

**ECO-SYSTEMATIC STUDIES ON BRYOPHYTES
OF WAYANAD, KERALA**

*Thesis submitted to the University of Calicut
in partial fulfilment of the requirements
for the degree of*

Doctor of Philosophy
in
Botany

by

Manju C. Nair

Department of Botany
University of Calicut
Kerala, India

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Dedicated

to.....my parents who made me dare a dream
to.....my friends who made my dream into a reality
to.....my teachers who guided through the way
and
to.....God, the essence of all.....

UNIVERSITY OF CALICUT

Department of Botany

Calicut University P.O. 673635 Kerala, India

(Mob) 9447170714 (O) 0494-2401144 Extn. 406, 407 (R) 0494-2400714 pvmadhu@sify.com Web: <http://pvmadhu.tripod.com>


Dr. P. V. Madhusoodanan

Professor
Collaborator, AICOPTAX
PI, KSCSTE Project

CERTIFICATE

Certified that the thesis entitled "**Eco-Systematic studies on the bryophytes of Wayanad, Kerala**" submitted by Ms. Manju C. Nair for the degree of **Doctor of Philosophy** in Botany of the University of Calicut is a bonafide record of research work done by her in this Department under my supervision. This has not previously been formed the basis for the award of any degree/ diploma.

Calicut University
03 February 2005




Prof. (Dr.) P. V. Madhusoodanan

DECLARATION

The thesis entitled "**Eco-Systematic studies on the bryophytes of Wayanad, Kerala**" submitted by me for the degree of Doctor of Philosophy in Botany of the University of Calicut has not been formed the basis for the award of any degree/ diploma to the best of my knowledge.

Calicut University

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Manju C. Nair

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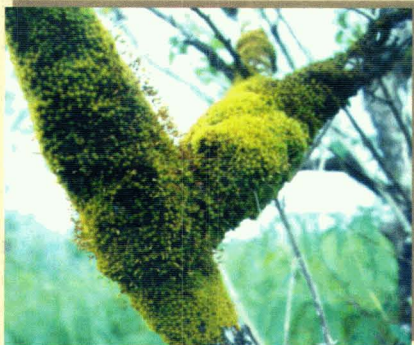
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INTRODUCTION

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Introduction.....

"I carried a basket for mosses and gathered some wild plants.
Oh! That we had a book of botany"

Dorothy Words worth

1. INTRODUCTION

Bryophytes are a diverse and distinct group of primitive plants, with about 25,000 species distributed the worldover, making it the second largest group of land plants next to the flowering plants. They are considered as “amphibians of plant kingdom” owing to their preference to aquatic and other wet habitat. Bryophytes are characterized by the absence of vascular tissues and having a unique life cycle with a dominant gametophyte generation except in few genera such as *Buxbaumia*. The sporophyte, which produces the spores, is dependent on the gametophyte for existence. The group includes three distinct lineages viz., liverworts, hornworts and mosses. They inhabit in a variety of microhabitats from the human habitation to higher altitude areas which includes soil (terrestrial), bark (epiphytic), leaves (epiphylls), rock (lithophytes) and water (aquatic). The diversity and frequency of bryophytes are maximum in the shady and wet regions compared to the open areas. The bryophytes are generally considered as a key group in our understanding of the phylogenetic interrelationship of modern land plants and pioneers in conquering the land with an environment hostile from their primitive home in fresh water.

1.1. ORIGIN AND EVOLUTION

Among extant embryophytes, bryophytes exhibit a series of traits suited similar to the aquatic habitat and thus appear as first batch for making the transition to land. The origin of bryophytes and their relationship to early land plants have been explained from the fossil records. The ancestors to land plants, particularly of fresh water origin were mostly growing close to a terrestrial habitat and thus exposed to temporal water level fluctuations. Such species could have overcome exposures to the aerial environment by developing drought resistant spores. The presence of cryptospores in sediments of Mid-Ordovician shows that the spores are arranged in permanent tetrads, a feature characteristic of land plants (Kenrick & Crane, 1997a). Some cryptosporic tetrads are reminiscent of bryophytes, such as the Sphaerocarpaceae (Gray, 1985). The ultrastructure of spore walls of *Dyadospora*

sp. and Sphaerocarpacean liverworts (Taylor, 1996) give evidence to the hypothesis that at least some of the early land plants have affinities with the liverwort lineage. The presence of trilete spores in the Lower Silurian period, shows bryophyte affinities, since trilete marks occur on spores of representatives of hornworts, liverworts, mosses and other land plants (Taylor, 1982). Cook and Graham (1998) suggested that Charophyceae and bryophytes have surface layers similar to the cuticle of vascular plants.

Except for *Torticaulis transwalliensis* the megafossils from the Mid to Upper Silurian exhibit no affinities to bryophytes and are related to vascular plants but with uncertain relationship (Kenrick & Crane, 1997a). The Sporogonites from Lower Devonian of Norway and Belgium consists of long, erect and unbranched axes bearing terminal sporangia similar to extant hepatics and the moss *Takakia* (Halle, 1916, 1936; Goffinet, 2000). Moreover, Sporogonites has a columella-like projection (Halle, 1936) a feature present in hornworts and primitive mosses Sphagnopsida, Andreaopsida and Takakiopsida (Schofield, 1985). But the systematic position of Sporogonites and thus its significance in the evolution of bryophytes remain uncertain (Kenrick & Crane, 1997b).

Hepaticites devonicus (Hueber, 1961) is the oldest unequivocal fossil bryophyte dates from the Upper Devonian and this plant is similar to the extant taxon, *Pallavicinia*. The earliest record of the moss in the fossil record is *Muscites plumatus* which could be from the Lower Carboniferous (Thomas, 1972), other fossils such as *Muscites polytrichaceous* and *M. bertrandi* are from the Upper Carboniferous (Krassilov & Schuster, 1984). The ornamentation of the Paleozoic spores *Streelispora* and *Aneurospora* has been compared to that of *Anthoceros*, and used as evidence to support the presence of bryophytes in the Silurian (Richardson, 1985). Eventhough the fossil record offers valuable insights into the taxonomic diversity of the early land plant flora, it fails to offer supportive evidence for the presence of bryophytes among early plant lineages (Goffinet, 2000). The lack of complexity and haplo-diplobiontic life cycle however, suggest that bryophytes compose a rather basal lineage of land plants.

