricolor* Cardot, Rev. Bryol. 38: 34. 1911. *B. penicillatum* Hampe, Linnaea 38: 215. 1874. *B. hampeanum* Müll. Hal., Gen. Musc. Frond. 217. 1900.

Plants small, 2 cm high, usually lithophytic, whitish to pale green, glossy, in tufts or compact; leaves imbricate, broadly ovate, apiculate apex, 0.6-1 mm long, hyaline above, yellowish green below; margins entire, differentiated by 2 rows of rectangular cells; costa percurrent, strong, ending far below apex; median cells rounded-hexagonal, 45-55 x 12-15 µm; apical cells larger, hyaline, thin walled, 55-65 x 8-10 µm; basal cells rectangular, thin walled, chlorophyllose, 25-35 x 10-12

µm; stem cells differentiated into two rows, outermost 2-3 layer of coloured cells and central large hyaline cells; seta long, red, erect but arcuate at tip, up to 1.8 cm; capsule red, pendulous, oval to cylindrical 2.3 mm long and 1 mm in diameter; operculum convex apiculate; spores small spherical, yellowish green, 9-11 µm (Plate 5.86).

Habitat: On rocky patches and crevices of rocks in evergreen forests and shola forests along with *Philonotis falcata* (Hook.) Mitt., *Anthoceros crispulus* (Mont.) Douin and some crustose and foliose lichens.

Discussion: A widely distributed species. Plant silvery green or whitish, closely imbricate habit can easily be identified from the field, slightly change the colour to greenish when it is growing in shady areas.

Distribution: World: Africa (Schultze-Motel, 1975), Australia (Spence & Ramsay, 2005), China (Redfearn Jr. & Wu, 1986), Hawaii (Staples, 2004), Japan (Noguchi & Iwatsuki, 1989), Philippines (Tan & Iwatsuki, 1991), United States (Redfearn Jr., 1979); **India:** Eastern Himalaya (Bansal & Nath, 2013), Himachal Pradesh (Choyal & Sharma, 2011), Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2005), Madhya Pradesh (Nath & Gupta, 2009), Manipur (Govindaparyi *et al.*, 2012), Odisha (Alam *et al.*, 2013), Tamil Nadu (Daniels, 2010), Uttarakhand (Bansal & Nath, 2015), Western Himalaya (Alam, 2013b).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1890-2050 m) 14.07.2017 *Mufeed* 7559; 14.04.2019 *Mufeed* 15601; Idivara Shola (2000 m) 12.07.2017 *Mufeed* 7348 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chandanathode (900m) *Manju C.N. & P.V.Madhusoodanan 80074a*, Near Chembra estate (1058 m) *Manju C.N. 120231* (CALI!).

Imbribryum N. Pedersen,
The Bryologist 108(3): 449. 2005.

Plants dioicous, acrocarpous, unbranched or sparsely branched by subfloral innovations; leaves lanceolate to ovate-lanceolate, acute, concave, erect, and evenly arranged along stem or slightly more crowded at stem apex, imbricate, margin plane

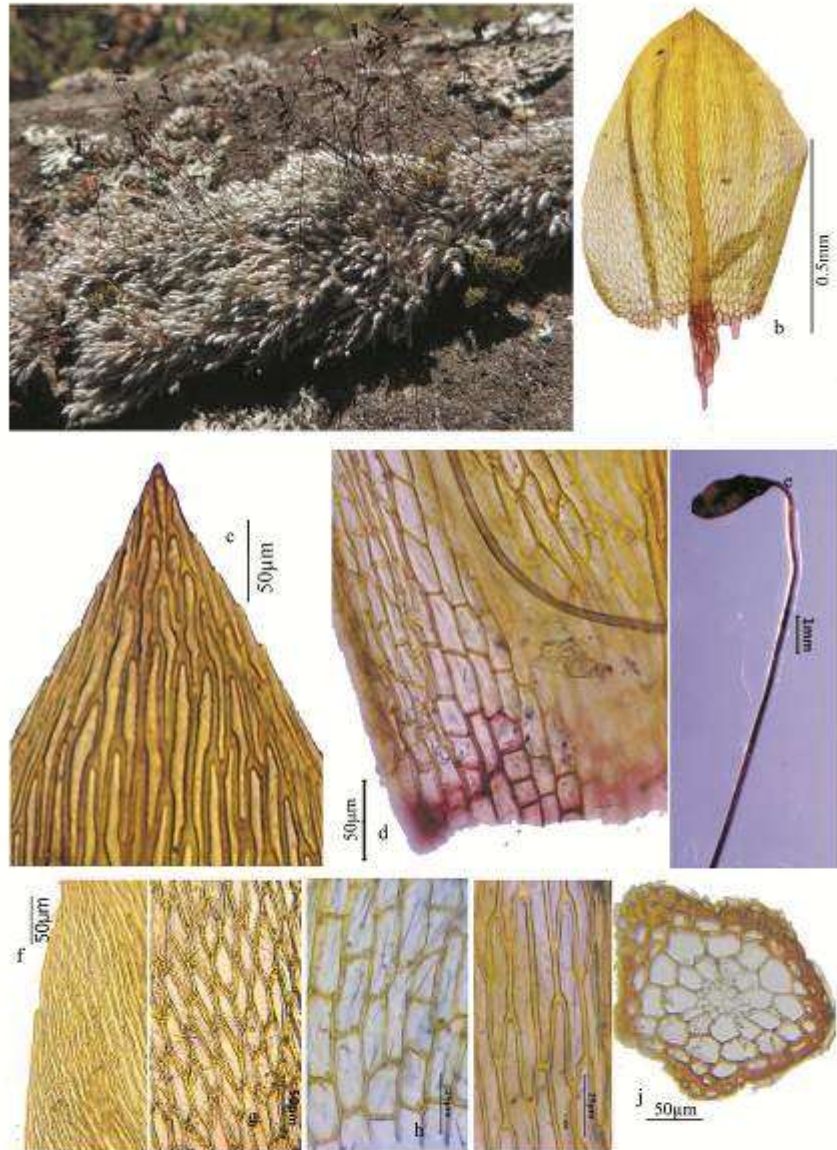


Plate 5. 86: *Bryum argenteum* Hedw. a. habit, b. leaf, c. leaf tip cells, d. leaf basal cells, e. sporophyte, f. leaf cells near apex, g. leaf middle cells, h. leaf basal cells, i. cells near costa, j. c.s. of stem

or recurved, entire or finely denticulate near leaf apex; leaf costa single, ending in leaf apex or shortly excurrent; mid-laminal cells rhomboidal to hexagonal, 42-178×8-28 µm, thin-walled or slightly thick-walled; basal lamina cells rectangular, 25-100×15-28 µm, thin-walled or slightly thick-walled; macronemata axillary, sparsely branched or strongly branched, stem with unbranched or slightly branched micronemata; rhizoidal tubers present; stem with narrow central strand, inner perichaetial leaves lanceolate, erect; costa ending in leaf apex or excurrent, margin entire; seta 7-30 mm with narrow central strand, not twisted or slightly dextrorse or sinistrorse in upper short neck, horizontal to pendulous; annulus with half; capsule obovate or ovate to pyriform with 2-3 rows of large, persisting or separating cells; exothecial cells elongate, sinuous, 2-3 rows of horizontally rectangular to quadrate cells below mouth of capsule; exostome well developed, brown to yellow-brown with hyaline, papillose apex; endostome well developed, basal membrane 50–65% of total endostome height, processes widely perforated, cilia nodose or appendiculate; spores 10-39 µm, finely papillose.

Imbribryum N. Pedersen was described based on molecular and morphological data by Pedersen and Hedenäs (2005) and Pedersen (2005). It consists primarily of the large imbricate-leaved species in *Bryum* section *Alpiniformia*.

Imbribryum alpinum (Huds. ex With.) N. Pedersen, *Bryologist* 108(3): 449. 2005. *Bryum alpinum* Huds. ex With., *Syst. Arr. Brit. Pl. Ed. 4* 3: 824. 1801; Bruehl, *Rec. Bot. Surv. India* 13(1): 53. 1931; Gangulee, *Mosses E. India & Adj. Reg.* 2(4): 1006. 1974; Daniels & Daniel, *Bryofl. S.-most W. Ghats, India*: 84. 2013; Bansal & Nath, *Frahmia* 4: 6. 2014; Daniels *et al.*, *Bryofl. Indira Gandhi Natl. Pk.*: 145. 2018; *Bryum subalpinum* Warnst., *Bot. Centralbl.* 72: 334. 1897. *Hypnum alpinum* (Huds. ex With.) F. Weber & D. Mohr, *Index Mus. Pl. Crypt.* [3]. 1803. *Mnium alpinum* (Huds. ex With.) P. Beauv, *Prodr. Aethéogam.* 73. 1805.

Plants medium sized, dark red to reddish green, when mature blackish to crimson red, acrocarpous, unbranched, 10-14 mm long, older stem densely radiculose at base, strongly imbricate when dry; leaves ovate lanceolate to lingulate, 2.20 mm long and 0.50 mm wide, acute at apex, concave, erect, imbricate, base not decurrent, margin plane or recurved, entire, finely serrulate distally; costa single, reddish,

shortly excurrent; mid lamina cells elongate to rhomboidal, 40-90 µm long and 8-20 µm wide, basal laminal cells rectangular to hexagonal, 40-80 µm long and 15-30 µm wide, stem with narrow strand, inner perichatial leaves lanceolate; monoicous; antheridia and archegonia forms as a cluster at the top the plant; sporophytes not seen (Plate 5.87).

Habitat: Terrestrial in open areas, in large wet rocks and land cuttings along with *Campylopus ericoides* (Griff.) A. Jaeger in shola forest.

Discussion: *Imbribryum alpinum* is reported as *Bryum alpinum* (Gangulee, 1974) from India and other areas of the world up to the work of Pedersen and Hedenäs (2005). *I. alpinum* is a relatively rare boreal-temperate species characterized by narrow, metallic red leaves when mature blackish to crimson red and elongate distal laminal cells.

Distribution: World: Azerbaijan (Ellis *et al.*, 2018), China (Redfearn Jr. and Wu, 1986), Ethiopia (Ellis *et al.*, 2019), Madagascar (Crosby *et al.*, 1983), Mexico (Moya and Soriano, 2011); United States (Weber, 1973); **India:** Eastern Himalaya (Bansal & Nath, 2013 as *Bryum alpinum*), Kerala (Bansal & Nath, 2014 as *Bryum alpinum*), Maharashtra (Magdum *et al.*, 2017), Manipur (Govindaparyari *et al.*, 2012 as *Bryum alpinum*), Meghalaya (Gangulee, 1974 as *Bryum alpinum*), Tamil Nadu (Alam *et al.*, 2011 & Daniels & Kariyappa, 2019 as *Bryum alpinum*), Uttarakhand (Bansal & Nath, 2015 as *Bryum alpinum*).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2240-2330 m) 07.11.2017 *Mufeed* 7410; 22.09.2018 *Mufeed* 9932 (ZGC).

Ptychostomum Hornsch.,
Syll. Pl. Nov. 1(3): 62-64. 1824.

Plants small to very large, in dense or open turfs, yellow-green to reddish brown; stems tufted, comose or evenly foliate; rhizoids few to many, rhizoidal tubers usually absent; leaves weakly to strongly contorted or shrunken when dry, erect to erect-spreading when moist, ovate, ovate-lanceolate, or orbicular, flat to concave; base usually decurrent or not; margins plane or revolute; apex obtuse to acuminate;

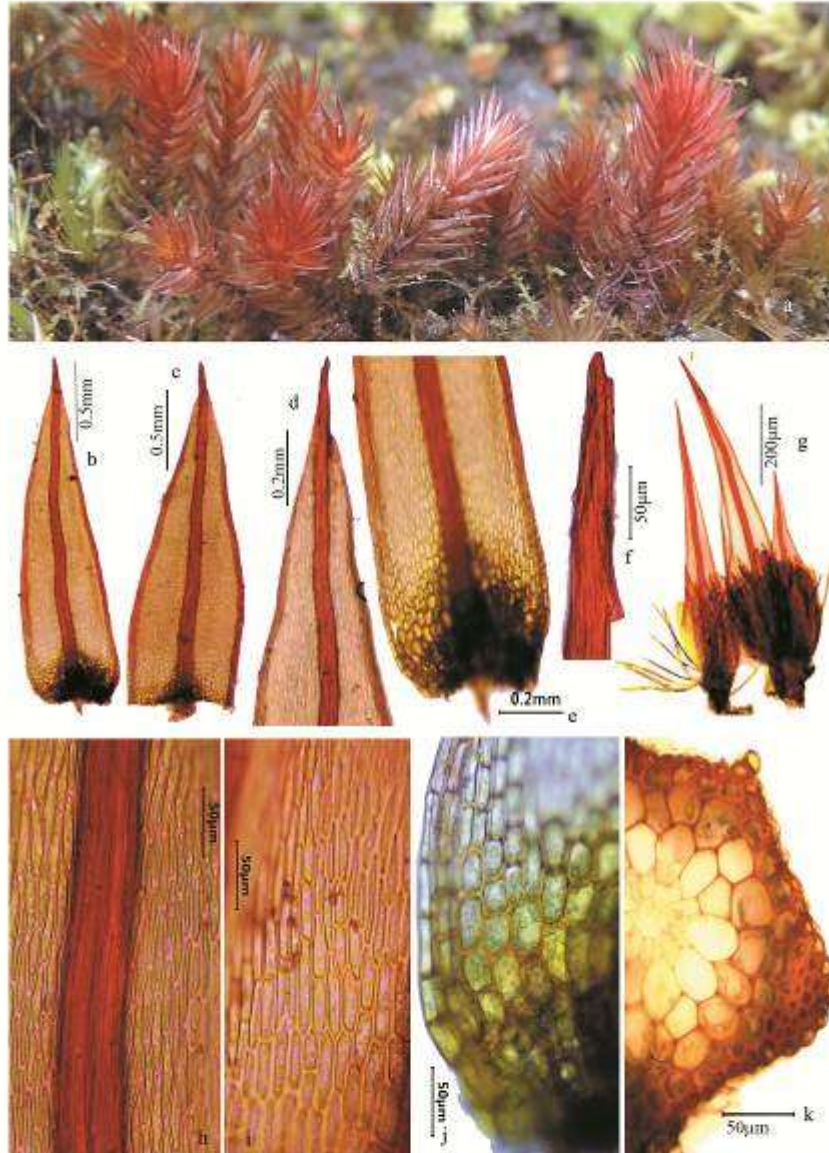


Plate 5. 87: *Imbriobryum alpinum* (Huds. ex With.) N. Pedersen, a. habit, b&c. leaf, d. leaf apex, e. leaf base, f. leaf tip, g. antheredral branch, h. cells near costa, i. cells, j. alar cells, k. c.s. of stem

costa usually percurrent to long-excurrent, awn smooth or denticulate; alar cells not differentiated; dioicous, synoicous, autoicous, or polyoicous; perigonia and perichaetia terminal; seta single, straight to flexuose; capsule suberect, inclined, or nutant, ovate, obovate, pyriform; operculum conic to low-convex, rounded to apiculate; spores shed singly, size often variable in same collection and capsule, 10–50 µm, smooth to distinctly papillose, yellow, brown, black, or green.

Ptychostomum pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pederson, J. Bryol. 29(2): 120. 2007. *Mnium pseudotriquetrum* Hedw., Sp. Musc. Frond. 190-191. 1801. *Bryum cubitale* Dicks. Ex With., Syst. Arr. Brit. Pl., ed. 4: 823. 1801. *B. pseudotriquetrum* (Hedw.) G. Gaertn., B. Mey. & Scherb. Oekon. Fl. Wetterau 3(2): 102. 1802; Gangulee, Mosses E. India & Adj. Reg. 2(4): 991. 1974. Ochi, J. Fac. Educ. Tottori Univ., Nat. Sci. 34: 57. 1985; Lal, Checklist Indian Moss 33. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 129. 2005; Daniels & Daniel, Bryofl. S.-most W. Ghats, India 94. 2013. *B. ventricosum* Relhan, Fl. Cantab., ed. Alt. 427. 1802. *B. pseudotriquetrum* (Hedw.) P. Gaertn *et al.* var. *obtusomucronatum* Cardot, Bull. Soc. Bot. Geneve 2, 1: 127. 1909. *B. pseudotriquetrum* (Hedw.) P. Gaertn. *et al.*, var. *gracilens* (Cardot) Ochi, Rev. Bryac. Japan 81. 1959. *B. ramentosum* Dixon, Rev. Bryol. Lichenol. 7: 108. 1934. *B. strictifolium* Dixon & Badhw., Rec. Bot. Surv. India 12: 174. 1938.

Plant caespitose, glossy, silvery green up to 4 cm long with sporophytes; leaves erectopatent, ovate, revolute, entire at margin, acuminate and faintly toothed at apex; basal leaves large, 4 mm long and 0.5 mm wide and small leaves up to 2 mm long and 0.4 mm wide; cells thin walled, smooth; apical ones rhomboid, 40-65x7-9 µm; middle cells rhomboid, 90-145x12-14 µm; basal cells rectangular, 80-100x12-15 µm; cells at margin narrow and elongate, forming an indistinct border, 75-110x6-9 µm; costa excurrent, shortly aristate; sporophytes with long seta up to 3 cm long; capsule ovoid, 3 mm long and 1.5 mm wide (Plate 5.88).

Habitat: Terrestrial, on land cuttings and on wet rocks along with *Pogonatum microstomum* (R.Br. ex Schwägr.) Brid.

Discussion: It is a widely distributed species in high altitude areas usually grown



Plate 5. 88: *Ptychostomum pseudotriquetrum* (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen, a & b. habit, c. leaves at basal, d. leaves at apex, e. leaf apex, f. leaf tip cells, g&h. leaf base, i&j. sporophyte, k. peristome teeth

altitude above 2000 m. During monsoon the plant seen as yellowish green color and turned brownish red in summer seasons. This species is characterized by sporophytes with long seta and ovoid capsule 3 mm long and 1.5 mm wide.

Distribution: World: Africa, Australia, Antarctica Canada, Columbia, Ecuador, Europe, Korea, Siberia, Venezuela, (Ireland *et al.*, 1987; Skotnicki, *et al.*, 2012), Nepal (Gangulee, 1974); **India:** Kerala (Nair *et al.*, 2005; Daniels & Kariyappa, 2019), Tamil Nadu (Daniels & Kariyappa, 2019), Western Himalaya (Alam, 2013b). Kumaon Himalaya, Sikkim, Kashmir (Gangulee, 1974).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2100 m) 07.11.2017 *Mufeed 7402* (ZGC); Pullaradi Shola (2350 m) 22.09.2018 *Mufeed 9907* (ZGC). .

Rhodobryum (Schimp.) Limpr.,
Laubm. Deutschl. 2(20): 444. 1892.

Plants large with underground stolon, robust in loose tufts; leaves usually large and spatulate, at apex leaves spreading and forming a rosette, lower leaves usually distant, scale like, bordered and toothed; costa strong, reach up to the top; cells at upper part elongate rhomboidal, basal cells elongate rectangular; seta apical long, capsule horizontal to pendulous, spores single.

Rhodobryum giganteum (Schwägr.) Paris, Index Bryol. 1116. 1898; Foreau, J. Madras Univ. 2: 249. 1930; J. Bombay Nat. Hist. Soc. 58: 26. 1961; Bruehl, Rec. Bot. Surv. India 13(1): 53. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 779. 1937; Gangulee, Mosses E. India & Adj. Reg. 2(4): 1020. 1974; Chopra, Taxon Indian Moss. 214. 1975; Mohamed, J. Hattori Bot. Lab. 55: 282. 1984; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 573. 2001; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 132. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 17. 2008; Daniels, Arch. Bryol. 65: 84. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 97. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 175. 2019. *Mnium giganteum* Schwägr., Sp. Musc. Frond., Suppl. 2, 2(1): 20. pl. 158. 1826. *Bryum giganteum* (Schwägr.) Arn. Mém., Soc. Linn. Paris 5: 279. 1827. *B. pseudogiganteum* Müll. Hal., Flora 82: 439. 1896. *B. sollyanum* Griff., Calcutta J.

Nat. Hist. 3: 61. 1843[1842]. *Rhodobryum pseudogiganteum* (Müll. Hal.) Paris, Index Bryol. 1119. 1898.

Plants dark greenish, large and robust, up to 6 cm high, stem stoloniferous, branched by subfloral innovation; leaves obovate to spatulate, terminal region forming rosettes of large crown, 14 mm long and 2 mm wide at base, margin is bordered by two layers of elongated cells, upper margin is toothed, lower leaves distant, scale like; costa strong excurrent; cells rhomboidal at upper part, 72-157 x 25-35 µm, basal cells elongate to rectangular, 80-148x26-32 µm; seta long, usually more than one sporophyte arises from the same area, capsule horizontal in young, when mature comes to pendulous, spores rounded, 15 µm diagonally (Plate 5.89).

Habitat: Found on the large wet rocky patch, on land cuttings and on roots of higher plants along with *Fissidens anomalus* Mont., *Plagiomnium rhynchophorum* (Hook.) T.J. Kop., *Dumortiera hirsuta* (Sw.) Nees, etc.

Discussion: A typical high altitude plant which is reported only from the hilly regions of South India mostly found in evergreen and shola forests (Nair *et al.*, 2005). This species is morphologically identifiable from the field itself by its large robust plant with comal tuft of leaves and the leaves are spatulate.

Distribution: World: Africa (O'Shea, 2006), China (Koponen *et al.*, 1982), Hawaii (Staples *et al.*, 2004), Nepal (Pradhan & Joshi, 2008), Papua New Guinea (Koponen & Norris, 1984); **India:** Karnataka (Frahm *et al.*, 2013, Schwarz, 2013), Kerala (Daniels & Kariyappa, 2019; Manju *et al.*, 2009; Nair *et al.*, 2005, 2006), Meghalaya, Uttar Pradesh (Gangulee, 1974), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019; Mohamed 1982), Uttarakhand (Saxena *et al.*, 2008).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1810 m) 22.09.2019 *Mufeed* 15636 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1760 m) *Manju C.N.* 120392 (CALI!).

Rosulabryum J.R. Spence,
Bryologist 99(2): 222–224. 1996.

Plants acrocarpous, branched by subfloral innovations, stems often densely radiculose, mostly strongly rosulate; leaves obovate to spatulate, variously contorted

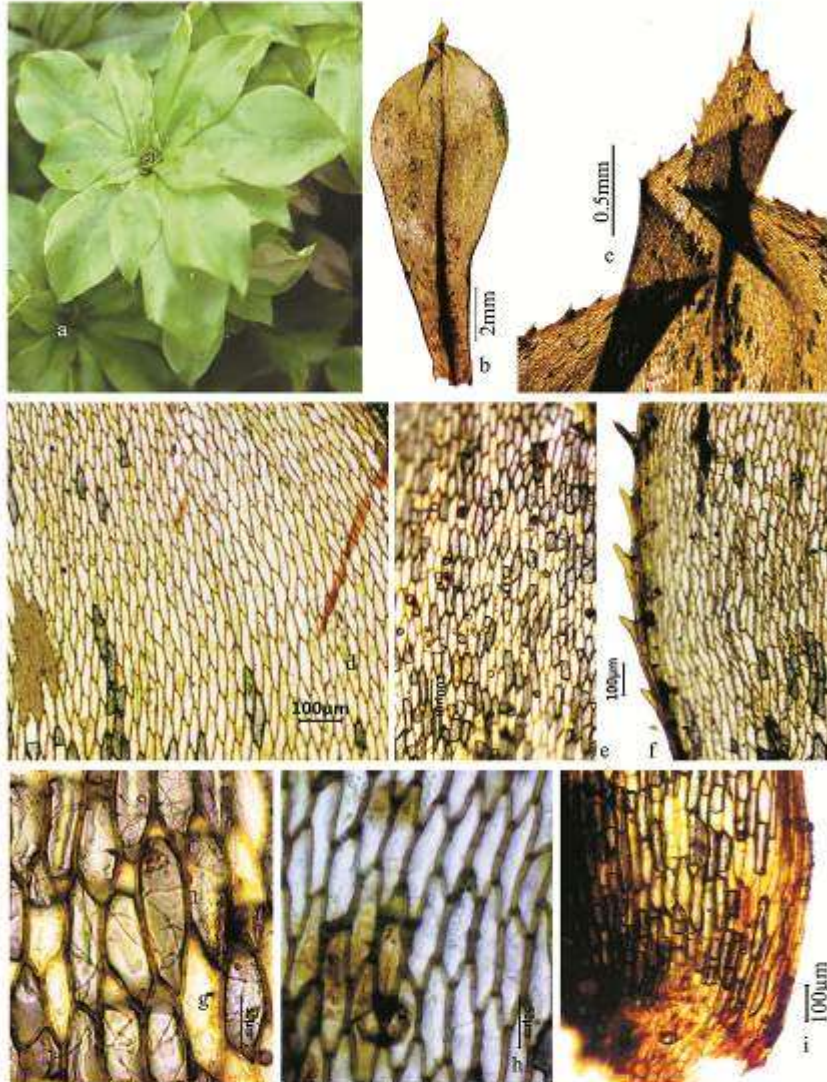


Plate 5. 89: *Rhodobryum giganteum* (Schwägr.) Paris, a. habit, b. leaf, c. leaf apex, d. leaf apex cells, e. leaf middle cells, f. leaf marginal cells, g. leaf cells near base enlarged, h. leaf cells middle enlarged, i. leaf basal cells

to spirally twisted around stem when dry; costa strong, usually excurrent; upper and middle laminal cells short rhomboidal, gradually rectangular and somewhat longer below, generally bordered by thickened elongate cells, upper margin denticulate to serrate by projecting cell ends or occasionally distinct cellular teeth; filiform, uniseriate gemmae in the leaf axils of some species; rhizoidal tubers usually present; dioicous or rarely synoicous; inner perichaetial and perigonal leaves somewhat differentiated, smaller than stem leaves; seta single or sometimes clustered, slender, elongate, capsule clavate to pyriform, often somewhat arcuate, peristome complete, with appendiculate cilia, spores 10-25 µm.

The genus *Rosulabryum* is described by Spence (1996) under the family Bryaceae. It comprises the species in section Capillaria (Rosulata and Trichophora) of *Bryum*. These species are characterized by rosulate leaves that are obovate with denticulate to serrate upper margins and have *Rhodobryum*-like areolation, rhizoidal tubers, capsules with unreduced peristomes, and small spores. He considered 54 taxa under the new genus. Later Spence (2014) in a detailed study on the family Bryaceae splits the family into two viz, Bryaceae and Rhodobryaceae. *Rosulabryum* is treated under the family Rhodobryaceae. Recently, Spence & Ramsay (2019) placed *Rosulabryum* again under Bryaceae.

Key to the species

- 1a. Plants medium sized, ±2 cm, marginal hyaline cells with 4-5 layers *R. billardierii*
- 1b. Plants large, ±12 cm, marginal hyaline cells with 2-3 layers *R. wightii*

Rosulabryum billardierii (Schwägr.) J.R. Spence, Bryologist 99: 223. 1996; Spence & Ramsay, Telopea 22: 126. 2019; *Bryum billardierii* Schwägr., Sp. Musc. Frond., Suppl., 1 2: 115, pl. 76. 1816; Gangulee, Mosses E. India & Adj. Reg. 2(4) 977. 1974; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 9. 2008; Daniels, Arch. Bryol. 65: 41. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 87. 2013; Bansal & Nath, Taiwan 58(3). 2013; Bansal & Nath, Frahmia 4: 1-11. 2014; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 149. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 160. 2019. *B. vellei* Cardot & P. de la Varde, Rev. Bryol. 50: 22. f. 8.

1923. *B. abruptinervium* Müll. Hal., Hedwigia 37: 102. 1898. *B. aeruginosum* Müll. Hal., Hedwigia 37: 95. 1898. *B. andicola* Hook., Syn. Pl. 1: 58-59. 1822. *B. viridulum* Müll. Hal., Hedwigia 37: 104. 1898. *Rhodobryum tasmanicum* Paris, Index Bryol. Suppl. 301. 1900. *R. breviramulosum* Hampe, Linnaea 40: 311. 1876. *Bryum madoriculum* Müll. Hal., Proc. Linn. Soc. New South Wales 30(Suppl.): 143. 1906.

Plants in dense tufts, bright yellowish green, brownish below, growing on humus or rocks; stem erect, reddish brown, 2 cm or more high; leaves erect spreading when moist, twisted around the leaf axis when dry, lower leaves small, distant, upper leaves large, clustered in prominent comal tufts, concave, spatulate, apex acute to acuminate, up to 4 mm long and 2 mm wide at middle, base slightly tapering, margin broad; costa strong, brownish, excurrent in a long arista; leaf cells thin walled, rhomboid above, 50 x 16 µm, slightly shorter below, rectangular at base, 50-55x20-25 µm, margin with 4-5 layers of elongated thick walled hyaline cells at the border part and fading to form 1-2 cell layers at base, narrow cells form a prominent border in the upper leaf; sporophytes not seen (Plate 5.90).

Habitat: Lithophytic, on wet rocks and small stones near stream in shola forest and grassland.

Discussion: It is a widely distributed species in the high altitude regions. This species is earlier reported as *Bryum billardierii* all over the world under the family Bryaceae. Spencer (1996) erected the new genus *Rosulabryum* and included it under the family Bryaceae later in 2014 he transferred this genus to Rhodobryaceae with the species *Rosulabryum billardierii*. Now it's coming under Bryaceae (Spence & Ramsay, 2019). *R. billardierii* is characterized by robust plant with spatulate leaves forming comal tuft at the tip; leaf margin forms thick elongated hyaline cells as border in the broad portion and fading to 1-2 layers of cells at base.

Distribution: World: Mexico, Philippines (Shevock & Yorong, 2018); **India:** Eastern Himalaya (Bansal & Nath, 2013 as *Bryum billardierii*), Karnataka (Schwarz & Frahm, 2013 as *B. billardierii*), Kerala (Bansal & Nath, 2014; Manju & Rajesh, 2013 as *Bryum billardierii*), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013;

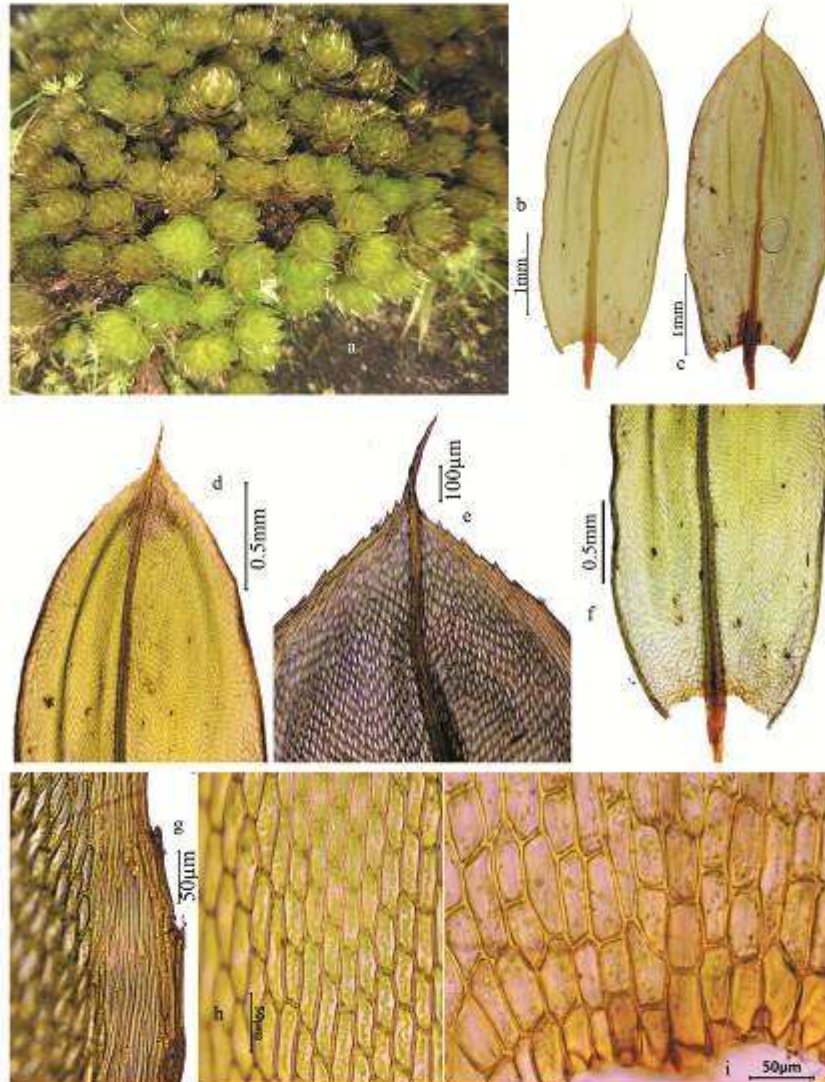


Plate 5. 90: *Rosulabryum billarderii* (Schwägr.) J.R. Spence, a. habit, b&c. leaves, d. leaf apex, e. leaf tip, f. leaf base, g. leaf margin, i. leaf cells middle, j. basal cells

Daniels *et al.*, 2018; Daniels & Kariyappa, 2019 as *B. billardiarei*), Uttarakhand (Bansal & Nath, 2015).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2300 m) 22.09.2018 Mufeed 9928 (ZGC).

Rosulabryum wightii (Mitt.) J.R. Spence, Bryologist 99: 223. 1996. *Bryum wightii* Mitt., J. Linn. Soc. Bot. Suppl. 1: 74. 1859; Gangulee, Mosses E. India & Adj. Reg. 2(4) 983. 1974; Mohamed, J. Bryol. 12: 24. 1982; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986; Nair *et al.*, Bryo. Wayand. W. Ghats 130. 2005; Bansal & Nath, Taiwania. 58(3): 209. 2013; Mufeed *et al.*, Frahmia 6: 5. 2014. *Rhodobryum strigosum* Paris, Index Bryol. Suppl. 300. 1900. *Bryum bohnhoffii* C. Mueller & Broth., Nat. Pflanzenfam. 1(3): 598. 1904. *B. pachycladum* Cardot ex. P. Vard., Rev. Bryol. 52: 38. 1925.

Plants yellowish green to reddish brown, densely tufted; stem elongate, reddish, simple or branched by sub floral innovations, up to 12 cm high, tomentose; leaves light green to reddish, often reddish brown, ± 5.67 mm long and ± 2.72 mm wide, loosely spreading when moist, not shrinking and appressed to stem when dry, lower margin reflexed, margin crenulated at tip, 2-3 rows of elongated cells forms the border, triangular to broadly ovate, wide base; costa strong, wider at base, narrower towards apex, brownish in older leaves, shortly excurrent; cells at upper half elongate to rhomboid, $66-101 \times 7-14.5$ μm , incrassate; basal cells rectangular, $89-125 \times 26-45$ μm ; sporophytes not seen (Plate 5.91).

Habitat: This species is found on rocky patch along with grasses and *Utricularia* sp. in shady areas and along with *Campylopus pilifer* Brid. in shola forest and grassland.

Discussion: *Rosulabryum wightii* is one of the largest species distributed in the hilly regions of Western Ghats. This species is previously reported as *B. wightii* (Gangulee, 1974) in India. Spence (1996) changed the genus into *Rosulabryum*. After the work of Spence (1996), many authors followed as *Bryum wightii* (Nair *et al.*, 2005; Daniels, 2010). This species is characterized by its large robust plant up to 12 cm long, stem pale brown or reddish, leaves large, acuminate and wider at base and the margin of the leaf is indistinct or 2 or 3 layers of elongated hyaline cells may be present.

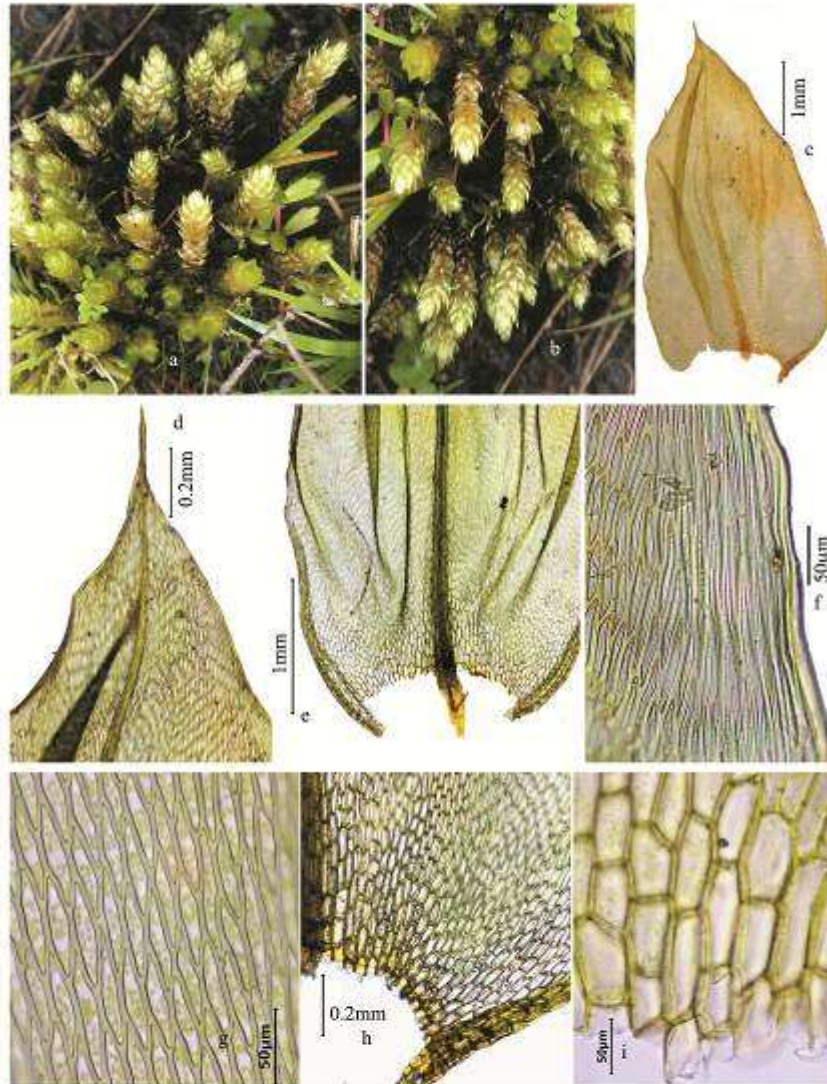


Plate 5. 91: *Rosulabryum wightii* (Mitt.) J.R. Spence, a&b. habit, c. leaf, d. leaf tip, e. leaf base, f. leaf margin apex, g. cells, h. basal cells, i. basal cells enlarged

Distribution: World: Australia (Spence & Ramsay, 2005), Sri Lanka (O'Shea, 2002); **India:** Goa, Maharashtra, (Bansal & Nath, 2014), Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2005), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2110 m) 22.09.2018 *Mufeed 9924* (ZGC).

Mniaceae Schwägr.,
Sp. Musc. 188. 1801, nom.cons.

Plants slender, medium sized to large, pale green to deep green with reddish colour, often compact or in loose tufts; stem erect or creeping, simple, mostly branched, with rhizoids all around; leaves small on the lower part of the stem becoming larger and forming rosettes towards the apex, oblong-ovate to ovate-lanceolate, twisted or curled when dry; margins often bordered by one to several rows of thick walled cells; costa ending below the apex, shortly excurrent; leaf cells mostly pentagonal to hexagonal or shortly rectangular, sometimes rounded with walls often thickened at corners; dioicous, rarely autoicous; capsules inclined to pendulous, rarely erect, peristome double, spores large yellowish, roughly or coarsely papillose.

Plagiomnium T.J. Kop.,
Ann. Bot. Fenn. 5(2): 145–147.

Plants light to dark greenish, robust; stem erect, branches partly basal, either erect or prostrate stolons and partly from the comal region; leaves small and lax at lower side, upper leaves large and closer, comal leaves larger, broadly ovate, oblong-elliptic to spatulate, notched at tip in some leaves, margin bordered by one to many layered cells, toothed; cells rounded hexagonal, rarely rhombic; seta erect, long; capsule inclined, rarely erect, mostly oblong-ovoid, sometimes curved.

Plagiomnium rhynchophorum (Hook.) T.J. Kop., Hikobia 6: 57. 1971; *Mnium rhynchophorum* Hook., Icon. Pl. 1: pl. 20, f. 3. 1836. *Bryum coriaceum* Griff., Calcutta J. Nat. Hist. 3: 60. 1843[1842]. *Mnium ligulaceum* Müll. Hal., Bot. Mag. (Tokyo) 49: 685. 1935. *M. minutidentatum* Müll. Hal., Gen. Musc. Frond. 134. 1900. *M. nietneri* Müll. Hal., Linnaea 36: 32. 1869. *M. pseudocrispum* Müll. Hal., Gen. Musc. Frond. 134. 1900. *Plagiomnium rostratum* (Schrad.) T.J. Kop.

Annal. Bot. Fen. 5(2): 147. 1968; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 177. 2019. *Mnium rostratum* Schrad., Bot. Zeitung (Regensburg), 1: 79. 1802; Gangulee, Mosses E. India & Adj. Reg. 2(4): 1042.1974; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 573. 2001. *M. cylindricum* Hoffm. ex Brid., Bryol. Univ. 1: 70. 1826. *M. longirostrum* Brid., Muscol. Recent. 2(3): 106. 1803. *M. rostratum* var. *integrifolium* Roell, Hedwigia 38: 263. 1894. *M. prorepens* Müll. Hal., Flora 82: 437. 1896.

Plants yellowish green, forming loose or compact creeping mats; main stem erect, 2 to 4cm. high; leaves on fertile, erect shoot more crowded at apex, spreading, curled and crumpled when dry, large, usually oblong, notched at tip; leaves oblong ovate; leaf cells usually pentagonal to hexagonal, apical cells 20x10 µm, middle cells 25x12 µm, basal cells 60-50x12 µm, margin often bordered by 1-4 rows of thick walled cells; costa shortly excurrent; cross section of stem is rounded in shape; epidermis with 2-3 layers, small, thickened wall, hypodermis cells are thin, large, 6-7 layers, pith cells are very small; seta strong and long up to 2 cm, reddish; capsule erect when young, pendulous at maturity, yellowish green, ovoid cylindrical, 3 × 1.5 mm (Plate 5.92).

Habitat: Found on the rocky patch, on land cuttings, concrete walls, barks of large trees and on roots of higher plants along with *Fissidens anomalus* Mont., *Rhodobryum giganteum* (Schwägr.) Paris, *Dumortiera hirsuta* (Sw.) Nees, etc. in evergreen and shola forests.

Discussion: This species is known in India as *Mnium rostratum* Schrad. Koponen (1968) synonymised *Mnium rostratum* Schrad. under *Plagiomnium rostratum* (Schrad.) T.J. Kop. Later, Koponen (1971) synonymised *Mnium rostratum* and *Plagiomnium rostratum* under *Plagiomnium rhynchophorum* (Hook.) T.J. Kop. Nair & Madhusoodanan (2001) and Nair *et al.* (2005) reported this species from Kerala as *Mnium rostratum*. The species is characterized by the plants with large robust compact creeping mats, leaves curled and crumpled when dry, usually notched at tip and whole leaf margin bordered by 1-4 layered thick walled cells.

Distribution: A cosmopolitan species distributed in the high altitude regions

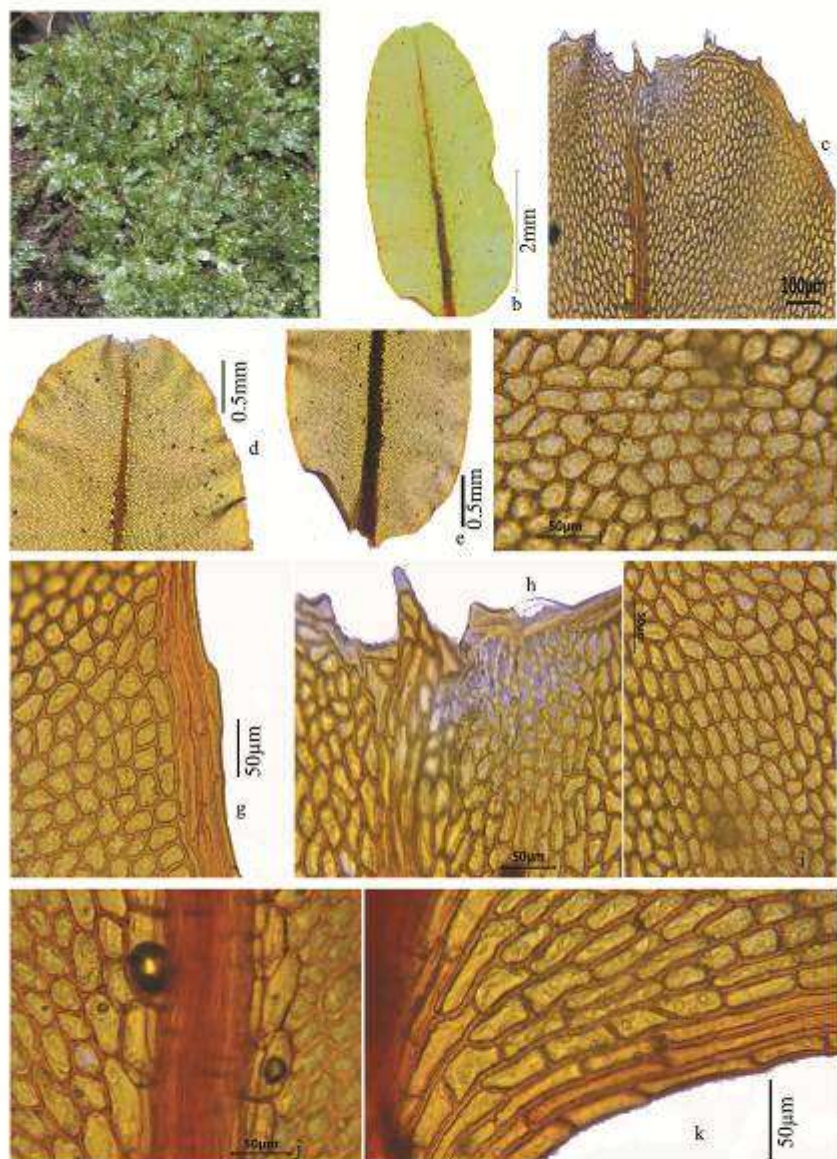


Plate 5. 92: *Plagiommium rhynchophorum* (Hook.) T.J. Kop., a. habit, b. leaf, c. leaf tip, d. leaf apex, e. leaf base, f. leaf cells, g. leaf margin, h. leaf tip cells, i. leaf middle cells, j. leaf cells near costa, k. leaf basal cells

especially in the sholas and evergreen forests. **World:** Africa (Ros *et al.*, 1999), Estonia (Vellak, 2015), Hungaria (Erzberger & Papp, 2004), Mexico (Moya *et al.*, 2011), Sri Lanka (O'Shea, 2002); **India:** Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland (Gangulee, 1974), Himalaya (Bahuguna *et al.*, 2015), Odisha (Mishra *et al.*, 2016), Kerala (Daniels & Kariyappa, 2019; Nair *et al.*, 2005), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1950-2310m) 02.08.2015 *Mufeed 13321*; 26.09.2018 *Mufeed 9988*; Pullaradi Shola (2280m) 25.03.2016 *Mufeed 10065* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Thirunelli RF (1350 m) *Manju C.N. 99616*, Chembra hills (1760m) *Manju C.N. 120396* (CAL!); Kashmir (2250-2750 m) 09.09.1961 *J.N. Vohra 573* (CAL!); West Bengal, Darjeeling (2100 m) October 1960 *H.C. Gangulee 5112* (CAL!).

Orthotrichales Dixon,
Man. Bryol. 409. 1932.

Orthotrichaceae Arn.,
Disp. Méth. Mousses 13. 1825.

Plants medium to large, usually dark coloured, forming in dense tufts on trees; stem without central strand, main stem creeping with erect short or long branches; leaves dense, appressed or tightly curled when dry, widely spreading when moist, lanceolate to ovate lanceolate; margin usually entire or revolute; costa strong; cells at apex rounded, papillose, basal cells elongated, often incrassate; capsule erect, smooth or sulcate, ovate cylindrical, operculum rostrate, peristome single or double.

Key to the genera

- 1a. Distal laminal cell papillae 2-6, clavate **Zygodon**
- 1b. Distal laminal cells smooth or papillae 1-4, 2-fid, conic, or clavate 2
- 2a. Leaves erect-appressed and straight when dry; marginal laminal cells gradually shorter than basal..... **Orthotrichum**
- 2b. Leaves straight and not crisped to flexuose and crisped when dry; marginal laminal cells abruptly shorter than basal..... 3
- 3a. Marginal laminal cells distinct from basal; basal laminal cells oblate to rounded..... **Groustiella**

- 3b. Marginal laminal cells not distinct from basal; basal laminal cells elongate, quadrate, rounded or elliptic4
- 4a. Distal laminal cells 8-12 µm in diagonal rows; calyptrae not plicate, basal lobes 4-6**Schlotheimia**
- 4b. Distal laminal cells 7-12 µm in vertical rows; calyptrae plicate or obscurely plicate, basal lobes many**Macromitrium**

***Groutiella* Steere,**

Bryologist 53(2): 145. 1950.

Plants brownish, robust, leaves straight and not crisped to flexuose when dry; main stem usually creeping, leaves elongate lanceolate, tip acute or blunt; laminal cells highly thick walled, rounded at top, marginal laminal cells distinct from basal, shorter than basal; basal laminal cells oblate to rounded; seta elongate, smooth, capsule ovate cylindrical, peristome double, calyptra mitriform, covering one third of the capsule.

Groutiella tomentosa (Hornsch.) Wijk & Margad., Taxon 9(2): 51. 1960; D.H. Vitt & H.A. Crum, Bryologist 73: 146. 1970; Manju *et al.*, Indian J. For. 32(3): 471. 2009; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 206. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 236. 2019. *Macromitrium tomentosum* Hornsch., Fl. Bras. 1(2): 21. 1840. *Micromitrium tomentosum* (Hornsch.) Paris, Index Bryol. (ed. 2) 3: 242. 1905. *Groutiella goniorrhyncha* (Dozy & Molk.) E.B. Bartram, Rev. Bryol. Lichénol. 23: 250. 1954; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1192. 1976; Tixier, Bull. Mus. Nat. Hist. Nat. Paris 4: 113. 1979. *G. laxotorquata* (Müll. Hal. ex Besch.) Wijk & Margad., Taxon 9: 51. 1960. *Macromitrium andamaniae* Müll. Hal., Index Bryol. Suppl. 236. 1900. *M. andamanum* Müll. Hal., Rev. Bryol. 28: 113. 1901. *M. cylindricum* Schimp., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 191. 1872. *M. diffractum* Cardot, Rev. Bryol. 28: 113. 1901. *M. fragile* Mitt., J. Linn. Soc., Bot. 12: 218. 1869. *M. subretusum* Broth., Musci Buitenzorg 2: 456, 459. 1904. *Micromitrium fragile* A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1872–73: 157. 1874. *M. prorepens* Schimp., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 191. 1872. *M. schlumbergeri* Schimp., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 191. 1872. *Schlotheimia goniorrhyncha* Dozy & Molk., Pl. Jungh. 3: 338. 1854.

Plants brownish, fairly robust; main stem creeping with erect secondary branches up to 3 cm high; leaves dense, curled at apex when dry, oblong-lanceolate, 1.50-2.25 mm long and 0.46-0.55 mm wide at base; apex apiculate, broadly acute in tip leaves, narrowly acute below, margin entire below, dentate at tip; costa ending as apiculus; laminal cells usually thick walled, cells at apex and middle round quadrate, 5-15 μm diagonally, cells near base elongated, 15-35x5 μm , cells at extreme base large, rectangular, 30 x 15 μm , with tuberculate papillae, basal marginal cells forming a row of transparent, smooth, thin walled, rectangular cells, 12-15x5 μm ; sporophytes not seen from the present collection (Plate 5.93).

Habitat: Epiphytic, creeping on the bark of large trees in evergreen forest.

Discussion: Gangulee (1976) reported this species as *Groutiella goniorrhyncha* (Dozy & Molk.) E.B. Bartram from Eastern India. Tixier (1979) also reported this species from Kodaikanal in Tamil Nadu as *G. goniorrhyncha*. Vitt (1994) synonymized *G. goniorrhyncha* under *G. tomentosa* based on the morphological similarity. But unknowingly Manju *et al.* (2009) reported *G. tomentosa* as new record for Peninsular India collected from Kerala. This species characterized by brownish plants with dense leaves, usually leaves are curled at apex when dry, laminal cells usually thick walled and marginal cells usually form a thin walled rectangular cells.

Distribution: World: Australia (Vitt & Ramsay, 1985), Brazil, Sri Lanka, Costa Rica, Guatemala, Jamaica, Java, Mexico, United States (Vitt & Crum, 1970), Thailand, Mexico, Philippine, Angola, Papua New Guinea (Ning-Ning *et al.*, 2011);

India: Andaman, Meghalaya (Gangulee, 1976), Kerala (Manju *et al.*, 2009; Manju & Rajesh, 2012), Tamil Nadu (Daniels, 2010, Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600 m) 14.07.2017 *Mufeed 7534b* (ZGC).

Macromitrium Brid.,

Muscol. Recent. Suppl. 4: 132. 1819.

Plants yellowish green or brownish, slender to robust, in dense tufts; stem long creeping, erect or ascending, simple or branched; leaves not crisped when dry, erect

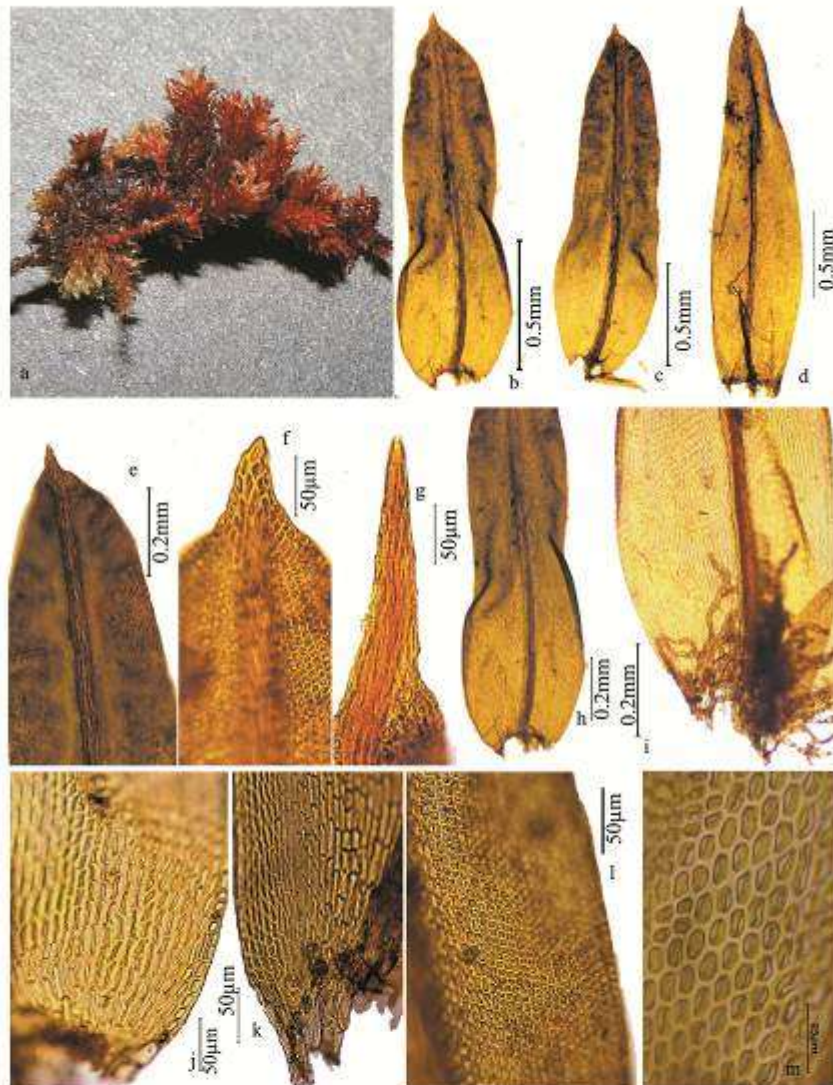


Plate 5. 93: *Groutiella tomentosa* (Dozy & Molk.) E.B. Bartram., a. habit, b,c&d. leaf, e&f. leaf apex, g. leaf tip cells, h. leaf base, i. leaf base enlarged with rhizoids, j. leaf basal margin, k. basal cells, l. cells at margin, m. middle leaf cells enlarged

to spreading when moist, smooth to undulate, near the base often concave, lanceolate to oblong lanceolate, obtuse or acute; costa moderately strong, ending below the apex or percurrent, sometimes shortly excurrent in a hair like arista; distal laminal cells 7-12 µm in vertical rows; usually rounded to quadrate or rounded to hexagonal, rich in chlorophyll, papillose to smooth, marginal laminal cells not distinct from basal, basal laminal cells elongate, quadrate, rounded, or elliptic, thickened, smooth to strongly papillose; capsule nearly spherical to oblong ovoid, calyptra campanulate, mostly covering the capsule, plicate or obscurely plicate, basal lobes many, spores large, papillose.

Key to the species

- 1a. Leaves oblong lanceolate, basal marginal cells bordered with 8 smooth thin walled cells ***M. sulcatum***
- 1b. Leaves elliptic lanceolate, basal marginal cells elongate and thin walled
 ***M. cf. flexuosum***

Macromitrium sulcatum (Hook.) Brid., Bryol. Univ. 1: 319. 1826; Mitt., Musc. Ind. Orient. 52. 1859; Broth., Rec. Bot. Surv. India 1(12): 318. 1899; Sedjwick, J. Bombay Nat. Hist. Soc. 19: 940. 1910; Dixon, Rec. Bot. Surv. India 10: 346. 1968; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1181. 1976; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 141. 2005; Chaudhary *et al.*, Bryoph. Fl. N. Konkan 159. 2008; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 14. 2008; Taiwania 54: 65. 2009; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 128. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 242. 2019. *Schlotheimia sulcata* Hook., Musci Exot. 2: 156. 1819. *Orthotrichum sulcatum* (Hook.) Hook. & Grev., Edinburgh J. Sci. 1: 129. 1824. *Macromitrium belangeri* Müll. Hal., Bot. Zeitung (Berlin) 20: 374. 1862. *M. bequaertii* Thér. & Naveau, Bull. Soc. Roy. Bot. Belgique 60: 50. 27. 1927. *M. ceylanicum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 52. 1859. *M. corrugatum* Wilson, Hooker's J. Bot. Kew Gard. Misc. 9: 328. 1857. *M. eckendorffii* Thér. & P. de la Varde, Rev. Bryol. Lichénol. 11: 176. 11 f. 2. 1939. *M. levatum* Mitt., J. Proc. Linn. Soc., Bot. 7: 152. 1863. *M. neelgheriense* Müll. Hal., Syn. Musc. Frond. 1: 737. 1849. *M. nilghiriense* Müll. Hal., ex Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1:

52. 1859. *M. ramentosum* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 301. 1873. *M. seriatum* Paris & Broth., Rev. Bryol. 34: 95. 1907. *M. trollii* Dixon, Repert. Spec. Nov. Regni Veg. 38: 104. 1935.

Plants dark greenish to brownish, robust, in dense tufts; stem prostrate erect, secondary stem branched; leaves dense, spirally twisted when dry, stiff, erect to spreading when moist, lanceolate to oblong lanceolate, 3.5 mm long 0.8 mm wide at base; costa strong, ending below apex or percurrent; laminal cells rounded or quadrate, cells at apex, 8-10 μ m diagonally, cells at middle 10-12 μ m diagonally; cells at base usually elongate, hyaline with thick walls, 35-55 μ m long and 8 μ m wide, margin at base bordered with 8 smooth thin walled cells; sporophyte not seen (Plate 5.94).

Habitat: Epiphytic, on branches of trees in shola forest.

Discussion: *Macromitrium sulcatum* (Hook.) Brid. is a widely distributed species in all types of forests from medium to high altitude areas. It is characterized by its greenish to brownish plants with oblong lanceolate leaves, laminal cells round to quadrangular with single papillae in each cells and the basal margin bordered with 8 smooth thin walled cells.

Distribution: World: Africa (Wilbraham, 2016), Nepal (Gangulee, 1976), Philippines (Tan & Iwaztuki, 1991), Borneo, Sri Lanka, Thailand, Vietnam (Eddy, 1996); **India:** Arunachal Pradesh, Meghalaya (Gangulee, 1976), Kerala (Nair *et al.*, 2005), Karnataka (Schwarz, 2013), Madhya Pradesh (Alam *et al.*, 2015), Odisha (Mishra *et al.*, 2016), Tamil Nadu (Blatter, 1929; Gangulee, 1976; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2050-2380 m) 07.11.2017 *Mufeed* 7404; 22.09.2018 *Mufeed* 9926; 14.04.2019 *Mufeed* 15606 (ZGC).

Macromitrium cf. **flexuosum** Mitt., J. Linn. Soc., Bot. 12: 208. 1869. *M. flexuosum* Schimp. ex Besch., Mém. Soc. Sci. Nat. Math. de Cherbourg 16: 189. 1872 (hom.).

Plants yellowish green or greenish brown, seen in rounded cushions; main stem creeping, secondary stem erect; leaves dense, spirally twisted when dry, spreading

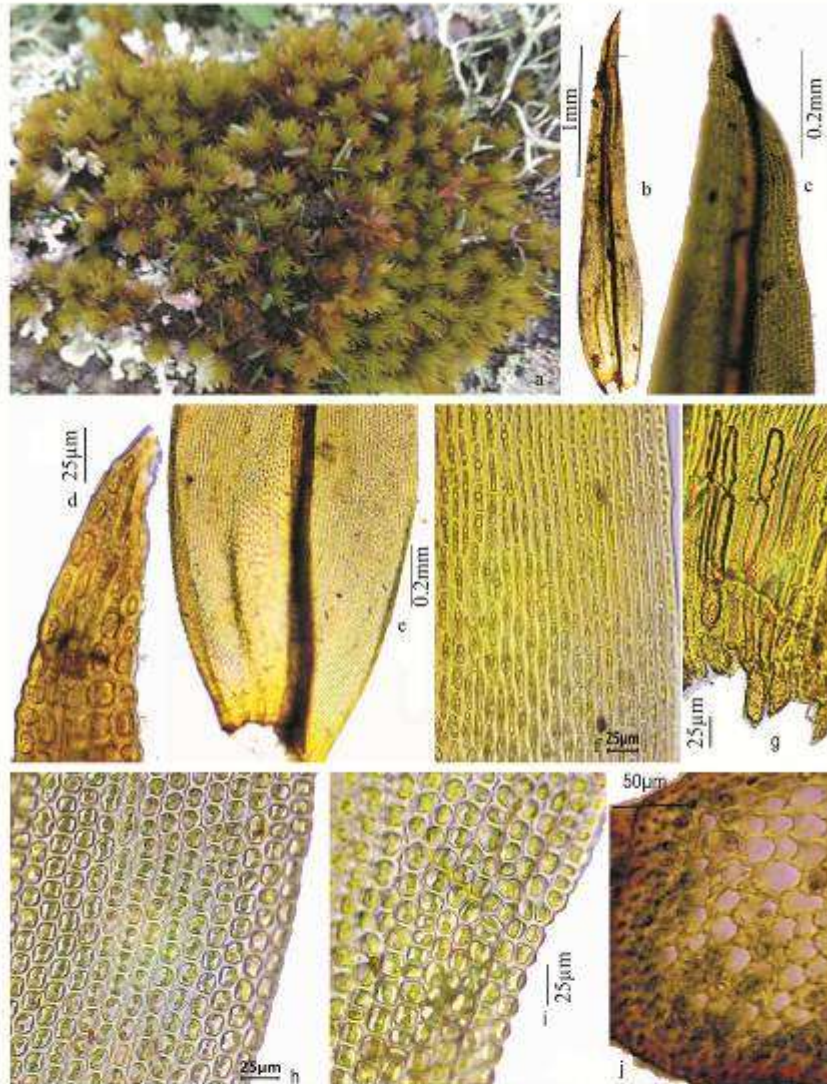


Plate 5. 94: *Macromitrium cf. flexuosum* Mitt., a, habit, b, leaf, c, leaf apex, d, leaf tip cells, e, leaf base, f, leaf cells at middle, g, leaf basal cells, h&i, leaf middle marginal cells, j, c.s. of stem

when moist, lanceolate to elliptic lanceolate, 3.2 mm long and 0.7 mm wide; costa strong, ending below apex; margin smooth, entire; cells at apex rounded to quadrate, 8-12 μm in diameter, cells at middle, 14-18 μm diagonally, cells at base usually elongate, rectangular, 20-35 μm long and 6-9 μm wide, multipapillate; sporophytes not observed (Plate 5.95).

Habitat: Epiphytic on the bark of tree trunks in shola forest.

Discussion: This species is closely related to *Macromitrium flexuosum*, but at this time I could not confirm the identity, hence it is given as *M. cf. flexuosum*. This species is characterized by yellowish green plants with elliptic lanceolate leaves and the laminal cells at base long and multipapillate. If it is confirmed as *M. flexuosum* later it may be a new record for India.

Distribution: World: Ecuador (Tropicos.org); **India:** Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Jandamala (2090 m) 09.11.2017 *Mufeed* 7465; Mannavan Shola (2000 m) 14.07.2017 *Mufeed* 7369 (ZGC).

Orthotrichum Hedw.,

Sp. Musc. Frond. 162–163. 1801.

Plants medium sized, in tufts, stems densely foliose, appressed and imbricated when dry; leaves lanceolate or oblong with short pointed apex; costa strong, ending near apex; cells at apex rhomboid, incrassate, smooth or papillose, 1-4, conic or clavate; marginal laminal cells gradually shorter than basal, cells at base elongated, thin walled and smooth; seta short, capsule immersed, elliptic or cylindrical with tapering apophysis, usually ribbed, peristome double, operculum short conical, calyptra campanulate.

Orthotrichum hookeri Wilson ex Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 48. 1859. *Dorcadionella hookeri* (Wilson ex Mitt.) Plášek, Sawicki & Ochya, Acta Mus. Siles. Sci. Nat. 65(3): 198. 2016. *Lewinskya hookeri* (Wilson ex Mitt.) F. Lara, Garilleti & Goffinet, Cryptog., Bryol. 37(4): 375. 2016. *Orthotrichum sikkimense* Herzog, Ann. Bryol. 12: 90. 11. 1939; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1163. 1976.

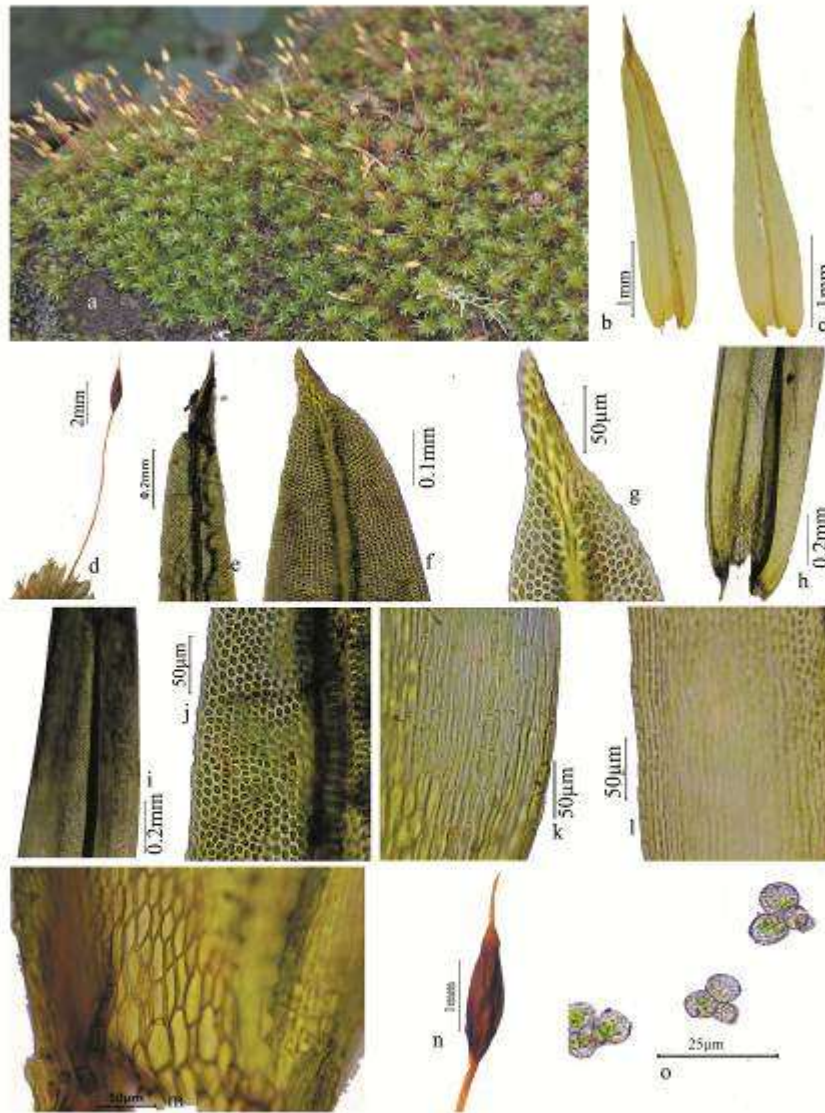


Plate 5. 95: *Macromitrium sulcatum* (Hook.) Brid., a. habit, b&c. leaf, d. sporophyte, e&f. leaf apex, g. leaf tip cells, h. leaf base, i. leaf middle, j. leaf marginal cells, k. leaf basal margin, l. leaf margin middle region, m. leaf basal cells, n. capsule, o. spore.

Plants orange green in tufts, brownish below, branching irregular; leaves dense, erectopatent, lanceolate from an elliptical base, 1.5 mm long and 0.5 mm wide at middle, apex usually acute, margin entire, narrowly revolute, canaliculated; costa percurrent or vanishing at the tip; laminal cells thick walled, cells at apex rounded-quadrangle, multipapillate, 6-8 μm , cells at middle gradually elongate and papillate, 8-10 μm , cells at base near costa elongated-rectangular, smooth, 15-25 x 5 μm ; seta long, up to 5 mm long, capsule erect, oblong-elliptical, 2 mm long and 0.8 mm diagonally, operculum conical apiculate, spores papillose, 30-40 μm , deep orange (Plate 5.96).

Habitat: Epiphytic, on trunks and branches in shola forest.

Discussion: *Orthotrichum hookeri* Wilson ex Mitt. is very rare in the study area. From India Gangulee (1976) reported *O. sikkimense* Herzog and *O. hookeri* from Eastern Himalayas, separating the two with minor differences. Lewinski (1992) synonymised *O. sikkimense* under *O. hookeri*. Since the genus was not earlier reported from Kerala, the present collection is a new record of this genus to Kerala and the species was not published from Peninsular India, hence it is a new record for Peninsular India. This species is characterized by orange to yellowish green plants above and brownish below, leaves lanceolate from an elliptical base with revolute margins and the laminal cells are thick walled and papillate.

Distribution: World: Bhutan, China, Nepal (Jia *et al.*, 2011), Mediterranean (Ros *et al.*, 2013), Southwest Asia (Kürschner & Frey 2011), Turkey (Uyar & Çetin, 2004; Kürschner & Erdağ 2005); **India:** Eastern Hiamalayas (Gangulee, 1976), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola, Mannavan Shola (2300 m) 03.03.2016 *Mufeed 10029* (ZGC).

Schlotheimia Brid.,

Muscol. Recent. Suppl. 2: 16–22. 1812.

Plants brownish in tufts, somewhat shiny; leaves dense, spirally twisted when dry, mucronate or hair pointed; cells at apex rounded, papillose, 1-2 per cell, distal laminal cells 8-12 μm in diagonal rows, incrassate, marginal laminal cells not



Plate 5. 96: *Orthotrichum hookeri* Wilson ex Mitt., a. habit, b. leaf, c&d. leaf apex, e. leaf cells middle, f. leaf base, g. cells near base, h. basal cells, i. sporophyte, j. spores

distinct from basal, basal lower cells basal laminal cells elongate, quadrate, rounded, or elliptic, often with porose walls; seta short, capsule erect, cylindric, calyptra large, covering entire capsule, not plicate, basal lobes 4-6, smooth or hairy.

Schlotheimia grevilleana Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 53. 1859; Foreau, J. Madras Univ. Sect. B. 3: 92. 1931; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1191. 1976. *S. calycina* Broth. & Paris, Rev. Bryol. 34: 30. 1907. *S. cyrtophylla* P. de la Varde, Rev. Bryol. Lichénol. 20: 5. 3. 1951. *S. fauriei* Cardot, Bot. Centralbl. 19(2): 106. 9. 1905. *S. grevillei* Kindb., Enum. Bryin. Exot. 75. 1888. *S. griffithiana* Paris, Index Bryol. (ed. 2)) 3: 344. 1905. *S. japonica* Besch. & Cardot, Bull. Herb. Boissier, sér. 2, 8: 336. 1908. *S. japonica* var. *sulcata* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 18: 250. 1908. *S. latifolia* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 18: 250. 1908. *S. macleai* Rehmman, Enum. Bryin. Exot., Suppl. 1. 94. 1889. *S. purpurascens* Paris, Rev. Bryol. 35: 44. 1908. *S. schweinfurthii* Müll. Hal., Linnaea 39: 408. 1875.

Plants golden brown, glossy in tufts; creeping stem produce erect branches; leaves dense, erect, oblong lingulate, spirally twisted when dry, 1.5-1.9 mm long and 0.5 mm wide at middle, margin flat, entire, apex acute or apiculate aristate; costa strong, excurrent, ending in a short arista; laminal cells thick walled, cells at apex quadrate rounded, usually with single papillae, 8-12 µm diagonally, cells at middle near the margin rhomboid, 20 µm long and 8 µm wide, marginal cells rectangular, 30-35 x 7 µm, cells at base large and rectangular, with porose less thickened walls, 35 x 9 µm; sporophytes not seen (Plate 5.97).

Habitat: Epiphytic on twigs and branches of trees in shola forest.

Discussion: This species is earlier reported from Assam by Gangulee (1976) and from Tamil Nadu (Foreau, 1931; Daniels, 2010). But this genus was not yet reported from Kerala. Hence the genus *Schlotheimia* Brid. with its species *S. grevilleana* Mitt. is a new genus and species record for Kerala. This species is characterized by golden brown glossy plants with oblong lingulate leaves, costa usually ending in a short arista and the laminal cells are 1 or 2 papillate.

Distribution: World: Africa (Vitt et al., 1993), China (Redfearn, *et al.*, 2006),

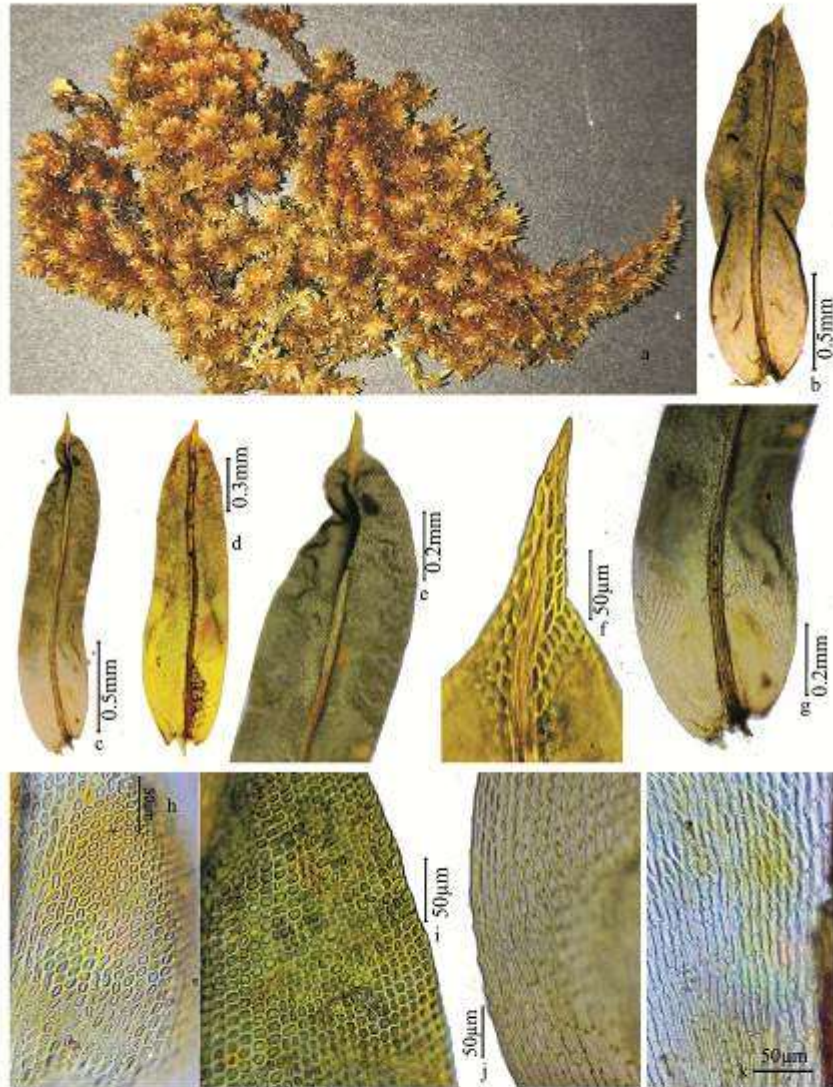


Plate 5.97: *Schlotheimia grevilleana* Mitt., a. habit, b,c&d. leaves, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf middle cells, i. leaf marginal cells, j. leaf basal margin, k. cells near costa

Japan, Sri Lanka, Indonesia, Philippines (O'Shea, 2006), Hong Kong (Zhang & Corlett, 2003); **India**: Assam (Gangulee, 1976), Kerala (present collection), Tamil Nadu (Foreau, 1930; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola, Mannavan Shola (1900 m) 14.07.2017 *Mufeed* 7563 (ZGC).

Zygodon Hooker & Taylor,
Musc. Brit. 70. 1818.

Plants light to dark green on rocks or trees, up to 10 cm long, stem erect, tomentose, branched; leaves 0.5-2.0 mm, loosely-erect and irregularly twisted or curved around stem, undulate when dry, erect-spreading to squarrose-recurved when moist, lanceolate to linear-lanceolate, usually apiculate to acute, leaf margin entire or denticulate near apex; costa percurrent, ending near apex, or rarely excurrent; upper laminal cells 4-15 μm wide, densely pluripapillose, smooth or with 2-6 small, clavate papillae per cell, thick-walled, basal laminal cells subquadrate to rectangular; dioicous, autoicous, or synoicous, rarely with sporophytes, seta long, slender, 2-12 mm long, capsule elliptic-oblong, 1-2 mm, strongly 8-ribbed along the entire length, peristome double, single, or lacking, spores 11-22 μm .

Zygodon viridissimus (Dickson) Bridel, Bryol. Univ. 1: 592. 1826; Gangulee, Mosses E. India & Adj. Reg. 1156. 1972. *Bryum viridissimum* Dickson, Pl. Crypt. Brit. fasc. 4: 9. 10 f. 18. 1801. *Zygodon aristatus* Lindb., Acta Soc. Sci. Fenn. 10: 542. 1875. *Z. mougeotii* Bruch & Schimp., Bryol. Eur. 3: 39. 206 (fasc. 4 Mon. 7. 1). 1838. *Z. viridissimus* var. *rupestris* Lindb. ex C. Hartm., Handb. i Skand. Fl. 382. 1861.

Plants 20-30 mm long, yellowish-green, yellowish-brown when dry, stem erect, reddish-brown, tomentose; leaves long, lanceolate, spirally arranged, appressed leaves when dry, erect spreading in moist condition, 0.5-1.0 mm long and 0.2-0.4 mm wide, tip acuminate, decurrent, margins entire or with irregularly serrated near apex, somewhat wavy; costa ending below apex with quadrate papillose cells only at apex, apical laminal cells 8-12 μm wide, thick walled, with 2-4 clavate papillae,

basal laminal cells subquadrate to rectangular, 12-14 x 5-7 µm; plants collected were sterile (Plate 5.98).

Habitat: Epiphytic on bark of trees in shola forest.

Discussion: *Zygodon viridissimus* (Dickson) Bridel was reported only from Sikkim (Gangulee, 1972) in India. The genus *Zygodon* was not reported from Kerala and the species *Z. viridissimus* was not yet reported from Peninsular India. Hence the present collection from Anamudi Shola National Park is an extended distribution of the genus to Kerala and the species to Peninsular India. This species is characterized by its lanceolate leaves with percurrent costa and leaf apical cells having 2-4 papillae.

Distribution: World: Algeria, Britain, Canada, Japan, Norway (Iwatsuki, 1991; Ireland *et al.*, 1987), America (Allen, 2002; Britton, 1908), Nepal (Gangulee, 1972); **India:** Kerala (present collection), Sikkim (Gangulee, 1972).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900-1950 m) 14.07.2017 *Mufeed* 7541, 7547 (ZGC).

Bartramiales M. Menzel,
J. Hattori Bot. Lab. 71: 242. 1992.

Bartramiaceae Schwägr.,
Sp. Musc. Frond. 90. 1830.

Plants erect or rarely decumbent, small to medium; stem simple with subfloral whorls of branches; leaves imbricate to widespread, straight or occasionally crisped, secund or circinate when dry, sometimes more or less falcate at branch apices, linear to broadly ovate-lanceolate or ovate-elliptical, shoulders absent to well-developed, acuminate to obtuse; costa single, strong, subpercurrent to long-excurrent, rarely rudimentary or absent, often scabrous on back; laminal cells long-rectangular to quadrate, papillose on abaxial or both sides at or near one or both end walls, smooth, alar cells typically not differentiated; synoicous, autoicous, or dioicous; seta short to long, smooth, straight, capsule stegocarpous, subglobose to oblong-cylindrical, erect to nodulous, often furrowed when dry or less frequently, irregularly wrinkled; annulus usually not differentiated; operculum convex, rarely rostrate, peristome

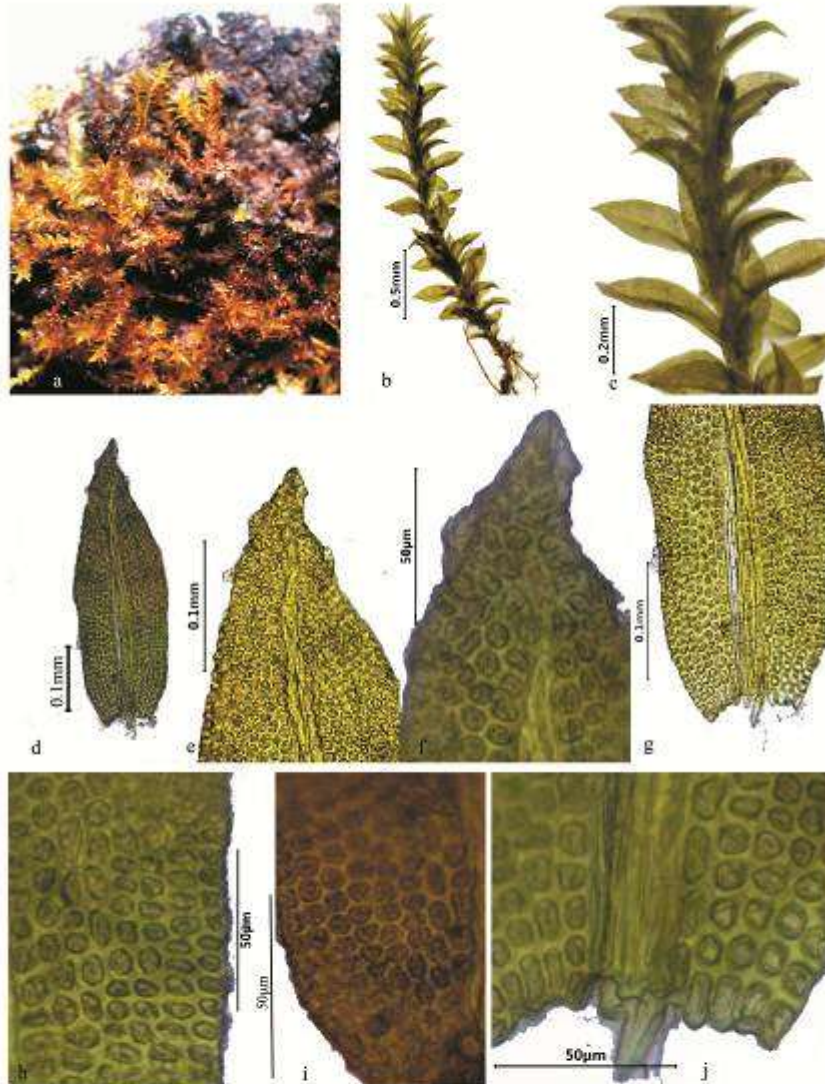


Plate 5. 98: *Zygodon viridissimus* (Dickson) Bridel: a. habit, b. single plant, c. leaf arrangement, d. leaf, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf marginal cells, i&j. leaf basal cells

double, single, or absent, spores globose, ovoid or reniform, variously ornamented, calyptra small, cucullate, glabrous.

***Philonotis* Brid.,**

Bryol. Univ. 2: 15–28, pl. 6, f. 5. 1827.

Plants usually forming mats, slender, variable in size; stems usually elongate, erect, tomentose below, with subfloral innovations; leaves lanceolate, acuminate, margin dentate or serrate or entire; midrib percurrent or excurrent; cells rectangular, papillate; sporophyte apical, erect, solitary, elongate, capsule ovoid to subglobose, distinctly furrowed when dry, peristome 2 rowed, operculum convex.

Key to the species

- 1a. Leaves stiff, stem dichotomously branched with whorled subfloral innovations, rhizoids papillose ***P. thwaitesii***
- 1b. Leaves falcate, stem not dichotomously branched, with less subfloral innovations, rhizoids smooth ***P. falcata***

Philonotis falcata (Hook.) Mitt., J. Proc. Linn. Soc., Bot. (Suppl. 1): 62. 1859. (Suppl. 1): 62. 1859; Gangulee, Mosses E. India & Adj. Reg. 2(4): 1110. 1974; Nair *et al.*, Folia Malaysiana 18(1): 24. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 16. 2008; Daniels, Arch. Bryol. 65: 76. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 77. 2013; *Bartramia falcata* Hook., Trans. Linn. Soc. London 9: 317. 27 f. 4. 1808. *B. fontana* var. *falcata* (Hook.) Bruch & Schimp., Bryol. Eur. 4: 49 (fasc. 12 Mon. 19). 1842. *B. subulosa* Griff., Calcutta J. Nat. Hist. 2: 512. 1842. *B. pseudofontana* Müll. Hal., Bot. Zeitung (Berlin) 14: 418. 1856. *Philonotis palustris* Mitt., J. Linn. Soc., Bot. 8: 150. 1865. *Philonotis carinata* Mitt., Trans. Linn. Soc. London, Bot. 3: 164. 1891. *P. rufocuspis* Besch., Rev. Bryol. 18: 88. 1891. *Philonotula japonica* Schimp., Ann. Sci. Nat., Bot., sér. 7, 17: 348. 1893. *Philonotis angularis* Müll., Hal., Nuovo Giorn. Bot. Ital., n.s. 3: 104. 1896. *P. giraldii* Müll. Hal., Nuovo Giorn. Bot. Ital., 3: 104. 1896. *P. japonica* (Schimp.) Paris, Index Bryol. 923. 1897. *Bartramia tsanii* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 251. 1897. *B. tomentosula* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 172. 1898. *B. afrofontana* Müll. Hal., Hedwigia 38: 93. 1899. *Philonotis setschuanica* var.

formosica Cardot, Beih. Bot. Centralbl., Abt. 2 19(2): 108. 1900. *P. tomentosula* (Müll. Hal.) Paris, Index Bryol. Suppl. 268. 1900. *P. tsanii* (Müll. Hal.) Paris, Index Bryol. Suppl. 268. 1900. *P. bodinierii* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 13: 82. 1. 1904. *P. laxiretis* Cardot, Bull. Soc. Bot. Genève 1: 122. 1909. *P. fallax* Dism., Mém. Soc. Bot. France 17: 35. 1910. *P. plumulosa* Cardot & Thér., Bull. Géogr. Bot. 21: 271. 1911. *P. bonatii* Copp., Bull. Soc. Vaud. Sci. Nat. 12(4): 9. 1911. *P. anisoclada* Cardot & P. de la Varde, Rev. Bryol. 50: 23. f. 13. 1923. *P. falcata* var. *carinata* (Mitt.) Ochi, Nova Hedwigia 4: 100. 1962.

Plants robust, yellowish green with brownish below, in extensive mats, branching from base; stem up to 1cm or more high, with a whorl of subfloral branches; leaves falcate, indistinctly spirally arranged, erecto-patent when moist, triangular ovate from a broad base, more or less falcate at tip of branches, acuminate, carinate, ± 0.9 mm long and ± 0.25 mm wide at base; margin flat, sharply denticulate all along, costa excurrent in a short arista; leaf cells narrow, ovate to hexagonal at tip, $25-35 \times 8 \mu\text{m}$, wider and rectangular at base, $22-42 \times 12-15 \mu\text{m}$, cells mamilllose at one or both ends; perichaetial leaves not much differentiated; seta apical, erect, red to brownish, $\pm 5 \times 3$ mm, furrowed when dry, capsule horizontal, outer peristome teeth lanceolate, brownish, hyaline at tip, spores rounded and brownish (Plate 5.99).

Habitat: Terrestrial, usually seen on land cuttings in shola forest and grassland.

Discussion: Koponen (1996) examined the status and distribution of *Philonotis falcata* and collected more than thousand specimens from different regions and examined various herbaria, and concluded that *P. falcata* is a southeast Asiatic species and does not occur in Europe and America. The report by Robinson (1967) is a misidentification from Europe and America. It is characterized by mamilllose cell at one or both ends with acute leaves, leaf margin flat and costa excurrent with short arista.

Distribution: World: China, Hawaii, Japan, Philippines, Siberia (Koponen, 1996);

India: Eastern & Western Himalaya (Gangulee, 1974), Jammu & Kashmir (Kour *et al.*, 2015), Kerala (Nair *et al.*, 2007), Madhya Pradesh (Mishra *et al.*, 2016), Tamil Nadu (Daniels, 2010).

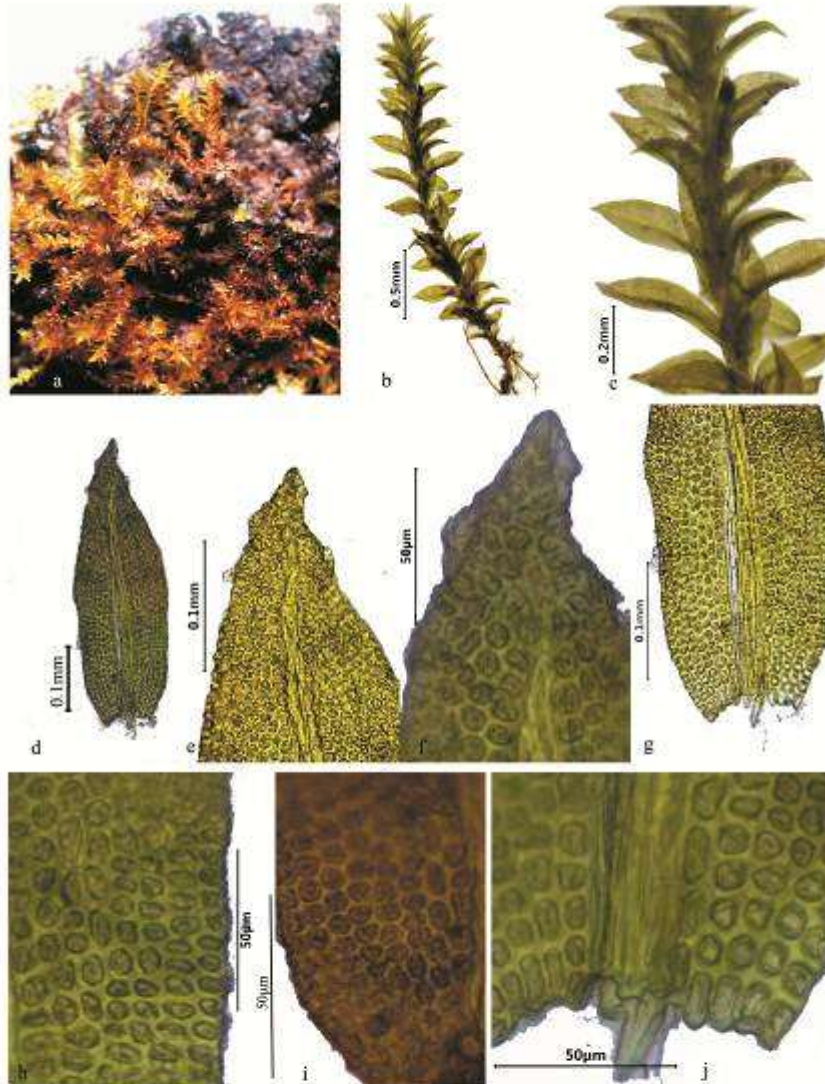


Plate 5. 98: *Zygodon viridissimus* (Dickson) Bridel: a. habit, b. single plant, c. leaf arrangement, d. leaf, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf marginal cells, i&j. leaf basal cells

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000 m) 12.07.2017 *Mufeed 7331a*; Iddalymotta (2350 m) 07.11.2017 *Mufeed 7408* (ZGC).