The antithetic and homologous theories of evolution of land plants discuss the relationship of bryophytes and its origin. Bryophytes show a peculiar feature where the sporophyte is short-lived and attached to the dominant gametophyte. The gametophyte is free-living and the biflagellate male gametes require a film of water to reach archegonia. These reproductive constraints point to an aquatic ancestry and thus to the possible significance of bryophytes in the phylogeny of land plants. Hofmeister (1851) proposed that the life cycle of plants is composed of two phases, a gametophyte bearing sexual organs and a sporophyte producing spores, and that these fundamental phases are homologous among plants. Celakovsky (1874) examined Hofmeister's observations in an evolutionary context, and his hypotheses were later developed into antithetic or interpolation theory (Bower, 1890, 1908). This theory proposes that land plants arose from an algal ancestor with a haplobiontic life cycle, composed of heteromorphic phases, a multicellular gametophyte and a unicellular sporophyte. In bryophytes the sporophyte would remain attached to and at least in part nutritionally dependent on the gametophyte. Increase in mitotic divisions would allow for additional growth in body size of the sporophytes for more complex tissues to develop and thereby giving rise to early vascular plants. In this scenario, bryophytes or an organism allied to them represent the ancestor to the line that give rise to the tracheophytes. The fossil record however does not provide unambiguous evidence in support of this hypothesis.

In contrast to antithetic theory, the homologous theory (Pringsheim, 1878) suggests that the ancestor to land plants had two isomorphic, independent and thus autotrophic phases. The central point of the homologous theory is that from an ancestor with isomorphic gametophyte and sporophyte, two divergent lines of evolution with variant dominant phases are formed. Here the dominant phase varies. In the first line, leading to the bryophytes, the sporophyte underwent reduction while the gametophyte became more complex. In contrast, the pteridophytes would have arisen by amplification of the sporophyte at the expense of the gametophyte. Although the proponents of this theory still consider bryophytes and pteridophytes are related (Zimmerman,

1932), the latter would have arisen independently from the former. From this it is clear that bryophytes had no significance regarding the evolution of polysporangiophyta.

It is also evident that these two alternative theories are inconsistent. Even within the antithetic theory, a direct transition from a gametophyte dominated life cycle to a sporophyte dominated one appears (Kenrick, 1994).

A charophycean ancestry of embryophytes suggests that the multicellular sporophyte of land plants arose *de novo*, as meiosis is delayed by interpolation of mitotic divisions. The multicellular sporophyte evolved through interpolation of mitotic divisions prior to sporogenesis. Recent phylogenetic reconstruction of relationships among extant lineages of land plants converge toward a hypothesis where the hornworts compose the most basal group, with the moss and liverworts forming a monophyletic clade sister to the polysporangiophytes. The interpretation of the fossil from Devonian reveal the early land plants are characterized by nearly isomorphic gametophytes and sporophytes. This revived the hypothesis that bryophytes may have evolved from such forms, and thus, that the sporophytes of bryophytes is the result of reduction through the loss of the ability to branch and to develop multiple sporangia (Goffinet, 2000).

Based on recent morphological cladistic analyses, the classical group "bryophytes" appears not to be monophyletic. Instead, the mosses seem to be more closely related to the vascular plants than to the hornworts or liverworts (Mishler & Churchill, 1984, 1985; Bremer *et al.*, 1987). Even more recent molecular cladistic analyses confirm the non-monophyly of the bryophytes, and the relatively basal position of the liverworts, although the precise interrelationships of the mosses, hornworts and tracheophytes remain problematic (Mishler *et al.*, 1994).

1.2. SIGNIFICANCE OF BRYOPHYTES

Eventhough there are no direct uses for bryophytes, they are ecologically significant as playing a key role in ecosystem dynamics. In recent years the studies on the various applied aspects of bryophytes have come to light particularly on horticultural value, utilization as medicine, as seed bed for higher

plants, as rock and mineral builders, use as bioindicators (Ando & Matsuo, 1984), in ecosystem nutrient dynamics, in pollution detection (Bates, 2000) and on global carbon budget (Neill, 2000).

1.2.1. Horticultural uses

Horticulturalists and landscape architects have found them valuable, particularly the peat moss, for the construction of moss gardens and miniature gardens. They serve as ground cover for Bonsai, as soil additives, in mulching and root packing materials (Perin, 1962). Mosses such as *Leucobryum bowringii* Mitt. and *L. neilgherriense* C.Muell. are mixed with soil or sand for cultivation of *Rhododendron* shrubs. *Rhytidoropsis robusta*, *Thuidium delicatulum* Mitt. and *Hypnum imponens* Hedw. have been used for culture of Orchids (Adderly, 1964; Perin, 1962). In nurseries, *Campylopus* sp. is found being used extensively for air layering in Kerala as it maintains moisture for several days (pers. obs.).

In the present study area, W.D. Theuerkauf of Narayana Gurukula at Periya maintains a garden where the prime undergrowth is the bryophytes introduced from different areas of South India. Mostly they maintain bryophytes as beds for higher plants and as seed beds.

In Japan, *Rhodobryum giganteum* and *Climacium japonicum* are planted for bowl cultivation and landscape trays since it looks very attractive (Ando, 1957). Majority of the species provide a substratum for the growth of higher plants, hence in nurseries and in local gardens bryophytes are conserved properly.

1.2.2. Medicinal uses

Since ancient times bryophytes have been in use by mankind, but most of them were based on the 'doctrine of signature'. The liverwort, *Marchantia polymorpha* and *Conocephalum conicum* having the shape of cross section of animal's liver, were used for curing liver diseases (Miller & Miller, 1979), for treatment of jaundice and externally to reduce inflammation (Hu, 1987). *Riccia* sp. was applied externally for the cure of ringworm disease as rosettes of *Riccia* resemble to that of ring worm.

Mosses such as *Sphagnum* is known for the layman as a packing material from the early days. It was found as a better absorbent than cotton in addition to its antibiotic qualities and was frequently used for surgical dressing by the people in armies (Schofield, 1969). The oil extract from the 'hair cap moss' *Polytrichum commune* is used to beautify and strengthen the hair (Pant & Tewari, 1990).

Glime and Saxena (1991) mentioned that *Rhodobryum giganteum* and *R. roseum* have been used as crude drugs for the treatment of cardio-vascular diseases and nervous prostration. *Polytrichum commune* reduces inflammation and acts as antipyretic, laxative and hemolytic agent (Glime & Saxena, 1991; Hu, 1987).