Philonotis thwaitesii Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 60. 1859; Gangulee, Mosses E. India & Adj. Reg. 2: 1121. 1974; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 574. 2001; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 138. 2005; Nair *et al.*, *Folia Malaysiana* 18(1): 28. 2007; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 16. 2008; Daniels, Arch. Bryol. 65: 77. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 77. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 129. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 145. 2019. *Bartramia thwaitesii* (Mitt.) Müll. Hal., Gen. Musc. Frond. 338. 1900. *Philonotis revoluta* Bosch & Sande Lac., Bryol. Jav. 1: 158. 128. 1861. *P. socia* Mitt., J. Proc. Linn. Soc., Bot. 8: 151. 1864. *P. savatieri* Broth., Nat. Pflanzenfam. I(3): 646. 1904. *P. appressifolia* Dixon, Hong Kong Naturalist, Suppl. 2: 18. 1933.

Plants yellowish green, brownish and tomentose below, slender to robust, in dense tufts, rhizoids papillose; stem erect or flexuous, up to 1cm long, dichotomously branched with whorled subfloral innovations; leaves erect, lanceolate, stiff, appressed to stem when dry, ± 1.3 mm long and ± 0.3 mm wide at base; apex acute, margin faintly denticulate, narrowly reflexed; costa excurrent or percurrent; cells near the apex shortly rectangular elongate, 25-45 μ m long and 5-8 μ m wide; cells near base 30-55 long and 5-10 μ m wide; seta apical, erect, ± 2 cm long; capsule erect, subglobose, furrowed when dry, 1.5 mm long and 1.2 mm wide, spores brownish rounded, 25-30 μ m diagonally (Plate 5.100).

Habitat: Lithophytic, usually seen on large rocky patches and on crevices of rocks in shola forest and grassland.

Discussion: It is a widely distributed species in the high altitude shola and evergreen forests of temperate climate. This species is characterized by the plants usually dichotomously branched with whorled subfloral innovations and numerous papillose rhizoids from base to top.

Distribution: World: China (Redfearn Jr. & Wu, 1986), Japan (Noguchi & Iwatsuki, 1989), Papua New Guinea (Koponen & Norris, 1996), Philippines (Tan &

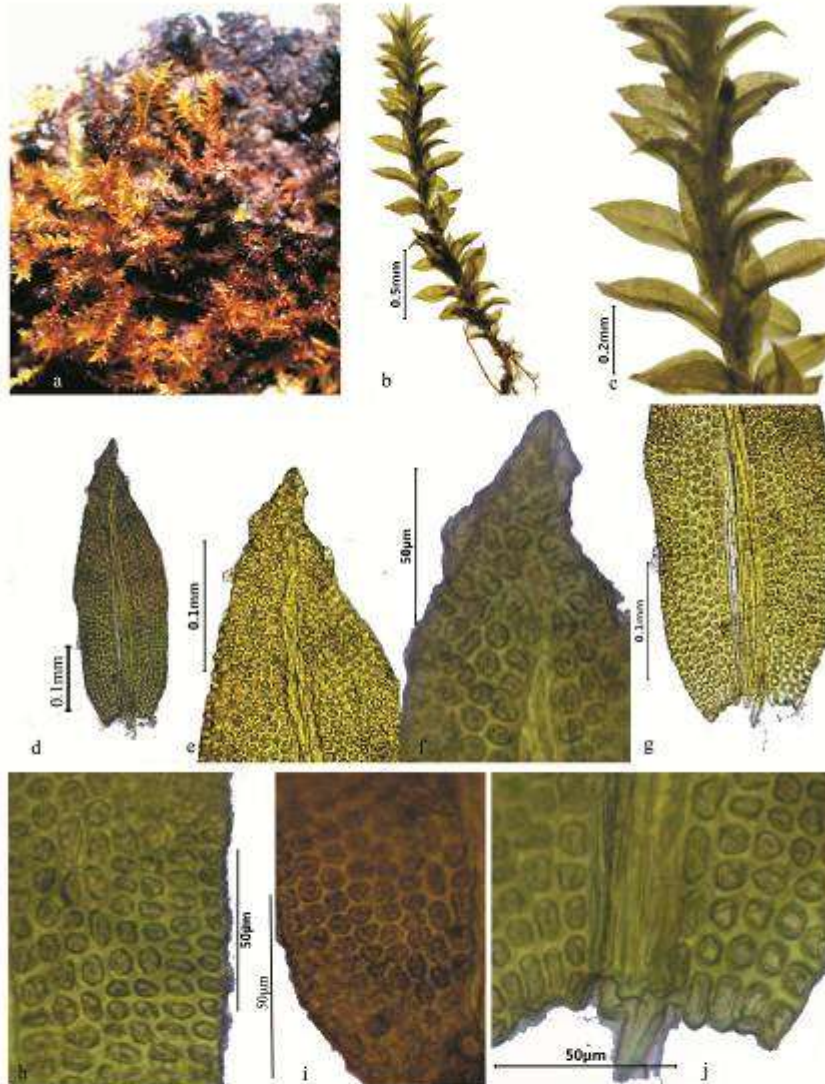


Plate 5. 98: *Zygodon viridissimus* (Dickson) Bridel: a. habit, b. single plant, c. leaf arrangement, d. leaf, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf marginal cells, i&j. leaf basal cells

Iwatsuki, 1991); **India:** Gujarat (Alam *et al.*, 2015), Karnataka (Schwarz, 2014), Kerala (Nair *et al.*, 2007), Rajasthan, Odisha (Mishra *et al.*, 2016), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2300-2350 m) 22.09.2018, *Mufeed* 9915, 9929 (ZGC).

Rhizogoniales Goffinet & W.R. Buck,
Monogr. Syst. Bot. Missouri Bot. Gard. 98: 235. 2004.

Rhizogoniaceae Broth.,
Die Nat. Pflanzenfam. 1(3): 614. 1904.

Plants in tufts, green above, brownish below; leaves spreading, linear lanceolate, tip curved when dry, margin thick, spinose with teeth; costa excurrent; leaf cells incrassate, rounded elongate, smooth; capsule sub-erect to horizontal, ovate to cylindrical, peristome normal, cilia smooth.

Pyrrhobryum Mitt.,
J. Linn. Soc. Bot. 10: 174. 1868.

Plants greenish, brownish when dry, robust, erect or flexuous; leaves spreading, laxly erect, linear-lanceolate, tip incurved when dry, margin usually dentate and thickened; costa single, strong, excurrent; cells smooth, incrassate, round or oval; seta long, erect to flexuous, arises from the base of the branches, capsule erect or sub erect.

Pyrrhobryum spiniforme (Hedw.) Mitt., J. Linn. Soc., Bot. 10: 174. 1868; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 133. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 17. 2008 & Taiwania 54: 65. 2009; Daniels, Arch. Bryol. 65: 82. 2010; Daniels & Daniel, Bryofl. S.-most W. Ghats, India: 102. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 164. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 179. 2019. *Hypnum spiniforme* Hedw., Sp. Musc. Frond. 236–237. 1801. *Rhizogonium spiniforme* (Hedw.) Bruch., Flora 29: 134. 1846; Gangulee, Mosses E. India & Adj. Reg. 4: 1067-1068. 1974. *Mnium spiniforme* (Hedw.) Müll. Hal., Syn. Musc. Frond. 1: 175. 1848. *Rhizogonium boninense* Z. Iwats., Bull. Natl. Sci. Mus. 12: 298. 1969. *R. pervilleanum* Besch., Ann. Sci. Nat. Bot. sér. 6, 10: 242. 1880.

Plants greenish, robust, in dense tufts, usually growing on decayed wood or logs near stream, up to 5cm long; leaves linear-lanceolate, incurved when dry, laxly arranged on stem, erect to spreading, upper leaves up to 5.5 mm long and 0.5 mm wide, lower leaves smaller, up to 2.2 x 0.4 mm, margin serrate with paired teeth; costa strong, excurrent, toothed on back; leaf cells incrassate, smooth, oval, rounded or quadrate hexagonal, apical cells 14-20 x 6-7 μm , basal cells 17-30 x 10 -11.2 μm , marginal cells 12-20 x 8-10 μm , spines in double layered with thick walls; seta brownish, arises from the base of stem, erect flexuous, up to 5cm long, capsule horizontal or inclined, capsule mouth reddish in colour, ovate cylindrical, 2.6 mm long and 1.2 mm wide, furrowed when dry, peristome teeth large, yellowish, spores yellowish green, 16-19 μm diagonally (Plate 5. 101 & 102).

Habitat: On decayed wood or logs or on roots of higher plants and on rocky patch in shola forests near streams.

Discussion: The Greek word ‘Pyrros’ means reddish colour of the capsule mouth, genus name given by this character. Mitten (1868) synonymised *Rhizogonium spiniforme* (Hedw.) Bruch. under *Pyrrhobryum spiniforme* (Hedw.) Mitt. but most of the authors followed *Rhizogonium spiniforme*. Hoe (1974), Koponen *et al.* (1986), etc. followed *Pyrrhobryum spiniforme* as valid species and *Rhizogonium spiniforme* as synonym of the former. Gangulee (1974) reported this species as *Rhizogonium spiniforme* from Eastern Himalayas. From Kerala Nair *et al.* (2005) reported this species from Wayanad district as *Pyrrhobryum spiniforme*. Here also followed as *P. spiniforme*. It is a very common species in the high altitude shola forests of Kerala. It is characterized by the stiff acrocarpic plants with sporophyte arise from the base of the stem, the cells are incrassate from top to bottom except the marginal cells, where the cells modified to double layered spines with thick walls.

Distribution: World: Africa (O’Shea, 2006), Australia (Dalton *et al.*, 1991), Bhutan (Long, 1994), China (Li & Crosby, 2007), Hong Kong (Zhang & Lin, 1997), Mauritius (Frahm *et al.*, 2009), Mexico (Moya & Soriano, 2011), Sri Lanka (O’Shea, 2002), Thailand (Frahm, 2012); **India:** Arunachal Pradesh, Assam, Meghalaya, West Bengal (Gangulee, 1974), Kerala (Daniels & Kariyappa, 2019; Madhusoodanan *et al.*, 2007; Nair *et al.*, 2005; 2006), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019).



Plate 5. 101: *Pyrrhobryum spiniforme* (Hedw.) Mitt., a&b. habit, c. leaf, d&e. young leaves, f&g. leaf apex, h. leaf base, i. basal marginal cells, j. leaf margin at middle, k. leaf basal cells, l. c.s. of stem

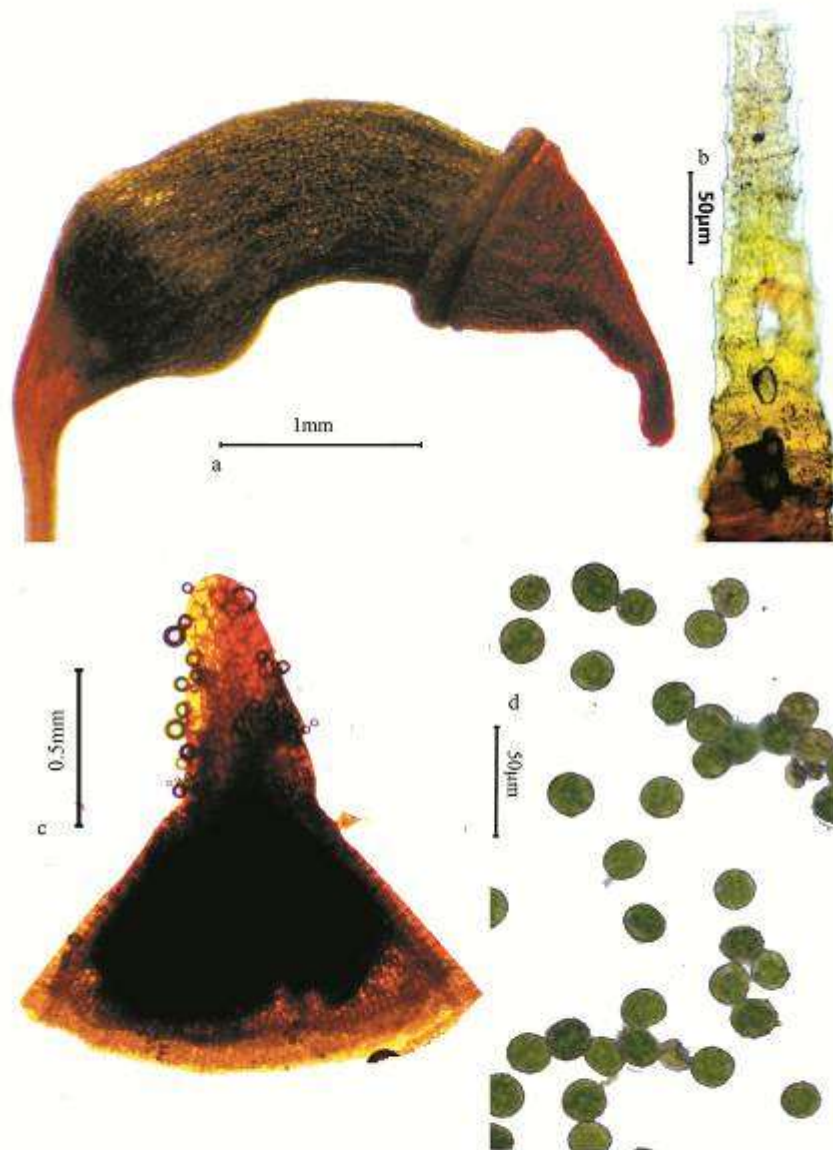


Plate 5. 102: *Pyrrhobryum spiniforme* (Hedw.) Mitt., a. capsule, b. peristome teeth, c. operculum, d. spore

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000-2050 m) 12.07.2017 *Mufeed 7307*; 24.09.2018 *Mufeed 9960* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1560 m) *Manju C.N. 99607* (CALI!).

Hypnodendrales N.E. Bell, A.E. Newton & D. Quandt,
The Bryologist 110: 554. 2007.

Racopilaceae Kindb.,
Bot. Centralbl. 76(3): 85. 1898.

Plant yellowish green to brownish; main stem creeping, branches prostrate; leaves lax on branches, dimorphic, in two lateral rows, spreading, ovate, aristate; cells on upper lamina rounded to quadrate, smooth, elongate rhomboid below; dorsal leaves much smaller, appressed with long arista; seta long, capsule erect or inclined.

Racopilum P. Beauv.,
Prodr. Aethéogam. 36–37, 87. 1805.

Plants slender to robust, green to yellowish green, irregularly branched, usually in extensive mats; leaves dimorphous, lateral leaves long, oblong-ovate, slightly asymmetric, margin slightly dentate or serrulate at apex; costa excurrent as a smooth arista, the arista may vary in length; dorsal leaves extremely variable, usually much smaller than the lateral leaves, narrowly triangular to ovate, nearly symmetric; lamina cells irregularly shaped, rounded, isodiametric, shortly rhomboidal to elongate-hexagonal, often in oblique rows, thin-walled or slightly incrassate, smooth, single papillae, cells at basal margins and towards base usually rectangular; seta elongate and capsule inclined.

Racopilum orthocarpum Wilson ex Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 136. 1859; Bruehl, Rec. Bot. Surv. India 13(1): 64. 1931; Chopra, Taxon Indian Moss. 292. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1199. 1976; Madhus. & Nair, J. Econ. Taxon. Bot. 28: 341. 2004; Nair *et al.*, Bryo. Wayanad, W. Ghats 1: 143. 2005; Daniels, Arch. Bryol. 65: 83. 2010; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 17. 2008; Arch. Bryol. 42: 9. 2009 & Taiwania 54: 65. 2009; Daniels & Daniel,

Bryofl. S.-most W. Ghats, India: 136. 2013; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 219. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 253. 2019. *Racopilum siamense* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 34. 1932.

Plants yellowish green, glossy, prostrate, up to 2 cm long; main stem forms secondary branches, less than 1 cm long; leaves dimorphic, in three rows, two lateral large leaves and one dorsal small leaves; lateral leaves up to 1.5 mm long 0.4 mm wide at base, asymmetrical, ovate, tip acute, long aristate, margin flat, slightly dentate at tip, lateral leaves originate parallel to stem; dorsal leaves much smaller, up to 1 mm long, 0.2 mm wide, appressed; costa strong, excurrent; leaf cells ovate to elongate, smooth, chlorophyllous, unipapillose, basal cells quadrate to rectangular, cells at middle 7-15 μm diagonally, at base 15-30 x 5-12 μm ; sporophytes not seen.

Habitat: Seen on decayed woods in shola forests (Plate 5.103).

Discussion: Zanten (2006) given a detailed picture on the genus *Racopilum* in the world, he reviewed all the species from Asia. In his observation the gametophyte of *R. orthocarpum* Wilson ex Mitt. is very much similar to *R. cuspidigerum* (Schwägr.) Ångstr. with some minor differences. So it is very difficult to distinguish these two species. Nair *et al.* (2005) reported these two species from Kerala with minor differences. Daniels & Kariyappa (2019) also considered these two species as separate. In *R. orthocarpum* the lateral and amphigastrial leaves are not so strongly dentate with long arista and capsule is erect. But in *R. cuspidigerum* strong dentation in lateral and amphigastrial leaves with arista not so long and capsule is horizontal. Re-examining the specimens during the present study, it reveals that both the species collected from different localities of Kerala are *R. orthocarpum*. The main characters of *R. orthocarpum* are yellowish green glossy plants with two types of leaves, lateral leaves larger than dorsal leaves and of different shapes, leaf with long aristate tip, margin of leaf tip slightly denticulate and laminal cells unipapillose.

Distribution: World: Bhutan, Burma, Nepal, Thailand (Zanten, 2006), Sri Lanka (O'Shea, 2002); **India:** Eastern Himalayas (Gangulee, 1974), Kerala (Nair *et al.*, 2005; Daniels & Kariyappa, 2019), Madhya Pradesh (Alam *et al.*, 2015), Odisha (Mishra *et al.*, 2016), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019).

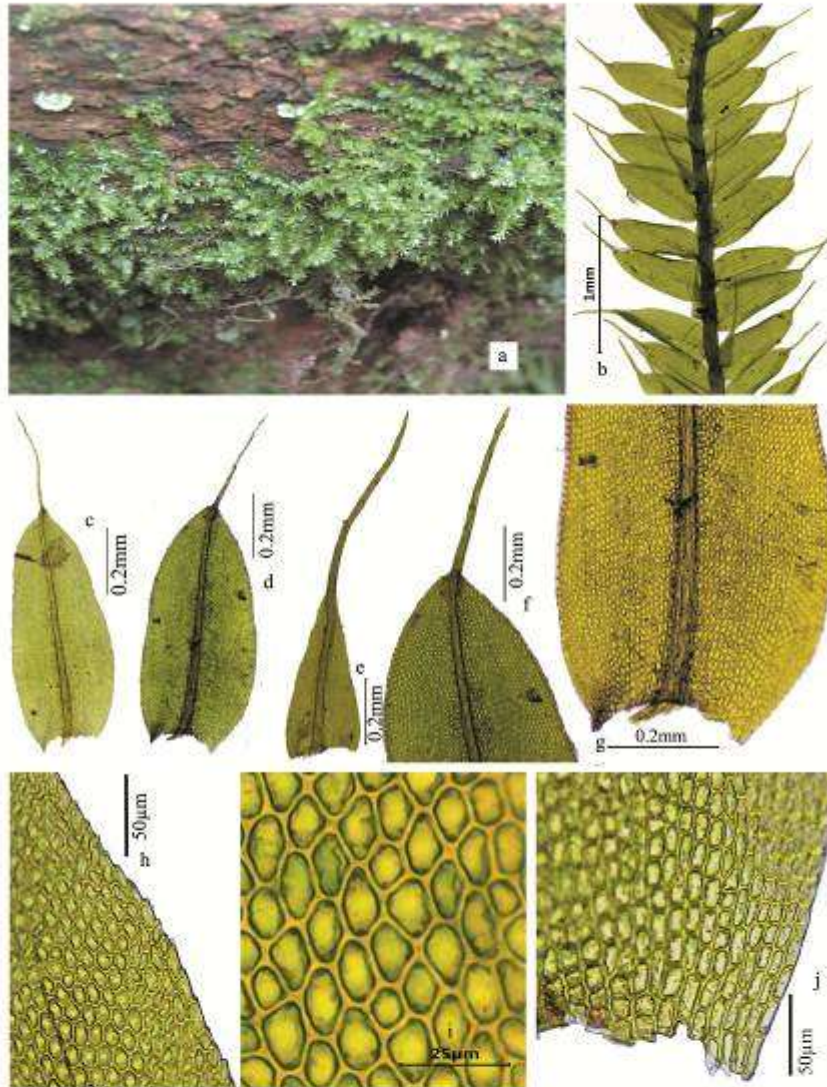


Plate 5. 103: *Racopilum orthocarpum* Wilson ex Mitt., a. habit, b. branch showing leaf arrangement on the stem, c&d. leaves, e. underleaf, f. leaf apex, g. leaf base, h. leaf marginal cells, i. leaf middle cells, j. leaf basal cells

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700-1900 m) 14.07.2017 *Mufeed* 7546; 24.09.2018 *Mufeed* 9968 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Muthanga range (890m) *Manju C.N. 84501* (as *R. cuspidigerum*), Sulthan Bathery (870-907m) *Manju C.N. 84357* (as *R. cuspidigerum*), Kurichiad (929m) *Manju C.N. 84560* (as *R. cuspidigerum*), Chembra hills (1380m) *Manju C.N. 120262* (as *R. cuspidigerum*), 120265 (as *R. orthocarpum*); Manikkunnumala, near MSSRF (980m) *Manju C.N. 120293* (as *R. cuspidigerum*); Kurichiad range (830m) *Manju C.N. 84523* (as *R. orthocarpum*); Tholpetty range (880m) *Manju C.N. 84573* (as *R. orthocarpum*), Muthanga range, Keeradamkolli (786-915m) *Saju K.A. 76098* (as *R. orthocarpum*), *Manju C.N. 84513* (as *R. orthocarpum*) (CALI!).

Hookeriales M. Fleisch.

Hedwigia 61: 397. 1920.

Key to the families

- 1a. Costa single 2
- 1b. Costa double or absent 3
- 2a. Leaves dimorphic with two dorsal lateral leaves and small ventral leaves; leaf margin narrowly bordered **Hypopterygiaceae**
- 2b. Leaves simple, without ventral leaves; leaf margin broadly bordered **Daltoniaceae**
- 3a. Laminal cells isodiametric to linear ... **Pilotrichaceae**
- 3b. Laminal cells hexagonal.. **Hookeriaceae**

Hypopterygiaceae Mitt.,

J. Proc. Linn. Soc., Bot. (Suppl. 1): 147. 1859.

Plants usually medium-sized to robust, rhizomatous, primary stem elongate or creeping, tomentose; secondary stem simple, plumose or dendroid; leaves dimorphous, lateral leaves complanate, ovate, slightly asymmetrical, serrate, narrowly bordered; ventral leaves small, symmetrical, appressed to stem, acuminate; costa single, percurrent or excurrent; cells hexagonal to quadrangular, smooth, calyptra cucullate or conical, naked, capsule exserted, erect or pendulous, peristome double, operculum rostrate.

Key to the genera

- 1a. Plants often dendroid, stem with central strand, costa ending just above 1/2 or 3/4th of leaf length in lateral leaves **Hypopterygium**
1b. Plants pinnately branched, often plumose, stem without central strand, costa excurrent in lateral leaves **Lopidium**

***Hypopterygium* Brid.,**

Bryol. Univ. 2: 709–718. 1827.

Plants robust, usually umbellate, stem creeping, usually branched, irregularly pinnate or frondose, central strand present; leaves partly or entirely complanate, dimorphous; leaves dull or slightly glossy, costa simple, reaching up to the middle in the lateral leaves, one-third to excurrent in amphigastria; laminal cells simple, bordered, hexagonal, thin-walled; seta short or long, capsule exserted, inclined or horizontal, peristome double.

Hypopterygium tamarisci (Sw.) Brid. ex Müll. Hal., Syn. Musc. Frond. 2(6): 8. 1851[1850]; P. Bruehl, Rec. Bot. Surv. India 13(1):84. 1931; Foreau, Madras Univ. 3: 121. 1931; Wadhwa, M.V.M. Patrika 6: 74.1971; Chopra, Taxon. Indian Mosses 397. 1975; Mohamed & H.Rob., Smith. Contr. Bot. 80: 37. 1991; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 2005. *Hypnum tamarisci* Sw., Fl. Ind. Occid. 3: 1825. 1806. *Hypopterygium frondiferum* Brid., Muscol. Recent. Suppl. 2: 87. 1812. *H. laricinum* Hook., Musci Exot. 1: 35. 1818. *H. laricinum* (Hook.) Brid., Bryol. Univ. 2: 714. 1827. *H. scutellatum* Taylor, London J. Bot. 6: 338. 1847. *H. brasiliense* Sull., Proc. Amer. Acad. Arts 3: 184. 1854. *H. tenellum* Müll. Hal., Bot. Zeitung (Berlin) 12: 557. 1854. *H. muelleri* Hampe, Linnaea 28: 215. 1856. *H. debile* Reichardt, Reise Novara 1(3): 194. 35. 1870. *H. argentinicum* Lorentz ex Müll. Hal., Linnaea 42: 404. 1879. *H. torulosum* Schimp. ex Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 326. 1880. *H. brevifolium* Broth., Bol. Soc. Brot. 8: 188. 1890. *H. subhumile* Renauld & Cardot, Rev. Bot. Bull. Mens. 9: 400. 1891. *H. grandistipulaceum* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 32(2): 28. 1893. *H. arbusculosum* Besch., Bull. Soc. Bot. France 45: 127. 1898. *H. bouvetii* Besch., Bull. Soc. Bot. France 45: 490. 1898. *H. brachypodium* Müll. Hal., Hedwigia 40: 288. 1901. *H. bowiei* Broth. & Watts, J. & Proc. Roy. Soc. New South Wales 49: 147. 1915. *H. tamarisci* subsp. *hildebrandtii* Kindb., Hedwigia 40: 288. 1901. *H. atrotheca* Dixon, J. Bot. 66: 350. 1928.

Plant dull green or bright greenish, spreading in wet condition, usually seen as mats, found on decayed woods and rocks; stem creeping, branched, up to 3 cm long, secondary branches usually 1cm long, cross section of stem circular in outline, differentiated into large thick walled hypodermal cells and small central cells; leaves dimorphous, lateral leaves usually large and dorsal leaves are small in size, lateral leaves up to 1 mm long and 0.7 mm wide at base, ovate, short acuminate, marginal cells bordered with 1 or 2 rows of hyaline elongated cells, entire at base and slightly serrate at apex; costa single, reaches up to the middle of leaves; cells hexagonal except at tip and margin, cells at tip narrow-elongated, 60 x 12 µm, cells at middle 30-32 x 12-15 µm, cells at margin elongate and narrow, 135 x 10 µm; amphigastria orbicular, short acuminate, 0.7 x 0.6 mm, wide at base; reproductive structure not seen (Plate 5.104).

Habitat: Plants usually seen on rocks and on decayed woods sometimes inhabit at the base of tree trunks along with *Thuidium glaucinum* (Mitt.) Bosch & Sande Lac and *Fissidens anomalus* Mont.

Discussion: *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal. is a widespread pantropical and warm-temperate species. The species shows considerable morphological and ecological variation across the world, mostly in size, sexuality and the presence or absence of propagules. The species is very common in South India, usually found on high altitude mountains of Western Ghats. From Kerala, Nair *et al.* (2005) collected this species from Chembra hills in Wayanad district at an altitude above 1300 m. The main characters of the species are frondose secondary stem which is irregularly pinnately branched, dimorphous leaves with lateral leaves short acuminate and strongly toothed at apex and entire at base.

Distribution: A widespread pantropical and warm temperate species found in high altitude temperate forests of the world. **World:** Brazil, Cameroon, Ethiopia, Kenya, Africa, Zimbabwe, Mauritius, Sri Lanka (O'Shea, 2006), Italy (Aleffi *et al.*, 2010), Philippines, Java, Malaysia, Sumatra, Borneo, New Guinea (Mohamed & Robinson, 1991 as *H. tenellum*), **India:** Andhra Pradesh (Sreenath *et al.*, 2020), Kerala (Madhusoodanan *et al.*, 2007; Nair *et al.*, 2005), Tamil Nadu (Daniels, 2010).

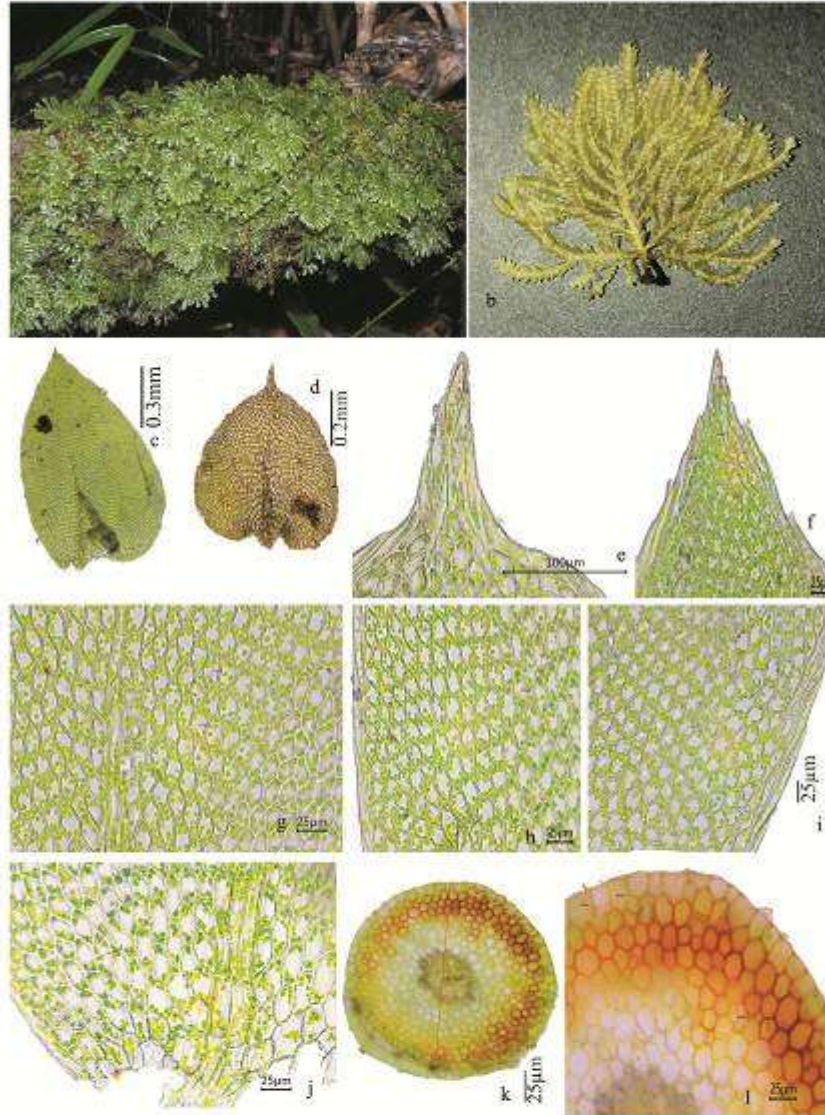


Plate 5. 104: *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal. a. habit, b. single plant, c. leaf, d. amphigastria (underleaf), e&f. leaf apex, g. leaf cells, h. leaf margin, i. leaf margin base, j. leaf basal cells, k&l. c.s. of stem

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2180-2300 m) 04.03.2016 *Mufeed* 10060; 04.03.2016 *Mufeed* 10074; 12.07.2017 *Mufeed* 7304; 26.09.2018 *Mufeed* 9995 ; Mannavan Shola (1945 m) 14.07.2017 *Mufeed* 7555 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1380m) *Manju C.N. 120313b*, Thirunelli (1300 m) *Manju C.N. 99615* (CALI!)

Lopidium Hooker f. & Wilson,
Fl. Nov. Zel., 2:119, 1854.

Plants robust or moderately robust, light green to yellowish green, with creeping stoloniform shoots; stem without central strand; fronds erect, elongate, more or less regularly pinnate, with simple or slightly pinnate branches; leaves complanate, distinctly dimorphic, lateral leaves spreading, narrow, oblong-lingulate, acute with a distinct apiculus, margin denticulate to entire; costa single, excurrent; cells small, rounded, smooth, incrassate; amphigastria smaller than lateral leaves, ovate with a broad base, margin denticulate, bordered on both sides, uncostate, percurrent to excurrent; autoicous or dioicous, calyptra cucullate, short, naked, not fringed, seta short, variably papillose, capsule suberect.

Lopidium struthiopteris (Brid.) M. Fleisch., Musci Buitenzorg. 3: 1073, 1908. *Hypnum struthiopteris* Brid., Muscol. Recent. Suppl. 2: 87. 1812. *Cyathophorella doii* Sakurai, Bot. Mag. (Tokyo) 46: 376. 1932. *Hypnum javanicum* Dozy & Molk., Bryol. Jav. 2: 8. 1861. *H. penniforme* Thunb. ex Brid., Muscol. Recent. Suppl. 2: 96. 1812. *Hypopterygium bonatii* Thér., Bull. Acad. Int. Géogr. Bot. 19: 23. 1909. *H. campenonii* Renauld & Cardot, Rev. Bot. Bull. Mens. 9: 400. 1891. *H. semimarginatum* Müll. Hal., J. Mus. Godeffroy 3(6): 80. 1874. *Lopidium javanicum* Hampe, Linnaea 38: 672. 1874. *L. pinnatum* Hampe, Linnaea 38: 672. 1874. *H. congoanum* Dixon & Thér., Mélanges Bryol. Lichénol. 75. 1942. *H. daymanianum* Broth. & Geh., Öfvers. Finska Vetensk.-Soc. Förh. 40: 193. 1898. *H. francii* Thér., Bull. Acad. Int. Géogr. Bot. 19: 22. 1909. *H. polythrix* Dixon, Kongel. Norske Vidensk. Selsk. Skr. (Trondheim) 1932(4): 15. 1932.

Plants usually large, robust, pinnately branched, yellowish green or dull green;

primary stem creeping, stoloniferous, up to 5 cm long, branched nearly to base; leaves usually dimorphous, stem leaves widely spreading, slightly arched with deflexed points when dry, ovate-lingulate from a broad, slightly clasping base, acuminate, up to 2 mm long and 0.5 mm wide, widest near base; margin denticulate at apex; bordered all around with 1 or 2 rows of narrow linear cells except at base and extreme tip, leaf base sometimes folded on one side; costa excurrent in an arista, 125 µm long; cells usually rounded or more or less circular in outline, cells at middle 7-12 µm diagonally, thick-walled, collenchymatous, cells at margin long and narrow, 80-100 x 5-6 µm; amphigastria ovate-lanceolate with a wide base, acuminate, 0.8 x 0.4 mm; distinctly bordered by 1-2 rows of linear cells except near the base; costa long-excurrent in an arista; sporophytes not seen (Plate 5.105).

Habitat: Epiphytic, on the exposed roots or upper part of tree trunks of large trees along with *Homaliodendron flabellatum* (Sm.) M. Fleisch.

Discussion: *Lopidium struthiopteris* (Brid.) M. Fleisch. is the widely distributed species in the genus and the plant is easily distinguished by its fan like fronds from other genera of the family. The taxa is very common and widely distributed in the study area at an altitude above 2000 m. This species is characterized by dimorphous leaves, amphigastria with excurrent costa and the cells bordered with 1 or 2 rows of elongated cells except at apex and base. This species was earlier reported from the Nilgiri hills of Tamil Nadu in South India. Hence the present collection is a new record for Kerala.

Distribution: World: Africa, Kenya, Mauritius, Sri Lanka (O'Shea, 2002, 2006), Japan (Noguchi *et al.*, 1991), Malaysia, Sumatra, Java, Philippines, New Guinea, New Caledonia (Mohamed & Robinson, 1991), Philippines (Tan & Iwatsuki, 1991); **India:** Kerala (present collection), Tamil Nadu (Mohamed & Robinson, 1991; Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2200-2250 m) 04.03.2016 *Mufeed 10070*; 12.07.2017 *Mufeed 7322*; 27.09.2018 *Mufeed 9890*; Mannavan Shola (1890 m) 24.09.2018 *Mufeed 9967* (ZGC).



Plate 5. 105: *Lopidium struthiopteris* (Brid.) M. Fleisch., a&b. habit, c. branching pattern, d. ventral view of plant with underleaves, e&f. lateral leaves, g. underleaf, h&i. leaf tip cells, j. leaf marginal cells, k&l. leaf basal cells, m. c.s. of stem

Daltoniaceae Schimp.,
Syn. Musc. Eur. 478. 1860.

Plants mostly small, stem usually with poor differentiation between inner and outer cortex, occasionally with hyalodermis, central strand absent; axillary hairs 3-4 (12)-celled, the basal one small and brown, the apical ones elongate and hyaline; leaves bordered, costa single, strong, rarely single and forked to absent; cells short, mostly firm-walled; seta elongate, often roughened, annulus present or absent, exostome cross-striolate and furrowed or papillose, unbordered and not furrowed, calyptra mitrate, fringed, otherwise mostly naked, unistratose.

Distichophyllum Dozy & Molk.,
Musc. Frond. Ined. Archip. Ind. 99. 1846.

Plants usually small or medium sized with robust growth; stem usually erect or prostrate; leaves weakly dimorphous, complanate, dorsal and ventral leaves not much different, crowded, ovate or oblong ovate or spatulate, usually entire or wavy, with a border of narrow elongated cells: costa single, extending from midleaf to leaf apex; cells at apex isodiametric, smooth, chlorophyllose, more lax, rectangular and elongated at base; calyptra mitriform, fringed at base, seta smooth, capsule erect to pendulous, operculum conic-rostrate, peristome double, spores small.

Key to the species

- 1a. Leaf apex rounded and apiculate; marginal cells at base 3 or 4 rows; costa $2/3^{\text{rd}}$ of the leaves ***D. nigricaule* var. *elmeri***
1b. Leaf apex round to obtuse with a sharp small point; marginal cells at base 2 or 3 rows; costa $3/4^{\text{th}}$ of the leaves ***D. schmidtii***

Distichophyllum nigricaule* var. *elmeri (Broth.) B.C.Tan & H.Rob., Smithsonian Contr. Bot. 75: 22. 1990. *D. elmeri* Broth., Leafl. Philipp. Bot. 2: 656. 1909. *D. sinuosulum* Dixon, J. Siam Soc., Nat. Hist. Suppl. 10(1): 15. 1935; Gangulee, Mosses E. India & Adj. Reg. 2: (6). 1490-1491. 1977. *D. cirratum* Renauld & Cardot, Rev. Bryol., 23:104, 1896.

Plants in lax tufts, medium sized, green or dull green; stem prostrate, laxly foliate, simple; leaves complanate, broadly obovate, 1.2 mm long and 0.5 mm wide, widest

at midleaf or slightly above, base narrowed, apex rounded and apiculate, margin entire, border well differentiated with 1 or 2 rows of linear cells near the apex, 3 or 4 rows of linear cells near the base; costa usually ends at middle or 2/3rd of the leaves; cells quadrate or hexagonal, near base 30-55x11-22 µm, near tip quadrate hexagonal, 11-15 µm, marginal cells elongated and narrow, 70x5-8 µm, cell walls slightly thickened, weakly collenchymatous; sporophytes not seen (Plate 5.106).

Habitat: Lithophytic, collected from wet rocks and small laterite stones near stream.

Discussion: The *D. nigricaula* var. *elmeri* is very rare in the study area. *D. elmeri* Broth., was first reported by Brotherus and Ferdinand (1909) and synonymised under *D. nigricaula* var. *elmeri* by Lin & Tan (1995). Gangulee (1977) reported this species from Nepal as *Distichophyllum sinuosulum* Dixon. The present collection is a new record for India. It is characterised by complanate leaves, cells of margin long and narrow and 1-4 layers. This variety was not reported from India, hence the present collection is a new record for India.

Distribution: World: Borneo, Java, Thailand, Ryukyu Islands, Taiwan, Sumatra, (Mohamed & Robinson, 1991), China (Lin & Tan, 1995), Philippines (Tan & Iwatsuki, 1991), Malaysia (Mohamed & Robinson, 1991), Nepal (Gangulee, 1977); **India:** Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2400 m) 27.09.2018 *Mufeed 9885* (ZGC).

Distichophyllum schmidtii Broth., Bot. Tidsskr. 24: 122. 1901; Bruehl, Rec. Bot. Surv. India 13(1): 80. 1931; Gangulee, Mosses E. India & Adj. Reg. 2(4): 1491, f. 746. 1974; Chopra, Taxon. Indian Moss.: 383. 1975; J. Lal, Checklist Indian Moss. 51: 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 11. 2008; Daniels, Arch. Bryol. 65: 51. 2010; Daniels & Daniel, Bryofl.S.-most W. Ghats, India: 139. 2013; Mishra *et al.*, PL. Sc. Tod. 3(2): 186-194. 2016; Daniels & Kariyappa, Bryofl. Agasth. Bio. Res. W. Ghats: 267. 2019.

Plants medium sized, green, usually seen in shades, lithophytic in the present study area; stem erect or slightly prostrate, up to 3 cm long, simple or branched; leaves shrunk and brittle when dry, broad, oblong-ovate, 1.2 mm long and 0.6 mm wide,

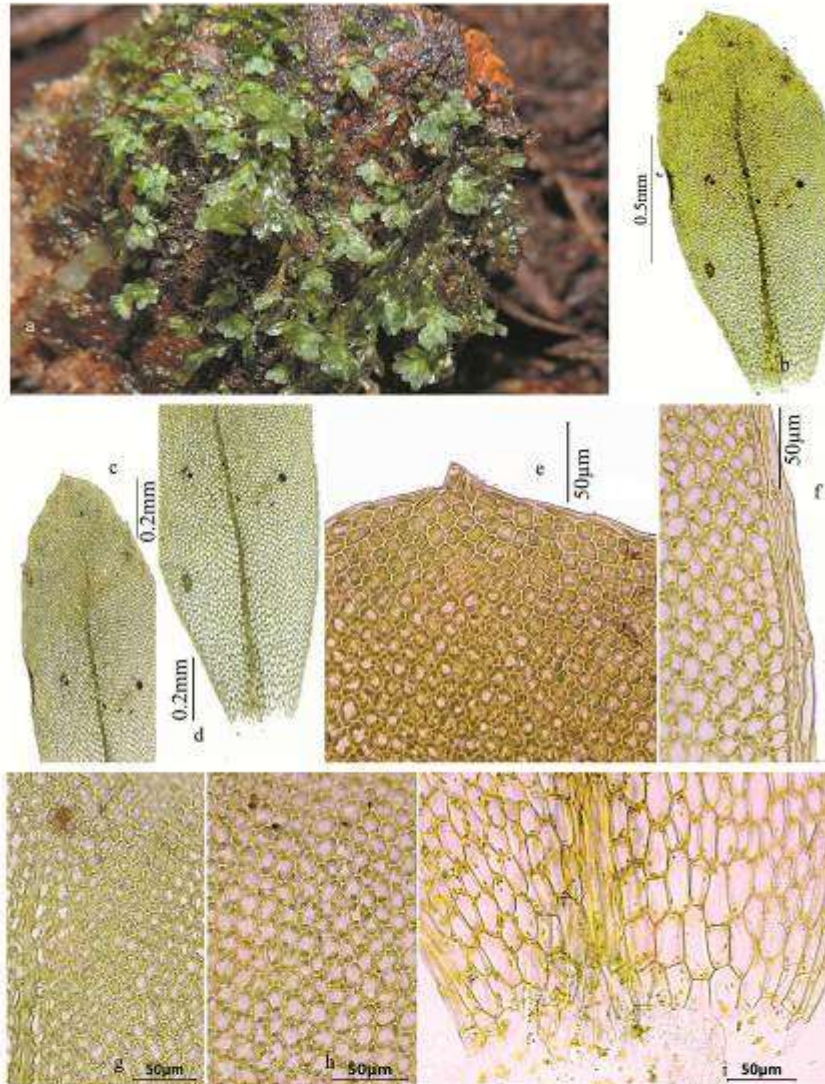


Plate 5. 106: *Distichophyllum nigricaula* var. *elmeri* (Broth.) B.C.Tan & H.Rob., a. habit, b. leaf, c. leaf apex, d. leaf base, e. leaf tip cells, f. leaf margin, g. leaf middle cells, h. cells above base, i. leaf basal cells

widest between middle and apex, round to obtuse with a sharp small pointed apex, 40 µm long, margin entire and plane, leaf border well differentiated, with 1-2 rows of linear cells near the apex, 2-3(-4) rows of linear cells near the base; costa flexuous on top, extending from 3/4th of leaf length, median and upper cells irregularly hexagonal, 20-25x15 µm, thin-walled, homogeneous, marginal cells long and narrow, 60-70 x 4-5 µm, basal cells near costa much larger below, lax, hexagonal to rectangular, 30-45 × 15-20 µm (Plate 5.107).

Habitat: Lithophytic on wet rocks and also on land cuttings near stream, seen along with *Dumortiera hirsuta* (Sw.) Nees. in the shola forest

Discussion: The present collection is recorded from high altitude areas of the study area, above 1800 m altitude. Mohamed & Robinson (1991) collected *D. Schmidtii* from very low altitude areas of Malayan region, they recorded this species from 100 m altitude. It is a widely distributed species in low and high altitude evergreen and shola forests. The species is characterized by the plants with oblong ovate leaves, widest at above middle region and the apex of the leaves are obtuse with a small single cell tip.

Distribution: World: Bangladesh (Banu-Fattah, 2005), Malaya, Singapore, Thailand (Mohamed & Robinson, 1991); **India:** Kerala (Manju *et al.*, 2008; Prajitha *et al.*, 2017), Odisha (Mishra *et al.*, 2016), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019), Western Himalaya (Gangulee, 1974).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1800 m) 14.04.2019 *Mufeed 15614* (ZGC).

Hookeriaceae Schimp.,

Coroll. Bryol. Eur. 101. 1856.

Plants small to robust, complanate, primary stem usually branched and prostrate, secondary stem prostrate to suberect, or pendent; leaves variable in shape; costa double or absent; cells large, hexagonal, smooth or papillose, alar cells not differentiated; monoicous or dioicous; calyptra generally mitriform, smooth, the base usually lobed or fringed-ciliate, seta short or elongate, smooth, papillose or ciliate, capsule inclined or horizontal, occasionally erect, peristome double, cilia lacking, rarely rudimentary.

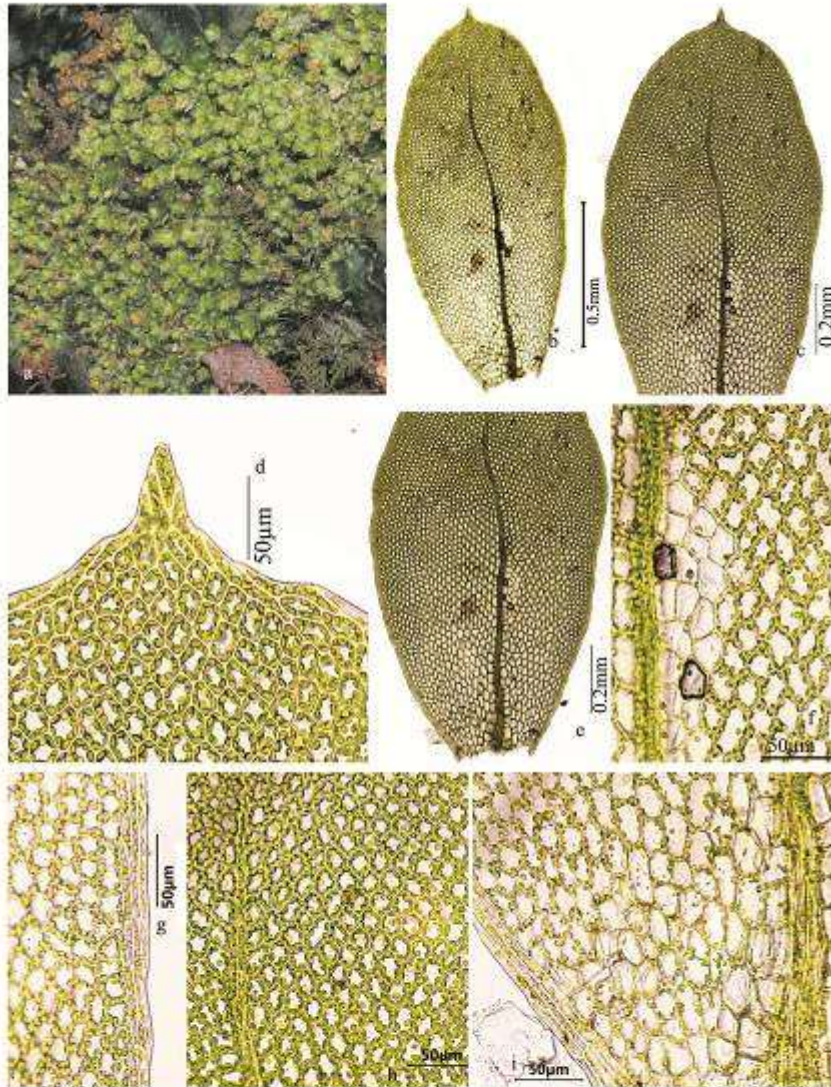


Plate 5. 107: *Distichophyllum schmidtii* Broth., a. habit, b. leaf, c. leaf apex, d. leaf tip cells, e. leaf lower part, f. cells near costa, g. leaf margin, h. middle leaf cells, i. leaf basal cells

***Hookeria* Sm.,**

Trans. Linn. Soc. London 9: 275–282, pl. 23. 1808.

Plants usually glossy, lax tufts; stem usually elongated with few branches, complanate; leaves usually covered and arranged in 5 rows, asymmetric, ovate or oblong ovate, margin flat or slightly wavy or entire, ecostate; cells rhomboid or hexagonal, thin walled; seta lateral, long, capsule pendulous or horizontal, spores small, asexual reproduction by gemmae.

Hookeria acutifolia Hook. & Grev., Edinburgh J. Sci. 2: 225–226, 1825; Tewari *et al.*, Yushania 4: 13–16. 1987; Gangulee, Mosses E. India & Adj. Reg. 2(6): 1493. 1977. *Hookeria grevilleana* Griff., Calcutta J. Nat. Hist. 3: 276. 1843[1842]. *Pterygophyllum acutifolium* (Hook. & Grev.) Müll. Hal., Linnaea 21: 194. 1848. *H. lucens* var. *acuminata* Müll. Hal., Syn. Musc. Frond. 2: 202. 1851. *H. sullivantii* Müll. Hal., Man. Mosses N. America 293. 1884. *P. nipponense* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 362. 1893. *H. megablastum* Müll. Hal., Flora 82: 460. 1896. *H. nipponensis* (Besch.) Broth., Nat. Pflanzenfam. I(3): 934. 1907.

Plant yellowish green or bright green, robust, up to 1.5 - 2 cm long, simple, creeping and tightly adherent to substrate; rhizoids brownish to reddish, dense along ventral surface of stem except apex; stems green, simple; leaves heteromorphic, complanate, widely spreading, curved when dry, ovate to narrowly ovate or acuminate, up to 3.81 mm long and 2 mm wide, widest at base, apex broad, acute, margin entire or flat or curvy, border cells not differentiated, costa absent; leaf cells large, thin walled, cells at apex hexagonal to rhomboidal, 90-115 x 40-45 µm, cells at middle hexagonal to irregularly pentagonal, 130-150 x 30-45 µm, cells at margin long, 220 x 40 µm, cells at base hexagonal to irregularly pentagonal, 230-250 x 58-60 µm; asexual reproduction by a cluster of gemmae on leaf tip, sexual reproductive structure not observed (Plate 5.108).

Habitat: Lithophytic, spread all over the rock filled land cuttings, along with *Lejeunea flava* (Sw.) Nees and *Floribundaria chrysonema* (Müll. Hal.) Broth. in shola forest.

Discussion: *Hookeria acutifolia* Hook. & Grev. was originally described by Hooker

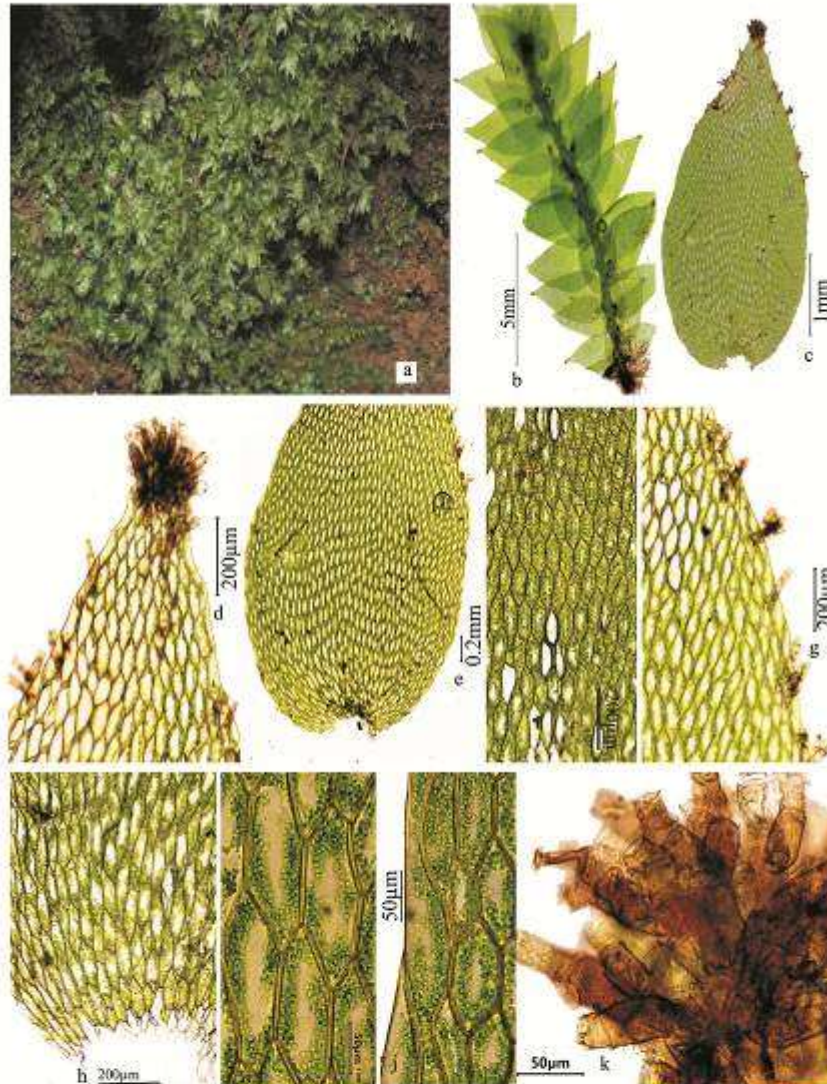


Plate 5. 108: *Hookeria acutifolia* Hook. & Grev., a. habit, b. single plant, c. leaf, d. leaf tip, e. leaf base, f. leaf cells at middle, g. leaf marginal cells, h. leaf basal cells, i&j. enlarged view of cells at base, k. gemmae

and Greville (1825) from Nepal. From South India this species was previously reported from Tamil Nadu, hence the present study is new record for Kerala. *H. acutifolia* is characterized by ecostate leaves with a cluster of gemmae at the tip of the cells, cells are large and thin walled, hexagonal to rhomboidal and undifferentiated leaf border.

Distribution: World: Africa, Hawaii, Turkey, United States, (Uyar & Ören 2013), China, Indonesia, Nepal, Philippines (Lin & Tan 1995), Thailand (Juengprayoon *et al.*, 2016); **India:** Kerala (present collection), Manipur (Govndapyari *et al.*, 2014), Tamil Nadu (Daniels, 2010), Uttarakhand (Bahuguna *et al.*, 2015).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900 m) 14.04.2019 *Mufeed 15617* (ZGC).

Pilotrichaceae Kindb.,
Bot. Centralbl. 77(2): 54. 1899.

Plants small to large, primary stem creeping, secondary stems spreading, ascending, erect and frondose; leaves often complanate, ovate to ovate-lanceolate, leaves often differentiated in symmetry, leaf margins usually bordered or not, dentate to serrate, rarely entire; costa double, parallel, converging or diverging, short, elongate or absent; leaf cells isodiametric to linear, smooth, papillose, alar cells not differentiated; autoicous or dioicous; seta short to elongate, smooth, papillose or spinose, cilia rudimentary or absent, calyptra mitrate or campanulate, smooth or hairy, spores smooth or papillose.

Key to the genera

- 1a. Leaves asymmetric, ovate lanceolate; costa double; margin serrulate above and entire below ***Lepidopilidium***
- 1b. Leaves oblong ovate, dimorphic; costa double; marginal cells elongate and form swollen teeth at apex ***Thamniopsis***

Lepidopilidium (Müll. Hal.) Broth.,
Nat. Pflanzenfam. 1(3): 942. 1907.

Plants usually green, yellow, brown, red or purple, in dense mats, erect, up to 7 cm long, irregularly branched with numerous short branches; rhizoids reddish brown;

leaves simple, weakly or strongly dimorphic, concave or flexuous, erect spreading, asymmetric, ovate lanceolate, straight to falcate, broadly to narrow acuminate, margin serrulate, sometimes entire below; costa double, extending up to midleaf; leaf cells smooth, sometimes porose, hexagonal to rhomboidal, rectangular below, alar cells not differentiated; plants monoicous or dioicous; seta short or elongate, capsule erect or suberect or inclined, reddish brown, spores yellow, spherical and finely papillose.

Lepidopilidium furcatum (Thwaites & Mitt.) Broth., Nat. Pflanzenfam. I(3): 944. 1907; Foreau, Jour. Mad. Univ. 2:238–250. 3: 126. 1931; Daniels & Kariyappa, Nelumbo. 54: 215. 2012. *Lepidopilum furcatum* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 310. 1873. *Lepidopilidium subdevexum* var. *intermedium* P. de la Varde, Rev. Bryol. Lichénol. 11: 183. 1939. *L. attenuatum* Thér., Recueil Publ. Soc. Havraise Études Diverses 96: 117. 1929. *L. theriotii* Naveau, Mélanges Bryol. Lichénol. 74. 1942. *L. hanningtonii* Mitt., J. Linn. Soc., Bot. 22: 309. 1886.

Plants reddish to golden brown, robust, main stem creeping, up to 7 cm long, branches prostrate or ascending, 1-2.5 cm long; leaves in several rows, somewhat complanatus, slightly heterophyllous, spreading oblong-ovate, sharply or gradually acute, 1.5 mm long and 0.4 mm wide; margin involute on one side, sharply dentate in upper half; costa double reaching above the midleaf, divergent; leaf cells thin walled, elongated to rhomboid, 85-95 x 9-12 µm at apex; cells at base gradually decreasing the size, 30-65 x 12-20 µm, marginal cells 100 x 60–80 µm; sporophyte young, erect, seta long, covered with calyptra; mature sporophyte not collected (Plate 5.109).

Habitat: Lithophytic, usually found on rocks near streams in shola forest.

Discussion: *Lepidopilidium furcatum* (Thwaites & Mitt.) Broth. is known only from the state of Tamil Nadu in India and reported by Potier de la Varde, (1925) from Kodaikanal, Foreau (1931) from Upper Palni and from Thirunelveli by Daniels & Kariyappa (2012). It is a very rare species and found only in altitude above 800 m. Ellis *et al.* (2020) reported this species as new record for Kerala based on the present collection.

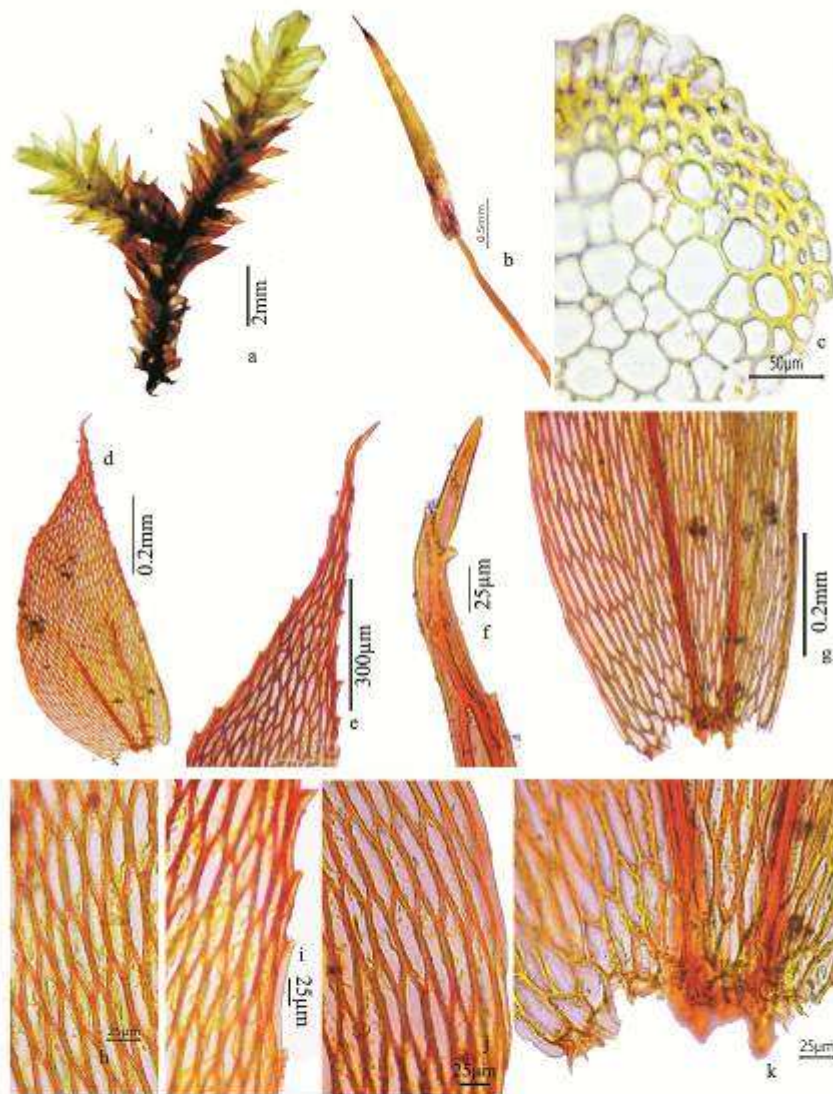


Plate 5.109: *Lepidopilidium furcatum* (Thwaites & Mitt.) Broth., a. habit, b. young plants, c. c.s. of stem, d. leaf, e. leaf apex, f. leaf tip cells, g. leaf base, h. leaf cells, i. apex leaf margin, j. leaf margin base, k. leaf basal cells

Distribution: World: Kenya, Madagascar, Tanzania, South Africa, and Zimbabwe (Atwood, 2015; Ho & Tan, 2009), Sri Lanka (O'Shea, 2002); **India:** Kerala (Ellis *et al.*, 2020), Tamil Nadu (Potier de la Varde, 1925; Foreau, 1930; Daniels & Kariyappa, 2012).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2000–2330 m) 12.07.2017 *Mufeed 7310a*.

Other specimen/s examined: India, Tamil Nadu, Palni Hills (2150 m) *H.C. Gangulee 265* (CAL).

Thamniopsis (Mitt.) M. Fleisch.
Musci Buitenzorg3: 952. 1908.

Plants medium to robust, stem with hyalodermis; leaves oblong-lanceolate to ovate, the lateral leaves often differentiated in symmetry; margins inconspicuously bordered by narrower and elongate marginal cells, serrate above and more often serrulate below, with teeth often swollen and bifid; costa double ending above midleaf, projecting or not; laminal cells hexagonal to long-hexagonal, smooth; autoicous, dioicous or rarely synoicous.

Thamniopsis utacamundiana (Mont.) W.R. Buck, Brittonia 39: 219. 1987. Verma *et al.*, Arch. Bryo. 102: 13. 2011. *Hookeria utacamundiana* Mont., Ann. Sci. Nat., Bot., sér. 2 17: 247. 1842. *Hookeriopsis utacamundiana* (Mont.) Broth., Nat. Pflanzenfam. I(3): 942. 1907; Gangulee, Mosses E. India & Adj. Reg. 2(6): 1513. 1977. *Lepidopilum utacamundianum* (Mont.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 116. 1859. *Hookeria acuminatula* Müll. Hal., Flora 82: 478. 1896. *H. ligulacea* Müll. Hal., Flora 82: 460. 1896. *H. purpurea* Müll. Hal., Flora 82: 459. 1896. *Hookeriopsis purpurea* (Müll. Hal.) Broth. Nat. Pflanzenfam. I(3): 942. 1907. *H. purpurea* var. *acuminatula* (Müll. Hal.) E.B. Bartram, Bernice P. Bishop Mus. Bull. 101: 195. 1933. *H. purpurea* var. *ligulacea* (Müll. Hal.) E.B. Bartram, Bernice P. Bishop Mus. Bull. 101: 195. 1933. *Lepidopilum macropus* Bosch & Sande Lac., Bryol. Jav. 2: 41. 164. 1862.

Plants yellowish green or dull green, main stem creeping, long, secondary branches prostrate or ascending, usually irregularly branched, up to 2-2.5 cm long; leaves arranged in several rows, heterophyllous, leaf apex usually variable, sharply acute or broadly acute, oblong ovate, up to 2 mm long and 0.7 mm wide, more wide at base, margin sharply dentate in upper part of the broad leaves, entire in sharply acute leaves; costa usually double; leaf cells thin walled, cells at apex elongate rhomboid, 50-75 μ m long and 10-13 μ m wide, cells at base rectangular, 45-75 μ m long and 12-20 μ m wide; seta erect, up to ± 2 cm; capsule horizontal, cylindrical, 1.6 mm long and 0.7 mm wide; cross section of stem usually without central strand, middle cells large and thick walled, outer cells usually small (Plate 5.110).

Habitat: Plant usually inhabits in different microhabitats such as tree trunks, logs and on soil in shola forest and grassland.

Discussion: *Thamniopsis utacamundiana* (Mont.) W.R. Buck shows high variation in the shape of leaf and leaf apex, it may be acute, obtuse or mucronate in some, due to this variation many authors described this species under different names all over the world (Vaz-Imbassahy & Costa, 2009). Gangulee (1977) reported this species from Eastern Himalayas as *Hookeriopsis utacamundiana*. Verma *et al.* (2011) reported this species from Tamil Nadu, and Daniels & Brijithlal (2012) reported this species from Kerala.

Distribution: World: Africa, Australia, China, Hawaii, Indonesia, Japan, Sri Lanka, Nepal, Taiwan, Thailand, Philippines, Papua New Guinea, Fiji Island, French Polynesia (Vaz-Imbassahy & Costa, 2009); **India:** Kerala (Daniels & Brijithlal, 2012), Sikkim (Gangulee, 1977), Tamil Nadu (Verma *et al.*, 2011).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900-2000 m) 14.07.2017 *Mufeed* 7387, 7396, 7529; Pullardi Shola (2000-2240 m) 12.07.2017 *Mufeed* 7307; 26.09.2018 *Mufeed* 9990, 9903 (ZGC).

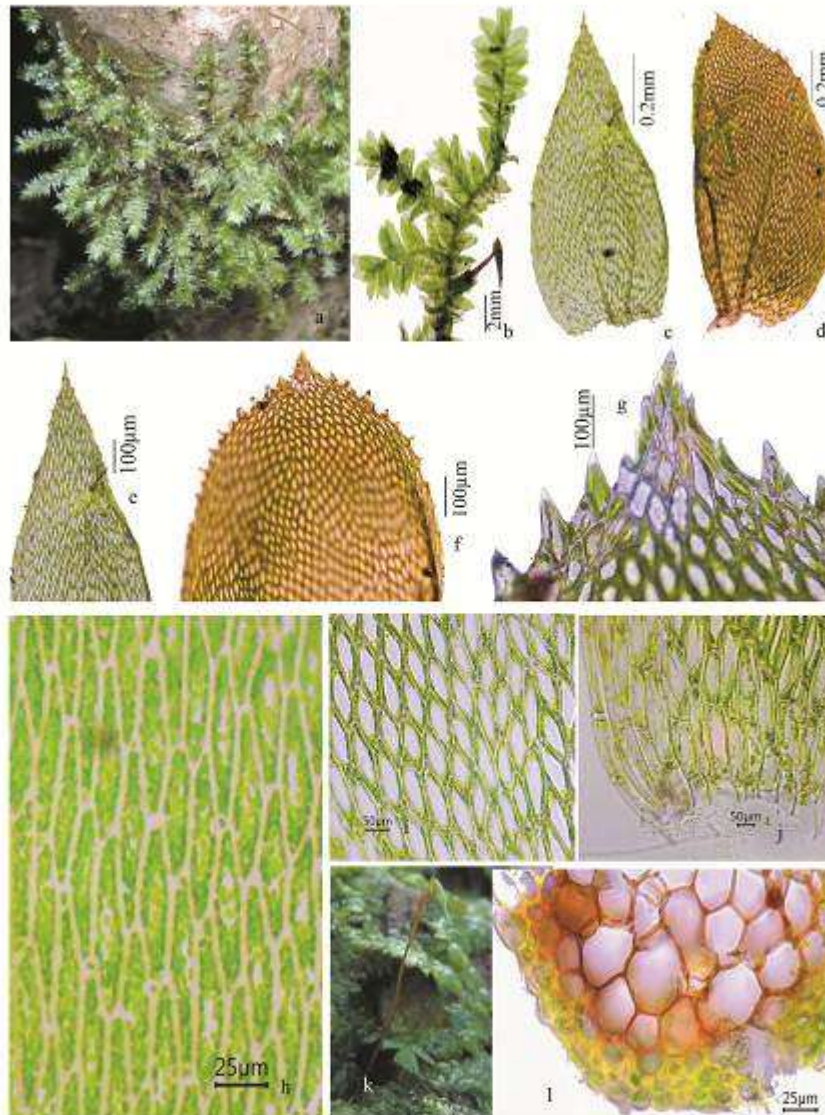


Plate 5. 110: *Thamniopsis utacamundiana* (Mont.) W.R.Buck, a. habit, b. single plant, c&d. leaf, e. leaf apex in young leaf, f. leaf apex, g. leaf tip cells, h&i. leaf middle cells, j. leaf basal cells, k. plant with sporophyte, l. c.s. of stem

Hypnales W. R. Buck & Vitt,

Taxon 35: 33. 1986.

Key to the families

- 1a. Stem usually twice or thrice or more pinnately branched; mostly with paraphyllia
.....2
- 1b. Stem rarely pinnately branched; without paraphyllia 3
- 2a. Leaf basal cells usually with differentiated alar cells**Brachytheciaceae**
- 2b. Leaf basal cells without differentiated alar cells4
- 3a. Endostome rarely hypnoid type5
- 3b. Endostome hypnoid type 6
- 4a. Leaves mostly dimorphic; branching tertiary or more **Thuidiaceae**
- 4b. Leaves slightly differentiated in size on branches and stem; branching usually
secondary 7
- 5a. Stem without central strand 8
- 5b. Stem with central strand, but reduced**Meteoriaceae**
- 6a. Alar cells differentiated into tinted large cells **Sematophyllaceae**
- 6b. Alar cells differentiated in colourless or pale cells ... 9
- 7a. Secondary branches ascending; leaves ovate to ovate lanceolate, not acuminate ..
..... **Regmatodontaceae**
- 7b. Secondary branches prostrate; leaves linear lanceolate from auriculate base,
shortly or longly acuminate **Leskeaceae**
- 8a. Costa single, double or bifurcate in some, rarely absent10
- 8b. Costa absent **Myuriaceae**
- 9a. Leaf apex plane or recurved 11
- 9b. Leaf apex serrate or dentate12
- 10a. Leaves usually arranged in single row or covered.....13
- 10b. Leaves arranged in 2- many rowed **Neckeraceae**
- 11a. Leaves acuminate; cells linear rhomboid to elliptic..... **Hylocomiaceae**
- 11b. Leaves shortly acuminate; cells narrow, linear, quadrate to subquadrate
.....**Plagiotheciaceae**
- 12a. Leaves falcate, ovate or oblong lanceolate, acuminate; costa double, short or
absent **Hypnaceae**
- 12b. Leaves lanceolate to ovate, symmetric or rarely asymmetric; costa single,
reaches up to 1/3- 3/4th or ecostate **Entodontaceae**
- 13a. Leaves ovate, concave, serrulate or dentate at apex; leaf cells linear, papillose;
costa double, short **Symphodontaceae**

- 13b. Leaves ovate acuminate; cells narrow elongate or incrassate; papillae absent; costa single or double or absent 14
- 14a. Branching flagelliform, secondary branches usually erect or rarely pendant **Pterobryaceae**
- 14b. Branching normal, secondary branches mostly hanging or rarely pendant **Cryphaeaceae**

Leskeaceae Schimp.,

Coroll. Bryol. Eur. 109. 1856.

Plants dark greenish to olive green, primary stem creeping, rhizoids few, secondary branches usually suberect or prostrate; leaves linear from auriculate ovate base, decurrent in some, acuminate or rarely long acuminate, usually smooth or rarely plicate, margin dentate or toothed; costa single, moderately strong, ending below apex; cells rhomboid to linear, mostly papillose; sporophyte on lateral branches; seta short or long; capsule ovoid, smooth; spores spherical, small.

Key to the genera

- 1a. Plants slender, pinnately branched; leaves cordate-lanceolate to filiform; costa single, long, ending at tip **Haplocladium**
- 1b. Plants slender to moderately robust, irregularly branched; leaves lanceolate to oblong ovate, shortly acuminate; costa single sometimes forked, ending at the midleaf **Rozea**

***Haplocladium* (Müll. Hal.) Müll. Hal.,**

Nuovo Giorn. Bot. Ital., N. S. 4: 276. 1897.

Plants autoicous, densely caespitose, slender, yellowish to dull green; stem creeping, with a central strand; pinnately branched; leaves cordate-lanceolate to filiform, paraphyllia present; costa single, long; cells ovate hexagonal to rhomboid; usually unipapillate; seta long, capsule mostly inclined, horizontal, peristome teeth hypnoid, operculum conic rostrate, spores small, fine papillose.

Haplocladium microphyllum (Hedw.) Broth., in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 1007.1907; Bruehl, Rec. Bot. Surv. India 13(1): 88. 1931; R.Watan., J. Hattori Bot. Lab. 36: 194.1972; Chopra, Taxon. Indian Moss. 434.1975; Gangulee, Mosses E. India & Adj. Reg. 3(7): 1607. 1978; Vohra, Rec. Bot. Surv. India 23: 83. 1983;

Lal, Checklist Indian Moss. 70. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7:13. 2008 & Arch. Bryol. 42: 8. 2009. *Hypnum microphyllum* Hedw., Sp. Musc. Frond. 269. 1801. *Leskea capillata* Mitt., J. Proc. Linn. Soc., Bot. 1: 130.1859. *Pseudoleskea latifolia* Sande Lac, in Miq., Ann. Mus. Bot. Lugduno-Batavi 2: 297. 1865. *Thuidium longinerve* Lindb., Contr. Fl. Crypt. As. 272. 1872. *Haplocladium microphyllum* subsp. *capillatum* (Mitt.) Reim., Hedwigia 76: 227. 1937. *H. microphyllum* subsp. *eumicrophyllum* Reim., Hedwigia 76: 227. 1937.

Plants forming in dense mats, yellowish green to dark green; stem usually creeping up to 2-3 cm long, pinnately branched; paraphyllia dense, lanceolate to filiform; stem leaves erectopatent, ovate-lanceolate, crenulated at margin, long apiculate, 0.6-0.7 x 0.2 mm; branch leaves erectopatent, concave, lanceolate, toothed at margin, acuminate, 0.6-0.8 x 0.18 mm; cells quadrate hexagonal to rhomboid, usually with single papillae; marginal cells large, pellucid, cells at apex 12-20 x 7-8 µm, cells at middle 8-12 x 6-9 µm, cells at base 15-20 x 4-8 µm, basal juxtacostal cells more elongate with fewer papillae; costa single, ending below apex; dioicous; sporophyte not seen (Plate 5.111).

Habitat: Terricolous, along with *Neckera pennata* Hedw. in shola forest.

Discussion: *Haplocladium microphyllum* (Hedw.) Broth. is a rare species in the study area. It is characterized by its small green plants with ovate-lanceolate leaves, stem leaves long apiculate and the cells are quadrate to hexagonal to rhomboid usually with single papillae.

Distribution: World: Bhutan, Nepal (Gangulee, 1978), China (Redfearn Jr. & Wu, 1986), Hawaii (Hoe, 1973), Jamaica (Welch & Crum, 1959), Mexico (Moya & Soriano, 2011), Vietnam (Ninh, 1993), West Indies (Britton, 1905); **India:** Assam (Gangulee, 1978), Jammu & Kashmir (Kour *et al.*, 2015), Kerala (Manju *et al.*, 2008; Manju & Rajesh, 2012), Sikkim (Gangulee, 1978), Tamil Nadu (Daniels & Kariyappa, 2019), Uttarakhand (Asthana & Sahu, 2013).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (1990 m) 12.07.2017 *Mufeed 7327b* (ZGC).

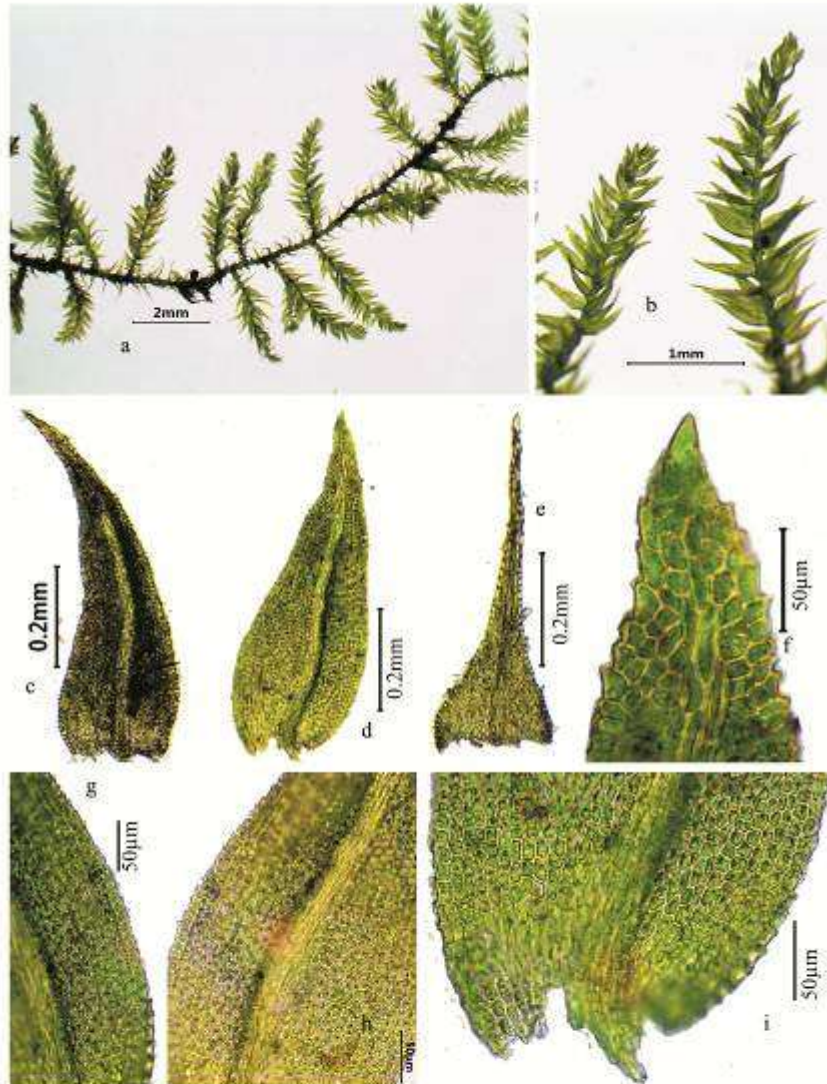


Plate 5. 111: *Haplocladium microphyllum* (Hedw.) Broth. a & b. habit, c & d. branch leaf, e. stem leaf, f. cells at apex, g. marginal cells, h. median cells, i. basal cells

***Rozea* Besch.,**

Mém. Soc. Sci. Nat. Math. Cherbourg 16: 241. 1872.

Plants slender to moderately robust, soft, green, golden, or reddish, shiny; stem creeping, closely and irregularly branched; branches suberect or ascending, julaceous; leaves crowded, imbricate when dry, erect-spreading when moist, concave, biplicate, rarely smooth, lanceolate to oblong-ovate, shortly acuminate; margin revolute, serrulate at the apex; costa single, sometimes forked, ending at the midleaf or somewhat longer; cells linear to linear-rhomboidal, smooth; basal cells quadrate to rectangular, frequently thick-walled, sometimes coloured; dioicous; perichaetial leaves pale, erect, lanceolate to oblong-ovate, subulate-acuminate, ecostate; seta elongate, slender, capsule erect, oblong to cylindric, reddish-brown to golden or dark-yellow, peristome double, endostome yellow, smooth or finely papillose, operculum rostrate, calyptrae cucullate, smooth, naked, spores spherical, finely papillose.

Rozea fulva Müll. Hal. ex M. Fleisch., Hedwigia 61: 405. 1920; Buck & Crum, *Bryologist*, 79: 415. 1976. *Stereophyllum fulvum* (Harv.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 279. 1880; Gangulee, Mosses E. India & Adj. Reg. 3(7): 1816. 1978; Magdum *et al.*, Biosci. Disc. 8(1): 78. 2017; Palani *et al.*, Pl. Sci. Today, 4(1): 53. 2017. *Leskea fulva* Harv., Icon. Pl. 1: pl. 23: f. 3. 1836. *Hypnum fulvum* (Harv.) Müll. Hal., Syn. Musc. Frond. 2: 353. 1851. *Rozea microcarpa* Broth., Symb. Sin. 4: 110. 1929.

Plants green to golden green, main stem creeping with simple branches; leaves laxly imbricate, erectopatent, elliptic lanceolate, concave, up to 1.10-1.30 x 0.3-0.4 mm at middle, apex narrow acute, margin minutely dentate or entire at apex; costa single, reaches up to half of the leaf length; laminal cells rhomboid, 30-35 x 5-6 µm, wide at apex, middle cells elongated, 50-70 x 6-8 µm, alar cells quadrate to irregularly rectangular, 15-20 µm long and 10-15 µm wide; reproductive structures not seen(Plate 5.112).

Habitat: Epiphytic, on tree barks in shola forest

Discussion: *Rozea fulva* Müll. Hal. ex M. Fleisch. from India is known as

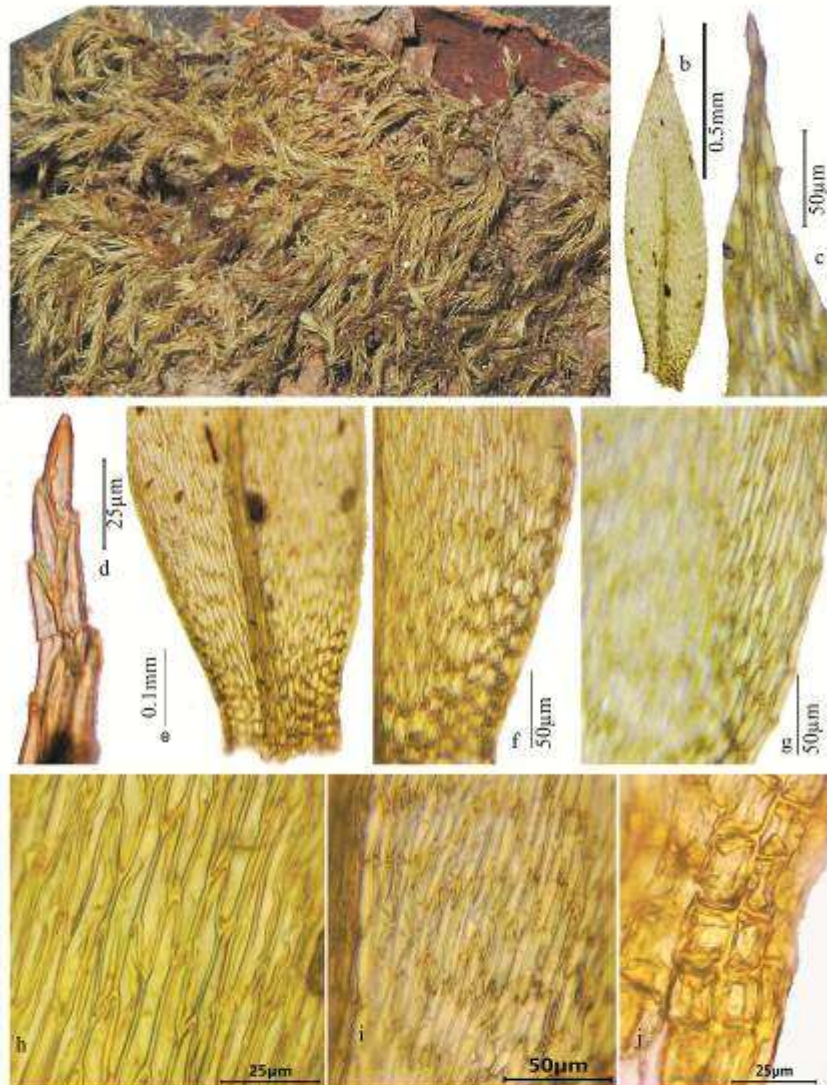


Plate 5. 112: *Rozea fulva* Müll. Hal. ex M. Fleisch., a. habit, b. leaf, c. leaf apex, d. leaf tip cells, e. leaf base, f&g. leaf basal marginal cells, h. leaf cells above base, i. leaf middle cells, j. alar cells

Stereophyllum fulvum (Harv.) A. Jaeger. Buck & Crum (1976) treated this species under *Rozea fulva*. The genus *Rozea* was not yet reported from Peninsular India, hence the genus is a new addition to Peninsular India and the species *R. fulva* is a new record for Kerala. This species is characterized by its golden green plants with creeping main stem, elliptic lanceolate leaves with single costa covering up to the midleaf and the cells are rhomboid except at alar region.

Distribution: World: China, Myanmar (Buck & Crum, 1976), Nepal (Gangulee, 1978); **India:** Himachal Pradesh (Choyal & Sharma S.K., 2011), Kerala (present collection), Maharashtra (Magdum *et al.*, 2017), Sikkim (Gangulee, 1978), Tamil Nadu (Palani *et al.*, 2017).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000 m) 04.03.2016 *Mufeed 10042* (ZGC).

Thuidiaceae Schimp.,

Syn. Musc. Eur. 493.1890.

Plants yellowish green, slender to robust, main stem creeping, branching primary, secondary, tertiary or more; stem leaves and branch leaves distinct, leaves small, distant, usually dimorphic, small scale like and large and chlorophyllose; large leaves usually ovate, broadly acuminate; costa single, strong ending below apex; stem leaves long aristate in some; laminal cells usually papillose or smooth; seta long smooth, capsule horizontal.

Thuidium Schimp.,

Bryol. Eur. 5: 157, (fasc. 49–51. Mon. 1.). 1852.

Plants very slender to robust in cushions; main stem creeping, irregularly divided; secondary stems erect to ascending, regularly pinnate, bipinnate or tripinnate; paraphyllia numerous in various cellular forms; leaves dimorphous, stem leaves differ from branch leaves, stem leaves larger, branch leaves smaller; costa single, leaf cells hexagonal or isodiametric, strongly papillose; autoicous or dioicous; seta long, capsule mostly arcuate, calyptra cucullate, mostly smooth.

Key to the species

1a. Plants yellowish green and brownish when mature; stem leaves long acuminate,

- apex hair pointed; praphyllia usually branched ***T. cymbifolium***
 1b. Plants yellowish green; stem leaves and branch leaves short acuminate;
 paraphyllia non branching and filiform ***T. glaucinum***

Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk., Bryol. Jav. 2: 115. 221. 1865. *Hypnum cymbifolium* Dozy & Molk., Ann. Sci. Nat. Bot., sér. 3, 2: 306. 1844. *Thuidium japonicum* Dozy & Molk. ex Sande Lac., Ann. Mus. Bot. Lugduno-Batavi, 2: 297. pl. 10. 1866. *Hypnum casuarinum* Müll. Hal. Linnaea 38: 569. 1874. *Thuidium angustifrons* Paris. Index Bryol. 1275. 1898. *T. viridiforme* Cardot, Bull. Soc. Bot. Genève 3: 284. 1911. *T. subpycnothallum* Cardot. Bull. Soc. Bot. Genève 3: 284. 1911. *T. dodabettense* M. Fleisch., Hedwigia 69: 94. 1929. *T. plicatum* var. *brevifolium* E.B. Bartram, Bernice P. Bishop Mus. Bull. 101: 205. 1933. *T. cymbifolium* var. *robustum* Dixon Ann. Bryol. 12: 54. 1939. *T. paraviride* Sakurai, Bot. Mag. (Tokyo) 57: 350. 11. 1943.

Plants dioicous, robust, yellowish green, main stem turn to brownish when mature; plants in dense mats, primary stem creeping, up to 15 cm long, irregularly divided, branches regularly pinnate; paraphyllia present, usually branched; stem leaves erect, concave, ovate, shortly acuminate, up to 2 cm long; branch leaves dense, erectopate, strongly appressed to stem and imbricate when dry, concave, ovate-lanceolate, apex acute, up to 0.5 mm long, much smaller in younger branches, margin crenulated; paraphyllia usually branched; perichaetial leaves long acuminate; costa ending below apex; stem leaf cells quadrate hexagonal to rhomboid, 8 - 11µm long and 8-9µm wide, median ones 15– 18µm long and 15-17µm wide, basal cells 20-25µm long and 10-15µm wide, smooth, irregularly crenulate; costa excurrent in stem leaves, ending below apex in branch leaves; sporophyte not observed (Plate 5.113).

Habitat: Epiphytic, on roots of higher plants and on decayed woods in shola forest.