Pant *et al.* (1986) reported that burned moss ash mixed with fat and honey in the form of ointment is used for cuts, burns and wounds by the people of Himalayan region. Pant and Tewari (1989) also reported that people in Pithoragarh of Uttaranchal district as well as in the villages of north-western Himalayas use *Marchantia polymorpha* L. or *M. palmata* Nees as a medicine for boils and abscesses.

Bryophytes display an interesting range of antibiotic activity. The lipophylic extracts of several liverworts such as *Bazzania*, *Frullania*, *Marchantia*, *Plagiochila*, *Porella*, *Radula*, etc. show antibacterial and antifungal activities (Asakawa, 1990). Some of the bryophytes have also been detected as inhibitory for carcinogenic growth (Belkin *et al.*, 1952-53). He first tried alcoholic and acidic extracts of *Polytrichum juniperinum*, on mice to test anticancer activity against sarcoma and found that the results were promising.

The local people at Attappadi of Palakkad district, Kerala State call mosses as 'kallupasa' and use a mixture of paste made from some leafy liverworts such as *Radula* sp. and *Spruceanthus semirepundus* to cure burns (Mr. M.Remesh, KFRI, pers.com.).

Although there is not much scientific evidence to support the effectiveness of these treatments, however some successful experimental and clinical evaluations are being carried out in China (Ding, 1982).

1.2.3. Pollution indicators

Bryophytes play a significant role as indicators of environmental pollution and these plants can be employed in developing an Index of Atmospheric Purity (IAP), because most of them have a sharply defined and rather narrow ecological range. These plants have been successfully used to monitor air borne pollution due to industrial emission. Nash (1972) in his studies on mosses such as *Ceratodon purpureus*, *Atrichum undulatum* and *Polytrichum piliferum*, revealed that *Atrichum undulatum* is one of the best bioindicator of air pollution.

Bryophytes have also been found to be useful as indicators of water pollution. Bryophytes are excellent indicators of acid rain damage to ecosystem (Nash & Nash, 1974) and they can also be used as indicators of climate change and thereby study its effects on ecosystem (Gignac, 2001).

Mosses are the most frequently used plants for monitoring metal pollutants in terrestrial habitats (Tyler, 1971). Some species such as *Scapania undulata*, *Fontinalis antipyretica*, *Jungermannia vulcanicola*, etc. are quite useful in monitoring heavy metal pollution. Certain species of bryophytes have also been reported to grow on particular mineral deposits. Copper mosses such as *Mielichhoferia elongata*, *Scopelophila lingulata* and *S. cataractae* prefer to grow in very high concentrations of copper, sulphur and heavy metals (Leimprieht, 1895). Due to this property, bryophytes can be used as tools for geological prospects (Pant, 1981).

1.2.4. Ecological importance

Many species of bryophytes are used in land conservation. Pleurocarpous mosses such as *Hygrohypnum*, *Thuidium*, *Brachymenium*, etc. form a dense packing over stones and soil and preserve the microhabitat from erosion. Important role of bryophytes in soil management is their quality to build up rocks. Emig (1918) has observed the rock building in a stream where the dense tufts of *Didymon* sp. are more commonly distributed along moist ledges extending across the shallow streams. His observation explains that mosses act indirectly in the precipitation of CaCO_3 mainly by providing a larger absorptive and adsorptive surface for the evaporation of calcareous water. Some mosses

play an important role in slope formation (Marsh & Koerner, 1972). *Barbula unguiculata* Hedw., *Weissia controversa* Hedw. and *Bryum* sp. are valuable in erosion control (Conard, 1935).

In addition to these, bryophytes play an important role as pioneer plants in occupying primary habitats as well as secondary habitats after disturbance. They serve as homes for many invertebrates, and often provide construction material for bird's nest. Pant and Tewari (1989) reported that in the remote villages at district Almora on way to Pindari Glacier, mosses locally known as 'muk', are still utilized for making comfortable beddings and cushions by the nomadic herdsmen.

1.3. PRESENT STATUS

Eventhough the Indian subcontinent is blessed with rich bryoflora, the detailed documentation is but far from complete. This is mainly due to the lack of infrastructure and resources. This group was gravely neglected, may be due to the less direct economic potentials and associated glory. Eventhough the studies in liverworts are done in some extent, we cannot claim to have thorough knowledge of our moss wealth because many parts lie virgin or unexplored. Regional exploration of such a large and diverse group of plants still remains untouched.

More bryo-exploration is essential in unexplored areas otherwise many species would perish and disappear before being documented from these potential areas. Day by day the bryophyte luxuriance is dwindling, being replaced by monstrosities or urbanization due to an increasing pressures of population and other anthropogenic activities.

Moreover the lack of taxonomic literature is another major inadequacy in the study of bryophytes. The difficulties are perhaps more acute in India especially in South India, since there are no modern bryophyte floras. The major work on Indian bryophytes is that of Gangulee's (1969-1980) Mosses of Eastern India and adjacent areas, which is yet to be completed. Much of the taxonomic literature is scattered and, for some groups, old and of limited value in identifying specimens. Identification of bryophytes is therefore very difficult

eventhough there are good libraries and herbaria available, in northern part of the state. Above all their small size and lack of trained specialist in this group make the identification more difficult.

1.4. OBJECTIVES OF THE PRESENT INVESTIGATION

1. To generate baseline data on the bryophytes of Wayanad district by undertaking a comprehensive field study with special reference to their distribution pattern along altitudinal and vegetation gradients.
2. To provide details of distribution, description and key to identification.
3. To study the basic ecological aspects of bryophytes.
4. To collect information on the uses of bryophytes from the study area.
5. Understanding the problems of conservation and documentation of the rare and threatened species in the study area.

1.5. RELEVANCE OF THE PRESENT INVESTIGATION

Bryophyte species tend to be highly specific with regard particular microenvironment factors such as temperature, light and water availability, substrate chemistry, etc. making them good ecological indicator species. Thus, bryophytes are attracting much attention recently from applied ecologists and conservation biologists. Despite this intrinsic interest and potential for scientific study, a major limitation in the use of bryophytes as study materials for evolutionary and ecological processes has been the lack of basic floristic and alpha taxonomic knowledge of the plants in many regions, especially in the tropics. The present work was undertaken with the objective of filling an informational gap so that an overall bryofloral picture of a mountainous district could be presented. Therefore, an attempt has been made to provide a record of bryophyte species collected from diverse habitats of the Wayanad. And this study also aims to present a model for the future eco-floristic studies on the bryophytes for the entire State.