Discussion: A widely distributed species in mountains. Daniels & Kariyappa (2019) and Manju *et al.* (2009) recorded this species from Agasthyamalai Biosphere reserve of Kerala. This species is characterized by yellowish green plants with tertiary branches, leaf shape varies in stem and branches, cells usually papillate and presence

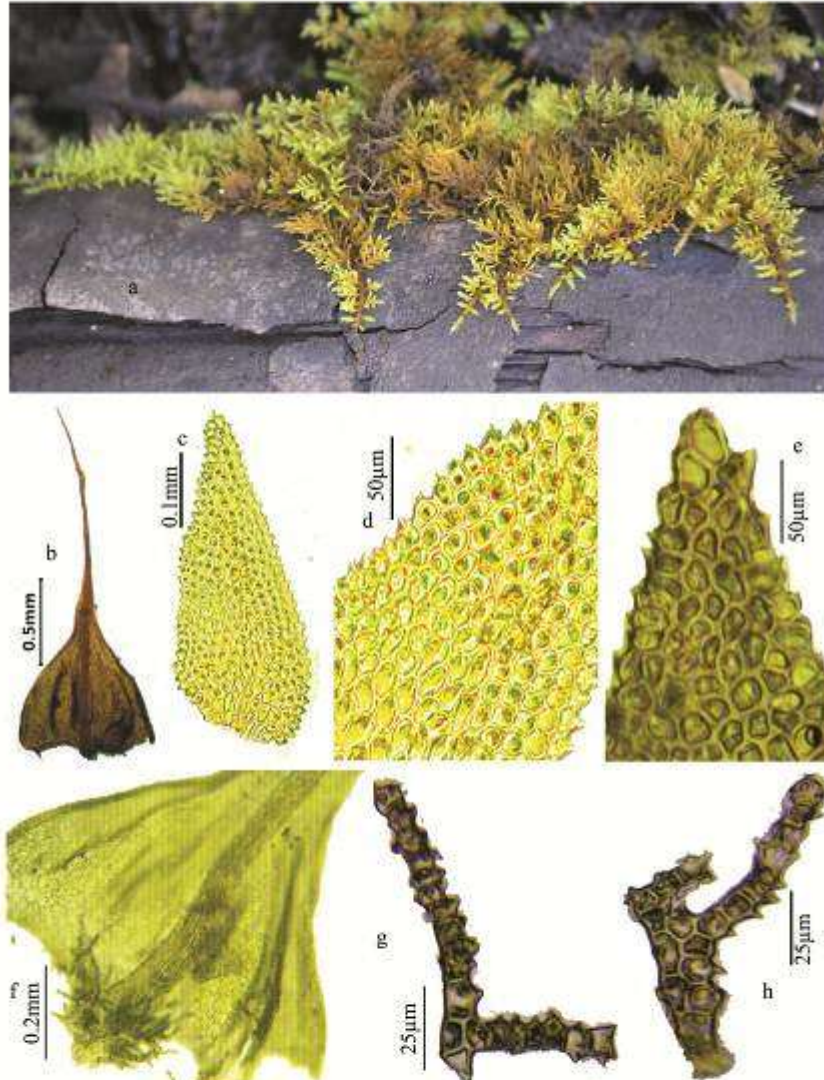


Plate 5. 113: *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk. a. habit, b. stem leaf, c. branch leaf, d. median cells, e. apical cells, f. leaf base with paraphyllia, g&h. branched paraphyllia

of branched paraphyllia.

Distribution: World: Australasia, Borneo, Bhutan, China, Fiji, Hawaiian Islands, Japan, Laos, Malaysia, Myanmar, Nepal, Ryukyu, Samoa, Sri Lanka, Thailand, Taiwan, Vietnam (Touw, 2001); **India:** Arunachal Pradesh, Assam, Manipur, Nagaland, Sikkim (Gangulee, 1978), Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh (Touw, 2001), Karnataka (Schwarz, 2013), Kerala (Manju *et al.*, 2009; Daniels & Kariyappa, 2019), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1772-2000 m) 02.08.2015 *Mufeed* 13318, 13325 (ZGC).

Other specimens examined: India, Kerala, Thiruvananthapuram district, Agasthamalai Biosphere Reserve, Ponkalappara (1250m) *Srinivas V.K.* 106612 (CALI!).

Thuidium glaucinum (Mitt.) Bosch & Sande Lac., *Bryol. Jav.* 2: 117. 222. 1865; Gangulee, Mosses E. India & Adj. Reg. 8: 1642. 1980. *Leskea glaucina* Mitt. J. Proc. Linn. Soc., Bot., Suppl. 1(2): 133. 1859. *Thuidium samoanum* Mitt. J. Linn. Soc., Bot. 10: 186. 1868. *Hypnum glaucinum* (Mitt.) Müll. Hal. *Linnaea* 36: 7. 1869. *Thuidium stevensii* Renauld & Cardot Bull. Soc. Roy. Bot. Belgique 38(1): 33. 1899. *Thuidium glaucinoides* Broth. Philipp. J. Sci. 3: 26. 1908. *T. cochlearifolium* Reimers & Sakurai Bot. Jahrb. Syst. 64: 549. 21 f. 5. 1931. *T. laticuspis* Sakurai Bot. Mag. Tokyo 60: 87. 1947.

Plant forming in large mats, yellowish green, main stem prostrate or ascending, up to 8 cm long, regularly bipinnate; stem leaves erect, concave, ovate, shortly acuminate or obtuse, 0.7 x 0.4 mm; branch leaves concave, ovate-lanceolate, acute, 0.4 x 0.2 mm, much smaller in younger branches; margin crenulate due to projecting papillae; paraphyllia filiform, non branching, up to 0.1 mm long, rare; costa ending below the tip or 3/4th of the leaves, in some leaves bifurcated costa may present; paraphyllia non branching and filiform; leaf cells quadrate-rhomboid, incrassate, usually with single papillae, 5-20 µm at middle and 11-20 µm at extreme base (Plate 5.114).

Habitat: Epiphytic on barks and logs.

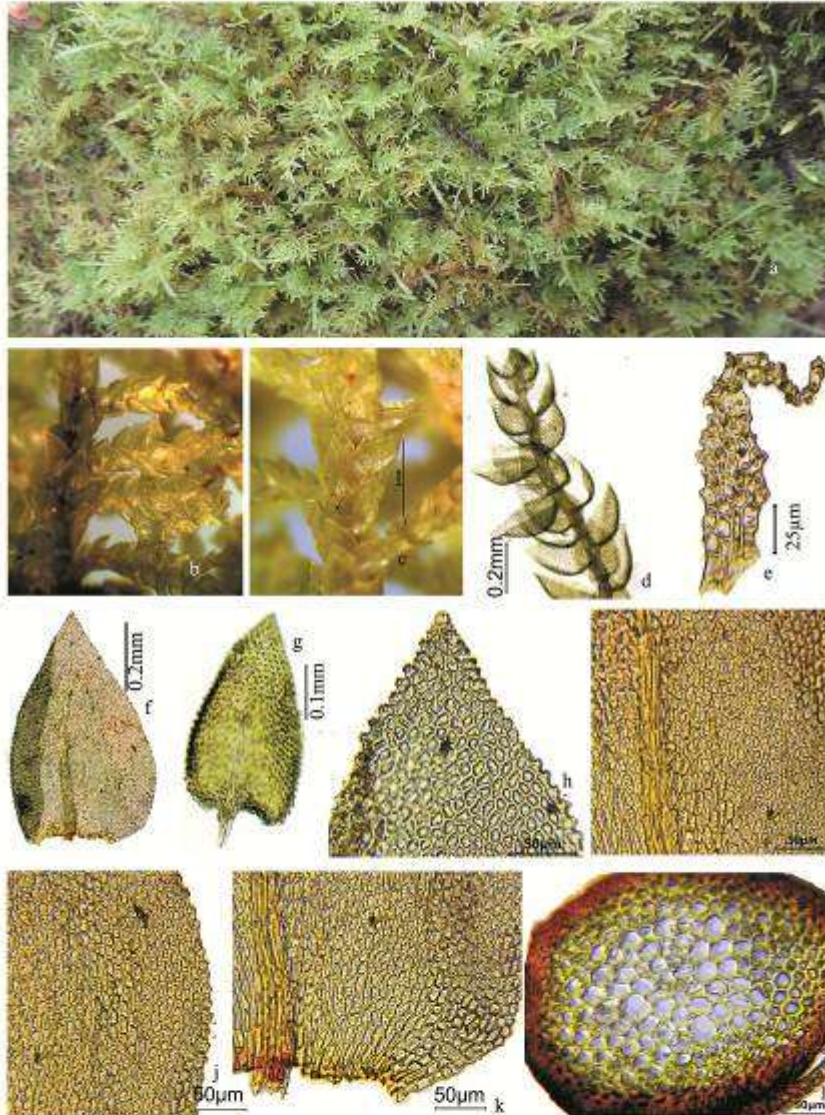


Plate 5. 114: *Thuidium glaucinum* (Mitt.) Bosch & Sande lac, a. habit, b. branch leaves, c. stem leaves, d. secondary branch, e. paraphyllia, f. stem leaf, g. branch leaf, h. leaf tip, i. leaf middle cells, j. leaf marginal cells, k. leaf basal cells, l. c.s. of stem

Discussion: This species is characterized by yellowish green plants with multiple branches and usually with non branching filiform paraphyllia. The present collection is a new record for Kerala.

Distribution: World: Borneo, China, Java, Laos, Luzon, Malay Peninsula, Moluccas, Myanmar, Sri Lanka, Sumatra, Taiwan, Thailand, Vietnam (Touw, 2001); **India:** Arunachal Pradesh, Sikkim, West Bengal (Gangulee, 1978), Karnataka (Schwarz, 2013), Kerala (present collection), Tamil Nadu (Alam *et al.*, 2011).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900 m) 14.07.2017 *Mufeed 7395* (ZGC).

Regmatodontaceae Broth.,
Nat. Pflanzenfam. I(3): 1125. 1908.

Plants dull, slender to robust growth in shade, lustreless, corticolous, growing in lax or thick mats; stems creeping, closely branched; paraphyllia barely thin; packed leaves with a crowded appearance, ovate to ovate lanceolate; costa usually ending below the apex, rarely short and double; leaf cells small, papillose, incrassate and sometimes elongate; seta smooth and long; capsule usually nodding or horizontal; peristome double; operculum rostrate; calyptra cucullate.

Regmatodon Brid.,
Bryol. Univ. 2: 204. 1827.

Plants slender to robust, closely branched; leaves dense, imbricate, erectopatent, concave, ovate to oblong ovate, short apiculate apex, margin entire or faintly dentate; costa single, incomplete; laminal cells incrassate; capsule erect or inclined; peristome double, exostome short and endostome long, inserted much below capsule mouth.

Regmatodon orthostegius Mont., Ann. Sci. Nat., Bot. sér. 2, 17: 248. 1842; Foreau, J. Madras Univ. 3: 122. 1930 & J. Bombay Nat. Hist. Soc. 58: 37. 1961; Bruehl, Rec. Bot. Surv. India 13(1): 86. 1931; Chopra, Taxon. Indian Moss.: 413. 1975; Gangulee, Mosses E. India & Adj. Reg. 3(7): 1563, f. 783. 1978; Vohra, Rec. Bot. Surv. India 23: 56. 1983; S.S. Kumar & Maniselvan, Res. Bull. Panjab Univ., New Ser., Sci. 44: 101. 1994; D.A. Eakin & B. Allen, Nova Hedwigia 69: 311. 1999; S.

Kumar & D.K. Singh, Bull. Bot. Surv. India 44: 132. 2002; Lal, Checklist Indian Moss.: 116. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 17. 2008; Daniels, Arch. Bryol. 65: 82. 2010; Daniels *et al.*, Bryofl. Indira Gandhi Natl. Pk.: 269. 2018. *Anhymenium polycarpon* Griff., Calcutta J. Nat. Hist. 3: 275. 1843. *A. polysetum* Griff., Not. Pl. Asiat. 2: 472. 1849. *Regmatodon polycarpus* (Griff.) Mitt., J. Proc. Linn. Soc., Bot. 1 (Suppl.): 127. 1859; D.A. Eakin, Nova Hedwigia 67: 144. 1998. *R. polysetus* (Griff.) Thér., Bull. Soc. Bot. Genève Sér. 2, 26: 88. 1936.

Plants caespitose, glossy, yellow-green, brownish when dry; main stems creeping, 2–3 cm long; branches pinnate, closely branched; leaves imbricate erectopatent, irregularly inrolled at margin; leaves 1–1.2 mm long and 0.4–0.5 mm wide, ovate, concave, smooth at apical margin, apiculate; cells irregularly elliptic-rectangular, smooth; apical cells 14–22 µm long and 8–10 µm wide; median ones 16–22 µm long and 5–10 µm wide; basal ones 16–26 µm long and 8–12 µm wide, sub-rectangular to quadrate; extreme basal ones, 12–24 µm long and 10–16 µm wide, more rectangular; costa single, more than half as long as leaf; seta long, blackish brown; capsule erect, cylindrical, 2 mm long and 0.6 mm wide, short exostome and long endostome (Plate 5.115).

Habitat: On bark of trees in shola forest.

Discussion: Gangulee (1978) reported two species from Eastern Himalayas *R. orthostegius* Mont. and *R. declinatus* (Hook.) Brid. The gametophytic characters are very similar and difficult to differentiate. The present collection shows more affinity to *R. orthostegius*. This species is characterized by yellowish green plants with closely branched nature, leaves ovate and concave with incrassate rhomboidal cells, sporophyte with short exostome and long endostome.

Distribution: World: Africa (Marline *et al.*, 2012), China (Redfearn Jr., 1990), Mexico (Moya & Soriano, 2011), Nepal (Gangulee, 1978), North & South America (Eakin, 1998), Sri Lanka (O'Shea, 2002); **India:** Kerala (present collection), Sikkim, Meghalaya, West Bengal (Gangulee, 1978), Tamil Nadu (Daniels *et al.*, 2018).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1900m) 14.07.2017 *Mufeed* 7562; Jandamala (2060m) 09.11.2017

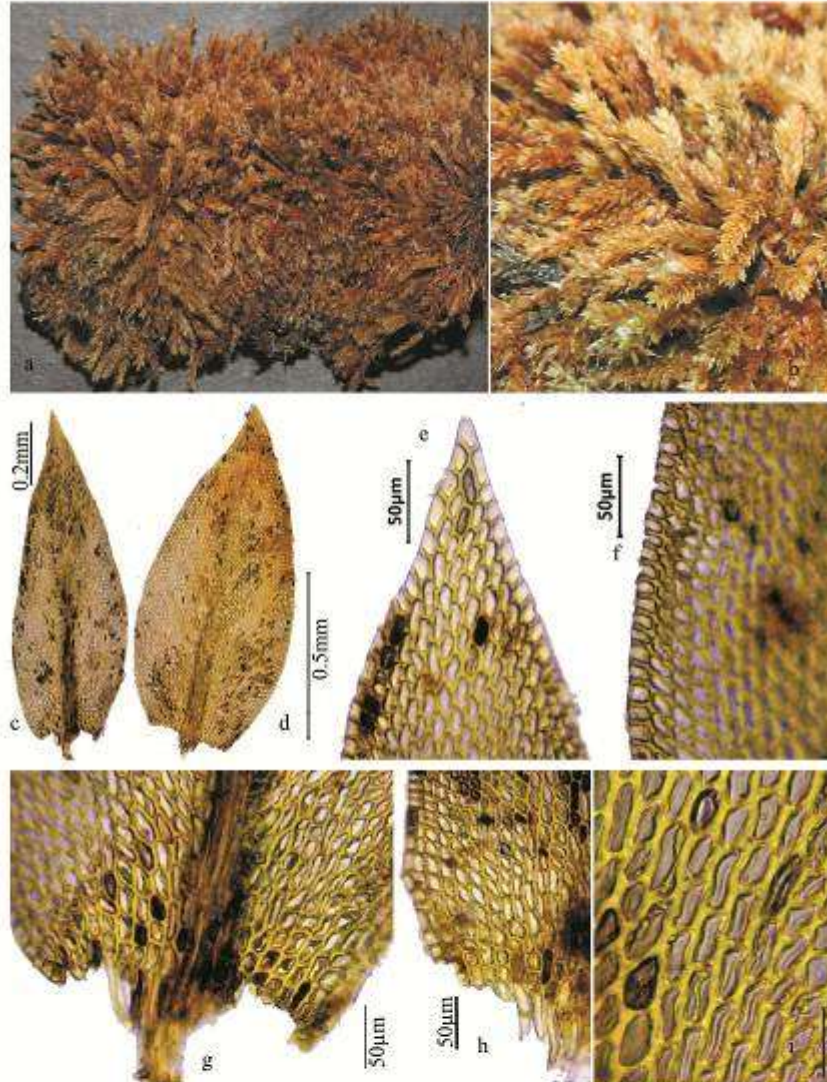


Plate 5. 115: *Regmatodon orthostegius* Mont., a&b. habit, c&d. leaves, e. leaf tip cells, f. leaf marginal cells, g&h. leaf basal cells, i. leaf laminal cells

Mufeed 7449 (ZGC).

Brachytheciaceae Schimp.,
Syn. Musc. Eur. (ed. 2) 637. 1876.

Plants yellowish green to darkish green, generally glossy, slender, branched; leaves costate, often plicate, sometimes strongly concave, paraphyllia may present in some; leaf base usually with differentiated alar cells; median cells smooth or with projecting ends; seta long, capsule long and usually ovate cylindrical; operculum conical, long rostrate.

Key to the genera

- 1a. Leaves mostly plicate 2
- 1b. Leaves not plicate ***Rhyncostegiella***
- 2a. Alar cells strongly differentiated as quadrangular cells ***Brachythecium***
- 2b. Alar cells not strongly differentiated, slightly inflated ***Eurhynchium***

Brachythecium Schimp.,
Bryol. Eur. 6: 5 (fasc. 52–56. Mon. 1.). 1853.

Plants long, slender, prostrate, branched; leaves imbricate, straight, ovate - acuminate, often plicate; costa single, covering more than ½ of leaf length; laminal cells rhomboid, alar distinct with quadrate or rectangular cells; monoicous or dioicous; seta rough or smooth, capsule inclined or horizontal, peristome normal hypnoid.

Key to the species

- 1a. Plants ovate to oblong ovate, base slightly auriculate ***B. buchananii***
- 1b. Plants ovate lanceolate, base not auriculate 2
- 2a. Costa reaches 2/3 of the leaf; leaf apex acuminate, margin denticulate at upper part ***B. formosanum***
- 2b. Costa reaches 1/2 of the leaf; Leaf apex long, narrow, margin dentate at extreme tip ***B. garovaglioides***

Brachythecium buchananii (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 341. 1878; Gangulee, Mosses E. India & Adj. Reg. (7)3: 1711. 1978; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 180. 2005; Daniels, Arch.

Bryol. 65: 39. 2010. *Hypnum buchananii* Hook., Trans. Linn. Soc. London 9: 320. 28 f. 3. 1808. *H. cuspidiferum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 78. 1859. *Brachythecium amnicola* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 3: 125. 1896. *B. thraustum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 270. 1897. *B. viridefactum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 270. 1897. *B. fasciculirameum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 269. 1897. *B. planiusculum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 268. 1897. *B. perminusculum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 200. 1898. *Rhynchostegium microrusciforme* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 202. 1898. *Brachythecium pilicuspis* Müll. Hal., Index Bryol. Suppl. 97. 1900. *B. buchananii* var. *japonicum* Cardot, Bull. Soc. Bot. Genève 3: 289. 1911. *B. abakanense* Kaal., Kongel. Norske Vidensk. Selsk. Skr. (Trondheim) 1918(2): 8. 1. 2d. 1919. *B. buchananii* var. *gracile* Broth. Bot. Mag. (Tokyo) 35: 69. 1921. *Platyhypnidium microrusciforme* (Müll. Hal.) M. Fleisch., Musci Buitenzorg 4: 1537. 1923. *Brachythecium yunnanense* Herzog, Hedwigia 65: 167. 1925. *B. siamense* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 36. 1932. *B. carinatum* Dixon, Rev. Bryol. Lichénol. 7: 114. 1934. *B. tenuipilum* Dixon, Sci. Rep. Natl. Tsing Hua Univ., Ser. B, Biol. Sci. 2: 130. 1936.

Plants slender, yellowish green, somewhat glossy in dense mats, more than 15 cm long; main stem creeping irregularly pinnately branched; leaves dense, erectopatent, concave, plicate, ovate to oblong lanceolate, apex acute to acuminate, $\pm$ 2.6 mm long and 1 mm wide, base slightly decussate and auriculate, margin denticulate in the upper half; costa single, covering about half the lamina length; leaf cells elongate, linear, rhomboid, apical cells somewhat long, 67 μ m long and 8 μ m wide; laminal cells 75 μ m long and 6 μ m wide, basal cells lax, wider at alar region, alar cells rectangular and inflated, 14 μ m long and 8 μ m wide; reproductive structures not seen (Plate 5.116).

Habitat: Epiphytic, usually on branches of shrubs in evergreen forest.

Discussion: *Brachythecium buchananii* (Hook.) A. Jaeger is a widely distributed species in low to high altitude evergreen and shola forests. It is characterised by its yellowish green glossy plants in dense mats, stem irregularly branched, leaves oblong-lanceolate margin denticulate at apical margin and basal cells differentiated

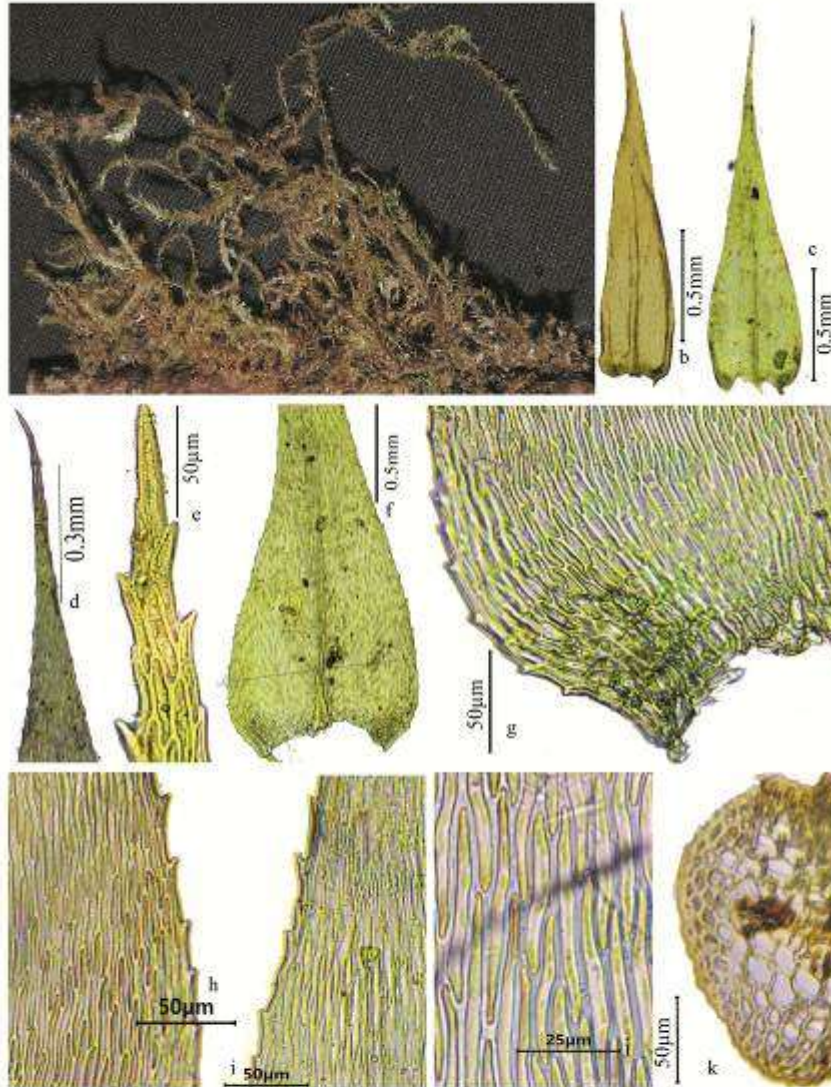


Plate 5. 116: *Brachythecium buechanani* (Hook.) A. Jaeger, a. habit, b&c. leaf, d. leaf tip, e. leaf tip cells, f. leaf base, g. leaf basal cells, h. leaf margin at base, i. leaf margin near apex, j. leaf middle cells, k. c.s. of stem

as quadrate rectangular alar cells.

Distribution: World: Bhutan, Nepal (Gangulee, 1978), China (Ignatov *et al.*, 1996), Japan (Iwatsuki, 1991) Laos, Korea, Philippines (Tan & Iwatsuki, 1991), Thailand, Vietnam, (Ignatov & Koponen, 1996); **India:** Arunachal Pradesh (Vohra & Kar 1996), Assam, Manipur, Uttarakhand, West Bengal (Gangulee 1976; Vohra, 1983), Karnataka (Brotherus 1899; Frahm *et al.*, 2013; Townsend 1988), Kerala (Nair *et al.*, 2005), Tamil Nadu (Daniels, 2010; Müller 1854).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600 m) 14.07.2017 *Mufeed* 7520 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Thirunelli RF (870-880m) *Manju C.N. 84608*, *Manju C.N. 84611* (CALI!).

Brachythecium formosanum Takaki, J. Hattori Bot. Lab. 15: 2. 8. 1955; Gangulee, Mosses E. India & Adj. Reg. (7)3: 1703. 1978.

Plants yellowish green, brownish below, medium sized and shiny; primary stem creeping with erect or ascending branches up to 10 cm long; leaves lax, larger, concave, plicate, ovate lanceolate, 1.8 mm long and 0.5 mm wide, apex acuminate, margin dentate in upper margin of leaf; costa covers middle to 2/3 of leaf length; laminal cells not incrassate, narrow elongate to linear at apex, $45-65 \times 5 \mu\text{m}$, median cells elongate-narrow, $80-90 \times 4 \mu\text{m}$, basal alar cells differentiated by quadrate rectangular cells, $20-35 \times 12-16 \mu\text{m}$; reproductive structures not seen (Plate 5.117).

Habitat: Epiphytic, hanging on branches in shola forest.

Discussion: *Brachythecium formosanum* Takaki is a rare species reported from very few areas. Takaki (1955) reported this species from Japan. Gangulee (1978) from Nepal. From India, this species was first reported by Vohra & Kar (1996) from Arunachal Pradesh. It was not recorded from Peninsular India yet. Hence the present collection is a new record for Peninsular India. It is characterized by yellowish green plants with a brownish base, leaves ovate-lanceolate with slightly dentate upper margin, costa usually covers $2/3^{\text{rd}}$ of the leaf and the laminal cells are narrow elongate except at alar region.

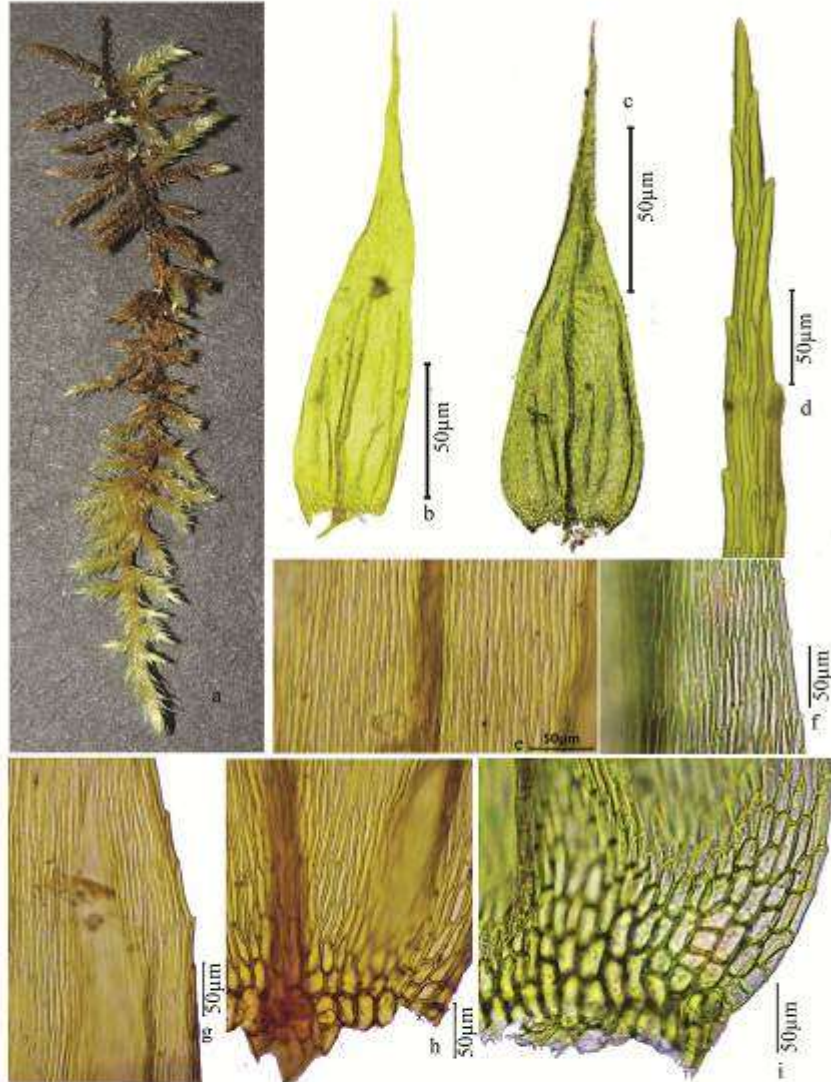


Plate 5. 117: *Brachythecium formosanum* Takaki, a. habit, b. branch leaf, c. stem leaf, d. leaf tip cells, e. leaf middle cells, f&g. leaf marginal cells, h&i. leaf basal cells

Distribution: World: Japan (Takaki, 1955), Nepal, Taiwan (Gangulee, 1978); **India:** Arunachal Pradesh (Vohra & Kar, 1996), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1850 m) 14.07.2017 *Mufeed* 7552 (ZGC).

Brachythecium garovaglioides Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 4: 270. 1897. *B. wichurae* (Broth.) Par., Index Bryol. Suppl. 52. 1990; Gangulee, Mosses E. India & Adj. Reg. 3(7): 1707. 1978. *Hypnum wichurae* Broth., Hedwigia, 38: 239. 1900. *Brachythecium kiushianum* Sak. In. Mag. Tok., 46: 381. 1932.

Plants more or less robust, pale green, not glossy, forming dense tufts; main stem creeping, with irregularly pinnately branched, erect or ascending, small branches; leaves terete but not imbricate, rather spreading to squarrose; ovate-lanceolate with long narrow acuminate tip, concave, plicate, dentate at tip, 2 mm long and 0.8 mm wide; costa single, covering more than half of leaf length; laminal cells narrow linear with pointed tips, not incrassate, cells at apex long, 60-70 µm long and 6 µm wide, cells at middle shorter and wider; basal cells are lax, rectangular, 25-30 µm long and 10 µm wide; alar cells clearly differentiated, 25-40 µm long and 10-15 µm wide; reproductive structures not seen (Plate 5.118).

Habitat: Epiphytic, on branches in shola trees.

Discussion: *Brachythecium garovaglioides* Müll. Hal., is a rare species. Gangulee (1978) reported this species as *B. wichurae* (Broth.) Par. from East Nepal. Wang *et al.* (2000) synonymised this species under *B. garovaglioides*. In India, Vohra (1996) reported this species as a new record for India from Arunachal Pradesh and not yet reported from Peninsular India. Hence the present collection is a new record for Peninsular India.

Distribution: World: China (Ignatov & Koponen, 1996), Japan (Noguchi, 1991), Nepal (Gangulee, 1978), Russia (Ignatov, 1992); **India:** Arunachal Pradesh (Vohra & Kar, 1996), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2050 m) 12.07.2017 *Mufeed* 7338 (ZGC).

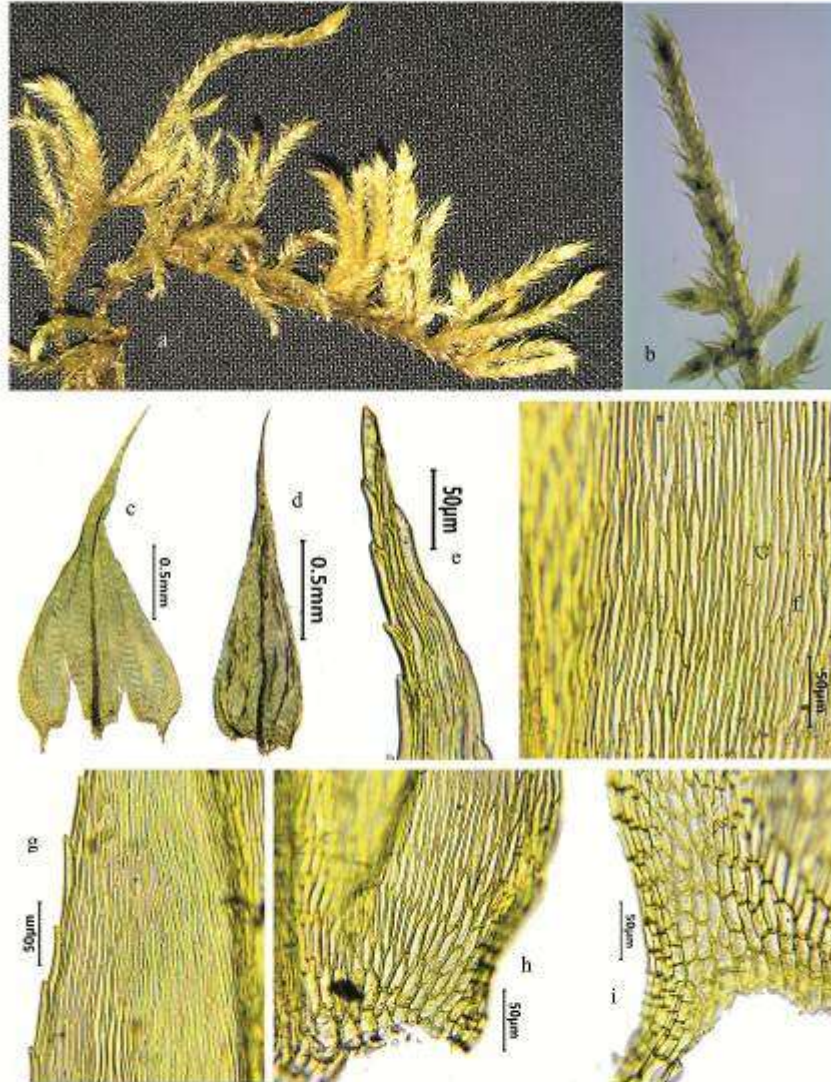


Plate 5. 118: *Brachythecium garovaglioides* Müll. Hal., a&b. habit, c. stem leaf, d. branch leaf, e. leaf tip cells, f. median cells, g. marginal cells, h&i. basal cells

***Eurhynchium* Schimp.,**

Bryol. Eur. 5: 217 (fasc. 57–61. Monogr. 1). 1854.

Plants usually forming tufts or mats, dark to yellowish green; stem with a central strand, often indistinct; leaves either heterophyllous or not, sometimes slightly plicate, broadly triangular or orbicular, with the apex acute in stem leaves, obtuse in branch leaves, costa reach from $\frac{1}{2}$ to more than $\frac{3}{4}$ th of the leaf length; median cells about 5 times as long as wide or longer; leaf bases decurrent, alar cells not strongly differentiated, small and quadrate or slightly inflated; plants dioicous; seta smooth or rough, capsule inclined or horizontal, with along rostrate operculum, endostome with well developed cilia.

Eurhynchium hians (Hedw.) Sande Lac., Ann. Mus. Bot. Lugduno-Batavi 2: 299. 1866; Gangulee, Mosses E. India & Adj. Reg. 3(7): 1738. 1978; Sandhyarani *et al.*, Jour. Ind. Bot. Soc. 90: 76. 2011; Manju *et al.*, Act. Bio. Plant. Agri. 90. 2014; Bahuguna *et al*, Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. 86(4): 941. 2016. *Hypnum hians* Hedw. Sp. Musc. Frond. 272–273, pl. 70, f. 11–14. 1801. *H. swartzii* Turner, Muscol. Hibern. Spic. 151, pl. 14, f. 1. 1804. *H. praemorsum* Thunb. Pl. Cap. Sp. Nov. 29. 1824. *H. cordatum* Harv., Icon. Pl. 1: pl. 24, f. 7. 1836. *H. praelongum* var. *swartzii* (Turner) Hartm., Handb. Skand. Fl. (ed. 3) 2: 305. 1838. *Eurhynchium swartzii* (Turner) Curn., Bryoth. Eur. 12: 593. 1862; Manju *et al.*, *Acta Biologica Plantarum Agriensis* 3: 90. 2014. *Hypnum distans* Lindb., Musci Scand. 34. 1879. *Eurhynchium praelongum* subsp. *swartzii* (Turner) Kindb., Eur. N. Amer. Bryin. 1: 96. 1897. *E. orotavense* Renaud & Cardot, Bull. Herb. Boissier, sér. 2, 2: 439. 7 f. 1–8. 1902. *E. praelongum* var. *laxirete* Renaud & Cardot, Bull. Herb. Boissier, sér. 2, 2: 439. 1902. *Oxyrrhynchium swartzii* (Turner) Warnst., Krypt.-Fl. Brandenburg, Laubm., 784. 792 f. 4. 1905. *Eurhynchium rappii* (R.S. Williams) Grout, Moss Fl. N. Amer. 2: 17. 1928. *Oxyrrhynchium rappii* R.S. Williams, Bryologist 30: 102 8. 1928.

Plants yellowish green, up to several centimetres long; usually seen in thin mats; main stem creeping, branches erect, pinnately arranged; leaves lax, concave, acuminate, up to 1.15 x 0.47 mm; branch leaves ovate, acute at tip, not plicate, margin denticulate from tip to base; costa covering $\frac{2}{3}$ rd of the leaf length; leaf cells

elongate-rhomboid, 62-75 x 6 µm, cells varies in size from top to bottom, basal cells broader than other regions; extreme basal cells rectangular; 17-30 x 10 µm; reproductive structures not observed (Plate 5.119).

Habitat: Epiphytic on branches in all altitudinal ranges of shola forest and grassland.

Discussion: It is a widely distributed and very common species in the study area. Manju *et al.* (2014) reported this taxa previously from Palakkad district as *E. swartzii*. It is characterized by its creeping plants which usually forms thin mats in branches of trees; leaves usually concave and acuminate with denticulate margin from tip to base.

Distribution: World: Cameroon (O'Shea, 2006), Ethiopia (O'Shea, 2006), Ivory Coast (O'Shea, 2006), Japan (Noguchi, 1991), Kenya (O'Shea, 2006), United States (Churchill, 1985); **India:** Andhra Pradesh (Sandhyarani *et al.*, 2011), Kerala (Manju *et al.*, 2014), Meghalaya, West Bengal (Gangulee, 1978), Uttarakhand (Bahuguna *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700-2000 m) 2.08.2015 *Mufeed* 13320, 13329; 14.07.2017 *Mufeed* 7519b, 7524; Pullaradi Shola (1900-2300 m) 12.07.2017 *Mufeed* 7316; 04.03.2016 *Mufeed* 10072 (ZGC).

***Rhynchostegiella* (Schimp.) Limpr.**

Laubm. Deutschl. 3: 207. 1896.

Plants small or minute, in lax or dense mats, yellowish green to deep green or blackish, often lustrous; rhizoids arranged in fascicles or scattered on stem, brownish, smooth; leaves usually appressed when dry, erect to erectopatent when moist, narrowly lanceolate to lanceolate-triangular, oval-lanceolate or oblong-lanceolate, concave to flat, lamina unistratose, apex acuminate, acute, sometimes obtuse, margin entire, sometimes denticulate near basal portion and at apex, plane, rarely recurved; base not or sometimes slightly decurrent; costa single, ending at midleaf to percurrent; cells long rhomboidal to vermicular, basal cells usually shorter and wider, weakly thick-walled; autoicous; seta erect, twisted, capsule

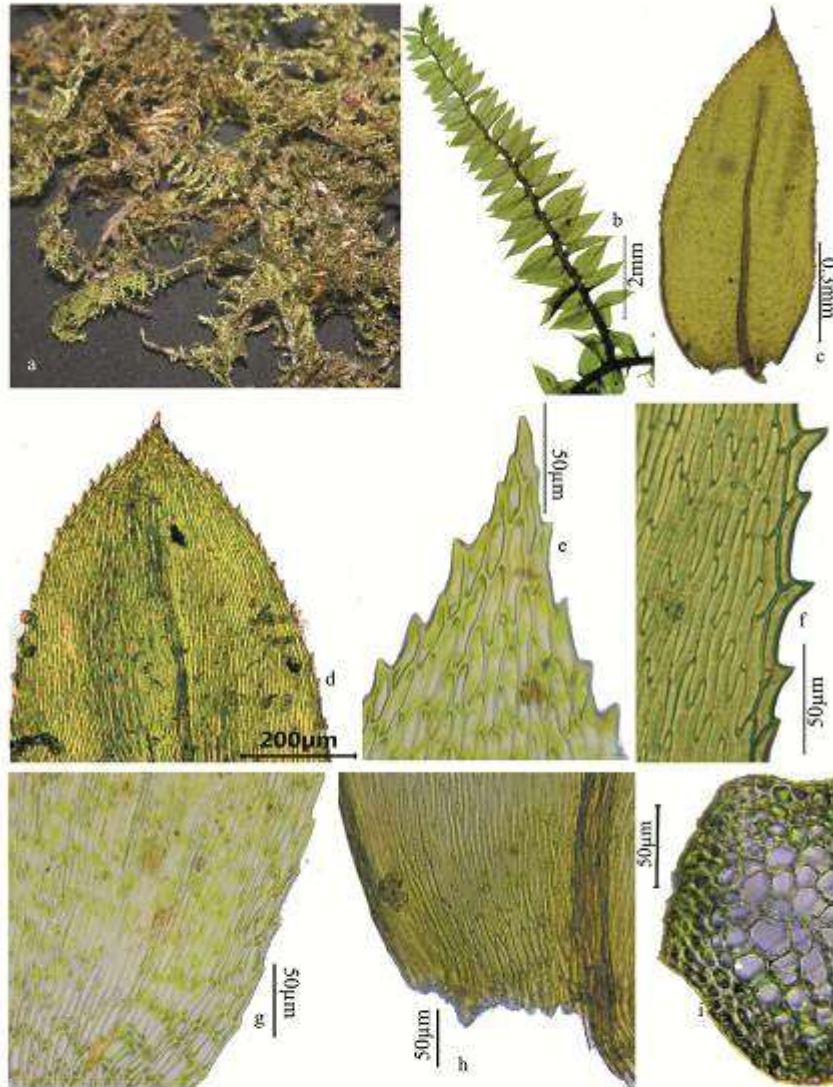


Plate 5. 119: *Eurhynchium hians* (Hedw.) Sande Lac., a. habit, b. branch, c. leaf, d. leaf apex, e. leaf tip cells enlarged view, f. leaf marginal cells, g. leaf basal margin, h. leaf basal cells, i. c.s. of stem

usually inclined, ovate-oblong, peristome double, operculum rostrate, calyptra cucullate.

Rhynchostegiella tenella (Dicks.) Limpr., Laubm. Deutschl. 3: 209. 1890; Guerra *et al.*, Phytotaxa 183(3): 195. 2014. *Hypnum tenellum* Dicks. Fasc. Pl. Crypt. Brit. 4: 16. 11 f. 12. 1801. *H. bourgaeana* Mitt., Nat. Hist. Azores 309. 1870. *H. exiguum* Blandow, Deutschl. Fl., Abt. II, Cryptog. 9: [12] ic. 1809. *H. micracanthis* Myrin, Årsberätt. Bot. Arbeten Upptäckter 1831: 329. 1832. *Pterigynandrum algericum* Brid., Gen. Index J. Bot. Linn. Soc. 332. 1888. *Rhynchostegiella algeriana* (Brid. ex P. Beauv.) Warnst., Krypt.-Fl. Brandenburg, Laubm. 800. 810 f. 4. 1906. *R. bourgaeana* (Mitt.) Broth. Nat. Pflanzenfam. I(3): 1162. 1909. *Rhynchostegium mediterraneum* Jur., Verh. Zool.-Bot. Ges. Wien 24: 378. 1874.

Plants small, slender, light green, slightly lustrous, up to 1.5 mm long; stems lax and irregularly branches; branches usually prostrate, occasionally semi-erect; leaves erect to erectopatent when dry, erectopatent to patent when moist, narrowly lanceolate to lanceolate-triangular, 0.6–1.0 mm long and 2.5 mm wide, flat; apex long and narrowly acuminate, rarely acute; margins entire or weakly denticulate from mid-leaf to apex, plane; costa single, finishing 3/4 leaf length, sometimes finishing in acumen or percurrent; upper and mid-lamina cells vermicular, slightly sinuous, (50)60–120(140) × 4–6(8) µm; basal cells 17–20(30) × 6–8 µm; alar cells occasionally differentiated as small group of 7–12 short-rectangular to quadrate cells, 11–18 × 8–10 µm; reproductive structures not observed (Plate 5.120).

Habitat: Terrestrial, on land cuttings along with *Pogonatum neesii* (Müll. Hal.) Dozy. in shola forest.

Discussion: *Rhynchostegiella tenella* (Dicks.) Limpr. is a very rare species and not reported earlier from India. Hence the present collection is a new record for India.

Distribution: World: Britain, Ireland (Smith, 1978), China (Redfearn Jr. & Wu, 1986), Macedonia (Papp *et al.*, 2019), Russia (Ignatov & Afonina, 1992), Spain (Guerra *et al.*, 2014); **India:** Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (1805 m) 23.09.2018 *Mufeed* 9934 (ZGC).

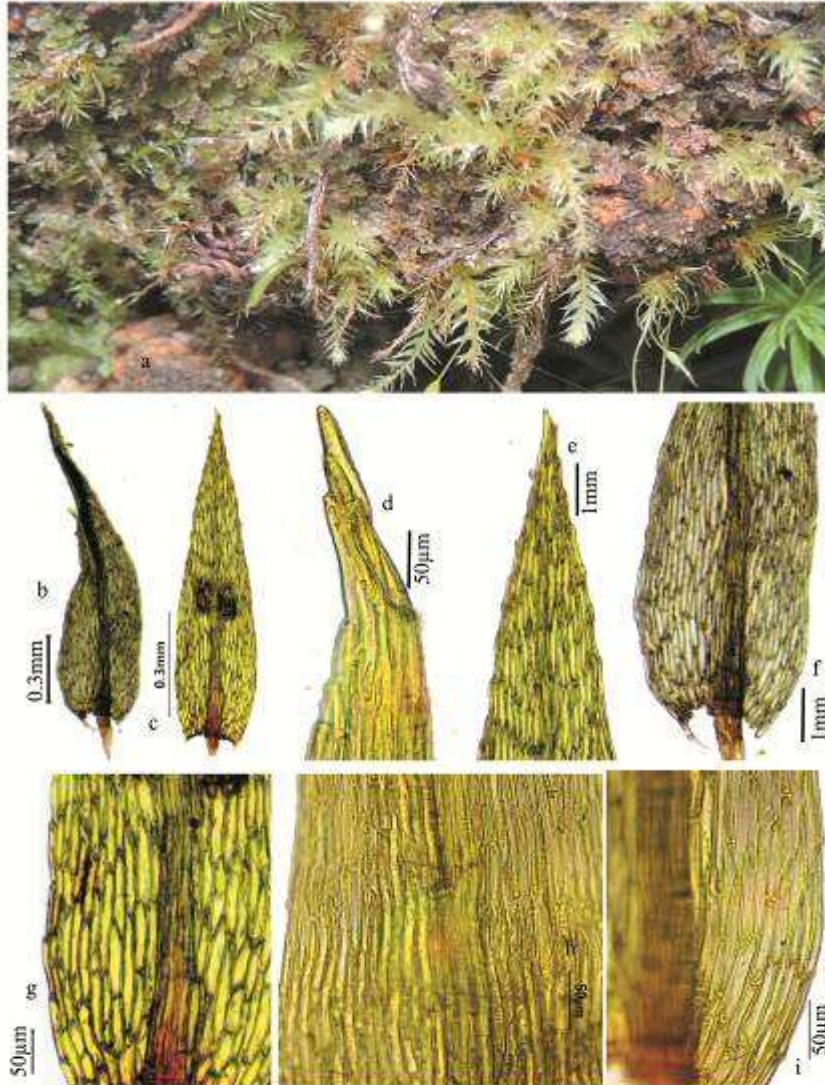


Plate 5. 120: *Rhynchostegiella tenella* (Dicks.) Limpr., a. habit, b&c. leaves, d. leaf tip cells, e. leaf apex, f. leaf base, g. leaf marginal cells, h. leaf middle cells, i. leaf basal cells

Meteoriaceae Kindb.,

Gen. Eur. N.- Amer. Bryin. 7. 1897.

Plants glossy, robust, usually epiphytic, primary stem creeping, secondary branches slender, flexuose, pendant, branched, densely foliose; leaves ovate-lanceolate, acuminate, either recurved or squarrose; costa single, slender, terminating below the tip; cells usually papillose, alar cells not differentiated; seta usually short, long in some, capsule exerted, peristome double, calyptra small, cucullate, spores very small.

Key to the genera

- 1a. Leaf with auriculate base, cells in divergent rows 2
- 1b. Leaf base not auriculate, cells arranged in vertical rows3
- 2a. Leaves generally 3-plicate; laminal cells unipapillose**Meteorium**
- 2b. Leaves if plicate with only 1 or 2 plicae; laminal cells multipapillose
.....**Cryptopapillaria**
- 3a. Plants slender; leaves narrow, lanceolate; apex filiform or flexuose-
capillaceous, rarely acuminate 4
- 3b. Plants robust; leaves broader, ovate; apex always acuminate 6
- 4a. Leaves widely spreading, multipapillose; cell outline obscure; costa reaching
mid-leaf **Floribundaria**
- 4b. Leaves appressed, scarcely papillose, cell outline distinct, generally ecostate,
Some leaves with single or small double costae 5
- 5a. Laminal cells truly papillose, unipapillose, cell outline not distinct
..... **Barbellopsis**
- 5b. Laminal cells scarcely papillose, usually 1 to 4 small papillae, cell outline
distinct **Barbella**
- 6a. Plants brownish or blackish when mature, primary stems creeping with tufts of
blackish rhizoids **Trachypus**
- 6b. Plants yellowish green or dark green when mature, primary stem creeping with
brownish rhizoids 7
- 7a. Alar cells mostly present, occasionally large, quadrate to rectangular, cell walls
mostly somewhat incrassate and pitted8
- 7b. Alar cells not differentiated or when present small, cells with porose walls9
- 8a. Laminal cells isodiametric to linear **Trachypodopsis**
- 8b. Laminal cells rhomboidal to hexagonal **Duthiella**
- 9a. Leaves ovate-lanceolate, not spreading at base with needle like hairy tip,
laminal cells usually with single papillae **Aerobryidium**

- 9b. Leaves ovate to orbicular arises from half sheathing or squarrose spreading base, shortly pointed to narrowly acuminate tip, unipapillate or multipapillate..10
- 10a. Leaves appressed; apex transversely undulate; costa extending more than two-thirds of the leaf length **Aerobryopsis**
- 10b. Leaves spreading to squarrose; apex straight; costa extending to half of the leaf length **Meteoriopsis**

Aerobryidium M. Fleisch. ex Broth.,

Nat. Pflanzenfam. 1(3): 820. 1906.

Plants robust, glossy, yellowish green with hanging secondary branches; leaves squarrose to erectopatent, ovate lanceolate, acuminate, somewhat undulate or plicate; costa single, reaches up to the middle and above; laminal cells linear elongate or rhomboid, unipapillate, with porose walls, lax and wider in alar regions; sporophyte usually on lateral short shoots; seta long, capsule ovate, peristome double, operculum obliquely rostrate, calyptra cucullate, spores small, papillose.

Aerobryidium filamentosum (Hook.) Fleisch., Nat. Pflanzenfam. I(3): 821. 1906. Bruehl, Rec. Bot. Surv. India 13(1): 72. 1931; Wadhwa, M.V.M. Patrika 4: 76. 1969; Chopra, Taxon. Indian Moss. 339. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1322. 1976; Lal, Checklist Indian Moss. 14. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 7. 2008; Daniels, Arch. Bryol. 65: 34. 2010; Daniels *et al.*, Bryoflor. Indira Gandhi Natl. Pk. 173. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 190. 2019. *Neckera filamentosa* Hook., Musci Exot. 2: 158. 1819. *Hypnum aureonitens* Hook. ex Schwägr. in Sp. Musc. Suppl., 3 (1): 221. 1827. *Pilotrichum filamentosum* (Hook.) Brid. In Bryol. Univ., 2 : 264. 1827. *Daltonia filamentosa* (Hook.) Arnott in Mem. Soc. Linn. Paris, 5 : 296. 1827. *Pilotrichum punctulatum* Müll. Hal., Bot. Zeit., 12 : 571. 1854. *Meteorium filamentosum* (Hook.) Mitt. In Musci ind. Or.: 91. 1859. *M. punctulatum* (Müll. Hal.) Mitt. In ibid.: 91. 1859. *Aerobryum filamentosum* (Hook.) M. Fleisch. ex Thér., Bull. Soc. Bot. Genève 26: 87. 1936. *Aerobryidium taiwanense* Nog., J. Hattori Bot. Lab. 3: 71. 27. 1948. *Aerobryidium subfilamentosum* Card., mss. in Chopra in Tax. Ind. Moss: 339. 1975.

Plants yellowish green above, dark brownish below, with hanging somewhat robust secondary branches up to 15cm long, stem covered with dense leaves; habit shows a

great variation based on their habitat and altitude; leaves imbricate, squarrose, dense, ovate-lanceolate, gradually narrowing in to a long and needle like point or cucullate in some leaf, ± 3 mm long and 1-1.2 mm wide at base; base is more or less auriculate; margin slightly wavy or faintly denticulate; costa single, covering upto $\frac{2}{3}$ of the leaf; leaf cells elongate rhomboid except at the tip, base and basal margin, with a single papilla on the middle of the lumen; cells at apex ± 30 μ m long and 5 μ m wide, cells at middle 50×6 μ m, basal alar cells smooth, quadrate, ± 55 μ m long and 15 μ m wide; c.s of stem round in shape with middle hyaline cells, 5–10 μ m at middle, 2–5 μ m at margin; sporophyte on short lateral shoots, seta long, capsule ovate, operculum oblique-rostrate, calyptra cucullate with a few hairs, peristome double, outer teeth lanceolate with zig-zag middle line, spores papillose, brown, 20-30 μ m diagonally (Plate 5.121).

Habitat: Epiphytic, hanging on branches in evergreen and shola forest.

Discussion: Vohra (1969) reported *Aerobryidium filamentosum* from Western Himalayas as new record to India. Gangulee (1976) listed this species from Eastern Himalayas. It is a very common high altitude species in South India. These plants are characterized by ovate-lanceolate leaves with needle like hairy tip and the laminal cells usually with single papillae.

Distribution: World: Bhutan, Celebes, Java, North Borneo, Sri Lanka, Sumatra, Thailand, Vietnam (Noguchi, 1976), Myanmar, China (Vohra, 1969), Philippines (Tan & Iwatsuki, 1991); **India:** Karnataka (Brotherus, 1899 as *Meteorium*, Gangulee, 1974; Shwarz, 2013), Kerala (Manju *et al.*, 2008b), Meghalaya, Sikkim, West Bengal (Gangulee, 1976), Tamil Nadu (Alam *et al.*, 2011; Daniels, 2010; Daniels *et al.*, 2018; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2210 m) 25.09.2018 *Mufeed* 9977; Mannavan Shola (1640-2300 m) 14.07.2017 *Mufeed* 7383, 7516a; 25.09.2018 *Mufeed* 7385, 7398; 12.07.2017 *Mufeed* 7553b; 03.03.2016 *Mufeed* 10007b; Pullaradi Shola (2000-2050 m) 12.07.2017 *Mufeed* 7312; 02.08.2015 *Mufeed* 13310; Idivara Shola (2050-2100 m) 12.07.2017 *Mufeed* 7329, 7342 (ZGC).

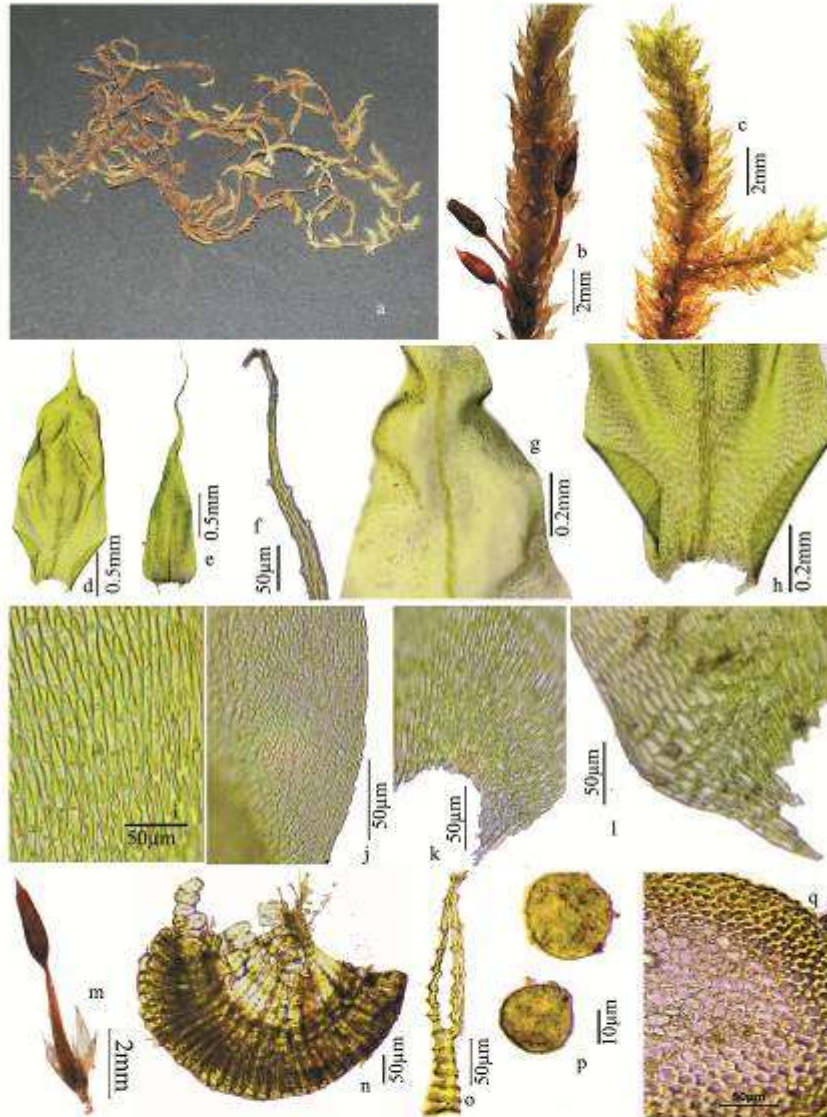


Plate 5. 121: *Aerobryidium filamentosum* (Hook.) M. Fleisch. a. habit, b. branch with sporophyte, c. leaf arrangement on the stem, d&e. leaf, f. leaf tip cells, g. leaf apex, h. leaf base, i. leaf middle cells, j. leaf margin, k&l. leaf basal cells, m. sporophyte, n. peristome, o. peristome teeth, p. spores, q. c.s. of stem

Other specimens examined: Western Himalaya, Srinagar (1072 m) 10.03.1963 J. N. Vohra & B.M. Wadhwa 1277 (CAL); Eastern Himalayas, Nepal, *Gangulee* (58/4) 1-2 (CAL).

Aerobryopsis M. Fleisch.,
Hedwigia 44:304.1905.

Plants slender, glossy, branching usually pinnate and pendant; leaf concave, smooth or narrowly ovate-orbicular with shorter or longer acumen, minutely toothed; costa thin, reaching above the midleaf; laminal cells rhomboid ovate to narrowly elliptic, usually with a papilla over the lumen, at the base shorter and wider; alar cells not differentiated; seta long, reddish; capsule erect or inclined, brown, straight or curved; calyptra cucullate; spores small, finely papillose.

Aerobryopsis wallichii (Brid.) A. Fleisch., Musci Fl. Buitenz. 3: 789. 1909; Bruehl, Rec. Bot. Surv. India 13(1): 72. 1931; Chopra, Taxon. Indian Moss. 337. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1319. 1976; Noguchi, J. Hattori Bot. Lab. 41: 295. 1976; Lal, Checklist Indian Moss. 14. 2005; Nair *et al.*, Bryop. Wayanad W. Ghats 1: 154. 2005; Prajitha *et al.*, Geophytology 42(2): 147. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 193. 2019. *Hypnum wallichii* Brid., Bryol. Univ. 2: 416. 1827. *Neckera wallichii* (Brid.) Card. ex C. Mueller in Syn. 2: 141. 1850. *Aerobryum wallichii* (Brid.) C. Mueller, Linnaea 40: 262. 1876. *Papillaria wallichii* (Brid.) Ren. & Card., Rev. Bryol. 23: 102. 1896.

Plants yellowish green, dark brown at maturity, slender, hanging from the branches, about 30 cm long, pinnately branched; leaves complanate, lanceolate, 2 mm long and 0.5 mm wide, wide at base, base flat, apex gradually narrowed into a long acuminate point, acumen 0.3 mm long, margin denticulate throughout, sharp at tip; costa single vanishing half the leaf, clear at the basal part, becomes faint at tip; leaf cells narrow, elongate with a single central papilla except at apex and basal cells; 40–52 µm long and 6–8 µm wide at tip, 55–60 x 5 µm, wide below; alar cells little prominent with smooth wide cells, 15–19 x 13–15 µm (Plate 5.122).

Habitat: Epiphytic, hanging from branches in evergreen and shola forest.

Discussion: Yellowish green slender hanging plants up to 30 cm long. Leaves

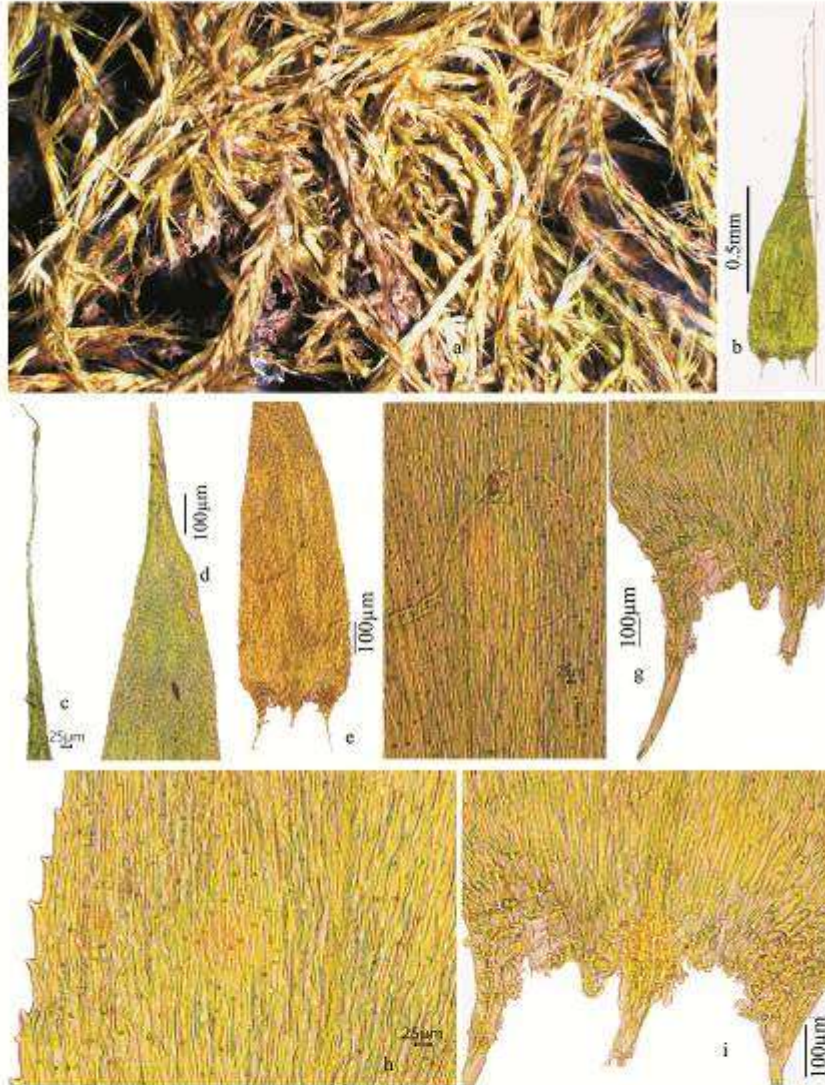


Plate 5. 122: *Aerobryopsis wallichii* (Brid.) M. Fleisch., a. habit, b. leaf, c. leaf extreme tip cells, d. cells from middle to tip, e. leaf base, f. leaf middle cells, g. leaf basal cells, h. leaf marginal cells, i. alar cells at base

lanceolate with a gradually narrowed tip, dentate margin and single costa reaches mid leaf.

Distribution: World: Africa (Een & Kristoferson, 1999), China (Redfearn Jr., 1986), Hawaii (Staples, 2004), Indonesia (Windadri, 2019), Nepal (Gangulee, 1976), Papua New Guinea (Norris & Koponen, 1990), Philippines (Tan, 1991), Sri Lanka (O'Shea, 2002), Vietnam; **India:** Kerala (Prajitha *et al.*, 2013), Sikkim, Tamil Nadu, West Bengal (Gangulee, 1976).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600 m) 14.07.2017 *Mufeed* 7530; Pullaradi Shola (2000 m) 12.07.2017 *Mufeed* 7311 (ZGC).

Other specimen/s examined: India, Kerala, Palakkad district, Silent Valley National Park (1200 m) 18.03.2011 *Rejilesh, Anoop & Hareesh* 5337 (MBGH).

Barbella M. Fleisch. ex Broth.,

Nat. Pflanzenfam. 1(3): 823–825, f. 613. 1906.

Plants slender in loose forms, secondary stem pendulous; usually filiform, unbranched or pinnately branched; tips usually acute, sometimes with flagelliform branches; leaves appressed, narrow lanceolate, acuminate, squarrose to complanate; generally ecostate, in some species costa single, incomplete; cells linear, scarcely papillose, usually 1 to 4 small papillae, basal cells lax, cell outline distinct; sporophytes on lateral shoots; seta short or long; capsule exserted, cylindrical; peristome double, hypnoid.

Barbella bombycina (Renauld & Cardot) M. Fleisch., Nat. Pflanzenfam. I(3): 824. 1906; Bruehl, Rec. Bot. Surv. India 13(1): 72. 1931; Chopra, Taxon. Indian Moss. 343. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1328-1330. 1976; Lal, Checklist Indian Moss. 20. 2005; Schwarz & Frahm, Pol. Bot. Jour. 58(2): 511-524. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 194. 2019; Ellis *et al.*, J. Bryol. 62: 1. 2020. *Meteorium bombycinum* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 38(1): 26. 1900.

Plants yellowish-green, brownish red when dry, lax, secondary branches long, pendulous, pinnately branched, complanate, stem cells rounded, small cells in

peripheral region and become large at the center, up to 20 cm or more; leaves spreading, neatly complanately arranged, ovate-lanceolate, 1.75 mm long and 73 mm wide near base, tip short acute, margin dentate; costa single, covering two third of leaf; leaf cells incrassate, elongate-linear, with 1 or 2 papillae at extreme tip and at base, 36 μ m long and 8 μ m wide at tip and 31 μ m long and 6 μ m wide at middle, cells at the alar region rectangular, 20 μ m long and 10 μ m wide; sporophyte not seen (Plate 5.123).

Habitat: Epiphytic, on barks in evergreen, shola and grassland trees in all altitudinal ranges.

Discussion: *Barbella bombycina* (Renauld & Cardot) M. Fleisch. is previously reported from Eastern India (Gangulee, 1976) and Western Himalayas (Alam, 2013b). Recently it is reported in South India from Karnataka state (Schwarz & Frahm, 2013). Ellis *et al.* (2020) reported this species as new record for Kerala based on the present collection. It is characterized by its yellowish green or green plants with hanging secondary branches, branches usually pinnate, leaves ovate-lanceolate with a short acute tip, dentate margin and single costa covering two third of leaf.

Distribution: World: Sri Lanka (O'Shea, 2002), Thailand (Touw, 1968); **India:** Eastern Himalaya (Gangulee, 1976), Karnataka (Schwarz, 2013), Kerala (Ellis *et al.*, 2020), Western Himalayas (Alam, 2013b).

Specimen/s examined: India: Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600- 1950 m) 14.07.2017 *Mufeed* 7503, 7506, 7531; Iddalymotta (2300 m) 22.09.2018 *Mufeed* 9985 (ZGC).

***Barbellopsis* Broth.,**

Symb. Sin. 4: 83. 1929.

Plants larger, more than 3 cm tall, perennial, on various substrata; stem pendant; leaves dull to glossy, not bordered, attached all around the stem, evenly spaced on the branches, leaves without lamellae or filaments on the adaxial surface; ecostate, or costa apparently lacking or double (short or long), extending less than 1/4 of the leaf length; leaf apex concolorous; laminal cells uniformly green, cell outline not



Plate 5. 123: *Barbella bombycina* (Renauld & Cardot) M. Fleisch. a. habit, b. single plant, c. leaf, d. leaf apex, e. leaf tip cells, f. leaf base, g. leaf cells at middle, h. leaf marginal cells, i. leaf basal cells

distinct, truly papillose, unipapillose, upper laminal cells papillose, prorulate or conspicuously ornamented, cells linear, alar cells quadrate, not inflated.

Note: Brotherus (1929) described this genus based on the type specimen *Barbelloopsis sinensis*, but this species was synonymised under *Barbella enervis* by Noguchi (1976), again *Barbella enervis* is included under *Barbelloopsis trichophora* by Buck (1998). Allen (2010) also followed this classification. The present treatment also follows Buck (1998) & Allen (2010).

Barbelloopsis trichophora (Mont.) W.R. Buck, Mem. New York Bot. Gard. 82: 265. 1998; Daniels, Arch. Bryol. 65: 37. 2010; Frahm *et al.*, Frahmia 128: 2. 2013. *Isothecium trichophorum* Mont., Ann. Sci. Nat., Bot., sér. 2, 19: 238. 1843. *Meteorium compressum* Mitt., Trans. & Proc. Roy. Soc. Victoria 19: 83. 1882. *M. cubense* Mitt., J. Linn. Soc., Bot. 12: 435. 1869. *M. enerve* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 317. 1873. *Neckera trichophoroides* Hampe ex Müll. Hal., Linnaea 38: 668. 1874. *Papillaria compressum* (Mitt.) Kindb., Enum. Bryin. Exot., Suppl. 2: 102. 1891. *Pilotrichella trichophoroides* (Hampe ex Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875–76: 259 (Gen. Sp. Musc. 2: 163). 1877. *Barbella trichophora* (Mont.) M. Fleisch., Nat. Pflanzenfam. 1(3): 824. 1906; Frahm *et al.*, Frahmia 128: 2. 2013. *B. cubensis* (Mitt.) Broth., Die Natürlichen Pflanzenfamilien 1(3): 824. 1906; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1326. 1976; Manju & Rajesh, Samagra 8: 24. 2012; *B. enervis* (Thwaites & Mitt.) M. Fleisch., Nat. Pflanzenfam. I(3): 824. 1906. *B. trichophoroides* (Hampe ex Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 824. 1906. *Dicladella cubensis* (Mitt.) W.R. Buck, J. Hattori Bot. Lab. 75: 57. 1994.

Plants yellowish green in tufts, dull coloured when dry, secondary branches pendulous, hanging on tree branches, up to 10 cm long or more, pinnately branched, usually complanate at tips and ending in filiform; leaves oblong-lanceolate, gradually narrowing into a subulate tip, up to 2.7 mm long and 0.5 mm wide at base, margin denticulate; costa absent; laminal cells linear elongate, 98–127 x 10 µm, tip, middle and marginal cells linear elongate, cells shorter and wider in basal regions, 33–53 µm long and 9–12 µm wide, alar cells rectangular to quadrate, 21–33 x 15 µm, 1 or 2 papillae in all cells except at extreme tip and base; sporophyte not seen (Plate 5.124).



Plate 5. 124: *Barbelopsis trichophora* (Mont.) W.R. Buck, a. habit, b. single plant, c&d. leaf, e. leaf apex, f. leaf apical cells, g. leaf middle cells, h. leaf marginal cells, i. leaf basal cells, j. leaf papillae

Habitat: Epiphytic, hanging from branches in evergreen and shola forest.

Discussion: This species was known from India as *Barbella cubensis* (Mitt.) Broth., *Barbella trichophora* (Mont.) M. Fleisch. and *Barbellopsis trichophora* (Mont.) W.R. Buck. Streiman (1993) synonymised *Barbella cubensis* with the morphologically similar *B. trichophora*. Buck (1998) synonymised all these species under *Barbellopsis trichophora*. From South India described this species as *Barbella cubensis* and *Barbellopsis trichophora*.

Distribution: World: Australia (Ramsay & Cairns, 2004), Bhutan, Nepal (Gangulee, 1976), China (Redfearn Jr., 1990), Hawaii (Staples *et al.*, 2004), Japan (Iwatsuki, 1991), Philippines (Tan & Iwatsuki, 1991), Sri Lanka (O'Shea, 2002), Vietnam (Ninh, 1993); **India:** Arunachal Pradesh (Vohra & Kar, 1996), Assam, West Bengal, Uttarakhand (Gangulee 1976), Karnataka (Frahm *et al.*, 2013), Kerala (Manju & Rajesh, 2012), Tamil Nadu (Daniels 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1690-1945 m) 14.07.2017 *Mufeed* 7504, 7545, 7585; 02.08.2015 *Mufeed* 13309; 14.07.2017 *Mufeed* 7388 (ZGC).

Cryptopapillaria M. Menzel,
Willdenowia 22: 181. 1992.

Plants yellowish-green, robust; secondary stems many, elongate; leaves closely or distantly imbricate when dry, erectopatent from a cordate or auriculate base when moist, oblong to lanceolate, apex shortly or longly acuminate or hair pointed, margin entire or minutely toothed, leaves if plicate 1 or 2 plicae; costa narrow, single, not percurrent; cells rhomboidal to linear, multipapillose, seen as two rows on the laminal cells, at base adjoining the costa hyaline, smooth, auricular in oblique rows, alar cells not distinct; seta very short, rough, capsule completely immersed or exserted, ovoid to oblong ovoid, peristome teeth yellowish white, calyptra small, more or less papillose.

Cryptopapillaria fuscescens (Hook.) M. Menzel, Willdenowia 22: 183. 1992; Broth., Rec. Bot. Surv. India 1(12): 323. 1899; P. Bruehl, Rec. Bot. Surv. India 13(1): 71. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 783. 1937; Foreau, J. Madras

Univ. Sect. B. 3; 119. 1931 & J. Bombay Nat. Hist. Soc. 58:33.1961; Chopra, Tax. India Mosses 333. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1284. 1976; Madhus. & Nair, J. Econ. Tax. Bot. 28: 341. 2004; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 155-156. 2005; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 195. 2019. *Neckera fuscescens* Hook., Musci Exot. 2: 157. 1819. *Daltonia fuscescens* (Hook.) Arn., Mém. Soc. Linn. Paris 5: 296. 1827. *Meteorium fuscescens* (Hook.) Bosch & Sande Lac., Bryol. Jav. 2: 93. 207. 1864.

Plants yellowish green, robust; secondary stems many, usually elongate, pendant, branches up to 12 cm long; leaves closely imbricate, erecto patent from an auriculate base, oblong lanceolate, up to 2.3 mm long and 0.8 mm wide, wide at base; apex acuminate or hair pointed, margin toothed; costa single, ending below apex; cells rhomboidal to linear; two rows of seriate papillae on the walls, cells at apex 30-35 µm long and 5 µm wide, cells at middle, 28-38 (45) × 5 µm, at base 20-30 × 4 µm, alar cells not distinct; sporophyte not seen (Plate 5.125).

Habitat: Epiphytic, hanging on branches in evergreen, shola and grassland in all altitudinal ranges.

Discussion: A widely distributed and morphologically variant species. Common in high altitude mountains of the Kerala State and a very common species in the study area. It is characterized by yellowish green hanging plants with leaves oblong lanceolate from an auriculate base and the laminal cells are rhomboidal with two rows of seriate papillae on the walls.

Distribution: World: Bhutan (Long, 1994), Borneo, China (Suleiman *et al.*, 2006), Burma, Thailand (America *et al.*, 2006), Indonesia (Gradstein *et al.*, 2005), Malaysia (Suleiman *et al.*, 2011), Nepal (Gangulee, 1974), Philippines (Linis, 2004), Samoa (Menzel, 1992), Sri Lanka (O'Shea, 2002); **India:** Assam, Maghalaya, West Bengal (Gangulee, 1976), Goa, Karnataka (Schwarz, 2013), Kerala (Manju & Rajesh, 2012), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000-2200 m) 03.03.2016 *Mufeed* 10032, 10034a, 10036; 12.07.2017 *Mufeed* 7328a, 7337a, 7351; Pullaradi Shola (2000-2300 m) *Mufeed* 10071;

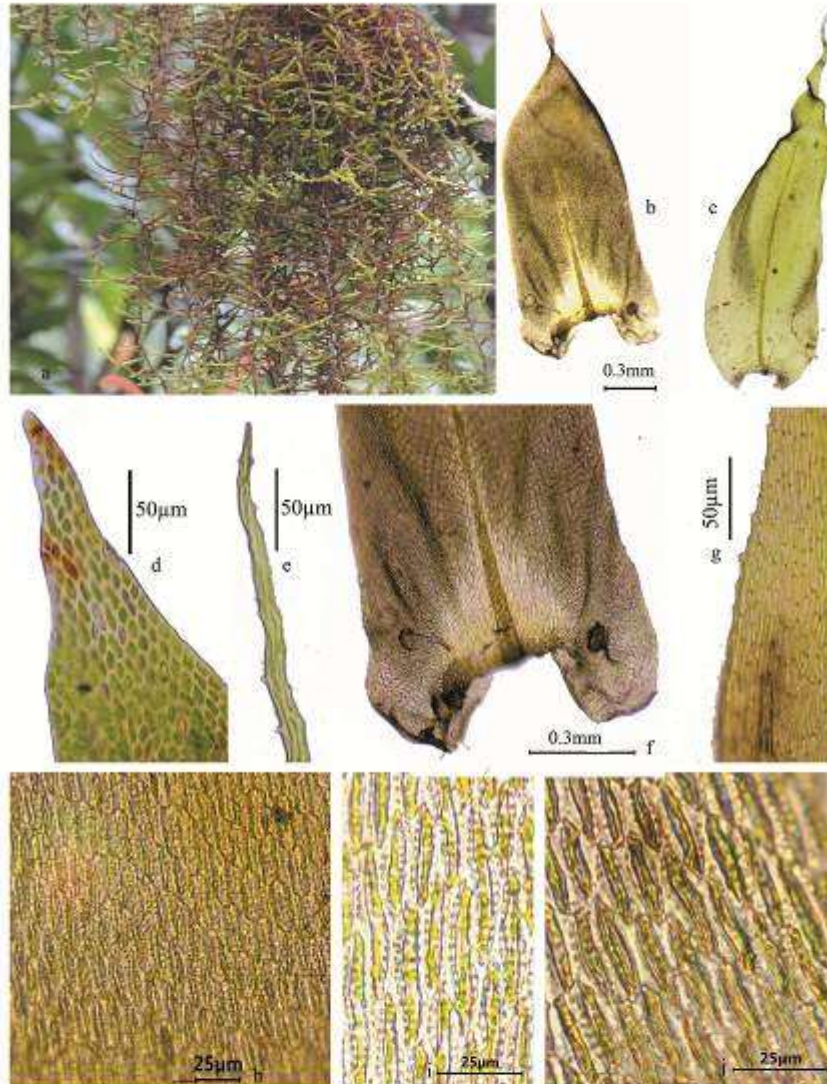


Plate 5, 125: *Cryptopapillaria fuscescens* (Hook.) M. Menzel, a. habit, b. branch leaf, c. stem leaf, d. branch leaf tip, e. stem leaf tip, f. leaf base, g. marginal cells, h. leaf cells, i&j. multiseriate arrangement of papillae

12.07.2017 *Mufeed* 7313c, 7321; Mannavan Shola (1600-2100 m) 14.07.2017 *Mufeed* 7507, 7523, 7565, 7569, 7573; 02.08.2015 *Mufeed* 13362; Jandamala (1948-2220 m) 09.11.2017 *Mufeed* 7457, 7467 (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Begur RF (840m) *Manju C.N.* 84593, Chembra hills (1394m) *Manju C.N.* 120316a (CALI!)

Duthiella Müll. Hal. ex Broth.,
Broth., Nat. Pflanzenfam. 1(3); 1009. 1908.

Plants robust, main stem creeping, stoloniform, secondary stem ascending upwards, more or less regularly pinnate, branches of unequal length; leaves all alike besides size differences, appressed when dry; leaves linear, lanceolate, acuminate from ovate decurrent or lanceolate base, dentate margin with prominent teeth, barely bordered; costa single, strong, ending below apex; cells rhomboid to hexagonal, usually with one papillae, cells at margin long and narrow, translucent, smooth, forming a narrow border, basal cells elongate, smooth, alar cells large, thin walled, hexagonal; sporophyte long; seta red, smooth; capsule tending or straight, oblong cylinder-shaped; calyptra cucullate, spores small, smooth.

Duthiella declinata (Mitt.) Zant., Blumea 9(2): 559. 1959; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1240. 1976; Nair *et al.*, *Phytomorphology*. 57: 13-14. 2007. *Trachypus declinatus* Mitt., Musc. Ind. Orient. 129. 1859. *Papillaria declinata* (Mitt.) A. Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-76: 273. 1877. *Trachypodopsis declinata* (Mitt.) M. Fleisch., Hedwigia 45: 65. 1906. *Duthiella mussooriensis* Reim., Hedwigia 76: 289. 1937.

Plants yellowish-green, brownish when dry, robust, main stem creeping, secondary stems many, ascending upwards, regularly pinnate, very small, up to 6cm long, branches of unequal length; leaves dense, stem leaves and branch leaves are slightly different; stem leaf linear-lanceolate, acuminate from ovate-lanceolate base, margin sharply serrate, 2.4 mm long and 0.5 mm wide; branch leaves linear-lanceolate with short acumen, 2.1 mm long and 0.6 mm wide; costa single, strong, ending below tip; cells rhomboid to hexagonal, thick walled, with one papillae except in smooth marginal cells, marginal cells can be distinguished from other cells, cells small at

apex, 40-45 µm long and 5-6 µm wide, median cells rhomboidal, 16-26 µm long and 5 µm wide, basal cells smooth, 30-35 µm long and 8-10 µm wide; alar cells quadrate, distinct, 10-15 µm long and 9-11 µm wide, walls of basal cells thin; reproductive structures not seen (Plate 5.126).

Habitat: Epiphytic, on trunks and branches in evergreen and shola forest.

Discussion: *Duthiella declinata* (Mitt.) Zant. is a widely distributed species among the four species reported and shows wide morphological variations based on microhabitat and altitude. This species is previously recorded by Manju *et al.* (2007) from Wayanad district as a new record for Peninsular India. The present collection from Anamudi Shola National Park also shows variations from other specimens reported from Kerala in the size of the plant and shape of leaf. This species is characterized by yellowish green plants with creeping main stem and ascending secondary stems, the leaves are linear-lanceolate with sharply serrate margin and the cells usually thick walled with one papillae except in smooth marginal cells which can be distinguished from other cells.

Distribution: World: Bhutan, Nepal (Gangulee, 1976), China (Redfearn Jr., 1986), Japan, Indonesia, New Guinea, Philippines (Tan & Iwatsuki, 1991); **India:** Kerala (Nair *et al.*, 2007), Meghalaya (Asthana & Srivastava, 2016), Western Himalaya (Lal, 2005).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1650-2000 m) 14.07.2017 *Mufeed* 7539, 7540; 24.09.2018 *Mufeed* 9958 (ZGC).

Floribundaria M. Fleisch.,
Hedwigia 44: 301. 1905.

Plants slender, delicate in loose tufts, small to medium-sized, pale green to yellow-green, stems complanately leaved, loosely or pinnately branched, widely spreading; branches short or elongate, simple, widely spreading when moist; branch leaves narrow, lanceolate, base little broad, gradually tapering to an elongate linear-lanceolate or flexuose-capillaceous apex, base cordate, margin denticulate or serrulate; costa reaches up to mid-leaf, often weak; laminal cells hyaline or obscure,

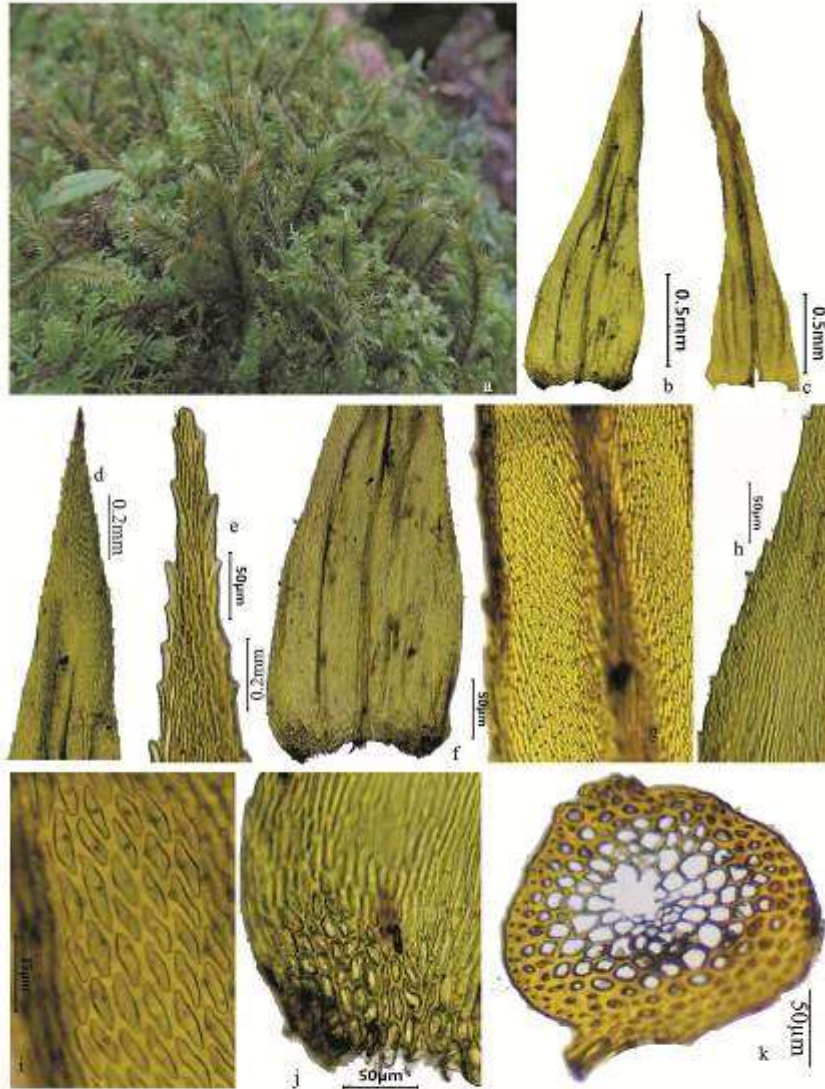


Plate 5. 126: *Duthiella declinata* (Mitt.) Zanten: a. habit, b&c. leaves, d. leaf apex, e. leaf tip cells, f. leaf base, g. leaf cells, h. leaf margin, i. papillae, j. leaf basal cells, k. c.s. of stem

sublinear to rhomboidal, multipapillose, arranged as one or two rows in lumen, thin-walled, sinuose; basal cells lax, papillae usually present, cell outline obscure; alar cells only slightly differentiated; seta short, smooth, often curved, capsule generally oblong, calyptra cucullate or mitrate, base lobed, with or without hairs, operculum conical to rostrate, with a curved beak.

Key to the species

- 1a. Plants smaller slender; cells usually with scattered papillae ***F. chrysonema***
 1b. Plants large robust; cells usually with uniseriate papillae ***F. floribunda***

Floribundaria chrysonema (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 822. 1906; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1305. 1976; Nair *et al.*, Arch. Bryol. 42: 1-12. 2009 (as *Barbella chrysonema* (Müll. Hal.) Nog. *Papillaria chrysonema* Müll. Hal., Bull. Soc. Roy. Bot. Belgique 34(2): 69. 1895[1896]. *P. chrysonema* var. *brachyclada* Ren & Card., Bull. Soc. R. Bot. Belg., 41(1): 73. 1905.

Plants delicate, filmy, yellowish, up to 5 cm long; branching usually pinnate in different planes; leaves feather like, lanceolate, widely spreading, 1-1.2 mm long and 0.2 mm at base, leaf apex apiculate or less acuminate, sometimes twisted, base cordate, margin flat, denticulate-serrate; costa single covering 2/3 of the leaf; lamina cells elongated, linear to rhomboid, incrassate, with a few small scattered papillae except at tip and extreme base, cells at apex 25-40 x 4 µm, cells at middle 45-55 x 5 µm, cells at base 25-45 x 4-8 µm; sporophyte not seen (Plate 5.127).

Habitat: Epiphytic, on branches and twigs and on logs. Also found on humus covered leaves in the forest floor of shola forest.

Discussion: The *Floribundaria chrysonema* (Müll. Hal.) Broth. is previously reported by Gangulee (1976) from Darjeeling. Nair *et al.* (2009) reported this species as new record for Peninsular India as *Barbella chrysonema* from Aralam Wildlife Sanctuary of Kannur district. Re-examining the specimen confirm the species as *Floribundaria chrysonema*. It is characterized by yellowish plants with feather like lanceolate leaves with denticulate margin and the cells usually show scattered papillae except at tip and extreme base.

Distribution: World: Bhutan (Gangulee, 1976), China (Redfearn Jr. & Wu, 1986);

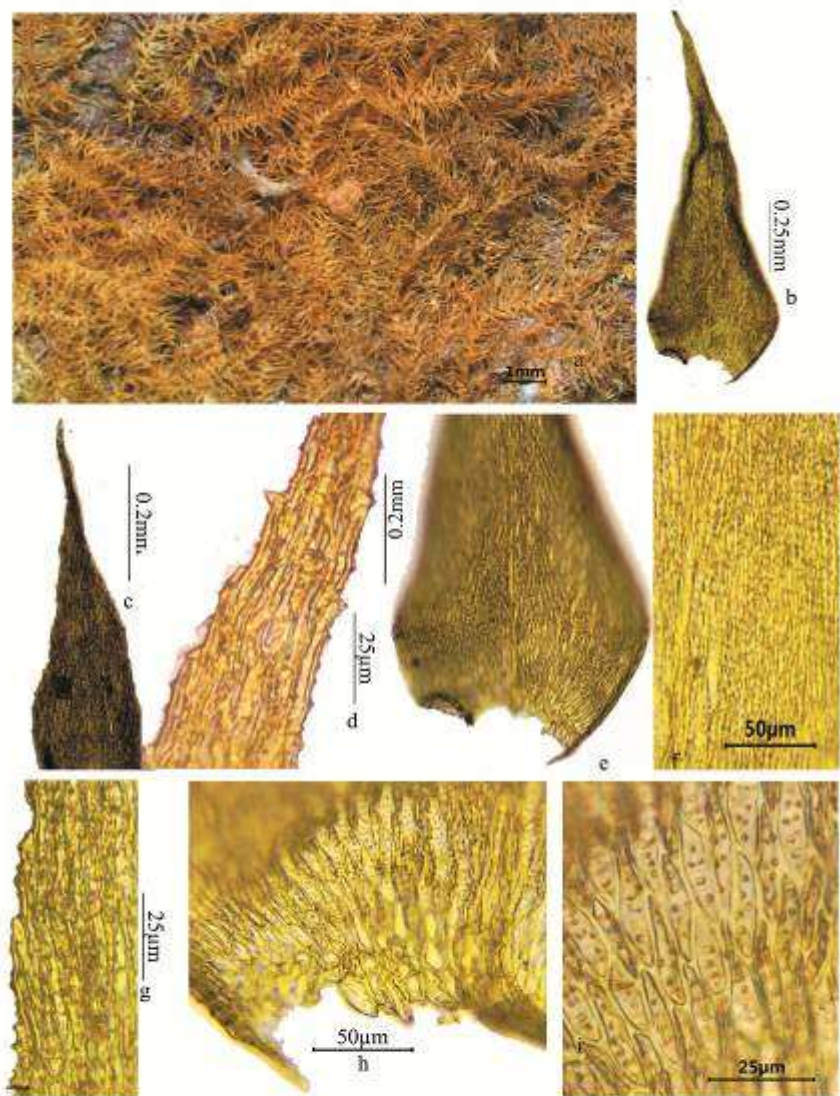


Plate 5. 127: *Floribundaria chrysonema* (Muell. Hal.) Broth. a. habit, b. leaf, c. leaf apex, d. apical cells, e. leaf base, f. leaf middle cells, g. leaf marginal cells, h. leaf basal cells, i. leaf cells with papillae

India: Kerala (Nair *et al.*, 2009), West Bengal, Sikkim (Gangulee, 1976).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000 m) 25.03.2016 *Mufeed 10043a, 10045* (ZGC).

Other specimen/s examined: India, Kerala, Kannur district, Ambalappara (1075 m), K.P.Rajesh 99773, Meenmutty (450m), Manju C.N. 87486 (CALI!).