STUDY AREA

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Study area.....

Love the haunts of nature,
Love the sunshine of the meadow,
Love the shadow of the forest,
Love the wind among the branches,
And the rain-shower, and the snow storm,
And the rushing of great rivers

Long Fellow

2. STUDY AREA

Wayanad district is one among the notable places in the Western Ghats of Peninsular India, due to its unique geographic position and its associated cultural and historical heritage and biodiversity. The area with 540 km² forms the major part of the well known Nilgiri Biosphere Reserve (NBR) in Kerala State (Fig. 1). It lies between 11° 40' and 12° 40' north latitudes and 75° 5' and 76° 10' east longitudes. A major part of the study area is bounded on the north east by Karnataka and east by Tamil Nadu states. The northern part of the area is bordered by Aralam Wildlife Sanctuary and Kottiyur range of Kannur Forest division and the west by Thamarassery and Peruvannamuzhi of Kozhikode district. The southern part is continuous with Kuttiady range and Vazhikadavu.

The name Wayanad is derived from 'Vayal' the Malayalam name for the paddy field or swampy area. In Sanskrit, the area is known by the name 'Mayakshethra' (Madras Manual of Administration Vol. III. p. 1025). This name has changed into Wayanad in Malayalam subsequently as 'Wayanad' orally. Wayanad has several names as Wayalnad, Wananad, Vazhinad and Veeravayalnadu.

The forest area in the tract is divided into Wayanad Wildlife Sanctuary and Reserved forests. The total extent of the Wayanad district is 520.78 km² of which Wayanad Wildlife Sanctuary (WWLS) includes 344.44 km² and is divided into two discontinuous portions with revenue lands in between. The north west portion of the sanctuary has only one range *viz.*, Tholpetty (between 11° 50' and 11° 59' N and 76° 2' and 76° 7' E) and has an area of 77.67 km². This range is continuous to Rajiv Gandhi National Park in Nagerhole of Karnataka in the North east, Kakkenkotte Reserved Forest of Karnataka in the north and Brahmagiri Hills of North Wayanad Division in Kerala in the East. The southern portion of the sanctuary (between 11° 35' and 11° 49' N and 76° 13' and 76° 27' E) consists of three ranges *viz.*, Kurichiad, Bathery and Muthanga with a total area of 266.77 km².

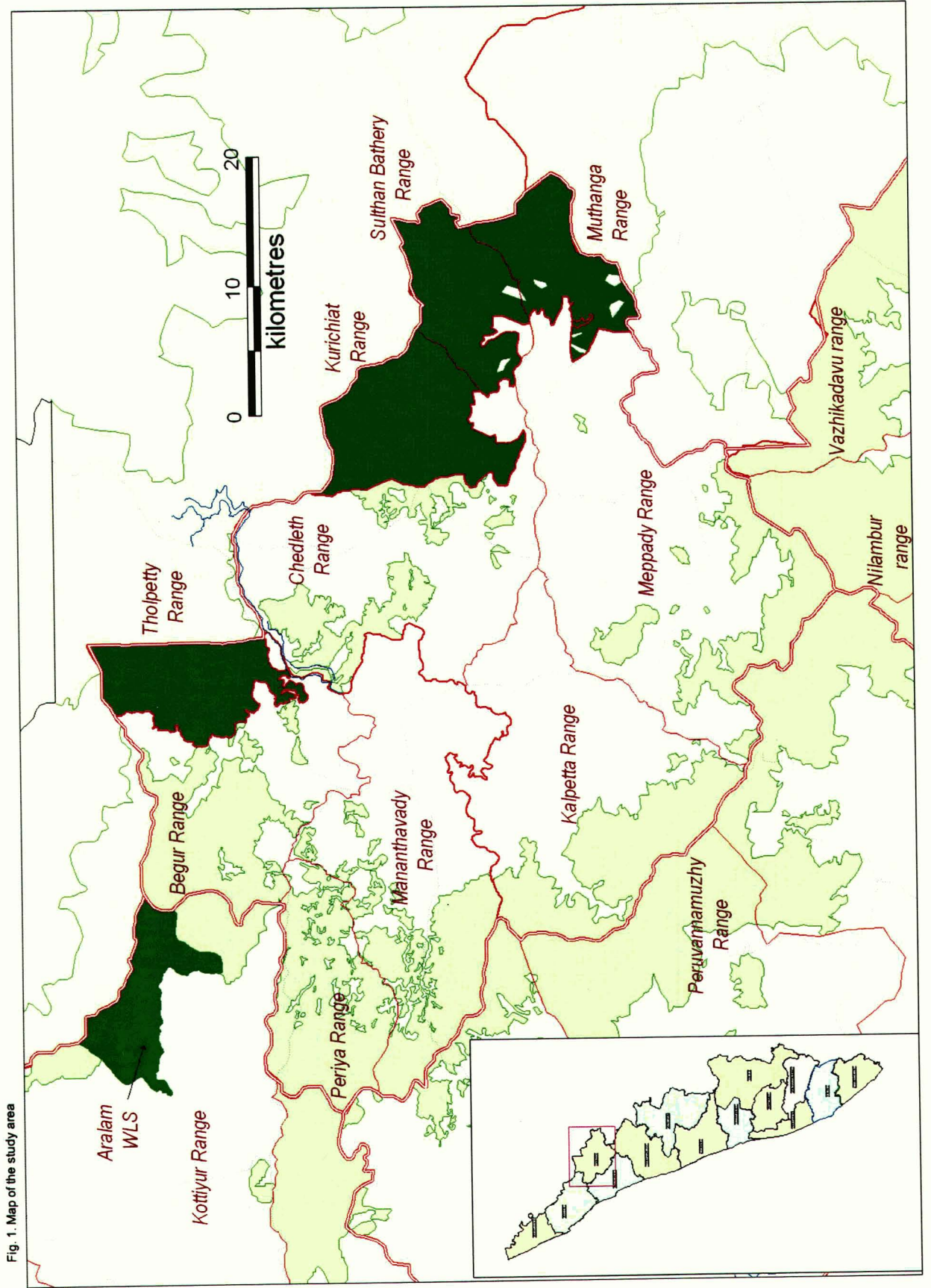


Fig. 1. Map of the study area

10 A
11

During the dawn of the century, the area was protected as Reserved Forests under the jurisdiction of Chedelesh Range. Subsequently Sulthan's Bathery Range was formed in 1924. After, 1958 south Wayanad was under Kozhikode forest division and north Wayanad under Wayanad Forest division. The area was declared as a sanctuary in 1973 and brought under the Wayanad Wildlife Division in 1985.

The sanctuary forms a significant part of the catchment area of *Kabini river* which flows into Karnataka. Northern part of Kurichiad range is drained by *Kannarampuzha* and *Kurichiat thodu* which flow northward and join with the *Kabini river*. Towards the south east, *Manjal thodu* and other streamlets join with the *Nuguhole river* which flows further north east to Karnataka. Southern portion of the sanctuary is drained by *Nulpuzha* and *Mavinahalla thodu* which combine to form the *Nuguhole river*. *Manjal thodu* and other small streams in the sanctuary become dry during peak summer season. *Nulpuzha* is the main perennial streamlet in the study area.

The reserved forest is under two administrative divisions, Wayanad north and south divisions. North division constitute Mananthavady, Periya and Begur ranges. South forms Kalpetta, Chedelesh and Meppadi ranges. The area of reserved forest falls between 11° 40' and 12° 40' north latitudes and 75° 5' and 76° 10' east longitudes. The Begur range comprises an area of about 266 km². It is contiguous to Mudumalai Wildlife Sanctuary (MWLS) of Tamil Nadu in the east and Bandipur Tiger Reserve (BTR) of Karnataka in the North and North east.

The elevation of the hills forming the Reserved forest varies from 700 m to 2,100 m above sea level, the highest peak being Brahmagiri in Tirunelli Reserve. In the Wildlife sanctuary the elevation ranges from 850 m at Muthanga to 1,147 m in Kurichiad range. At boundaries the elevation even come down to 100 m.

The maximum temperature ranges from 24° C in July to 31° C in March. December is the coolest period with 14-19° C. The average relative humidity ranges between 60% in January and 88% in June. The southwest monsoon which brings the greater part of the total rainfall bursts normally at the first week



a. Evergreen forest- view from Periya



b. Shola forest- view from Chembra hills

12-A 13

of June preceded by a few showers in April and May. The heaviest rainfall occurs in July and August. The northeast monsoon brings some showers in October and November.

The soil of the slopes of the main ridge is red sandy loam, generally 10 to 15 feet deep. On the plateau, the soil is rich clayey loam, generally with a depth of 2 to 4 feet having sub soil either a red gravel or yellowish clay of considerable depth.

2.1. Vegetation types in the study area following Champion & Seth (1968)

The forest areas of the Wayanad division can be broadly classified as

2.1.1 Tropical Wet Evergreen forests

2.1.2. West Coast Tropical Semi Evergreen forests

2.1.3. Southern Tropical Moist Deciduous forests

2.1.4. Southern Montane wet grasslands

2.1.5. Plantations

2.1.1. Tropical Wet Evergreen forests: This type is the climax of the tropical rain forest formation and is found usually at elevations above 700 m. It descends to 350 m in the Kottiyoor valley. The tropical rain forest formation is characterized by a very large number of inhabiting species. It is also characterized by a luxuriant growth of evergreen trees of different sizes and shapes arranged in three different stories. The main blocks of the evergreen forest occur in Periya, Kannothe, Kottiyoor, Meppadi and Begur Reserves (Plate 1a). The common liverworts in this type of forests include *Dumortiera hirsuta*, *Riccardia multifida* and *Asterella khasiana* and the mosses are *Garckea flexuosa*, *Hyophila involuta* and *Cryptopapillaria fuscescens*. The diversity and frequency of the bryophytes are maximum in this type of forests.

2.1.2. West Coast Tropical Semi Evergreen forests: This is an intermediate forest type between the wet evergreen and moist deciduous and therefore supports heterogenous mixture of species of two major types. The semi evergreen forests are confined to portions of Kannothe, Kottiyoor, Tirunelli and Kalpetta Reserves and Kurichiad range of the Sanctuary. The bryophytes

occurring in these forests is same as those of wet evergreen forests and diversity is also high.

2.1.3. Southern Tropical Moist Deciduous forests: A major portion of the WLS falls under this category. This type of forest occurs in the Wayanad plateau at elevations between 760 and 1,160 m and also in the plains below 150 m in elevation. During the dry season, most of the trees shed leaves and canopy cover is comparatively less. Bamboo brakes are distributed sporadically all over the habitat, including the perennial streams and wet areas. The upper canopy consists of *Terminalia tomentosa*, *T. paniculata*, *Pterocarpus marsupium*, *Tectona grandis*, *Grewia tiliaefolia*, *Adina cordifolia*, etc. The middle canopy comprises *Schleichera oleosa*, *Kydia calycina*, *Bridelia retusa*, *Cinnamomum zeylanicum*, etc. Major plants of the ground are *Helicteres isora*, *Lantana camara*, *Eupatorium odoratum*, *Zizyphus xylocarpus*, *Hibiscus furcatus*, etc. A few climbers such as *Butea parviflora*, *Caesalpinia* sp., *Calycopteris floribunda* are also seen. The species composition of bryophytes in these forests varies from that of wet evergreen and semi evergreen forests. The species diversity is maximum near to riparian habitat and some species such as *Frullania acutiloba*, *Frullania tamarisci*, *Lejeunea* sp., *Floribundaria walkeri*, *Fissides ceylonensis*, etc. are common. A notable feature in these forests are the occurrence of Termite mounds which harbours a variety of mosses such as *Fissidens ceylonensis*, *Hyophila involuta* and *Cyathodium cavernarum*.