Floribundaria floribunda (Dozy & Molk.) M. Fleisch., Hedwigia 44: 302. a–i. 1905; Bruehl, Rec. Bot. Surv. India 13(1): 73. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 783. 1937; Foreau, J. Madras Univ. Sect. B. 3: 120. 1931 & J. Bombay Nat. Hist. Soc. 58:32.1961; Wadhwa, M.V.M. Patrika 4: 92. 1969; Chopra, Taxon. Indian Moss. 346. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1301-1303. 1976; Lal, Checklist Indian Moss. 64. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 12. 2008; Alam *et al.*, Arch. Bryo. 112: 1-8. 2011; Frahm *et al.*, Frahmia 128: 6. 2013; Daniels & Daniel, Bryofl. S. Most W. Ghats, India 110. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 197. 2019. *Leskea floribunda* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 310. 1844. *Meteorium floribundum* (Dozy & Molk.) Dozy & Molk., Musc. Frond. Ined. Archip. Ind. 6: 162. 53. 1848. *Neckera capilliramea* Müll. Hal., Bot. Zeitung (Berlin) 17: 237. 1859. *Meteorium aeruginosum* Mitt., J. Linn. Soc., Bot. 10: 171. 5 B. 1868. *Neckera floribunda* var. *minor* Müll. Hal., Linnaea 36: 9. 1869. *Papillaria floribunda* (Dozy & Molk.) Müll. Hal., Linnaea 40: 267. 1876. *P. fulvastra* Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 265. 1880. *P. robillardii* Müll. Hal., Ann. Sci. Nat., Bot., sér. 6, 10: 266. 1880. *P. cameruniae* Müll. Hal. ex Dusén, Kongl. Svenska Vetensk. Acad. Handl., n.s. 28(2): 24. a–e; 2 f. 18. 1895. *P. floribunda* var. *brevifolia* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 38(1): 21. 1900. *Floribundaria floribunda* fo. *fulvastra* M. Fleisch., Musci Buitenzorg 3: 820. 1907. *F. floribunda* fo. *morokae* M. Fleisch., Musci Buitenzorg 3: 820. 1907. *F. floribunda* var. *revolutifolia* M. Fleisch., Musci Buitenzorg 3: 820. 1908. *F. floribunda* var. *serrata* M. Fleisch., Musci Buitenzorg 3: 820. 1908. *F. baldwinii* Broth., Bernice P. Bishop Mus. Bull. 40: 22. 1927. *Trachypus pilifolius* Dixon, Blumea 9: 489. 1959.

Plants yellowish green in dense masses, hanging, pinnately branched, up to 10 cm

long; leaves arranged feather like, wide spreading, lanceolate, leaf tip acuminate, cordate at base, 1.3 x 0.4 mm at base, margin denticulate, flat; costa single, covering up to ½ of the leaf; laminal cells moderately thickened, narrow elongate, with a row of small papillae in series on the lumen except at extreme tip and base; cells at apex, 30-40 µm long and 4 µm wide, cells at lower half 40-55 x 5-8 µm; reproductive structures not seen in present collection (Plate 5.128).

Habitat: Epiphytic, hanging on branches and twigs in shola forest.

Discussion: It is a very common species in high altitude areas of Kerala. This species is characterised by the feather like hanging plants bearing lanceolate leaves with a row of uniseriate papillae.

Distribution: World: Africa (O'Shea, 2006), Australia (Menzel, 1992), China (Redfearn Jr. & Wu, 1986), Hawaii (Shevock *et al.*, 2019), Japan (Suzuki, 2016), Nepal (Gangulee, 1976), Philippines (Tan & Iwatsuki, 1991), Sri Lanka (O'Shea, 2002), Thailand (Noguchi, 1972); **India:** Arunachal Pradesh, Assam, Bhutan, Manipur, Sikkim (Gangulee, 1976), Karnataka (Schwarz, 2013), Kerala (Prajitha & Manju, 2013), Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2000 m) 24.09.2018 *Mufeed* 9952; Idivara Shola (2000-2200 m) 25.03.2016 *Mufeed* 10037; 24.03.2016 *Mufeed* 10011 (ZGC).

Meteoriopsis M. Fleisch. ex Broth.,
Nat. Pflanzenfam. 1(3): 825. 1906.

Plants slender to robust, secondary stem many, long, pendant, pinnate and leafy stem; leaves ovate to orbicular arises from half sheathing or squarrose spreading base, shortly pointed to narrowly acuminate, margin minutely or strongly dentate; costa single, ending in the upper part of the leaf; laminal cells slightly rhomboid to linear, unipapillate or multipapillate; alar cells not differentiated; seta short, capsule erect, ovoid to oblong, brown, peristome teeth lanceolate, operculum with straight or oblique beak, calyptra hairy, many lobed, covering only on the upper part of the urn.

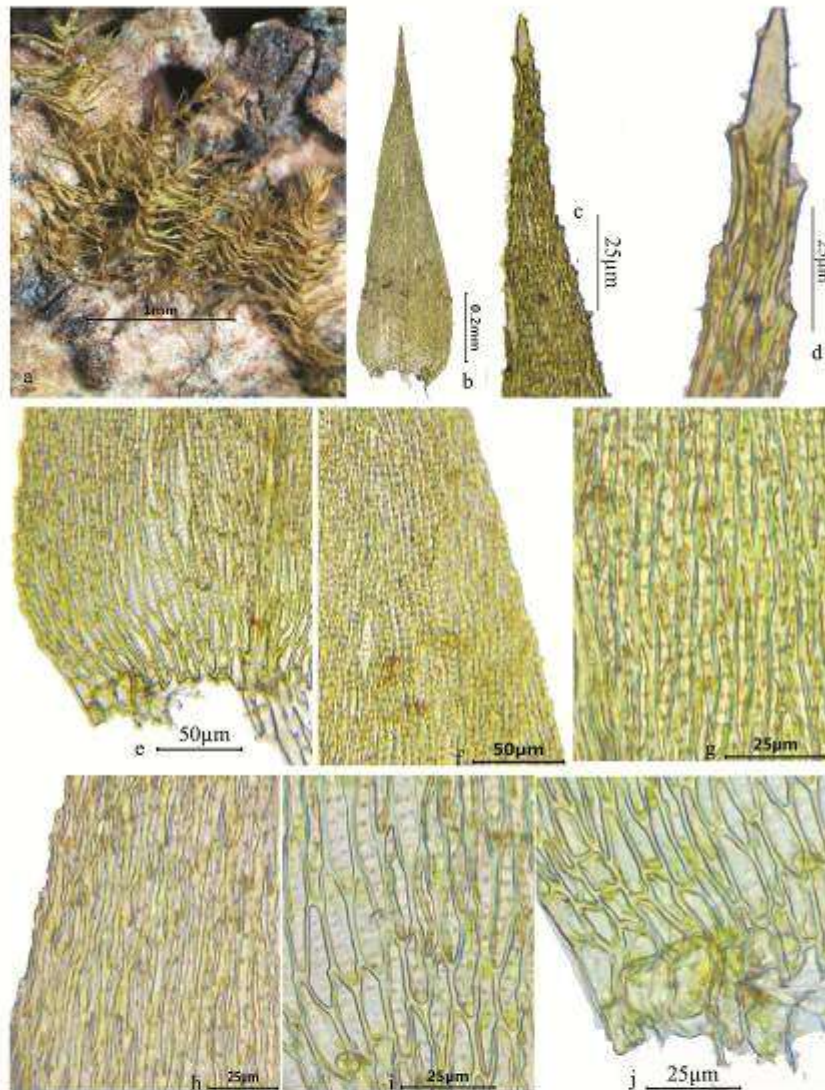


Plate 5. 128: *Floribundaria floribunda* (Dozy & Molk.) M. Fleisch. a. habit, b. leaf, c&d. leaf tip cells, e. leaf base, f. leaf margin, g. leaf middle cells, h. leaf marginal cells, i&j. leaf basal cells

Meteoriopsis ancistrodes (Renauld & Cardot) Broth., Nat. Pflanzenfam. I(3): 826. 1906; Bruehl, Rec. Bot. Surv. India 13(1): 74. 1931; Chopra, Taxon. Indian Moss. 351. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1348. 1976; Lal, Checklist Indian Moss. 88. 2005; Nath & Bansal, Phytotaxa, 3(1): 44. 2010; Asthana & Sahu, Frahmia 7. 2013; Daniels & Daniel, Bryoflor. Indira Gandhi Natl. Pk. 180. 2018; Tamizharasi *et al.*, Int. Jour. Dev. Res. 8(1): 18214. 2018. *Meteoriopsis conanensis* C. Gao, Acta Phytotax. Sin. 17: 116. f. 2: 8–31. 1979. *Meteorium ancistrodes* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 34(2): 72. 1895[1896]. *M. himalyense* Par. In Ind. Bryol. 797. 1897. *M. squarrosulum* Fleisch. In Syd.: Bot. Jahresber, 30(1): 253. 1903. *M. reclinata* var. *ancistrodes* (Renauld & Cardot) Nog., J. Hattori Bot. Lab. 41: 338. 1976. *Pseudobarbella ancistrodes* (Ren. & Card.) Manuel, Bryologist 80: 596. 1977.

Plants yellowish green in tufts; secondary branches pendulous, irregularly pinnately branched, up to 30 cm long; leaves dense, patent with tips not much deflexed, ovate-lanceolate, usually canaliculate and folded, cordate at base, folded here and there, slowly narrowed into an aristate tip, $\pm 2.5 \times 0.7$ mm at base, margin sharply denticulate at tip; costa single, vanishing at mid leaf, laminal cells linear to linear rhomboid, thick walled, 2 or 3 papillae at except at tip and extreme base; cells at apex, 40-50 $\times$ 5 μ m, cells at middle, 35-50 $\times$ 8 μ m, cells at base 30-35 $\times$ 4-8 μ m; sporophyte not seen (Plate 5.129).

Habitat: Epiphytic, on branches and trunks in shola forest.

Discussion: Nath & Bansal (2010) recently gave a new combination for *Meteoriopsis ancistrodes* (Renauld & Cardot) Broth. based on the collection from Kerala state, they changed *M. ancistrodes* in to *Pseudotrachypus ancistrodes* (Renauld & Cardot) Nath & Bansal. But in the present study followed *Meteoriopsis ancistrodes*. It is characterised by the plants with irregularly pinnate branches, ovate-lanceolate leaves, folded here and there and the margin of the leaf sharply denticulate.

Distribution: World: Bhutan, Nepal (Gangulee, 1976), China (Redfearn Jr., 1986), Malaya (Mohamed & Tan, 1988), Sumatra (Ho et al., 2006), Thailand (Touw, 1968);

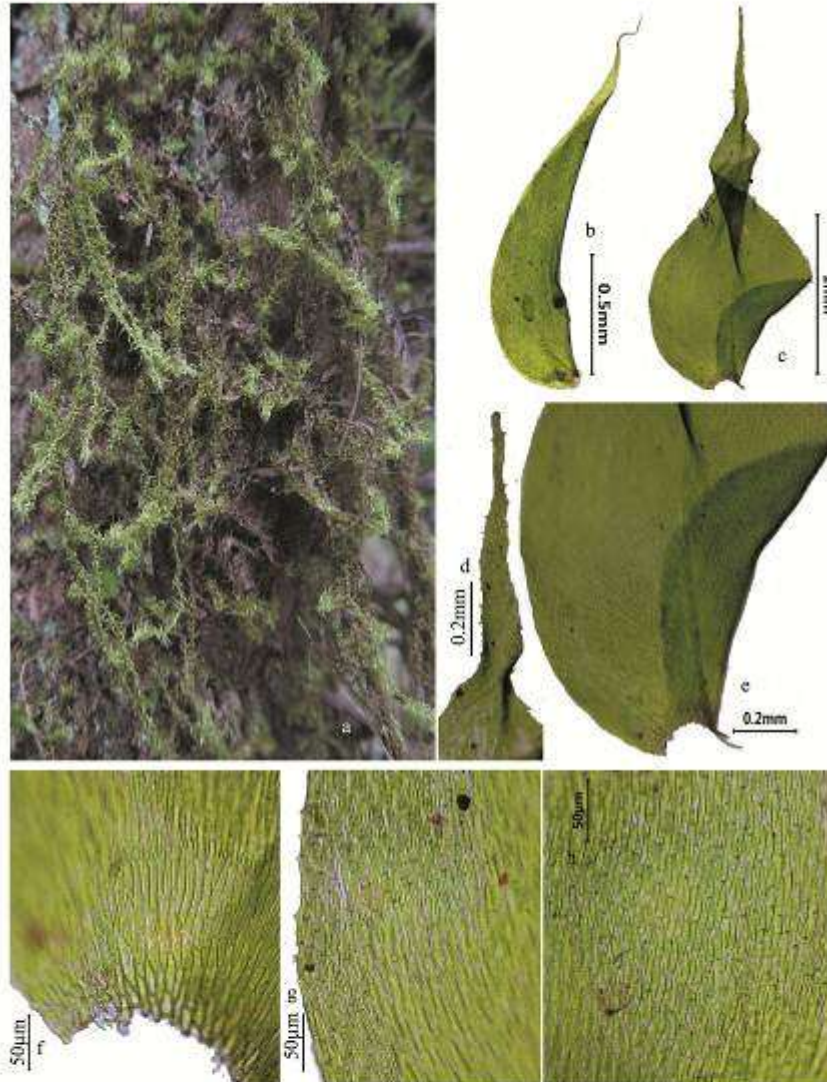


Plate 5. 129: *Meteoropsis ancistrodes* (Renauld & Cardot) Broth. : a. habit, b. leaf folded view, c. leaf, d. leaf apex, e. leaf base, f. leaf basal cells, g. leaf marginal cells, h. leaf middle cells

India: Kerala (Nath & Bansal, 2010 as *Pseudotrachypus ancistrodes*), Tamil Nadu (Tamizharasi *et al.*, 2018), Uttarakhand (Asthana & Sahu, 2013), West Bengal (Gangulee, 1976).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2100 m) 14.07.2017 *Mufeed 7516b*; Iddalymotta (1850 m) 22.09.2018 *Mufeed 9921* (ZGC).

***Meteorium* Dozy & Molk.**

Musc. Frond. Ined. Archip. Ind. 157. 1848.

Plants glossy, robust with julaceous shoots, distantly pinnately branched; leaves dense, oblong-ovate, tri-plicate, subulate to acuminate, auriculate at base; costa single, covering about half the leaf; unipapillose leaf cells, papillae either in centre of lumen, axillary hairs consisting of 1-4 short brown basal cells and 2-6 round hyaline apical cells; leaf cells thick walled, narrow, elongate, linear to rhomboid; sporophytes have seta-oriented, ovoid to oblong capsule; peristome double.

Meteorium buchananii (Brid.) Broth., Nat. Pflanzenfam. I(3): 818. 1906; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1293. 1976; Vohra & Kar, Nelumbo 38(1-4): 46. 1996; Verma *et al.*, Frahmia 102: 6. 2011. *Isothecium buchananii* Brid., Bryol. Univ. 2: 363. 1827. *Neckera buchananii* (Brid.) Müll. Hal., Syn. Musc. Frond. 2: 670. 1851. *Papillaria buchananii* (Brid.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 875: 272 (Gen. Sp. Musc. 2: 176). 1877. *Pilotrichella buchananii* (Brid.) Besch., Ann. Sci. Nat., Bot., sér. 7, 15: 74. 1892. *Trachypus buchananii* (Brid.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 129. 1859.

Plants golden green above and brownish below, hanging or suberect, pinnately branched, up to 10 cm long; leaves dense, imbricate, erect, concave, plicate, oblong-ovate, base auriculate and wide, 3 mm long and 1.5 mm wide at base; apex rounded, suddenly narrowed down into a more or less long subula, margin minutely crenulated and undulate; costa single, covering two thirds of the leaf; leaf cells incrassate, uni papillate, linear oblong to narrow rhomboidal in the subula, cells at tip 40-50 x 6 µm, cells at middle elongate rhomboid, 20-25 x 4-6 µm, cells at base 10-20 x 5-10 µm, juxta costal cells at base narrowly rectangular with highly porose

walls; sporophytes not seen (Plate 5.130).

Habitat: Epiphytic, hanging on branches and twigs in evergreen and shola forest.

Discussion: *Meteorium buchananii* (Brid.) Broth. is a very common high altitude mountain species of Nilgiri and Western Ghats of Kerala. Plants usually green above and brownish below, hanging or suberect branches, leaves oblong ovate with auriculate base, suddenly narrowed down into a more or less long subula and the laminal cells usually unipapillate.

Distribution: World: Bhutan, Nepal (Gangulee, 1978), China (Wu *et al.*, 2002), Japan (Noguchi & Iwatsuki, 1989), Papua New Guinea (Norris & Koponen, 1985), Sri Lanka (O'Shea, 2002), Vietnam (Ninh, 1993); **India:** Arunachal Pradesh (Vohra & Kar, 1996), Kerala (Dandotiya *et al.*, 2011), Manipur, Sikkim, West Bengal (Gangulee, 1976), Tamil Nadu (Daniels, 2010), Uttarakhand (Bahuguna *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600-2000 m) 02.08.2015 *Mufeed 13312*; 14.07.2014 *Mufeed 7393, 7520* (ZGC).

Other specimen/s examined: India, Eastern Himalayas (1700 m) 20.10.1958 *H.C. Gangulee 3471d* (CAL!); Western Himalayas (1520 m) 03.03.1963 *J.N. Vohra & B.M. Wadhwa 1373* (CAL!); North-Western Himalayas (2500 m) 25.03.1963 *J.N. Vohra & B.M. Wadhwa 564* (CAL!).

Trachypodopsis M. Fleisch.,
Hedwigia 45: 64. 1906.

Plants moderately slender to fairly robust, yellowish-green, often brownish, hanging down; primary stem creeping, secondary stem long, hanging down, irregularly pinnate; leaves appressed to horizontally spreading when dry, often crisped near apex, from an ovate or broadly ovate, faintly to strongly auriculate base, short to very long-acuminate, leaf margin rather faintly to strongly serrate or toothed; branch leaves sometimes shorter acuminate than the stem leaves; costa single, ending below apex; leaf cells almost isodiametric to linear, on both sides unipapillate over lumen or smooth; border cells either more elongate and forming a leaf border or not, cells

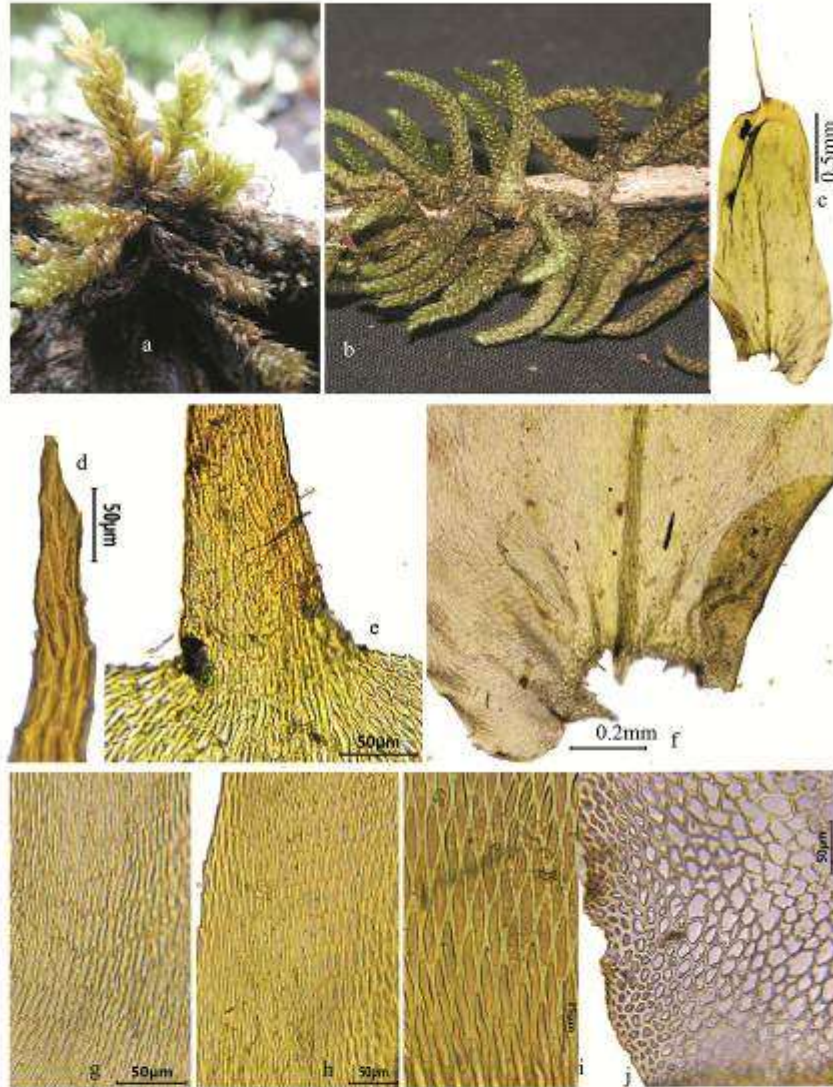


Plate 5. 130: *Meteorium buchananii* (Brid.) Broth., a&b. habit, c. leaf, d. leaf extreme tip cells, e. leaf cells near tip, f. leaf base, g. cells near middle, h. cells at margin, i. leaf cells enlarged, j. c.s. of stem

towards base more elongate, smooth, cells in the auricles mostly quadrate to rectangular, smooth, alar cells mostly present, occasionally large, quadrate to rectangular, cell walls mostly somewhat incrassate and pitted; dioicous, sporophyte lateral, seta long, erect, capsule subglobular to ovoid, peristome double, calyptra small, cucullate, spores subglobular, papillose.

Trachypodopsis serrulata (P. Beauv.) M. Fleisch., Hedwigia 45: 67. 1906; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1234. 1976; Schwarz & Frahm, Polish Bot. J. 58(2): 522. 2013; Rawat *et al.*, Bangladesh J. Taxon. 23(2): 104. 2016. *Pilotrichum serrulatum* P. Beauv., Prodr. Aethéogam. 83. 1805. *Neckera nodicaulis* Müll. Hal., Linnaea 40: 269. 1876. *Trachypus nodicaulis* (Müll. Hal.) Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 270. 1880. *Papillaria rutenbergii* Müll. Hal., Abh. Naturwiss. Vereins Bremen 7: 209. 1881. *Trachypus rutenbergii* Müll. Hal., Abh. Naturwiss. Vereins Bremen 7: 209. 1881. *Neckera macleana* Rehmman, Index Bryol. 852. 1897.

Plants yellowish brown, moderately slender to fairly robust, dense to lax mats or hanging down; secondary stem 10 cm or more long, procumbent, irregularly pinnately branched, occasionally dichotomously branched; leaves appressed to horizontally spreading when dry, up to 1 mm long and 0.4 mm wide, falcate secund, plicatae, lanceolate, more or less auriculate base gradually or somewhat abruptly rather short to very long and narrowly acuminate leaf apex, leaf margin rather faintly to strongly serrate or toothed, teeth sometimes finely denticulate; auricles small to rather large, sometimes faintly shaped like a snail-shell; costa single, ending below apex; laminal cells subisodiametric to linear, on both sides unipapillate over lumen; cells at apex, 25 x 5 µm, cells at margin 15-20 x 5 µm, cells at middle 10-20 x 6 µm, cells at base elongate, 20-30 x 3-5 µm; alar cells hardly developed to more or less distinct, but never large and numerous, quadrate to rectangular; cell walls mostly somewhat incrassate, pitted; sporophytes not seen (Plate 5.131).

Habitat: Epiphytic, hanging on branches in shola forest.

Discussion: Widely distributed species in high altitude shola forests. It is characterized by slender plants with plicate lanceolate leaves which is auriculate at

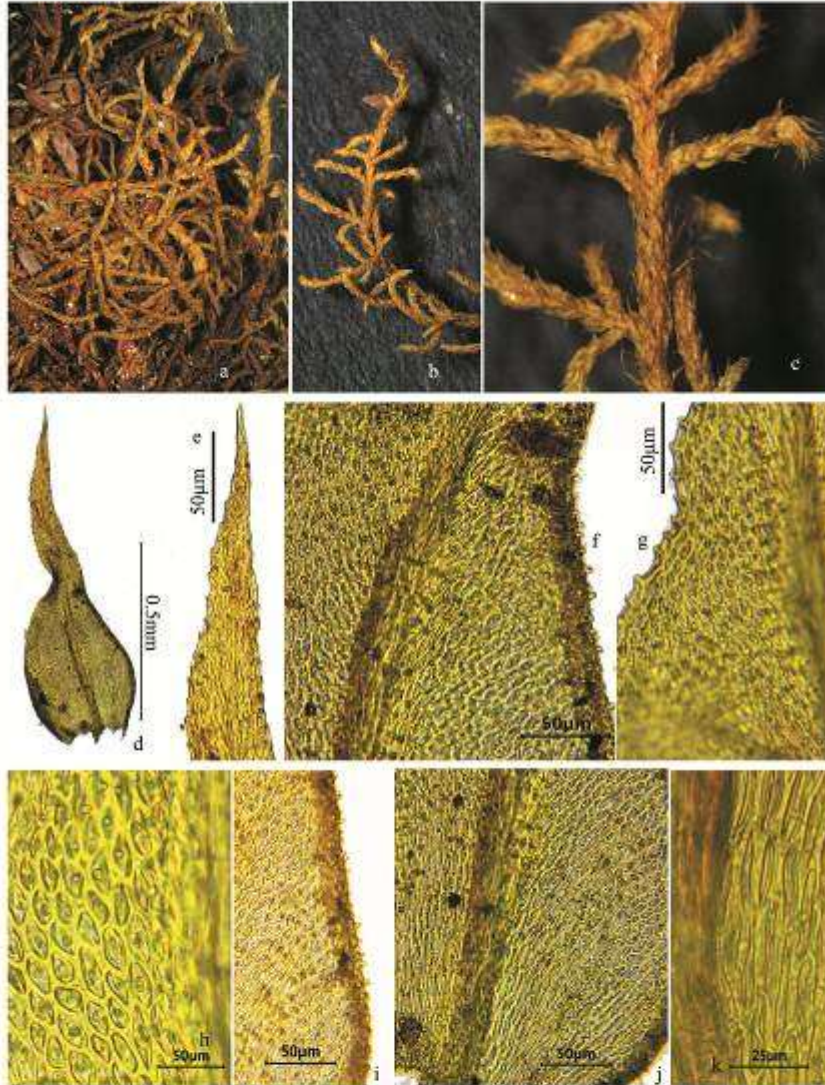


Plate 5. 131: *Trachypodopsis serrulata* (P. Beauv.) M. Fleisch., a&b. habit, c. leaf arrangement, d. leaf, e. leaf apex, f&g. leaf margin, h. leaf cells showing papillae, i. leaf marginal cells, j. leaf basal cells, k. leaf cells enlarged

base and laminal cells rhomboidal elliptical to linear with unipapillose on both sides over lumen.

Distribution: World: Africa (Magill & Rooy, 1998), Bhutan, Nepal (Gangulee, 1976), China (Wu *et al.*, 2002), Kenya, Malawi, Tanzania, Uganda, Zimbabwe (Kis, 1985), Madagascar (Crosby, 1983), Philippines (Tan & Iwatsuki, 1991); **India:** Andaman Islands (Gangulee, 1976); Arunachal Pradesh, Manipur, Sikkim, West Bengal, Nagaland (Gangulee, 1976), Karnataka (Schwarz, 2013), Kerala (Manju *et al.*, 2005), Tamil Nadu (Daniels *et al.*, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (1900 m) 03.03.2016 *Mufeed 10025* (ZGC).

***Trachypus* Reinw. & Hornsch.,**

Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 14(2): 708. 1829.

Plants very slender to robust, greenish, brownish or blackish, dense to lax mats; primary stems creeping, with tufts of blackish rhizoids and more or less scale-like lower leaves; secondary stems procumbent, ascending or somewhat hanging down, densely to remotely, irregularly or more or less regularly pinnately branched; leaves appressed to stem or horizontally spreading when dry, rarely strongly recurved when dry, up to 5 mm long, plane to longitudinally plicate, from an ovate or broadly ovate, mostly not auriculate base gradually or somewhat abruptly, short to very long and narrowly acuminate; leaf margin almost entire to moderately serrate in the upper half of the leaf, mostly crenulated; costa single, rather strong and ending above midleaf or rather faint and ending in or below midleaf; leaf cells hexagonal to elongate or linear; alar cells few, quadrate to rectangular, mostly strongly crenulate by numerous papillae, basal cells and rarely also the border cells in the upper half of the leaf smooth and more pellucid; dioicous, sporophyte on small lateral shoots, seta long, capsule erect, ovoid, brown or black, operculum conic rostrate, peristome double, calyptra campanulate, spores large, papillose.

***Trachypus bicolor* Reinw. & Hornsch.,** Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 14(2): 708. f. 39. 1829; Mitt., J. Proc. Linn. Soc., Bot. 1: 127. 1859; Bruehl, Rec. Bot. Surv. India 13(1): 64. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39:

780. 1937; Chopra, Tax. India Mosses 310. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1227. 1976; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 149. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7: 18.2008; Arch. Bryol. 42: 9. 2009 & Taiwania 54: 65. 2009; Daniels, Arch. Bryol. 65: 92. 2010. *Papillaria bicolor* (Reinw. & Hornsch.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875–76: 273 (Gen. Sp. Musc. 2: 177). 1877. *Floribundaria crispata* E.B. Bartram, Bryologist 48: 119. 1945. *Trachypus bicolor* var. *rigidus* (Broth. & Paris) Cardot, Beih. Bot. Centralbl., Abt. 2 19(2): 116. 1905. *T. perplicatus* Dixon, Farlowia 1: 35. 1943.

Plants medium-sized, green or yellowish green or yellowish brown, often blackish when older, in dense or lax mats; primary stems creeping, at times stoloniferous, stolons with reduced, scale-like leaves; secondary stems erect, simple or irregularly to regularly pinnately branched, up to 15 cm long; stems in cross section with sclerodermis of 3–5 rows of small, reddish brown, thick-walled cells, cortical cells enlarged, yellow to hyaline, firm-walled, central strand small, weakly developed; paraphyllia absent; leaves erect to spreading, somewhat crispate above when dry, ovate-lanceolate, 2-3 mm long, plane to somewhat plicate, erect-clasping at base, acuminate, ending in short hyaline hair-points, weakly auriculate, shortly decurrent, margin plane or narrowly recurved below, serrulate below, papillose-crenulate above; costa single, ending above midleaf; upper and median cells densely serially pluripapillose, over cell walls, long-hexagonal to linear, thick-walled, porose, 30–40 x 4–5 µm, extreme basal cells elongate, porose, smooth; alar cells weakly developed, quadrate to rectangular, lightly papillose, thick-walled, porose; sporophytes not seen (Plate 5.132).

Habitat: Epiphytic, on twigs and branches in evergreen and shola forest.

Discussion: *Trachypus bicolor* Reinw. & Hornsch. is a very common high altitude species. Comparing to the earlier collection, it shows that the leaves shows high variation in the morphological characters. It is characterized by the plants with yellowish brown colour above and blackish below, branching irregularly to regularly pinnate, leaves ovate lanceolate, crispate above when dry, tip ending in short hyaline hair point and the laminal cells are pluripapillose.

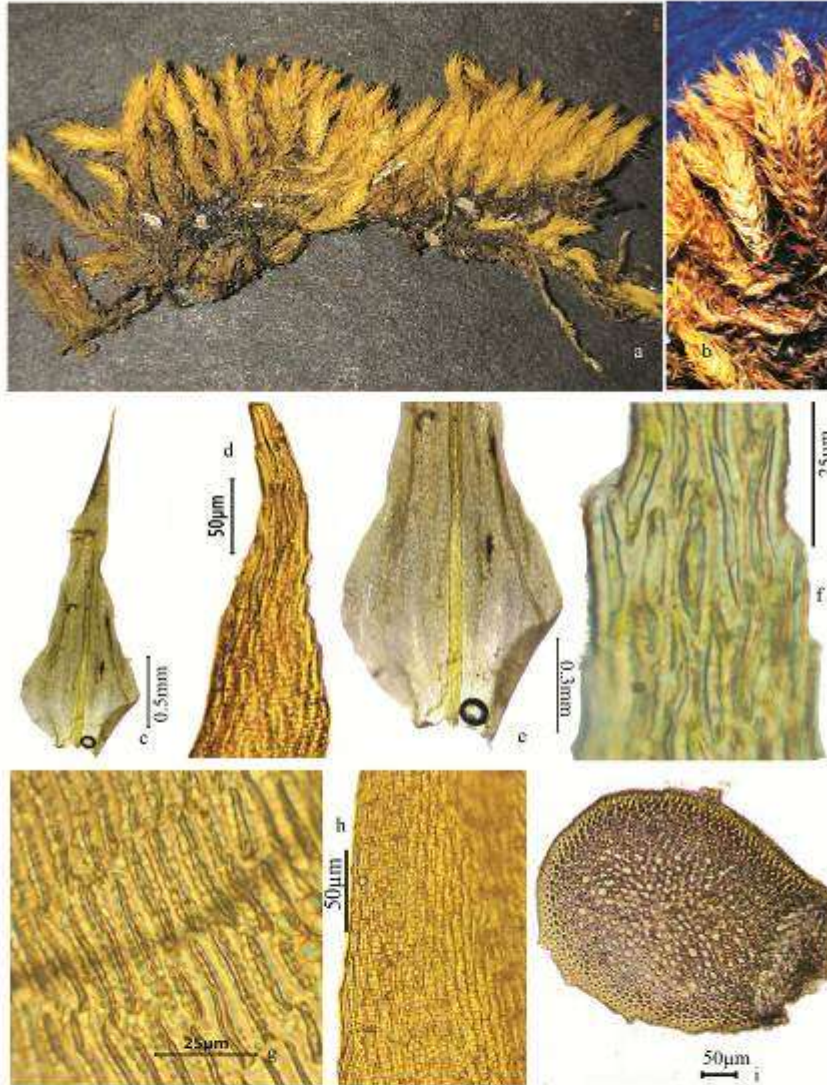


Plate 5. 132: *Trachypus bicolor* Reinw. & Hornsch., a&b. habit, c. leaf, d. leaf tip cells, e. leaf base, f. cells near tip, g. leaf middle cells, h. cells at margin, i. c.s. of stem

Distribution: World: China, Fiji, Hawaii, Indonesia, Japan, Nepal, Sri Lanka (Zanten, 1959); **India:** Arunachal Pradesh, Sikkim, West Bengal (Gangulee, 1976), Kerala (Manju *et al.*, 2005), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000–2260 m) 03.03.2016 *Mufeed 10006, 10008*; 14.07.2017 *Mufeed 7374b*; Iddalymotta (2210–2300 m) 03.03.2016 *Mufeed 10021b*; 07.11.2017 *Mufeed 7403* (ZGC).

Hypnaceae Schimp.

Coroll. Bryol. Eur. 113. 1856.

Plants robust, yellow to bright green, glossy, stem prostrate, irregularly regularly pinnate; leaves falcate, ovate or oblong lanceolate, acuminate; costa double, short or absent; paraphyllia usually present; laminal cells linear to linear flexuose; alar cells quadrate; seta long, capsule horizontal to suberect, operculum conic, obtuse to rostrate, calyptra cucullate, smooth, peristome teeth hypnoid, spores smooth to finely papillose.

Key to the genera

- 1a. Laminal cells elongate rhomboidal or linear 2
- 1b. Laminal cells ovate-rhomboidal **Vesicularia**
- 2a. Plants slender to robust with falcate secund leaves **Hypnum**
- 2b. Plants slender with ovate lanceolate leaves 3
- 3a. Leaves dentate or serrate; cells at apex papillate, alar cells not differentiated
..... **Taxiphyllum**
- 3b. Leaves minutely toothed; cells at apex non papillate; alar cells quadrate
rectangular **Isoptergium**

Hypnum Hedw.,

Sp. Musc. Frond. 236–297, pl. 59, f. 8–9; pl. 60–77. 1801.

Plants usually slender to robust, yellowish green or golden yellow, usually glossy; stem creeping and rarely erect, irregularly or pinnately branched, usually with falcate branch tip, with or without central strand; leaves erect, falcate secund, sometimes decurrent at base or more or less concave, margin plane or recurved, entire or serrulate; costa short, double, often absent; paraphyllia usually present; leaf

cells linear rhomboidal to linear, basal cells often thick walled, inflated, quadrate to rounded hexagonal; autoicous or dioicous, seta large, capsule slightly inclined, sometimes horizontal to suberect, operculum conic-rostrate, calyptra cucullate, smooth, spores spherical.

Hypnum cupressiforme Hedw., Sp. Musc. Frond. 291. 1801; Mont., Ann. Sci. Nat., Bot. 2, 17: 244. 1842; Bruehl, Rec. Bot. Surv. India 13(1): 109. 1931; Dixon, Notes Roy. Bot. Gard. Edinburgh 19: 299. 1938; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1974. 1980; Daniels, Arch. Bryol. 65: 64. 2010; Lal, Checklist Indian Moss. 78. 2005; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res. 313. 2019. *Hypnum decipiens* Hoffm. ex Brid., Muscol. Recent. Suppl. 2: 120. 1801. *H. fastigiatum* Wibel, Arch. Bot. (Leipzig) 3: 283. 1805. *Stereodon cupressiformis* (Hedw.) Brid. Ex Mitt., J. Proc. Linn. Soc., Bot. 1(Suppl.) 96. 1859. *S. complexus* Mitt., J. Linn. Soc., Bot. 8: 41. 1864. *Hypnum pseudofastigiatum* Müll. Hal. & Kindb. in Macoun, Cat. Canad. Pl., Musci 6: 235. 1892. *Cupressina filaris* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 3: 122. 1896. *Hypnum filare* Müll. Hal. In Paris, Index Bryol. Suppl. 200. 1900. *H. teichophyllum* Stirt., Ann. Scott. Nat. Hist. 16: 177. 1907. *H. deflectens* Stirt., Ann. Scott. Nat. Hist. 19: 243. 1910.

Plants up to 10 cm long, robust, greenish and shiny, slightly yellowish when dry, usually seen in the bark of large trees; stem slender, creeping, irregularly pinnately branched, branching spreading or often curved; leaves 1.7 mm long and 0.45 mm wide, imbricate, strongly curved, concave, ovate or oblong lanceolate, margin smooth; costa short, double but in some leaves costa indistinct; leaf cells linear except at base, middle cells linear and elongated than apex, 55-70 x 3-5 µm; at the apex 30-35 x 4 µm, basal alar cells quadrate to subquadrate, yellowish brown, 10-30 x 13-17 µm; sporophyte not seen (Plate 5.133).

Habitat: Epiphytic, seen on the barks of the large trees like Pines and on roots of higher plants in shola forest.

Discussion: *Hypnum cupressiforme* Hedw. is a widely distributed species in low and high altitude areas of Kerala. It is characterized by irregularly branched medium sized plants, leaves strongly curved, costa very short, double or absent in some leaves.

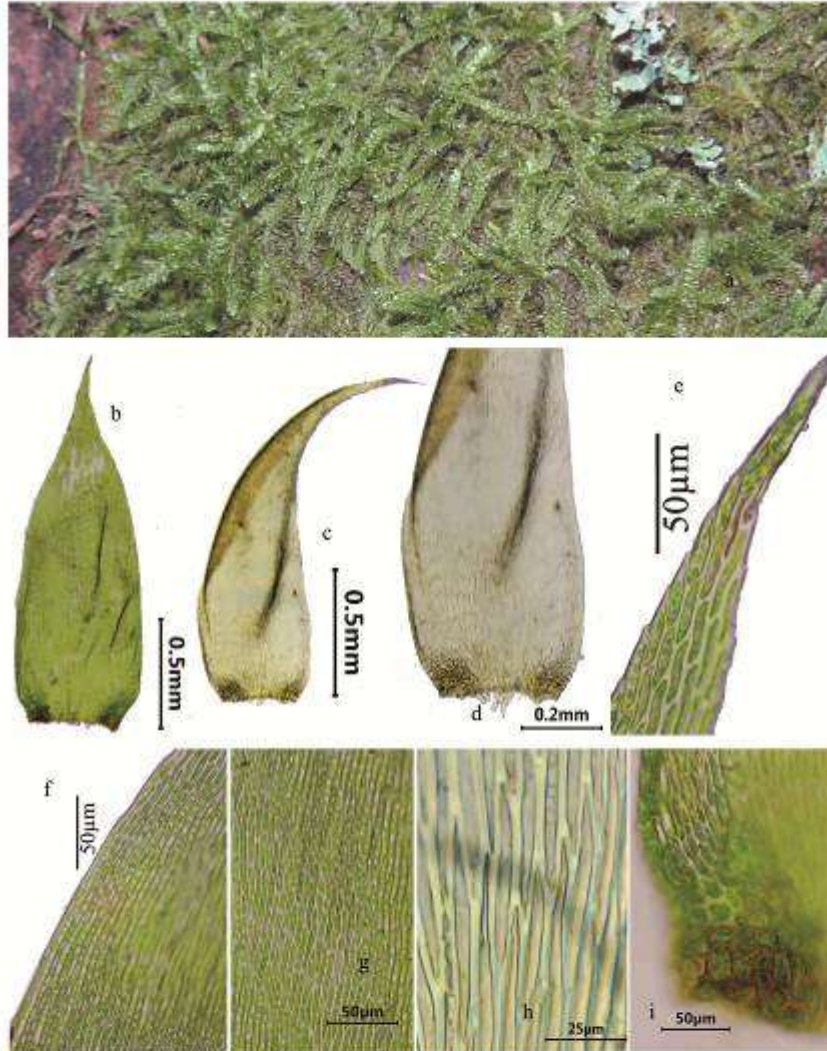


Plate 5. 133: *Hypnum cupressiforme* Hedw. a. habit, b & c. leaf, d. leaf base, e. leaf tip cells, f. marginal cells, g. median cells, h. cells enlarged, i. alar cells

Distribution: World: Australia (Dalton *et al.*, 1991), China (Redfearn Jr., 1989), Japan (Noguchi, 1994), New Zealand (Beever *et al.*, 1992), Philippines (Tan, 1991), United States (Mahler, 1978); **India:** Jammu & Kashmir (Kour *et al.*, 2015), Kerala (Dannels & Kariyappa, 2019), Sikkim, Meghalaya (Gangulee, 1980), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019), Uttaranchal (Kumar & Singh, 2002).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2174 m) 02.08.2015 *Mufeed* 13344; Mannavan Shola (2340 m) 25.09.2018 *Mufeed* 9986 (ZGC).

***Isopterygium* Mitt.**

J. Linn. Soc., Bot. 12: 21, 497–500. 1869.

Plants usually thin, glossy, yellowish green; stem irregularly pinnately branched; leaves ovate lanceolate, entire or slightly serrulate or faintly toothed at apex; costa usually double or absent; laminal cells elongate, alar cells quadrate rectangular, indistinct, slightly coloured; dioicous or autoicous; capsules inclined, operculum conic.

Isopterygium serrulatum M. Fleisch., Musci Buitenzorg 4: 1433. 1923; Bruehl, Rec. Bot. Surv. India 13(1): 112. 1931; Chopra, Taxon. Indian Moss. 535. 1975; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1951. 1980; Lal, Checklist Indian Moss. 80. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 14. 2008 & Arch. Bryol. 42: 8. 2009; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res. 320. 2019. *Plagiothecium serrulatum* Broth., Musci Buitenzorg 4: 1433. 1923.

Plants yellowish green, slender, glossy, usually creeping or ascending, irregularly branched; leaves distichous, spreading, concave, ovate lanceolate, 0.6 mm long and 0.15 mm wide, apex acute, margin dentate at apex; costa short, double, very faint; laminal cells narrow, rhomboid, 50-65 µm long and 5 µm wide, basal cells irregularly rectangular, 10-20 µm long and 10-15 µm wide; sporophyte not seen from the study area (Plate 5.134).

Habitat: Epiphytic, on bark, base and roots of higher plants in shola forest, evergreen forest and in grassland found in all altitudinal ranges of Mannavan Shola.

Discussion: Gangulee (1980) reported *Isopterygium serrulatum* M. Fleisch. from

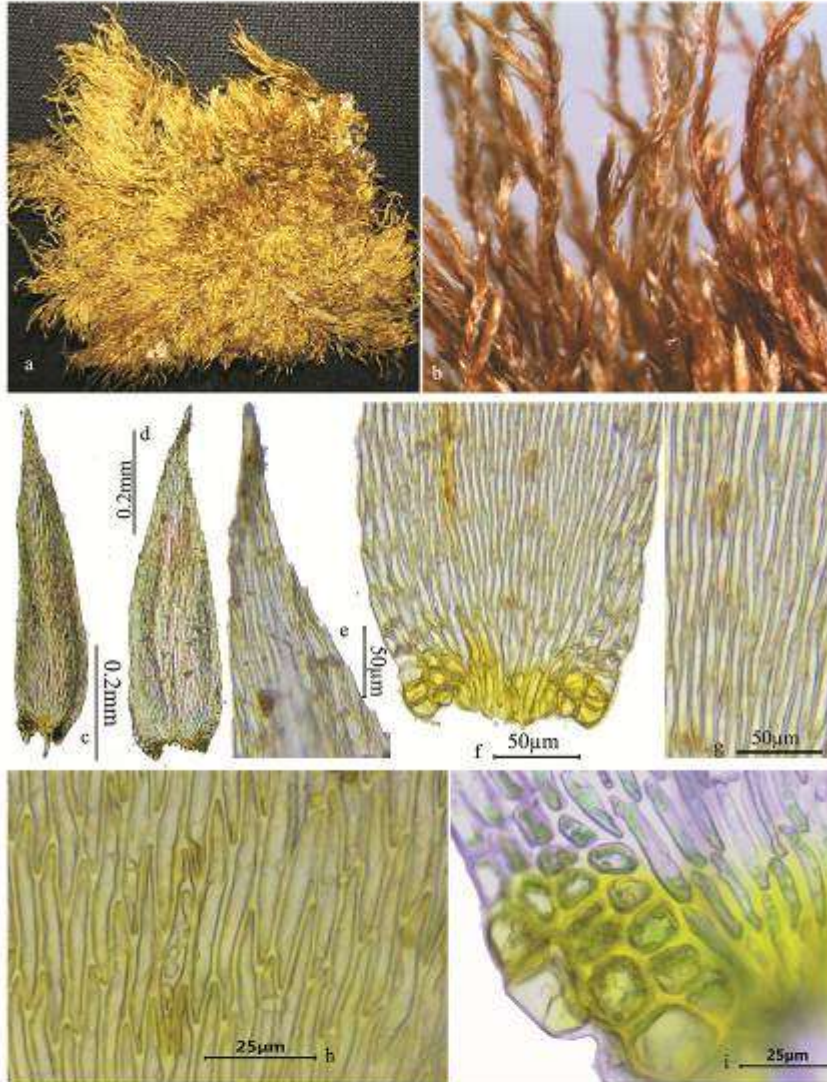


Plate 5. 134: *Isopterygium serrulatum* M. Fleisch., a&b. habit, c&d. leaf, e. leaf apex, f. leaf base, g&h. leaf middle cells, i. alar cells

Eastern Himalayas and commented that it is an endemic species. After this collection O'Shea (2003) reported this species from Bangladesh. From South India Manju *et al.* (2008) from Kerala and Daniels & Kariyappa (2019) from Tamil Nadu were reported this species. It is characterized by small creeping or ascending glossy plants, leaves ovate lanceolate with dentate margin at apex and the costa is short double and very faint.

Distribution: World: Bangladesh (O'Shea, 2003); **India:** Kerala (Manju *et al.*, 2008; Daniels & Kariyappa, 2019), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019), West Bengal (Gangulee, 1980).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600-2300 m) 03.03.2016 *Mufeed 10021*; 14.07.2017 *Mufeed 7508b, 7510, 7519a, 7521* (ZGC).

***Taxiphyllum* M. Fleisch.**

Musci Buitenzorg 4: 1434–1438. 1923.

Plants thin, medium sized, glossy, green or yellowish green; stem creeping, irregularly branched; leaves complanate, ovate lanceolate, dentate or entire at margin, acuminate; laminal cells usually elongate to rhomboid, minutely papillose on tips; costa short, double, or absent; dioicous, seta long or short, capsule inclined, ovate cylindrical, operculum rostrate.

Taxiphyllum taxirameum (Mitt.) M. Fleisch., Musci Buitenzorg 4: 1435. 1923; Bruehl, Rec. Bot. Surv. India 13(1): 113. 1931; Chopra, Taxon. Indian Moss. 536. 1975; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1945. 1980; Lal, Checklist Indian Moss. 130. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 18. 2008 & Taiwan 54: 66. 2009; Daniels *et al.*, Bryoflor. Indira Gandhi Natl. Pk. 267. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res. 1: 322. 2019. *Stereodon taxirameus* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 105. 1859. *Isopterygium planissimum* Mitt., J. Linn. Soc., Bot. 12: 498. 1869. *Rhynchostegium geophilum* Austin, Musci Appalach. 345. 1870. *Isopterygium geophilum* (Austin) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 437 (Gen. Sp. Musc. 2: 503). 1878. *I. taxirameum* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77:

439 (Gen. Sp. Musc. 2: 505). 1878. *I. elegantifrons* Müll. Hal., Hedwigia 37: 251. 1898. *I. maniae* Renauld & Paris, Rev. Bryol. 29: 84. 1902. *Hylocomium isopterygioides* Broth. & Paris, Rev. Bryol. 33: 27. 1906. *Isopterygium cavernicola* Cardot, Rev. Bryol. 37: 56. 1910. *Plagiothecium geophilum* (Austin) Grout, Moss. Hand-lens Microsc. 370. 1910. *Isopterygium tsunodae* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 62A(9): 42. 1921. *Taxiphyllum geophilum* (Austin) M. Fleisch., Musci Buitenzorg 4: 1435. 1923. *T. maniae* (Renauld & Paris) M. Fleisch., Musci Buitenzorg 4: 1435, 1436. 1923.

Plants in thin to dense mats, yellowish-green, glossy, stem up to 6 cm long, prostrate, rarely radiculose ventrally; leaves rigid, usually distant, wide-spreading to squarrose, flat or somewhat concave, smooth or plicate, 1-1.3 x 0.3-0.6 mm, ovate or oblong-lanceolate, rarely narrowly ovate, acuminate or abruptly narrowed to an acute tip; margin very narrowly recurved almost to apex, sometimes plane, serrulate to serrate throughout; costa short double; cells elongate, median cells 50-75 x 5 µm; basal cells elongate, 40-60 x 10-15 µm; asexually reproduce by gemmae, elongated, aggregated at the tip of the shoot; reproductive structures not seen (Plate 5.135).

Habitat: Epiphytic, on branches and twigs in shola forest and grasslands in all altitudinal ranges.

Discussion: A common species in medium and high altitude mountains of South India and widely distributed in the study area. From Kerala this species was previously reported by Manju *et al.* (2008 & 2009). It is characterized by yellowish green glossy plants with oblong lanceolate leaves which are serrate throughout and the costa is short and double.

Distribution: World: Bangladesh (O'Shea, 2003), Bhutan, Nepal, (Gangulee, 1980), China (Higuchi *et al.*, 2010), Indonesia (Tan *et al.*, 2006), Japan (Suzuki, 2016), Malaysia (Suleiman *et al.*, 2017), Sri Lanka (O'Shea, 2002), Thailand (Noguchi, 1972), Uganda (O'Shea *et al.*, 2003); **India:** Arunachal Pradesh, Assam, Orissa, West Bengal (Gangulee, 1980), Jammu & Kashmir (Sharma *et al.*, 2016), Kerala (Mufeed *et al.*, 2014), Punjab (Bartram, 1955), Tamil Nadu (Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park,

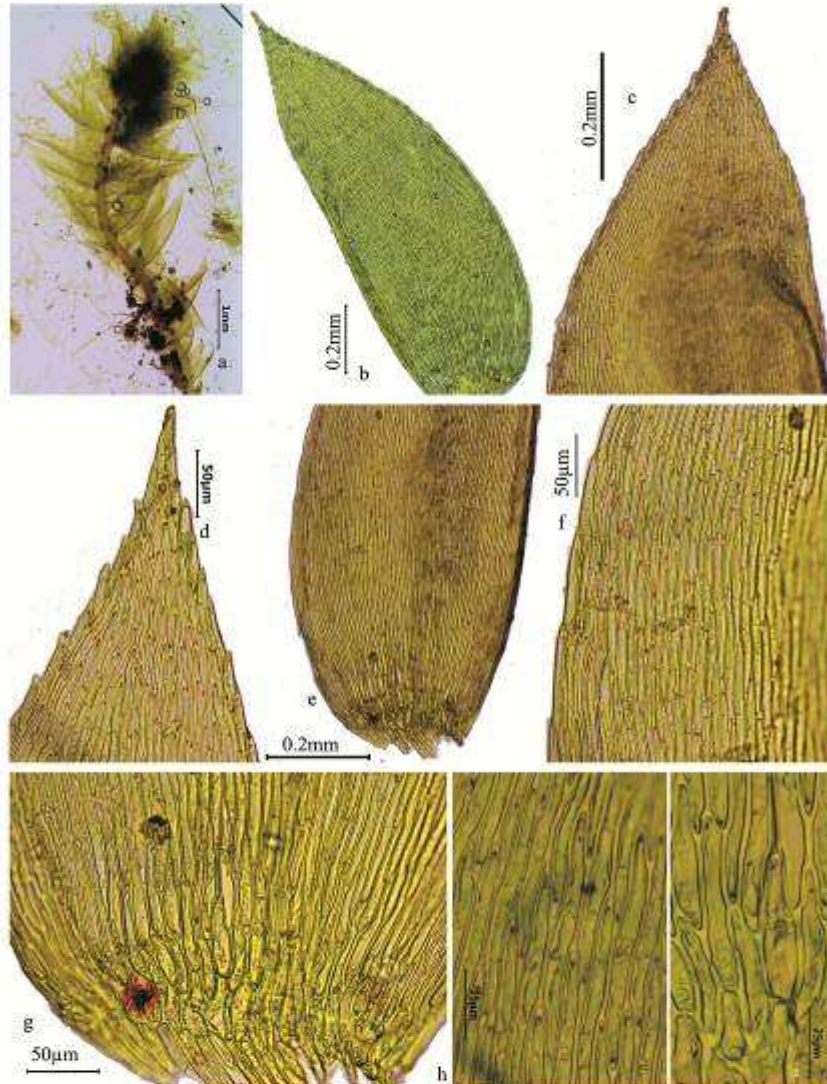


Plate 5. 135: *Taxiphyllum taxirameum* (Mitt.) M. Fleisch., a. habit, b. leaf, c. leaf apex, d. leaf tip cells, e. leaf base, f. leaf marginal cells, g. leaf basal cells, h&i. leaf cells at base

Mannavan Shola (1700-1890 m) 14.07.2017 *Mufeed* 7558b, 7574; Iddalymotta (2000-2260 m) 03.03.2016 *Mufeed* 10005; 02.08.2015 *Mufeed* 13322 (ZGC).

Vesicularia (Müll. Hal.) Müll. Hal.,
Bot. Jahrb. Syst. 23(3): 330. 1896.

Plants yellowish green to dull green in mats; stem creeping, pinnately branched, spreading, complanate; leaves ovate, long or short acuminate, entire or faintly denticulate margin; costa double, short or absent; leaf cells lax, elongate, ovate rhomboid, smooth, chlorophyllose, alar cells not differentiated; seta long, capsule horizontal to drooping, operculum conic, calyptra cucullate.

Key to the genera

- 1a. Leaves ovate with acute tip; costa double, short, weak, reaches up to mid leaf
..... ***V. levieri***
1b. Leaves ovate to lanceolate with acute tip; costa usually absent ***V. vesicularis***

Vesicularia levieri Cardot, J. Indian Bot. 2: 187, 10. 1921; H.N. Dixon, J. Indian Bot. 2(6-7): 180. 1921; Gangulee, Mosses E. India & Adj. Reg. 3(8): 2000. 1980; Frahm *et al.*, Arch. Bryol. 158: 11. 2013; Ellis *et al.*, J. Bryol. 41(4): 380. 2019.

Plants yellowish green, creeping; branching irregularly pinnate with short branches; leaves erectopatent, some of them falcate, ovate with acute tip, concave, up to 2 mm long and 0.8 mm wide at middle; margin finely denticulate in upper half, crenulated below; costa short double; laminal cells rhomboid, 100-125 x 15-20 µm: at extreme base irregularly rectangular cells, 35-60 x 15-25 µm; reproductive structures not seen (Plate 5.136).

Habitat: Epiphytic, on barks in shola forest.

Discussion: It is an endemic species to India. Dixon (1921) described this species as syntype from Karnataka. Later, Gangulee (1980) reported this species from Andaman Islands. The present collection is a new record for Kerala. It is characterized by yellowish green plants with erectopatent falcate leaves with acute tip and the costa is usually double and short.

Distribution: India: Andaman Islands (Gangulee, 1980), Karnataka (Dixon, 1921; Frahm *et al.*, 2013), Kerala (present collection).

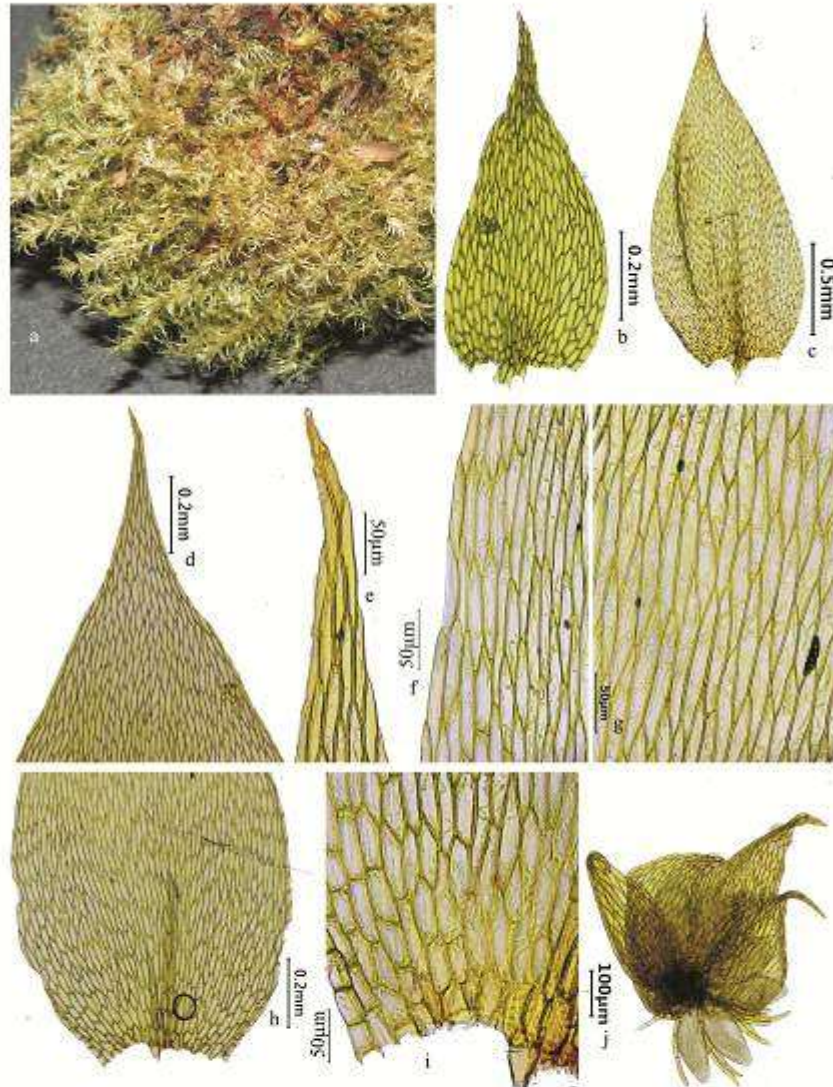


Plate 5. 136: *Vesicularia levieri* Cardot, a. habit, b&c. leaf, d. leaf apex, e. leaf extreme tip, f. leaf margin, g. leaf cells, g. leaf base showing double costa, i. leaf basal cells, j. antheridial cluster with perigonial leaves

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 14.07.2017 *Mufeed* 7537 (ZGC).

Vesicularia vesicularis (Schwägr.) Broth. var. ***vesicularis*** Nat. Pflanzenfam. 1(3): 1094. 1908; Bruehl, Rec. Bot. Surv. India 13(1): 113. 1931; Chopra, Taxon. Indian Moss. 538. 1975; Lal, Checklist Indian Moss. 140. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 190. 2005; Frahm *et al.*, Arch. Bryol. 158: 11. 2013. *Hypnum vesiculare* Schwägr., Sp. Musc. Suppl. 2(2): 167. 1827. *Pterygophyllum montagnei* Bel., Voyag. Ind. Or. Bot. 2: 85. 1834. *Hookeria meyeniana* Hamp., Icon. Musc. 3. 1844. *Hypnum montagnei* Schimp in Montin, Remon de la Sagra, Hist. Fis. Cuba Bot. Pl. Cell. 9: 530. 1845. *H. meyenianum* (Hamp.) Müll. Hal., Synop. Musc. Frond. 2: 233. 1851. *Ectropothecium meyenianum* (Hamp.) Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-78: 268. 1880. *E. montagnei* (Bel.) A. Jaeger, *ibid.* 269. 1880. *Vesicularia montagnei* (Bel.) Broth. in Engl & Prantl, Nat. Pflanzenfam. 1(3): 1094. 1908; Gangulee, Mosses E. India & Adj. Reg. 3(8): 2001. 1980; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 323. 2019.

Plants yellowish green or pale yellow, creeping, branching irregularly pinnate with short branches; leaves erectopatent, some of them falcate, ovate lanceolate with acute tip, concave, up to 1 mm long and 0.2 mm wide at middle, margin entire; costa absent; laminal cells rhomboid, 45-60 x 4-6 µm, at extreme base irregular rectangular cells, 25 x 15 µm; reproductive structures not seen (Plate 5.137).

Habitat: Epiphytic, on barks of trees in shola forest.

Discussion: Gangulee (1980) treated this species as *Vesicularia montagnei* (Bel.) Broth. collected from Arunachal Pradesh and West Bengal. O'Shea (2006) synonymised this under *Vesicularia vesicularis* (Schwägr.) Broth. var. *vesicularis*. Nair *et al.* (2005) accepted this and considered *V. vesicularis*. Some authors like, Daniels & Kariyappa (2019) followed Gangulee (1980). Here, following O'Shea (2006) as both the species shows similar gametophytic characters.

Distribution: World: Bangladesh (Gangulee, 1980), Japan (Noguchi *et al.*, 1994), Philippines (Tan & Iwatsuki, 1991), Thailand (Dixon, 1932); **India:** Arunachal Pradesh, West Bengal (Gangulee, 1980), Kerala (Nair *et al.*, 2005), Tamil Nadu (Daniels & Kariyappa, 2019).



Plate 5. 137: *Vesicularia vesicularis* (Schwaegr.) Broth. var. *vesicularis*, a&b. habit, c. single plant, d. leaf, e. leaf apex, f. cells at tip, g. leaf base, h. basal cells

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000 m) 04.03.2016 *Mufeed 10041* (ZGC).

Hylocomiaceae M. Fleisch.

Nova Guinea 12(2): 125. 1914.

Plants rigid, robust, pinnate, glossy, densely foliate in loose tufts; stem leaves often differentiated from branch leaves; leaves acuminate, serrated at tip or completely serrated at margin; costa double, rarely single; alar cells well differentiated, rarely indistinct, cells linear- rhomboid to elliptic; seta long, smooth, capsule large, ovoid, mostly horizontal, sometimes erect, operculum short, conic.

Key to the genera

- 1a. Plants slender, leaves lanceolate with cordate base **Ctenidium**
- 1b. Plants moderately robust, leaves oblong or ovate-lanceolate with cordate base.. 2
- 2a. Leaves longitudinally plicate; costa double reaching up to mid leaf; faintly toothed **Macrothamnium**
- 2b. Leaves not plicate; costa short double; margin dentate at apex .. **Leptohymenium**

Ctenidium (Schimp.) Mitt.,

J. Linn. Soc., Bot. 12: 509. 1869.

Plants slender, branches prostrate; leaves lanceolate, cordate at base, toothed at margin, acuminate; costa double, very short or absent; cells linear to elongated, papillate at apex or absent; alar region differentiated; seta long, reddish, capsules inclined to horizontal, ovoid cylindrical, mostly curved at base, calyptra often pilose, operculum conic, apiculate, peristome teeth 2 rowed, hypnoid.

Ctenidium lychnites (Mitt.) Broth., Nat. Pflanzenfam. I(3): 1048. 1909; Brühl, Rec. Bot. Surv. India 13(1): 118. 1931; Chopra, Taxon. Indian Moss. 540.1975; Gangulee, Mosses E. India & Adj. Reg. 3(8): 2013. 1980; Lal, Checklist Indian Moss.: 43. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 190. 2005; Manju *et al.*, Trop. Bryol. Res. Rep. 7:10. 2008 & Taiwania 54: 66. 2009; Daniels, Arch. Bryol. 65: 48. 2010; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 306. 2019. *Stereodon lychnites* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 114. 1859. *Hypnum lychnites* (Mitt.) Müll. Hal., Linnaea 36: 8. 1869. *Hyocomium lychnites* (Mitt.) Mitt., Trans.

Linn. Soc. London, Bot. 3: 177. 1891.

Plants slender, yellowish to golden green in dense tufts, main stem creeping, branching more or less regularly pinnate; leaves lanceolate, imbricate, erectopatent, narrowed into a slender curved acumen from a wide cordate base, 1.8 mm long and 0.5-0.6 mm wide at base, margin strongly denticulate almost to base; costa very short, indistinct, double or in some leaves ecostate; laminal cells linear, cells at apex, 40-55 µm long and 5 µm wide, cells at middle, 45-65 µm long and 5-7 µm wide, cells at base 20-30 µm long and 5 µm wide; alar cells hyaline, quadrate rectangular, 8-12 µm long and 8-10 µm wide; sporophyte not observed (Plate 5.138).

Habitat: Epiphytic, on branches and twigs in evergreen and shola forest in all altitudinal ranges.

Discussion: *Ctenidium lychnites* (Mitt.) Broth. is a widely distributed species in evergreen and shola forests of high altitude regions. It is characterized by its yellowish green plants with short branches, leaves narrow into slender, curved acumen from a cordate base with denticulate margin and the costa is usually absent if present it is double very small and indistinct.

Distribution: World: China (Redfearn Jr., 1986), Malaysia (Tixier, 1974), Philippines (Vohra & Kar, 1996), Sri Lanka (Herath *et al.*, 2019); **India:** Kerala (Nair *et al.*, 2005; Manju *et al.*, 2008 & 2009), Nicobar Islands (Vohra & Kar, 1996), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019),

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Jandamala (1850 m) 09.11.2017 *Mufeed* 7445; Mannavan Shola (1650-2300 m) 24.09.2018 *Mufeed* 7544,10012 (ZGC).

Other specimen/s examined: India, Tamil Nadu, Palni Hills 1959 *Gangulee* (78/20) 2-2 (CAL!).

***Leptohymenium* Schwägr.**

Sp. Musc. Frond., Suppl. 3 (1,2): 246. 1828.

Plants moderately robust, glossy, rigid, yellowish green to brownish in thick tufts; branching pinnate to tripinnate, may be flagellate; paraphyllia usually absent; leaves acuminate from a cordate to oblong ovate base, concave; costa short double; leaf

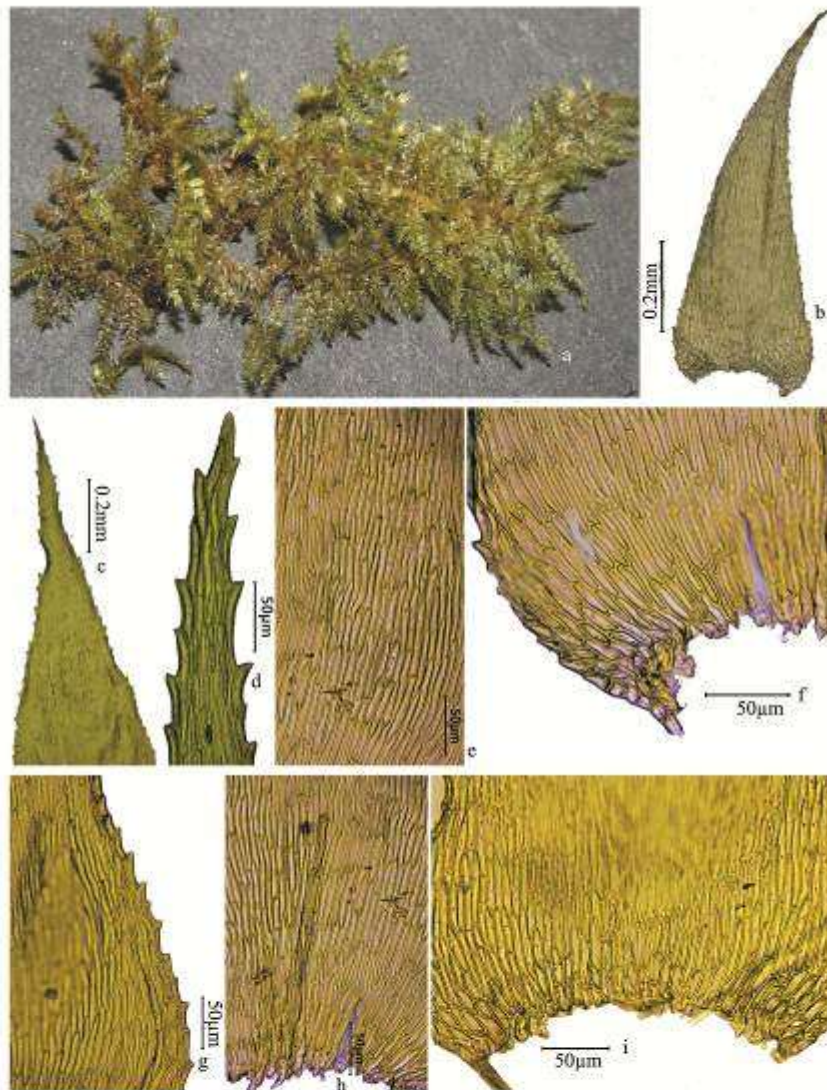


Plate 5. 138: *Ctenidium lychnites* (Mitt.) Broth., a. habit, b. leaf, c. leaf apex, d. leaf tip cells enlarged, e. leaf middle cells, f. leaf basal cells, g. leaf marginal cells, h. leaf base showing double costa, i. leaf base

cells linear rhomboid, papillose at cell tips; margin dentate at tip; alar cells differentiated; seta long and slender; capsule erect, symmetrical, ovate cylindrical; operculum conical apiculate.

Leptohymenium tenue (Hook.) Schwägr., Sp. Musc. Frond., Suppl. 3 (1,2): 246. 1828; Gangulee, Mosses E. India & Adj. Reg. 3(8): 2035. 1980; Lal, Checklist Indian Moss. 82. 2005; Manju & Rajesh, J. Econ. Tax. Bot. 34(2): 392. 2010. *Neckera tenuis* Hook., Trans. Linn. Soc. London 9: 315, 27 f. 3. 1808. *Bruchia tenue* (Hook.) Hornsch., Flora 8: 9. 1825. *Pterigynandrum tenue* (Hook.) Brid., Bryol. Univ. 2: 187. 1827. *Hypnum tenue* (Hook.) Müll. Hal., Syn. Musc. Frond. 2: 452. 1851. *Stereodon tenuis* (Hook.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 114. 1859. *Pleurozium ehrenbergianum* (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 537. 1869. *Hylocomium ehrenbergianum* (Müll. Hal.) Besch., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 255. 1872. *Leptohymenium patulum* Schimp. ex Besch., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 246. 1872. *L. patulum* Schimp. ex Besch., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 246. 1872. *Stenothecium tenue* (Hook.) Müll. Hal., Index Bryol. 4: 320. 1905. *Leptohymenium ehrenbergianum* (Müll. Hal.) M. Fleisch. & Thér., Smithsonian Misc. Collect. 85(4): 44. 1931.

Plants in dense tufts, fairly robust, brownish green, glossy; main stem creeping and secondary branches usually ascending or erect; branches bare at base, densely leafy above; leaves patent to spreading, oblong lanceolate to ovate lanceolate, concave, apex short acute apiculate, 1.9 x 0.7 mm, wide at base; margin dentate at apex; costa short, double; laminal cells linear rhomboid 60-70 x 6 µm, cells at apex 15-25 x 5 µm, alar region differentiated by groups of hyaline cells, quadrangular to sub-quadrangular, 10-20 x 7-10 µm; sporophyte not seen (Plate 5.139).

Habitat: Epiphytic, on branches and twigs associated with *Myurium borii* (Dixon) Magill and *Cryptopapillaria fuscescens* (Hook.) M. Menzel in shola forest.

Discussion: A common species in high altitude mountain of Kerala. It is characterized by its oblong lanceolate leaves with short double costa and the alar region differentiated by groups of hyaline quadrangular to sub-quadrangular cells.

Distribution: World: Bhutan, Nepal (Gangulee, 1980), China (Redfearn Jr. & Wu,

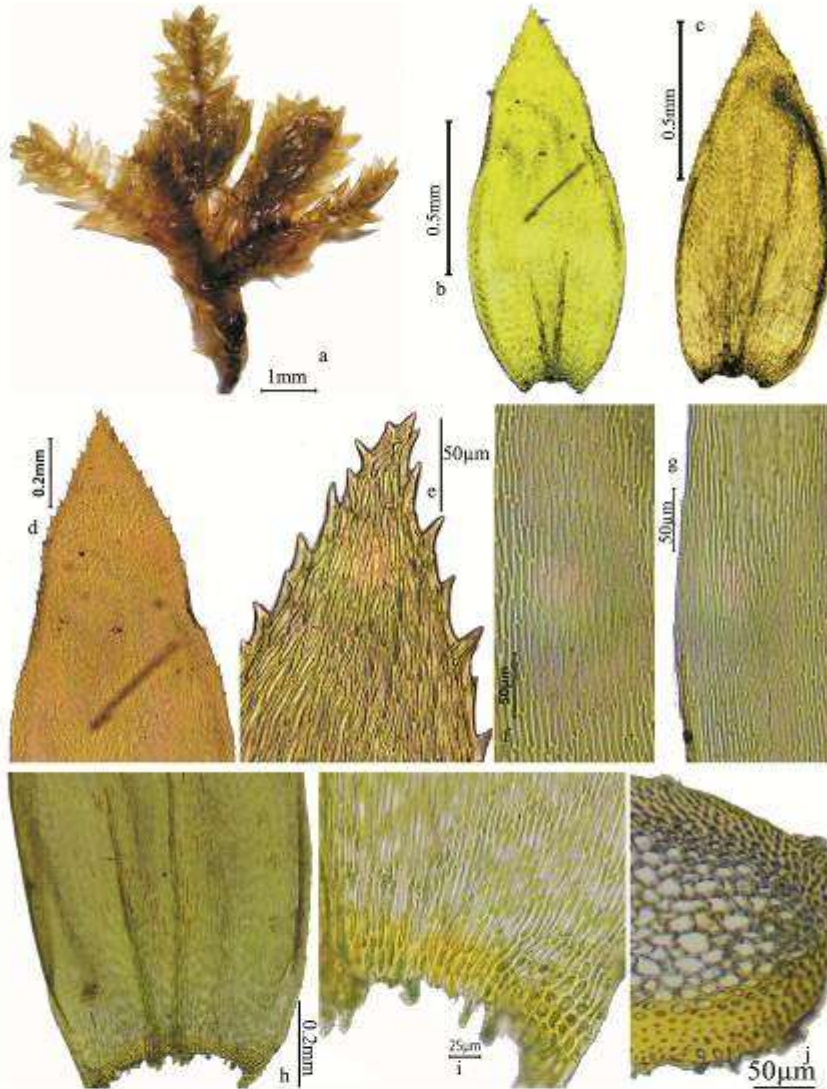


Plate 5. 139: *Leptohymerium tenue* (Hook.) Schwägr., a. habit b&c. leaf d. leaf apex e. leaf tip cells f. leaf cells g. leaf marginal cells h. leaf base i. leaf basal cells j. stem c.s.

1986), Mexico (Rohrer, 1986), Philippines (Tan & Iwatsuki, 1991), Thailand (Touw, 1986); **India:** Kerala (Manju & Rajesh, 2010), Nagaland, Sikkim, West Bengal (Gangulee, 1980).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000 m) 12.07.2017 *Mufeed 7313a* (ZGC).

Macrothamnium M. Fleisch.,
Nova Guinea 12: 125. 1914.

Plants glossy, moderately robust; stem prostrate, with curved, ascending branches, usually branched at or near the base; leaves distant but above densely arranged with fasciculate branches; leaves heteromorphous, cordate or ovate lanceolate, sometimes indistinctly longitudinally plicate, faintly or strongly toothed; stem leaves strongly acuminate; costa double, either distinctly reaching to the midleaf or shorter; cells linear rhomboid to elliptic, mostly with small papillae on the upper angles; near the base shorter and wider, colourless, alar cells mostly not differentiated; branch leaves broadly ovate to ovate spatulate; seta long, capsule inclined to pendulous, ovoid-oblong to thick cylindric, shining brown.

Macrothamnium macrocarpum (Reinw. & Hornsch.) Fleisch., Hedwigia 44: 308. 1905; Gangulee, Mosses E. India & Adj. Reg. 3(8): 2029. 1980; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 155. 2005. *Hypnum macrocarpum* Reinw. & Hornsch., Nova Acta Leop. 14: 725, 41. 1829. *H. discriminatum* Mont. Syn. Musc. Frond. 2: 452. 1851. *H. pseudostriatum* Müll. Hal. Bot. Zeitung (Berlin) 14: 458. 1856. *Macrothamnium pseudostriatum* (Müll. Hal.) M. Fleisch. Hedwigia 44: 310. 1905. *Microthamnium submacrocarpum* A. Jaeger ex Renauld & Cardot Bull. Soc. Roy. Bot. Belgique 41(1): 99. 1905. *Macrothamnium mauense* Broth. Bernice P. Bishop Mus. Bull. 40: 34. 1927. *M. longirostre* Dixon Trav. Bryol. 1[13]: 19. 1942.

Plants robust, yellowish green to golden, glossy, simple, bi or tri pinnate branches; leaves spreading, base broadly wide, cordate to orbicular, plicate, margin denticulate, acute at the apex, stem leaves and branch leaves similar but size may vary, 1-1.5 x 0.9 mm at middle; costa short, double, reach up to midleaf; laminal cells narrow rhomboid, cells at apex 14-16 x 5-8 µm, cells at middle 12-20 x 4-7

µm, cells at margin 10-12 x 6-8 µm, cells at extreme base 32-34 x 7 µm, alar cells not differentiated; c.s. of stem rounded to oval, central strand small; reproductive structure not seen (Plate 5.140).

Habitat: Epiphytic, on branches of the trees in shola forest seen at altitude above 2200 m.

Discussion: *Macrothamnium macrocarpum* (Reinw. & Hornsch.) Fleisch. is a very common high altitude species in Kerala, but rarely spotted in the study area. It is characterized by golden glossy branched plants with cordate to orbicular leaves with short double costa, which reach up to middle, laminal cells are rhomboid and strongly denticulate at margin.

Distribution: World: Nepal, Bhutan (Gangulee, 1980), Sri Lanka (O'Shea, 2002); **India:** Kerala (Nair *et al.*, 2005), Arunachal Pradesh, Assam, Sikkim (Gangulee, 1980), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2320 m) 03.03.2016 *Mufeed 10020*; Iddalymotta (2240 m) 07.11.2017 *Mufeed 7410* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Chembra hills (1560-1760 m) *Manju C.N. 99608*, *Manju C.N. 120398*, Periya (960 m) *Manju C.N. 99612* (CALI!).

Symphyodontaceae M. Fleisch.,

Musci Buitenzorg 4: 1110. 1923.

Plants glossy, caespitose, medium to robust; branching pinnate, ascending, rarely pendant; leaves ovate, concave, serrulate or dentate at apex; leaf cells linear, generally papillose; costa double, short; seta long, capsules erect or nodding, operculum conic rostrate, calyptra cucullate.

Symphyodon Mont.,

Ann. Sci. Nat. Bot., s6r. 2, 16: 279. 1841.

Plants small to large, yellowish green, golden yellow, stem prostrate, irregularly pinnately branched to regularly bipinnately or tripinnately branched; central strand

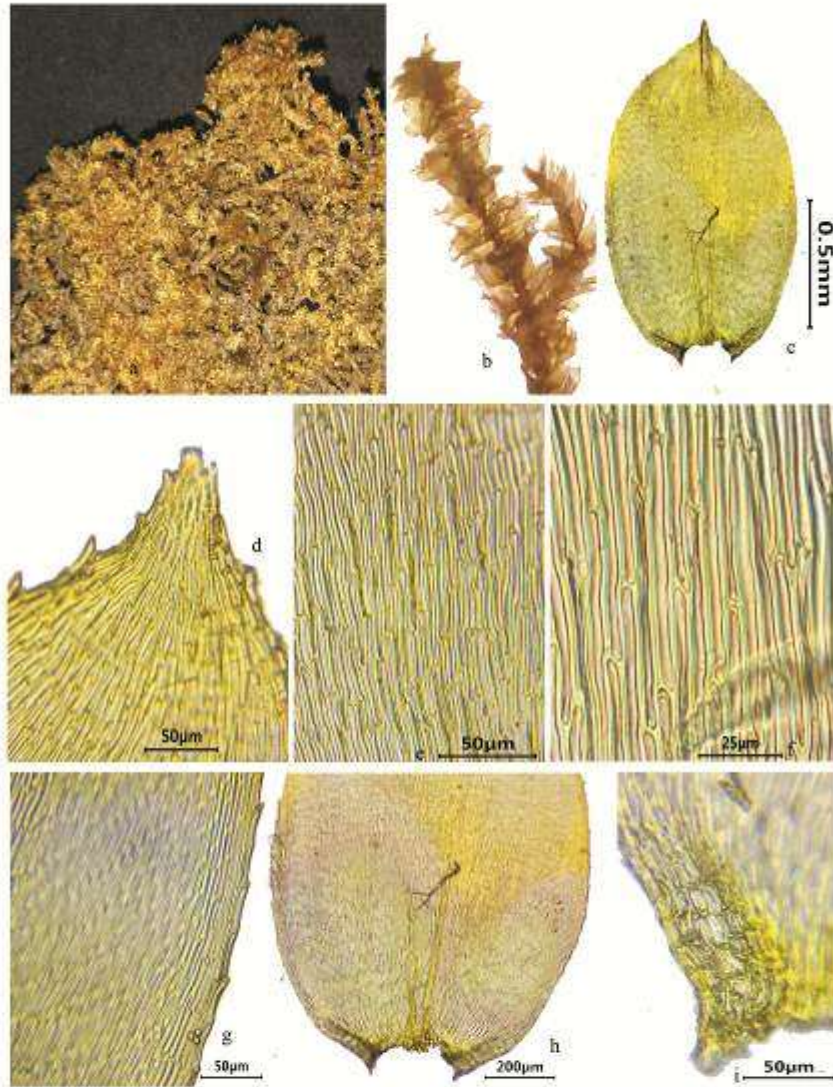


Plate 5. 140: *Macrothamnium macrocarpum* (Reinw. & Hornsch.) M. Fleisch., a&b. habit, c. leaf, d. leaf tip, e&f. leaf middle cells, g. leaf margin, h. leaf base with double costa, i. alar cells

absent; stem and branch leaves similar or dimorphic, plane to deeply concave; leaves oval to oblong-ovate, oblong-lanceolate or lingulate, leaf apex truncate, rounded, obtuse, apiculate, or acute to acuminate; margin plane to slightly inflexed, finely serrulate or dentate; costa double, unequal, extending to 1/2 of total leaf length; apical leaf cells undifferentiated or conspicuously shorter than adjacent cells, median cells linear, alar cells more or less differentiated, quadrate to subquadrate, or irregularly rectangular, thin to thick walled of 3-5 rows of cells extending 3-6 cells up above margin; dioicous.

Symphyodon erraticus (Mitt.) A. Jaeger, Ber. Thatigk. St. Gallischen Naturwiss. Ges.: 296. 1878; Bruehl, Rec. Bot. Surv. India 13(1): 83. 1931; Gangulee, Mosses E. India & Adj. Reg. 2(6): 1517, f. 759. 1977; He, Bryologist 103: 75. 2000; Lal, Checklist Indian Moss. 128. 2005; Daniels & Daniel, Bryofl. Indira Gandhi Natl. Pk. 231. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 279. 2019. *Stereodon erraticus* Mitt., J. Proc. Linn. Soc., Bot. 2(Suppl.): 111. 1859.

Plants robust, 1–1.5 cm long, yellowish green, stem creeping, ovate, without a central strand; branches erect, 2–3 pinnate; leaves many-rowed, patent, 1.10–1.20 mm long and 0.35–0.45 mm wide, ovate-lanceolate, concave, margin entire below, recurved above, toothed at apex; cells linear elongate, sometimes with raised, papillate apices; apical cells 17–20 x 4–6 µm; median cells 44–55 x 5–7 µm, basal cells 25–40 x 7–10 µm, cells at extreme base quadrate, 13–23 x 8–10 µm; costa short, double, 1/3 as long as leaf; sporophyte not observed (Plate 5.141).

Habitat: Epiphytic, on barks of trees in shola forest.

Discussion: *Symphyodon erraticus* (Mitt.) A. Jaeger is an Asiatic species found in high altitude areas. From India, this taxa is earlier reported only from Eastern Himalayas and Tamil Nadu. Hence the present collection is a new record to Kerala. It is characterized by yellowish green plants, ovate-lanceolate leaves with short double costa and laminal cells linear elongate.

Distribution: World: Bangladesh (O’Shea, 2003), Bhutan, Nepal (Gangulee, 1977), Indonesia (Ho *et al.*, 2006), Sri Lanka, Myanmar, Thailand (He & Snider, 2000); **India:** Eastern Himalaya (Gangulee, 1978), Kerala (present collection), Tamil Nadu (Sreebha *et al.*, 2015b).

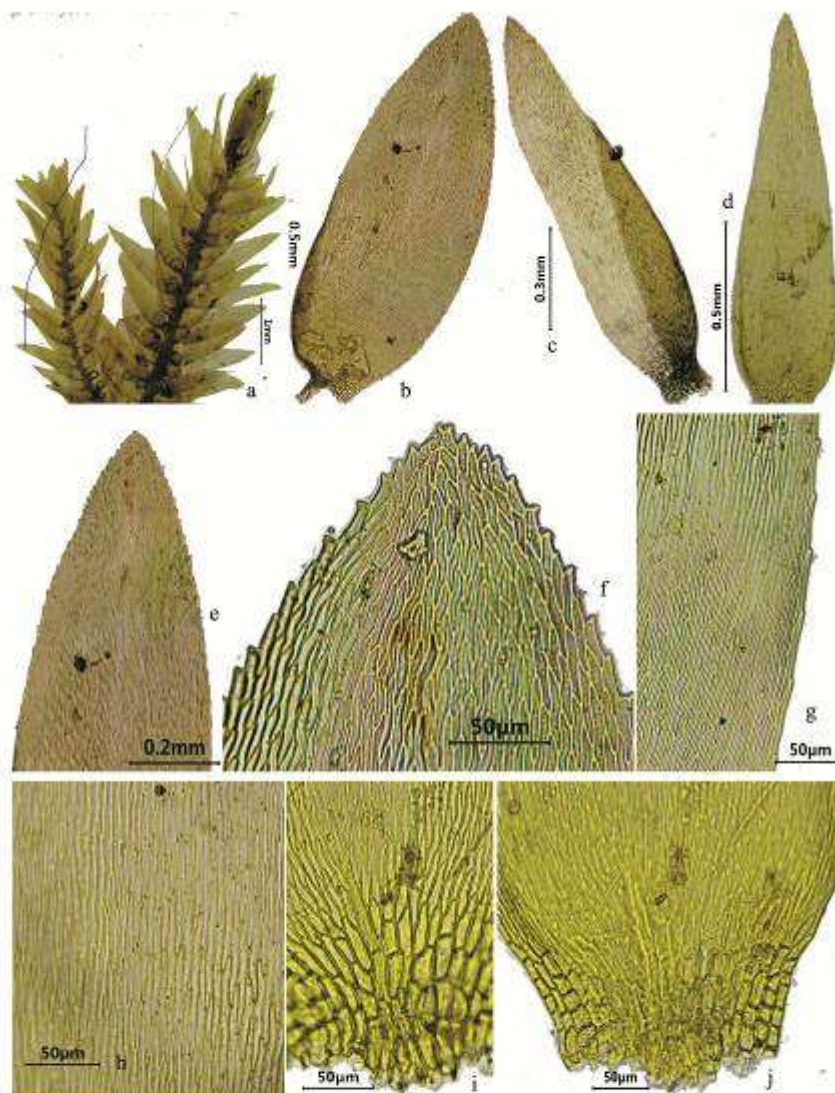


Plate 5. 141: *Symphyodon erraticus* (Mitt.) A. Jaeger. a. habit, b,c&d. leaves, e. leaf tip, f. leaf tip cells, g. leaf marginal cells, h. leaf middle cells, i. juxta costal cells, j. leaf basal cells

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 01.07.2017 *Mufeed 10059* (ZGC).

Plagiotheciaceae M. Fleisch.,
Nova Guinea 8(2): 748. 1912.

Plants robust, main stems creeping, branches irregularly pinnate, complanate; leaves concave, short acuminate; cells narrow, elongate, subquadrate or quadrate at alar region; costa as long as leaf or shorter, single or double, rarely absent; seta smooth, reddish, capsules nodding to erect, peristome teeth 2 rowed, hypnoid, operculum conic rostrate, calyptra cucullate.

Plagiothecium Schimp.,
Bryol. Eur. 5: 179. 1851.

Plants loosely tufted, glossy, main stem creeping, irregularly branched, branches mostly complanate; leaves slightly asymmetrical on sides, ovate, concave, shortly pointed, decurrent; costa short double, unequally forked or absent; laminal cells narrow elongate, alar differentiated; seta long, capsule inclined.

Key to the species

- 1a. Leaf with acuminate tip, margin serrated at tip; alar cells completely distributed at decurrent base ***P. entodontella***
- 1b. Leaf with a narrow long acumen, margin not serrated; alar cells prominent only at basal margin of leaf, quadrate ***P. argentatum***

Plagiothecium entodontella Broth. ex Dixon, J. Siam. Soc. Nat. Hist. suppl. 10(1): 28. 1935; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1805. 1980; Jyothilakshmi *et al.*, Plant Sci. Tod. 3(2): 141. 2016.

Plants medium sized, creeping, yellowish green, pale yellow when dry, glossy plants in scattered tufts, branching irregular; leaves lax, strongly decurrent at base, erectopatent to all slides, concave, ovate, leaf tip acute, margin serrated at tip, 1.5 x 0.4 mm; costa faint, very obscure, only at leaf base; laminal cells rhomboid at tip, 35-45 x 5 µm, elongated below, 75-95 x 3-4 µm, alar cells complete at decurrent base, 20-30(50) x 12-18 µm; reproductive structures not seen (Plate 5.142).