2.1.4. Southern montane wet temperate forests: These forests are seen in the upper reaches of Thirunelli areas, Periya in north division and Chembra hills in southern division (Plate 1b). The forest type of Chembra hills ranges from tropical wet evergreen to montane subtropical forest, associated with vast areas of grassland. The shola patches are seen from about 1,500 m extending up to 1,800 m. The vegetation is characterized by trees, shrubs, ferns and orchids. Some of the common tree species found in this area are *Litsea floribunda*, *Cinnamomum* sp., *Syzygium wightianum*, *Myristica* sp., *Oreocnide integrifolia*, and *Aporosa lindleana*, *Bischoffia japonica*, etc. Shrubs that are found in this area include *Psychotria* sp., *Maesa indica*, *Ixora sivarajiana*, *Ardisia pauciflora*, *Saprosma* sp., *Eurya nitida*, etc. Herbs include *Justicia betonia*, *Ophiorrhiza*

prostrata, *Pilea melastomoides*, *Anaphalis wightiana*, *Osbeckia cupularis*, *Christisonia tubulosa*, etc. Climbers such as *Calamus* sp., *Piper* sp., *Smilax zeylanica* and Orchids such as *Oberonia wynadensis*, *Cymbidium aloifolium*, *Bulbophyllum nilghiriense* and *Pholidota pallida* are also present on the trunks of mature trees. In shola's the bryophyte diversity is maximum and the species distribution is unique compared to other types of forests. The diversity of the liverwort genus *Plagiochila* is maximum in these forests. *Dumortiera hirsuta*, *Thuidium tamariscellum*, *Hypopterigium aristatum*, *Racopilum orthocarpum*, etc. are common in sholas. Some rare species such as *Trichocolea tomentella* and *Jungermannia appressifolia* are also observed in these areas. In grasslands the habitat specific species such as *Entosthodon wichurae*, *Campylopus flexuosus*, *C. ericoides*, etc. are common with maximum frequency.

2.1.5. Plantations: Total area of the plantation in the study area is about 163 km² and Teak (Plate 2a) and Eucalyptus form major plantation crops. The teak plantations are of different age groups ranging from 80 years to the recently regenerated one. The area is occupied by the weed *Lantana camara*. Most of these plantations have a belt of natural forests and good undergrowth of shrubs, herbs and grass species. The bryophyte species diversity and abundance is minimum in these artificial forests. The common species found in these areas are *Fissidens ceylonensis*, *Garckea flexuosa*, *Hyophila involuta* and *Bryum argenteum*.

2.2. Human habitations and Cultivation

The study area is occupied by large number of settlements where cultivation is practised. These settlements are near to the moist deciduous forests and teak plantations. The people occupy almost all the 'vayals' with perennial water sources. A population of more than 25,000 live in and around the protected area. The cultivation of food crops in plantation coups during the first two years of their opening and the cultivation of coffee, pepper, arecanuts, oranges and single crop paddy are the main features of the local agricultural practice.

The tribes living in the forest plateau are the Kurichiars, Kurumbas, Paniyans, a few Kattunaikans and Uralis. The Paniyars and the Kurumbas



a. Teak plantation in Wayanad Wildlife sanctuary



b. Riparian habitat- Mananthavady puzha near Thirunelli

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residing inside the forests of the Wayanad plateau are the major Wayanad hill tribes. Some of the settlements are occupied by non-tribes.

The Paniyans are an aboriginal race, owning no land, but cultivating paddy for the chetties, an agricultural community, living almost entirely in the unreserves. They speak an aboriginal language and also a dialect of Malayalam. Occasionally, they practice shifting cultivation in the virgin forests if the local subordinates are in cordial relations with their chetty masters. At present, they live by extending labour to neighbouring estates as well as to the Forest Department.

The Kurumbas of the Wayanad fall under three categories, the Mullu (Bamboo) Kurumbas, the Bet (Felling) Kurumbas, and the Jen (Honey) Kurumbas. Of these, the Mullukurumbas are socially and economically advanced. They cultivate various crops in the adjoining wetlands and own cattle. They work for the forest department as and when needed. The Bet Kurumbas are the local axeman. They do much work for neighbouring estates but the forest dwellers depend upon the departmental extraction of timber for their livelihood. The Jen Kurumbas are the least civilized of the jungle tribes. They mostly live in the forest, depending on honey, roots, fruits, etc.

The Kattunaikans are considered as the least civilized among the tribes and depend on the forest by collecting non-wood forest produces such as honey, tubers, fruits and medicinal plants.

For the last several years, there has been an influx of land hungry people from Central Travancore. These people, who are very expert farmers have occupied large tracts of private forests belonging to 'Jenmies', the land lords. The demand made them on the reserved forests is very little.

The diversity of bryophytes in and around the settlement is very little represented by few common species such as *Hyophila involuta*, *Fissidens ceylonensis* and *Garckea flexuosa*. Some species such as *Meteoriopsis squarrosa*, *Frullania acutiloba*, *Porella campylophylla*, etc. are seen as epiphytes in the plantation trees. The diversity of these species is very low due to human interference.

HORTI
MALABARICI
PARS DUODECIMA, & ULTIMA.

DE

HERBIS

Puem-peda. Lut.

சுவசுவசு Mal.

بونه چھوڑا Arab.

Tab. 37.



HENRICUM VAN RHEDE TOT DRAKESTEIN,

Topographus et Mychthi, Malabarici Regni G. Senatus, Legatus, Consul, et
Indiæ Belgicæ Societatis Extraneus, & Eques Ordinis sancti Huberti
et Praeceptoris Praesidis et Ultramarinae Provinciae adscriptus.

In orbem reuocata & Latinitate donata.

ABRAHAMUS A POOT M. D.

Review of the literature.....

Natura particularis, & Commentarius descriptivus

JOANNES TOMMELINUS

"As we cannot know the reason for a fact before
We know the fact,
We cannot know what a thing is before we know that it is

Accedit, prout supra praescriptum, generis totius Oryzae Index

Aristotle

3. REVIEW OF THE LITERATURE

The first ever work dealing exclusively with taxonomy of bryophytes was by Dillenius's *Historia Muscorum* (1741), which also includes algae, lichen, lycopods, etc. Linnaeus (1753) in his *Species Plantarum*, which is considered as the beginning for the principle of priority for *Sphagnum* included some Indian mosses also. Hedwig's (1801) *Species Muscorum* is considered for applying the priority in case of other mosses. Mitten's (1869) *Musci Austro-Americani* and Spreuce's (1884-1886) *Hepaticae Amazonicae et Andinae*, formed the foundation for American Bryology. During early part of the present century, bryophytes collected mainly by missionaries, from different parts of the world including the tropics, were worked out in Europe by Mitten (1869), Mueller (1905-1916) and others but who had never seen these plants in living condition.