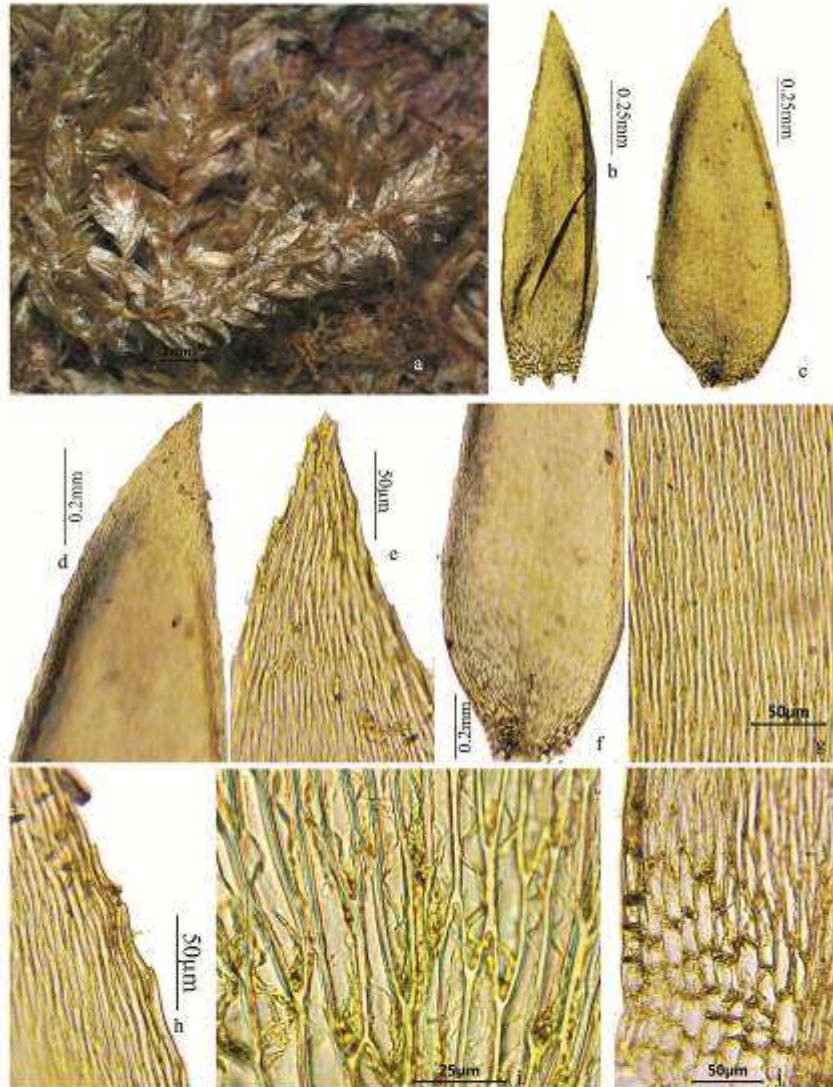


Plate 5. 143: *Plagiothecium entodontella* Broth. ex Dixon, a. habit, b&c. leaf, d&e. leaf apex, f. leaf base, g. leaf cells at middle, h. leaf margin, i. leaf middle cells enlarged, j. leaf basal cells

Habitat: Epiphytic, on bark of trees associated with *Floribundaria chrysonema* (Dozy & Molk.) M. Fleisch. and *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.

Discussion: *Plagiothecium entodontella* Broth. ex Dixon is a rare species in the study area and earlier reported only from Thailand and India. Jyothilakshmi *et al.* (2016) reported this species from one of the sacred grove in the low altitude semi evergreen patch of Kerala as new record for South India. This species is characterized by yellowish green creeping plants with acute leaf tip and strongly decurrent leaf base with faint costa, also characterized by the prominent, quadrate alar cells. Spotted along with other mosses, such as *aerobryidium filamentosum* and *fissidens anomalus*.

Distribution: **World:** Thailand (Sukkharak & Chantanaorrapint, 2014); **India:** Eastern Himalaya, Manipur, Sikkim (Gangulee, 1978), Kerala (Jyothilakshmi *et al.*, 2016).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000 m) 04.03.2016 *Mufeed 10043b* (ZGC).

Plagiothecium argentatum (Mitt.) Q. Zuo, J. Bryol. 33(3): 227. 2011. *Hypnum argentatum* Mitt. in Musci Ind. Or, 77. 1859. *Struckia argentata* (Mitt.) Müll. Hal. in Arch. Ver. Freund. Naturg. Mecklenb., 47: 129. 1893; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1842. 1980. *Pterogoniella argentata* (Hamp.) Jaeg. In Ber. S. Gall. Naturw. Ges. 1875-76: 212. 1877. *Struckia argyreola* Müll. Hal. in Arch. Ver. Freund. Naturg. Mecklenburg, 47: 129. 1893. *S. pallescens* Müll. Hal. in id. 129. 1897. *S. mollis* Besch. In Broth., Nat. Pfl. 1(3):895. 1907.

Plants medium sized, whitish green with silvery lustre; stem simple creeping with irregular branches; pseudoparaphyllia absent; leaves erectopatent, not decurrent, ovate lanceolate, concave, with a narrow long acumen, margin not serrated, smooth throughout, 2.5 mm long and 1 mm wide; costa forked, short, double; laminal cells linear elongate, cells at apex elongate rhomboid, 35- 45 x 7-9 µm, middle cell elongate, 120-150 x 10 µm, alar cells prominent, quadrate, thick walled, 10-20(-35) x 10-20 µm; sporophyte not observed (Plate 5.143).

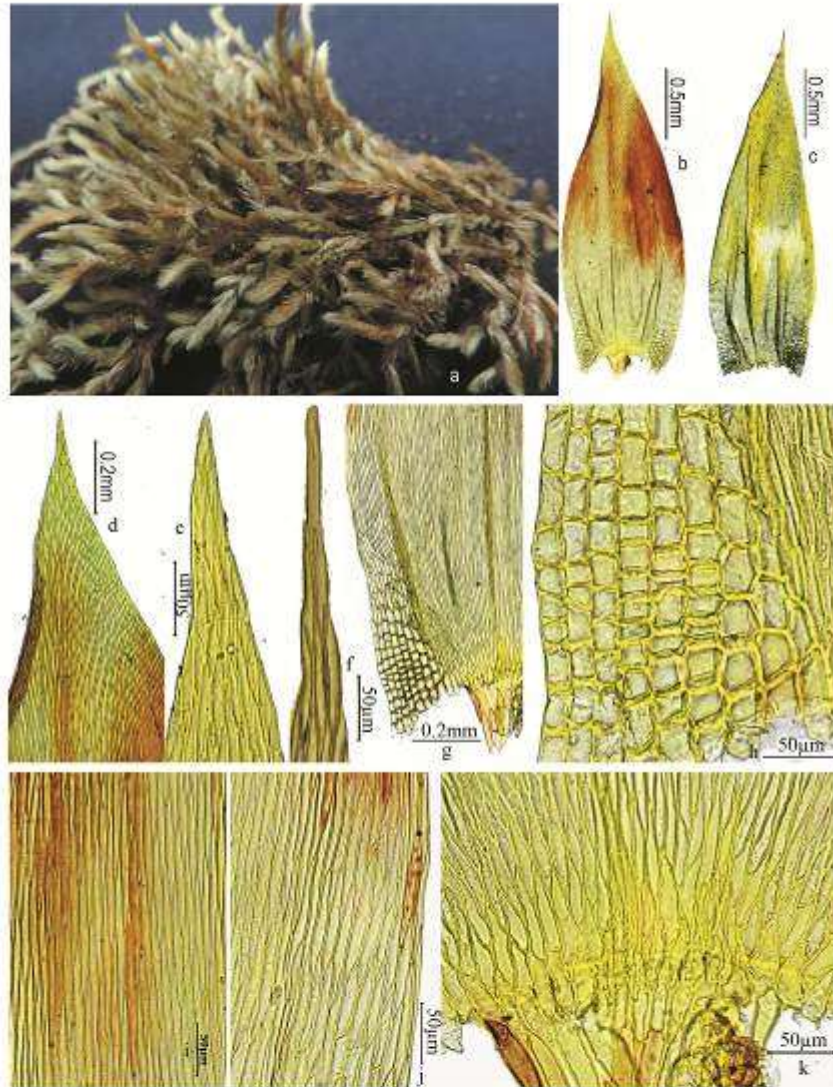


Plate 5, 142; *Plagiothecium argentatum* (Mitt.) Q. Zuo, a. habit, b&c. leaf, d-f. leaf apex, g. leaf base with alar cells, h. enlarged view of alar cells, i&j. leaf middle cells, k. enlarged view of base with double costa

Habitat: Epiphytic, on the exposed roots of trees in shola forest.

Discussion: From India this species was earlier reported as *Struckia argentata* (Mitt.) Müll. Hal. by Gangulee (1978) from North East India and adjacent regions. Tan *et al.* (1990) discussed the status of Himalayan *Struckia* Müll. Hal. and Russian *Cephalocladium* Laz. and commented on the three taxa of *Struckia argentata* in detail. The Asian genus *Struckia* Müll. Hal. is reduced to a synonym of *Plagiothecium* Bruch & Schimp. by Zuo *et al.* (2011) due to the similarity in the gametophyte characters. This species was not yet reported from South India, hence the present collection of the species *P. argentatum* (Mitt.) Q. Zuo is a new record for South India.

Distribution: World: Bhutan, Nepal (Gangulee, 1978); **India:** Assam, Sikkim, West Bengal (Gangulee, 1978), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2100 m) 26.04.2016 *Mufeed 13367* (ZGC).

Entodontaceae Kindb.

Gen. Eur. N.- Amer. Bryin. 7. 1897.

Plants medium-sized in thin to dense flat mats, often glossy, stem creeping, simple or sparingly and irregularly branched, complanate-foliate to julaceous; rhizoids in clusters; leaves erect to wide-spreading, usually imbricate when dry, lanceolate to ovate, symmetric or rarely asymmetric, margin plane or incurved, entire to serrulate distally; apex obtuse to long-acuminate; costa single, 1/3-3/4 of leaf length, or rarely ecostate; alar cells differentiated, quadrate, rectangular; middle laminal cells linear to rhomboidal, smooth, rarely 1-papillose; autoicous or rarely dioicous; seta single, long, straight to somewhat flexuose, smooth, capsule cernuous or erect, straight or slightly curved, calyptra cucullate, smooth, naked, spores ovoid, minutely papillose.

Entodon Müll. Hal.,

Linnaea 18(6)704.1844.

Plants pale yellow-yellowish green, glossy, forming mat on log or rocks, delicate to robust; stem prostrate, complanate to foliate, pinnately branched; branches, simple; stem leaves oblong ovate-oblong lanceolate, concave; margin slightly dentate above

and crenulate below; costa double, short or faint; leaf cells narrow elongate to rhomboid linear, alar cells numerous, quadrate or rectangular extending up to costa or not; branch leaves similar to stem leaves but smaller; sporophyte on main stem; seta long, smooth, yellowish to reddish; capsule erect, cylindrical to urn shaped.

Entodon laetus (Griff.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 295. 1878; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1771. 1980; Alam *et al.*, Pl. Sci. Tod. 2(4): 164. 2015; Magdum *et al.*, Biosci. Discov. 8(1): 78. 2017. *Neckera laeta* Griff., Calcutta J. Nat. Hist. 3: 67. 1843. *Cylindrothecium laetum* (Griff.) Paris, 300. 1894. *Stereodon laetus* (Griff.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 107. 1859.

Plants usually medium sized, yellowish green, glossy, irregularly pinnately branched; leaves complanate, imbricate, erectopatent, concave, ovate elliptical, apex acute, 1.4 mm long and 0.6 mm wide near base, margin finely crenulated at top and tip incurved in some leaves; costa double, short; paraphyllia multicellular, triangular, forming a single layered narrow tip; laminal cells elongate elliptical at apex, 30-40(-50) μm long and 8 μm wide, cells at middle 120-140 x 8 μm , cells at base rectangular to quadrate, 15-25(-35) x 15-20 μm ; reproductive structures not seen (Plate 5.144).

Habitat: Epiphytic, on barks of lower branches in shola forest.

Discussion: Gangulee (1980) reported *Entodon laetus* (Griff.) A. Jaeger from Eastern Himalayas. From Peninsular India this species was earlier reported from Gujarat and Maharashtra, but not yet reported from Kerala. Hence the present collection is a new record for Kerala. It is characterized by its yellowish green glossy plants with erectopatent leaves and the leaves concave to ovate elliptical with short double costa.

Distribution: World: Bhutan, Nepal (Gangulee, 1980); **India:** Assam, Meghalaya, West Bengal (Gangulee, 1980), Gujarat (Chaudhary *et al.*, 2006; Chaudhary & Sharma, 2007; Alam *et al.*, 2015), Kerala (Present collection), Maharashtra (Magdum *et al.*, 2017).

Specimens examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2200 m) 26.09.2018 *Mufeed 10055* (ZGC).

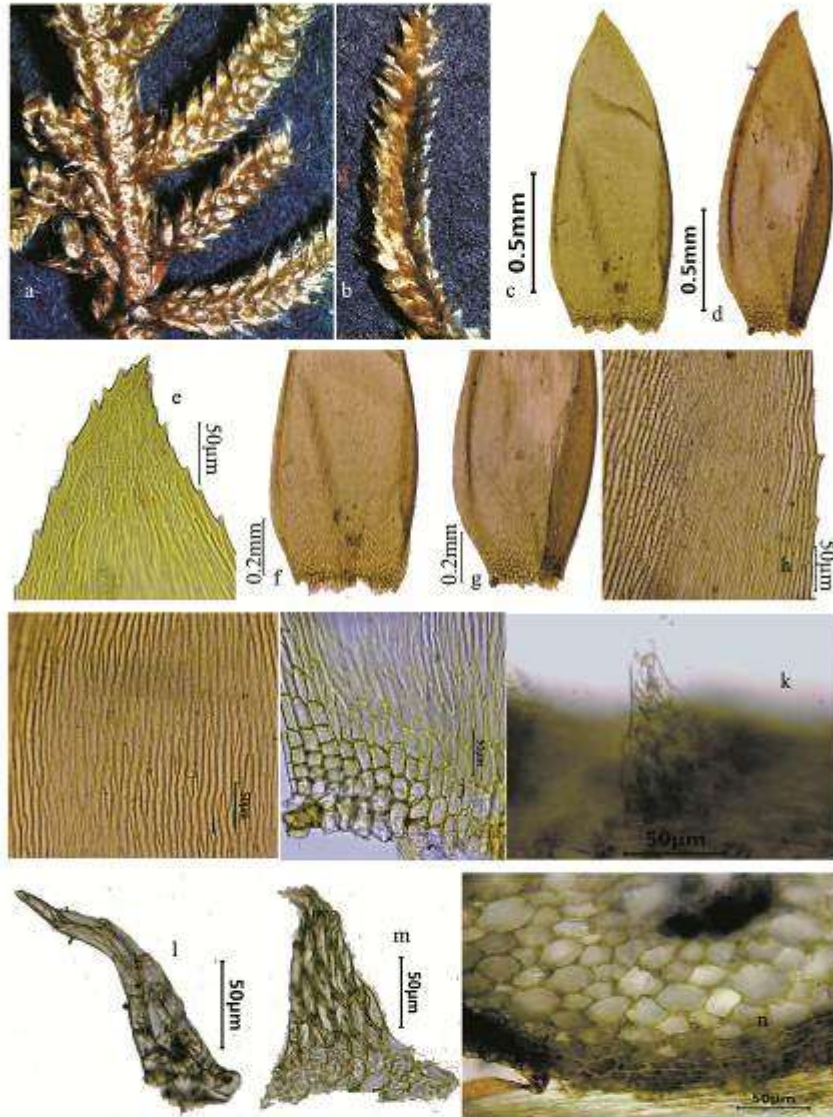


Plate 5. 144: *Entodon laetus* (Griff.) A. Jaeger, a&b. habit, c&d. leaves, e. leaf tip cells, f&g. leaf base, h. marginal cells, i. leaf middle cells, j. leaf basal cells, k,l&m. parapyllia, n. c.s. of stem

Sematophyllaceae Broth.,

Nat. Pflanzenfam. 1(3): 706. 1905.

Plants slender to robust, yellowish green to brown, glossy, irregularly or pinnately branched; leaves ovate, acuminate; laminal cells linear to rhomboid, smooth or papillate; alar region differentiated, tinted large cells; costa reaches up to the half of the leaf or shorter, single, double or absent; sporophyte arises from main stem or branches; seta erect or papillose, capsule erect to pendant, peristome teeth 2-rowed.

Key to the genera

- 1a. Leaves strongly falcate secund to circinate; long acuminate and occasionally twisted; leaf base with single basal row of 2-4 large swollen thick walled elongated cells **Warburgiella**
- 1b. Leaves ovate-lanceolate, narrow acuminate; leaf base with single row of 5-6 large quadrangular elongated cells **Wijkia**

Warburgiella Müll. Hal.,

Monsunia 1: 176. 1900.

Plants small, in dense glossy yellowish green to yellowish brown mats; stems creeping, elongate, irregularly pinnate to bipinnately branched, branches short or long, with short erect-divergent cuspidate tips; stem and branch leaves similar; pseudoparaphyllia foliose; leaves strongly falcate-secund to circinate, lanceolate to ovate-lanceolate, ecostate, with an expanded sheathing base, in some species abruptly long-acuminate, the acumen occasionally twisted; margin sharply serrate to ± entire above, entire below, plane but occasionally appearing involute due to the strong concavity; laminal cells elongate to narrowly linear, porulose or smooth, occasionally unipapillose; alar region often coloured, with a single basal row of 2–4 large swollen thick-walled elongate cells; supra-alar cells subquadrate in a single row of 1–3.

Warburgiella cuppressinoides Müll. Hal. ex Broth., Monsunia 1: 176. 1900; Tan *et al.*, Acta Bryol. Asiatica 7: 42. 2017. *Stereodon leptorhyncoides* Mitt., J. Linn. Soc. Bot. Suppl. 1:103. 1859. *Warburgiella leptorhyncoides* (Mitt.) Fleisch., Musci Fl. Buitenzorg 4:1253. 1923; Montagne, Ann. Sci. Nat. Bot., sér. 2, 17: 248. 1842; Chopra, Taxon Indian Moss. 510. 1975; Daniels, Arch. Bryol. 65: 94. 2010.

Rhaphidostegium subleptorrhynchoides M. Fleisch., Hedwigia 44: 321 ic. 1905.
Warburgiella subleptorrhynchoides (M. Fleisch.) M. Fleisch., Musci Buitenzorg 4: 1250. 203. 1923.

Plants usually seen in dense tufts, yellowish green, glossy, usually seen on rotten barks of the trees; stems prostrate, irregularly branched; branches mostly ends with a hooked form; leaves falcate, concave, twisted when dry, oblique in nature, ovate-elongate, gradually form an elongated apex, leaves 1.3-1.5 x 0.2-0.3 mm at base; costa absent, laminal cells linear elongate, 45-55 x 9 µm at tip, 38-50 x 5 µm at middle, marginal cells linear to elongate, cells slightly larger in lower regions; alar cells consisting of 2-3, inflated, single rowed, colourless cells, 62-65 x 25 µm; young sporophyte in reddish colour, mature one not observed (Plate 5.145).

Habitat: Epiphytic on barks of large trees in evergreen forest at low altitude.

Discussion: This species was reported from South India as *Warburgiella leptorrhynchoides* (Mitt.) Fleisch. from Nilghiri and Palni hills. It was synonymised under *W. cupressinoides* Müll. Hal. ex Broth. by Tan *et al.* (2017). It was not reported earlier from Kerala, hence the present collection is a new genus record for Kerala along with the species *W. cupressiniodes*. It is characterized by yellowish green glossy plants, absence of costa and the alar cells in a single row with two or more large inflated cells.

Distribution: World: Australia (Ramsay *et al.*, 2004), China (Redfearn Jr. & Wu, 1986; Wu *et al.*, 2005), Indonesia, Papua New Guinea, (Tan *et al.*, 2017), Sri Lanka, Philippines, Sumatra (Tan & Iwatsuki, 1991), Taiwan (Tan & Yu, 1999); **India:** Kerala (present collection), Tamil Nadu (Montagne, 1842; Chopra, 1975; Daniels, 2010 as *W. leptorrhynchoides*).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1600 m) 14.07.2017 *Mufeed* 7527 (ZGC).

Wijkia H.A. Crum,
Bryologist 74(2): 170. 1971.

Plants long, creeping, once or twice pinnate; leaves differentiated in stem and branches; leaves ovate lanceolate, narrow acuminate; costa usually absent or faintly

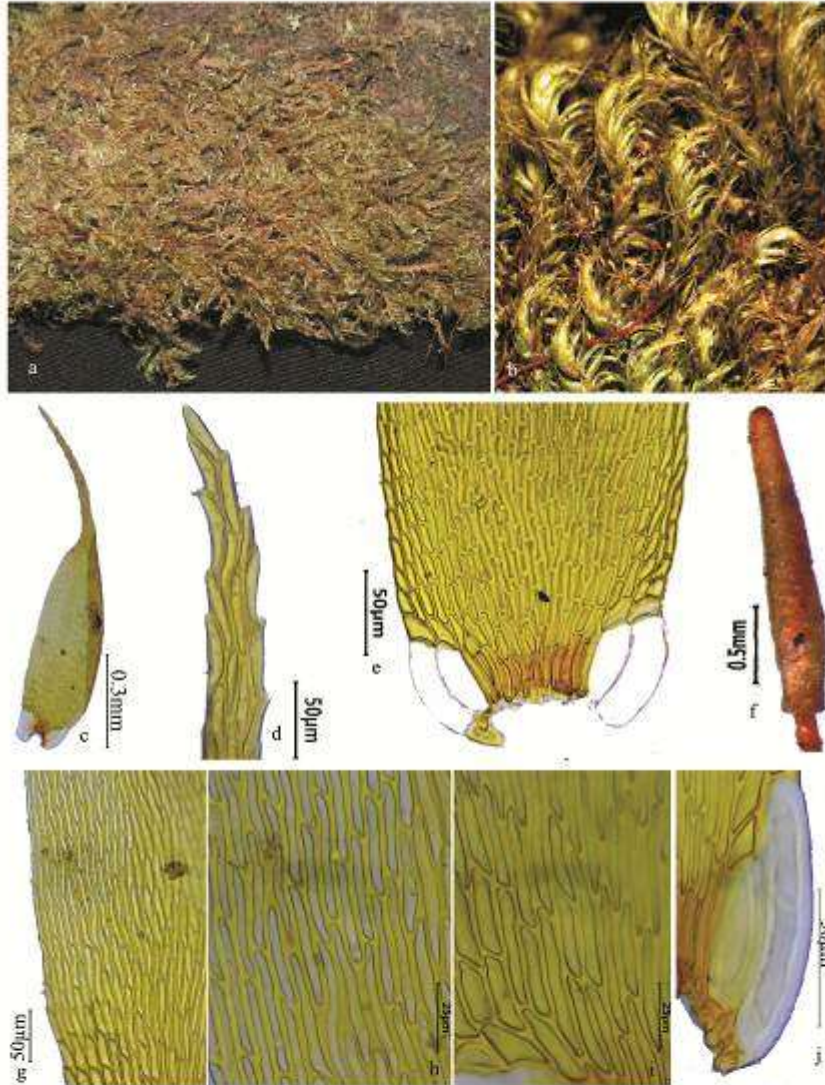


Plate 5. 145: *Warburgiella cupressinoides* Müll. Hal. ex Broth. a&b, habit, c, leaf, d, leaf tip cells, e, leaf base, f, young sporophyte, g, leaf marginal cells, h, leaf middle cells, i, leaf basal cells, j, alar cells

short double, laminal cells long, narrow, smooth or papillose; alar cells distinct, a row of 5-6 quadrangular cells; paraphyllia rarely seen; seta long, smooth, capsule inclined, arcuate, peristome normal, operculum conic rostrate.

Key to the species

- 1a. Leaves highly deflexed with narrow acuminate tips ***W. deflexifolia***
 1b. Leaves not deflexed with narrow apex ***W. surcularis***

Wijkia deflexifolia (Mitt. ex Renauld & Cardot) H.A. Crum, Bryologist 74: 171. 1971; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1860. 1980; Manju *et al.*, Acta Biol. Plant. Agri. 3: 91. 2014; Palani *et al.*, Pl. Sci. Tod. 4(1): 53. 2017. *Acanthocladium deflexifolium* Mitt. ex Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 92. 1902[1905]. *Acanthocladium benguetense* Broth., Philipp. J. Sci. 31: 294. 1926. *Brotherella subintegra* Broth. Ann. Bryol. 1: 24. 1928.

Plants brownish yellow green with reddish stems, glossy in dense tufts, pinnately branched; leaves erectopatent with deflexed tips, ovate-lanceolate, 0.8 mm long and 0.4 mm wide; tip deflexed and narrow acuminate, margin smooth; ecostate; leaf cells linear, 70-100 x 5-6 µm, alar differentiated by 3 or 4 large cells in one row with some irregular cells at tip and becoming narrower along the line of insertion, alar cells 70-80 x 30 µm; sporophyte on main branches, seta slender, erect to flexuose, purplish, up to 1cm long, capsule horizontal, arcuate, cylindrical (Plate 5.146).

Habitat: Epiphytic, on decayed woods in shola forest.

Discussion: *Wijkia deflexifolia* (Mitt. ex Renauld & Cardot) H.A. Crum is rare in the study area. It was reported from Eastern Himalayas and Bhutan by Gangulee (1980). Manju *et al.* (2014) reported this species from Silent Valley National Park of Palakkad district in Kerala, as a new record for Peninsular India. This species is characterized by its deflexed narrow acuminate leaf tip and the alar cells are differentiated by 3 or 4 large cells in one row with some irregular cells at tip and becoming narrower along the line of insertion.

Distribution: World: Bhutan (Gangulee, 1980), China (Tan & Yu, 1999), Taiwan (Chiang, 1996) Thailand (Printarakul *et al.*, 2013); **India:** Kerala (Manju *et al.*, 2014), Tamil Nadu (Palani *et al.*, 2017), West Bengal (Gangulee, 1980).

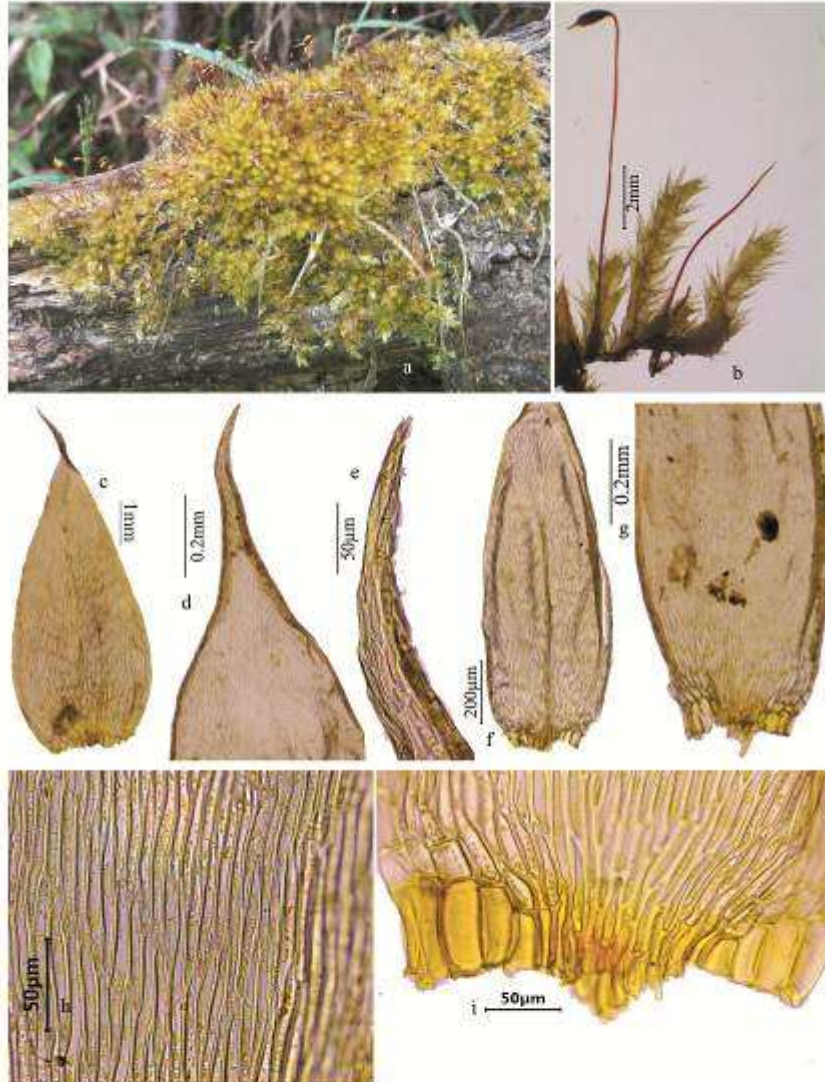


Plate 5. 146: *Wijkia deflexifolia* (Mitt. ex Renauld & Cardot) H.A. Crum, a. habit, b. habit with sporophyte, c. leaf, d. leaf apex, e. leaf tip cells, f&g. leaf base, h. leaf cells at middle, i. leaf basal cells

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2100 m) 26.09.2018 Mufeed 9937 (ZGC).

Wijkia surcularis (Mitt.) H.A. Crum, Bryologist 74: 173. 1971; Chopra, Taxon. Indian Moss. 502. 1975; Gangulee, Mosses E. India & Adj. Reg. 3(8): 1862. 1980; Lal, Checklist Indian Moss. 142. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 18. 2008 & Taiwania 54: 66. 2009; Rajesh, Taiwania 55(2): 173. 2010; Mufeed *et al.*, Frahmia 6: 7. 2014; Rajesh & Manju, Frahmia, 5: 9. 2014. *Stereodon surcularis* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 112. 1859. *Hylocomium surculare* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 352. 1880. *Hypnum surculare* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 344. 1880. *Acanthocladium surculare* (Mitt.) Broth., Index Bryol. (ed. 2) 1: 3. 1903.

Plants robust, glossy, yellowish green to brownish, branching pinnate; leaves dense, not deflexed, imbricate, erectopatent, concave, oblong-lanceolate, almost smooth at margin, narrowed at apex, 1.5 mm long and 0.35 mm wide at base; costa usually absent; cells elongate, cells at apex linear, 50 x 8 µm, cells at middle, narrow, elongate, slightly rhomboid, 85-95 x 6 µm, basal cells pitted, elongate, irregularly rhomboid, 30-40 x 6-10 µm, alar cells rectangular, tinted, 40-50 x 20-40 µm; seta long up to 1 cm, capsule sub erect, ovate, brownish, 1.7 mm long and 0.5 mm wide, peristome teeth 2-rowed; operculum conic rostrate (Plate 5.147).

Habitat: Epiphytic, on decayed woods associated with *Leucoloma molle* (Müll. Hal.) Mitt. in shola forest.

Discussion: *Wijkia surcularis* (Mitt.) H.A. Crum, is a common southeast Asiatic species, distributed in Eastern Himalayas and Western Ghats of South India. From Kerala it is previously reported by Nair *et al.* (2005) & Mufeed *et al.* (2014).

Distribution: World: China (Tan & Yu, 1999), Malaysia (Chua & Suleiman, 2015), Nepal, Myanmar, Thailand (Gangulee, 1980), Sri Lanka (O'Shea, 2006); **India:** Andaman (Rajesh, 2010), Kerala (Manju *et al.*, 2008), Meghalaya, Sikkim (Gangulee, 1980).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park,

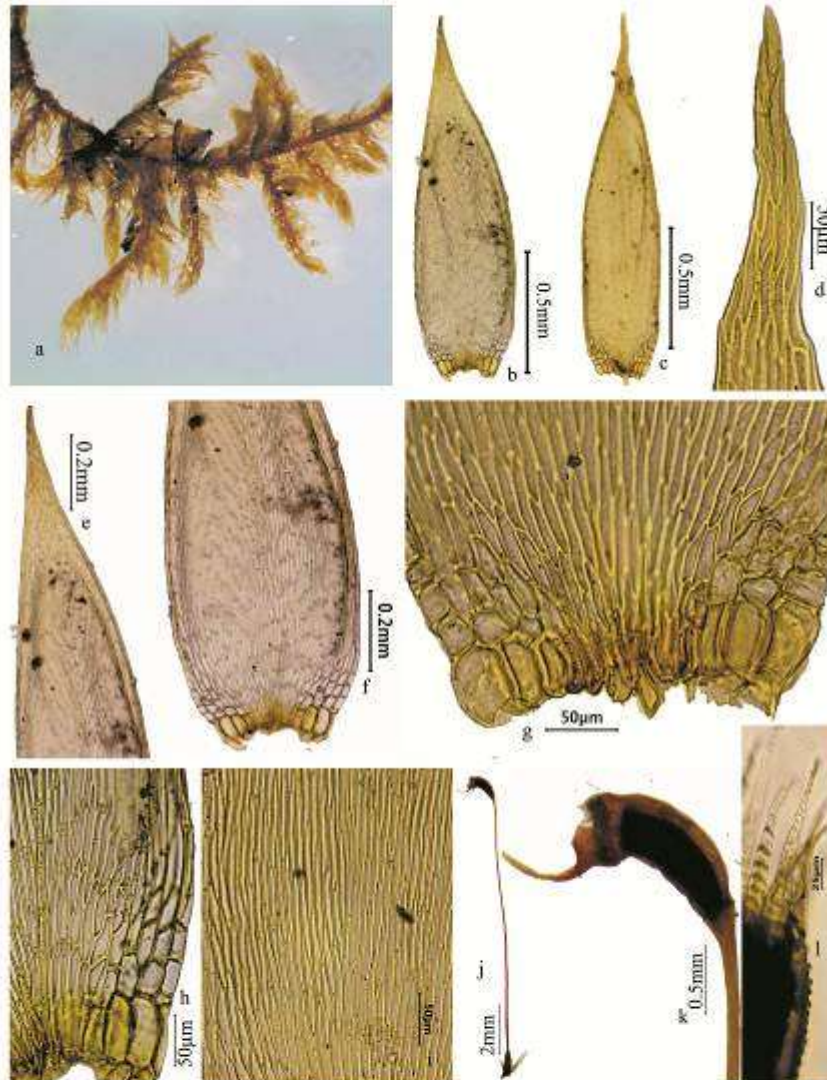


Plate 5. 147: *Wijkia surcularis* (Mitt.) H.A. Crum, a.habit, b&c. leaf, d.leaf tip cells, e. leaf apex, f. leaf base, g. leaf base enlarged, h. alar cells, i. leaf middle cells, j. sporophyte, k. capsule, l. peristome teeth

Mannavan Shola (1950 m) 02.08.2015 *Mufeed 13313a* (ZGC).

Cryphaeaceae Schimp.,

Coroll. Bryol. Eur. 97. 1856.

Plants slender to robust, corticolous, mostly hanging; primary stem creeping, stoloniferous, secondary stem branched; leaves imbricate, erect and appressed when dry, ovate, acuminate, concave; costa single, ending below apex; leaf cells incrassate, ovoid, elongate near base; sporophyte terminal on branches or on short side branches; seta short, capsule usually completely hidden, peristome single or double, calyptra small, campanulate or cucullate.

Key to the genera

- 1a. Leaves linear lanceolate from half sheathing base; costa ending below the apex
..... ***Pilotrichopsis***
- 1b. Leaves ovate, acute or acuminate, not sheathing; costa reaches far below apex
..... ***Schoenobryum***

***Pilotrichopsis* Besch.,**

J. Bot. (Morot) 13: 38. 1899.

Plants rhizomatous, hanging from the branches, branching twice or thrice; leaves erect, linear lanceolate from an half sheathing ovate base, margin recurved towards the base, plane or toothed above; laminal cells usually thick walled, cells at apex elliptic, at basal margin quadrate, cells elongate near costa and with oblique rows towards margin; costa ending below the apex; autoicous, sporophytes on short lateral shoots, capsule completely immersed within perichaetial leaves, peristome double.

Pilotrichopsis dentata (Mitt.) Besch., J. Bot. (Morot) 13: 38. 1899; Chopra, Taxon. Indian Moss. 302. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1213. 1976; Lal, Checklist Indian Moss. 104. 2005. *Dendropogon dentatus* Mitt., Trans. Linn. Soc. London, Bot. 3: 170. 1891. *Pilotrichopsis erecta* Sakurai, Bot. Mag. (Tokyo) 46: 375. 1932.

Plants yellowish green to brownish, long; main stem creeping, secondary branching twice or thrice, hanging; leaves on branches dense, imbricate, erect to erectopatent,

not much differentiated when dry, linear lanceolate from an ovate concave base, acuminate, widest at middle, 1-1.2 mm long and 0.5 mm wide, margin usually entire below, dentate in the narrow apex, usually flat; costa ending below apex; laminal cells thick-walled and elliptical, 12-17 μm long and 5-7 μm wide, juxta costal cells at base long linear, 40-50 μm long and 5 μm wide, marginal cells ovate to quadrate, 6-9 μm long and 10 μm wide; sporophytes not seen (Plate 5.148).

Habitat: Epiphytic, on bark of trees and also hanging on branches in shola trees in all altitudinal ranges.

Discussion: *Pilotrichopsis dentata* (Mitt.) Besch. is an Asiatic species widely distributed in Asian countries. But it is a very rare species in the study area. From India, Gangulee (1976) reported this taxa from Eastern Himalayas. The present collection is a new record for Peninsular India and the genus is a new record for Kerala.

Distribution: World: China (Redfearn Jr. & Wu, 1986), Hong Kong (So & Yip, 1995), Japan (Noguchi & Iwatsuki, 1989), Philippines (Tan & Iwatsuki, 1991), Taiwan (Lai, 1977), Vietnam (Ninh, 1993); **India:** Arunachal Pradesh, Manipur (Gangulee, 1976), Kerala (present collection).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (1700 m) 14.07.2017 *Mufeed* 7570; Pullaradi Shola (2250 m) 04.03.2016 *Mufeed* 100069 (ZGC).

Schoenobryum Dozy & Molk.,

Musc. Frond. Ined. Archip. Ind. 6: 183–185. 1848.

Plants slender to moderately robust; main stem creeping, secondary stem ascending; leaves imbricate, ovate, acute to acuminate, entire or toothed towards the apex; costa reach little above middle; laminal cells thick walled, finely papillose, ovate elliptical; juxtacostal cells linear, alar cells usually obliquely rounded to quadrate; capsule fully immersed, ovate oblong; operculum conical; spores large.

Schoenobryum concavifolium (Griff.) Gangulee, Mosses E. India & Adj. Reg. 5: 1209. 1976; Chopra, Taxon. Indian Moss. 300. 1975; Lal, Checklist Indian Moss. 122. 2005; Nair *et al.*, Bryo. Wayanad. 129. 2005; Manju *et al.*, Trop. Bryo. Res.

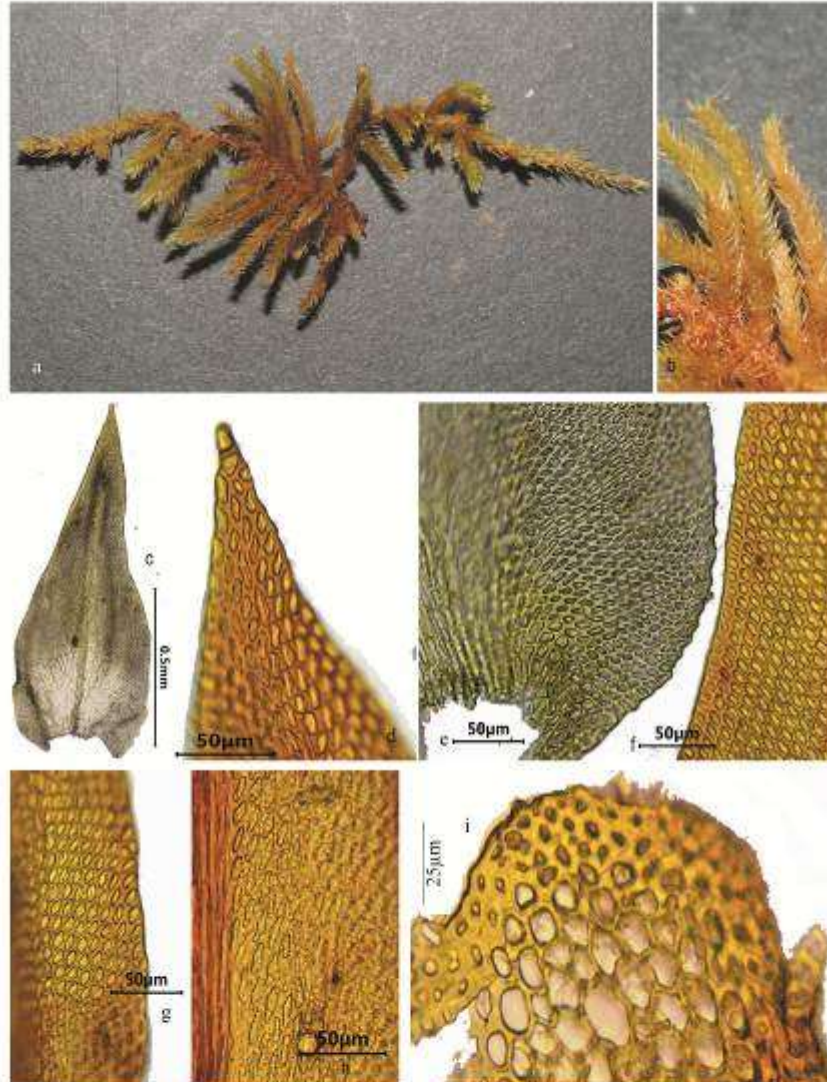


Plate 5. 148: *Pilotrichopsis dentata* (Mitt.) Besch., a. habit, b. secondary branch, c. leaf, d. leaf tip, e. leaf base, f. leaf marginal cells, g. leaf cells, h. leaf basal cells, i. c.s. of stem

Rep. 7: 17. 2008; Daniels, Arch. Bryol. 65: 85. 2010; Daniels & Daniel, Bryoflor. Indira Gandhi Natl. Pk. 167. 2018. *Orthotrichum concavifolium* Griff., Calcutta J. Nat. Hist. 2(8): 484. 1842. *Grimmia julacea* Hornsch., Fl. Bras. (2): 7. 1840. *Schoenobryum julaceum* Dozy & Molk., Musc. Frond. Ined. Archip. Ind. 184. 1848. *Cryphaea concavifolia* (Griff.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 125. 1859. *C. gardneri* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 125. 1859. *Acrocryphaea concavifolia* (Griff.) Bosch & Sande Lac., Bryol. Jav. 2: 106. 1864. *A. mexicana* Schimp., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 217. 1872. *A. gardneri* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1874–75: 178. 1876. *Cryphaea coffeae* Müll. Hal., Hedwigia 37: 240. 1898. *C. welwitschii* Duby, Mém. Soc. Phys. Genève 21: 426. 1872. *Acrocryphaea julacea* var. *costaricensis* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 32(1): 175. 1894. *A. coffeae* (Müll. Hal.) Paris, Index Bryol. Suppl. 1. 1900. *A. madagassa* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 739. 1905. *A. latifolia* Broth. & P. de la Varde, Bull. Soc. Bot. France 72: 357. f. 8. 1925. *Schoenobryum coffeae* (Müll. Hal.) Manuel, Bryologist 80: 523. 1977. *S. gardneri* (Mitt.) Manuel, Bryologist 80: 523. 1977. *S. latifolium* (Broth. & P. de la Varde) Manuel, Bryologist 80: 523. 1977. *S. plicatulum* (Dixon & Thér.) Manuel, Bryologist 80: 523. 1977. *S. robustum* (Broth.) Manuel, Bryologist 80: 523. 1977. *S. subintegrum* (Renauld & Cardot) Manuel, Bryologist 80: 524. 1977. *S. tisserantii* (Thér. & P. de la Varde) Manuel, Bryologist 80: 524. 1977. *S. welwitschii* (Duby) Manuel, Bryologist 80: 524. 1977.

Plants creeping, stiff, rhizomatous, giving rise to erect, rigid, yellowish green, julaceous shoots; leaves dense, erectopatent to spreading, concave, broadly ovate, 1.3-1.5 mm long and 0.5-0.6 mm wide at base, apex acute, shortly acuminate, margin flat and entire; costa ending above 1/3 leaf length; laminal cells ovate to elliptical, 12-20 µm long and 8 µm wide, at base juxta costal cells narrow elongated, 40-55 µm long and 5 µm wide, shorter and oblique cells towards margin; sporophytes on terminal branches; seta almost absent keeping capsule hidden, peristome single, operculum short conical, calyptra short, campanulate, only covering operculum, spores large (Plate 5.149).

Habitat: Epiphytic on branches in shola forest.



Plate 5. 149: *Schoenobryum concavifolium* (Griff.) Gangulee, a. habit, b&c. leaves, d. leaf tip, e. leaf cells, f. leaf margin, g. leaf base, h. leaf basal cells

Discussion: About seven valid species are reported under this genus worldwide. But only *Schoenobryum concavifolium* is reported from India. It is a very common species in the study area. Gangulee (1976) described this species from Eastern Himalayas and from South India it is reported from medium and high altitude mountains by Nair *et al.* (2005) and Manju *et al.* (2008). It is characterized by its immersed capsule and specific arrangement of leaf cells at the basal region.

Distribution: World: Africa, Australia, America, Philippines, Sri Lanka (O'Shea, 2003), Bangladesh, Nepal (Gangulee, 1976); **India:** Kerala (Nair *et al.*, 2005; Manju *et al.*, 2008), Manipur, Meghalaya (Gangulee, 1976), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (1950-2010 m) 03.03.2016 *Mufeed 10039*; 04.03.2016 *Mufeed 10044*; Idivara Shola (2000-2200 m) 12.07.2017 *Mufeed 7336,7340,7343,7354c*; Jandamala (2060-2200 m) 09.11.2017 *Mufeed 7468* (ZGC).

Pterobryaceae Kindb.,

Eur. N. Amer. Bryin. 1: 15. 1897.

Plants with flagelliform branches or not; stems without a central strand; branches erect or pendant; leaves dense, ovate, acuminate; cells narrow elongate, incrassate, porose on walls; alar region distinct; costa absent or if present, single or double; capsule immersed to exserted; calyptra smooth.

Key to the genera

- 1a. leaves ovate cordate; costa single, rarely faintly double ***Pterobryopsis***
- 1b. Costa usually absent; leaves broadly ovate to ovate oblong ***Garovaglia***

Garovaglia Endl.,

Gen. Pl. 57. 1836.

Plants robust, branched or not; leaves dense, erect spreading, broadly ovate to oblong, usually plicate or not; leaf apex narrower, forming a subulate often twisted and curved acumen; laminal cells incrassate, thick walled, porose; costa usually absent; sporophytes on short lateral branches, capsule immersed, ovoid cylindric, peristome 2-rowed, calyptra campanulate or mitriform.

Garovaglia plicata (Brid.) Bosch & Sande Lac., Bryol. Jav. 2: 79. 1863; Bruehl,

Rec. Bot. Surv. India 13(1): 69. 1931; Chopra, Taxon. Indian Moss. 326. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1256. 1976; Hyvonen, Acta Bot. Fenn. 137: 28. 1989; Lal, Checklist Indian Moss. 66. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 13. 2008 & Taiwan 54: 65. 2009; Daniels & Daniel, Bryoflor. S. –most W. Ghats, India 131. 2013; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 245. 2019. *Esenbeckia plicata* Brid., Bryol. Univ. 2: 754. 1827. *Neckera plicata* (Brid.) Schwägr., Sp. Musc. Frond., Suppl. 3 2(1): 268. 1829. *Pilotrichum plicatum* (Brid.) Müll. Hal., Syn. Musc. Frond. 2: 158. 1850. *Garovaglia powellii* Mitt., J. Linn. Soc., Bot. 10: 169. 1868. *Endotrichum plicatum* (Brid.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875–76: 231. 1877. *Garovaglia tahitensis* Besch. ex Schimp., Ann. Sci. Nat., Bot., sér. 7, 20: 34. 1895. *G. subintegra* Dixon, Farlowia 1: 36. 1943.

Plants pale green to golden green, dark brown below; main stem creeping, wiry, irregularly branched; leaves dense, erectopatent, ovate-lanceolate, acuminate, cucullate, plicate, faintly toothed at apical margin, 2.8 mm long and 1 mm wide; laminal cells narrow, elongate, incrassate, porose below and faint above, cells at apex 55 µm long and 6 µm wide, cells at middle 68-73 µm long and 6-7 µm wide, cells at base reddish brown, 10-20 µm long and 14-16 µm wide; alar region not distinct; ecostate; sporophytes not seen (Plate 5.150).

Habitat: Epiphytic on bark and branches of *Elaeocarpus serratus* L.

Discussion: The species usually seen above 2000 m altitude in the study area. Gangulee (1976) reported this taxa from Eastern Himalayas. It is a widely distributed species in evergreen and shola forests of South India and reported by Manju *et al.* (2008) from Kerala and Tamil Nadu by Daniels *et al.* (2013).

Distribution: World: Borneo (Mohamed *et al.*, 2003), China (Redfearn Jr. & Wu, 1986), Indonesia (Ho *et al.*, 2006), Malaysia (Maryani *et al.*, 2015); **India:** Kerala (Manju *et al.*, 2008), Sikkim (Gangulee, 1976), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Iddalymotta (2055 m) 07.11.2017 *Mufeed 7406* (ZGC).

Other specimen/s examined: Chembra hills (1370-1770 m) *Manju C.N. 120253*,

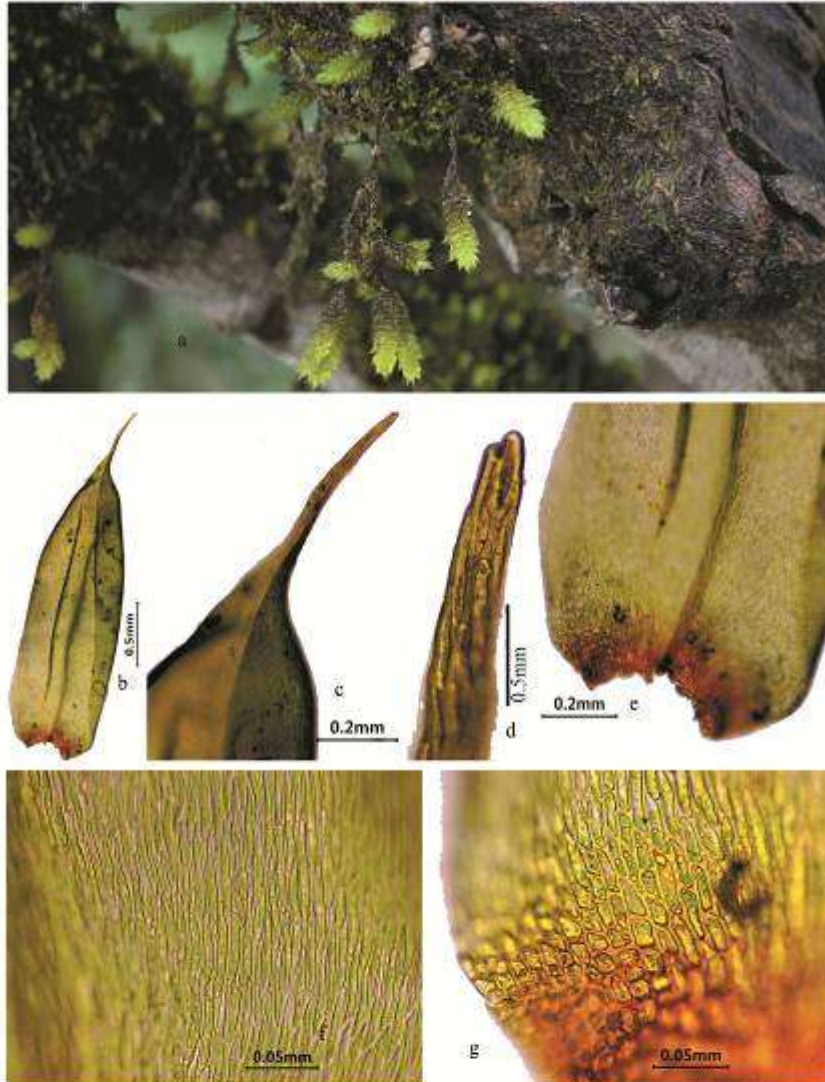


Plate 5. 150: *Garovaglia plicata* (Brid.) Bosch & Sande Lac. a. habit, b. leaf, c. leaf apex, d. cells apex, e. leaf base, f. median cells, g. basal cells

Manju C.N. 120399, Thirunelli RF (1280 m) Manju C.N. 99620 (CALI!).

Pterobryopsis M. Fleisch.,
Hedwigia 45: 56. 1905.

Plants glossy, slender to robust, golden yellowish to green, creeping; branches erect or pendant, flexuose; leaves dense, concave, acuminate or apiculate, ovate to cordate; cells narrowly elongate; porose on walls or not; costa single, rarely faintly double, mostly ending in the middle; capsules immersed or exserted, peristome teeth 2-rowed, operculum rostrate, spores rounded, large.

Key to the species

- 1a. Plants usually irregularly branched, flagelliform; tip apiculate..... ***P. acuminata***
- 1b. Plants usually pinnately branched, not flagelliform; tip shortly acuminate
..... ***P. orientalis***

Pterobryopsis acuminata (Hook.) M. Fleisch., Hedwigia 45: 59. 1905; Bruehl, Rec. Bot. Surv. India 13(1): 70. 1931; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1273. 1976; Lal, Checklist Indian Moss. 114. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 152. 2005; Chaudhary *et al.*, Bryoph. Fl. N. Konkan 221. 2008; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 16. 2008 & Arch. Bryol. 42: 9. 2009; Daniels, Arch. Bryol. 65: 81. 2010; Sreenath *et al.*, Jour. Threat. Taxa 12(4): 15485. 2020. *Neckera acuminata* Hook., Musci Exot. 2: 15. 151. 1819. *Garovaglia conchophylla* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 69. 1905. *Pterobryopsis handelii* Broth., Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1, 133: 572. 1924. *P. morrisonicola* Nog., J. Hattori Bot. Lab. 2: 69. 1948.

Plants yellowish green, creeping, wiry, pinnately branched, up to 5 cm long; branching usually ascending or pendant; leaves dense, imbricate, erectopate, apiculate, ovate to cordate, cucullate; distinctly auriculate, involute at margins, 2-2.3 mm long and 1-1.2 mm wide at base; laminal cells incrassate, narrow elongate, with porose walls below and faint above; cells at apex 35-55 x 6-8 µm, cells at middle long, 60-75 x 6 µm, cells at base 30-45 x 6 µm; alar cells indistinct, elongate to rectangular, reddish brown in colour, 12-25 x 12-14 µm; costa single, reaches above the middle; sporophytes not seen (Plate 5.151).

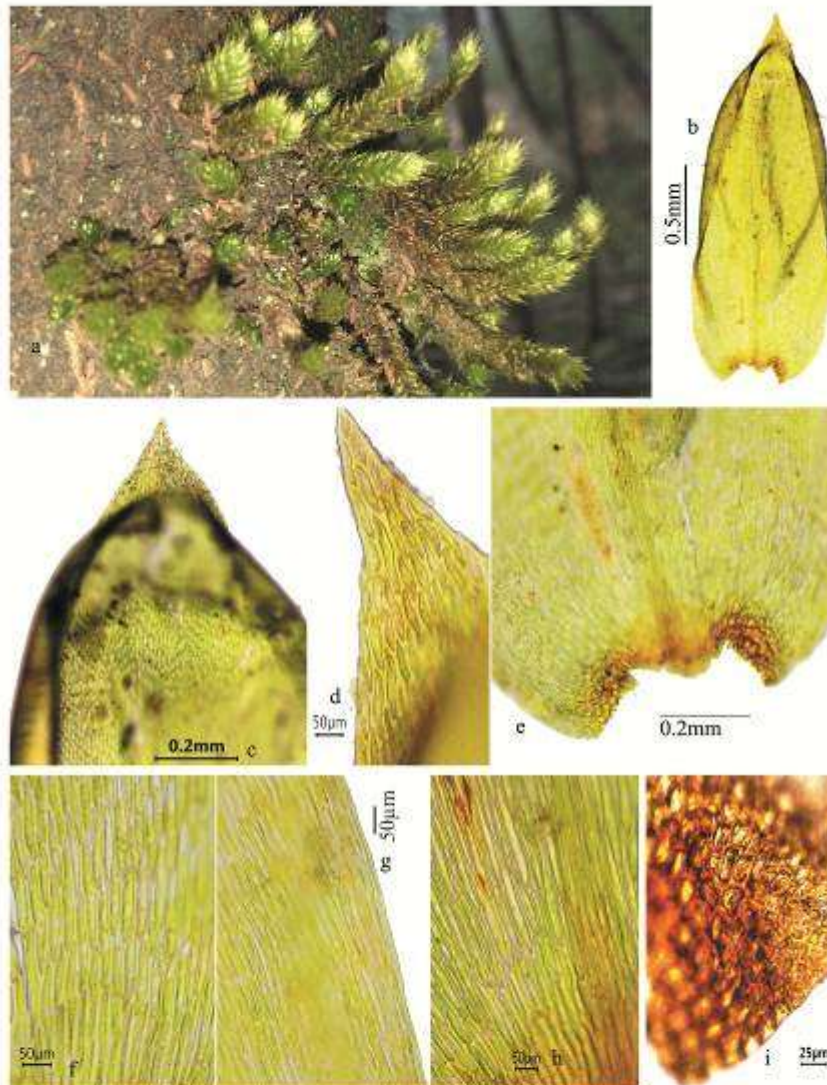


Plate 5. 151: *Pterobryopsis acuminata* (Hook.) M. Fleisch. a. habit, b. leaf, c. leaf apex, d. tip cells, e. leaf base, f. middle cells, g. marginal cells, h. basal cells near costa, i. alar cells.

Habitat: Epiphytic, on bark and on branches of shola trees.

Discussion: It is a rare species of *Pterobryopsis* distributed in evergreen and shola forests of Kerala. Nair *et al.* (2005) reported this species earlier from Kerala. It is characterized by its irregularly branched plants with flagelliform tip and apiculate leaf tip.

Distribution: **World:** Myanmar, Nepal (Gangulee, 1976); **India:** Gujarat (Chaudhary *et al.*, 2008), Kerala (Nair *et al.*, 2005), Maharashtra (Magdum *et al.*, 2017), Meghalaya, Sikkim (Gangulee, 1976), Tamil Nadu (Daniels, 2010; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Idivara Shola (2000-2200 m) 12.07.2017 *Mufeed* 7339, 7356a (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Mananthavady puzha (1100 m) *Manju C.N.* 99648 (ZGC!); Myanmar (915 m) March 1901 *H.C. Gangulee* (57/7)7-1 (CAL!).

Pterobryopsis orientalis (Müll. Hal.) M. Fleisch., *Hedwigia* 59: 217. 1917; Gangulee, *Mosses E. India & Adj. Reg.* 2(5): 1272. 1976; Lal, *Checklist Indian Moss.* 114. 2005; *Neckera orientalis* Müll. Hal., *Bot. Zeitung (Berlin)* 14: 437. 1856. *Endotrichum foulkesianum* A. Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1875-76: 233. 1877. *Garovaglia juliramea* Müll. Hal., *Bull. Soc. Roy. Bot. Belgique* 8(1): 19. 1900.

Plants golden yellowish to green, robust, rigid, main stem creeping, secondary stem irregularly branched, branches usually flagelliform, erect; leaves elongate ovate, shortly acuminate, slightly serrate above, plicate, 3 x 1.3 mm; costa strong, vanishing above the middle, flexuous above; laminal cells elongate-rhomboid at the upper region, 60-90 x 10 µm, small rhomboidal cells at middle and base, 45-65 x 8 µm, alar cells rounded-quadrate, smooth, yellowish orange to dark brownish, 25-45 x 15-20 µm; sporophyte not seen (Plate 5.152).

Habitat: Epiphytic on bark and branches of large trees in shola forest.

Discussion: A common species in high altitude mountains of South India. Previously reported from Wayanad district of Kerala by Nair *et al.* (2005) as a new record.

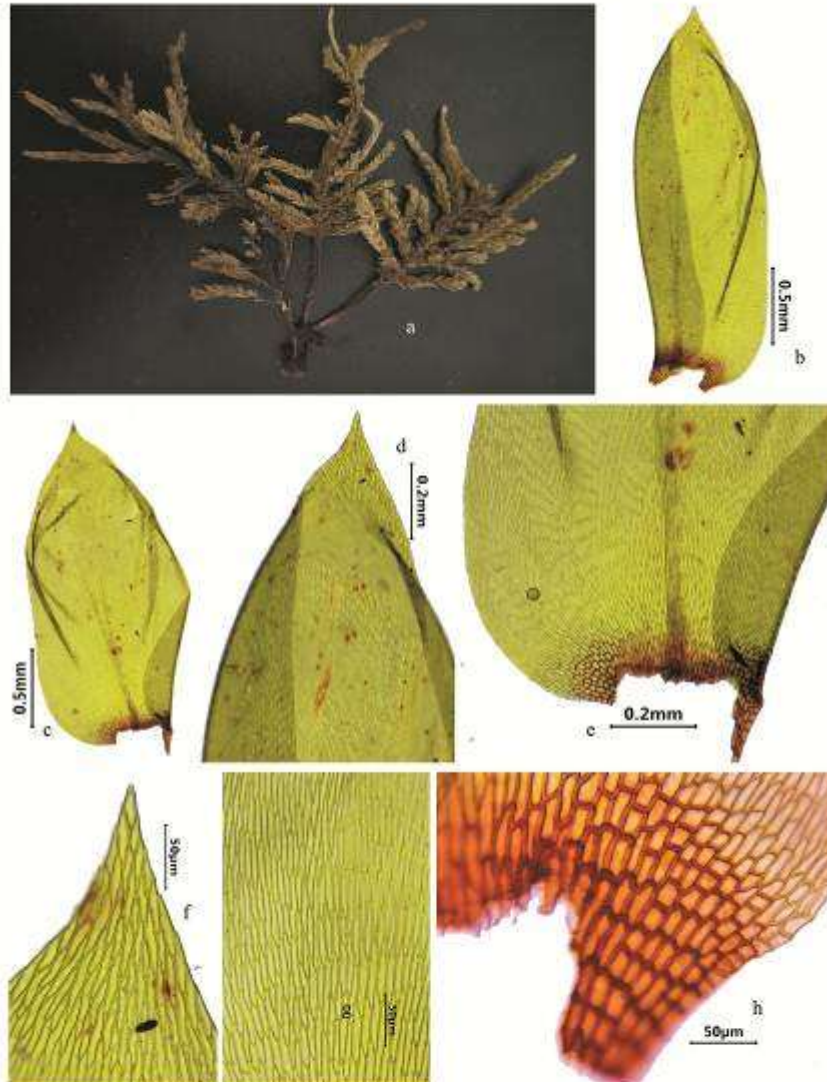


Plate 5: 152. *Pterobryopsis orientalis* (Müll. Hal.) M. Fleisch. a. habit, b & c. leaf, d. leaf apex, e. leaf base, f. tip cells, g. median cells, h. alar cells

Distribution: World: China (Higuchi *et al.*, 2010), Nepal (Gangulee, 1976), Thailand (Touw, 1968), Vietnam (Ninh, 1993); **India:** Karnataka (Schwarz, 2013), Kerala (Nair *et al.*, 2005), Nagaland, Sikkim, West Bengal (Gangulee, 1976), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2130 m) 02.08.2015 *Mufeed 13350*; Idivara Shola (2000 m) 04.03.2016 *Mufeed 10046* (ZGC).

Other specimen/s examined: India, Kerala, Wayanad district, Kurichiad range (750-858m) *Manju C.N. 84531, 84555*, Chandanathode (950 m) *Manju C.N. 80108* (CALI!). West Bengal (1676 m) 30.08.1900 *H.C. Gangulee (57/7)5-1* (CAL).

Neckeraceae Schimp.,

Coroll. Bryol. Eur. 99. 1856.

Plants robust, glossy; stem creeping, filiform, without central strand; secondary branches erect or pendant, irregularly pinnate; leaves 2–many rowed, complanate or imbricate, wavy, acute at apex; leaf cells rhomboid to linear rhomboid, smooth; alar region distinct; costa single rarely double or bifurcate; sporophytes on lateral branches; capsules exserted or not.

Key to the genera

- 1a. Plants frondose, leaves 2-rowed; branches bipinnate or tripinnate, usually erect
..... ***Homaliodendron***
- 1b. Plants not frondose, leaves usually 8-rowed; branches pinnate, usually pendant ..
..... ***Neckera***

Homaliodendron M. Fleisch.,

Hedwigia 45: 72. 1906.

Plants robust, frondose, glossy; primary stem creeping giving rise to rigid secondary stems called stipes, without a central strand; stipes usually bipinnate or tripinnately branched; leaves 4-rowed, spreading, longitudinally plicate when dry, lingulate, rarely rotundate spathulate, serrate at apical margin; cells incrassate, polygonal rhomboid to elongate; alar cells distinct; costa single, distinct or not; peristome teeth 2-rowed; calyptra cucullate.

Key to the species

- 1a. Plants oblong spatulate; toothed at apex 2
- 1b. Plants oblong lingulate; entire or faintly crenulate at apex ***H. microdendron***
- 2a. Leaf apex usually with distantly 3-toothed; costa reaches up to the middle of leaf
..... ***H. flabellatum***
- 2b. Leaf apex usually with 5-6 teeth; costa usually ends above the middle of leaf
..... ***H. rectifolium***

Homaliiodendron flabellatum (Sm.) M. Fleisch., Hedwigia 45: 74. 1906; Bruehl, Rec. Bot. Surv. India 13(1): 77. 1931; Foreau, J. Madras Univ. 3: 121. 1931 & J. Bombay Nat. Hist. Soc. 58: 34. 1961; Dixon, J. J. Bombay Nat. Hist. Soc. 39: 785. 1937; Wadhwa, M.V.M. Patrika 6: 72. 1971; Chopra, Taxon. Indian Moss. 369. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1426. 1976; T. Ninh, J. Hattori. Bot. Lab. 57: 34. 1984; Enroth, Acta Bot. Fenn. 137: 61. 1989; Nair & Madhusoodanan, J. Econ. Taxon. Bot. 25: 574. 2001; Lal, Checklist Indian Moss. 72. 2005; Nair *et al.*, Bryophyt. Wayanad W. Ghats: 162. 2005; Manju *et al.*, Trop. Bryo. Res. Rep. 7: 13. 2008; Arch. Bryol. 42: 8. 2009 & Taiwania 54: 65. 2009; Daniels, Arch. Bryol. 65: 62. 2010; Daniels & Daniel, Bryofl. S. most W. Ghats, India. 119. 2013; Daniels *et al.*, Bryoflor. Indira Gandhi Natl. Pk. 196. 2018; Daniels & Kariyappa, Bryofl. Agasthyamalai Bio. Res.: 1: 195. 2019. *Hookeria flabellata* Sm., Trans. Linn. Soc. London 9: 280. 1808. *Leskea flabellata* (Sm.) Schwägr., Sp. Musc. Frond., Suppl. 1, 2: 164. 1816. *Homalia flabellata* (Sm.) Brid., Bryol. Univ. 2: 812. 1827. *Climacium neckeroides* Brid., Bryol. Univ. 2: 276. 1827. *Homalia flabellata* (Sm.) Brid., Bryol. Univ. 2: 812. 1827. *Pterygophyllum decompositum* Brid., Bryol. Univ. 2: 764. 1827. *Hypnum flabellatum* (Sm.) Dicks. ex Müll. Hal., Syn. Musc. Frond. 2: 225. 1850. *Leskea decomposita* Brid., Syn. Musc. Frond. 2: 42. 1850. *Neckera australasica* Müll. Hal., Syn. Musc. Frond. 2: 42. 1850. *N. decomposita* (Brid.) Müll. Hal., Syn. Musc. Frond. 2: 42. 1850. *N. javanica* Müll. Hal., Syn. Musc. Frond. 2: 41. 1850. *N. scalpellifolia* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 119. 1859. *Homalia scalpellifolia* (Mitt.) Bosch & Sande Lac., Bryol. Jav. 2: 60. 180. 1863. *Porotrichum decompositum* (Brid.) Mitt., J. Linn. Soc., Bot. 12: 463. 1869. *Homalia intermedia* Ångstr., Öfvers. Förh. Kongl. Svenska Vetensk.-

Akad. 29(4): 17. 1872. *Neckera mohriana* Müll. Hal., Linnaea 38: 646. 1874. *Homalia mohriana* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875–76: 298. 1877. *H. mohrii* Müll. Hal. ex Kindb., Enum. Bryin. Exot. 16. 1888. *H. praelonga* Reichardt, Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. 175: 573. 1877. *Porotrichum flabellatum* (Sm.) Mitt., Trans. Linn. Soc. London, Bot. 3: 175. 1891. *P. scalpellifolium* (Mitt.) Mitt., Trans. Linn. Soc. London, Bot. 3: 175. 1891. *Homalia densa* Bosw., J. Bot. 30: 98. 1892. *Porotrichum grandidens* Müll. Hal., Hedwigia 37: 243. 1898. *Homali dendron densum* (Bosw.) Broth., Nat. Pflanzenfam. I(3): 851. 1906. *H. mohrianum* (Müll. Hal.) M. Fleisch., Hedwigia 45: 77. 1906. *H. scalpellifolium* (Mitt.) M. Fleisch., Hedwigia 45: 75. 1906. *H. squarrosulum* M. Fleisch. ex P. de la Varde, Rev. Bryol. Lichénol. 10: 141. 1937. *H. decompositum* (Brid.) K.A. Wagner, Bryologist 55: 144. 1952.

Plants robust, lax, glossy, pale green, primary stem creeping; branches pinnate, frondose, complanate; leaves 2-rowed, horizontally spreading, complanate, longitudinally plicate when dry, asymmetric, oblong-lingulate, inflexed on one side at the base, obtuse to acute and distantly toothed at apex and usually with 3 teeth, faintly crenulate below, 1 mm long and 0.4 mm wide; stem leaves usually larger than branch leaves; cells at apex and middle rhomboid to polygonal, incrassate, 12–20 µm long and 6–8 µm wide, cells at base elongate, 25–35 µm long and 5 µm wide, cells at margin usually quadrate rectangular, 8–10 µm long and 6–8 µm wide; costa single, ending below apex, rarely bifurcate; sporophyte not seen (Plate 5.153).

Habitat: Epiphytic, on trunks of large trees in shola forest from 1800 m above.

Discussion: Very common taxa in shola forests of Western Ghats. This species is characterized by the frondose plants with leaves having costa reach up to the middle and the leaf apex with 3 prominent tooth.

Distribution: World: China (Redfearn Jr. & Wu, 1986), Hawaii (Miller, 1954), Indonesia (Ho *et al.*, 2006), Japan (Suzuki, 2016), Mexico (Moya & Soriano, 2011), Nepal, Bhutan (Gangulee, 1976), Sri Lanka (Tan, 2005); **India:** Arunachal Pradesh, Sikkim, Meghalaya, West Bengal (Gangulee, 1976), Karnataka (Frahm *et al.*, 2013; Schwarz, 2013), Kerala (Nair & Madhusoodanan 2001), Tamil Nadu (Daniels, 2010);

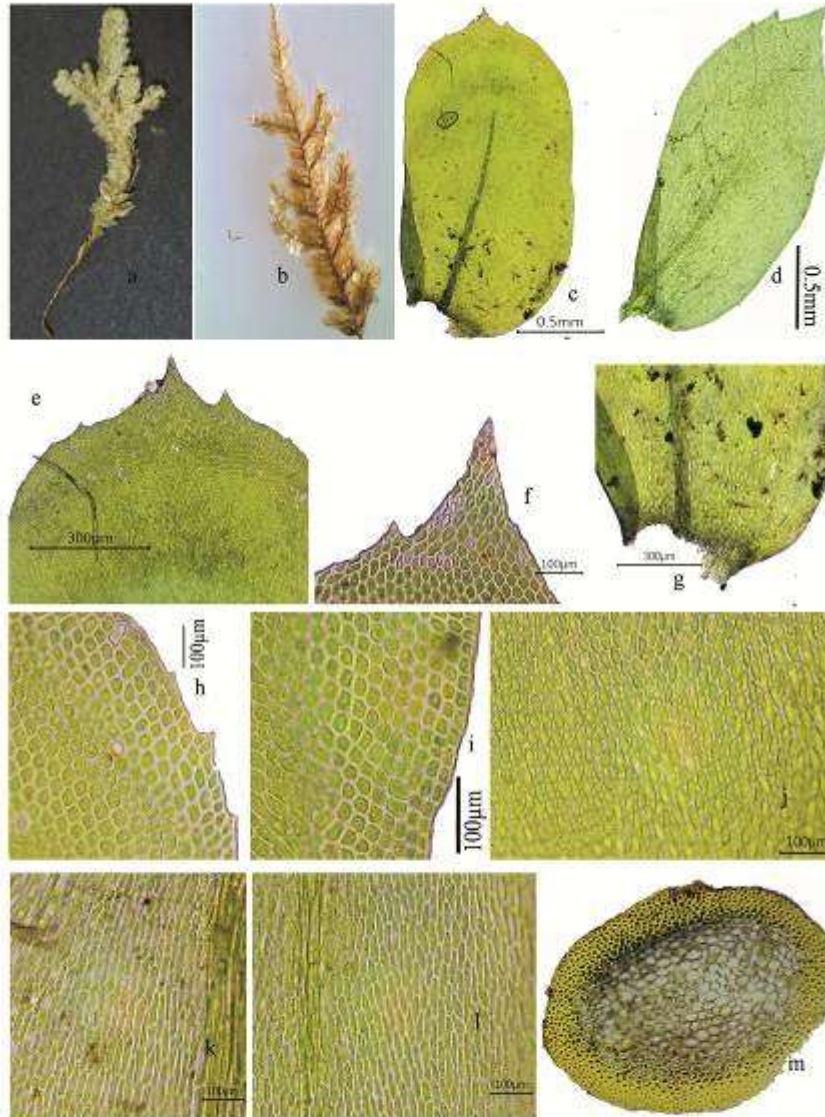


Plate 5. 153: *Homaliodendron flabellatum* (Sm.) M. Fleisch. a & b. habit, c&d. leaf, e. leaf apex, f. cells at apex, g. leaf base, h. margin at apex, i. margin at base, j. median cells, k&l. basal cells, m. c.s. of stem

Daniels *et al.*, 2018; Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000 m) 02.08.2015 *Mufeed 13306*; Pullaradi Shola (2250 m) 04.03.2016 *Mufeed 10057*; Idivara Shola (2000m) 12.07.2017 *Mufeed 7349* (ZGC).

Other specimen/s examined: India, West Bengal, Darjeeling (2150 m) 09. 10. 1957 *H.C. Gangulee 4970* (III) (CAL).

Homaliodendron microdendron (Mont.) M. Fleisch., *Hedwigia* 45: 78. 1906; Bruehl, *Rec. Bot. Surv. India* 13(1): 77. 1931; Foreau, *J. Bombay Nat. Hist. Soc.* 58: 33. 1961; Wadhwa, *M.V.M. Patrika* 6: 72. 1971; Chopra, *Taxon. Indian Moss.* 369. 1975; Gangulee, *Mosses E. India & Adj. Reg.* 2(5): 1414. 1976; T. Ninh, J. Hattori. *Bot. Lab.* 57:14.1984; Lal, *Checklist Indian Moss.* 72. 2005; Manju *et al.*, *Trop. Bryol. Res. Rep.* 7: 13. 2008; *Arch. Bryol.* 42: 8. 2009 & *Taiwania* 54: 65. 2009; Daniels, *Arch. Bryol.* 65: 62. 2010; Daniels & Daniel, *Bryofl. S. most W. Ghats, India.* 120. 2013; Daniels & Kariyappa, *Bryofl. Agasthyamalai Bio. Res.:* 1: 226. 2019. *Hookeria microdendron* Mont., *Ann. Sci. Nat., Bot., sér. 2*, 19: 240. 1843. *Hypnum spathulifolium* Müll. Hal., *Syn. Musc. Frond.* 2: 231. 1851. *Neckera glossophylla* Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1(2): 119. 1859. *Homalia microdendron* (Mont.) A. Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1875–76: 296. 1877. *Homaliodendron excisum* M. Fleisch., *Hedwigia* 45: 78. 1906. *H. glossophyllum* (Mitt.) M. Fleisch., *Hedwigia* 45: 78. 1906. *H. spathulifolium* (Müll. Hal.) M. Fleisch., *Hedwigia* 45: 78. 1906. *H. elegantulum* Thér. *Rev. Bryol.* 49: 7. 1. 1922. *Circulifolium microdendron* (Mont.) S. Olsson, *Enroth & D. Quandt, Organisms Diversity Evol.* 10(2): 120. 2010.

Plants slender, yellow green, creeping, wiry; secondary stem usually erect, complanate; leaves 2-rowed, longitudinally plicate when dry, asymmetric; stem leaves and branch leaves varies in size; leaves oblong spatulate, asymmetric, inflexed on one side at base, blunt or faintly apiculate, entire to faintly crenulate at apex, entire below, 0.9-1 x 0.5-0.6 mm, apex more broad; apical cells and median cells quadrate rhomboid, 12-22 x 7-12 µm, cells at base elongate, rectangular with a few shorter ones at leaf attachment, 17-27 x 8 µm, marginal cells 2-rowed; costa

single, reaches above middle; reproductive structures not seen (Plate 5.154).

Habitat: Epiphytic, on bark of large trees along with *Porella madagascariensis* (Nees & Mont.) Trevis. in shola forest.

Discussion: Compared to other species in the study area, *Homaliodendron microdendron* (Mont.) M. Fleisch. is clearly differentiated by its faintly crenulate nature of leaf at apex but in other species apex is serrate or dentate.

Distribution: World: Bangladesh (O'Shea, 2003), China (Redfearn Jr., 1990), Hong Kong (So & Yip, 1995), Malaysia (Suleiman *et al.*, 2009), Philippines (Noguchi, 1963), Taiwan (Lin, 1981), Thailand (Touw, 1986), Vietnam (Ninh, 1993); **India:** Kerala (Manju *et al.*, 2008, 2009), Manipur, Meghalaya (Gangulee, 1976), Tamil Nadu (Daniels & Kariyappa, 2019).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullaradi Shola (2100 m) 04.03.2016 *Mufeed 10049*; Idivara Shola (2000 m) 12.07.2017 *Mufeed 7341b* (ZGC).

Other specimen/s examined: India, Eastern Himalayas *Gangulee* (60/6) 2-2 (CAL!).

Homaliodendron rectifolium (Mitt.) M. Fleisch., Hedwigia 45: 75. 1906; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1418. 1976. *Neckera rectifolia* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 119. 1859. *Homalia rectifolia* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875–76: 299. 1877.

Plants yellow green, main stem distantly covered by scale leaves, appressed to stem, 2-rowed; leaves horizontal to slightly raised, complanate, asymmetrically oblong-lingulate, longitudinally plicatae when dry, 1.9 mm long and 1 mm wide, apex obtuse, acuminate; margin clearly serrate to dentate at tip, usually 5-6 teeth, entire below, incurved at base on one side; costa single, covering 2/3rd of the leaf; leaf cells incrassate, smooth, rhomboid to hexagonal in lamina, 12-17 x 8-12 µm, cells at base elongated, 25-35 x 5-8 µm, marginal cells with 2-rows of very short rectangular cells, 6-10 x 4-8 µm; sporophyte not seen (Plate 5.155).

Habitat: Epiphytic, on barks of tree trunks in shola forest.

Discussion: Gangulee (1976) reported this species from Eastern Himalayas and

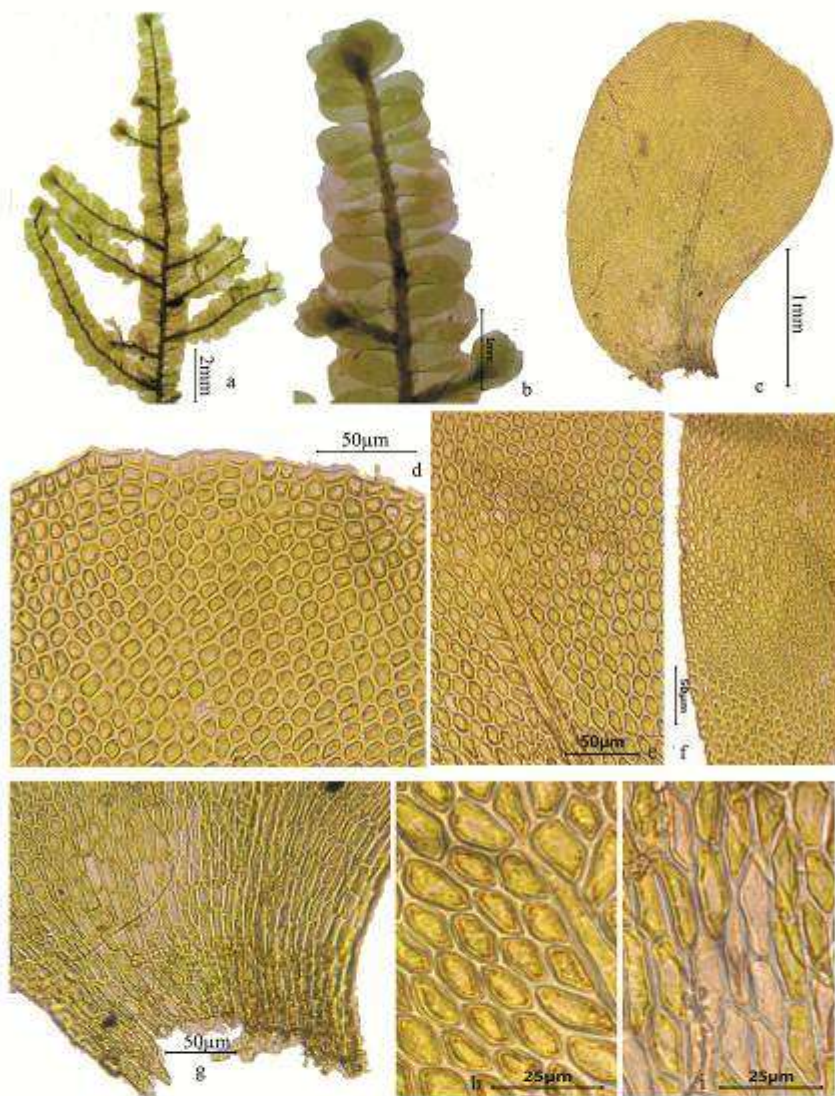


Plate 5. 154: *Homaliodendron microdendron* (Mont.) M. Fleisch. a. habit, b. branch, c. leaf, d. leaf apex, e. leaf middle cells, f. leaf margin, g. leaf base, h&i. leaf basal cells

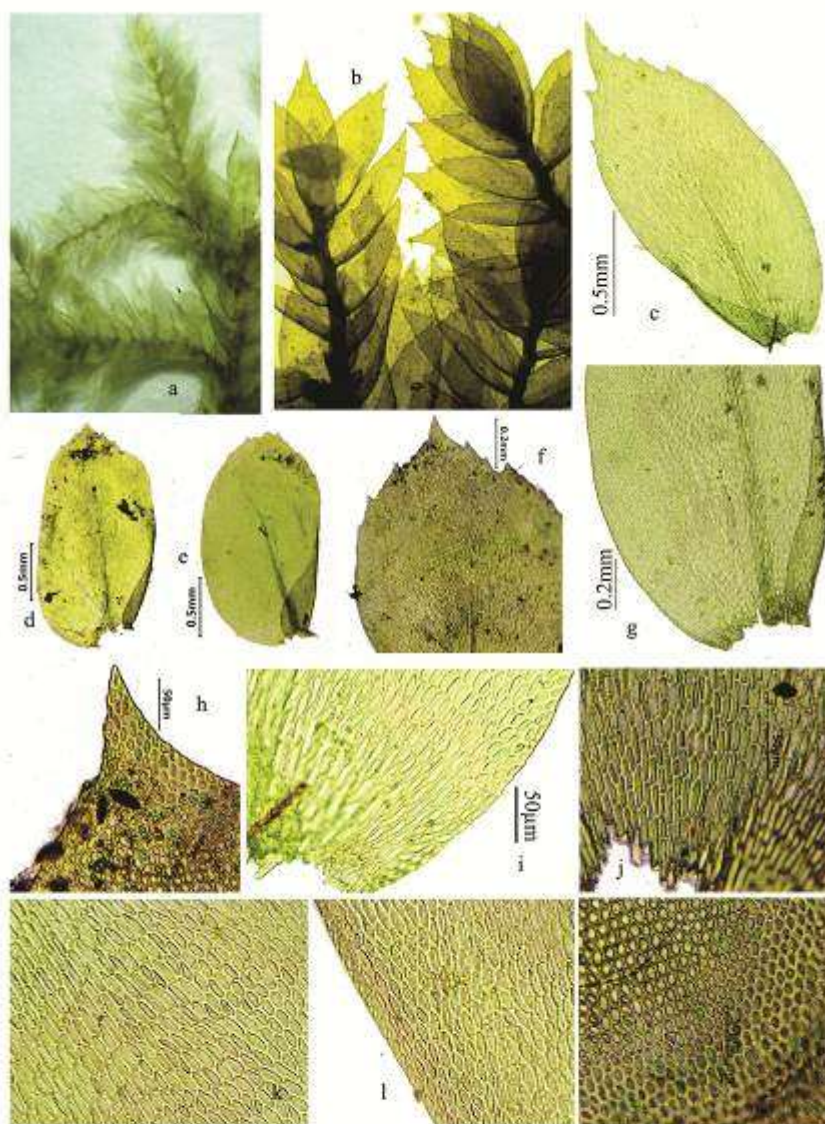


Plate 5. 155: *Homaliodendron rectifolium* (Mitt.) M. Fleisch. a & b. habit, c,d&e. leaves, f. leaf apex, g. leaf base, h. leaf tip cells, i. leaf base cells, j. cells near costa, k. median cells, l. marginal cells, m. cells at apex

there is no report of this species from Peninsular India. Hence the present collection is a new record for Peninsular India.

Distribution: World: China (Redfearn Jr., 1986), Nepal (Gangulee, 1976); **India:** Kerala (present collection), Sikkim, Meghalaya (Gangulee, 1976).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2176 m) 04.03.2015 *Mufeed* 13343; Idivara Shola (2000 m) 12.07.2017 *Mufeed* 7362 (ZGC).

***Neckera* Hedw.,**

Sp. Musc. Frond. 200–210, pl. 46, f. 10–15; pl. 47–48. 1801.

Plants robust, creeping, caespitose, glossy; branches pinnate, complanate, pendant, rarely ascending; leaves 8-rowed, transversely undulate, broadly ovate, concave, acuminate; costa single, less than $\frac{1}{2}$ or long ending below apex; cells porose, linear at base, rhomboid at apex, alar region distinct; sporophytes on lateral shoots; capsules ovoid, peristome teeth 2-rowed, neckeroid, operculum conic rostrate, calyptra cucullate.

***Neckera pennata* Hedw.,** Sp. Musc. Frond. 200–201. 1801; Chopra, Taxon. Indian Moss. 360. 1975; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1383. 1976; Lal, Checklist Indian Moss. 94. 2005; A.E. Daniels, Arch. Bryol. 65: 72. 2010. *Hypnum pennatum* (Hedw.) Hoffm. ex Funck, Allg. Lit.-Zeitung (Jena) 1801(38): 301. 1801. *Fontinalis pennata* (Hedw.) Jolycl., Syst. Sex. Vég. 747. 1803. *Pilotrichum pennatum* (Hedw.) P. Beauv., Prodr. Aethéogam. 83. 1805. *Cryptopodia pennata* (Hedw.) Röhl., Deutschl. Fl. (ed. 2), Kryptog. Gew. 3: 82. 1813. *Cryptopodium pennatum* (Hedw.) Fürnr., Flora 10: 81. 1827. *Daltonia pennata* (Hedw.) Arn., Mém. Soc. Linn. Paris 5: 295. 1827. *Distichia pennata* (Hedw.) Brid., Bryol. Univ. 2: 787. 1827. *Neckera oligocarpa* Bruch, Disp. Musc. Scand. 1. 1842. *N. hymenodonta* Müll. Hal., Bot. Zeitung (Berlin) 9: 564. 1851. *Eleutera pennata* (Hedw.) Stuntz, Bull. Torrey Bot. Club 27: 205. 1900. *Rhystophyllum pennatum* (Hedw.) E. Britton, Bryologist 8: 6. 1904. *Neckera abbreviata* Cardot, Bull. Soc. Bot. Genève 3: 277. 1911.

Plants robust, creeping, yellowish green, usually pendant or occasionally horizontal, irregularly pinnate; leaves ovate-lanceolate, narrowing down at tip and forms a short

acumen, complanate, asymmetrical, incurved on one side, spreading horizontally, undulate when dry, 1.4 mm long and 0.5 mm wide, wide at middle, margin faintly crenulated at tip, incurved at base on one side; costa single, very short, single or bifurcate, laminal cells linear, incrassate; cells at apex, 27-32 x 5-7 μ m, cells at middle elongate, 70-100 x 7 μ m, cells at base, smaller and slightly rectangular, 38-45 x 8 μ m; alar cells differentiated into quadrate rectangular cells, colourless, 25-40 x 10-12 μ m; reproductive structures not observed (Plate 5.156).

Habitat: Epiphytic on branches and bark of trees, rarely seen in land cuttings.

Discussion: A widely distributed taxa all over the world but not reported from Kerala. Hence the present collection is a new record for Kerala. Usually this species is seen as epiphytic one, but during the present study it is observed on land cuttings also.

Distribution: World: Africa (O'Shea, 2006), America (Worley & Iwatsuki, 1970), Australia (Dalton *et al.*, 1991), Bhutan (Gangulee, 1976), China (Radfearn & Wu, 1986), Japan (Noguchi & Iwatsuki, 1989), New Zealand (Beever *et al.*, 1971), Russia (Ignatova *et al.*, 2009); **India:** Assam (Gangulee, 1976), Kerala (present collection), Manipur (Govindaparyi, 2014), Tamil Nadu (Daniels, 2010).

Specimen/s examined: India, Kerala, Idukki district, Anamudi Shola National Park, Pullardi Shola (2000-2100 m) 12.07.2017 *Mufeed* 7317, 7326; Idivara Shola (2100 m) 12.07.2017 *Mufeed* 7358; Mannavan Shola (1700-2215 m) 14.07.2017 *Mufeed* 7580; 22.09.2018 *Mufeed* 9904 (ZGC).

Myuriaceae Broth. ex M. Fleisch.,
Musci Buitenzorg 4: 1663. 1923.

Plants robust, glossy in dense tufts, stem without central strand; secondary branches erect or ascending; leaves dense, ovate-lanceolate, acuminate; costa absent; laminal cells linear except in base where cells are quadrangular, smooth; sporophyte on short lateral branches; seta long, capsule erect, ovate, peristome double, calyptra cucullate.

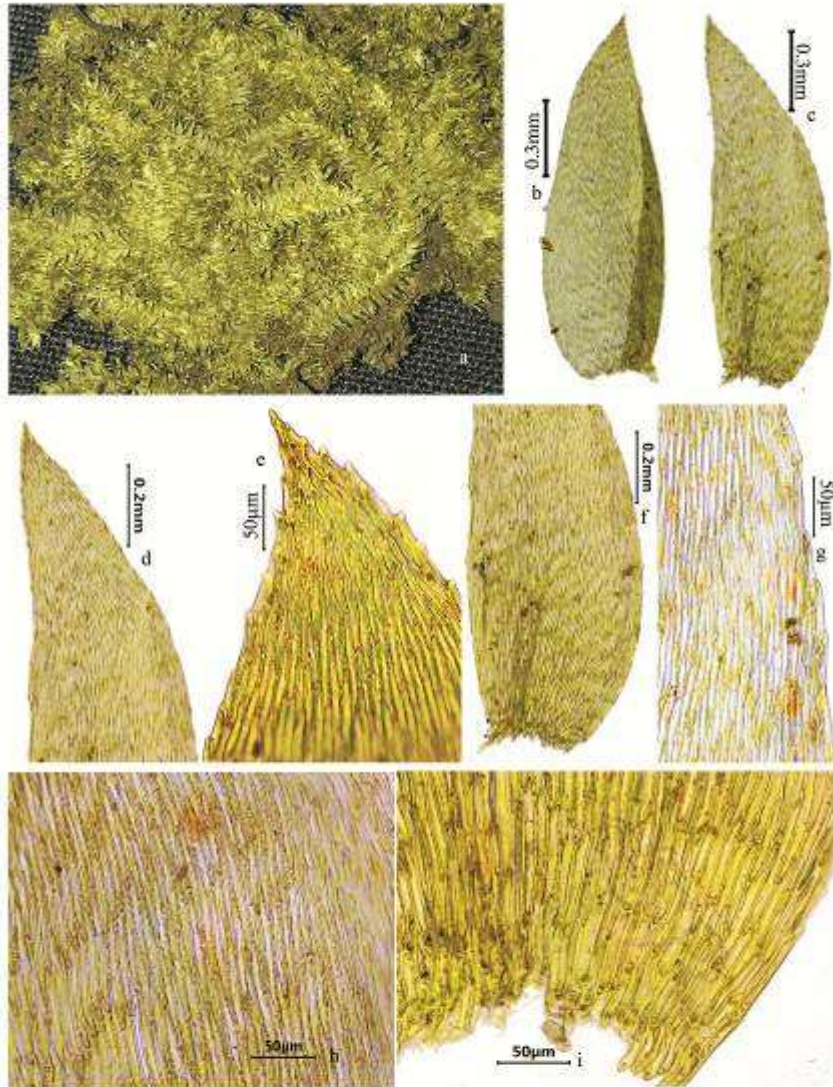


Plate 5. 156: *Neckera pennata* Hedw., a. habit, b&c. leaf, d. leaf apex, e. leaf tip cells, f. leaf base with double costa, g. leaf marginal cells, h. cells at middle, i. leaf basal cells

***Myurium* Schimp.,**

Syn. Musc. Eur. 695. 1860.

Plants lustrous, golden green above, brown below, branches usually densely tufted, suberect, simple or sparingly branched; leaves dense, erect, concave, ovate to ovate-lanceolate, sharply acuminate; laminal cells elongate, smooth, usually with pitted walls; sporophyte on short lateral branches; seta long, capsule erect.

Myurium borii (Dixon) Magill, J. Hattori Bot. Lab. 48: 68. 1980; Gangulee, Mosses E. India & Adj. Reg. 2(5): 1275. 1976; Ellis *et al.*, J. Bryol. 42(2): 199. 2020. *Symphysodontella borii* Dixon, J. Bombay Nat. Hist. Soc. 39: 781. 1937.

Plants light green above, brownish below, medium size, secondary strands slender, pinnately branched, about 2 cm long, cross section of stem shows two types of cells, outer 3-4 layer of cells thick, smaller, inner most layer of cells somewhat large and thin walled; leaves dense, imbricate, erect, concave, plicate, ovate-lanceolate, up to 1.5 mm long and 0.40 mm wide, acute and apiculate at tip, margin very faintly denticulate at tip, costa faint or ecostate; leaf cells lightly incrassate, elongate linear, 70-75 x 10-12 µm at base; stem attachment cells are coloured; alar cells differentiated, deep brown, rectangular, 18-24 x 10-18 µm, smaller, gradually becoming longer above, up to 25-40 x 12-14 µm; sporophyte not observed (Plate 5.157).

Habitat: Epiphytic moss seen on bark, twigs and branches in shola trees along with *Leptohymenium tenue* (Hook.) Schwägr., *Pterobryopsis orientalis* (Müll. Hal.) M. Fleisch. and *Cryptopapillaria fuscescens* (Hook.) M. Menzel.

Discussion: Previously reported in India (Gangulee, 1976) from Eastern Himalayas. Gangulee reported this species as *Symphysodontella borii* Dixon, later synonymised with *Myurium borii* by Magill (1980). Ellis *et al.* (2020) reported this species as new record for Western Ghats based on the present collection.

Distribution: World: Sri Lanka (Tan, 2005), Thailand (Printarakul *et al.*, 2012);

India: Arunachal Pradesh (Gangulee, 1976), Kerala (Ellis *et al.*, 2020).

Specimen/s examined: India: Kerala, Idukki district, Anamudi Shola National Park, Mannavan Shola (2000 m) 12.07.2017 *Mufeed 7313d* (ZGC).

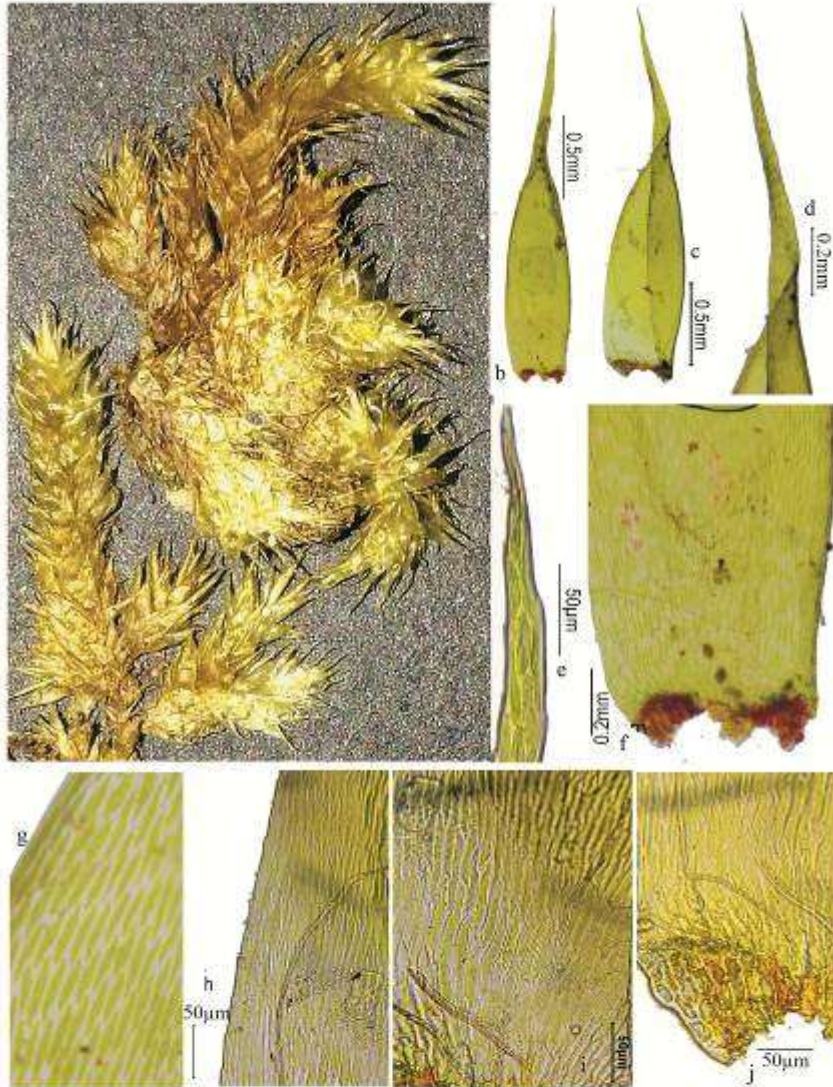


Plate 5. 157: *Symphysodontella borii* Dixon a, habit, b&c. leaf, d&e. leaf apex, f, leaf base with coloured alar cells, g&h, leaf marginal cells, i, leaf basal cells, j. enlarged view of alar cells

ECOLOGY OF BRYOPHYTES IN THE ANAMUDI SHOLA NATIONAL PARK

Ecological studies of Cryptogams have not got much attention in India. The works on this aspect are very few. Plant community ecological studies in India, are mainly concentrated on angiospermic trees and shrubs. The bryophytes being small, and the chance of occurring many species in a small patch itself is really challenging to ecologists. It is not easy to identify them all in the field itself. That makes the enumeration and quantification of bryophytes from the field as a hectic task. It is a time-consuming task. Some such studies were conducted on the Lichens and Bryophytes in Himalayan area by Negi and Gadgil (1996, 1997, 2001), Negi (2000a), Negi and Upreti (2000), Pinokiyo *et al.* (2008), Bahuguna *et al.* (2014), Upreti and Tandon (2014) and Joshi *et al.* (2016). In Southern India very few studies are there, such as Nayaka *et al.* (2001). Community ecological parameters such as species turnover, similarity assessments, etc. along gradients of habitat, microhabitats and altitude were not attempted by many in Southern India or India at large.

The studies on community ecology and related works were conducted by many in other parts of the world such as Van Reenen and Gradstein (1984), Gradstein and Salazar (1992), Wolf (1993), González-Mancebo and Hernández-Garcia (1996), Grytnes *et al.* (2006), Bruun *et al.* (2006), Grau *et al.* (2007), Ah-Peng *et al.* (2007). These studies also resulted in planning better conservation strategies. Both qualitative and quantitative techniques were adopted for the community ecological studies of bryophytes. Recently, some noteworthy studies such as Costa *et al.* (2018) and Jiang *et al.* (2018) presented excellent synthesis of bryophyte community ecology. Glime (2019) provided an in depth review of ecology of bryophytes, along altitudinal and latitudinal gradients. Marline *et al.* (2020) examined the patterns of epiphytic bryophyte distribution along the altitudinal gradient in Marojejy National Park of Madagascar. They also commented that four major patterns of distribution are shown by bryophytes with respect to elevational gradient, viz., monotonic decrease, monotonic increase, hump-shaped

and multi modal. Of which the most common one, the hump-shaped with high richness at mid elevation, was observed in Marojejy National Park of Madagascar where altitude ranges from 250-2050 m.

The present study examined the general ecology of bryophytes such as the diversity of species across different vegetation types, shola forests, microhabitats and altitudinal gradients (Table 6. 1 & 6. 2).

Distribution of Bryophytes in the Anamudi Shola National Park

Among the three sholas, the Mannavan Shola is the biggest (5.18 km²) and supports highest bryophyte species diversity (125 spp.). The other two, Pullaradi (48 spp. In 1.62 km²) and Idivara (23 spp. In 0.61 km²) are smaller, and support bryophyte species accordingly. The Mannavan Shola is unique in having the highest number of non-shared species (89 spp.) compared to Pullaradi (16 spp.) and Idivara (10 spp.) (Table 6.3). The bryophyte species composition of Idivara Shola shows only 15%-20% similarity with the other two sholas (Fig. 6.1&2). Only 5 species viz., *Lejeunea flava* (Sw.) Nees, *Aerobryidium filamentosum* (Hook.) Fleisch., *Cryptopapillaria fuscescens* (Hook.) M. Menzel, *Homaliiodendron flabellatum* (Sm.) M. Fleisch., *Neckera pennata* Hedw. were found as common for all the three sholas. The other patterns of sharing of species are as follows; Mannavan and Pullaradi - 25 spp., Mannavan and Idivara – 6 spp., Pullaradi and Idivara – 2 spp.

Fig. 6.1: Distribution of bryophytes in three major shola patches of the Anamudi Shola National Park.

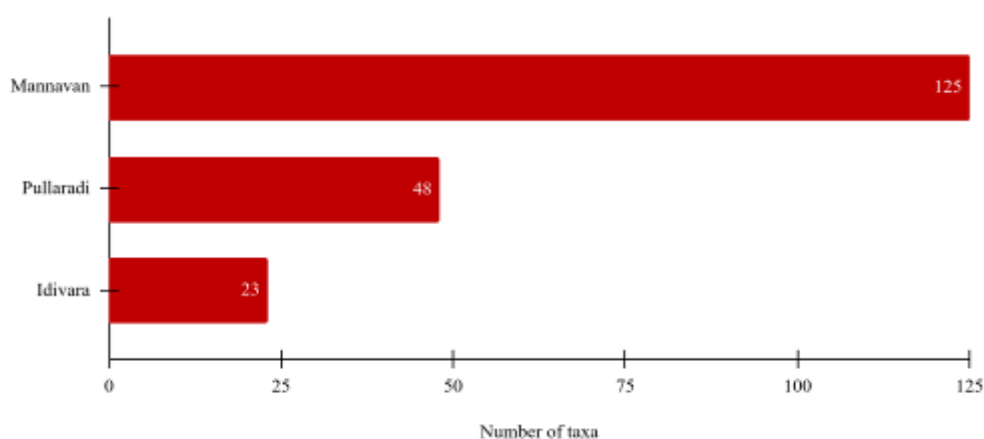
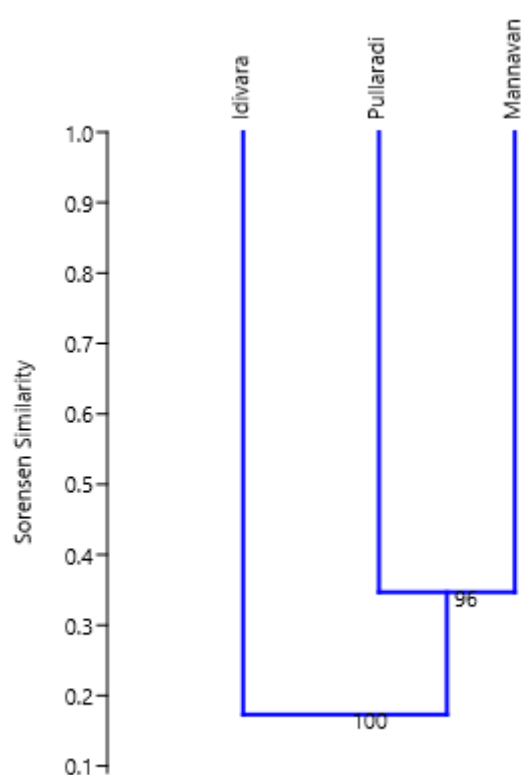


Table 6.3: Sorensen Similarity Index of bryophyte sharedness along microhabitats of Anamudi Shola National Park

Sholas	Mannavan	Pullaradi	Idivara
Mannavan	1.00	0.35	0.15
Pullaradi		1.00	0.20
Idivara			1.00

Fig. 6.2: Dendrogram based on Sorensen Similarity Index showing the pattern of distribution of bryophytes in Anamudi Shola National Park.



Distribution of bryophytes along vegetational gradient in Shola National Park

Out of the 153 species recorded, 141 were from the shola vegetation (Fig. 6.3). Among the 141 species present in shola, 96 are exclusive (*i.e.*, *ca.* 68%) (Table 6.4) in that vegetation type. It indicates the significance of the shola vegetation in holding the bryophyte diversity. The extent of evergreen forest type is very less compared to sholas in the National Park. Hence it is reflected in the diversity of the bryophytes also, limiting to 29 species, of which 8 are exclusives. The number of

bryophyte species in grassland is 25, including 4 exclusives. Four species viz., *Lophocolea bidentata* (L.) Dumort., *Barbella bombycina* (Renauld & Cardot) M. Fleisch., *Cryptopapillaria fuscescens* (Hook.) M. Menzel and *Isopterygium serrulatum* M. Fleisch. occur in Shola, Evergreen and Grassland vegetations. The patches of Tea plantations in the outskirts of the National Park are also with less number of bryophytes, limiting to 8 species. It was reflected in the dendrogram (Fig. 6.4) also, forming an early branch. None of these 8 species are exclusive in the tea plantation, but extend to Shola, Grassland or Evergreen forest; showing 10%–12 % similarity with other vegetation types (Table 6.4).

Fig. 6.3: Distribution of bryophytes along vegetational types of Shola National Park.

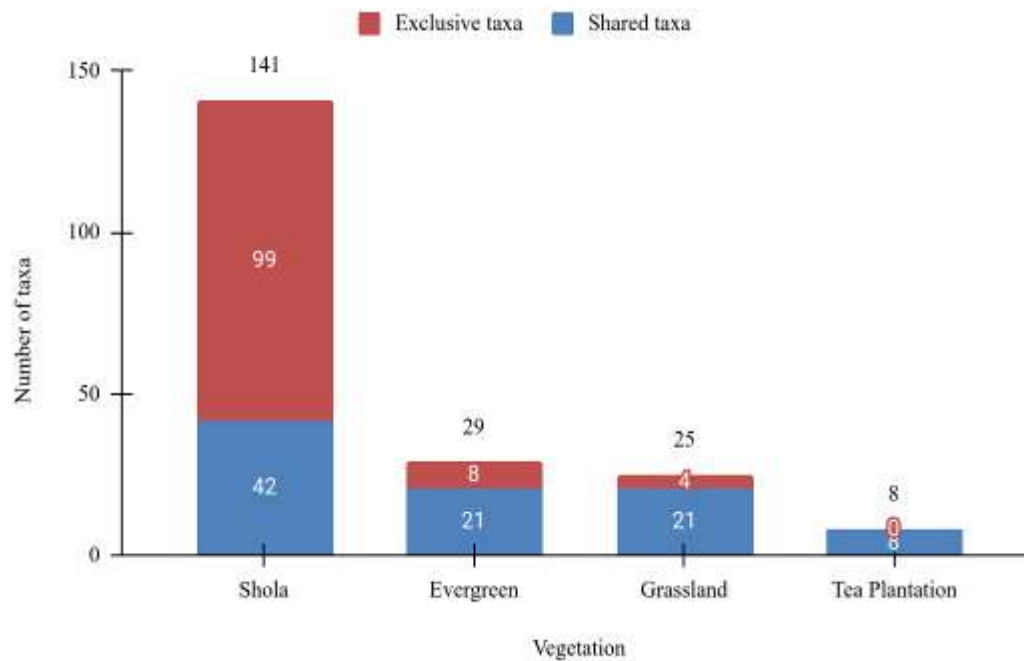
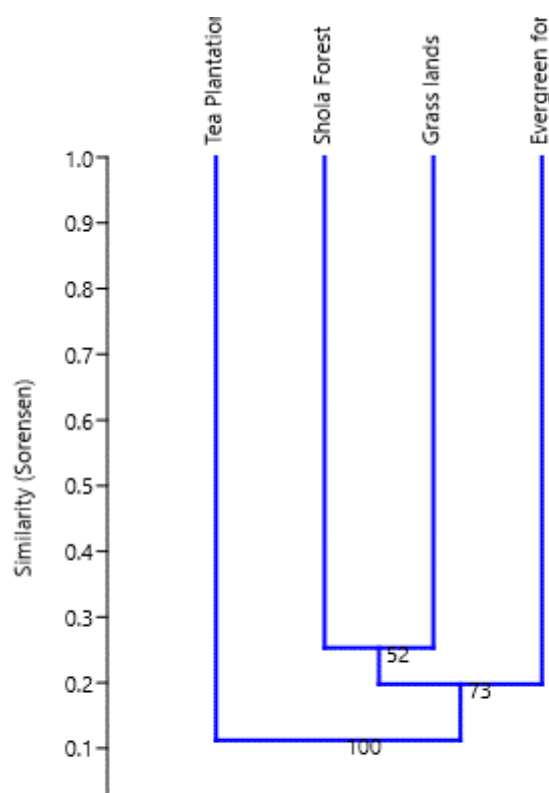


Table 6. 4: Sorensen Similarity Index of Bryophyte sharedness along vegetation types of Shola National Park.

Vegetation types	Evergreen	Shola	Grasslands	Tea Plantation
Evergreen	1.000	0.247	0.148	0.108
Shola		1.000	0.253	0.107
Grasslands			1.000	0.121
Tea Plantation				1.000

Fig.6. 4: Dendrogram based on Sorensen Similarity Index showing the pattern of distribution of bryophytes along vegetational gradients in Shola National Park.



Distribution of bryophytes along microhabitats of Shola National Park

The distribution of bryophytes in different microhabitats shows interesting patterns (Fig. 6.5). The bark of the trees and shrubs is the major microhabitat in holding maximum species (58 spp.). The other major congenial microhabitats are terrestrial (with 43 spp.) and twigs and branches (with 35 spp.) of trees and shrubs. Epiphyllous microhabitat is the least speciose in terms of number, having two species only. The other microhabitats hold different species (Fig.6.5).

The results of cluster analysis based on the Sorensen Similarity Index show the pattern of bryophyte sharedness along microhabitats of the shola system. The dendrogram (Fig. 6.6) reveals the first grouping of Epiphyllous as a distinct branch

from all others. The epiphyllous bryophytes are very few in shola, represented by two species, *Microlejeunea punctiformis* (Taylor) Steph. and *Lejeunea cocoes* Mitt. of which the earlier one also grows on barks. The rest of the microhabitats, forms two major groups based on the degree of sharedness of bryophytes. First group is composed of twigs, barks, exposed roots and logs. The twigs and barks show 24% similarity in the species composition. Similarly, the logs and exposed roots (17%). The other group is larger with microhabitats such as humus, land cuttings, terrestrial, crevices, concrete walls and different rocks (small, large and wet). Among which humus remained as a distinct microhabitat, without having much shared species. The other microhabitats differ based on the degree of sharedness of species (Table 6:5).

Fig. 6.5: Distribution of bryophytes along microhabitats of Shola National Park (Bark of trees: Bk, Concrete wall: CW, Crevices of rocks: CR, Epiphyllous, Ep, Roots of higher plants: Rt, Humus covered leaves: Hu, Land cuttings: LC, Logs & decayed parts: Lg, Large Rocks: LR, Small Rocks & stones: SR, Wet Rocks: WR, Terrestrial: Tr, Twigs and Branches: Tg)

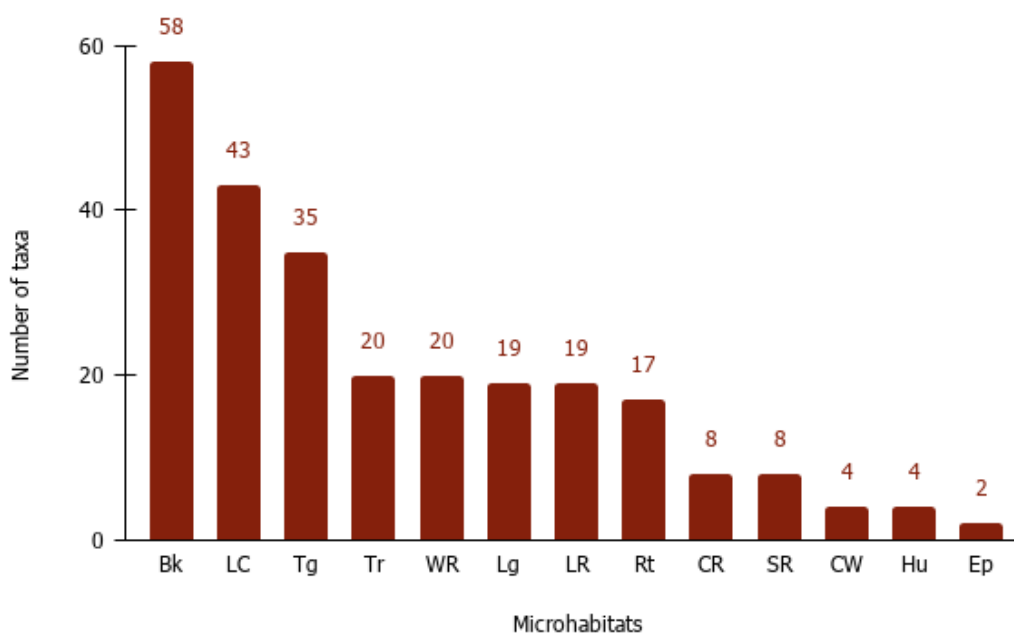
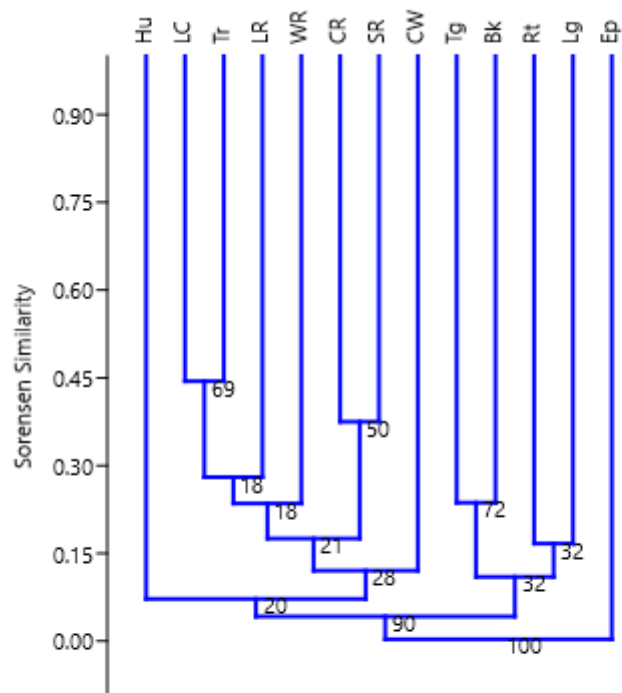


Table 6. 5: Sorensen Similarity Index of bryophyte sharedness along microhabitats of Shola National Park.

	Bk	CR	Rt	LC	Lg	LR	Tg	Tr	WR	CW	Ep	SR	Hu
Bk	1.00	0.00	0.16	0.04	0.13	0.05	0.24	0.08	0.03	0.03	0.03	0.00	0.06
CR		1.00	0.00	0.16	0.00	0.30	0.00	0.14	0.14	0.00	0.00	0.38	0.17
Rt			1.00	0.10	0.17	0.11	0.00	0.05	0.22	0.10	0.00	0.00	0.00
LC				1.00	0.03	0.35	0.00	0.44	0.35	0.13	0.00	0.16	0.00
Lg					1.00	0.11	0.15	0.05	0.05	0.00	0.00	0.00	0.09
LR						1.00	0.04	0.21	0.26	0.26	0.00	0.15	0.09
Tg							1.00	0.00	0.00	0.00	0.00	0.00	0.10
Tr								1.00	0.10	0.17	0.00	0.07	0.00
WR									1.00	0.00	0.00	0.29	0.08
CW										1.00	0.00	0.17	0.00
Ep											1.00	0.00	0.00
SR												1.00	0.17
Hu													1.00

Fig. 6.6: Dendrogram based on Sorensen Similarity Index showing the pattern of distribution of bryophytes along microhabitats in Shola National Park.



Distribution of Bryophytes along the altitudinal gradient in Shola National Park.

The altitudinal profile of the Anamudi Shola NP varies from 1600 m msl to 2440 m msl. The area of extent and vegetation also vary along this profile, from lower to higher zone. It is not uniform in all the three Shola patches (Table 6.6). The composition of bryophytes also hence changes along the altitudinal gradient.

Table 6.6: Distribution of vegetation types along altitudinal zones of Shola National Park

Altitudinal zones	Vegetation types in				
	Mannavan		Pullaradi		Idivara
2401-2500	Grasslands		-		-
2301-2400	Grasslands		Shola		-
2201-2300	Shola	Grasslands	Shola		-
2101-2200	Shola	Grasslands	Shola		Shola
2001-2100	Shola		Shola		Shola Tea plantation
1901-2000	Shola		Shola	Tea plantation	Shola
1801-1900	Shola		Shola	Wattle plantation	-
1701-1800	Evergreen	Silver Oak plantation	-		-
1600-1700	Evergreen	Tribal settlements	-		-

Fig. 6.7: Distribution of bryophytes along the altitudinal gradient in Shola National Park.

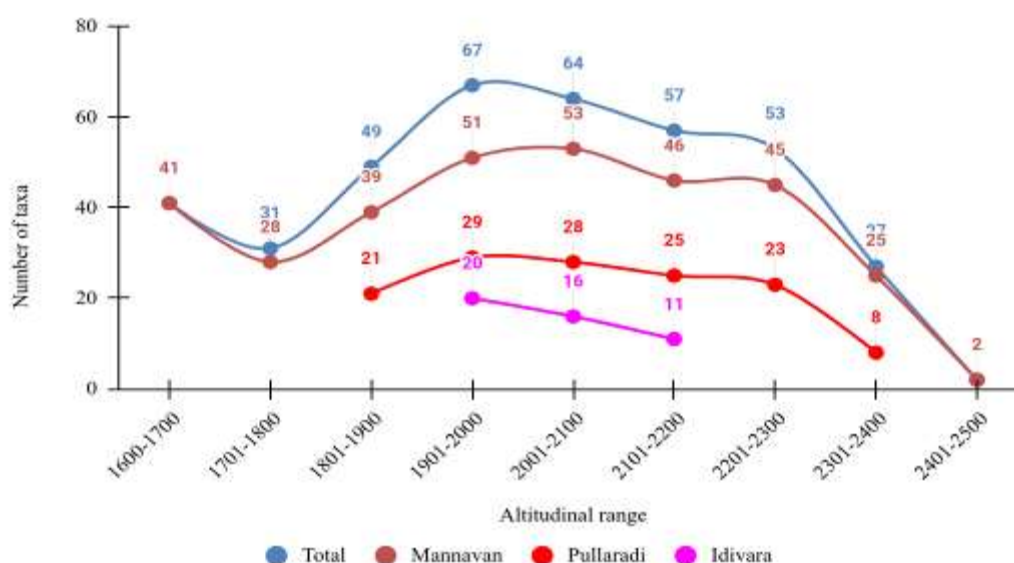


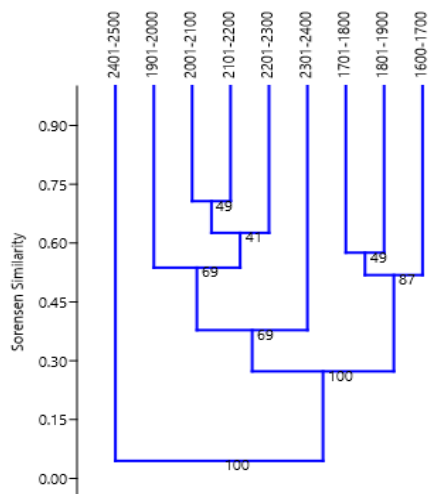
Table 6.7: Bryophyte distribution in different altitudinal zones in three sholas

Alt. range	Number of bryophyte species			
	Total	Mannavan	Pullaradi	Idivara
1600-1700	41	41		
1701-1800	31	28		
1801-1900	49	39	21	
1901-2000	67	51	29	20
2001-2100	64	53	28	16
2101-2200	57	46	25	11
2201-2300	53	45	23	
2301-2400	27	25	8	
2401-2500	2	2		

Table 6.8: Sorensen Similarity Index of bryophyte sharedness along the altitudinal gradient in Shola National Park.

Altitude range	1600-1700	1701-1800	1801-1900	1901-2000	2001-2100	2101-2200	2201-2300	2301-2400	2401-2500
1600-1700	1.00	0.57	0.47	0.34	0.23	0.26	0.28	0.15	0.05
1701-1800		1.00	0.58	0.39	0.24	0.22	0.23	0.11	0.06
1801-1900			1.00	0.53	0.37	0.30	0.31	0.14	0.04
1901-2000				1.00	0.68	0.52	0.41	0.20	0.03
2001-2100					1.00	0.71	0.57	0.36	0.03
2101-2200						1.00	0.69	0.44	0.04
2201-2300							1.00	0.51	0.04
2301-2400								1.00	0.07
2401-2500									1.00

Fig. 6. 8: Dendrogram based on Sorensen Similarity Index showing the pattern of distribution of bryophytes along the altitudinal gradient in Shola National Park.



The analysis of data of bryophyte distribution along the altitudinal gradient showed the general hump-shaped pattern. It increased slightly, and then decreased to a minimum. In the first zone (1600-1700) 41 species were recorded. It showed an unusual dip to 31 species in the next zone (1701-1800). Compared to the first zone, the second zone is vastly planted with Silver oaks (*Grevillea robusta* A.Cunn. ex R.Br.). It is not a suitable habitat for bryophytes, and hence the diversity is less in this zone. In the next zones (1800-2300) it increased and remained stable to some extent. This area is occupied by shola vegetation in all the three sites. In the highest reaches of the NP, the diversity of bryophytes is less due to the less availability of congenial microhabitats. This area is occupied by grasslands and a large extent of bare exposed rocks. These are poor in providing suitable microhabitats for bryophytes (Table 6.7).

The Sorensen Similarity Index also indicates these trends (Table 6.8; Fig. 6.8). The pattern of hump-shaped curve is the commonest one reported by earlier workers (Marline *et al.*, 2020), except for a dip due to the poor stand quality. The same trend was observed, when the three Sholas were examined separately. The Mannavan Shola, being the largest, and with all the vegetation types, follows the same line of pattern. Pullaradi Shola ranging between 1800 to 2400, mainly with Shola vegetation, is also showing the humped pattern of species diversity. Idivara Shola, ranging between 1900 to 2200, is the smallest among the three, but shows a slightly decreasing trend of species diversity.

Table 6. 1: Data on distribution of bryophyte species in three major shola patches, along different vegetation types and in different altitudinal zones of Anamudi Shola National Park (0= absent, 1= present)

Species	Bryophyte distribution in three major sholas			Bryophyte species along different vegetation types				Bryophyte species along different altitudinal zones								
	Mannavan	Pullaradi	Idivara	Evergreen forest	Shola Forest	Grass lands	Tea Plantation	1600-1700	1701-1800	1801-1900	1901-2000	2001-2100	2101-2200	2201-2300	2301-2400	2401-2500
<i>Marchantia polymorpha</i> L.	0	1	0	1	1	0	1	0	0	1	0	0	0	1	0	0
<i>Asterella leptophylla</i> (Mont.) Pande, K.P. Srivast. & Sultan Khan ex Grolle	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0
<i>Plagiochasma appendiculatum</i> Lehm. & Lindenb.	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0
<i>Reboulia hemisphaerica</i> (L.) Raddi	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
<i>Conocephalum conicum</i> (L.) Dumort.	1	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0
<i>Wiesnerella denudata</i> (Mitt.) Steph.	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Dumortiera hirsuta</i> (Sw.) Nees	1	1	0	1	1	0	0	0	0	1	1	0	0	0	0	0
<i>Fossombronina pusilla</i> (L.) Nees	1	0	0	0	1	1	0	0	0	0	0	1	1	1	1	0
<i>Pallavicinia ambigua</i> (Mitt.) Steph.	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
<i>Metzgeria lindbergii</i> Schiffn.	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Metzgeria</i> sp.	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
<i>Aneura pinguis</i> (L.) Dumort.	0	1	0	0	1	0	0	0	0	1	1	1	1	1	0	0
<i>Riccardia levieri</i> Schiffn.	1	0	0	0	1	1	1	0	0	1	1	1	1	1	1	0
<i>Frullania campanulata</i> Sande. Lac.	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0
<i>Frullania muscicola</i> Steph.	0	1	0	0	1	0	0	0	1	1	1	1	0	0	0	0
<i>Frullania polyptera</i> Taylor	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Frullania tamarisci</i> (L.) Dumort.	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0

<i>Acanthocoleus yoshinaganus</i> (S. Hatt.) Kruijt	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Cheilolejeunea subopaca</i> (Mitt.) Mizut.	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Cheilolejeunea udarii</i> G. Asthana, S. C. Srivat. & A.K. Asthana	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Cheilolejeunea xanthocarpa</i> (Lehm. & Lindenb.) Malombe	1	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0
<i>Colura calyptrifolia</i> (Hook.) Dumort.	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0
<i>Drepanolejeunea angustifolia</i> (Mitt.) Grolle	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Drepanolejeunea ternatensis</i> (Gottsche) Steph.	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Lejeunea cocoes</i> Mitt.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Lejeunea flava</i> (Sw.) Nees	1	1	1	0	1	0	1	1	1	1	1	1	0	0	1	0
<i>Lejeunea subacuta</i> Mitt.	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Microlejeunea punctiformis</i> (Taylor) Steph.	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0
<i>Spruceanthes semirependus</i> (Nees) Verd.	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Porella acutifolia</i> (Lehm. & Lindenb.) Trevis.	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0
<i>Porella campylophylla</i> (Lehm. & Lindenb.) Trevis.	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Porella madagascarensis</i> (Nees & Mont.) Trevis.	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Porella perottetiana</i> (Mont.) Trevis.	1	0	1	1	1	0	0	1	1	1	1	1	1	0	0	0
<i>Radula acuta</i> Mitt.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Gongylanthus himalayensis</i> Grolle	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Calypogeia azurea</i> Stotler & Crotz	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Cylindrocolea kiaeri</i> (Austin) Vána	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1
<i>Herbertus aduncus</i> (Dicks.) Gray.subsp. <i>aduncus</i>	1	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0
<i>Solenostoma hyalinum</i> (Lyell) Mitt.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
<i>Bazzania tridens</i> (Reinw., Blume et Nees) Trev.	1	1	0	0	1	0	0	0	0	0	0	1	1	1	0	0
<i>Chiloscyphus campanulatus</i> Steph.	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0

<i>Heteroscyphus argutus</i> (Reiw., Blume & Nees) Schiffin.	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0
<i>Heteroscyphus perfoliatus</i> (Mont.) Schiffin.	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Lophocolea bidentata</i> (L.) Dumort.	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0
<i>Lophocolea minor</i> Nees	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Lophocolea muricata</i> (Lehm.) Nees.	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Notoscyphus lutescens</i> (Lehm. & Lindenb.) Mitt.	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Plagiochila arbuscula</i> (Brid. ex Lehm. & Lindenb.) Lindenb.	1	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0
<i>Plagiochila durelii</i> Schiffin.	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
<i>Plagiochila fruticosa</i> Mitt.	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Plagiochila indica</i> Mitt. ex Steph.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Plagiochila junghuhniana</i> Sande Lac.	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
<i>Plagiochila sciophila</i> Nees ex Lindenb.	1	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0
<i>Plagiochila uniformis</i> Mitt.	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Gottschelia schizopleura</i> (Spruce) Grolle	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0
<i>Plicanthus birmensis</i> (Steph.) R.M. Schust.	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Plicanthus hirtellus</i> (F. Weber) R.M. Schust.	1	1	0	0	1	0	1	0	0	1	1	1	1	0	0	0
<i>Anthoceros crispulus</i> (Mont.) Douin	1	1	0	0	0	1	0	0	0	0	0	0	1	1	1	0
<i>Phaeoceros carolinianus</i> (Michx.) Prosk.	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
<i>Pogonatum microstomum</i> (R.Br. ex Schwägr.) Brid.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Pogonatum neesii</i> (Müll. Hal.) Dozy	1	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0
<i>Timmia megapolitana</i> Hedw.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Entosthodon wichurae</i> M. Fleisch.	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
<i>Funaria hygrometrica</i> Hedw.	1	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0
<i>Fissidens anomalus</i> Mont.	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	0

<i>Fissidens crispulus</i> Brid.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Fissidens speluncae</i> Broth.	1	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0
<i>Fissidens taxifolius</i> Hedw.	1	1	0	0	1	0	0	0	0	0	1	1	1	1	0	0
<i>Fissidens zollingeri</i> Mont.	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Ceratodon purpureus</i> (Hedw.) Brid.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Aongstroemia orientalis</i> Mitt.	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Campylopus ericoides</i> (Griff.) A. Jaeger.	1	1	0	0	1	1	0	0	0	1	1	1	1	1	1	0
<i>Campylopus fragilis</i> (Brid.) Bruch & Schimp. subsp. <i>goughii</i> (Mitt.) J.-P. Frahm	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0
<i>Campylopus subulatus</i> Schimp. ex Milde	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
<i>Campylopus pilifer</i> Brid.	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0
<i>Campylopus schmidii</i> (Müll. Hal.) A. Jaeger	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
<i>Leucoloma molle</i> (Müll. Hal.) Mitt.	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Leucobryum aduncum</i> Dozy & Molk.	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0
<i>Leucobryum juniperoideum</i> (Brid.) Müll. Hal.	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0
<i>Didymodon revolutus</i> (Cardot) R.S. Williams	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Hymenostylium recurvirostrum</i> (Hedw.) Dixon	1	0	0	0	1	0	0	1	1	1	1	1	1	1	0	0
<i>Brachymenium leptophyllum</i> (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0
<i>Bryum argenteum</i> Hedw.	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0
<i>Imbribryum alpinum</i> (Huds. ex With.) N. Pedersen	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
<i>Ptychostomum pseudotriquetrum</i> (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pederson	1	1	0	0	1	0	0	0	0	0	0	1	1	1	1	0
<i>Rhodobryum giganteum</i> (Schwägr.) Paris	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
<i>Rosulabryum billardieri</i> (Schwaegr.) J.R. Spence	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0
<i>Rosulabryum wightii</i> (Mitt.) J.R. Spence	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0

<i>Plagiomnium rhynchophorum</i> (Hook.) T.J. Kop.	1	1	0	1	1	0	0	0	0	0	1	1	1	1	1	0
<i>Groutiella tomentosa</i> (Hornsch.) Wijk & Margad.	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Macromitrium sulcatum</i> (Hook.) Brid.	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0
<i>Macromitrium cf. flexuosum</i> Mitt.	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Orthotrichum hookeri</i> Wilson ex Mitt.	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
<i>Schlotheimia grevilleana</i> Mitt.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Zygodon viridissimus</i> (Dickson) Bridel	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
<i>Philonotis falcata</i> (Hook.) Mitt.	1	0	1	0	1	1	0	0	0	0	1	1	1	1	1	0
<i>Philonotis thwaitesii</i> Mitt.	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0
<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Racopilum orthocarpum</i> Wilson ex Mitt.	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0
<i>Hypopterygium tamarisci</i> (Sw.) Brid. ex Müll. Hal.	1	1	0	0	1	0	0	0	0	0	1	1	1	1	0	0
<i>Lopidium struthiopteris</i> (Brid.) M. Fleisch.	1	1	0	0	1	0	0	0	0	1	1	1	1	1	0	0
<i>Distichophyllum nigricaula</i> var. <i>elmeri</i> (Broth.) B.C.Tan & H.Rob.	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0
<i>Distichophyllum schmidtii</i> Broth.	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
<i>Hookeria acutifolia</i> Hook. & Grev.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Lepidopilidium furcatum</i> (Thwaites & Mitt.) Broth.	0	1	0	0	1	0	0	0	0	0	1	1	1	1	1	0
<i>Thamniopsis utacamundiana</i> (Mont.) W.R. Buck	1	1	0	0	1	1	0	0	0	1	1	1	1	1	0	0
<i>Haplocladium microphyllum</i> (Hedw.) Broth.	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Rozea fulva</i> Müll. Hal. ex M. Fleisch.	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Thuidium cymbifolium</i> (Dozy & Molk.) Dozy & Molk.	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
<i>Thuidium glaucinum</i> (Mitt.) Bosch & Sande Lac.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Regmatodon orthostegius</i> Mont.	1	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0
<i>Brachythecium buchananii</i> (Hook.) A. Jaeger	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0

<i>Brachythecium formosanum</i> Takaki	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Brachythecium garovaglioides</i> Müll. Hal.	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Eurhynchium hians</i> (Hedw.) Sande Lac.	1	1	0	0	1	1	0	1	0	1	1	1	1	1	0	0
<i>Rhynchostegiella tenella</i> (Dicks.) Limpr.	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Aerobryidium filamentosum</i> (Hook.) Fleisch.	1	1	1	1	1	0	0	1	1	1	1	1	1	1	0	0
<i>Aerobryopsis wallichii</i> (Brid.) A. Fleisch.	1	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0
<i>Barbella bombycina</i> (Renauld & Cardot) M. Fleisch.	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	0
<i>Barbellopsis trichophora</i> (Mont.) W.R. Buck	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0
<i>Cryptopapillaria fuscescens</i> (Hook.) M. Menzel	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0
<i>Duthiella declinata</i> (Mitt.) Zant.	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0
<i>Floribundaria chrysonema</i> (Müll. Hal.) Broth.	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Floribundaria floribunda</i> (Dozy & Molk.) M. Fleisch.	1	0	1	0	1	0	0	0	0	0	1	1	1	0	0	0
<i>Meteoriopsis ancistrodes</i> (Renauld & Cardot) Broth.	1	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0
<i>Meteorium buchananii</i> (Brid.) Broth.	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0
<i>Trachypodopsis serrulata</i> (P. Beauv.) M. Fleisch.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
<i>Trachypus bicolor</i> Reinw. & Hornsch.	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0
<i>Hypnum cupressiforme</i> Hedw.	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0
<i>Isopterygium serrulatum</i> M. Fleisch.	1	0	0	1	1	1	0	1	0	0	0	0	0	1	0	0
<i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0
<i>Vesicularia levieri</i> Cardot	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Vesicularia vesicularis</i> (Schwaegr.) Broth. var. <i>vesicularis</i>	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Ctenidium lychnites</i> (Mitt.) Broth.	1	1	0	1	1	0	0	1	1	1	0	0	0	1	0	0
<i>Leptohymenium tenue</i> (Hook.) Schwägr.	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Macrothamnium macrocarpum</i> (Reinw. & Hornsch.)	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0

Fleisch.																
<i>Symphyodon erraticus</i> (Mitt.) A. Jaeger	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Plagiothecium entodontella</i> Broth. ex Dixon	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Plagiothecium argentatum</i> (Mitt.) Q. Zuo	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Entodon laetus</i> (Griff.) A. Jaeger	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Warburgiella cuppressinoides</i> Müll. Hal. ex Broth.	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
<i>Wijkia deflexifolia</i> (Mitt. ex Renauld & Cardot) H.A. Crum	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Wijkia surcularis</i> (Mitt.) H.A. Crum	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>Pilotrichopsis dentata</i> (Mitt.) Besch.	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0
<i>Schoenobryum concavifolium</i> (Griff.) Gangulee	0	1	1	0	1	0	0	0	0	0	1	1	1	0	0	0
<i>Garovaglia plicata</i> (Brid.) Bosch & Sande Lac.	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Pterobryopsis acuminata</i> (Hook.) M. Fleisch.	0	0	1	0	1	0	0	0	0	0	1	1	1	0	0	0
<i>Pterobryopsis orientalis</i> (Müll. Hal.) M. Fleisch.	1	0	1	0	1	0	0	0	0	0	1	1	1	0	0	0
<i>Homaliodendron flabellatum</i> (Sm.) M. Fleisch.	1	1	1	0	1	0	0	0	0	0	1	1	1	1	0	0
<i>Homaliodendron microdendron</i> (Mont.) M. Fleisch.	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0
<i>Homaliodendron rectifolium</i> (Mitt.) M. Fleisch.	1	0	1	0	1	0	0	0	0	0	1	1	1	0	0	0
<i>Neckera pennata</i> Hedw.	1	1	1	0	1	0	0	1	0	0	1	1	1	1	0	0
<i>Myurium borii</i> (Dixon) Magill	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

Table 6. 2: Data on distribution of bryophyte species along different microhabitats of the Shola National Park (0= absent, 1= present)

(Bk: Bark, Tg: Twigs & Branches, Lg: Logs & Decayed parts, Rt: Roots of higher plants, Hu: Humus covered leaves, Tr: Terrestrial, LC: Land Cuttings, CR: Crevices of rocks, LR: Large Rocks, SR: Small Rocks, WR: Wet Rocks, CW: Concrete wall, Ep: Epiphyllous)

Species	Bk	Tg	Lg	Rt	Hu	Tr	LC	CR	LR	WR	SR	CW	Ep
<i>Marchantia polymorpha</i> L.	0	0	0	0	0	0	1	0	1	1	0	0	0
<i>Asterella leptophylla</i> (Mont.) Pande, K.P. Srivast. & Sultan Khan ex Grolle	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Plagiochasma appendiculatum</i> Lehm. & Lindenb.	0	0	0	0	0	1	1	0	1	0	0	1	0
<i>Reboulia hemisphaerica</i> (L.) Raddi	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Conocephalum conicum</i> (L.) Dumort.	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Wiesnerella denudata</i> (Mitt.) Steph.	0	0	0	1	0	0	0	0	0	1	0	0	0
<i>Dumortiera hirsuta</i> (Sw.) Nees	0	0	0	0	0	0	1	1	1	1	0	0	0
<i>Fossombronina pusilla</i> (L.) Nees	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Pallavicinia ambigua</i> (Mitt.) Steph.	0	0	0	0	0	0	1	0	0	1	0	0	0
<i>Metzgeria lindbergii</i> Schiffn.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Metzgeria</i> sp.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aneura pinguis</i> (L.) Dumort.	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Riccardia levieri</i> Schiffn.	0	0	0	0	0	0	0	1	0	1	1	0	0
<i>Frullania campanulata</i> Sande. Lac.	0	0	1	0	0	0	0	0	1	0	0	0	0
<i>Frullania muscicola</i> Steph.	0	1	1	0	0	0	0	0	0	0	0	0	0
<i>Frullania polyptera</i> Taylor	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Frullania tamarisci</i> (L.) Dumort.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Acanthocoleus yoshinaganus</i> (S. Hatt.) Kruijt	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cheilolejeunea subopaca</i> (Mitt.) Mizut.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cheilolejeunea udarii</i> G. Asthana, S. C. Srivat. & A.K. Asthana	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cheilolejeunea xanthocarpa</i> (Lehm. & Lindenb.) Malombe	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Colura calyptrifolia</i> (Hook.) Dumort.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Drepanolejeunea angustifolia</i> (Mitt.) Grolle	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Drepanolejeunea ternatensis</i> (Gottsche) Steph.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lejeunea cocoes</i> Mitt.	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Lejeunea flava</i> (Sw.) Nees	1	1	0	0	0	0	0	0	0	0	0	0	0

<i>Lejeunea subacuta</i> Mitt.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Microlejeunea punctiformis</i> (Taylor) Steph.	1	0	0	0	0	0	0	0	0	0	0	0	1
<i>Spruceanthus semirependus</i> (Nees) Verd.	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Porella acutifolia</i> (Lehm. & Lindenb.) Trevis.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Porella campylophylla</i> (Lehm. & Lindenb.) Trevis.	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Porella madagascariensis</i> (Nees & Mont.) Trevis.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Porella perottetiana</i> (Mont.) Trevis.	1	1	0	0	1	0	0	0	1	0	0	0	0
<i>Radula acuta</i> Mitt.	0	0	0	0	0	0	1	1	0	0	1	0	0
<i>Gongylanthus himalayensis</i> Grolle	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Calypogeia azurea</i> Stotler & Crotz	1	0	1	0	0	0	0	0	0	0	0	0	0
<i>Cylindrocolea kiaeri</i> (Austin) Vána	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Herbertus aduncus</i> (Dicks.) Gray.subsp. <i>aduncus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Solenostoma hyalinum</i> (Lyell) Mitt.	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Bazzania tridens</i> (Reinw., Blume et Nees) Trev.	0	0	0	1	0	0	1	0	0	0	0	0	0
<i>Chiloscyphus campanulatus</i> Steph.	0	0	0	0	0	0	1	0	1	1	0	0	0
<i>Heteroscyphus argutus</i> (Reiw., Blume & Nees) Schiffin.	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Heteroscyphus perfoliatus</i> (Mont.) Schiffin.	0	0	0	0	0	0	0	0	0	1	1	0	0
<i>Lophocolea bidentata</i> (L.) Dumort.	0	0	1	0	0	0	1	0	0	0	0	0	0
<i>Lophocolea minor</i> Nees	0	0	0	1	0	1	0	0	0	0	0	0	0
<i>Lophocolea muricata</i> (Lehm.) Nees.	0	1	1	0	0	0	0	0	0	0	0	0	0
<i>Notoscyphus lutescens</i> (Lehm. & Lindenb.) Mitt.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila arbuscula</i> (Brid. ex Lehm. & Lindenb.) Lindenb.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila dorelii</i> Schiffn.	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Plagiochila fruticosa</i> Mitt.	0	1	1	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila indica</i> Mitt. ex Steph.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila junghuhniana</i> Sande Lac.	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila sciophila</i> Nees ex Lindenb.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiochila uniformis</i> Mitt.	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Gottschelia schizopleura</i> (Spruce) Grolle	0	0	0	0	0	1	1	0	0	1	0	0	0
<i>Plicanthus birmensis</i> (Steph.) R.M. Schust.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plicanthus hirtellus</i> (F. Weber) R.M. Schust.	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Anthoceros crispulus</i> (Mont.) Douin	0	0	0	0	0	1	1	0	0	0	0	0	0

<i>Phaeoceros carolinianus</i> (Michx.) Prosk.	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Pogonatum microstomum</i> (R.Br. ex Schwägr.) Brid.	0	0	0	0	0	1	1	1	1	0	0	0	0
<i>Pogonatum neesii</i> (Müll. Hal.) Dozy	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Timmia megapolitana</i> Hedw.	0	0	0	0	0	1	0	1	0	0	0	0	0
<i>Entosthodon wichurae</i> M. Fleisch.	0	0	0	0	0	0	1	0	1	0	1	0	0
<i>Funaria hygrometrica</i> Hedw.	0	0	0	0	0	1	1	0	1	0	1	1	0
<i>Fissidens anomalus</i> Mont.	1	0	0	1	0	0	0	0	0	1	0	0	0
<i>Fissidens crispulus</i> Brid.	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Fissidens speluncae</i> Broth.	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Fissidens taxifolius</i> Hedw.	0	0	0	0	0	1	1	0	0	1	0	0	0
<i>Fissidens zollingeri</i> Mont.	0	0	0	0	0	0	1	1	0	0	1	0	0
<i>Ceratodon purpureus</i> (Hedw.) Brid.	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Aongstroemia orientalis</i> Mitt.	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Campylopus ericoides</i> (Griff.) A. Jaeger.	0	0	0	0	0	0	1	0	1	1	0	0	0
<i>Campylopus fragilis</i> (Brid.) Bruch & Schimp. subsp. <i>goughii</i> (Mitt.) J.-P. Frahm	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Campylopus subulatus</i> Schimp. ex Milde	0	0	0	0	0	1	1	0	0	0	0	0	0
<i>Campylopus pilifer</i> Brid.	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Campylopus schmidii</i> (Müll. Hal.) A. Jaeger	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Leucoloma molle</i> (Müll. Hal.) Mitt.	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Leucobryum aduncum</i> Dozy & Molk.	1	0	1	0	0	0	0	0	0	0	0	0	0
<i>Leucobryum juniperoideum</i> (Brid.) Müll. Hal.	1	0	1	0	0	0	0	0	0	0	0	0	0
<i>Didymodon revolutus</i> (Cardot) R.S. Williams	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Hymenostylium recurvirostrum</i> (Hedw.) Dixon	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Brachymenium leptophyllum</i> (Bruch & Schimp. ex Müll. Hal.) Bruch & Schimp. ex A. Jaeger	0	0	0	0	0	1	1	0	1	0	0	0	0
<i>Bryum argenteum</i> Hedw.	0	0	0	0	0	0	0	1	1	0	0	0	0
<i>Imbricobryum alpinum</i> (Huds. ex With.) N. Pedersen	0	0	0	0	0	0	1	0	0	1	0	0	0
<i>Ptychostomum pseudotriquetrum</i> (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pederson	0	0	0	0	0	0	1	0	0	1	0	0	0
<i>Rhodobryum giganteum</i> (Schwägr.) Paris	0	0	0	1	0	0	1	0	0	1	0	0	0
<i>Rosulabryum billardieri</i> (Schwaeagr.) J.R. Spence	0	0	0	0	0	0	0	0	0	1	1	0	0
<i>Rosulabryum wightii</i> (Mitt.) J.R. Spence	0	0	0	0	0	0	0	0	1	1	0	0	0
<i>Plagiomnium rhynchophorum</i> (Hook.) T.J. Kop.	1	0	0	1	0	0	1	0	1	0	0	1	0

<i>Groutiella tomentosa</i> (Hornsch.) Wijk & Margad.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Macromitrium sulcatum</i> (Hook.) Brid.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Macromitrium</i> cf. <i>flexuosum</i> Mitt.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Orthotrichum hookeri</i> Wilson ex Mitt.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Schlotheimia grevilleana</i> Mitt.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Zygodon viridissimus</i> (Dickson) Bridel	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Philonotis falcata</i> (Hook.) Mitt.	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Philonotis thwaitesii</i> Mitt.	0	0	0	0	0	0	0	1	1	0	0	0	0
<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	0	0	1	1	0	0	0	0	0	1	0	0	0
<i>Racopilum orthocarpum</i> Wilson ex Mitt.	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Hypopterygium tamarisci</i> (Sw.) Brid. ex Müll. Hal.	0	0	1	1	0	0	0	0	1	0	0	0	0
<i>Lopidium struthiopteris</i> (Brid.) M. Fleisch.	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Distichophyllum nigricaulum</i> var. <i>elmeri</i> (Broth.) B.C.Tan & H.Rob.	0	0	0	0	0	0	0	0	0	1	1	0	0
<i>Distichophyllum schmidtii</i> Broth.	0	0	0	0	0	0	1	0	0	1	0	0	0
<i>Hookeria acutifolia</i> Hook. & Grev.	0	0	0	0	0	0	1	0	1	0	0	0	0
<i>Lepidopilidium furcatum</i> (Thwaites & Mitt.) Broth.	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Thamniopsis utacamundiana</i> (Mont.) W.R. Buck	1	0	1	0	0	1	0	0	0	0	0	0	0
<i>Haplocladium microphyllum</i> (Hedw.) Broth.	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Rozea fulva</i> Müll. Hal. ex M. Fleisch.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thuidium cymbifolium</i> (Dozy & Molk.) Dozy & Molk.	0	0	1	1	0	0	0	0	0	0	0	0	0
<i>Thuidium glaucinum</i> (Mitt.) Bosch & Sande Lac.	1	0	1	0	0	0	0	0	0	0	0	0	0
<i>Regmatodon orthostegius</i> Mont.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Brachythecium buchananii</i> (Hook.) A. Jaeger	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Brachythecium formosanum</i> Takaki	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Brachythecium garovaglioides</i> Müll. Hal.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Eurhynchium hians</i> (Hedw.) Sande Lac.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Rhynchostegiella tenella</i> (Dicks.) Limpr.	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Aerobryidium filamentosum</i> (Hook.) Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Aerobryopsis wallichii</i> (Brid.) A. Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Barbella bombycina</i> (Renauld & Cardot) M. Fleisch.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Barbellopsis trichophora</i> (Mont.) W.R. Buck	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Cryptopapillaria fuscescens</i> (Hook.) M. Menzel	0	1	0	0	0	0	0	0	0	0	0	0	0

<i>Duthiella declinata</i> (Mitt.) Zant.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Floribundaria chrysonema</i> (Müll. Hal.) Broth.	0	1	1	0	0	0	0	0	0	0	0	0	0
<i>Floribundaria floribunda</i> (Dozy & Molk.) M. Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Meteoriopsis ancistrodes</i> (Renauld & Cardot) Broth.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Meteorium buchananii</i> (Brid.) Broth.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Trachypodopsis serrulata</i> (P. Beauv.) M. Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Trachypus bicolor</i> Reinw. & Hornsch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Hypnum cupressiforme</i> Hedw.	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Isopterygium serrulatum</i> M. Fleisch.	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Vesicularia levieri</i> Cardot	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vesicularia vesicularis</i> (Schwaegr.) Broth. var. <i>vesicularis</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ctenidium lychnites</i> (Mitt.) Broth.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Leptohymenium tenue</i> (Hook.) Schwägr.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Macrothamnium macrocarpum</i> (Reinw. & Hornsch.) Fleisch.	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Symphyodon erraticus</i> (Mitt.) A. Jaeger	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiothecium entodontella</i> Broth. ex Dixon	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Plagiothecium argentatum</i> (Mitt.) Q. Zuo	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Entodon laetus</i> (Griff.) A. Jaeger	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Warburgiella cuppressinoides</i> Müll. Hal. ex Broth.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Wijkia deflexifolia</i> (Mitt. ex Renauld & Cardot) H.A. Crum	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Wijkia surcularis</i> (Mitt.) H.A. Crum	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Pilotrichopsis dentata</i> (Mitt.) Besch.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Schoenobryum concavifolium</i> (Griff.) Gangulee	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Garovaglia plicata</i> (Brid.) Bosch & Sande Lac.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Pterobryopsis acuminata</i> (Hook.) M. Fleisch.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Pterobryopsis orientalis</i> (Müll. Hal.) M. Fleisch.	1	1	0	0	0	0	0	0	0	0	0	0	0
<i>Homaliiodendron flabellatum</i> (Sm.) M. Fleisch.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Homaliiodendron microdendron</i> (Mont.) M. Fleisch.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Homaliiodendron rectifolium</i> (Mitt.) M. Fleisch.	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Neckera pennata</i> Hedw.	1	0	0	0	0	1	1	0	0	0	0	0	0
<i>Myurium borii</i> (Dixon) Magill	1	0	0	0	0	1	0	0	0	0	0	0	0

SUMMARY AND CONCLUSION

The bryophyte studies in Kerala have improved a lot in the recent past by adding new records and novelties. The regional approaches of studying smaller areas with deeper intensity are probably the best method in documenting the diversity of this group. Hence the present work is significant in this aspect. The present study was aimed mainly to document the bryophyte diversity of the Anamudi Shola National Park in Idukki district, the biodiversity rich area in the Western Ghats of Southern India.

The area is very less compared to other protected areas in Idukki district, however, holds three sholas viz, Mannavan Shola, Pullaradi Shola and Idivara Shola together comprise 7.5 sq. km. From this small area more than 1000 specimens were collected in different seasons during 2015-2019.

The present study resulted in the recording of a total of 153 taxa including two subspecies and one variety. Among these one liverwort and five mosses turned as new record to India; one liverwort and six mosses as new records for Peninsular India; one moss as a new record for Western Ghats; one liverwort and one moss as new records for South India; 11 liverworts, one hornwort and 13 mosses as new records for Kerala. One liverwort genus and 5 moss genera were newly reported to Kerala. Among the 153 taxa two liverworts viz., *Chiloscyphus campanulatus* Steph. and *Plagiochila uniformis* Mitt. are endemic to India and one liverwort viz., *Cheilolejeunea udari* G. Asthana, S. C. Srivat. & A.K. Asthana is endemic to South India. Table 7.1. shows the details of the new additions from the area.

A total of six orders in liverworts, two in hornwort and 12 orders in mosses are reported. Liverworts include 23 families and 35 genera including a total of 57 species. In hornworts two families and two genera and two species and in mosses under 12 order 33 families, 70 genera and 94 species are reported. Among the liverwort families Lejeuneaceae is the most widely distributed one with 7 genera and 11 species followed by Plagiochilaceae with 7 species. In mosses Meteoriaceae is the largest family with 11 genera and 12 species followed by Bryaceae with 6 genera

and 7 species. The genera *Fissidens* and *Campylopus* each with five species are the largest genera with maximum species in mosses. In Liverworts, *Plagiochila* is the largest genus with seven species.

The general ecological patterns of bryophytes of the study area were studied. These include the pattern of distribution of bryophytes in different vegetation types, microhabitats and altitudinal zones (1600-2500, with intervals of 100 m). Among the three sholas, the Mannavan Shola is the biggest (5.18 km²) and supports highest bryophyte species diversity with 125 spp. The other two sholas, Pullaradi and Idivara are with 48 and 23 species respectively. The Mannavan Shola is unique in having the highest number of non-shared species (89 spp.) compared to Pullaradi (16 spp.) and Idivara (10 spp.). Out of the 153 taxa recorded, a total of 141 was from the Shola vegetation. Among the 141 species present in Shola, 96 are exclusive to that vegetation type. It indicates the significance of the shola vegetation in holding the bryophyte diversity. Only five species viz., *Lejeunea flava* (Sw.) Nees, *Aerobryidium filamentosum* (Hook.) Fleisch., *Cryptopapillaria fuscescens* (Hook.) M. Menzel, *Homaliiodendron flabellatum* (Sm.) M. Fleisch., *Neckera pennata* Hedw. are found as common to all these sholas.

The extent of evergreen forest type is very less in the area compared to shola vegetation. Hence it is reflected in the diversity of the bryophytes also limiting to 29 species. At higher altitudes the vegetation is formed of grassland, with 25 bryophyte species. The patches of Tea plantations in the outskirts of the National Park are also with less number of bryophytes, limiting to 8 species.

The distribution of bryophytes in different microhabitats shows an interesting pattern. The bark of the trees and shrubs is the major microhabitat in holding maximum species with 58 species. The other major congenial microhabitats are terrestrial with 43 species and twigs and branches with 35 species of trees and shrubs. Epiphyllous microhabitat is the least speciose in terms of number, having only two species. The other microhabitats like terrestrial, land cuttings, rocky patch, crevices of rocks, etc. hold different species composition.

The altitudinal profile of the Shola NP varies from 1600 m msl to 2440 m

msl. From lower to the higher zone, the area of extent and composition of vegetation also vary along this profile. It is not uniform in all the three Shola patches. The analysis of data of bryophyte distribution along the altitudinal gradient showed interesting patterns. It increased slightly, and then decreased to a minimum. In the first zone from (1600-1700 m), 41 species were recorded. It dipped to 29 species in the next zone. Compared to the first zone, the second zone is vastly planted with Silver oaks, reducing the availability of suitable microhabitats for bryophytes. In the next zones (1800-2300 m) it increased and remained stable to some extent. In the highest reaches of the NP, the bryophyte species diversity is less due to the less availability of congenial habitat. This part is occupied by grasslands and large bare, exposed rocks, which are poor in providing suitable microhabitats for bryophytes.

Table 7.1: List of new records as part of the present study on bryophytes of Anamudi Shola NP.

Taxa	Family
Addition to the flora of India	
Liverworts	
<i>Colura calyptrifolia</i> (Hook.) Dumort.	Lejeuneaceae
Mosses	
<i>Didymodon revolutus</i> (Cardot) R.S. Williams	Pottiaceae
<i>Distichophyllum nigricaulis</i> var. <i>elmeri</i> (Broth.) B.C.Tan & H.Rob.	Daltoniaceae
<i>Fissidens speluncae</i> Broth.	Fissidentaceae
<i>Macromitrium</i> cf. <i>flexuosum</i> Mitt.	Orthotrichaceae
<i>Rhynchostegiella tenella</i> (Dicks.) Limpr.	Brachytheciaceae
Addition to the flora of Peninsular india	
Liverworts	
<i>Radula acuta</i> Mitt.	Radulaceae
Mosses	
<i>Aongstroemia orientalis</i> Mitt.	Dicranaceae
<i>Orthotrichum hookeri</i> Wilson ex Mitt.	Orthotrichaceae
<i>Brachythecium formosanum</i> Takaki	Brachytheciaceae
<i>Brachythecium garovaglioides</i> Müll. Hal.	Brachytheciaceae
<i>Pilotrichopsis dentata</i> (Mitt.) Besch.	Cryphaeaceae

<i>Homaliiodendron rectifolium</i> (Mitt.) M. Fleisch.	Neckeraceae
New genus record for Kerala	
Liverworts	
<i>Colura</i>	Lejeuneaceae
Mosses	
<i>Ceratodon</i>	Ditrichaceae
<i>Didymodon</i>	Pottiaceae
<i>Orthotrichum</i>	Orthotrichaceae
<i>Pilotrichopsis</i>	Cryphaeaceae
<i>Warburgiella</i>	Sematophyllaceae
Addition to the flora of Western Ghats	
Liverwort	
<i>Wiesnerella denudata</i> (Mitt.) Steph.	Wiesnerellaceae
Moss	
<i>Myurium borii</i> (Dixon) Magill	Myuriaceae
Addition to the flora of South India	
Liverwort	
<i>Plagiochila uniformis</i> Mitt.	Plagiochilaceae
Moss	
<i>Plagiothecium argentatum</i> (Mitt.) Q. Zuo	Plagiotheciaceae
Addition to the flora of Kerala	
Liverworts	
<i>Calypogeia azurea</i> Stotler & Crotz	Calypogeiaceae
<i>Chiloscyphus campanulatus</i> Steph.	Lophocoleaceae
<i>Cheilolejeunea udarii</i> G. Asthana, S. C. Srivat. & A.K. Asthana	Lejeuneaceae
<i>Drepanolejeunea ternatensis</i> (Gottsche) Steph.	Lejeuneaceae
<i>Frullania campanulata</i> Sande. Lac.	Frullaniaceae
<i>Frullania polyptera</i> Taylor	Frullaniaceae
<i>Gottschelia schizopleura</i> (Spruce) Grolle	Scapaniaceae
<i>Metzgeria lindbergii</i> Schiffn.	Metzgeriaceae
<i>Plagiochila junghuhniana</i> Sande Lac.	Plagiochilaceae
<i>Porella madagascariensis</i> (Nees & Mont.) Trevis.	Porellaceae
<i>Porella perrottetiana</i> (Mont.) Trevis.	Porellaceae
Hornworts	

<i>Phaeoceros carolinianus</i> (Michx.) Prosk.	Notothyladaceae
Mosses	
<i>Barbella bombycina</i> (Renauld & Cardot) M. Fleisch.	Meteoriaceae
<i>Ceratodon purpureus</i> (Hedw.) Brid.	Ditrichaceae
<i>Entodon laetus</i> (Griff.) A. Jaeger	Entodontaceae
<i>Hookeria acutifolia</i> Hook. & Grev.	Hookeriaceae
<i>Leucoloma molle</i> (Müll. Hal.) Mitt.	Dicranaceae
<i>Lepidopilidium furcatum</i> (Thwaites & Mitt.) Broth.	Pilotrichaceae
<i>Lopidium struthiopteris</i> (Brid.) M. Fleisch.	Hypopterygiaceae
<i>Neckera pennata</i> Hedw.	Neckeraceae
<i>Rozea fulva</i> Müll. Hal. ex M. Fleisch.	Leskeaceae
<i>Symphyodon erraticus</i> (Mitt.) A. Jaeger	Symphyodontaceae
<i>Thuidium glaucinum</i> (Mitt.) Bosch & Sande Lac.	Thuidiaceae
<i>Timmia megapolitana</i> Hedw.	Timmiaceae
<i>Warburgiella cuppressinoides</i> Müll. Hal. ex Broth.	Sematophyllaceae
Species Endemic to India	
<i>Chiloscyphus campanulatus</i> Steph.	Lophocoleaceae
<i>Plagiochila uniformis</i> Mitt.	Plagiochilaceae
Species Endemic to South India	
<i>Cheilolejeunea udari</i> G. Asthana, S. C. Srivat. & A.K. Asthana	Lejeuneaceae

Conservation; problems and prospects of the study area

The Anamudi Shola National Park is surrounded by Eravikulam National Park, Pambadum Shola National Park, Chinnar Wildlife Sanctuary, Mathikettan Shola National Park, and other protected areas of Idukki district. It thus forms an integral part of the network of protected areas, ensuring continuum of the forest ecosystem in the area. Since its formation as a National Park, the area is well administered and protected by the Kerala Forest and Wildlife Department. The human activities are strictly restricted to ensure the quality of the habitats in the area. No operations for extraction of timber or other items are practiced in the NP. The plantations of Wattle and Silver oak within the NP are left for natural succession. The area was subjected to some sort of disturbances before declaring it as NP. Nature is now healing the damages caused during that period. It is steadily recovering to its uniqueness. The bryophytes present in the area, thus do not possess any specific threat. The population of bryophytes, along with the myriads of other life forms are well-conserved in the Anamudi Shola NP.

BIBLIOGRAPHY

- Abeywickrama, B.A. and Jansen, M.A.B., 1978. A checklist of the liverworts of Sri Lanka. *UNESCO: Man and the Biosphere National Committee for Sri Lanka*, 1: 1-10.
- Abramov, I.I. and Abramova, A.L., 1983. Konspekt flor'i mhov Mongol'skoj Narodnoj Respubliki. *Biologiceskie Resursy Prirodnye Uslovija Mongol'skoj Narodnoj Respubliki*, 17: 221.
- Agnew, S. and Vondráček, M., 1975. A moss flora of Iraq. *Fedd. Repert.*, 86(6-8): 341-489.
- Ah-Peng, C., Chuah-Petiot, M., Descamps-Julien, B., Bardat, J., Stamenoff, P. and Strasberg, D., 2007. Bryophyte diversity and distribution along an altitudinal gradient on a lava flow in La Réunion. *Diversity and distributions*, 13(5): 654-662.
- Akatova, T.V. and Ignatova, E.A., 2000. *Pogonatum neesii* (Polytrichaceae, Musci) in the Russian Caucasus. *Arctoa*, 9: 127-128.
- Akhani, H. and Kürschner, H., 2004. An annotated and updated checklist of the Iranian bryoflora. *Cryptog. Bryol.*, 25: 315-347.
- Alam, A. and Srivastava, S.C., 2011. Liverwort diversity in Palni Hills (Tamil Nadu), India, a checklist. *Nelumbo*, 51: 99-122.
- Alam, A., 2009. Rare and endangered terrestrial Hepaticae of Nilgiri and Palni Hills, Tamil Nadu. *J. Indian Bot. Soc.*, 88 (3&4): 227-230.
- Alam, A., 2012. Some Indian bryophytes known for their biologically active compounds. *Inter. J. Appl. Bio. Pharm. Tech.*, 3(2): 239-246.
- Alam, A., 2013a. Bio-monitoring of metal deposition in Ranthambhore National Park (Rajasthan), India using *Plagiochasma rupestre* (G. Frost) Stephani. *Arch. Bryol.*, 106: 1-8.
- Alam, A., 2013b. Moss flora of Western Himalayas, India-An updated Checklist. *Arch. Bryol.*, 168: 1-28.
- Alam, A., 2014a. Morphotaxonomy of *Fossombronia Raddi* (Metzgeriales) from Nilgiri Hills (India). *Frahmia*, 7: 1-12.
- Alam, A., 2014b. Morphotaxonomy of three rare terricolous taxa of Jungermanniales occurring in Nilgiri hills (Western Ghats) India. *Inter. J. Envir.*, 3(2): 263-275.

- Alam, A., Behera, K.K., Vats, S. and Iqbal, M., 2013. A preliminary study on bryodiversity of Similipal Biosphere Reserve (Odisha), India. *Arch. Bryol.*, 157: 1-9.
- Alam, A., Rawat, K.K., Verma, P.K., Sharma, V. and Gupta, D.S., 2015. Moss flora of Central India. *Pl. Sci. Today*, 2(4): 159-171.
- Alam, A., Sharma, V. and Sharma, S.C. 2011a. Bryoflora of Ranthambhore Tiger Reserve, Rajasthan (India). *Arch. Bryol.*, 106: 1-8.
- Alam, A., Verma, P.K., Asthana, G. and Yadav, S., 2011b. Moss Flora of Palni Hills (Tamil Nadu), India-A Checklist. *Arch. Bryol.*, 112: 1-8. (ISSN 0945-3466)
- Alcala, A.A., 2019. Diversity of mosses in Mt. Makiling forest reserve, Philippines. *Biodiv. J. Biol. Diver.*, 20(6): 1729–1734.
- Aleffi, M., Ricci, S. and Tacchi, R., 2010. *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal. (Hypopterygiaceae, Bryopsida), new to Italy. *Cryptog. Bryol.*, 31. 293-295.
- Allen, B., 2002. Moss flora of Central America, Part 2. Encalyptaceae–Orthotrichaceae. *Monographs in Systematic Botany, Missouri Botanical Garden* 90: i–viii, 1–699.
- Alonso, M., Jimenez, J.A. and Cano, M.J., 2018. New synonyms and typifications in *Chionoloma tenuirostre* (Pottiaceae, Bryophyta). *Phytotaxa*, 373(2):147-154.
- Amakawa, T., 1963. New or little known Asiatic species of the family Jungermanniaceae I. *J. Hattori Bot. Lab.*, 26: 20-26.
- Amakawa, T., 1966. New or little known Asiatic species of the family Jungermanniaceae II. *J. Hattori Bot. Lab.*, 29: 253-266.
- Amakawa, T., 1967. New or little known Asiatic species of the family Jungermanniaceae III. *J. Hattori Bot. Lab.*, 30: 181-198.
- Amakawa, T., 1968. New or little known Asiatic species of the family Jungermanniaceae IV. *J. Hattori Bot. Lab.*, 31: 101-112.
- Amakawa, T., 1969. New or little known Asiatic species of the family Jungermanniaceae V. *J. Hattori Bot. Lab.*, 32: 123-128.
- Amakawa, T., 1970. New or little known Asiatic species of the family Jungermanniaceae VI. *Jungermannia comata* Nees and its allies. *J. Hattori Bot. Lab.*, 33: 153-160.
- Amakawa, T., 1972. New or little known Asiatic species of the family Jungermanniaceae VII. *Jungermannia truncata* complex. *J. Hattori Bot. Lab.*, 35: 382-390.

- America, S., Center, W.L.B., Press, M.B.G., Books, R. and Botanica, R. 2006. An Annotated Checklist and Atlas of the Mosses of Thailand. *Malay*, 134: 475.
- Anderson, L.E., 1963. Modern species concept: mosses. *Bryologist* 66: 107-119.
- Anderson, L.E., 1974. Bryology, 1947-1972. *Ann. Missouri Bot. Gard.*, 61(1): 56-85.
- Aruna, K.B. and Krishnappa, M., 2014. Distribution of Bryophytes in Malanad regions of Chikmagalur District, Karnataka, The Western Ghats. *Life Sci. Leafl.* 49: 65-88.
- Aruna, K.P. and Krishnappa, M. 2018. Phytochemistry and Antimicrobial activities of *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid. (Bryophyta; Musci: Polytrichaceae). *Int. J. Bot. Stud.*, 3(1): 120-125.
- Arunachalam, A., Sarmah, R., Adhikari, D., Majumder, M. and Khan, M.L. 2004. Anthropogenic threats and biodiversity conservation in Namdapha nature reserve in the Indian Eastern Himalayas. *Curr. Sci.*, 87(4): 447-454.
- Ashish, T., Asthana, A.K. and Srivastava, A., 2015. A study on genus *Fissidens* Hedw. in Meghalaya (North-Eastern Hills), India. *Taiwania*, 60(3): 137-142.
- Asthana, A.K. and Sahu, V., 2013. Bryophyte diversity in Mukteshwar (Uttarakhand): an overview. *Arch. Bryol.*, 154: 1-11.
- Asthana, A.K. and Sahu, V., 2015. *Campylopus schmidii* (Müll. Hal.) A. Jaegr. (Bryophyta) a New Addition to Indian Himalaya. *Nat. Acad. Sci. Lett.*, 38(5): 437-439.
- Asthana A.K. and Sahu, V. 2020. A new variety of *Paraleucobryum* (Lindb. ex Limpr.) Loeske from Western Himalaya, India. *Nat. Acad. Sci. Lett.*, 1-3
- Asthana A.K. and Srivastava, S.C., 1991. Indian Hornworts (A Taxonomic Study). *Bryophytorum Bibliotheca*, 41: 1-160.
- Asthana, A.K. and Gupta, R., 2015. Hornwort diversity at Pachmarhi Biosphere Reserve (Madhya Pradesh), India. *Pl. Sci. Today*, 2(4): 145-150.
- Asthana, A.K. and Srivastava, S.C., 1986. A new *Folioceros* from Silent Valley. *Crypt. Bryol. et Lichenol.*, 7(2): 149-153.
- Asthana, A.K. and Srivastava, A., 2015. A study on genus *Fissidens* Hedw. in Meghalaya (North-Eastern Hills), India. *Taiwania*, 60(3): 137 – 142.
- Asthana, A.K. and Srivastava, P., 2016. Three mosses new to bryoflora of Eastern Ghats. *Cryptogam Biodiversity and Assessment* 1(1): 64-70.
- Asthana, A.K. and Srivastava, S.C., 1991. Indian Hornworts (A taxonomic study)

- Bryoph. Biblio.*, (Germany) 42: 1-158.
- Asthana, A.K. and V. Nath., 1994. Distributional pattern of *Phaeoceros* Prosk. in Kumaon and Garhwal region: Western Himalayas. *Crypt. Bryol. et Lichenol.* 15: 129-134.
- Asthana, A.K., Sahu, V. and Gupta, D., 2019. A new species of genus *Cololejeunea* (Spruce) Schiffn. (Lejeuneaceae) from India. *J. Bryol.*, 41(3): 274-277.
- Asthana, G. and Shukla, A., 2009. Two epiphyllous species of *Drepanolejeunea* (Spruce) Schiffn. new to the Indian bryoflora. *J. Bryol.*, 31: 139-142.
- Asthana, G. and Shukla, A., 2010. *Colura leratii* (Steph.) Steph. new to India. *Bryo. Diver. Evol.*, 32(1): 100-102.
- Asthana, G., Srivastava, S.C., and Asthana, A. K., 1995. The genus *Cheilolejeunea* in India. *Lindbergia*, 20: 125-143.
- Atherton, I., Bosanquet, S.D. and Lawley, M., (eds.) 2010. Mosses and liverworts of Britain and Ireland: a field guide (p. 848). Plymouth: *British Bryological Society*.
- Atwood, J.J., 2015. Taxonomic Revision of the Moss Genus *Lepidopilidium* (Pilotrichaceae) 1. *Ann. Missouri Bot. Gard.*, 100(4): 364-392.
- Aziz, M. and Vohra, J.N., 2008. Pottiaceae (Musci) of India. *Bishen Singh Mahendra Pal Singh, Dehra Dun*.
- Azuelo, A.G., Sariana, L.G. and Pabualan, M.P., 2011. Some medicinal bryophytes: their ethnobotanical uses and morphology. *Asian J. Biod.*, 92: 49-80.
- Bagwan, S.A. and Kore, B.A., 2012. Liverworts and Hornworts of Kas Plateau. *The Bioscan*, 7(2): 289-290.
- Bahuguna, Y.M., Gairola, S., Semwal, D.P., Uniyal, P.L. and Bhatt, A.B., 2013. *Bryophytes and ecosystem. Biodiversity of lower plants*. IK International Publishing House Pvt. Ltd., New Delhi, 279-296.
- Bahuguna, Y.M., Gairola, S., Uniyal, P.L. and Bhatt, A.B., 2016. Moss Flora of Kedarnath Wildlife Sanctuary (KWLS), Garhwal Himalaya, India. *Proc. Nat. Acad. Sci. B: Biol. Sci.* 86(4): 931-943.
- Bahuguna, Yateesh Mohan, Gairola Sumeet, D. P. Semwal, and Prem L. Uniyal. 2014. Species diversity and composition of bryophytic vegetation in Garhwal Himalaya with special reference to Kedarnath Wildlife Sanctuary (KWLS), Uttarakhand, India. *International Journal of Ecology and Environmental Sciences*, 40: 75-85.

- Bansal, P. and Nath, V., 2013. Current Status of Genus *Bryum* Hedw. in Eastern Himalaya, India. *Taiwania*, 58(3): 205-212.
- Bansal, P. and Nath, V., 2014. Genus *Bryum* Hedw. in Peninsular India. *Frahmia* 4: 1-11.
- Bansal, P. and Nath, V., 2015. Diversity in the reproductive structures of *Bryum* Hedw. (Bryophyta) of Garhwal hills, Uttarakhand, India. *Int. J. Pl. Repr. Biol.*, 7(2): 92-103.
- Banu-Fattah, K. 2001. A comprehensive checklist of bryophytes of Bangladesh. *Bangladesh J. Pl. Taxon*, 8: 7-18.
- Banu-Fattah, K., 2005. *Distichophyllum schmidtii* Broth. (hookeriaceae) - A new report from Bangladesh, *Bangladesh J. Bot.* 34: 45-47.
- Bapna, K.R. and Choudhary, B.L., 1989. Mosses of Rajasthan-II. Dicranales and Pottiales. *J. Indian Bot. Soc.*, 68: 379-388.
- Bapna, K.R. and Kachroo, P., 2000a. *Hepaticology in India I*. Himanshu Publications, Udaipur.
- Bapna, K.R. and Kachroo, P., 2000b. *Hepaticology in India II*. Himanshu Publications, Udaipur.
- Barbhuiya, H.A. and Singh, S.K., 2012. Liverwort and Hornwort of Borail Wild Life Sanctuary, Assam, India. *Arch. Bryol.*, 130: 1-12.
- Bartram, E.B., 1955. North Western Himalayan mosses I. *Bull. Torr. Bot. Cl.*, 82: 22-29.
- Bartram, E.B., 1956. North Western Himalayan mosses II. *Rev. Bryol. et Lichenol.* 29(3-4): 165-172.
- Barukial, J., Gogoi, P. and Barrua, P., 2002. A checklist of Bryophytes of Brahmaputra Valley. *Adv. Plant Sci.*, 15: 89-94.
- Basha, S.K.M., John, P.M. and Reddy, S.K., 2015. Bryoflora of Eastern Ghats, Andhra Pradesh, India. *Abst. Nat. Conf. Cryptog. Res. India Prog. Pros.*, 71.
- Beckmann, K.G. and Scott, G.A.M., 1989. *Gongylanthus scariosus* (Lehm.) Stephani- A liverwort new to Australia. *Lindbergia* 15: 79-84.
- Beever, J., Allison, K. W. and Child, J., 1992. The mosses of New Zealand. *Dunedin, University of Otago Press.*, 1-284.
- Beever, J.E., 1999. Studies of *Fissidens* (Bryophyta: Musci) in new Zealand: A synopsis and key to taxa. *New Zealand J. Bot.*, 37(4): 659-670.

- Bhardwaj, D.C., 1948. *J. Indian Bot. Soc.*, 27: 3-7.
- Bhardwaj, D.C., 1950. Studies in Indian Anthocerotaceae- I. The morphology of *Anthoceros crispulus* (Montin) Douin. *J. Indian Bot. Soc.*, 29: 145-163.
- Bhardwaj, D.C., 1960a. Studies in Indian Anthocerotaceae- II. The morphology of *Anthoceros* cf. *gemmulosus* (Hattori) Pande. *J. Indian Bot. Soc.*, 37: 75-92.
- Bhardwaj, D.C., 1960b. Studies in Indian Anthocerotaceae- III. The morphology of *Anthoceros erectus* Kash. and some other species. *J. Indian bot. Soc.*, 39: 568-592.
- Bhardwaj, D.C., 1965a. Studies in Indian Anthocerotaceae. IV. On the morphology of *Anthoceros mammilispurus* Bhardwaj. and *A. dixitians* (Mahabale) Prosk. *J. Indian Bot. Soc.*, 44: 347-364.
- Bhardwaj, D.C., 1965b. Studies in Indian Anthocerotaceae. VI. Some aspects of morphology of *Phaceros* Prosk. *Phytomorphology*, 15: 140-145.
- Bhardwaj, D.C., 1971. On *Folioceros*, a new genus of Anthocerotales. *Geophytology*, 1: 6-15.
- Bhardwaj, D.C., 1972. On some Asian and African species of *Folioceros* Bhardwaj. *Geophytology*, 2: 74-89.
- Bhat, V., 2009. Mosses of Western Ghats and coastal belt of Karnataka-A taxonomic study (Doctoral dissertation, Ph. D. Thesis, Mangalore University, Mangalore)
- Bhattacharya, S., Ojha, S.N. and Ray, S., 2017. Variation in gametophytic and sporophytic features among three disjunct populations of *Funaria hygrometrica*. *Nelumbo*, 59(1): 110-117.
- Bhattacharyya, S.D., Bhattacharyya, D. and Sharma, G.D., 2011. Disjunct distributional record of an endemic liverwort *Chiloscyphus campanulatus* Steph. from Assam in Indo-Burma biodiversity hotspot. *Curr. Sci.*, 101(7): 825-827.
- Biju, P.M. and Daniels, A.E.D., 2017. *Leucobryum aduncum* var. *scalare* (Leucobryaceae: Bryophyta)-new to the Eastern Ghats. *Pl. Sci. Today*, 4(2): 64-67.
- Biju, P.M., Sreebha, R. and Daniels, A.E.D., 2017. *Ectropothecium sodale* (Hypnaceae, Bryophyta)—New to India from the Peninsula. *Act. Bot. Hung.*, 59(1-2): 9-12.
- Bir, S.S. and Chopra, R.N., 1972. Thallose liverworts from Dalhousie, North Western Himalayas. *Bryologist*, 75: 371-372.

- Bir, S.S., 1970. Thallose liverworts from Nainital, Northwestern Himalayas. *Bryologist*, 73: 395-396.
- Bischler- Causse, H, Gradstein, S.R., Jovet-Ast, S., Long D.G. and Allen, N.S., 2005. *Fl. Neotr. Mon.* 97, Marchantiidae 1-262.
- Bischler, H. and Piippo S. 1991. Bryophyte flora of the Huon Peninsula, Papua New Guinea. L. Marchantia (Marchantiaceae, Hepaticae). *Ann. Bot. Fenn.*, 28: 277-301.
- Bischler-Causse, H., 1979. Plagiochasma Lehm. & Lindenb. III. Les taxa d' Asie et d'océanie. *J. Hattori Bot. Lab.* 45: 25-79.
- Bischler-Causse, H., 1989. Marchantia L. The Asiatic and Oceanic taxa. *Bryophytorum Bibliotheca*, 38:1–317.
- Bischler-Causse, H., 1993. Marchantia L. The European and African taxa. *Bryophytorum Bibliotheca*, 45: 1-129.
- Blatter, E., 1929. Mosses of the Bombay Presidency, the High Wavy Mountain and Mt. Abu. *J. Bombay Nat. Hist. Soc.*, 33: 869-879.
- Blockeel, T.L., Kiebach, T. and Long, D.G., 2019. *Hygrohypnum subeugyrium* (Renauld & Cardot) Broth.(Hypnales), a neglected British moss, with a note on its occurrence in the Himalayas. *J. Bryol.*, 41(1): 12-20.
- Bodade, R.G., Borkar, P.S., Saiful, A.M. and Khobragade, C.N., 2008. *In vitro* screening of bryophytes for antimicrobial activity. *J. Medi. Pl.*, 7: 23-28.
- Bonner, C.B.E., 1966. *Index Hepaticarum* Vol. VI. *Geobeliella* to *Jubula*. J. Cramer University.
- Borovichev, E. and Bakalin, V., 2017. Genus *Fossombronia* (Fossombroniaceae, Marchantiophyta) in the Russian Far East. *Crypt. Bryol.*, 38(1): 61-73.
- Brassard, G.R., 1979. The moss genus *Timmia*. 1. Introduction, and revision of *T. norvegica* and allied taxa. *Lindbergia*, 5: 39-53.
- Brijithlal, N.D., Mabel, J.L. and Daniels, A.E.D., 2008. Additions to the moss flora of peninsular India from the Neyyar Wildlife Sanctuary, Kerala, India. *Indian J. Forest.*, 31: 643-646.
- Britton, E.G., 1908. The genus *Zygodon* in North America. *The bryologist*, 11(4): 61-66.
- Brotherus, V.F., 1898. Contribution to the bryological flora of the North Western Himalayas. *Acta. Soc. Sci. Fenn.*, 24(2): 1-46.

- Brotherus, V.F., 1899. Contributions to the Bryological flora of Southern India. *Rec. Bot. Surv. India*, 1: 311-329.
- Brown, R., 1866. *The Miscellaneous botanical works of Robert Brown*. 1: 1-612. Royal Society.
- Bruehl, P., 1931. A census of Indian mosses with analytical keys to the genera. *Rec. Bot. Surv. India*, 13: 1-135.
- Bruggeman-Nannenga, M.A. and Arts, T., 2010. A revision of the Fissidentaceae (Musci) of La Reunion (including all species known from Mauritius and Rodriguez). *J. Bryol.*, 32(3): 170-207.
- Bruggeman-Nannenga, M.A. and Berendsen, W., 1990. On the peristome types found in the Fissidentaceae and their importance for the classification. *J. Hattori Bot. Lab.*, 68: 193-234.
- Bruggeman-Nannenga, M.A. and Pursell, R.A., 1995. Notes on *Fissidens* V. *Lindbergia*, 20: 49-55.
- Bruggeman-Nannenga, M.A., 1990. On the anatomy of the costa in *Fissidens*. *Trop. Bryol.*, 3: 37-44.
- Bruggeman-Nannenga, M.A., 1997. Notes on *Fissidens* VI. New combinations and validation of some names. *J. Hattori Bot. Lab.*, 81: 155-173.
- Bruggeman-Nannenga, M.A., 2009. Notes on *Fissidens* VII-IX. *J. Bryol.*, 31: 106-116.
- Bruggeman-Nannenga, M.A., 2013. Subgenus *Fissidens* in tropical Eastern Africa with emphasis on the Tanzanian collections by Tamas Pócs. *Polish Bot. J.*, 58(2): 369-417.
- Bruggeman-Nannenga, M.A., Daniels, A.E.D. and Kariyappa, K.C., 2015. Notes on little known moss *Fissidens firmus* Mitt. (Fissidentaceae). *J. Bryol.*, 37(3): 178-183.
- Bruggeman-Nannenga, M.A., Manjula, K.M. and Manju, C.N., 2016. *Fissidens enervis* (Fissidentaceae; Bryophyta) new to Asia. *Lindbergia*, 39: 29-32.
- Bruggemann-Nannenga, M.A., 1978. Notes on *Fissidens*. I and II. *Proc. Konink. Neder. Akad.* 387-402.
- Bruggeman-Nannenga, M.A. and Berendsen, W., 1990. On the peristome types found in the Fissidentaceae and their importance for the classification. *J. Hattori Bot. Lab.*, 68: 193-234.
- Brummit, R.K. and Powell, C.E., 1992. Authors of plant name. *Royal Bot. Garden, Kew*: 731.