Jussieu (1836) used the term 'mosses' to include true mosses. However the remaining groups was not known at that time. It was Brown (1866) who introduced the term "Bryophyta" a Greek word derived by combining 'Bryon' = moss, 'phyton' = plant and treated under 'Acotyledonae' which included algae, fungi, lichen and mosses, but not the liverworts. Eichler (1883) divided Bryophytes into two classes, the Hepaticae to include all liverworts and Musci to include all mosses. Engler (1892) subdivided each of the two classes into three orders. Hepaticae was divided into Marchantiales, Jungermanniales and Anthocerotales and Musci into Sphagnales, Andreales and Bryales. The anomalous position of Anthocerotales as an order of the class Hepaticae was pointed out by many investigators very early itself. However, it was Howe (1899) who gave the class status to the order Anthocerotales. He named it Anthocerotes and divided the bryophytes into three classes viz., Hepaticae, Anthocerotes and Musci. Many eminent Hepaticologists such as Smith (1955) and Schuster (1958, 1966) have accepted the system of Howe (1899) with a modification of the term Anthocerotes as Anthocerotae.

The studies on the mosses of India is said to have commenced when the road to Nepal was opened. The first step towards our knowledge of the moss

flora of this region was done by Buchanan Hamilton, a Medical Officer in British Embassy in 1802, who first collected mosses from Nepal. The first paper on the mosses of this region *Musci Nepalensis* was published in 1808 by Hooker, who later (1818-1820) described several species for the first time. This was followed by two papers on Indian muscology jointly published by Hooker and Greville (1825). Schwaegrichen (1811-1842) included some Indian mosses in his supplement to Hedwig's *Species Muscorum*. Royle (1839) reproduced the catalogue of Wallich, which contains a list of 113 species of mosses mainly from Nepal, of which 55 species listed by Royle himself from Mussoorie (Western Himalayas). This also includes a brief note on hepatics and liverworts. Wallich (1841) enumerated 148 mosses collected in East Indies, with reference to the figures of new species published in Hooker's *Icones Plantarum*. Montagne (1842a & b) published an account of the mosses from the Nilgiris. Subsequently Griffith (1842, 1843) published an account of a number of mosses and liverworts from Khasia hills in Meghalaya. Collections of liverworts from the Himalayas by Wallich and Wight were also included in the *Synopsis Hepaticarum* of Gottsche *et al.* (1844, 1847).

The first noteworthy contribution to Indian bryology in its early days can be found in Griffith's (1849a & b) *Notulae and Plantae Asiaticae*. The *Icones Plantarum Asiaticarum*, which was based on his collections during 1835-1838, was published posthumously. His discovery of the remarkable monotypic liverwort *Monoselenium tenerum* Griff. attracted attention all over the world. Mitten and Wilson (1857) enumerated the mosses collected by J.D. Hooker and Thomson from India. Mitten's (1859) *Musci Indiae Orientalis* was the most important comprehensive work embodying all the Indian species known at that time. He recorded nearly 800 species belonging to 85 genera and 19 families including a large number of novelties. Later Mitten (1860, 1861) published *Hepaticae Indiae Orientalis* a comprehensive treatment of Indian liverworts, which included the diagnoses of several new plants, and a detailed list of all Indian liverworts known till date. This work was mainly based on collections by Hooker from the Himalayas, the Khasia hills, by Hooker and Thomson and from Sri Lanka by Gardner and Thwaites respectively.

Mueller (1853, 1854a & b, 1869-1870, 1871, 1878) brought out several articles on the Indian mosses. Hampe (1872-1873) described some Sri Lankan mosses based on Beccari's collection. Mitten (1873) published an account of the mosses of this Island collected by Thwaites describing a number of new species under the joint authorship of Thwaites and Mitten. Reference to mosses from India can also be seen in the publications of Jaeger (1870-1879).

In the post-Mitten period much progress has been made through direct and indirect contributions. Brotherus (1898) described a few mosses from North Western Himalayas. Subsequently in 1899 he published an account of 96 species of mosses from Coorg in the Western Ghats including 20 novelties. Schiffner in 1898 brought out an exhaustive list of species recorded till then from East India.

Stephani's *Species Hepaticarum* (1906-1924) in six volumes, a world monograph on liverworts, included description of a large number of taxa from India, Myanmar, Sri Lanka and adjoining Indian territories such as Nepal, Madura and the Andaman and Nicobar Islands. Eventhough the status of the plants included in this treatment were questioned by the modern bryologists, this work still remains as a valuable reference to the present workers. Other noteworthy contributions in this period were those of Mueller's (1901) "*Scapaniae Indiae Orientalis*" and Gola's (1914) on Kashmir Hepatics. Contributions by Dixon (1910, 1930, 1942), Bruehl (1931), Bartram (1955, 1960) and Robinson (1956) on Indian hepatics also added further information.

3.1. Liverworts

The liverworts received more attention than mosses by Indian botanists. The detailed studies on Indian bryology was started by S.R. Kashyap, the father of Indian Bryology. He in 1914 published an article on 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) include 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, 1976a,b), 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* viz., *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. In 1925 Kashyap and Dutt described *Notothylas indica* Kashyap from the plains of Uttar Pradesh.

Pande and Kashyap (1922) published the life history of *Aneura indica* Steph. The configuration and formation of sexual organs in *Marchantia palmata* Nees. were studied by Choudhuri (1927). Khanna (1929) carried out a comprehensive study of the morphology of *Cyathodium kashyapii*. Later, he (1936) described a new species of *Anthoceros* viz., *A. kozhii* Khanna, based on the collections from Kerala, and also made a comparison of all the then available twenty species of *Anthoceros* in India describing their sexuality, size, structure, involucre, capsule, spores and also the distribution. Sethi (1931) worked on the morphology and life history of *Sauchia spongiosa* (Kashyap) S.Hatt.

Verdoorn (1930,1934) published a monograph of Indo-Malayan Frullaniaceae and Jubulaceae and also described a new variety, *Frullania gravilleana* var. *gebaueri* Verd., from the Darjeeling. In 1932 Pande made an exhaustive study on the gametophyte and sporophyte of *Notothylas indica* Kashyap. He in 1934 studied the species *N. levieri* Steph. ex Schiffn. in detail and has also made a historical review of the genus *Notothylas* and studied the gametophyte and sporophyte characters.

Pande (1936) published the first review on the studies of Indian liverworts and commented on the contributions made by eminent earlier workers in India such as Griffith, Mitten, Stephani, Kashyap, Gola, etc.