- Bruun, H.H., Moen, J., Virtanen, R., Grytnes, J.A., Oksanen, L. and Angerbjörn, A., 2006. Effects of altitude and topography on species richness of vascular plants, bryophytes and lichens in alpine communities. *J. Vegetation Sci.*, 17(1): 37-46.
- Buck, W.R. and Crum, H., 1976. Revision of the genus *Rozea* (Musci). *Bryologist*, 79: 406-421.
- Buck, W.R. and Ireland, R.R., 1985. A reclassification of the Plagiotheciaceae. *Nova Hedwigia*, 41(1-4): 89-125.
- Buck, W.R., 1987. Taxonomic and nomenclatural rearrangement in the Hookeriales with notes on West Indian taxa. *Brittonia*, 39: 210–224.
- Buck, W.R., 1994. A new attempt at understanding the Meteoriaceae (Papers to commemorate the late Dr. Sinske Hattori' s contributions-2-). *J. Hattori Bot. Lab.*, (75): 51-72.
- Buczkowska, K., Bakalin, V., Bączkiewicz, A., Agüero, B., Gonera, P., Ślipiko, M., Szczecińska, M. and Sawicki, J., 2018. Does *Calypogeia azurea* (Calypogeiaceae, Marchantiophyta) occur outside Europe? Molecular and morphological evidence. *PloS one*, 13(10): 204-218.
- Burley, J.S. And Pritchard, N.M., 1990. Revision of the genus *Ceratodon* (Bryophyta). *Harv. Pap. Bot.*, 17-76.
- Cai, Q.Y., Guan, B.C., Ge, G. and Fang, Y.M., 2019. Molecular Phylogeny of Chinese Thuidiaceae with emphasis on *Thuidium* and *Pelekium*. arXiv preprint arXiv:1902.06032. (online)
- Cairns, A., Meagher, D. and Ramsay, H., 2019. A revised checklist of the moss flora of the Australian Wet Tropics. *Telopea*, 22: 1-30.
- Campbell, D.H., 1918. Studies on some East Indian Hepaticae. *Ann. Bot.* 32(127): 319-338.
- Cano, M.J., 2016. New records of Pottiaceae (Bryophyta) from Cape Verde. *Nova Hedwigia*, 103(3-4): 373-383.
- Cargill, D.C. and Fuhrer, B.A., 2008. Taxonomic studies of the Australian Anthocerotophyta II: the genus *Phaeoceros*. *Fieldiana Botany*, 47: 239-254.
- Cargill, D.C., Manju C.N., Deepa, K.M., Chandini V. K. and Rajesh, K.P., 2019. A New Indian Species of *Riccia* with connections to Northern Australia. *J. Bryol.*, 41(3): 1-7.
- Casas, C., 2009. Handbook of liverworts and hornworts of the Iberian Peninsula and the Balearic Islands: illustrated keys to genera and species. Publ. *Institut*

- Champion, H. G. and Seth, S.K., 1968. A revised survey of the forest types of India. Govt. of India Press, New Delhi.
- Chandini V.K., Mufeed B., Manju C.N. and Rajesh K.P., 2020. The genus *Drepanolejeunea* (Spruce) Schiffn. (Lejeuneaceae; Marchantiophyta) in the Western Ghats with special reference to Kerala. *Pl. Sci. Today*, 7(3): 476-493.
- Chaturvedi, S.K. and Chaturvedi, S., 2008. Diversity of thalloid Liverworts in Mokokchung and Zunheboto districts, Nagaland, India. In: Mohamed, H. Baki, B.B., Nasrulhaq-Boyce, A. and Lee, P.KY. (eds.), *Bryology in the New Millennium*. Kuala Lumpur: University of Malaya, 83-91.
- Chaudhary, B.L. and Sharma, T.P., 2007. Epiphytic bryophytes of Gujarat-I, India. *Current trends in bryology. Bishen Singh Mahendra Pal Singh, DehraDun, India*, 287-330.
- Chaudhary, B.L., Sharma, T.P. and Bhagora, F.S., 2008. *Bryophyte Flora of North Konkan, Maharashtra (India)*. Himanshu Publications, New delhi
- Chaudhary, B.L., Sharma, T.P. and Charu, S., 2006. *Bryophyte flora of Gujarat (India)*. Himanshu Publications, New Delhi.
- Chavan, S.J., 2010. Studies on the family Lejeunaceae from Andaman Islands, India. *Bioinfolet.*, 7(1): 4-8.
- Chiang, T.Y., 1996. *Wijkia tanytricha* (Mont.) Crum (Musci, Sematophyllaceae), a new record to the moss flora of Taiwan. *Bot. Bull.-Acad. Sinica Taipei*, 37: 147-150.
- Chopra, N., 1960. Mosses of Nainital (Himalayas, India). *J. Hattori Bot. Lab.*, 23: 80-84.
- Chopra, R.N. and Kanta, V., 1966. Some mosses from Delhi, India. *Bryologist*, 69(4): 509-510.
- Chopra, R.N., 2005. *Biology of bryophytes*. New Age International.
- Chopra, R.S. and Kumar, S.S., 1981. *Musci of the Western Himalayas and Adjacent Plains. Vol. 5*. Chronica Botanica Company, New Delhi.
- Chopra, R.S., 1938. Notes on Indian Hepatics I. South India. *Proc. Ind. Acad. Sci., Ser B*, 7: 239-251.
- Chopra, R.S., 1943. A census of Indian Hepatics. *J. Indian Bot. Soc.*, 22: 237-259.
- Chopra, R.S., 1975. *Taxonomy of Indian Mosses (An introduction)*. In Botanical monograph No. 10. Publications & Information Directorate (CSIR), New

- Delhi, India. 1-599.
- Choudhary, B.L. and Deora, G.S., 1993. *Moss flora of Rajasthan (India)*. Himanshu Publications, Delhi. 1-127.
- Choudhary, B.L., Sharma, T.P. and Bhagora, F.S., 2008. *Bryophyte flora of North Konkan Maharashtra-India*. Himanshu Publications, Udaipur. 314.
- Choudhary, B.L., Sharma, T.P. and Sanadhya, C., 2006. *Bryophyte Flora of Gujarat (India)*. Himanshu publications, Udaipur. 1-187.
- Choyal, R. and Sharma, S.K., 2011. Study of moss flora and growth forms of moss in varied habitats in Dharmshala of Kangra district (H.P.), India. *Indian J. Fund. Appl. Life Sci.* 1(3): 271-273.
- Chua, M.S. and Suleiman, M., 2015. Additions to the moss flora of Imbak Canyon Conservation Area, Malaysian Borneo. *Bryophyte Diversity and Evolution*, 37(2): 23-30.
- Chua, M.S., 2018. Lectotypification on *Acroporium hyalinum* (Reinw. ex Schwägr.) Mitt.(Hypnales: Sematophyllaceae). *Telopea*, 21: 175-185.
- Chuah-Petiot M.S., 2011. A checklist of Hepaticae and Anthocerotae of Malaysia. *Polish Bot. J.*, 56(1): 1-44.
- Churchill, S., Gonzalez, G.C. and Linares, E.C., 1995. *Prodromus Bryologiae Novo-Granatensis Introduccion A La Flora De Musgos De Colombia Part. 2* (No. 582.34 G4754p Ej. 2 004158). Guadalupe Ltda.
- Churchill, S.P., 1985. synopsis of the Kansas mosses with keys and distribution maps. *Univ. Kansas. Sci. Bull.*, 53:1-64
- Churchill, S.P., 1989. Bryologia Novo Granatensis. Estudios de los musgos de Columbia IV. Catalogo Nuevo de los musgos de Colombia. *Trop. Bryol.*, 1: 95-132.
- Costa, D.P., Couto, G.P., Siqueira, M.F. and Churchill, S.P., 2018. Bryofloristic affinities between Itatiaia National Park and tropical Andean countries. *Phytotaxa*, 346(3): 203-220.
- Crandall-Stotler, B., 1980. Morphogenetic designs and a theory of Bryophyte origins and divergence, *Bio Sci.*, 30(9): 580-585.
- Crandall-Stotler, B., Stotler, R.E. and Geissler, P., 1987. A biosystematic study of the subspecies of *Frullania tamarisci* (L.). *Bryologist*, 90(4): 287-308.
- Crandall-Stotler, B., Stotler, R.E. and Long, D.G., 2009. Phylogeny and classification of the Marchantiophyta. *Ed. J. Bot.*, 66(1): 155-198.
- Crandall-Stotler, B.J. and Bartholomew-Began, S.E., 2007. Morphology of mosses

- (phylum Bryophyta). *Flora of North America North of Mexico*, 27: 3-13.
- Crosby, M.R. and Magill, R.E., 2006. *Index of Bryophytes* 2005. Missouri Botanical Garden.
- Crosby, M.R., Magill, R.E., Allen, B. and He, S., 1999. A Checklist of the Mosses. *Missouri Bot. Garden*.
- Crosby, M.R., Schultze-Motel, U. and Schultze-Motel, W., 1983. Katalog der Laubmoose von Madagaskar und den umliegenden Inseln. *Willdenowia*, 13: 187-255.
- Crum, H. A., 1973. Mosses of the Great Lakes Forest. *J. Hattori Bot. Lab.*, 35: 269-298.
- Crum, H.A. and Buck, W.R., 1990. List of the mosses of North America north of Mexico. *Bryologist*, 93: 448-499.
- Dabhade, G.T., 1998. *Mosses of Khandala and Mahabaleshwar in Western Ghats, Classic Graphics, Thane, India.*, 117-120.
- Dalton, P.J., Seppelt, R.D. and Buchanan, A.M., 1991. An annotated checklist of Tasmanian mosses. *Asp. Tasmanian Bot.*, 15-32.
- Damscholt K., 2002. Illustrated Flora of Nordic Liverworts and Hornworts. Lund, *Nordic bryological society*, 840.
- Dandotiya, D., Govindapuri, H., Suman, S. and Uniyal, P.L., 2011. Checklist of the bryophytes of India. *Arch. Bryol.*, 88: 1-126.
- Daniels A.E.D. and Kariyappa K.C., 2012. Notes on a little known moss from the Western Ghats. *Nelumbo*, 54: 213-217.
- Daniels, A. and Daniel, P. 2009a. *Cololejeunea distalopapillata* and *C. vidaliana* (Lejeuneaceae) new to the liverwort flora of India. *Act. Bot. Hung.*, 51(1-2): 61-66.
- Daniels, A. and Daniel, P. 2009b. The Australian *Spruceanthus thozetianus* (Hepaticae: Lejeuneaceae) discovered in the Western Ghats of India. *Act. Bot. Hung.*, 51(3-4): 283-287.
- Daniels, A., Kariyappa, K., Mabel, J., Raja, R. and Daniel, P., 2010c. The overlooked and rare liverwort *Frullania ramuligera* (Nees) Mont. (Frullaniaceae) rediscovered in the Western Ghats of India. *Act. Bot. Hung.*, 52(3-4): 297-303.
- Daniels, A.D., Biju, P.M. and Asha, V., 2019. The moss genus *Regmatodon* Brid. (Regmatodontaceae)-new to the Eastern Ghats. *Pl. Sci. Today*, 6(4): 439-441.

- Daniels, A.D., Sreebha, R. and Kariyappa, K.C., 2018. *Bryoflora of Indira Gandhi National Park in Anamalai Hills, India*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
- Daniels, A.E.D, Kariyappa, K. and Daniel, P., 2011c. The liverwort *Thysananthus spathulistipus* (Lejeuneaceae) long-lost in India rediscovered. *Acta Botanica Hungarica*, 53(3-4): 283-289.
- Daniels, A.E.D. and Brijithlal, N.D., 2012. Three mosses added to the bryoflora of the Western Ghats from the Neyyar Wildlife Sanctuary, Kerala. *Indian J. Forest.*, 35(4): 507-510.
- Daniels, A.E.D. and Daniel, P., 2013. *The bryoflora of the southernmost Western Ghats, India*. Bishen Singh Mahendra Pal Singh, New Delhi.
- Daniels, A.E.D. and Kariyappa, K.C., 2013. *Cheilolejeunea trapezia* (Nees) Kachroo & RM Schust. ex Mizut. var. *ceylanica* (Gottsche) AED Daniels & KC Kariyappa comb. *et stat. nov.* (Lejeuneaceae) from India. *Taiwania*, 58(2): 140-145.
- Daniels, A.E.D. and Kariyappa, K.C., 2019. *Bryoflora of the Agasthyamalai Biosphere Reserve, Western Ghats, India*, Bishen Singh Mahendra Pal Singh, Dehra Dun. 658.
- Daniels, A.E.D. and Mabel, J.L., 2009. Two mosses new to the bryoflora of the Indian mainland. *Nelumbo*, 51: 179-182.
- Daniels, A.E.D. and Raja, R.D.A., 2011. The New Guinean *Thysananthus appendiculatus* (Lejeuneaceae) discovered in the Western Ghats of India. *Lindbergia*, 34: 40-43.
- Daniels, A.E.D., 2003. *Studies on the Bryoflora of the Southern Western Ghats, India*. Ph.D. Thesis, Manonmaniam Sundaranar University.
- Daniels, A.E.D., 2004. Bryophytes. In: Annamalai, R. (ed.), Tamil Nadu Biodiversity Strategy and Action plan. Wild Plant Diversity. Govt. of Tamil Nadu, Chennai. 49-70.
- Daniels, A.E.D., 2010. Checklist of the bryophytes of Tamil Nadu, India. *Arch. Bryol.*, 65: 1-117.
- Daniels, A.E.D., Kariyappa, K.C. and Daniel, P., 2011a. Two Species of *Daltonia* Hook & Taylor (Daltoniaceae: Bryophyta) New to the Moss Flora of India. *Nelumbo*, 53: 133-139.
- Daniels, A.E.D., Kariyappa, K.C. and Daniel, P., 2011b. The moss genus *Ochrobryum* Mitt. (Leucobryaceae) added to the bryoflora of the Western Ghats. *Nelumbo*, 53: 155-160.

- Daniels, A.E.D., Kariyappaa, K.C. and Daniel, P., 2010b. A new species of *Spruceanthus* Verd. (Hepaticae: Lejeuneaceae) from the Western Ghats of India. *Cryptog. Bryol.*, 31(2): 121.
- Daniels, A.E.D., Mabel, J.L. and Daniel, P., 2012. The Erpodiaceae (Bryophyta: Isobryales) of India. *Taiwania*, 57(2): 168-182.
- Daniels, A.E.D., Mabel, J.L. and Sreeji, S., 2011. Mosses new to the bryoflora of the Western Ghats from the Agasthyamalai Biosphere Reserve. *Nelumbo*, 53: 145-154.
- Daniels, A.E.D., Preetha, M.M., Asha, V. and Biju, P.M. 2018. Genus *Symphysodontella* M. Fleisch. (Pterobryaceae: Bryophyta)-new to the moss flora of the Eastern Ghats. *Pl. Sci. Today*, 5(1): 19-23.
- Daniels, A.E.D., Preetha, M.M., Asha, V.V., Monisha, P. and Biju, P.M., 2018. Genus *Notoscyphus* Mitt.– new to the liverwort flora of the Eastern Ghats. *Pl. Sci. Today*, 5(2): 81–83.
- Daniels, A.E.D., Raja, R.D.A. and Daniel, P., 2010a. *Indopottia zanderi* (Bryophyta, Pottiaceae) gen. et sp. nov. from the Western Ghats of India. *J. Bryol.*, 32: 216–219.
- Daniels, A.E.D., Sreebha, R. and Kariyappa, K.C., 2016. *Syntrichia amphidiacea* (Pottiaceae)- new to India from the Western Ghats. *Lindbergia*, 39(4): 35-38.
- Dash, P.K. and Saxena, D.K., 2009. Bryoflora of Khandadhar Hill ranges, Orissa, India. *Geobios*, 36(2-3): 113-116.
- De Freitas Vaz-Imbassahy, T. and Da Costa, D.P., 2008. The Pilotrichaceae (Hookeriales) of Rio de Janeiro, Brazil. *Bryologist*, 111(4): 551-575.
- Deepa K.M. and Manju C.N., 2016. *Clevea pusilla* (Steph.) Rubasinghe & D.G. Long (Cleveaceae; Marchantiophyta) a rare species from the Western Ghats of Tamil Nadu, India. In: *Cryptogam Biodiversity and Assessment*, 1(1): 52-54.
- Deepa K.M., Mufeed, B. and Manju C.N., 2019. *Wiesnerella denudata* (Mitt.) Steph. (Marchantiales: Marchantiophyta) a rare species in the Western Ghats of India. *Lindbergia*, 42(1): 1-4.
- Deepa, K.M., Leena, T.N., Suhana, M., Manju, C.N. and Rajesh, K.P., 2012. Bryophyte diversity of Malabar wildlife Sanctuary, Kerala, located in the Western Ghats of India. Pp. 11-24. In: Nagarajan, B., Kunhikannan, C., Sasidharan, K. R. and Krishnakumar, N. (eds.) *Tropical Ecosystems: Structure, Function and Services*. Institute of Forest Genetics and Tree

Breeding, Coimbatore.

- Deepa, K.M., Manju, C.N. and Rajesh, K.P. 2015. *Exormotheca ceylonensis* Meijer (Marchantiophyta)- an endangered liverwort of India, now recorded from a highly threatened habitat of Kerala. *Frahmia*, 11: 1-4.
- Dey, M. and Singh, D.K., 2012. *Epiphyllous liverworts of Eastern Himalaya*. Botanical Survey of India, 1-415.
- Dey, M., Singh, D. and Singh, D.K., 2009. Some new and noteworthy records of Hepaticae from Eastern Himalaya, India. *Indian J. Forest.*, 32: 669-684.
- Dey, M., Singh, D. and Singh, D.K., 2013. The genus *Drepanolejeunea* (Marchantiophyta: Lejeuneaceae) in India with a note on three new additions from Eastern Himalaya. *Trop. Bryol.*, 35: 14-25.
- Dillenius, J.J., 1741. *Historia Muscorum*. Oxford: Theatro Sheldoniano.
- Dixit, A.K. and Kerketta, M.A., 2019. Richness of thalloid liverworts in Bilaspur, Achanakmar-Amarkantak Biosphere Reserve and Lafa hills, Chhattisgarh (India). *Pl. Sci. Today*, 6(3): 287-298.
- Dixon H.N., 1932. On the moss flora of Siam. *Journal of the Siam society, natural history supplement*, 9(1): 1-51.
- Dixon, H.N. and Potier de la Varde, R., 1927. Contribution à la flore bryologique de l'Inde méridionale. *Archives de Botanique, Bull. Mensuel*, 1(8-9): 161-184.
- Dixon, H.N., 1909. Mosses from Western Ghats. *J. Bot. London.*, 47:157-164.
- Dixon, H.N., 1914. Report on the mosses collected by Mr. C. E. C. Fischer and others from south India and Ceylon. *Rec. Bot. Surv. India*. 6: 75-89.
- Dixon, H.N., 1921. On a collection of mosses from the Kanara district. *J. Indian Bot. Soc.*, 2: 174-188.
- Dixon, H.N., 1925. Mosses from the Mt. Everest Expedition, 1924. *J. Indian Bot.*, 63: 221-222.
- Dong, S., Schaefer-Verwimp, A., Pocs, T., Feldberg, K., Czumaj, K., Schmidt, A.R., Schneider, H. and Heinrich, J., 2013. Size doesn't matter—recircumscription of *Microlejeunea* (Lejeuneaceae, Porellales) based on molecular and morphological evidence, *Phytotaxa*, 85 (2): 41–55.
- Drugova, T.P., 2010. The genus *Aongstroemia* (Dicranaceae, Bryophyta) in Russia. *Arctoa*, 19: 247-252.
- During, H.J., 1979. Life strategies of bryophytes: a preliminary review. *Lindbergia*, 5: 2-18.

- Eakin, D.A. and Allen, B., 1999. A nomenclatural note on *Regmatodon*. *Nova Hedwigia*, 69: 311–312.
- Eakin, D.A., 1998. A taxonomic revision of the moss genus *Regmatodon*. *Nova Hedwigia*, 67: 139–152.
- Easa, P.S., 2003. Biodiversity documentation for Kerala, Part IV: Bryophytes. *KFRI Handbook No.17. Kerala Forest Research Institute, Peechi*.
- Eddy, A., 1988. A Handbook of Melanesian Mosses. *British Museum of Natural History, London, UK*.
- Eddy, A., 1996. A Handbook of Malesian Mosses: Splachnobryaceae to Leptostomataceae (Vol. 1). *British Museum of Natural History, London, UK*.
- Een, G. and Kristoferson, L., 1999. A small collection of bryophytes from the Seychelles. *Trop. Bryol.*, 17: 35-38.
- Eichler, A.W., 1883. Syllabus der vorlesungen uber soecielle und medicinisch – pharmaceutische Botanik. 3rd ed. Berlin.
- Ellis L.T., Afonina, O.M., Aleffi, M., Andriamiarosa, R.L., Bačkor, M., Goga, M., Bednarek-Ochyra, H., Callaghan, D.A., Campisi, P., Dia, MG, et al., 2018. New national and regional bryophyte records, 55. *J. Bryol.*, 40(2):173–187.
- Ellis, L.T., 1989. A taxonomic revision of Calymperes in Southern India and neighbouring Islands. *J. Bryol.*, 15: 697-732.
- Ellis, L.T., 1992a. *Fissidens ceylonensis* Dozy & Molkeb. (Musci: Fissidentaceae) and some allied taxa from Southern India. *Bull. Brit. Mus. (Nat. Hist.), Bot.*, 22: 153-156.
- Ellis, L.T., 1992b. Towards a moss flora of Southern India. *Bryobrothera.*, 1: 133-136.
- Ellis, L.T., Afonina, O.M., Doroshina, G. Ya., Agudelo, C., Andriamiarisoa, R.L., Asthana, A.K., Gupta, D., Gupta, R., Rawat, K.K., Sahu, V., Aymerich, P., Bednarek-Ochyra, H., Brugués, M., Ruiz, E., Sáez, L., Callaghan, D.A., Caspari, S., Drapela, P., Dugarova, O.D., Tubanova, D. Ya., Erzberger, P., Flores, J.R., Suárez, G.M., Fedosov, V.E., Gospodinov, G., Gradstein, S.R., Reeb, C., Jukonienė, I., Subkaitė, M., Kučera, J., Lee, G.E., Lombo, Y.J., Suarez, K.Y., Lebouvier, M., Majumdar, S., Müller, F., Nagy, J., Norhazrina, N., Papp, B., Plášek, V., Pócs, T., Puglisi, M., Schäfer-Verwimp, A., Shirzadian, S., Singh, D.K., Ștefănuț, S., Torzewski, K., Melick, H. va, Wolski, G.J. and Zander, R.H., 2019. New national and regional bryophyte records, 58. *J. Bryol.*, 41(1): 63-84.
- Ellis, L.T., Aleffi, M., Bakalin V.A., Bednarek-Ochyra, H., Bergamini, A.,

- Beveridge, P., Choi, S.S., Fedosov, V.E., Gabriel, R., Gallego, M.T., Grdovic, S., Gupta, R., Nath, V., Asthana, A.K., Jennings, L., Kuřschner, H., Lebouvier, M., Nair, M.C., Manjula, K.M., Rajesh, K. P., Nobis, M., Nowak, A., Park, S.J., Sun, B.-Y., Wigginton, M. J. *et al.*, 2015. New National and regional bryophyte records 42, *J. Bryol.*, 37(1): 68-85.
- Ellis, L.T., Amélio, L.A., Peralta, D.F., Bačkor, M., Baisheva, E.Z., Bednarek-Ochyra, H., Burghardt, M., Czernyadjeva, I.V., Kholod, S.S., Potemkin, A.D. and Erdağ, A., 2019. New national and regional bryophyte records, 59. *J. Bryol.*, 41(2): 177-194.
- Ellis, L.T., Bayliss, J., Bruggeman-Nannenga, M.A., Cykowska, B., Ochyra, R., Gremmen, N.J.M., Frahm, J.P., Hedderson, T.A., Heras, P., Infante, V.M. and Hugonnot, V., 2014. New national and regional bryophyte records, 38. *J. Bryol.*, 36(1): 61-72.
- Ellis, L.T., O.M. Afonina, J.J. Atwood, H. Bednarek-Ochyra, M. Burghardt, S. Dragičević, S. Vuksanović, B. Espinoza-Prieto, J. Opisso, M. Goga, M. Bačkor, A. Graulach, V. Hugonnot, N. E. Koroleva, V.K. Chandini, C.N. Manju, B. Mufeed, R. Natcheva, N. Norhazrina, N. Syazwana, D. F. Peralta, V. Plášek, S. Yu. Popov, R. D. Porley, A. Rimac, A. Alegro, N. Vuković, N. Koletić, V. Šegota, M.S. Sabovljević, A. Schäfer-Verwimp, C. Sérgio, S. Ștefănut, M.A. Taha, U.Y. Abou-Salama and Wolski, G. J., 2020. New national and regional bryophyte records, 62. *J. Bryol.*, 42 (2): 195-208.
- El-Saadawi, W. and Badawi, A., 1977. The moss flora of Egypt. I. Order Pottiales. Public. *Cairo University Herbarium* 7: 181-206.
- Engel, J.J., 2010. Austral Hepaticae 45. A monograph of the genus *Chiloscyphus corda* (Lophocoleaceae) for Australasia. *Field. Bot.*, 48: 1-206.
- Engler, A., 1892. *Über die Hochgebirgsflora des tropischen Afrika* (No. 1-5). Verlag der Königl. Akademie der Wissenschaften in Commission bei G. Reimer.
- Engler, A., Prantl, K., Pilger, R.K.F. and Krause, K. 1909. *Die Natürlichen pflanzenfamilien nebst ihren gattungen und wichtigeren arten, insbesondere den nutzpflanzen, unter mitwirkung zahlreicher hervorragender fachgelehrten begründet* (Vol. 1). W. Engelmann.
- Erzberger, P. and Papp, B., 2004. Annotated checklist of Hungarian bryophytes. *Stu. Bot. Hung.*, 35: 91-149.
- Erzberger, P., 2016. The Genus *Fissidens* (Fissidentacea, Bryophyta) in Hungary. *Studia Botanica Hungarica*, 47(1): 41-139.
- Figueiredo, A.C., Garcia, C., Sim-Sim, M., Sérgio, C., Pedro, L.G. and Barroso, J.G.,

2010. Volatiles from *Plicanthus hirtellus* (F. Weber) RM Schust. and *Radula boryana* (F. Weber) Nees (Hepaticae) grown in São Tomé e Príncipe Archipelago. *Flavour and fragrance journal*, 25(4): 219-222.
- Florschütz-de Waard, J. and Florschütz, P. A., 1979. Estudios sobre criptógamas Colombianas III. Lista comentada de los musgos de Colombia. *Bryologist*, 82: 215–259.
- Foreau G., 1930. Notes on the bryological geography for the Presidency of Madras. *J. Madras Univ.* 2: 238–250. 3:118–136.
- Foreau, G., 1961. The moss flora of the Palni Hills. *J. Bombay Nat. Hist. Soc.* 58: 12-47.
- Foreau, G., 1964. Some South Indian mosses. *J. Bombay Nat. Hist. Soc.*, 61: 223-226.
- Forrest, L.L., Allen, N.S., Gudino, J.A., Korpelainen, H. and Long, D.G., 2011. Molecular and morphological evidence for distinct species in *Dumortiera* (Dumortieraceae). *Bryologist*, 114(1): 102-115.
- Forzza, R.C., Leitman, P.M., Costa, A.F., Carvalho Jr, A.A., Peixoto, A.L., Walter, B.M.T., Bicudo, C., Zappi, D., Costa, D.P., Lleras, E D.P., Lleras, E. and Martinelli, G., 2010. Lista de espécies da flora do Brasil. *Jardim Botânico do Rio de Janeiro*. <http://floradobrasil.jbrj.gov.br/2010/>
- Frahm, J.P., 1984. A survey of the genus *Campylopus* Brid. in Sri Lanka. *J. Bryol.*, 13(2): 163-191.
- Frahm, J.P., 1987. A revised list of the *Campylopus* species of the world. *Bryol. Beitr.*, 7: 1-117.
- Frahm, J.P., 1992. A revision of the east-Asian species of *Campylopus*. *J. Hattori Bot. Lab.*, 71: 133-164.
- Frahm, J.P., 1994. A new synopsis of the *Campylopus* species from Australia. *J. Bryol.*, 18(2): 311-327.
- Frahm, J.P., 1999. A type catalogue of Campylopodioideae and Paraleucobryoideae (Musci, Dicranaceae), Part II, *Campylopus*. *Trop. Bryol.*, 16:17-102.
- Frahm, J.P., 2010. Mosses and Liverworts of the Mediterranean: an illustrated field guide. Herstellung und Verlag: Books on Demand GmbH, Norderstedt.
- Frahm, J.P., 2012. A revision of Campylopodioideae (Musci, Dicranaceae) from India. *Arch. Bryol.*, 150: 1-5.
- Frahm, J.P., 2012. Mosses and Liverworts of Thailand-a picture book. *Archive for bryology special volume*, 11: 1-62.

- Frahm, J.P., O'Shea, B.J. and Ho, B.C., 2009. The moss flora of Mauritius. *Arch. Bryol.*, 51: 1-26.
- Frahm, J.P., Pócs, T., O'shea, B., Koponen, T., Piipo, S., Enroth, J., Rao, P. and Fang, Y., 2003. Manual of tropical bryology. *Trop. Bryol.*, 23: 9-91.
- Frahm, J.P., Schwarz, U. and Manju, C.N., 2013. A checklist of the mosses of Karnataka, India. *Arch. Bryol.*, 158: 1-15.
- Frank, K.D., 2015. Apparent dispersal of *Reboulia hemisphaerica* (Aytoniaceae) by springtails. *Bartonia*, (67): 85-89.
- Frey, W., 1974. Die Lebermoose des Iran und Afghanistans. *Bryologist*, 77(1): 48-56.
- Furuki, T. and Mizutani, M., 1994. Checklist of Japanese Hepaticae and Anthocerotae, 1993. *Proc. Bryol. Soc. Japan*, 6: 75-83.
- Furuki, T., 1994. Checklist of Japanese Hepaticae and Anthocerotae, In: *Proc. Bryol. Soc. Japan*, 6: 75-83.
- Furuki, T., Yamada, K., Hattori, S. and Nishimura, N., 1993. Hepaticae collected from Pakistan in 1991. In: Nakaïke, T. & Malik, S. *Crypt. Fl. Pakistan*, 2: 221-229.
- Ganesh T., Ganesan, R., Devy, M.S., Davidar, P., and Bawa, K.S., 1996. Assessment of plant biodiversity at a mid elevation evergreen forest of Kalakkad-Mundanthurai Tiger Reserve, Western Ghats, India. *Curr. Sci.*, 71(5): 379-392.
- Gangulee, H.C. and Chatterjee, N.K., 1962. Cytological studies in the mosses of Eastern India. III. *Caryologia*, 15(2): 367-400.
- Gangulee, H.C., (1969-1980). *Mosses of Eastern India and adjacent regions*. Vols. I-III, (Fasc. 1-8), BSI, Calcutta.
- Gangulee, H.C., 1957. Mosses of Eastern India. I. Eubryinales. Series I. Fissidentales. *Bull. Bot. Soc. Bengal*, 11: 59-84.
- Gangulee, H.C., 1959. Mosses of Eastern India. II. Eubryiidae. Series II. Dicranales, Family: Ditrichaceae. *Bull. Bot. Soc. Bengal*, 13: 1-9.
- Gangulee, H.C., 1960. Mosses of Eastern India. Eubryiidae. Series II. Dicranales (contd.) Family: Dicranaceae. *Bull. Bot. Soc. Bengal*, 14: 10-57.
- Gangulee, H.C., 1961. Mosses of Eastern India. Eubryiidae. Series II. Dicranales (contd.) Family: Leucobryaceae and series III. Pottiales: Family Calymperaceae. *J. Bombay Nat. Hist. Soc.*, 60(3): 606-637.

- Gangulee, H.C., 1985. *Handbook of Indian Mosses*. Amerind Publishing Co., New Delhi.
- Gao, C. and Chang, K. C., 1983. Index Muscorum Chinae Boreali-Orientalis. *J. Hattori Bot. Lab.*, 54: 187- 205.
- Gaur and Nautiyal, 1981. Thallose liverworts from Srinagar and adjacent areas-I. *Indian J. Forest.*, 4: 75-76.
- Gautam, S.P. and Thakur, M.K., 1981. A note on the distribution of Hepaticae in Jabalpur, Madhya Pradesh (India). *J. Econ. Tax. Bot.*, 2: 195-196.
- Geffert, J.L., Frahm, J.P., Barthlott, W. and Mutke, J., 2013. Global moss diversity: spatial and taxonomic patterns of species richness. *J. Bryol.*, 35(1): 1-11.
- Ghatge, M.M., Shaikh, S.D. and Dongare, M., 2011. Study on the metal absorption by two bryophytes from Koyana Wildlife Sanctuary (India). *J. Exp. Sci.*, 2(3): 49-50.
- Ghosh, J.P., 2006. A preliminary check-list of hepatics of West Bengal. *Bull. Bot. Surv. India*, 48: 73-102.
- Gier, L.J., 1980. A preliminary study of the Thuidiaceae (Musci) of Latin America. *J. Bryol.*, 11(2): 253-309.
- Glenny, D., 1998. A revised checklist of New Zealand liverworts and hornworts. *Tuhinga*, 10: 11–149
- Glime, J. M. (2007, 2009, 2018, 2020). *Bryophyte ecology*: Online handbook of bryophytes, Michigan Technological University.
- Glime, J.M. and Gradstein, S.R., 2018. Tropics: General Ecology. Chapt. 8-1. In: Glime, J. M. *Bryophyte Ecology*. Volume 4. 8-1-1 Habitat and Role. E-book sponsored by Michigan Technological University and the International Association of Bryologists.
- Glime, J.M., 2006. Uses. Bryophyte ecology. *E-book sponsored by Michigan Technological University and the International Association of Bryologists. published online at <http://www.bryoecol.mtu.edu>*.
- Glime, J.M., 2019. Tropics In: Glime, J. M. (ed.) *Bryophyte Ecology*. Volume 4. Habitat and Role. Ebook 8-8-1 sponsored by Michigan Technological University and the International Association of Bryologists. Last updated 22 July 2020 and available at <http://digitalcommons.mtu.edu/bryophyte-ecology4/>. (accessed 30-August-2020).
- Goffinet, B. and Buck, W.R., 2018. The evolution of body form in bryophytes. *Ann. Pl. Rev.*, 45: 51-89.

- Goffinet, B., 2000. Origin and phylogenetic relationships of bryophytes. In: A.J. Shaw & B.Goffinet (eds.), *Bryophyte Biology*, 124-149, Cambridge.
- Goffinet, B., Buck, W.R. & Shaw, A.J., 2009. Morphology, anatomy, and classification of the Bryophyta. In: Goffinet, B. & Shaw, A.J. (Eds.), *Bryophyte Biology (second edition)*. Cambridge University Press, Cambridge 53–138.
- Gökler, I., Ozenoglu, H. and Kiremit, F., 2000. A new liverwort for the flora of Turkey. *Turk J. Bot.*, 24: 81-83.
- Gökler, I., 1998. Liverworts (Marchantiopsida) of the Altindere Valley National Park. *Turk. J. Bot.*, 22(6): 409-412.
- González-Mancebo, J.M. and Hernández-García, C.D., 1996. Bryophyte life strategies along an altitudinal gradient in El Canal y los Tiles (La Palma, Canary Islands). *J. Bryol*, 19(2):243-255.
- Gottsche, C.M., Lindenberg, J.B.W. and Nees, V.E., 1844. *Synopsis Hepaticarum. Hamburgi*. 192-200.
- Govindaparyi, H., Kumari, P., Bahuguna, Y.M. and Uniyal, P.L., 2012. Evolution of species richness of acrocarpous mosses in Imphal District, Manipur, India. *Taiwania*, 57(1): 14-26.
- Govndaparyi, H., 2014. Habitat preference in pleurocarpus mosses of Imphal district, Manipur, India. *Evansia*, 31(3): 99-108.
- Gradstein, R. and Culmsee, H., 2010. Bryophyte diversity on tree trunks in montane forests of Central Sulawesi, Indonesia. *Trop. Bryol.*, 31(2): 95-105.
- Gradstein, S.R. and Salazar, A.N., 1992. Bryophyte diversity along an altitudinal gradient in Dárien National Park, Panama. *Trop. Bryol.*, 5: 61-71.
- Gradstein, S.R., 2015. Annotated key to the species of Plagiochila (Marchantiophyta) from Brazil. *Pesquisas, Botânica*, 67: 23-36.
- Gradstein, S.R., Churchill, S.P. and Salazar-Allen, N., 2001. Guide to the bryophytes of tropical America. *Mem. -New York Bot. Gard.*, 8-67.
- Gradstein, S.R., Pócs, T. and Vána, J., 1983. Disjunct hepaticae in tropical America and Africa. *Act. Bot. Hung.*, 29(1-4): 127-171.
- Gradstein, S.R., Tan, B.C., Zhu, R.L., Ho., B.C., Druebert, C. and Pitopang, R., 2005. A catalogue of the bryophytes of Sulawesi, Indonesia. *J. Hattori Bot. Lab.*, 98: 213-257.
- Grau, O., Grytnes, J.A. and Birks, H.J.B., 2007. A comparison of altitudinal species richness patterns of bryophytes with other plant groups in Nepal, Central

- Himalaya. *J. Biogeogr.*, 34(11): 1907-1915.
- Griffith, W. 1843. Muscologia Itineris Assamici. *Calcutta J. Nat. Hist.* 3: 56-75; 270-282.
- Griffith, W., 1842. Muscologia Itineris Assamici. *Calcutta J. Nat. Hist.* 2: 65-512.
- Grolle, R. and Piippo, S., 1984. Annotated catalogue of Western Melanesian bryophytes. I. *Acta Bot. Fennici*, 125: 1-86.
- Grolle, R., 1987 "1986": Miscellanea hepaticologica 241– 250. *J. Hattori Bot. Lab.*, 61: 249–255.
- Grolle, R., 1995. The Hepaticae and Anthocerotae of the East African islands: an annotated catalogue. *Bryophyt. Biblioth.*, 48: 1–178.
- Grolle, R., Schill, D.B. and Long, D.G. 2003. Notes on *Gottschia* (Jungermanniales, Lophoziaceae), with a description of *G. patoniae*, a new species from the East Himalaya. *J. Bryol.* 25(1): 3-6.
- Grolle, R., Schultze-Motel, W., 1972. Vorläufiges Verzeichnis der Lebermoose von Samoa. *J. Hatt. Bot. Lab.*, 36: 75-89.
- Grytnes, J.A., Heegaard, E. and Ihlen, P.G., 2006. Species richness of vascular plants, bryophytes, and lichens along an altitudinal gradient in western Norway. *Acta Oecologica*, 29(3): 241-246.
- Guerra, J., Ríos, D. and Gallego, M.T., 2014. A revision of the genus *Rhynchostegiella* (Brachytheciaceae) in the Iberian Peninsula and Balearic Islands. *Phytotaxa*, 183(3): 193-200.
- Gunawardene, N.R., Daniels, D.A., Gunatilleke, I.A.U.N., Gunatilleke, C.V.S., Karunakaran, P.V., Nayak, G.K., Prasad, S., Puyravaud, P., Ramesh, B.R., Subramanian, K.A. and Vasanthi, G., 2007. A brief overview of the Western Ghats–Sri Lanka biodiversity hotspot. *Curr. Sci.*, 93(11): 1567-1572.
- Guo, S.L., Enroth, J. and Koponen, T., 2007. Bryophyte flora of Hunan Province, China. 11. Orthotrichaceae (Musi). *Ann. Bot. Fenn.*, 44:1-34.
- Guo, S.L., Ma, Y.H., Cao, T. and Lou, Y.X., 2012. A synopsis of *Macromitrium* (Orthotrichaceae) in China. *Crypt. Bryol.*, 33(4): 341-355.
- Gupta, D., Sahu, V., Rawat, K.K., Pande, N. and Asthana, A.K. 2018. The genus *Porella* (Porellaceae) in Govind Wildlife Sanctuary, Uttarakhand, India. *Hattoria*, 9: 11-30.
- Gupta, R., Nath, V. and Asthana, A.K., 2016. Present status of family Dicranaceae (Bryophyta) in Pachmarhi Wildlife Sanctuary, Central India. *Taiwania*, 61(3): 253-259.

- Gupta, R., Nath, V. and Asthana, A.K., 2017. Two Species of *Fissidens* (Fissidentaceae): new to Indian Bryoflora. *Natl. Acad. Sci. Lett.*, 40(4): 295-299.
- Hallingbäck, T. and Hodgetts, N., 2000. Status survey and conservation action plan for bryophytes: mosses, liverworts and hornworts. IUCN: Cambridge.
- Hallingbäck, T. and Tan, B.C., 2014. Past and present activities and future strategy of bryophyte conservation. *Phytotaxa*, 9(1): 266-274.
- Hasegawa, J., 1984. Taxonomical studies on Asian Anthocerotae IV. A revision of the genera *Anthoceros*, *Phaeoceros* and *Folioceros* in Japan. *J. Hattori Bot. Lab.*, 57: 241–272.
- Hässel De Menéndez, G.G., 1987. *Phaeoceros laevis* (L.) Prosk. and *P. carolinianus* (Michx.) Prosk., their spores. *J. Hattori Bot. Lab.*, 62: 281–288.
- Hassel, K., Appelgren, L., Blom, H.H., Flynn, K.M., Gaarder, G., Heegaard, E., Høitomt, T., Jordal, J.B., Lima, M., Söderström, L. and Wangen, K., 2014. *Colura calyptrifolia* a new oceanic liverwort to Norway and Scandinavia. *Lindbergia*, 37: 1-5.
- Hattori, S. and Amakawa, T., 1971. A new genus *Horikawaella* from Nepal. *Misc. Bryol. et Lichenol.*, 5: 165-1 68.
- Hattori, S., 1966. Anthocerotae and Hepaticae. In H. Hara (ed.), *The Flora of Eastern Himalaya*, 1: 501-536. University of Tokyo.
- Hattori, S., 1969. Studies on the Asiatic species of the genus *Porella* (Hepaticae) II. *J. Hattori Bot. Lab.*, 32: 319-359.
- Hattori, S., 1972a. *Frullania tamarisci*-complex and the species concept. *J. Hattori Bot. Lab.*, 35: 202-251.
- Hattori, S., 1972b. Notes on Asiatic species of the genus *Frullania*, Hepaticae.1. *J. Hattori Bot. Lab.*, 36: 109-1 40.
- Hattori, S., 1973a. Notes on Asiatic species of the genus *Frullania*, Hepaticae.11. *J. Hattori Bot. Lab.*, 37: 55-84.
- Hattori, S., 1973b. Notes on Asiatic species of the genus *Frullania*, Hepaticae.111. *J. Hattori Bot. Lab.*, 37: 85-120.
- Hattori, S., 1973c. Notes on Asiatic species of the genus *Frullania*, Hepaticae.IV. *J. Hattori Bot. Lab.*, 37: 121-1 52.
- Hattori, S., 1974a. Notes on Asiatic species of the genus *Frullania*, Hepaticae.V. *J. Hattori Bot. Lab.*, 38: 185-221.
- Hattori, S., 1974b. Notes on Asiatic species of the genus *Frullania*, Hepaticae.VI. *J.*

- Hattori Bot. Lab. 38: 222-274.
- Hattori, S., 1975a. Anthocerotae and Hepaticae in H. Ohashi (ed.) Flora of the Eastern Himalaya 3rd report. *Mus. Niv. Tokyo. Bull.*, 8: 206-242.
- Hattori, S., 1975b. Notes on Asiatic species of the genus *Frullania*, Hepaticae.VII. *J. Hattori Bot. Lab.*, 39: 277-313.
- Hattori, S., 1975c. Notes on Asiatic species of the genus *Frullania*, Hepaticae.VIII. *Bull. Natn. Sci. Mus. Ser. B(Bot.)*, 1: 141-163.
- Hattori, S., 1975d. A revision of Indian species of *Frullania* (Hepaticae) published by W. Mitten in 1861. *Bull. Nat. Sci. Mus. Ser. B.(Bot.)*, 11: 73-81.
- Hattori, S., 1975e. Bryophyta, Anthocerotae & Hepaticae. In: H. Ohahi (ed.), The Flora of Eastern Himalaya. Third Report, *Univ. Mus. Univ. Tokyo Bull.*, 8: 206-242.
- Hattori, S., 1975f. Studies on the Asiatic species of the genus *Porella* (Hepaticae) V. *J. Hattori Bot. Lab.*, 39: 269-276.
- Hattori, S., 1976a. Notes on Asiatic species of the genus *Frullania*, Hepaticae. IX. *Bull. Natn. Sci. Mus., Ser. B(Bot.)*, 2: 7-21 .
- Hattori, S., 1976b. Notes on Asiatic species of the genus *Frullania*, Hepaticae. X. *J. Hattori Bot. Lab.*, 40: 461-507.
- Hattori, S., 1976c. Studies on the Asiatic species of the genus *Porella* (Hepaticae) VI. *J. Hatton Bot. Lab.*, 40: 121 -1 38.
- Hattori, S., 1978a. A note on Asian *Porella platyphylla*. *Misc. Bryol. Lichenol.*, 8: 1-2.
- Hattori, S., 1978b. Notes on the Asiatic species of the genus *Frullania*, Hepaticae. XI. *J. Hattori Bot. Lab.*, 44: 525-554.
- Hattori, S., 1979. Dr. H. Inoue's collection of *Frullania* (Hepaticae) made in Ceylon. *J. Jap. Bot.*, 54: 22-26.
- Hattori, S., 1980. Notes on the Asiatic species of the genus *Frullania*, Hepaticae. XII. *J. Hattori Bot. Lab.*, 47: 85-125.
- He, Q. and Jia, Y., 2019. Reappraisal of the taxonomic status of *Metzgeria fukuokana* Kuwahara (Metzgeriaceae, Marchantiophyta). *J. Bryol.*, 41(1): 36-41.
- He, Q. and Zhu, R.L., 2014. Notes on early land plants today. 48. *Drepanolejeunea longifolia*, a new synonym of *Drepanolejeunea angustifolia* (Marchantiophyta, Lejeuneaceae). *Phytotaxa*, 162(4): 234-235.

- He, S. and Snider, J.A., 2000. A taxonomic revision of *Symphiodon* (Musci: Symphyodontaceae). *Bryologist*, 103: 52-81.
- Hedenäs, L., 1992. Flora of Madeiran pleurocarpous mosses (Isobryales, Hypnobryales, Hookeriales). *J. Cramer.*, 44: 1-161.
- Hedwig, J., 1801. *Species muscorum frondosorum descripto et tabulis aensis 77 coloratis illustrate*. Leipzig.
- Henderson, N.F., 1929. Ohio Mosses, Dicranales. 29: 197-217.
- Herath, H.K., Ruklani, N.C.S. and Rubasinghe, S.C.K., 2019. Three new additions to the moss flora of Sri Lanka. *Ceylon J. Sci.*, 48(4): 339-343.
- Herzog, G., 1939. Music's dialects: A non-universal language. *Independent Journal of Columbia University*, 6:1-2.
- Higuchi, M. and Nishimura, N. 2003. Mosses of Pakistan. *J. Hattori Bot. Lab.*, 93: 273-291.
- Higuchi, M., Nishimura, N. and Li, X.J., 2010. Mosses of Xishuangbanna, Yunnan, China. *Biodiversity inventory in the western Pacific region. III. Indochina and southeastern China. Memoirs of the National Museum of Nature and Science*, 46: 83-94.
- Hile, V.K. and Dhabhade, G.T., 2011. Genus *Fissidens* Hedw. from Thal Ghat (Kasara Ghat) in Western Ghats. *Indian J. Appl. Pure Biol.*, 26(2): 235-240.
- Hill, M.O., Bell, N., Bruggeman-Nannenga, M.A., Brugués, M., Cano, M.J., Enroth, J., Flatberg, K.I., Frahm, J.P., Gallego, M.T., Garilleti, R. and Guerra, J., 2006. An annotated checklist of the mosses of Europe and Macaronesia. *J. Bryol.*, 28(3): 198-267.
- Ho, B.C. and Tan, B.C., 2002. Additions to the moss flora of Endau Rompin National Park, Johore State, Peninsular Malaysia. *Trop. Bryol.*, 22: 67-76.
- Ho, B.C., Tan, B.C. and Hernawati, N.S., 2006. A checklist of mosses of Sumatra, Indonesia. *J. Hattori Bot. Lab.*, 100: 143-190.
- Hodgetts, N.G., Söderström, L., Blockeel, T.L., Caspari, S., Ignatov, M.S., Konstantinova, N.A., Lockhart, N., Papp, B., Schröck, C., Sim-Sim, M. and Bell, D., 2020. An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus. *J. Bryol.*, 42(1): 1-116.
- Hoe, W.J., 1973. Additional new and noteworthy records for Hawaiian mosses. 2. *Bryologist*, 76(2): 296-298.
- Hoe, W.J., 1974. Annotated checklist of Hawaiian mosses. *Lyonia*, 1(1): 1-45.

- Holzinger, J.M., 1920. On our American form of *Timmia Megapolitana* Hedw. *Bryologist*, 23(6): 86-xi.
- Hong, W.S., 1993. The family Geocalycaceae (Hepaticae) in North America, west of the hundredth meridian. *Bryologist*, 96(4): 592-597.
- Hong, W.S., 1997. The Hepaticae and Anthocerotae of the Korean peninsula: an annotated list of taxa. *Lindbergia*, 22: 134-142.
- Hooker, W.J. and Greville, R.K., 1825. On the genus *Hookeria* of Smith of the order Musci. *Edinb. J. Sci.*, 2: 221-236.
- Hooker, W.J., 1808. XXIV. Musci Nepalenses; or Descriptions of several new Mosses from Nepal. *Trans. Linn. Soc. Lond.*, 9(1): 307-322.
- Hooker, W.J., 1818-1820: "Musci Exotici"; containing descriptions of new or little known foreign mosses and other cryptogamic subjects. Volumes I, 2. Longmans, London.
- Horikawa, Y., 1951. Tropical bryophytes in the Japanese Archipelago. *J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot., (Botany)* 6: 27-38.
- Howe, M.A., 1899. Hepaticae and Anthocerotes of California. *Mem. Torrey Bot. Club.*, 7: 1-208.
- Hyvönen, J. and Koponen, T., 2019. Bryophyte flora of Hunan Province, China 27. Polytrichaceae (Bryophyta).
- Hyvönen, J. and Lai, M.J., 1991. Polytrichaceae (Musci) in Taiwan (China). *J. Hattori Bot. Lab.*, 70: 119-141.
- Hyvönen, J., 1989. The bryophytes of Sabah (North Borneo) with special reference to the Bryotrop transect of Mount Kinabalu. VI. Polytrichaceae and Buxbaumiaceae (Bryopsida). *Willdenowia*, 569-589.
- Ignatov M.S. and Ignatova E.A., 2003. *Brachythecium buchananii* (Brachytheciaceae, Musci)- A new species for Uzbekistan. *Arctoa*, 12: 113-114.
- Ignatov M.S. and Milyutina I.A., 2010. The Genus *Brachythecium* (Brachytheciaceae, Musci) in Russia: comments on species and key for identification. *Arctoa*, 19: 1-30.
- Ignatov, M.S. and Afonina, O.M., 1992. List of Mosses in the Territory of the Former USSR. *Arctoa*, 1(1-2): 1-85.
- Ignatov, M.S. and Koponen, T., 1996. On the taxonomy of some east Asian *Brachythecium* (Brachytheciaceae, Musci). *Ann. Bot. Fenn.*, 33(4): 285-301.
- Ignatov, M.S., 1992. Checklist of mosses of the former USSR. *Arctoa. J. Bryol.*, 1:1-

- Ignatov, M.S., 1993. Moss diversity patterns on the territory of the former USSR. *Arctoa*, 2: 13-47.
- Inoue H., 1974. Contributions to the knowledge of the Plagiochilaceae of southeastern Asia. XV. Enumeration of *Plagiochila* species from Thailand. *J. Hattori Bot. Lab.*, 38: 555-563.
- Inoue, H., 1962. Contribution to the knowledge of the Plagiochilaceae of southeastern Asia. III. Studies of *Plagiochila sciophila-acanthophylla* complex. *J. Hattori Bot. Lab.*, 25: 91-101.
- Inoue, Y. and Tsubota, H., 2014. On the systematic position of the genus *Timmiella* (Dicranidae, Bryopsida) and its allied genera, with the description of a new family Timmiellaceae. *Phytotaxa*, 181(3): 151-162.
- Ireland, Jr., R. R., Brassard, G. R. Schofield, W. B. and Vitt, D. H., 1987. Checklist of the mosses of Canada II. *Lindbergia*, 13: 1-62.
- Iwasuki, Z. and Suzuki, T., 1982. A taxonomic revision of Japanese species of *Fissidens* (Musci). *J. Hattori Bot. Lab.*, 54: 329-508.
- Iwasuki, Z. and Suzuki, T., 2005. Notes on *Fissidens pulchellus* and *F. longtonianus* sp. nov. (Bryopsida: Fissidentaceae) in India. *J. Bryol.*, 27: 241-245.
- Iwatsuki, Z. and Suzuki, T., 1995. *Fissidens* (Musci, Fissidentaceae) in Vanuatu (New Hebrides) collected by Dr. M. Higuchi. *Fragm. Florist. Geobot.*, 40: 153-158.
- Iwatsuki, Z. and Suzuki, T., 2002. Three new species of *Fissidens* from Japan. *J. Hattori Bot. Lab.*, 92: 165-173.
- Iwatsuki, Z., 1972. Geographical isolation and speciation of bryophytes in some islands of eastern Asia. *J. Hattori Bot. Lab.*, 35: 126-141.
- Iwatsuki, Z., 1982. Speciation of the moss genus *Fissidens* in New Caledonia (preliminary report). *J. Hattori Bot. Lab.*, 52: 113-126.
- Iwatsuki, Z., 1991. Catalog of the mosses of Japan. *Hattori Bot. Lab.*, 1-182.
- Iwatsuki, Z., and Mohamed, M.A.H., 1987. The genus *Fissidens* in Peninsular Malaysia and Singapore (a preliminary study). *J. Hattori Bot. Lab.*, 62: 339-360.
- Jaeger, A., 1870-1879. *Genera et Species Muscorum*. San Gallis.
- Järvinen, I., 1976. Distribution maps of *Lophocolea*, *Geocalyx* and *Harpanthus* in Eastern Fennoscandia. *Lindbergia*, 4: 337-343.

- Jia, Y., He, S., Guo, S. L., 2011. Moss Flora of China (Orthotrichaceae), *Science Press. Beijing, New York: Science Press and St Louis: Missouri Botanical Garden.*, 5: 22–117.
- Jiang, T., Yang, X., Zhong, Y., Tang, Q., Liu, Y. and Su, Z., 2018. Species composition and diversity of ground bryophytes across a forest edge-to-interior gradient. *Scientific reports*, 8(1): 11868.
- Jiménez, J.A., Ros, R.M. and Cano, M.J., 2003. *Didymodon revolutus* (Bryopsida, Pottiaceae), a species new to the Asian flora. *Bryologist*, 106: 575–577.
- Jones, E.W., 1953. African Hepatics: V. *Lophocolea*, with Notes on *Chiloscyphus* and *Leptoscyphus*. *Trans. Brit. Bryol. Soc.*, 2(2): 172-202.
- Joshi, Y., Tripathi, M., Jinnah, Z., Bisht, K. and Upreti, D.K., 2016. Host specificity of epiphytic macrolichens: a case study of Jageshwar forest (Uttarakhand) India. *Trop. Ecol.*, 57(1): 1-8.
- Juengprayoon, W., Poopath, M. and Chantanaorrapint, S., 2016. *Hookeria acutifolia* (Hookeriaceae, Bryophyta), a genus and species new for Thailand. *Polish Bot. J.*, 61(2): 237-241.
- Juslén, A. 2006. Revision of Asian Herbertus (Herbertaceae, Marchantiophyta). *Ann. Bot. Fennici*, 43: 409-436.
- Jussieu, A.L., 1836. *Introduction in Historium plantarum*. Paris (Imprime chez Paul Renouard.) 1-111.
- Jyothilakshmi, G.R., Manju, C.N., Venugopal, M. and Chandini, V.K., 2016. Bryophyte diversity in the Sacred groves, with special reference to Vallikkattukavu of Kozhikode district in Western Ghats. *Pl. Sci. Today*, 3(2): 135-141.
- Kachroo, P. 1954. Distribution of the Rebouliaaceae in India. *Bryologist*, 56: 159-166.
- Kachroo, P., 1956. Morphology of *Pallavicinia* with reference to its species problem and the individuality of Pallaviciniaceae. *Proc. Natl. Inst. Sci. India*, 22: 6-21.
- Kallarackal, J., 2010. Water use by Eucalyptus grandis plantations in comparison with grasslands located in the downhill areas of Mannavan Shola in the Western Ghats of Kerala. *Kelara Forestry Research Institute (KFRI) Research Report*, 332: 1-52.
- Kalpna, B., Sadasivaiah, B., Sowgandhica, M., Rao, N.B. and Pullaiah, T., 2015. Bryophytes of Mahabubnagar district, Telangana. *Abst. Nat. Conf. Cryptog. Res. India Prog. Pros.*, 89.

- Karczmarz, Kazimierz. Bryophytes from Nepal. *Lindbergia*, (1981): 126-130.
- Kariyappa, K.C. and Daniels, A.E.D., 2010. The African Moss *Trachyphyllum dusenii* (Mull. Hal. ex Broth.) Broth. (Hypnobryales: Entodontaceae) in India. *Nelumbo*, 52: 131-134.
- Kashyap, S.R. and Dutt, N.L., 1925. The genus *Notothylas* in India. *Proc. Lahore Phil. Soc.*, 4: 49-56.
- Kashyap, S.R. and Pande, S.K., 1922. A contribution to the life history of *Aneura indica* St. *J. Indian Bot.*, 3: 79-89.
- Kashyap, S.R., 1914a. Morphological and Biological notes on New and Little known West- Himalayan Liverworts. I. *New Phytol.*, 13(6/7): 206-226.
- Kashyap, S.R., 1914b. Morphological and Biological notes on New and Little known West- Himalayan Liverworts. II. *New Phytol.*, 13(9): 308-323.
- Kashyap, S.R., 1915. Morphological and biological notes on new and little known West Himalayan Liverworts, III. *New Phytol.*, 14: 1-18.
- Kashyap, S.R., 1916. Liverworts of the western Himalays and the Punjab, with notes on known species and description of new species. I. *J. Bombay Nat. Hist. Soc.*, 24: 343-350.
- Kashyap, S.R., 1917. Liverworts of the western Himalays and the Punjab with notes on known species and description of new species. II. *J. Bombay Nat. Hist. Soc.*, 25: 279-281.
- Kashyap, S.R., 1919. The relationships of liverworts especially in light of some recently discovered Himalayan forms. *Proc. Asiat. Soc. Bengal*, 15: 152-166.
- Kashyap, S.R., 1920. Distribution of liverworts in the Western Himalayas. *Journ. Ind. Bot.*, 1: 149.
- Kashyap, S.R., 1921. Notes on the distribution of liverworts in the western Himalayas. Ladak and Kashmir. *Journ. Ind. Bot.*, 2: 80.
- Kashyap, S.R., 1929-1932. *Liverworts of the Western Himalayas and the Punjab Plain*, Part I & II (Reprint 1972). Research co. Publications, Trinagar, Delhi.
- Katagiri, T. and Furuki T., 2012. Checklist of Japanese liverworts and hornworts. *Bryol. Res.*, 10(7): 193-210.
- Kaul, R.K. and Dhar, G.L., 1968. Some Bryophytes of Kashmir Valley. *Kashmir Sci.*, 5: 233-237.
- Khatun, H. and Hadiuzzaman, S., 2005. Pleurocarpous mosses of Bangladesh: Meteoriaceae and Pterobryaceae. *Bangl. J. Pl. Tax.*, 12(1): 53-57.

- Kis, G., 1985. Mosses of South-East Tropical Africa. An annotated list with distributional data. *Institute of Ecology and Botany of the Hungarian Academy of Sciences, Vácrátót, Hungary.*
- Kishore Kumar, K., 1997. Two new records of ferns for Kerala State, India. *Indian Fern Journal*, 14: 110-112.
- Konstantinova N.A., Potemkin, A.D. and Schljakov, R.N., 1992. Checklist of the Hepaticae and Anthocerotae of the former USSR. *Proc. Bryol. Soc. Japan*, 6: 75–83.
- Konstantinova, N.A., Bakalin, V.A., Andrejeva, E.N., Bezgodov, A.G., Borovichev, E.A., Dulin, M.V. and Mamontov, Yu.S., 2009. Checklist of liverworts (Marchantiophyta) of Russia. *Arctoa*, 18: 1–64.
- Koponen, T. and Norris, D.H., 1984. Bryophyte flora of the Huon Peninsula, Papua New Guinea. IV. Anomobryum, Bryum and Rhodobryum (Bryaceae, Musci). *In Annales Botanici Fennici*, 21: 265-290.
- Koponen, T., 1970. How to make a moss wet? *Misc. Bryol. Lichenol.*, 5: 124 (in Japanese).
- Koponen, T., 1982. The family Mniaceae in Australasia and the Pacific. *J. Hattori Bot. Lab.*, 52: 75-86.
- Koponen, T., 1997. Notes on *Philonotis* (Bartramiaceae, Musci). 1. Status and distribution of *Philonotis falcata* (Hook.) Mitt. *Arctoa*, 6: 113-118.
- Koponen, T., 1998. Notes on *Philonotis* (Musci, Bartramiaceae). 3. A synopsis of the genus in China. *J. Hattori Bot. Lab.*, 84: 21-27.
- Koponen, T., 2012. Notes on *Philonotis* (Bartramiaceae, Musci). 10. *Philonotis fontana* added to, and *P. thwaitesii* excluded from South American flora. *Polish Bot. J.*, 57(1): 145-148.
- Koponen, T., Enroth, J., Fang, Y., Huttunen, S., Hyvonen, J., Ignatov, M., Juslen, A., Lai, M., Piippo, S., Potemkin, A., and Rao, P., 2000. Bryophyte flora of Hunan Province, China. 1. Bryophytes from Mangshan Nature Reserve and Wulingyuan Global Cultural Heritage Area. *Ann. Bot. Fennici*, 37: 11-39.
- Koponen, T., Touw, A. and Norris, D.H., 1986. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XIV. *Acta Bot. Fenn.*, 133: 1–24.
- Kour, A., Rao, A. and Kapila, S., 2015. Taxonomic Study of some Mosses of Doodhpathri (Budgam) J&K, India. *Int.J. Adv. Phar., Biol. Chem.*, 4(1): 196-208.

- Krayesky D. M., Crandall-Stotler B. and Stotler R.E., 2005. A revision of the genus *Fossombronia* Raddi in East Asia and Oceania. *J. Hattori Bot. Lab.*, 98: 1-45.
- Krishnan, M., Pradeep, V.G., Aswathy, D.P., Remya Krishnan, J.M., and Murugan, K., 2014. Wonder herbals-bryophytes, of the Ponmudi hills, of southern Western Ghats: window into the need for conservation. *World J. Pharm. Pharmaceu. Sci.*, 3(4): 1548-1562.
- Kruijt, R. C., 1988. A monograph of the genera *Dicranolejeunea* and *Acanthocoleus*. *Bryoph. Biblioth.*, 36: 1-135.
- Kumar, K.K., 2015. A checklist to the vascular flora of Anamudi Shola National Park, Munnar, Idukki district, Kerala. *Nat. Sci.*, 11(1): 51-73.
- Kumar, S. and Singh, D.K., 2002. Contribution to the Mosses of Gobind National Park, Uttaranchal, India. *Nelumbo*, 44(1-4): 119-134.
- Kumar, S.S. and Anand, S., 1990. Cytological observations on some west Himalayan liverworts-1. *J. Cytol. Genet.*, 25:1-11.
- Kumar, S.S. and Arora, M., 1988. Cytological studies on some West Himalayan species of *Fissidens* Hedw. *Lindbergia*, 14: 138-140.
- Kürschner, H. and Erdağ A., 2005. Bryophytes of Turkey: An Annotated Reference List of the Species with Synonyms from the Recent Literature and an Annotated List of Turkish, Bryological Literature. *Turkish J. Bot.*, 29: 95-154.
- Kürschner, H. and Frey W., 2011. Liverworts, mosses and hornworts of Southwest Asia (Marchantiophyta, Bryophyta, Anthocerotophyta). *Nova Hedwigia Supplement*, 139: 1-240.
- Kürschner, H., 2006. A bryophyte flora of Socotra Island, Yemenin. In: Kilian, N. and Hubaishan, M.A. (eds.), *Biodiversity of Socotra: forests, woodlands and bryophytes. Englera* 28. BGBM. Berlin-Dahlem., 97-162.
- Kuwahara, Y., 1958. A revision of the Japanese species of the genus *Metzgeria*. *J. Hattori Bot. Lab.*, 20: 124-141.
- La Farge, C., Williams, K.H. and England, J.H., 2013. Regeneration of Little Ice Age bryophytes emerging from a polar glacier with implications of totipotency in extreme environments. *Proc. Nat. Acad. Sci.*, 110(24): 9839-9844.
- Lacey, W.S., 1969. Fossil bryophytes. *Biol. Rev.* 44(2): 189-205.

- Lai, M.J., 1977. Bryoflora of Yuenyang Lake Natural Reserve, Taiwan. *Bryologist*, 153-155.
- Lai, M.J., 1978. The genus *Rhizogonium* Brid.(Musci) in Taiwan. *Taiwania* 23: 66-74.
- Lai, M.J., Zhu, R.L. and Chantanaorrapint, S. 2008. Liverworts and hornworts of Thailand: an updated checklist and bryofloristic accounts. *Annal. Bot. Fenn.*, 45(5): 321-341.
- Lal, J., 1977. *Colura* Dum. (Hepaticae), a genus new to Indian Flora. *Curr. Sci.*, 46: 618
- Lal, J., 2005. A checklist of Indian mosses. Dehra Dun: Bishen Singh Mahendra Pal Singh, 1–164.
- Langer, A. and Tanwir, M., 2002. Liverwort and hornwort flora of Tehsil Mendhar (North-West Himalaya), India. *Geophytology*, 30: 81-84.
- Lapshina, E.D., Ignatova, E.A., Ignatov, M.S. And Ganasevich, G.N., 2020. The Mosses of the Khulga River Basin (Subpolar Urals, Khanty-Mansi Autonomous Area-Yugra). *Novosti sistematiki nizshikh rastenii*, 54(1): 211-241.
- Lara, F., Mazimpaka, V., Medina, R., Caparrós, R. and Garilleti, R., 2010. Northeastern Turkey, an unnoticed but very important area for the Orthotrichaceae (Bryophyta). *Nova Hedwig.*, 138: 165-180.
- Lavate, R.A. Patil, S.B. Dongare, M. Sathe, S. and Magdum, S. 2015. *Pallavicinia lyellii* (Hook.) Gray,(Pallaviciniaceae): an addition to the hepatic flora of Maharashtra, India. *Pl. Sci. Today*, 2(4):192-196.
- Lavate, R.A., Patil, S.B., Shimpale, V.B., Dongare, M.M. and Patil, S.M., 2014. *Marchantia linearis* Lehm. et Linenb. (Marchantiophyta, Marchantiaceae): a new report from the Western Ghats of Maharashtra, India. *DAV Intl. J. Sci.*, 3(1): 42-46.
- Li, X.J. and Crosby, M.R., (eds.) 2007. Moss Flora of China English Version Volume 4. Bryaceae-Timmiaceae, Missouri Botanical Garden Press.
- Li, Z-H and Iwatsuki, Z., 2001. *Fissidentaceae. Moss flora of China*. Science Press & Missouri Botanical Garden Beijing, New York & St. Louis. 2: 3-67.
- Lin P.-J. and Tan B.C., 1995. Contribution to the Bryoflora of China (12): A taxonomic revision of Chinese Hookeriaceae (Musci). *Harvard Pap. Bot.*, 7: 25–68.
- Lin, S.H., 1981. Exsiccatae of the bryophytes of Taiwan. *Bryologist*, 84: 359-362.

- Lindenberg, J.B.W., 1840. Species hepaticarum, fasc. 2–4. Henry & Cohen, Bonn, 37–120.
- Linis, V.C., 2014. Biogeographical notes on the moss floras of Bicol Peninsula in Luzon and the Catanduanes Islands, The Philippines. *Philip. J. Sci.*, 142: 119-133.
- Linnaeus, C., 1753. *Species Plantarum*. Ed. 2. Vol. II. Musci. Holmiae.
- Liu, C.M., Zhu, R.L., Liu, R.H., Li, H.L., Shan, L., Xu, X.K. and Zhang, W.D. 2009. cis-Clerodane diterpenoids from the liverwort *Gottschelia schizopleura* and their cytotoxic activity. *Planta medica*, 75(15): 1597-1601.
- Logatoc, Eugene L.R., Annalee S.H., Pastor L., Malabrigo Jr, and William Sm Gruezo., 2019. Notes on Liverwort Specimens from the Philippine Cordilleras in the Botanical Herbarium of the UPLB Museum of Natural History (CAHUP). *Mount. J. Sci. Interdisc. Res.*, 79(2): 7-20.
- Long, D.G. and Grolle, R., 1990. Hepaticae of Bhutan. *J. Hattori Bot. Lab.*, 68: 381-440.
- Long, D.G. and Rubasinghe, S.C., 2014. Liverworts and hornworts of Sri Lanka: a revised checklist. *Cey. J. Sci. Biol. Sci.*, 43(1): 1-36.
- Long, D.G. and Váňa, J., 2007. The genus *Gottschelia* Grolle (Jungermanniopsida, Lophoziaceae) in China, with a description of *G. grollei*, sp. nov. *J. Bryol.*, 29(3): 165-168.
- Long, D.G., 1979: Hepaticae from Bhutan, East Himalaya. *Lindbergia*, 5: 54–62.
- Long, D.G., 1994. Mosses of Bhutan II. A checklist of the mosses of Bhutan. *J. Bryol.*, 18(2): 339-364.
- Long, D.G., 1995. The Musci Indici: its authors, types and localities. *Bot. J. Linn. Soc.*, 119: 1–33.
- Long, D.G., 2005. Notes on Himalayan Hepaticae 2: New records and extensions of range for some Himalayan leaf Liverworts. *Cryptog. Bryol.*, 26(1): 97-107.
- Long, D.G., 2006a. Notes on Himalayan Hepaticae 3: new records and extensions of range for some Himalayan Marchantiales. *Cryptog. Bryol.*, 27: 119-129.
- Long, D.G., 2006b. Revision of the genus *Asterella* P. Beauv. in Eurasia. *Bryophyt. Biblio.*, 63: 1–299.
- Lubos, L.C. 2010. Species richness, distribution, and status of mosses in selected mountains in Mindanao, Philippines. *Asian Journal of Biodiversity*, 1(1): 72-90.

- Madhusoodanan, P.V. and Nair, M.C., 2003. *Ricciocarpos natans* (L.) Corda (Ricciaceae) and *Notothylas levieri* Schiffn. ex Steph.(Notothylaceae), two new bryophyte records for South India. *Indian J. Forest.*, 26(3): 295-298.
- Madhusoodanan, P.V. and Nair, M.C., 2004. Pleurocarpous mosses of Eravikulam National Park, Kerala-1. *J. Econ. Taxo. Bot.*, 28: 338-346.
- Madhusoodanan, P.V., Nair, M.C. and Easa, P.S., 2007. Diversity of Bryophytes in Eravikulam National Park, Kerala (South India). In: (Eds.) Nath, V. & A.K. Asthana *Current Trends in Bryology*, 255-267.
- Mägdefrau, K., 1982. Life-forms of bryophytes. *Bryophyte ecology*, 45-58.
- Magdum S.M., Patil S.M., Lavate R.A. and Dongare, M.M., 2017. Checklist of mosses from the Western Ghats of Maharashtra, India. *Biosci. Disc.*, 8 (1): 73- 81.
- Magill, R.E. and Leistner, O., 1981. Flora of Southern Africa. Bryophyta. Part 1. Mosses. Fascicle 1 Sphagnaceae-Grimmiaceae. Edited by OA Leistner. *Botanical Research Institute, Department of Agriculture and Fisheries.*, 15: 1-291
- Magill, R.E. and van Rooy, J., 1998. Bryophyta, Part 1 Mosses, Fascicle 3, Erpodiaceae-Hookeriaceae. *Flora of Southern Africa. Pretoria: National Botanical Institute*, 445-622.
- Magill, R.E., 1980. Monograph of the genus *Symphysodontella* (Pterobryaceae, Musci). *J. Hattori Bot. Lab.*, 48: 33 - 70.
- Mahabale, T.S., 1958. Taxonomy of liverworts and mosses. *Mem. Indian Bot. Soc.*, 1: 37-42.
- Mahler, W.F., 1978. Preliminary checklist of mosses of New Mexico. *Bryologist*, 593-599.
- Majumdar, S. and Singh, D.K., 2017. First Report of *Anastrophyllum lignicola* (Anastrophyllaceae, Marchantiophyta) from Arunachal Pradesh in Eastern Himalaya of India. *Nat. Acad. Sci. Let.*, 40(6): 439-444.
- Majumdar, S., Dey, M., Singh, D.K. 2012. Additions to Himalayan species of *Radula* Dumort. (Marchantiophyta: Radulaceae) from Arunachal Pradesh, India. *Indian J. Forest.*, 35: 263-268.
- Malcolm, B. and Malcolm, N., 2006. Mosses and other bryophytes. *Micro-Optics Press*.
- Maniselvan, P. and Kumar, S.S., 2000. A report on the moss flora of Udhagamandalam in South India - II (Tamil Nadu). *Res. Bull. Panjab Univ*.

Sci., 49: 29-34.

- Manju C. N., Rajilesh, V.K., Prajitha B. and Prakashkumar R., 2014. Contribution to the Bryophyte flora of India: Silent Valley National Park in the Western Ghats, India. *Acta Biol. Plant. Agr.*, 3: 73-98.
- Manju C.N, Rajesh, K.P., Jitha, S., Reshma, P.K. and Prakashkumar, R. 2011b. Bryophyte diversity of Kakkavayal Reserve Forest in the Western Ghats, Kerala. *Arch. Bryol.*, 108: 1-7.
- Manju C.N., 2013. Current Status and distribution of bryophytes of the Western Ghats, India. *Proceedings of the UGC National Seminar, Western Ghats-Biogeography Biodiversity and Conservation* 50-64.
- Manju C.N., Chandini V.K. and Mufeed B., 2017b. *Physcomitrium immersum* Sull. (Funariales: Bryophyta) an addition to the bryoflora of the Western Ghats. *Geophytology*, 47(1) : 45-47.
- Manju C.N., Leena, T.N., Deepa K.M., Rajesh, K.P. and Prakashkumar, R., 2012. *Lejeunea cocoes* (Lejeuneaceae; Marchantiophyta) in the Western Ghats of India. *Act. Bot. Hung.*, 54: 341-343.
- Manju C.N., Pócs, T., Rajesh, K.P. and Prakashkumar, R., 2012c. Lejeuneaceae (Marchantiophyta) of the Western Ghats, India. *Acta Biol. Plant. Agr.*, 2: 127-147.
- Manju C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2011. *Chiloscyphus chinnarensis* (Lophocoleaceae, Hepaticae): A new species from the Western Ghats of India. *Acta Bot. Hung.*, 53: 151-157.
- Manju C.N., Rajilesh, V.K., Prajitha B. and Prakashkumar, R., 2014. Contribution to the Bryophyte flora of India: Silent Valley National Park in the Western Ghats, India. *Acta Biol. Plant. Agr.*, 3: 73-98.
- Manju, C. and Rajesh, K., 2009. Bryophyte diversity in the high altitude grasslands of the Western Ghats, India. *Act. Bot. Hung.*, 51(3-4): 329-335.
- Manju, C. N. and Rajesh, K.P., 2012. *Symphysodontella madhusoodananii* sp. nov. (Pterobryaceae; Moss) from the Western Ghats of India. *Phytokeys*, 18: 39–44.
- Manju, C. N., Pócs, T., Rajesh, K. P. and Prakashkumar, R., 2012. Lejeuneaceae (Marchantiophyta) of the Western Ghats, India. *Acta Biol. Plant. Agr.*, 2: 127–147.
- Manju, C.N. and Rajesh, K.P., 2009. *Notoscyphus pandei* Udar & Kumar (Marchantiophyta, Hepaticae) from the Western Ghats of Kerala State, India. *J. Econ. Tax. Bot.*, 33(2): 342-344.

- Manju, C.N. and Rajesh, K.P., 2010. *Leptohymenium* Schwaegr. (Hylocomiaceae: Bryopsida): a new generic record for Western Ghats, peninsular India. *J. Econ. Tax. Bot.*, 34(2): 391-393.
- Manju, C.N. and Rajesh, K.P., 2011. Contribution to the Bryophyte flora of India: the Parambikulam Tiger Reserve in the Western Ghats. *Arch. Bryol.*, 42: 1-10.
- Manju, C.N. and Rajesh, K.P., 2012. Present status of bryophyte diversity in Kerala. *Samagra*, 8: 20-27.
- Manju, C.N. and Rajesh, K.P., 2014. Systematic studies on the mosses of Southern Western Ghats in Kerala, India. In: *Perspectives on Biodiversity of India*. (Eds.) Kumar, B., Rajendran P.N., and Peethambaran C.K., Centre for Innovation in Science and Social Action (CISSA), Thiruvananthapuram, 337-346.
- Manju, C.N. and Rajesh, K.P., 2017. *Bryophytes of Kerala, Liverworts Vol.1*, Malabar Natural History Society & Centre for Research in Indigenous Knowledge Science & Culture.
- Manju, C.N. Rajilesh V.K., Deepa K.M., and Prakashkumar, R., 2015a. The Genus *Calycularia* (Marchantiophyta) in Kerala part of Western Ghats. *Act. Bot. Hung.*, 57(3-4): 401-406.
- Manju, C.N., Aswathy, T., Pournami, K.V. and Rajesh, K.P., 2017. *Amblystegium serpens* (Hedw.) Schimp. (Amblystegiaceae: Bryophyta) from Indian Peninsula. *Asian J. Biol. Life Sci.*, 6: 412-413.
- Manju, C.N., Chandini V.K. and Rajesh, K.P., 2020. An overview of the family Calymperaceae (Bryophyta) in Western Ghats with special reference to Kerala and its status in India. In: Alam, A (Edt.) *Recent Advances in Botanical Science*, Contemporary Research on Bryophytes, Bentham Science & Publishers Pte. Ltd, Singapore; Vol. 1: 52-80. (ISSN: 978-981-143376-4)
- Manju, C.N., Chandini, V.K. and Rajesh, K.P., 2017a. *Cololejeunea manilalia* (Lejeuneaceae: Marchantiophyta), a new species from the Western Ghats of India. *Act. Bot. Hung.*, 59(1-2): 261-268.
- Manju, C.N., Chandini, V.K. and Rajesh, K.P., 2019. *Micromitrium vazhanicum* (Micromitriaceae; Bryophyta) a new species from the Western Ghats of India. *Bryologist*, 122(2): 297-306.
- Manju, C.N., Chandini, V.K., Rajesh, K.P. and Sabarish, S., 2019. Rediscovery of *Oreoweisia brevidens* Herzog (Dicranaceae; Bryophyta) an Indian endemic

- species from Western Ghats reported after 75 years. *Lindbergia*, 42: 1-4.
- Manju, C.N., Manjula K.M., Deepa K.M., Rajesh, K.P. and Chandini V.K., 2015b. *Aulacopilum beccarii* (Erpodiaceae: Bryophyta) from the Western Ghats of Kerala. *Geophytology*, 45(1): 62-65.
- Manju, C.N., Martin, K.P., Sreekumar, V.B. and Rajesh, K.P. 2012a. Morphological and molecular differentiation of *Aerobryopsis eravikulamensis* sp. nov. (Metoriaceae: Bryophyta) and closely related taxa of the Western Ghats of India. *Bryologist*, 115(1): 42-50.
- Manju, C.N., Nikesh, P.R. and Rajesh, K.P., 2011a. *Exormotheca tuberifera* (Marchantiophyta, Exormothecaceae) from the Western Ghats of Kerala, India. *Taiwania*, 56(4): 330-332.
- Manju, C.N., Prajitha, B. Prakashkumar, R. and Ma, W.Z., 2020 (in press) *Bryocrumia malabarica* sp. nov. (Bryophyta; Hypnaceae) a second species of the genus from the Western Ghats of India. *Act. Bot. Hung.*, (Accepted on 03.08.2020)
- Manju, C.N., Prajitha, B. Rajilesh, V.K., Anoop, K.P. and Prakashkumar, R., 2012b. *Trichosteleum stigmatosum* (Sematophyllaceae) from Silent Valley National Park, a new record for India. *Taiwania*, 57: 222-224.
- Manju, C.N., Rajesh, K.P. and Prakashkumar, R., 2012a. Life forms of Bryophytes in the Western Ghats, India. Pp. 1-10. In : Nagarajan, B., Kunhikannan, C., Sasidharan, K. R. and Krishnakumar, N. (eds.) *Tropical Ecosystems: Structure, Function and Services*. Institute of Forest Genetics and Tree Breeding, Coimbatore.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V. 2009d. *Lindbergia* Kindb. (Leskeaceae: Bryopsida)- a new genus record for Peninsular India. *Indian J Forest.*, 32(2): 295-296.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2008. Checklist of Bryophytes of Kerala, India. *Trop. Bryol. Res. Rep.*, 7: 1-24.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2008. Ecological observations on the Bryophytes of Eravikulam National Park, South India. *Geophytology*, 37: 51-53.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2009. Contribution to the bryophyte flora of India: Agasthyamalai Biosphere Reserve in Western Ghats. *Taiwania*, 54(1): 57-68.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2009a. Contribution to the Bryophyte flora of India. The Aralam Wildlife sanctuary in the Western

- Ghats. *Arch. Bryol.*, 42: 1-12.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2009b. *Jungermannia obliquifolia* (Schiffn.) Vana (Marchantiophyta, Hepaticae) from India. *Bangladesh J. Pl. Taxon.*, 16(1): 95-97.
- Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V., 2009e. *Groutiella tomentosa* (Hornsch.) Wijk & Margad. (Orthotrichaceae; Bryopsida), a new record from Peninsular India *Indian J. Forest.*, 32(3): 471-472.
- Manju, C.N., Rajesh, K.P. and R. Prakashkumar, R., 2012b. On the identity of *Riccia fluitans* (Ricciaceae: Marchantiophyta) in India. *Acta Biol. Plant. Agr.*, 2: 117-121.
- Manjula K.M. and Manju C.N., 2016. Genus *Fissidens* Hedw. (Fissidentaceae; Bryophyta) from Eastern Ghats of Andhra Pradesh, India. In: *Cryptogam Biodiversity and Assessment*, 1(2): 1-19.
- Manjula K.M. and Manju C.N., 2020. An account of Section *Crispidium* of *Fissidens* Subgen. *Pachyissidens* in Western Ghats of India with description of a new variety and an extension range. *Taiwania*, 65(3): 295–314.
- Manjula K.M., Manju C.N. and Rajesh K.P., 2017. *Fissidens manilalia* sp. nov. (Fissidentaceae), a new corticolous species from a semi-urban habitat in India. *Bryologist*, 120(3): 263-269.
- Manjula K.M., Manju, C.N. and Rajesh, K.P., 2015a. *Fissidens macrosporus* Dixon (Fissidentaceae: Bryophyta) – a little known species of the Western Ghats rediscovered after more than 90 years. *Lindbergia*, 38: 1-3.
- Manjula, K.M. and Manju C.N., 2018. Diversity of the genus *Fissidens* Hedw. (Fissidentaceae; Bryophyta) in Kerala, In: *Perspectives on Biodiversity of India Vol. III*. (eds. P.N. Krishnan, et al., CISSA) IVth Indian Biodiversity Congress -2017. 78-84.
- Manjula, K.M., Manju, C.N., Rajilesh V.K. and Chandini V.K., 2015b. *Fissidens linearis* (Fissidentaceae: Bryophyta) a new record for India. *Acta Bot. Hung.*, 57(1-2):1-4.
- Manjula, K.M., Vidya, V. and Manju, C.N., 2013b. The genus *Bazzania* (Marchantiophyta) in Kerala. *Samagra*, 9: 23-27.
- Manjula, K.M., Vidya, V., Manju, C.N. and Prakashkumar, R., 2013a. Systematic studies on the family Geocalycaceae (Marchantiophyta) of Kerala, India. *Arch. Bryol.*, 176: 1-21.
- Manuel, M.G., 1977. Monograph of the genus *Meteoriopsis* (Bryopsida: Meteoriaceae). *Bryologist*, 80(4): 584-599.

- Marline, L., Ah-Peng, C. and Hedderson, T.A., 2020. Epiphytic bryophyte diversity and range distributions along an elevational gradient in Marojejy, Madagascar. *Biotropica*. 2020;00:1–11. DOI: 10.1111/btp.12781
- Marline, L., Andriamiarisoa, R.L., Bardat, J., Chuah-Petiot, M., Hedderson, T.A., Reeb, C., Strasberg, D., Wilding, N. and Ah-Peng, C., 2012. Checklist of the bryophytes of Madagascar. *Cryptog. Bryol.*, 33(3): 199-255.
- Maryani, A.A., Anuar, M. and Suleiman, M., 2015. Mosses of Sinua at eastern part of Trusmadi Forest Reserve, Sabah, Malaysia. *Sep. Bull.*, 21&22: 27-48.
- Mathew, G. Mohandas, K. and Brijesh, C., 2001. Insect fauna of the Sholas of Idukki and Wayanad Districts. In shola forest of Kerala, *Environment and Biodiversity, KFRI. Trissur* 1-317.
- Matthew, K.M., 1973. Location of the type materials of some south Indian mosses. *Revue Bryol. Lichénol.*, 39: 517-528.
- McCarthy, P.M., 2006. *Checklist of Australian Liverworts and Hornworts*. Australian Biological Resources Study, Canberra. Version 6 April 2006.
- Mehta, D.N., Gujar, R.V. and Shah, D.G., 2016. Status of family Fissidentaceae in Gujarat. In: *Cryptogam Biodiversity and Assessment*, 1(1): 84-91.
- Meijer, W., 1960. Notes on the species of *Bazzania* (Hepaticae). *Blumea*, 10(2): 368.
- Menon, G. and Dabhade, G.T., 2017. Leafy hepatics from some regions of Western Ghats (Maharashtra). *Res. Pl. Biol.*, 7: 5-12.
- Menzel, M., 1988. The bryophytes of Sabah (North Borneo) with special reference to the BRYOTROP transect of Mount Kinabalu. I. The study area and its bryological exploration. *Willdenowia*, 18: 281-300.
- Menzel, M., 1992. The bryophytes of Sabah (North Borneo) with special reference to the Bryotrop transect of Mount Kinabalu. XVII. Meteoriaceae (Leucodontales, Bryopsida). *Willdenowia*, 22: 171-196.
- Miller, H.A., 1954. Field observations on associations of Hawaiian mosses. *Bryologist*, 57(2): 167-172.
- Miller, H.A., 1960. A preliminary list of Micronesian Bryophytes. *Bryologist*, 63: 116-125.
- Mishra, M., Dash, P.K., Alam, A., Sahoo, S. and Das, R., 2016. Current status of diversity and distribution of bryophytes of Odisha. *Pl. Sci. Today*, 3(2): 186-194.
- Mitten, W. and Wilson, W., 1857. Enumeration of the mosses collected in India by Dr. J.D. Hooker, F.R.S. and Dr. Thomas Thomson, F.R.S. Hooker's *J. Bot.*

- Kew Gard. Misc.*, 9: 289-300, 321-323, 363-370.
- Mitten, W., 1861. Hepaticae Indiae Orientalis, an enumeration of the Hepaticae of East Indies. *J. Proc. Linn. Soc. Bot.*, 5: 89-128.
- Mitten, W., 1868. A list of the Musci collected by the Rev. Thomas Powell in the Samoa or Navigator's Islands. *J. Linn. Soc., (Bot.)* 10: 166-195.
- Mitten, W., 1873. New species of Musci collected in Ceylon by Dr. Thwaites. *J. Proc. Linn. Soc. Bot.*, 13: 293-326.
- Mizutani, M., 1963. On some Indian species of the family Lejeuneaceae described by W. Mitten. *J. Hattori Bot. Lab.*, 26: 171-184.
- Mizutani, M., 1971. Lejeunea from the Himalyan region. *J. Hattori Bot. Lab.*, 34: 445- 457.
- Mizutani, M., 1975. Epiphyllous species of Lejeuneaceae from the Philippines. *J. Hattori Bot. Lab.*, 39: 255–262.
- Mizutani, M., 1978. Lejeuneaceae from Ishigaki and Iriomote Islands of Ryukyu Archipelago. *J. Hattori Bot. Lab.*, 44: 121–136.
- Mizutani, M., 1986. Lejeuneaceae from Seram Island, Indonesia. *J. Hattori Bot. Lab.*, 61: 299–308.
- Mizutani, M., 1990. Notes on the Lejeuneaceae. 16. *Drepanolejeunea thwaitesiana* and its related species from Asia. *J. Hattori Bot. Lab.*, 68: 367–380.
- Mizutani, M., 2000. Polymorphism of *Bazzania tridens* in Japan. *Bryol. Res.*, 7: 323-327.
- Mohamed, H. and Damanhuri, A., 1990. *Bryum tuberosum*, a new species from Peninsular Malaysia. *Bryologist*, 93(3): 288-289.
- Mohamed, H. and Robinson, H.E., 1991. A taxonomic revision of the moss families Hookeriaceae and Hypopterygiaceae in Malaya. Smithsonian contributions to botany.
- Mohamed, H. and Tan, B.C., 1988. A checklist of mosses of Peninsular Malaya and Singapore. *Bryologist*, 91: 24-44.
- Mohamed, H., Thai, J.K. and Bakar, B., 2003. Mosses of Gunung Serapi, Sarawak, Borneo. *Tropical Bryology*, 139-146.
- Mohamed, M.A. Haji, 1979. A taxonomic study of *Bryum billardieri* Schwaegr. and related species. *J. Bryol.*, 10(4): 401-465.
- Mohamed, M.A. Haji, 1984. A synopsis of the genus *Rhodobryum* *J. Hattori Bot. Lab.*, 55: 281-293.

- Mohamed, M.A. Haji, and Robinson, H.E., 1991. *A taxonomic revision of the moss families Hookeriaceae and Hypopterygiaceae in Malaya*. Smithsonian contributions to botany.
- Mohamed, M.A.H., Biradar, N.V. and Vaidya, J.G., 1986. A contribution to the moss flora of North Western Ghats, India. *J. Bombay Nat. Hist. Soc.*, 83(3): 689-691.
- Mohamed, M.A. Haji, 1984. A synopsis of the genus *Rhodobryum* in Asia. *J. Hattori Bot. Lab.*, 55: 281-293.
- Montagne, C., 1842. Cryptogamae Nilgherienses seu plantarum cellularium in montibus peninsulae indicae Neel-Gherries dictis a Cl. Perrottet collectarum enumeratio. *Musci. Ann. des Sci. Natur. Bot. Ser.*, 2(17): 243-256.
- Morris, J.L., Puttick, M.N., Clark, J.W., Edwards, D., Kenrick, P., Pressel, S., Wellman, C.H., Yang, Z., Schneider, H. and Donoghue, P.C., 2018. The timescale of early land plant evolution. *Proc. Nat. Acad. Sci.*, 115(10): E2274-E2283.
- Moya, D.C. and Soriano, Á. C., 2011. Bryophyta (Musci) Divers. Florist. *Oaxaca*, 137-148: 65-66.
- Moya, D.C., Soriano, A. M. C., Aguilar, V. M. G. and Sánchez-González, A., 2011. Musgos del Parque Nacional Los Mármoles, Hidalgo, México. *Boletín de la Sociedad Botánica de México*, 89: 19-26.
- Mufeed B., V.K. Chandini, Manju C.N. and Rajesh K.P., 2018. *Colura calyptrifolia* (Lejeuneaceae: Marchantiophyta) a rare leafy liverwort from the Western Ghats of India. *Nelumbo*, 60(2): 147-152.
- Mufeed, B and Manju C.N., 2018. New distribution record of a rare taxa *Gottschelia schizopleura* (Spruce) Grolle, of Jungermanniales occurring in Anamudi Shola National Park in the Western Ghats of Kerala. *Pl. Sci. Today*, 5(1): 29-31.
- Mufeed, B. and Manju C.N., 2017. *Porella perrottetiana* (Mont.) Trevis. (Jungermanniales) a species from Western Ghats of Kerala. *Act. Bot. Hung.*, 59(1-2): 269-272.
- Mufeed, B. Deepa, K.M., Haripriya, P. and Manju C.N., 2014. Moss (Bryophyta) diversity of Thusharagiri hills, Kerala, India. *Frahmia*, 6: 1-9.
- Müller, C., 1853. Musci Neilgherienses I. *Bot. Zeit. Regensburg*, 11: 17-21, 33-40, 57-62.
- Müller, C., 1854a. Musci Neilgherienses II. *Bot. Zeit. Regensburg*, 556-559, 569-574.

- Müller, C., 1854b. *Hypnum pseudostramineum*. *Bot. Zeit. Regensburg*, 12: 500-503.
- Müller, C., 1859. Supplementum novum ad Synopsin Muscorum. *Bot. Zeitung, (Berlin)* 17: 197-248.
- Müller, C., 1869-1870. De Muscorum Ceylonensium collectione. *Linnaea*, 36: 1-40.
- Müller, C., 1871. Musci Indici Novi . *Linnaea*, 37: 163-182.
- Müller, C., 1878. *Decas Muscorum Indicon novor Flora*.
- Müller, F. and Pursell, R.A. 2003. The genus *Fissidens* (Musci, Fissidentaceae) in Chile. *J. Hattori Bot. Lab.* 93: 117-139.
- Nair M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2005. Little known *Plagiochila* (Dum.) Dum. (Plagiochilaceae: Hepaticae) from India. *Geophytology*, 35: 39-44.
- Nair, M.C. and Madhusoodanan, P.V. 2004. Bryophyte diversity of Kerala - A Bird's eye view account. Proc. Sixteenth Kerala Science Congress. 29-31 January.
- Nair, M.C. and Madhusoodanan, P.V., 2001. Contribution to the bryophyte flora of Eravikulam National Park, Kerala. *J. Econ. Tax. Bot.*, 25: 569-574.
- Nair, M.C. and Madhusoodanan, P.V., 2006. A preliminary survey of the bryophyte flora of Vellarimala in Western Ghats of Kerala. *Indian J. For.*, 29(2): 191-196.
- Nair, M.C., K.P. Rajesh and Madhusoodanan P.V., 2005. *Bryophytes of Wayanad in Western Ghats*. Malabar Natural History Society, Kozhikode, i-iv + 284.
- Nair, M.C., K.P. Rajesh and Madhusoodanan, P.V., 2004. *Bryum tuberosum* Mohamed & Damanhuri, a new record for India. *Indian J. Forest.*, 27: 39-40.
- Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2006a. Bryophytes of Chinnar Wildlife Sanctuary (South India)-A preliminary account. *Geophytology*, 36(1&2): 7-15.
- Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2006b. *Lejeunea exilis* (Lejeuneaceae: Hepaticae): a new record to India. *Acta Bot. Hung.*, 48 (1-2): 85-87.
- Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2007a. Three new bryophyte records for Peninsular India. *Indian J. Forest.*, 30: 349-352.
- Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2007b. The genus *Philonotis* Brid. (Bartramiaceae: Bryopsida) in Peninsular India. *Folia Malaysiana*, 18(1): 21-32; (corrigendum) 8(2): 137-140.
- Nameer, P., 2001. Richness of avifauna in the Sholas of Munnar, Idukki

- District. *Shola Forests of Kerala: Environment and Biodiversity*, 1-365.
- Narayan, B., Karunakaran, P.V. and Singh, D.K., 2001. Contribution to the Bryoflora of Great Himalayan National Park, Kullu, Himachal Pradesh-I. *Indian J. Forest.*, 24: 265-278.
- Nath, V. and Nivedan, A., 2007. Studies on the variability of *Plagiochasma appendiculatum* L. et al. in India -I. *J. Econ. Tax. Bot.*, 31: 189-198.
- Nath, V. and Asthana, A.K., 1998. Diversity and distribution of genus *Frullania Raddi* in South India. *J. Hattori Bot. Lab.*, 85: 63-82.
- Nath, V. and Gupta, R., 2009. Taxonomic Assessment of Family Bryaceae (Bryopsida) of Pachmarhi Biosphere Reserve (Madhya Pradesh), India. *Nelumbo*, 51: 161-174.
- Nath, V., Asthana, A.K. and Gupta, R., 2011. An overview of family Pottiaceae (Bryopsida) in central India with special reference to Pachmarhi Biosphere Reserve (PBR). *Lindbergia*, 34: 30-39
- Nath, V., Asthana, A.K. and Kapoor, R., 2007. Enumeration of the Mosses in Amarkantak (Madhya Pradesh), India-I. *Taiwania*, 52(2): 168-176.
- Nath, V., Asthana, A.K. and Singh, A.P., 2000. Role of bryophytes in soil management and rock binding. *Geophytology*, 2: 95-100.
- Nath, V., Pande, N., Asthana, A.K. and Gupta, R., 2012. Epiphytic moss flora of Pachmarhi Biosphere Reserve (MP): An important aspect of Bryophyte diversity. *Nat. Acad. Sci. Let.*, 35(3): 195-200.
- National Wildlife Database, May 2019, Wildlife Institute of India
- Nayaka, S., Upreti, D.K. and Divakar, P.K., 2001. Distribution and diversity of lichens in Meghamalai Wildlife Sanctuary, Kambam District, Tamil Nadu, India. *Biol. Mem.*, 27(1): 1-51.
- Negi, H.R. and Gadgil, M., 1996. Patterns of distribution of macrolichens in western parts of Nanda Devi Biosphere Reserve. *Curr. Sci.*, 71(7): 568-575.
- Negi, H.R. and Gadgil, M., 1997. Species diversity and community ecology of mosses: A case study from Garwal Himalaya. *Int. J. Ecol. Environ. Sci.*, 23: 445-462.
- Negi, H.R. and Gadgil, M., 2001. Ecological niche of certain terricolous liverworts from selected localities of Garhwal Himalayas: A preliminary study. In: *Perspectives in Indian Bryology*. Bishen Singh Mahendra Pal Singh, Dehradun, 23-33.
- Negi, H.R. and Upreti, D.K., 2000. Species diversity and relative abundance of

- lichens in Rumbak catchment of Hemis National Park in Ladakh. *Curr. Sci.*, 1105-1112.
- Negi, H.R., 2000a. Species richness and turnover of moss communities in western parts of Nanda Devi Biosphere Reserve. *Int. J. Ecol. Environ. Sci.*, 26: 11-26.
- Negi, H.R., 2000b. On the patterns of abundance and diversity of macrolichens of Chopta-Tunganath in the Garhwal Himalaya. *J. Biosci.*, 25(4): 367-378.
- Negi, K., Tewari, S.D. and Chaturvedi, P., 2018. Antibacterial activity of *Marchantia papillata* Raddi subsp. *grossibarba* (steph.) Bischl. against *Staphylococcus aureus*. *Indian J. Tradit. Knowle.*, 17 (4): 763 - 769.
- Nicolson, D.H., C.R. Suresh and K.S. Manilal. 1988. *An interpretation of Rheed's Hortus Malabaricus*. Koeltz, Scientific Book, FRG.
- Ning-Ning, Y., Yu, J. and Jian-Cheng, Z., 2011. Synonymy and typifications in *Groutiella tomentosa* (Orthotrichaceae, Bryopsida). *Novon: J. Bot. Nomen.*, 21(2): 290-293.
- Ninh, T., 1993. Mosses of the Tam Dao mountains, Vietnam. *Bryologist*, 96(4): 573-581.
- Noguchi, A. and Iwatzuki, Z., 1989. Illustrated moss flora of Japan, *Hattori Bot. Lab.*, 3: 492-742.
- Noguchi, A., 1957. Mosses of South India (from Kodaikanal, Coonoor, Ootacamund). *Bot. Inst. Fac. Sci. Kumamoto Univ.*, 27.
- Noguchi, A., 1958. A small collection of Mosses from Southern India. Kumamoto. *J. Sci. Ser. B. Sec.*, 4: 1-4.
- Noguchi, A., 1963. A Collection of Mosses from the Philippines. Faculty of Science, Tohoku University.
- Noguchi, A., 1964. A list of mosses from Kashmir and Pakistan. *Candollea*, 19: 191-198.
- Noguchi, A., 1972. Mosses of Thailand. *Lindbergia*, 1: 169-183.
- Noguchi, A., 1973. Mosses of Ceylon collected by Dr. Hiroshi Inoue. *Bull. Nat. Sci. Musc.*, 16(2): 305-316.
- Noguchi, A., 1976. A taxonomic revision of the family Meteoriaceae of Asia. *J. Hattori Bot. Lab.*, 41: 231-357.
- Noguchi, A., 1991. Illustrated moss flora of Japan, *Hattori Bot. Lab.*, Nichinan., 4: 743-1012.
- Noguchi, A., 1994. Illustrated moss flora of Japan, *Hattori Bot. Lab.* 5: 1013- 1253.

- Norio T., 1962. Attributive plant geography of *Anomobryum fuji-alpinum* TAK. *Pla. Clas. Geo*, 20(1): 234-237.
- Norris, D.H. and Koponen, T., 1989. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXVIII. Pottiaceae (Musci). *Acta Bot. Fenn.*, 137: 81-138.
- Norris, D.H. and Koponen, T., 1990. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXXIII. Leskeaceae and Fabroniaceae (Musci) plus corrigenda and addenda to previous papers. In *Annales botanici fennici*, 1-12.
- Norris, D.H. and Shevock, J.R., 2004. Contributions toward a bryoflora of California: I. A specimen-based catalogue of mosses. *Madroño*, 1-131.
- Ochyra, R., Sollman, P. and Lebouvier, M., 2015. *Hymenostylium recurvirostrum* (Pottiaceae), a moss genus and species newly discovered in the southern polar regions. *Herzogia*, 28(2): 599-606.
- Omar, I., Nair M.C., Asthana, A.K., and Asthana, G., 2020. *Orthomnion javense* (Mniaceae, Bryophyta), new to India and Nepal. *Phytotaxa*, 432(2): 283-288.
- Orgaz, J.D., Cano, M.J. and Guerra, J., 2012. A taxonomic study of genus *Brachythecium* Schimp.(Brachytheciaceae, Bryophyta) in the Mediterranean region. *Nova Hedwig.*, 95(3-4): 295-318.
- O'Shea, B.J., 1998. Notes on Seychelles mosses. 3-4. A revision of *Papillidiopsis* (Broth.) Buck & Tan, *Rhaphidostichum* Fleisch. and *Warburgiella* Müll. Hal. ex Broth.(Sematophyllaceae, Bryopsida) in Africa. *Trop. Bryol.*, 15: 75-88.
- O'Shea, B.J., 2002. Checklist of the mosses of Sri Lanka. *J. Hattori Bot. Lab.*, 92: 125-164.
- O'Shea, B.J., 2003. An overview of the mosses of Bangladesh, with a revised checklist. *J. Hattori Bot. Lab.*, 93: 259-272.
- O'Shea, B.J., 2006. Checklist of the mosses of sub-Saharan Africa. 5. *Trop. Bryol. Res. Rep.*, 6: 1-252
- Ozdemir, T. and Batan, N., 2017. Bryophyte checklist of Giresun, North east Turkey. *Anatolian Bryol.*, 3(1): 1-8.
- Palani, R., Sathish, S.S., Thamizharasi, T. and Vijayakanth, P., 2017. Checklist of Mosses (Bryophyta) of Bodamalai Hills in Eastern Ghats, Tamil Nadu. *Pl. Sci. Today*, 4(1): 49-54.
- Pande S. K. and Ahmad S., 1944. Liverworts of Lucknow and its neighbourhood. *Proc. Indian. Sci. Congr.*, 31(3): 80.
- Pande, N. and Singh, J.S., 1989. Bryophyte biomass of dominant species and net production of different communities in various habitats of the Nainital hills,

- NW Himalaya. *Lindbergia*, 14(3): 155-161.
- Pandé, S. K., Srivastava, K. P. and Ahmad, S. 1957. Epiphyllous liverworts of India and Ceylon II. *J. Indian Bot. Soc.*, 36: 335–347.
- Pande, S.K. and Bhardwaj, D.C., 1952. The present position of Indian Hepaticology with a note on the Hepatic Vegetation of the country. *The Palaeobotanist*, 368-381.
- Pande, S.K. and Kashyap, S.R., 1922. A contribution to the life history of *Aneura indica* St. *J. Indian Bot. Soc.*, 3: 78-89.
- Pande, S.K. and Singh, V.B., 1959. On *Jamesoniella microphylla* (Nees) Schiff. new to Indian flora. *Bull. Bot. Soc. Univ. Sagar*, 2: 1-2.
- Pande, S.K. and Srivastava, K.P., 1952. The hepatic vegetation of Pachmarhi (Madhya Pradesh): A preliminary survey. *J. Indian Bot. Soc.*, 31: 342-351.
- Pande, S.K., 1936. Studies in Indian liverworts: A review. *J. Indian Bot. Soc.*, 15: 221-233.
- Pant, G. and Tewari, S.D., 1984. *Distichophyllum schmidtii* Broth, and *Thamnobryum latifolium* (Bosch, and Lac.) Nieuwl. New records for India. *Ind. J. Forest.*, 7(2):159-160.
- Papp, B., 2008. Contributions to the bryophyte flora of the Mt. Taebaek, South Korea. *Stud. Bot. Hung.*, 39: 89-100.
- Papp, B., Pantović, J. and Sabovljević, M.S., 2019. Additions to the bryophyte flora of the Republic of Northern Macedonia. *Cryptog Bryol.*, 40(15): 159-166.
- Parihar, N.S., 1965. An introduction to embryophyta: bryophyta (Vol. 1). Central Book Depot.
- Parihar, N.S., Lai, B. and Katiyar, N., 1994. *Hepatics and Anthocerotes of India-A New Annotated Checklist*. Central Book Depot, Allahabad, 106.
- Paton J.A., 1999. The liverwort flora of the British Isles. Colchester, 626.
- Pedersen N., 2005. Validation of *Imbriobryum* (Bryaceae). *Bryologist*, 108: 449.
- Pedersen, N. and Hedenäs, L., 2005. Taxonomic and nomenclatural implications of phylogenetic studies of the Bryaceae based on molecular data and morphology. *Bryologist*, 108: 123–128.
- Peng, T. and Zhu, R.L., 2013. A revision of the genus *Anthoceros* (Anthocerotaceae, Anthocerotophyta) in China. *Phytotaxa*, 100(1): 21-35.
- Perold, S.M., 2001. Studies in the liverwort family Aneuraceae (Metzgeriales) from southern Africa. 1. The genus *Aneura* and its local

- representative. *Bothalia*, 31(2): 167-173.
- Pfeiffer, T., Kruijer, J.D., Frey, W. and Stech, M., 2000. Systematics of the *Hypopterygium tamarisci* complex (Hypopterygiaceae, Bryopsida): implications of molecular and morphological data. Studies in austral temperate rain forest bryophytes 9, *J. Hattori Bot. Lab.*, 89: 55–70.
- Phatak, S., Vijayan, M.N. and Samuel, C., 2007. Biodiversity and distribution of Bryophytes of Goa- A preliminary study. In *Current trends in Bryology*, (eds.) Nath, V. and A.K. Asthana, Bishen Singh Mahendra Pal Singh, 149-160.
- Phephu, N. and van Rooy, J., 2014. Studies in the liverwort family Metzgeriaceae (Metzgeriales) from southern Africa. 2. The African species. *Telopea*, 17: 311-318.
- Phephu, N., 2013. *A taxonomic revision of Thuidiaceae (Bryophyta) in Africa and the East African islands* (Doctoral dissertation, University of Pretoria).
- Piippo, S., 1988. The bryophyte flora of the Huon Peninsula, Papua New Guinea. XXII. Targioniaceae, Weisnerellaceae, Aytoniaceae, and Ricciaceae (Marchantiales, Hepaticae). *Ann. Bot. Fennici*, 25 : 97-107.
- Piippo, S., 1990. Annotated catalogue of Chinese hepaticae and anthocerotae. *J. Hattori Bot. Lab.*, 68: 1-192.
- Piippo, S., 1991. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XLIX. *Targionia* (Targioniaceae, Hepaticae). *Ann. Bot. Fennici*, 28: 273-276.
- Piippo, S., He, X. and Koponen, T., 1997. Hepatics from North Western Sichuan, China, with a check list of Sichuan Hepatics. *Ann. Bot. Fennici*, 34(1): 51-63.
- Piippo, S., He, X., Juslen, A., Tan, B.C., Murphy, D.H. and Pocs, T., 2002. Hepatic and Hornwort flora of Singapore. *Ann. Bot. Fennici*, 39: 101-127.
- Pinokiyo, A., Singh, K.P. and Singh, J.S., 2008. Diversity and distribution of lichens in relation to altitude within a protected biodiversity hot spot, north-east India. *The Lichenologist*, 40(1): 47-62.
- Pócs, T. and Eggers, J., 2007. Bryophytes from the Fiji Islands, II. An account of the genus *Colura*, with a description of *C. vitiensis* sp. nov. *Polish Bot. J.*, 52: 81–92.
- Pócs, T. and Ninh, T., 2012. New or little known epiphyllous liverworts, XVII. Records from the Cát Tiên National Park, Southern Vietnam. *Acta Biol. Plant. Agr.*, 2: 11-19.

- Pócs, T., 1965. Prodrome de la bryoflore du Vietnam. *Acta Acad. Paed. Agriensis*, 3: 453-495.
- Pócs, T., 1982. Tropical forest bryophytes. In: *Bryophyte ecology*, 59-104.
- Pócs, T., 2013. The genus *Colura* (Lejeuneaceae) in New Guinea and in the neighboring areas. *Chenia*, 11: 12–38.
- Pócs, T., Mizutani, M. and Piippo, S., 1994. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXV. Preliminary contributions on Lejeuneaceae (Hepaticae) 1. *Ann. Bot. Fenn.*, 31: 179–190.
- Pócs, T., Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V., 2007. Liverwort (Marchantiopsida) records from the Western Ghats (Kerala State, Peninsular India). *Acta Bot. Hung.*, 49: 121-129.
- Pócs, T., Sass-Gyarmati, A., Naikatini, A., Tiuwawa, M., Braggins, J., Pócs, S. and von Konrat, M., 2011. New liverwort (Marchantiophyta) records for the Fiji Islands. *Telopea*, 13: 455–494.
- Pócs, T., Tram, N.K.T., He, Q., Katagiri, T. and Luong, T.T., 2019. New records for the liverwort and hornwort flora of Vietnam, 1. *Acta Bot. Hung.*, 61(3-4): 397-413.
- Pollawatn, R., 2008. *Systematic treatment of Sematophyllaceae (Musci) in Thailand* (Doctoral dissertation, Universität Bonn).
- Porley R.D., 1997. British Bryological Society Expedition to Mulanje Mountain, Malawi. 8. Lejeuneaceae: *Colura* (Hepaticae). *J. Bryol.*, 19: 799-803.
- Porley, R.D. and Ellis, R.W., 2002. *Timmia megapolitana* Hedw. (Bryopsida, Timmiales) new to the British Isles. *J. Bryol.*, 24(2): 151-156.
- Potemkin A.D., Borovichev E.A. and Ginzburg E.G., 2017. *Calypogeia azurea* (Calypogeiaceae, Marchantiophyta) in the Northwestern European Russia. *Nov. Sist. Nizsh. Rast.*, 51: 263–273.
- Potemkin, A.D., 2018. *Calypogeia fissa* (Calypogeiaceae, Marchantiophyta) in the North Western European Russia. *News of Systematics of lower plants*, 52(1): 173-181.
- Potemkin, A.D., Borovichev, E.A. and Ginzburg, E.G., 2017. *Calypogeia azurea* (Calypogeiaceae, Marchantiophyta) in the Northwestern European Russia. *Novosti Sist. Nizsh. Rast.*, 51: 263–273.
- Potier de la Varde, R.P., 1925. *Mousses recueillies dans le Haut Oubangui par M. le Testu*.
- Pradhan, N. and Joshi, S.D., 2008. A diversity account of Bryaceae (Bryophyta):

- Musci) of Nepal. *J. Nat. Hist. Mus.*, 23: 19-26.
- Pradhan, N. and Joshi, S.D., 2009. Liverworts and Hornworts of Nepal : *a synopsis*. *Botanica Orientalis*, 6: 69-75.
- Pradhan, N., 2013. Diversity and status of bryophytes in Panch Pokhari region of the northern Sindhupalchok district of central Nepal. *J. Nat. Hist. Mus.*, 27: 45-58.
- Prajitha, B., C.N. Manju and Prakashkumar, R., 2013. *Aerobryopsis wallichii* (Moss; Bryophyta) a new record for India. *Geophytology*, 42(2): 147-149.
- Prajitha, B., Manju, C.N and Prakashkumar, R., 2017. New record of two mosses from Malabar Wildlife Sanctuary in the Western Ghats of India. *Geophytology*, 47(2): 155-159.
- Printarakul, N., Tan, B.C., Santanachote, K. and Akiyama, H., 2013. New and Noteworthy records of mosses from doi (mt.) inthanon, Chiang Mai, Chom Tong district, Northern Thailand. *Pol. Bot. Journ.*, 58(1): 245-257.
- Printarakul, N., Tan, B.C., Santanachote, K. and Wongkuna, K., 2012. Nine new records of mosses from Doi Suthep-Pui National Park and a new variety of *Fissidens* from Thailand. *Cryptog. Bryol.*, 33(1): 23-32.
- Proskauer, J., 1948. Studies on the morphology of *Anthoceros*. I. *Ann. Bot.*, 12(47): 237-265.
- Proskauer, J., 1948. Studies on the Morphology of *Anthoceros*. II. *Ann. Bot.*, 12(48): 427-439.
- Pursell, R.A. and Bruggeman-Nannenga, M.A., 2004. A revision of the infrageneric taxa of *Fissidens*. *Bryologist*, 107: 1-20,
- Pursell, R.A., 1990. *Fissidens* in the Neotropics. *Trop. Bryol.*, 2: 193-200.
- Pursell, R.A., 1994. Taxonomic notes on Neotropical *Fissidens*. *Bryologist*, 97: 253-271.
- Pursell, R.A., 1997. Taxonomic notes on Neotropical *Fissidens* II. An Addendum. *American Bryol. Lichenol. Soc.*, 100: 193-197
- Pursell, R.A., 1999. Taxonomic Notes on Neotropical *Fissidens* III. Addendum II. *Bryologist*, 102(1): 125-127.
- Pursell, R.A., 2007. *Fissidentaceae (Vol. 101)*. New York Botanical Garden Press Dept.
- Putzke, J., 2020. Bryophytes and their Associates in South Shetland Islands-Antarctica. *Contemporary Research on Bryophytes*, 1: 8-19.

- Raddi, J., 1818. *Novarium vel rariorum ex cryptogamia stirpium in agro florentinum collectarum decades due. Opuscoli scientifici* 2: 357-358.
- Rai, M., Srivastava, P. and Srivastava, S.N., 2016. Observations on fertile populations of two *Porella* (Porellaceae, Marchantiophyta) species from Kumaun Region in the Western Himalaya, India. *Pl. Sci. Today*, 3(2): 142-148.
- Rajeevan, B., 1990. *Studies on the Bryophyte flora of the Idukki District, Kerala*. Ph.D. Thesis, Bharathiar University, Coimbatore.
- Rajesh K.P., Mufeed, B. and Manju, C.N., 2013. *Symphyodon complanatus* (Symphyodontaceae: Moss) a new record for Kerala (India). *Samagra*, 9: 28-30.
- Rajesh, K.P. and Manju, C.N., 2014. Bryophyte diversity of the lowlands and midlands of Kozhikode district, Kerala, India. *Frahmia*, 5: 1-10.
- Rajesh, K.P., 2010. Three new bryophyte records for Andaman Islands, India. *Taiwania*, 55(2): 172-176.
- Rajilesh, V.K., Madhusoodanan P.V. and Prakashkumar, R., 2018. *Plagiochila magna* Inoue. (Plagiochilaceae) from Mathikettan Shola National Park, Idukki- New record to Peninsular India. *Annal. Pl. Sci.*, 7: 1946-1948.
- Ramesh, M. and Manju C.N., 2009. Ethnobryological notes from Western Ghats, India. *Bryologist*, 112(3): 532-537.
- Ramsay, H.P. and Cairns, A., 2004. Habitat, distribution and the phytogeographical affinities of mosses in the Wet Tropics bioregion, north-east Queensland, Australia. *Cunninghamia*, 8: 371-408.
- Ramsay, H.P., 1900. *Warburgiella* Müll. Hal. ex Broth., *Monsunia*, 1: 176.
- Ramsay, H.P., 1997. Cytotaxonomic studies on some Polytrichales from Australia, New Zealand, Papua New Guinea and Vanuatu. *J. Hattori Bot. Lab.*, 82: 213-226.
- Ramsay, H.P., Schofield, W.B. & Tan, B.C., 2004. The family Sematophyllaceae (Bryopsida) in Australia. Part 2. Acroporium, Clastobryum, Macrohymenium, Meiotheciella, Meiothecium, Papillidiopsis, Radulina, Rhaphidorrhynchium, Trichosteleum, Warburgiella, *J. Hattori Bot. Lab.*, 95: 1-69 .
- Rani, S.S., 2014. *Bryophytes of Andhra Pradesh*. Bishen Singh Mahendra Pal Singh, Dehradun.

- Rashid, A., Mishrad, R. and Sharma, A., 2012. Bryoflora of district Rajouri-Jammu and Kashmir State, India. *Arch. Bryol.*, 145:1-11.
- Rawat, K.K. and Srivastava, S.C., 2007. *Genus Plagiochila in Eastern Hiamalaya (India)*. Bishen Singh Mahendra Pal Singh, Dehradun.
- Rawat, K.K. and Verma, P.K., 2014. On a collection of Liverwort from Tawang, Arunachal Pradesh, India with *Frullania rhystocolea* Herzog new to India. *Frahmi,a* 8: 1-7.
- Rawat, K.K., Alam, A. and Verma, P.K., 2015. Moss flora of Rajasthan and Punjab plains. *Pl. Sci. Today*, 2(4): 154-158.
- Rawat, K.K., Sahu, V., Singh, C.P. and Verma, P.K., 2017. Additions to the bryophyte flora of Tawang, Arunachal Pradesh, India. *Frahmia*, 14: 1-17.
- Redfearn Jr, P.L., 1979. Bryophytes of the Interior Highlands of North America XVI. Species of the Ozark National Forest, Sylamore Division, and adjacent areas in Stone County, Arkansas. *Bryologist*, 82: 483-486.
- Redfearn Jr., P. L. and Wu, P.C., 1986. Catalogue of the mosses of China. *Ann. Missouri Bot. Gard.*, 73: 177–208.
- Redfearn, Jr. P. L., 1983. Mosses of the Interior Highlands of North America, reprinted with changes and additions. *Annal. Missouri Bot. Gard.*, 59: 1–104.
- Redfearn, Jr. P.L. 1990. Tropical component of the moss flora of China. *Trop. Bryol.*, 2: 201-222.
- Redfearn, Jr.P.L. 1986. Catalogue of the mosses of China. *Annal. Missou. Bot. Gard.*, 73(1): 177-208.
- Reese, W.D. and Pursell, R.A., 2002. The *Fissidens* flora of Amazonian forest floor termite structures. *Bryologist*, 105(2): 185-189.
- Reinwardt, C.G.C., Blume, C.L. and Nees von Esenbeck, C.G., 1824. Hepaticarum iavanicarum, supplementum. *Nov. Act. Acad. Caes. Leop. –Carol. Nat.*, 12 (1): 409–417.
- Remesh, M. and Manju, C.N., 2009. Ethnobryological notes from Western Ghats, India. *Bryologist*, 112(3): 532-537.
- Renliang, H., 1983. A revision of the Chinese species of Entodon (Musci, Entodontaceae). *Bryologist*, 86(3): 193-233.
- Rheede, H.V., 1678-1703. Hortus Indicus Malabaricus. 12 vols.
- Roads, E., Longton, R.E. and Convey, P., 2014. Millennial time scale regeneration in a moss from Antarctica. *Curr. Biol.*, 24(6): R222-R223.

- Robinson, H., 1964. A small collection of bryophytes from upper Assam. *Journ. Hattori Bot. Lab.*, 27: 124-130.
- Robinson, H., 1967. Preliminary studies on the bryophytes of Colombia. *Bryologist*, 70: 1–61.
- Robinson, H., 1968. Notes on Bryophytes from the Himalayas and Assam. *Bryologist*, 71(2): 82-97.
- Robinson, H., 1990. A functional evolution of the Leucobryaceae. *Trop. Bryol.*, 2: 223-237.
- Rohrer, J.R., 1986. *Leptohymenium tenue* and *Elmeriobryum guatemalense*, sp. nov. in Mexico and Central America. *Bryologist*, 28-31.
- Ros, R.M., Cano, M.J. and Guerra, J., 1999. Bryophyte checklist of Northern Africa. *J. Bryol.*, 21(3): 207-244.
- Ros, R.M., Mazimpaka, V., Abou-Salama, U., Aleffi, M., Blockeel, T.L., Brugué's, M., Cano, M.J., Cros, R.M., Dia, M.G., Dirkse, G.M., El Saadawi, W., Erda, A., Ganeva, A., Gonzalez Mancebo, J.M., Herrnstadt, I., Khalil, K., Ku'rschner, H., Lanfranco, E., Losada-Lima, A., Refai, M.S., Rodriguez-Nunez, S., Sabovljevic, M., Sergio, C., Shabbara, H., Sim-Sim, M. and Soderstrom, L., 2007. Hepatics and Anthocerotales of the Mediterranean, an annotated checklist. *Crypt., Bryol.*, 28: 351–437.
- Ros, R.M., Mazimpaka, V., Abou-Salama, U., Aleffi, M., Blockeel, T.L., Bruges, M., Cros, R.M., Dia, M.G., Dirkse, G.M., Draper, I., Elsaadawi, W., Erdag, A., Ganeva, A., Gabriel, R., Gonzalezmancebo, J.M., Granger, C., Herrnstadt, I., Hugonnot, V., Khalil, K., Kürschner, H., Losada-Lima, A., Luis, L., Mifsud, S., Privitera, M., Puglisi, M., Sabovljević, M., Sergio, C., Shabbara, H.M., Sim-Sim, M., Sotiaux, A., Tacchi, R., Vanderpoorten, A., Werner, O., 2013. Mosses of the Mediterranean, an Annotated Checklist. *Cryptog. Bryol.*, 34: 99–283.
- Russel, T.H., 1908. Mosses and Liverworts.
- Sahu, V. and Asthana, A.K., 2014. Diversity of liverworts and hornworts in Pithoragarh and its neighbouring areas, Western Himalaya of India. *Ind. Journ. Forest.*, 140: 389-394
- Sahu, V. and Asthana, A.K., 2015. Bryophyte diversity in Terai regions of Uttar Pradesh, India with some new additions to the state. *Trop. Pl. Res.*, 2(3): 180-191.
- Sandhya Rani, S., M. Sowghandhika, K. S. Nagesh, B. Susheela, and T. Pullaiah. 2014. Bryophytes of Andhra Pradesh. *Bishen Singh Mahendra Pal Singh*,

Dehradun, India. 1-275.

- Sandhyarani, S., Sowghandika, M., Susheela, B., Nagesh, K.S. and Pullaiah, T., 2011. Additions to the bryoflora of southern peninsular India. *The Journal of Indian Botanical Society*, 90(1 & 2): 75-79.
- Sathish, S.S., Kavitha, R. and Kumar, S.S., 2013. Bryophytes in India-the current status. *Int. J. Res. Eng. Biosci.*, 1(4): 23.
- Savitha, A., Nair, M.C., Rajesh, K.P. and Ramani, M.P., 2008. *Cololejeunea latilobula* (Herzog) Tixier and *Schiffneriolejeunea pulopenangensis* (Gott.) Gradst. (Lejeuneaceae: Marchantiopsida) two new bryophyte records for Kerala *J. Econ. Tax. Bot.*, 32: 577-580.
- Saxena, D.K., and Harinder, 2004. Uses of bryophytes. *Resonance*, 9(6): 56-65.
- Saxena, D.K., Singh, S. and Srivastava, K., 2008. Taxonomy of Rhodobrym from Kumaon and Garhwal region of Uttarakhand, India. *Ind. Journ. Forest.*, 31(3): 437-440
- Schiffner, V., 1910. Über die Gattungen *Chiloscyphus* und *Heteroscyphus* n. gen. *Oesterr. Bot. Zeitschr.*, 60: 169-173.
- Schimper, W.P., 1856. Coroll. Bryol. Eur. 140 pp. E. Schweizerbart, Stuttgart.
- Schoefield, W.B., 2019. Introduction to Bryology, *Britannica*.
- Schuster R.M., 1980. *The Hepaticae and Anthocerotae of North America*. Vol. IV. Columbia University Press.
- Schuster R.M., 1992a. The Hepaticae and Anthocerotae of North America east of the hundredth meridian. Vol. 5. Chicago, 854.
- Schuster, R.M., 1992b. The Hepaticae and Anthocerotae of North America, Vol. 6. *Field Museum of Natural History*, Chicago.
- Schuster, R.M., 2002. Revisionary studies of the Chandonanthoideae (Jungermanniales, Jungermanniaceae). *Nov. Hedwig.*, 74(3-4): 465-496.
- Schwägrichen, F., 1811-1842. (Species Muscorum, Hedwig) Opus posthumum supplementum primum scriptum. *Leipzig. Suppl.*, 1(I): 1811; (II) 1816. Suppl 2(I): 1826-27. Suppl. 3(I): 1827-28; (II): 1829-30. Suppl. 4(I): 1842.
- Schwarz, U. and Frahm, J.P., 2013. A contribution to the bryoflora of the Western Ghats in Karnataka State, India. *Polish Bot. J.*, 58(2): 511-524.
- Schwarz, U., 2013. An Updated Checklist of Bryophytes of Karnataka. *Arch. Bryol.*, 181: 1-42.
- Schwarz, U., 2014. *Fissidens brevinervis* Broth.– New to Indian moos Flora.

- Frahmia*, 3: 1-6.
- Scott G.A.M., 1985. *Southern Australian Liverworts*. Canberra, pp. 216.
- Scott, G.A., 1987. Studies in Ancient Bryology, I. Introduction and Liverworts to 1500 AD. *J. Bryol.*, 14(4): 625-634.
- Sedgwick, L.J., 1910. A first list of mosses from Western India. *J. Bombay Nat. Hist. Soc.*, 19: 938-942.
- Seppelt, R.D., McIntosh, T.T., Ireland, R.R., Robinson, H., Yip, K.L. and Buck, W.R., 2007. Ditrichaceae Limpricht. *Fl. North Amer.*, 27: 443-467.
- Sequiera, S. and Kumar, M., 2008. Epiphyte host relationship of macrolichens in the tropical wet evergreen forests of Silent Valley National Park, Western Ghats, India. *Trop. Ecol.*, 49(2): 211.
- Sharma, A and Bhagat, M. 2017. Studies on the reproductive biology of *Wiesnerella denudata* (Mitt.) Steph. a rare hepatic. *Trop. Pl. Res.*, 4(3): 396-400.
- Sharma, A., Langer, A. and Uniyal, P.L., 2016. A preliminary report on the mosses of Rajouri and Poonch districts of Jammu & Kashmir, India. *Evansia*, 33(1): 26-33.
- Sharma, D. and Alam, A., 2011. Present status of liverwort diversity at Pachmarhi (Madhya Pradesh). *J. Indian Bot. Soc.*, 90 (3 & 4): 332-338.
- Sharma, D. and Srivastava, S.C., 1993. Indian Lepidoziinae (A Taxonomic Revision). *Bryophyt. Biblio.*, 47: 1-354.
- Sharma, P.D., 1971. Abnormal Sex Organs in *Pogonatum microstomum* (R. Br.) Brid., and on the Origin of Gametangia in Mosses. *Bryologist*, 74(4): 458-463.
- Shaw, A.J. and Goffinet, B., (eds.) 2000. *Bryophyte biology*. Cambridge University Press.
- Shaw, A.J., Szövényi, P. and Shaw, B., 2011. Bryophyte diversity and evolution: windows into the early evolution of land plants. *Amer. J. Bot.*, 98(3): 352-369.
- Shaw, B., Crandall-Stotler, B., Váňa, J., Stotler, R.E., von Konrat, M., Engel, J.J., Davis, E.C., Long, D.G., Sova, P. and Shaw, A.J., 2015. Phylogenetic relationships and morphological evolution in a major clade of leafy liverworts (phylum Marchantiophyta, order Jungermanniales): suborder Jungermanniineae. *Syst. Bot.*, 40(1): 27-45.
- Shevock, J.R. and Yorong, A.P., 2018. New additions to the moss flora of Mindanao Island, Republic of the Philippines. *Philippine Journal of Systematic*

Biology, 12(1), pp.67-72.

- Shu, L., Cheng, X.-F., Daniels, A.E.D., Yong, K.T. and Zhu, R.L., 2015. Taxonomy and distribution of *Cheilolejeunea larsenii* Mizut.(Marchantiophyta, Lejeuneaceae), with special reference to three new synonyms. *J. Bryol.*, 37(4): 297-303.
- Shu, L., Xiang, Y-L., Cheng, X-F., Wei, Y-M., 2017. New Liverwort and Hornwort record for Vietnam. *Crypt. Bryol.*, 38(4): 411-445.
- Singh D. and Singh D.K., 2017. Two new species of *Riccardia* (Aneuraceae, Marchantiophyta) from Eastern Himalaya, India with notes on the genus in Sikkim. *Taiwania*, 62(1): 33-42.
- Singh S. K., Pócs T., Singh D. and Kumar S., 2020. A synopsis of *Colura* (Dumort.) Dumort. (Marchantiophyta: Lejeuneaceae) in India. *Cryptog. Bryol.*, 41 (10): 111-129.
- Singh, A.P. and Nath, V., 2007. *Hepaticae of Khasi and Jaintia Hills: Eastern Himalayas*. Bishen Singh Mahendra pal Singh, pp. 382
- Singh, C.P. and Verma, P.K., 2017. Additions to the bryophyte flora of Tawang, Arunachal Pradesh, India. *Frahmia*, 14: 1-17.
- Singh, D. and Singh, D.K., 2008. A note on *Metzgeria conjugata* Lindb. (Hepaticae: Metzgeriaceae) from India. *Geophytology*, 37: 47-49.
- Singh, D. and Singh, D.K., 2013. A note on the status of *Metzgeria macrospora* (Metzgeriaceae, Marchantiophyta). *Nelumbo*, 55: 166-171.
- Singh, D. and Singh, D.K., 2013. Some new and noteworthy records of family Lejeuneaceae (Marchantiophyta) from Sikkim, India. *Nelumbo*, 55: 153-165.
- Singh, D., 2016. Two new records of family Lejeuneaceae (Marchantiophyta) from Sikkim, India. *Indian J. Forest.*, 39(3): 267-272.
- Singh, D., Dey, M. and Singh, D.K., 2010a. A synoptic flora of liverworts and hornworts of Manipur. *Nelumbo*, 52: 9-52.
- Singh, D., Dey, M. and Upadhyay, G.K., 2010b. A preliminary survey of hepaticae of little Andaman Island. *Nelumbo*, 52: 125-130.
- Singh, D.K. and Singh, D., 2007. Rediscovery of *Cyathodium acrotrichum* Schiffn. (Hepaticae: Cyathodiaceae)- A long- lost liverwort often treated as doubtful taxon. *Curr. Sci.*, 92(10): 1354- 1356.
- Singh, D.K. and Singh, S.K., 2003. *Conocepalum japonicum* (Thunb.) Grolle (Bryophyta: Conocepalaceae)- A liverwort rediscovered in Indian Bryoflora. *Indian J. Forest.*, 26(4): 442-444.

- Singh, D.K. and Singh, S.K., 2008. Diversity in Liverworts and Hornworts of Great Himalayan National Park, Western Himalaya, India. *Bryology in the New Millennium, University of Malaya, Kuala Lumpur* 57-81.
- Singh, D.K. and Singh, S.K., 2015. *Manual of Liverworts and Hornworts of Himachal Pradesh, India (p.17)*. Dehradun (India): Bishen Singh Mahendra Pal Singh.
- Singh, D.K., 1996. Hepaticae (Bryophyta). In: Hajra, P.K. (ed.), *A contribution to the flora of Namdapha Arunachal Pradesh*. BSI, Calcutta, 46-67.
- Singh, D.K., Dey, M. and Singh, D., 2016. The genus *Radula* (Radulaceae, Marchantiophyta) in Andaman & Nicobar Islands, India. *J. Bryol.*, 38(3): 195-210.
- Singh, D.K., Singh, D. and Dey, M., 2008. A catalogue of the Hepaticae and Anthocerotae of Sikkim. In: Mohamed, H., Baki, B.B., Nasrulhaq-Boyce, A. and Lee, P.K.Y. (eds.), *Bryology in the New Millennium*. University of Malaya, Kuala Lumpur, 93-135.
- Singh, D.K., Singh, S.K. and Day, M., 2006. On a collection of Hepaticae from Andaman Islands. *Phytotaxonomy*, 6: 99-104.
- Singh, D.K., Singh, S.K. and Singh, D., 2016. Liverworts and Hornworts of India. An annotated Checklist. *Botanical Survey of India, Howrah, India*. pp. 1-439.
- Singh, S. K. and Barbhuiya, H.A., 2012. A compendium to Marchantiophyta and Anthocerotophyta of Assam, India. *Arch. Bryol.*, 149: 1–30.
- Singh, S. K. and Singh, D. K., 2007. A preliminary census of Hepaticae and Anthocerotae of Doon Valley. *Bull. Bot. Surv. India.*, 49: 1-14.
- Singh, S.K. and Kumar, S., 2013. Two new distributional records of Liverworts (Marchantiophyta) from Meghalaya. *Keanean J. Sci.*, 2: 25-30.
- Singh, S.K. and Kumar, S., 2016. A preliminary study on liverworts and hornworts of Tripura, North-East India. *Nelumbo*, 58: 130-151.
- Singh, S.K. and Singh D., 2016. Epiphyllous Liverworts of India: An Overview. *Pl. Sci. Today*, 3(2): 157-174.
- Singh, S.K. and Singh, D., 2018. A new species of the genus *Metzgeria* Raddi (Metzgeriaceae, Marchantiophyta) from India. *Cryptog. Bryol.*, 39(1): 47-53.
- Singh, S.K. and Singh, D.K., 2002. Contribution to the Liverworts of Gobind National Park, Uttaranchal, India. *Bull. Bot. Surv. India*, 44(1-4): 99-118.

- Singh, S.K. and Singh, D.K., 2007. A preliminary census of Hepaticae and Anthocerotae of Doon Valley. *Bull. Bot. Surv. India*, 49: 1-14.
- Singh, S.K. and Singh, D.K., 2007. Contribution to the bryoflora of Great Himalayan National Park, Kullu, Himachal Pradesh V: Genus *Plagiochila* (Dumort.) Dumort. (Plagiochilaceae). *Indian J. Forest.*, 30(1): 101-12.
- Singh, S.K. and Singh, D.K., 2007. Some new and noteworthy records of Hepaticae and Anthocerotae from Western Himalaya, India. *Cryptog. Bryol.*, 28(3), pp.253.
- Singh, S.K. and Singh, D.K., 2009. *Hepaticae and Anthocerotae of Great Himalayan National Park and its environs (HP), India*. Dehra Dun: Botanical Survey of India.
- Singh, S.K. and Singh, D.K., 2010. A catalogue of the liverworts and hornworts of Himachal Pradesh, India. *Arch. Bryol.*, 61: 1-13.
- Singh, S.K., 2013. A checklist of liverworts, hornworts and mosses of Uttar Pradesh, India. *Geophytology*, 42(2): 163-166.
- Singh, S.K., 2018. Contributions to the Hepaticae and Anthocerotae of Mizoram IX. Genus *Marchantia* L. *Ind. For.*, 144(5): 461–464.
- Skotnicki, M. L., Selkirk, P. M. and Boger, S. D., 2012. New records of three moss species (*Ptychostomum pseudotriquetrum*, *Schistidium antarctici*, and *Coscinodon lawianus*) from the southern Prince Charles Mountains, Mac. Robertson Land, Antarctica. *Polar Rec.*, 48(4): 394–400.
- Smith A.J.E., 1978. The Moss Flora of Britain and Ireland. Cambridge, Cambridge University Press, pp.706.
- So, M.L. and Grolle, R., 2000. Checklist of *Plagiochila* in Asia. *J. Hattori Bot. Lab.*, 88: 199-243.
- So, M.L. and Grolle, R., 2001. On several little-known species of *Plagiochila* (Hepaticae) in Asia. *J. Bryol.*, 23: 123-132.
- So, M.L. and Yip, K.L., 1995. Mosses new to Hong Kong (II). *Trop. Bryol.*, 10: 15-20.
- So, M.L. and Zhu, R.L., 1996. Studies on Hong Kong Hepatics II. Notes on some newly recorded liverworts from Hong Kong. *Trop. Bryol.*, 12: 11-20.
- So, M.L., 1995. *Mosses and Liverworts of Hong Kong*. Heavenly People Depot. Pp.1-162.
- So, M.L., 2001a. *Plagiochila* (Hepaticae, Plagiochilaceae) in China. *Syst. Bot. Monog.*, 60: 1-124.

- So, M.L., 2001b. Recognised species of *Plagiochila* in Australasia and some Island groups of the Pacific Ocean. *New Zealand J. Bot.*, 39(3): 395-421.
- So, M.L., 2002. The Genus *Porella* (Porellaceae, Hepaticae) in Australasia and the South Pacific. *Syst. Bot.*, 27(1): 4-13.
- So, M.L., 2003. The genus *Metzgeria* (Hepaticae) in Asia. *J. Hattori Bot. Lab.*, 94: 159-177.
- So, M.L., 2005. *Porella* (Porellaceae, Marchantiophyta) in Latin America. *New Zealand J. Bot.*, 43(1): 301-321.
- So, M.L., 2006. *Radula* (Radulaceae, Marchantiophyta) in the south pacific. *J. Hattori Bot. Lab.*, 99: 207-232.
- Söderström L., Urmi E. and Váňa J. 2002. Distribution of Hepaticae and Anthocerotae in Europe and Macaronesia. *Lindbergia*, 27: 3-47.
- Söderström, L., Gradstein, S. R. and Hagborg, A., 2010. Checklist of the hornworts and liverworts of Java. *Phytotaxa*, 9: 53–149.
- Söderström, L., Hagborg, A., Konrat, M.V., Bartolomew-Began, S., Bell, D., Briscoe, L., Brown, E., Cargill, D.C., Costa, D.P., Crandall-Stotler, B.J., Cooper, E.D., Dauphin, G., Engel, J.J., Feldberg, K., Glenney, D., Gradstein, S.R., HE, X., Heinrichs, J., Hentschel, J., Ilkiu-Borges, A.L., Katagiri, T., Konstantinova, N.A., Larrain, J., Long, D.G., Nebel, M., Pócs, T., Puche, F., Reinerdrehwald, E., Renner, M.A.M., Sass-Gyarmati, A., Schäfer-verwimp, A., Moragues, J.G.S., Stotler, R.E., Sukkharak, P. Thiers, B.M., Uribe, J., Váňa, J., Villarreal, J.C., Wigginton, M., Zhang, L. and Zhu, R.L., 2016. World check list of hornworts and liverworts. *Phytokeys*, 59: 1-828.
- Söderström, L., Hagborg, A., Pocs, T., Sass- Gyarmati, A., Brown, E., von Konrat, M. and Renner, M., 2011. Checklist of Hornworts and Liverworts of Fiji. *Telopea*, 13: 405-454.
- Söderström, L., Urmi, E. and Vana, J., 2007. The distribution of Hepaticae and Anthocerotae in Europe and Macaronesia - 1-427. *Cryptog. Bryol.* 28: 299-350.
- Sollman, P., 2005. Studies on some Asian mosses of the Pottiales, mainly from the Himalayas. *Trop. Bryol.*, 26: 81-88.
- Spence, J.R. and Ramsay, H.P., 2005. Bryaceae. Flora of Australia, Vol. 51. Government Printing Service, Canberra (in press).
- Spence, J.R. and Ramsay, H.P., 2005. New genera and combinations in the Bryaceae (Bryales, Musci) for Australia. *Phytologia*, 87: 61–72.

- Spence, J.R. and Ramsay, H.P., 2019. Revised keys and additions to the Australian Bryaceae (Bryopsida), *Telopea*, 22: 99-134.
- Spence, J.R., 1996. *Rosulabryum* genus novum (Bryaceae). *Bryologist*, 99: 221–225.
- Spence, J.R., 2005. New genera and combinations in Bryaceae (Bryales, Musci) for North America. *Phytologia*, 87: 15–28.
- Spence, J.R., 2007. Nomenclatural changes in the Bryaceae (Bryopsida) for North America II. *Phytologia*, 89: 110–114.
- Spence, J.R., 2009. Nomenclatural changes in the Bryaceae (Bryopsida) for North America III. *Phytologia*, 91: 493–499.
- Spence, J.R., 2014. 42. Bryaceae Schwägrichen. 117-185.
- Spence, J.R., 2014. Bryaceae Schwägr. In: Zander R.H. (ed.) Bryophyte flora of North America, Vol. 28 (Flora of North America Editorial Committee, Oxford University Press, New York).
- Spruce R., 1884. Hepaticae of the Amazon and Andes of Peru and Ecuador. *Trans. & Proc. Bot. Soc. Edinburgh*, 15: 1–308.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2015a. *Ceratolejeunea belangeriana* (Lejeuneaceae), new to India from the Western Ghats. *Acta Bot. Hung.*, 57(1-2): 225-231.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2015b. *Symphyodon erraticus* (Symphyodontaceae): an addition to the moss flora of the Western Ghats. *Pl. Sci. Today*, 2(4): 129-131.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2015c. New records of two Himalayan liverworts in the Western Ghats. *Nelumbo*, 57: 100-105.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2016a. Additions to the moss flora of peninsular India from the Western Ghats. *Acta Bot. Hung.*, 58(3-4): 425-429.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2016b. Genus *Wijkia* (Sematophyllaceae, Bryophyta) in the Western Ghats of India. *Acta Bot. Hung.*, 58(3-4): 431-434.
- Sreebha, R., Kariyappa, K.C. and Daniels, A.E.D., 2016c. Rediscovery of a long-lost moss *Fissidens serratus* var. *serratus* in the Western Ghats of India. *Acta Bot. Hung.*, 58(1-2): 183-186.
- Sreenath, A., Kumar, M.A., Anjaneyulu, P. and Boyina, R.P.R., 2020. Three moss families (Bryopsida: Calymperaceae, Hyopterygiaceae, & Pterobryaceae): new distribution records to bryoflora of Andhra Pradesh, India. *J. Threat.*

- Taxa*, 12(4): 15481-15488.
- Sreenivasan, C. 1974. *Mosses of South India*. Annamalai University, Annamalai Nagar.
- Srivastava S.C. and Dixit, R., 1996. Species of *Plagiochila* (Dumort.) Dumort. (Plagiochilaceae) from Lilam in Kumaon, Western Himalayas, India. *Geophytology*, 25: 91-103.
- Srivastava, A. and Srivastava, S.C., 2002. *Indian Geocalycaceae (Hepaticae)*. Bishen Singh Mahendra Pal Singh.
- Srivastava, S.C. and Alam, A. 2002. A collection of *Frullania* from Nilgiri with *F. densiloba* St. as a new record for India. *J. Bombay Nat. Hist. Soc.*, 99(2): 232-237.
- Srivastava, S.C. and Alam, A., 2004. *Frullania riojaneirensis* (Raddi) Spruce—an addition to Indian bryoflora. *Geophytology*, 33(1&2): 47-51.
- Srivastava, S.C. and Asthana, A.K., 1987. Morpho-taxonomy of *Anthoceros crispulus* (Mont.) Douin from south India. *Proc. Pl. Sci.*, 97(5): 385-389.
- Srivastava, S.C. and Rawat, K.K., 2011. On an endangered liverwort (Marchantiophyta) from India: proposal for red listing. *Nelumbo*, 53: 201-204.
- Srivastava, S.C. and Sharma, D., 2000. A preliminary study on the liverwort and hornwort flora of Silent Valley (Kerala). In: Chauhan (ed.), *Prof D.D. Nautiyal Commemoration Volume Recent Trends in Botanical Researches*, 55-75.
- Srivastava, S.C. and Udar, R., 1975. The genus *Fossombronia* Raddi in India with a note on the Indian taxa of the family Fossombroniaceae. *Nova Hedwig.*, 26: 799 – 845.
- Srivastava, S.C. and Udar, R., 1979. Distribution of Metzgeriales in India. *J. Indian Bot. Soc.*, 58: 33–39.
- Srivastava, S.C. and Verma, P.K., 2005. *Gongylanthus indicus* Sp. Nov. (Hepaticae) from Nilgiri hills, India. *Indian J. Forest.*, 28(2): 200-205.
- Srivastava, S.C., 1967. On fertile plants of *Lunularia cruciata* in South India. *Curr. Sci.*, 36: 299-300.
- Srivastava, S.C., 1976. A new *Metzgeria* from Assam. *J. Indian Bot. Soc.*, 55: 194-197.
- Srivastava, S.N, Rai, M. and Srivastava, P., 2016. On the occurrence of *Spruceanthus semirepandus* (Nees) Verd. (Lejeuneaceae; Marchantiophyta)

- in Western Himalaya, India. *Indian J. Pl. Sci.*, 5(1): 27-32.
- Srivatava, S.C., Chakraborty, D. and Alam, A., 2015. Bryology in India-Retrospect and Prospects. *Pl. Sci. Today*, 2(4): 123-125.
- Stafleu, F. A. and Cowan, R. S., 1976. Taxonomic literature. Second edition. Volume I: A–G. *Regnum Veg.* 94(xl): 1–1136.
- Staples, G. W., Imada, C. T., Hoe, W. J. and Smith, C. W., 2004. A revised checklist of Hawaiian mosses. *Trop. Bryol.*, 25: 35–69.
- Staples, G.W. and Imada, C. T., 2006. Checklist of Hawaiian anthocerototes and hepatics. *Trop. Bryol.* 28: 15–47.
- Steel, D.T., 1978. The taxonomy of *Lophocolea bidentata* (L.) Dum. and *L. cuspidata* (Nees) Limpr. *J. Bryol.*, 10(1): 49-59.
- Stephani, F., 1898-1900. *Species Hepaticarum I*. Georg et Cie, Lyon, meme Maison, Geneve & Bale.
- Stephani, F., 1906. *Species Hepaticarum II*. Georg et Cie, Lyon, meme Maison, Geneve & Bale. 615.
- Stephani, F., 1910. *Species Hepaticarum 2*: Geneva.
- Stephani, F., 1912–1917. *Species Hepaticarum 5*. Georg & Cie, Lyon, même Maison, Genèveet Bale, 1044.
- Stotler, R.E. and Crandall-Stotler, B., 1977. A checklist of the liverworts and hornworts of North America. *Bryologist*, 80: 405-428.
- Stotler, R.E. and Crandall-Stotler, B., 2005. Typification of *Jungermannia pusilla* L. (≡ *Fossombronia pusilla* (L.)Nees). *J. Bryol.*, 27(1): 71-73.
- Stotler, R.E. and Crandall-Stotler, B.J., 2017. A synopsis of the liverwort flora of North America north of Mexico. *Ann. Missouri Bot. Gard.*, 102(4): 574–709.
- Stotler, R.E. and Crotz, D.K., 1983. On *Mnium trichomanis* Linnaeus (Hepatophyta). *Taxon*, 32: 64–75.
- Sudhikumar, A.V., Mathew, M.J., Sunish, E., Murugesan, S. and Sebastian, P.A., 2005. Preliminary studies on the spider fauna in Mannavan Shola forest, Kerala, India (Araneae). *European Arachnology Supplement*, 1: 319-327.
- Sukkharak, P. and Chantanaorrapint, S., 2014. Bryophyte studies in Thailand: past, present, and future. *Cryptog. Bryol.*, 35(1): 5-17.
- Sukkharak, P., 2018. A revision of the genus *Frullania* (Marchantiophyta: Frullaniaceae) in Thailand. *Nova Hedwig.*, 106(1-2):115-207.
- Sukkharak, P., Kitlap, P., Likananonn, A. and He, S., 2014. A preliminary study of

- bryophytes in the Khao Soi Dao wildlife sanctuary, Chanthaburi Province, Thailand. *Songklanakarin J. Sci. Tech.*, 36(5): 527-534.
- Suleiman, M. and Edwards, S.R., 2002. Mosses of Mt. Trus Madi, Sabah, Malaysia. *Trop. Bryol.*, 21: 57-64.
- Suleiman, M., Akiyama, H. and Tan, B.C., 2006. A revised catalogue of mosses reported from Borneo. *J. Hattori Bot. Lab.*, 99: 107-183.
- Suleiman, M., Fadzilah, A.K. and Masundang, D.P., 2011. The mosses of Mount Lumaku, Sipitang, Sabah, Malaysia. *Trop. Bryol.*, 33: 23-30.
- Suleiman, M., Masundang, D.P. and Akiyama, H., 2017. The Mosses of Crocker Range Park, Malaysian Borneo. *PhytoKeys*, 88: 71.
- Suleiman, M., Masundang, D.P. and Tan, B.C., 2009. A checklist of mosses from Golden Hope oil palm plantation and surrounding areas, Tawau, Sabah, East Malaysia. *Journal of Tropical Biology & Conservation*, 5: 53-60.
- Suzuki, T., 2015. *Aongstroemia longipes* (Somm.) Bruch & Schimp. newly found in Japan. *Hattoria*, 6: 49-51.
- Suzuki, T., 2016. A revised new catalog of the mosses of Japan. *Hattoria*, 7: 9-223.
- Swartz, O., 1788. *Medusa unguiculata* och *Actinia pusilla*; upptäckte och beskrifne. – *Kongl. Vet. Acad. Nya Handl.*, 9 (7-9): 198-203.
- Swarupanandan, K., Sasidharan, N., Chacko, K.C. and Basha, S.C., 1998. *Studies on the Shola forests of Kerala*. Kerala Forest Research Institute Research Report, 158.
- Szweykowski, K., Buczkowska and Odrzykoski, I.J., 2005. *Conocephalum salebrosum* (Marchantiopsida, Conocephalaceae) - a new Holarctic liverwort species. *Pl. Syst. & Evol.*, 253: 133-158.
- Takaki, N., 1955. Researches on the Brachytheciaceae of Japan and its adjacent areas. II. *J. Hattori Bot. Lab.*, 15: 1-69.
- Tan B.C., Koponen, T.J. and Norris D.H., 2017. Bryophyte flora of Hunan Province, China. Sematophyllaceae (Musci). *Acta Bryolich. Asiat.*, 3-70
- Tan, B.C. and Engel, J.J., 1986. An annotated checklist of Philippine Hepaticae. *J. Hattori Bot. Lab.*, 60: 283-355.
- Tan, B.C. and Iwatsuki, Z., 1991. A new annotated Philippine moss checklist. *Harw. Pap. Bot.*, 1-64.
- Tan, B.C. and Iwatsuki, Z., 1996. Hot spots of Mosses in Asia. *Anales Inst. Biol. Univ. Nac. Auton. Mexico. Ser. Bot.*, 67 (1): 159-167.

- Tan, B.C. and Robinson, H.E., 1990. A review of Philippine Hookeriaceae taxa (Musci). *Smithsonian contributions to botany*, 75: 1-41.
- Tan, B.C. and Yu, J., 1999. A preliminary revision of Chinese Sematophyllaceae. *The Journal of the Hattori Botanical Laboratory*, 86: 1-70.
- Tan, B.C., 2005. New species records of Sri Lankan mosses. *Raffl. Bull. Zool.*, 12: 5-8.
- Tan, B.C., Buck, W.R. and Ignatov, M.S., 1990. On the Himalayan *Struckia* C. Muell. and Russian *Cephalocladium* Lazar. (Musci, Hypnaceae). *Lindbergia*, 16: 100-104.
- Tan, B.C., Ho, B.C., Linis, V., Iskandar, E.A., Nurhasanah, I., Mulyati, S. and Haerida, I., 2006. Mosses of Gunung Halimun National Park, West Java, Indonesia. *Reinwardtia*, 12(3): 205-214.
- Tan, B.C., Koponen, T. and Norris, D.H., 2017. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXX. Sematophyllaceae (Musci) 1. *Acanthorrhynchium*, *Acroporium*, *Clastobryophilum*, *Pseudopiloecium*, *Radulina* and *Trichosteleum*. In *Annales Botanici Fennici*, (pp. 35-78). Finnish Zoological and Botanical Publishing Board.
- Tan, B.C., Zhao, J.C. and Hu, R.L., 1995. An updated checklist of mosses of Xinjiang, China. *Arctoa*, 4: 1-14.
- Taylor, M.D., 1846. *New Hepaticae*. *Lond. J. Bot.*, 5: 414-417.
- Tewari, S.D., Pant, G., Airi, S.K. and Adhikari, P.S., 1987. *Hookeria acutifolia* Hook. & Grey., a new record for Western Himalaya, India. *Yushania*, 4: 13-16.
- Thamizharasi, T., Sahaya Sathish, S., Palani, R., Vimala, A. and Vijayakanth, P., 2018. Enumeration and phytogeographical pattern of mosses (Bryopsida) in Kalrayan Hills of Eastern Ghats of Tamilnadu, India. *Int. J. Develop. Res.*, 8(1): 18212-18216
- Thoker S.A. and Patel S., 2019. Bryophyte diversity of Jammu & Kashmir State, India. *Inter. Res. Jour. Biolog. Sci.*, 8(5): 21-28.
- Thomas, B., Chandrashekara, U.M. and Rajendran, A., 2011. Floristic diversity along an altitudinal gradient of Mannavan Shola forest in Southern Western ghats of Kerala. *J. Res. Biol.*, 2: 101-109.
- Thouvenot L, Gradstein SR, Hagborg A, Soderstrom L, Bardat J., 2011. Checklist of the liverworts and hornworts of New Caledonia. *Crypt., Bryol.*, 32: 287-390.

- Tixier, P., 1967. Bryophytae Indosinicae. *Dacca Univ. Stu.*, 15: 1–14.
- Tixier, P., 1974. Contribution to the bryological knowledge of Malaysia. II. Kedah Peak. *Nat. Hist. Bull. Siam Soc.*, 25: 15-28.
- Tixier, P., 1983. Bryophyta Exotica VIII: Mosses of Sri Lanka-Collections of C. Ruinard. *Ceylon J. Sci. Biol.Sci.*, 16(1&2): 7: 24-57.
- Touw, A., 1968. Miscellaneous notes on Thai mosses. *Natural History Bulletin of the Siam Society*, 22: 217-244.
- Touw, A., 2001. A taxonomic revision of the Thuidiaceae (Musci) of tropical Asia, the western Pacific, and Hawaii. *J. Hattori Bot. Lab.*, 91: 1-136.
- Townsend, C.C., 1988. Mosses from the Nandi Hills, Mysore State, India. *Journ. Bryol.*, 15:289–291.
- Udar, R. and Nath,V., 1971. Oil bodies in South Indian liverworts. *Curr. Sci.*, 40: 638-640.
- Udar, R. and Awasthi, U.S., 1982. The genus *Drepanolejeunea* St. in India. *J. Hattori Bot. Lab.*, 53: 419–437.
- Udar, R. and Awasthi, U.S., 1983. The genus *Leucolejeunea* Evans in India. *Proc. Indian Nat. Sci. Acad.*, 49: 249–256.
- Udar, R. and Gupta, A., 1983. Differentiation of the genus *Targionia* L. in India-II. The east Himalayan and South Indian complex and description of a new species of *Targionia*. *Geophytology*, 13: 83-87.
- Udar, R. and Jain, A., 1984. Liverworts of Kerala-I. Marchantiales. *Indian J. Forest.*, 7: 300-304.
- Udar, R. and Kumar, A., 1985. Family Cephaloziellaceae in South India. *Geophytology*, 15: 141-145.
- Udar, R. and Shaheen, F., 1983a. Morpho-taxonomy of *Porella perrottetiana* (Montin) Trev. from South India. *J. Indian Bot. Soc.*, 62: 319-325.
- Udar, R. and Singh, D.K., 1981. Some new combinations under *Phaeoceros* Proskauer. *Geophytology*, 11: 257–258.
- Udar, R., 1970. Bryophytes in the Indian Botanical Society and botany in India. (1920-1970). *Indian Bot. Soc. Golden Jubilee Sess.*, 25-27.
- Udar, R., 1976. *Bryology in India*: In Pama Primlane, (ed.), *Chron. Bot.*, New Delhi.
- Upreti, D.K. and Tandon, P.K., 2014. Species Diversity and Host Specificity of Epiphytic Lichens: A Case Study in Two Forest Stands of Central India. *Int. J. Ecol. Envt. Sciences*, 39(4): 251-270.

- Uyar, G. and Çetin, B., (2004) A new check-list of the mosses of Turkey. *Journ. Bryol.*, 26: 203–220.
- Uyar, G. and Ören, M., 2013. Three remarkable new moss records for South-West Asia from northern Turkey. *Turkish J. Bot.*, 37: 363–368.
- Van Reenen, G.B.A. and Gradstein, S.R., 1983. Studies on colombian cryptogams xx: a transect analysis of the bryophyte vegetation along an altitudinal gradient on the Sierra Nevada de Santa Marta, Colombia. *Act. Bot. Neerl.*, 32(3): 163-175.
- Van Zanten, B.O., 1959. Trachypodaceae: A critical revision, Groningen: IJdo.
- Van Zanten, B.O., 2006. A synoptic review of the Racopilaceae (Bryophyta, Musci). 1. Asian, Pacific and Australasian species of the genus *Racopilum*. *J. Hattori Bot. Lab.*, 100: 527-552.
- Váňa, J. and Piippo, S., 1989. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXXI. Cephaloziaceae subfam. Alobielloideae, Cephaloziellaceae, Antheliaceae and Lophoziaceae (Hepaticae). In: *Annal. Bot. Fenn.*, 20: 263-290.
- Váňa, J., Grolle, R. and Long, D.G., 2012. Taxonomic realignments and new records of *Gongylanthus* and *Southbya* (Marchantiophyta: Southbyaceae) from the Sino-Himalayan region. *Nova Hedw.*, 95(1–2): 183–196.
- Váňa, J., Söderström, L., Hagborg, A. and Konrat, M.von., 2013. Notes on early land plants today. 40. Notes on Cephaloziellaceae (Marchantiophyta). *Phytotaxa*, 112(1): 1–6.
- Varde, R. Potier De La., 1925. Nouvellesherborisations dans la sud de l' Inde. *Rev. Bryol.*, 52: 37-43.
- Vashistha, B.D., 2007. Mosses of Plains of Northern India and Adjacent Regions. In: V. Nath and A. K. Asthana, (eds.), *Current trends in Bryology*. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. 177-187.
- Vásquez, C., Calva, J., Morocho, R., Donoso, D.A. and Benítez, Á., 2019. Bryophyte Communities along a Tropical Urban River Respond to Heavy Metal and Arsenic Pollution. *Water*, 11(4): 813.
- Vaz-Imbassahy, T.D.F. and da Costa, D.P., 2009. New combinations and new synonyms in Pilotrichaceae (Bryophyta) II. *Nova Hedwig.*, 88(3-4): 465-474.
- Vellak, K., Ingerpuu, N., Leis, M. and Ehrlich, L., 2015. Annotated checklist of Estonian bryophytes. *Folia cryptogamica estonica*, 52: 109-127.
- Venugopal, M. and Manju, C.N., 2017. Bryophyte diversity of Thamarassery pass

- (Wayanad pass) in the Western Ghats of Kerala. *Pl. Sci. Today*, 4(1): 40-47.
- Verma, P.K. and Srivastava, S.C., 2008. *Plagiochila junghuhniana* Sande Lac. new to Indian Mainland (Nilgiri Hills, Western Ghats). *J. Bombay. Nat. Hist. Soc.*, 105(2): 236-238.
- Verma, P.K., Alam, A. and Rawat, K.K., 2013. Assessment of liverwort and hornwort flora of Nilgiri Hills, Western Ghats (India). *Polish Bot. J.*, 58(2): 525-537.
- Verma, P.K., Alam, A. and Srivastava, S.C., 2011. Status of Mosses in Nilgiri Hills (Western Ghats), India. *Arch. Bryol.*, 102: 1-16.
- Verma, P.K., Rawat, K.K., Yadav, A. and Das, N., 2012. The Liverwort and Hornwort flora of Hoollongapar Gibbon Sanctuary, Jorhat (Assam)-1. *Arch. Bryol.*, 152: 1-16.
- Vidya, V., Manjula K.M. and Manju C.N., 2014. A synopsis of the family Pottiaceae (Bryophyta) of Kerala, India. *Acta Biol. Pl. Agr.*, 3: 43-72.
- Vidya, V., Manjula, K.M., Manju, C.N., Rajesh, K.P. and Prakashkumar, R., 2015. A synopsis of the family Pottiaceae (Bryophyta) of Kerala, India. *Acta Biol. Plant. Agr.*, 3: 43-72.
- Vieira, C., Séneca, A., Sérgio, C. and Ferreira, M.T., 2012. Bryophyte taxonomic and functional groups as indicators of fine scale ecological gradients in mountain streams. *Ecol. Indic.*, 18: 98-107.
- Virtanen, V. 2000. Taxonomic Studies of the Bartramiaceae, *Bryopsida*, 31: 1-34.
- Vitt, D.H. and Crum, H., 1970. *Groustiella tomentosa* new to the United States. *Bryologist*, 73(1): 145-149.
- Vitt, D.H. and Ramsay, H.P., 1985. The Macromitrium complex in Australasia (Orthotrichaceae: Bryopsida). Part1. Taxonomy and phylogenetic relationship. *J. Hattori Bot. Lab.*, 59: 325-451.
- Vitt, D.H., Crandall-Stotler, B. and Wood, A.J. 2014. Bryophytes, survival in a dry world through tolerance and avoidance. Plant ecology and evolution in harsh environments. New York, USA: *Nova Science*, 267-295.
- Vitt, D.H., Koponen, T. and Norris, D.H., 1993. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LIII. *Acta Bot. Fennica*, 148: 5-25.
- Vohra, J.N., 1969. A Contribution to the Moss Flora of Western Himalayas. *Nelumbo*, 11(1-2): 41-50.
- Vohra, J.N., 1970. A Contribution to the Mossflora of Western Himalaya-II. *Nelumbo*, 12(1-4): 97-103.

- Vohra, J.N., 1981a. *Pogonatum hexagonum* Mitt., an endemic moss to India from Silent Valley, Kerala. B.S.I. News Letter 7(1): 8.
- Vohra, J.N., 1981b. 250 mosses collected from Mullaperiyar and its catchment area in Idukki dist. of Kerala. B.S.I. News Letter 7(1): 2.
- Vohra, J.N., 1983. Hypnobryales suborder Leskeineae of the Himalayas. *Rec. Bot. Surv. India.*, 23: 1-336.
- Vohra, J.N., Roychoudhary, K.N., Ghosh, K.N., Kar, R.K., Singh, B.D. and Singh, R.K., 1982. Observations on the cryptogamic flora of Silent Valley. In: *Botanical Studies on Silent Valley*. Special Bulletin, pp. 1-40, Botanical Survey of India, Howrah.
- Vohra, V.N. and Kar, B.D., 1996. On a collection of mosses from Arunachal Pradesh. *Nelumbo*, 38(1-4): 46-54.
- Wadhwa, M., 1969-1971. Checklist of the moss flora of the Peninsular India including Western Ghats and Nilgiri. Parts I & II. M.V.M. *Patrika*, 4: 74-93; 6: 70-76.
- Wallich, N., 1841. Musci Indicae: Mosses collected in East Indies by Dr. N. Wallich. *J. Bot.*, 2: 1-21.
- Wang, J., Gradstein, S.R., Daniels, A.E.D. and Zhu, R.-L. 2014. New synonymy in *Ptychanthus striatus* (Lejeuneaceae, Marchantiophyta). *Phytotaxa*, 158(2): 195–200.
- Wang, J., Lai, M.J. and Zhu, R.L., 2011. Liverworts and hornworts of Taiwan: an updated checklist and floristic accounts. *Annal. Bot. Fenn.*, 48(5): 369-395.
- Wang, J., Lai, M.J. and Zhu, R.L., 2011. Liverworts and hornworts of Taiwan: an updated checklist and floristic accounts. *Annal. Bot. Fenn.*, 48(5): 369-395.
- Wang, M.Z. and Luo, J.X., 1994. A revision of Polytrichaceae of Hengduan Mountains in China. *Chenia*, 2: 33-44.
- Wasala, W.M.P.S. and Rubasinghe, S.C.K., 2019. Taxonomic treatment of the family Polytrichaceae Schwägr. in Sri Lanka. *Ceylon J. Sci.*, 48(1): 3-17.
- Wasala, W.M.P.S. and Rubasinghe, S.C.K., 2019. Taxonomic treatment of the family Polytrichaceae Schwägr. in Sri Lanka. *Ceylon J. Sci.*, 48(1): 3-17.
- Watanabe, R., 1991. Notes on the Thuidiaceae in Asia. 1. *J. Hattori Bot. Lab.*, 69: 37-47.
- Watson, W., 1925. The bryophytes and lichens of arctic-alpine vegetation. *J. Ecol.*, 13(1): 1-26.
- Weber, W.A., 1973. Guide to the mosses of Colorado: keys and ecological notes

- based on field and herbarium studies. *Institute of Arctic and Alpine Research. Occasional Paper*, (6). 6: 1-48
- Welch, W.H. and Crum, H., 1959. A contribution to the Jamaican moss flora. *The Bryologist*, 62(3): 165-179.
- Welch, W.H., 1969. Hookeriaceae Species and Distribution in Africa, Europe, Asia, Australia and Oceania. In: *Proc. Ind. Acad. Sci.*, 79: 377-387.
- Werner, O., Ros, R.M. and Guerra, J., 2002. Direct amplification and NaOH extraction: two rapid and simple methods for preparing bryophyte DNA for polymerase chain reaction (PCR). *J. Bryol.*, 24(2): 127-131.
- Whittier, H.O. and Miller, H.A., 1967. Mosses of the Society Islands: *Fissidens*. *Bryologist*, 70(1): 76-93.
- Wigginton, M. J., 2009. Checklist and distribution of the liverworts and hornworts of sub-Saharan Africa, including the East African Islands. *Trop. Bryol. Res. Rep.*, 8: 1–116.
- Wigginton, M. J., 2018. Checklist and distribution of the liverworts and hornworts of sub-Saharan Africa, including the East African Islands. *Trop. Bryol. Res. Rep.*, 9: 1–138.
- Wilbraham, J., 2016. Taxonomic notes on African Orthotrichaceae I. New synonymy in *Macromitrium*. *J. Bryol.*, 38(2): 87-93.
- Wilson R., Gradstein S.R., Schneider H. and Heinrichs, J., 2007. Unravelling the phylogeny of Lejeuneaceae (Jungermanniopsida): evidence for four main lineages. *Mol. Phylo. Evol.*, 43: 270-282.
- Windadri, F.I., 2019, August. Mosses diversity from Lombok island, West Nusa Tenggara. In *IOP Conference Series: Earth and Environmental Science*, 308: 1-8.
- Wolf, J.H., 1993. Diversity patterns and biomass of epiphytic bryophytes and lichens along an altitudinal gradient in the northern Andes. *Ann. Missouri Bot. Garden*, 928-960.
- Worley, I.A. and Iwatsuki, Z., 1970. A checklist of the mosses of Alaska. *Bryologist*, 59-71.
- Wu, P.-C., Crosby, M. R. and He, S., 2005. Sematophyllaceae–Polytrichaceae. 8. viii +385 pages. In *Moss Fl. China*. Science Press & Missouri Botanical Garden, Beijing, New York & St. Louis.
- Wu, Y.H., Gao, C. and Tan, B.C., 2002. The bryophytes of Gansu Province, China: a newly updated checklist. *Arctoa*, 11: 11-22.

- Yamada K., 1979. A revision of Asian taxa of *Radula*, Hepaticae. *J. Hattori Bot. Lab.*, 45: 201–322.
- Yamada, K. and Choe, D.M., 1997. A checklist of Hepaticae and Anthocerotae in the Korean Peninsula. *J. Hattori Bot. Lab.*, 81: 281-306.
- Yamada, K. and Iwatsuki, Z., 2006. Catalog of the hepatics of Japan. *Journ. Hattori Bot. Lab.*, 99:1-106.
- Yamaguchi, T., 1993. A revision of the genus *Leucobryum* (Musci) in Asia. *J. Hattori Bot. Lab.*, 73: 1–123.
- Yang, J.D., Yao, K.Y. and Lin, S.H., 2013. Two species of *Colura* (family: Lejeuneaceae) newly recorded to Taiwan. *Taiwan J. Biodiv.*, 15 (4): 331-341.
- Ye, W. and Zhu, R.L. 2010. *Leucolejeunea*, a new synonym of *Cheilolejeunea* (Lejeuneaceae), with special reference to new combinations and nomenclature. *J. Bryol.*, 32: 279-282.
- Yu-Huan, W.U., Chien, G. And Tan, B.C., 2002. The Bryophytes of Gansu Province, China: A New Annotated Checklist 11: 11-12.
- Zander, R. H., 1993. Genera of the Pottiaceae: mosses of harsh environments. *Bull. Buffalo Soc. Nat. Sci.*, 32: 378.
- Zander, R.H. and Eckel, P.M., 1993. Genera of the Pottiaceae: mosses of harsh environments. Buffalo, New York: *Buffalo Society of Natural Sciences*.
- Zander, R.H., 1994. *Didymodon* Hedw., In: A. J. Sharp, H. Crum & P. M. Eckel (eds.), The Moss Flora of Mexico, 299–319.
- Zanten, B. O. van., 1959. Trachypodaceae. *Blumea*, 9(2): 477-575.
- Zanten, B. O. van., 2006. A synoptic review of the Racopilaceae (Bryophyta, Musci). 1. Asian, Pacific and Australasian species of the genus *Racopilum*. *J. Hattori Bot. Lab.*, 100: 527–552.
- Zhang, L. and Corlett, R.T., 2003. Phytogeography of Hong Kong bryophytes. *Journal of biogeography*, 30(9): 1329-1337.
- Zhang, L. and Lin, P.J. 1997. A checklist of bryophytes from Hong Kong. *J. Hattori Bot. Lab.*, 81: 307-326.
- Zhao, J. and Han, L., 1999. A revision of the genus *Timmia* Hedw. (Timmiaceae, Musci) of China. *Acta Bot. Bor.-Occident. Sinica*, 19(1): 151-161.
- Zhao, W.-L., Liu, S.-X., Huang, J., Yu, R., Zheng, F.-X. and Li, J.-L., 2002. A study on the bryophyta plants resources in Hubei, China V. A preliminary list of the mosses of Triangle Hill in Xishui County, Hubei Province, China. *J.*

- Huanggang Norm. Univ.*, 22: 39–45.
- Zhu, R.L. and Gradstein, S.R., 2005. Monograph of *Lopholejeunea* (Lejeuneaceae, Hepaticae) in Asia. *Syst. Bot. Monogr.*, 74: 1–98.
- Zhu, R.L. and So, M.L., 1996. *Mosses & Liverworts of Hong Kong* (Vol. 2). Heavenly People Depot.
- Zhu, R.L. and So, M.L., 2001. Epiphyllous liverworts of China. *Beih. Nova Hedwigia*, 121: 1–418.
- Zhu, R.L., X.F. Bi and Shu, L., 2019. *Mohamedia*, a new genus of Lejeuneaceae (Marchantiophyta) from Oceania and tropical Asia. *Bryologist*, 122: 84–97.
- Zhu, R.L. and So, M.L., 1999. The genus *Leucolejeunea* (Hepaticae, Lejeuneaceae) in China. *Nova Hedwig.*, 68: 225–232
- Zhu, R.L., So, M.L., Wang, Y-F., 2002. The genus *Cheilolejeunea* (Hepaticae, Lejeuneaceae) in China. *Nova Hedwig.*, 75: 387–408.
- Zhu, Y., Buck, W.R. and Wang, Y., 2010. A revision of *Entodon* (Entodontaceae) in East Asia. *Bryologist*, 113(3): 516–589.
- Zuo, Q., Higuchi, M., Wang, Y.F., Arikawa, T. and Hirayama, Y., 2011. The status of *Struckia* Müll.Hal. (Plagiotheciaceae, Bryopsida) inferred from multiple nuclear and chloroplast loci. *J. Bryol.*, 33(3): 221–229.

Appendix 1

Glossary of technical terms

Abscission	Layer detaching from the stems that bear them at a predetermined place, the abscission zone.
Acrocarpy	Producing sporophytes at the tips of main stems.
Acostate	In mosses, lacking a nerves.
Acute	Tapering with nearly straight margins to a point with an angle less than 90
Adaxial	Facing towards a stem or an axis, hence leaf's "upperside" or "inner" surface.
Annulus	Ring, of sporophyte mouth with thick walled cells involved in opening of the sporangium.
Anomalous	Out of the ordinar, unlike others in its group.
Anterior	Positioned in front of another organ.
Antheridium (Plural antheridia)	A bryophyte's male reproductive organ.
Antherozoid (Spermatozoid)	A biflagellate sperm (male gamete) of a bryophyte.
Apical lamina	The upper portion of leaf above the vaginant laminae on the same side in the specialised leaf of <i>Fissidens</i> .
Apiculate	In mosses, leaf ending in a short point that's part of the leaf lamina rather than the tip of the costa.
Apiculus	A short abrupt point at a tip or apex.
Archegonium (Plural archegonia)	A bryophyte's female reproductive organ.
Auriculate	Equipped with ear-like structures, usually near the base.
Autoicous	Monoicous, producing both male and female sex organs on the same plant but in separate inflorescences.
Axillary	Said of anything that's located in an axil.
Axillary hyaline nodule	Cluster of enlarged hyaline cortical cells located in the axils of leaves, morphologically it is a branch primodia.
Bifurcating	Forking, dividing into two sharp branches or prongs.
Bistratose	Two cell layer thick.
Caducous	Falling off soon after formation, not persistent.
Calyptra	Enlarged remains of archegonia.

Capsule	A dry dehiscent fruit composed of two or more united carpels, opening by valves, slits or pores.
Cauline	Part of or belonging to the stem.
Central strand	A group of elongated cells with narrow lumina located in the center of the stem.
Chlorophyllose	Having chlorophyll and therefore green ,as in the ordinary leaf cells of most bryophytes.
Cladautoicous	Perigonia and perichaetia are terminal on elongate branches of the same plant.
Cladistics	A philosophy of classification that arranges organisms by their common ancestry, based on the branching of the evolutionary family tree, as perceived by shared character state.
Clavate	Club shaped; thickened towards the end.
Complanate	Flattened
Contorted	Irregularly bent, twisted and curved.
Convex	Curving or bulging out.
Corticolous	Living on bark.
Corrugate	Regularly or evenly wavy, folded or wrinkled in one direction.
Costa (Plural Costae)	Thickened mid rib or nerve of a leaf.
Crispate	Curled or ruffled.
Crenulate	Margin of leaf with small, crenate teeth.
Crumbled	Break or fall apart into small fragments, especially as part of a process of deterioration
Cucullate	Resembling or shaped like a hood.
Decumbent	Prostrate towards the base but erect or ascending towards the tip.
Decurrent	Said of leaf margins that extent below the leaf's insertion as ridges or wings on the stem.
Dentate	Prominently toothed with acute symmetrical projections pointing outwards.
Dichotomous	Forking,dividing into two equal branches.
Dimorphic	Having two distinctly different forms,
Dioicous	Perigonia and perichaetia are produced on separate gametophytes of more or less same size or the perigonial plant may be smaller.
Distal	Towards the apex of the structure or towards opposite end of attachment.
Distichous	Arranged in to opposite rows
Dorsal lamina	The wing opposite to the Vaginant laminae of <i>Fissidens</i> leaf.

Duplicate	Arranged or growing in pairs.
Ecostate	Leaves without a midrib.
Elimbate	Lacking a differentiated border for leaf.
Embryophyte	Any plant that produces an embryo during its life cycle.
Edangered	An organism seriously at risk of extinction.
Endostomes	In many mosses, the inner peristome, usually arising from a basal membrane and consisting of segments alternating with one or more thin cilia.
Epidermis	Outermost layer of stem.
Epilithic	Growing on rock.
Epiphyllous	A plant that grows on the living leaves of another plant.
Ephemeral	Short-lived, soon disappearing or remaining for a very short time.
Equitant	Clasping or straddling the stem
Etymology	Origin of the particular word.
Excurrent	Extending beyond the apex.
Exothecium	The outermost layer of cells in a sporangium.
Falcate secund	Falcate is curve of a leaf. term secund refers to the orientation of the leaves pointing in the same direction
Filiform	Filamentous, thread-like long and slender .
Fimbriate	Fringed.
Foot	The base of the sporophyte that is embedded in the gametophyte and extracts water, mineral nutrients and photosynthate.
Frondiform	Resembling a frond, as of a fern; having stem and leaves fused in one.
Fugacious	Lasting for a very short time or falling away early.
Gametophyte	The multicellular gamete producing generation of an embryophyte. It begins as a haploid spore shed by the sporophyte.
Gemma (Plural Gemmae)	Multicellular vegetative propagule, it may be subterranean (underground), rhizoidal, axillary and epiphyllous.
Gemmiform	Bud-like.
Greater lamina	The lower wing of vaginant laminae in <i>Fissidens</i> leaf.
Gregarious	Growing in groups and locally dominant.
Gonioautoicous	Gemmiform perigonal branches produced in leaf axils below a terminal perichaetium.

Guttula (Plural Guttulae)	One or more oil-like droplets in cell lumina or nucleus like hyaline spots.
Haplolepidous	Said of a joined peristome tooth in which each segment of its outer face is formed from remnants of the walls of only a single cell.
Holotype	A specimen that's designated as an authentic reference specimen by the author of a new species, subspecies or variety.
Homostichous	Minor laminae of all leaves in both sides of the stem oriented in a single rank.
Hyaline	Almost transparent.
Imbricate	Overlapping like tiles
Incrassate	Thick, stout.
Intra generic	Within the genus
Intra laminal / Intra marginal	Limbium/ semilimbium bordered with one or more rows of chlorophyllose laminal cells.
Invalid	A name or epithet that may be effectively published but is not in accordance with Articles 32-45 of the I.C.B.N.
Lamellae	A projection on the back of a peristome tooth.
Lanceolate	Narrowly ovate and tapering to a point at the apex.
Lectotype	In a case where a holotype was never designated for a scientific name, a specimen that's selected to act as the type, the selection is made by a later author from the material studied by the original author of the name.
Lenticular	A 3 –dimensional body that is circular in section and convex on both sides.
Laterally heterostichous	Minor laminae facing up on one rank of leaves in on side of stem and opposite in the other side.
lamina	In mosses, the flat blade of a leaf, not including the midrib if present.
Limbium (Plural Limbia)	A band of unistratose to pluristratose, hyaline to yellowish prosenchymatous sterile cells
Lingulate	Tongue shaped
Lithophyte	Plant growing on rock.
Lumen	(of cells) the space within the cell walls; (of spore wall) the space bounded by reticulations.
Macronemata	Rhizoids arising from the base of branches
Major lamina	Larger wing of vaginant laminae (Same as greater lamina)
Mamilla (Plural Mamillae)	Rounded projection of a uniformly thickened cell

	wall with nipple like tip.
Mamillate	Withnipple-like processes.
Microenvironment	The immediate environment of a taxa, especially as adistinct part of a larger environment.
Micronemata	a plant with micronemata has a dense coating of rhizoids over the entire stem up to the bases of the youngest leaves
Minor lamina	Smaller wing of vaginant laminae
Mitrate (or mitriform)	Shaped like a bishop's cap.
Monoicous	Antheridia and archegonia produced on the same plant.
Monomorphic	Having only a single form, not variable. All stems, exclusive of the gemiform(bud like) perigonal stems, are more or less the same length.
Monophyletic group	A single common ancestorplus all of its descendants.
Mucronulate	Ending in a very short stiff point.
Multistratose	More than one layer of cells
Obscure	Dark, indistinct or hard to see, as with leaf cells obscured by dence surface papillae or cell walls obscured by vacuoles.
Obtuse	Blunt, with the sides making an angle of more than 90°.
Operculum	In mosses ,the lid that blocks the capsule mouth;in liverworts, the apical portion of a sporangium that opens during dehiscence.
Outer cortical cells	Cells found beneath the epidermis.
Palmate (frondiform)	Arranged like the fingers of a hand
Papilla (Plural Papillae)	A minute solid protuberance on a cell surface or a local thickening of the wall.
Papillate	Roughened or ornamented with one or more papillae per cell.
Percurrent	Extending to the apex but not beyond
Perichaetium (Plural perichaetia)	Female sex organs plus the surrounding cluster of modified leaves.
Peripheral guide cells	On the edge
Perigonium (Plural Perigonia)	The male sex organs plus the cluster of modified leaves surrounding them
Peristome	A single or double circle of teeth inside the mouth of a moss capsule.
Phaneropore	A stomate that's fully exposed on the surface,with its guard cells on the same level as the adjacent exothelial cells.

Pinnate	Arranged like a barbs on a feather
Pluripapillose	Having several (2-6) papillae per cell.
Pluristratose	Three or more layered
Primordium	The embryonic stage of a leaf or other organ,made up of undifferentiated cells.
Protologue	The original description of a taxon; more correctly everything. Associated with a name at its valid publication.
Protonema (plural protonemata)	The first growth stage of a bryophyte,produced from a germinating spore ,gemma,or other propagule.
Polymorphic	Having more than one forms, highly variable. Perichaetial stems are much shorter and with fewer pairs of leaves than the infertile stems.
Polyoicous	Having the archegonia and antheridia sometimes on the same plant and sometimes on different plants
Polyphyllous	With many leaves or leaflets.
Polyploidy	The state of having three or more sets of chromosomes.
Prorate	Having a roughened surface caused by the protruding tips of prosenchymatous cells overlapping at their ends.
Prosenchymatous	Composed of prosenchyma, a tissue made up of long, tapering, parallel cells over lapping at their tips rather than joined end to end.
Protuberant	Bulging out
Proximal	Towards the base of the structure or towards the point of insertion.
Pseudautoicous	Although physiologically dioicous, the production of dwarf males to some degree mimics the male/female relationship of autoicous taxa.
Rejected name	Illegitimate, incorrect binomial rejected by I.C.B.
Rhizautoicous	Monoicous, with the perigonium can be gemmiform on a short branch attached to the perichaetial stem by rhizoids. It may be clustered around the base of perichaetial stem or scattered throughout the collection.
Robust	Strong, thick, vigorous.
Rostrate	Beaked.
Rosulate	Arranged in the form of a rosette or in rosettes
Ruffled	thallus bears lamellae on its dorsal surface that give a leafy appearance

Saxicolous	Growing on rock.
Scabrous	Rough to touch, with small pointed protrusions.
Scarious	Thin and dry, not green; also spelled scariose.
Semilimbium	Limbic cells not present throughout the leaf margin, present either on vaginallaminae alone or on vaginallaminae and at base of apical lamina.
Serrate	Toothed like a saw, with regular acute and angled teeth pointing towards the apex.
Serrulate	Minutely serrate.
Seta	Stalk of capsule.
Sheathing	Enveloping and enclosing, with a sheath.
Sinistorse	Twining spirally upward around an axis from right to left
Smooth	Lacking any surface irregularities such as papillae, spines, mamillae etc.
Specific epithet	In scientific names, the part that follows the genus name.
Sporophyte	The spore producing generation of an embryophyte. It begins as a diploid zygote formed by the fusion of an antherozoid and an egg.
Squamose	Covered with scales.
Stegocarpous	Having a capsule that opens by a deciduous lid
Stereid cell	“Stiffener” cells that support the leaves and stems of some mosses.
Strong limbium	Stereid cells of limbium elongate with sharply pointed ends and with a wall thicker than the diameter of the lumen.
Stomatose	Having stomata.
Sub percurrent	Not extending up to apex or ending many cells below apex.
Subterranean	Below the soil.
Subulate	Shaped like an awl, tapering to a fine point from a broad base.
Synous	Both antheridia and archegonia occur in the same perichaetium.
Synonym	The different names used for the same taxonomic group or taxon.
Terrestrial	On or in the ground.
Theca	The outer covering of sporophyte.
Tooth	Small pointed projection, usually triangular.
Trabeculate	Having the appearance of minute girders or crossed beams.

Unistratose	One cell layer thick.
Vaginant lamina (Plural Vaginantlaminae)	The clasping proximal (lower) portion of the <i>Fissidens</i> leaf. It is a slotted forward edge that sheaths the stem at leaf insertion.
Ventral	Synonymous with the abaxial or lower surface abaxial is technically more precise, whereas lower surface is easier to understand.
Vulnerable	Threatened in its survival.
Weak limbidium	Stereid cells of limbidium with more or less truncate (having a blunt end) end and the walls are usually thinner than the lumina.