Chopra (1938a) in his notes on South Indian Hepatics, based on the Herbarium specimens in the Punjab University, recorded three new species and several new records. He (1938b) also listed three species of *Riccia* along with a list of species and several new records for Southern India. A study of *Aitchisoniella himalayensis* Kashyap was carried out by Ahmad (1938) and found that this monotypic, monoecious genus occurs only in India. Later, Ahmad (1942) described three new species of *Riccia* of which *R. mangalorica* Ahmad (= *R. plana* Taylor) was collected from Mangalore, the other two *R. gangetica* Ahmad and *R. orientalis* Ahmad (now treated as *R. hirta* (Austin) Underw.) were collected from Uttar Pradesh and Kumaun Himalayas respectively. Chopra (1943b) opined that *Riccia gangetica* Ahmad could not be treated as a separate species, as it does not differ from *R. himalayensis* Steph ex Kashyap.

The studies on the chromosomal analysis in Indian liverworts were first carried out by Mehra. He (1938) determined the chromosome number of Indian members *Fossombronia himalayensis* Kashyap, *Petalophyllum indicum* Kashyap and *Sewardiella tuberifera* Kashyap and found the basic chromosome number as $x=9$. Srinivasan (1940) studied the morphology, life history and cytology of *Riccia himalayensis* Steph. ex Kashyap collected from Madras and its suburbs and determined the haploid chromosome number as $n=8$. Developmental morphology and cytology of *Marchantia palmata* Nees were also worked out by Srinivasan (1944) and its haploid chromosome number was determined as $n=9$. Srinivasan in 1945 reported the occurrence of some peculiar spores in *Dumortiera hirsuta* Reinw., et al. Mehra (1948) also studied the chromosome number of *Cryptomitrium himalayense* Kashyap. Following this, he carried out some more cytological investigations (Mehra, 1959; Mehra & Khanna, 1961; Mehra & Pathania, 1959). His theories on the origin of the thallus in Marchantiales, their evolutionary trends (Mehra, 1957a & b, 1969) and the phyletic evolution in the hepaticae (Mehra, 1967) are commendable

contributions. He also contributed to the embryological studies of liverworts (Mehra & Khanna, 1950; Mehra & Sokhi, 1972; Mehra & Vasishta, 1950).

Mehra and Handoo (1953) studied the morphology of *Anthoceros erectus* Kashyap and *A. himalayensis* (= *Phaeoceros himalayensis* (Kashyap) Prosk.) and provided a note on the phylogeny of Anthocerotales. Mahabale (1941) described *Aspiromitus dixianthus* from Khandala, near Poona. Pande and Srivastava (1942) described a new species of *Nowellia indica* (= *Delavayella serrata* Steph.) from the Western Himalayas. Later Pande and Misra (1943a) published a new species *Leptocolea himalayensis*, from this area. Pande (1958) commented that this could also occur in South India and Eastern Himalayas. Pande and Misra (1943b) published an illustrated account of five species of epiphyllous liverworts viz., *Rectolejeunea aloba* (Sande-Lac.) Steph., *Leptolejeunea himalayensis* Pande & Misra, *L. lanciloba* Steph., *Cololejeunea himalayensis* Pande & Misra, and *C. hispidissima* (Steph.) Herzog. Among these *Leptolejeunea himalayensis* and *Cololejeunea himalayensis* were new to science. All the species were collected by H.S.Rao, L.Pfleiderer and S.K.Pande, from Gersoppa falls and Kudremukh in Southern India and the study was later continued by Pande *et al.* (1957). Chopra (1943a) published a *Census of Indian Hepatics* enumerating 626 species representing 114 genera and 18 families. This work also contain a very useful key to genera.

Pande and Bhardwaj (1949) in their studies on Indian Hepaticae reported three species viz., *Conocephalum supradecompositum* (Lindb.) Steph., *Anthoceros crispulus* (Montin) Douin and *Aspiromitus harrisanus* Steph., as new to Indian flora.

The genus *Megaceros* was first reported from India by Schiffner and Pande (1950) as *M. stahlia* Steph. This species was reported to be highly restricted in Java and Darjeeling (Pande, 1958, 1960). Pande and Bhardwaj (1952) commented on the status of Indian Hepaticology with a note on the hepatic vegetation of the country. A preliminary survey of the Hepatic vegetation of Pachmarhi by Pande and Srivastava (1952) revealed 32 species of liverworts, belonging to 23 genera and 13 families and Kaul (2001) updated the list incorporating later developments since 1952.

Studies conducted on the genus *Asterella* by Pande *et al.* (1953a & b) reported the occurrence of abnormal female receptacles in *Asterella blumeana* (Nees) Kachroo and *A. khasiana* (Griff.) Pande. Pande *et al.* (1954a & b, 1955) described *Riella viswanathai* Pande, Misra & Srivast. (= *Riella affinis* Howe & Underw.) and also studied the Indian Metzgerineae with a detailed analysis of the morphology and development of *Fossombronia himalayensis* Kashyap and *Sewardiella tuberifera* Kashyap. An elaborate study of some of the little known Indian species of *Asterella* was provided by Pande *et al.* (1954c). They had reported *A. multiflora* Steph. and *A. maculata* Steph. and provided an account on the distribution of Indian species of *Asterella*.

Pande and Srivastava (1953b) gave an account of the distribution of the genus *Pallavicinia* in India, including *Pallavicinia canarus* Steph. from India, a species established by Ghosh and Chakravarty (1943). Pande and Srivastava (1955) described *Cephalozia herzogiana* from Pachmarhi, Madhya Pradesh.

Kachroo (1954a) discussed the distribution of the family Rebouliaceae with about 39 species in India. Kachroo (1956) provided an account on the morphology of *Pallavicinia ambigua* (Mitt.) Steph., *P. lyellii* (Hook.) Gray and *P. longispina* Steph.

Udar (1956) recorded two species of *Riccia sorocarpa* Bisch. and *R. hueheneriana* Lindenb., two common European species as new records for India from Sikkim-Himalayas. Pande and Udar (1957a) studied the Indian species of *Riccia* and described a new species, *R. aravalliensis* Pande & Udar from Mt. Abu. Pande and Udar (1958) described 11 species of *Riccia* from South India including a new species *viz.*, *R. tuberculata* Pande & Udar (= *R. grollei* Udar). Two of the little known species *viz.*, *R. melanospora* Kashyap and *R. plana* Taylor have been described in detail and *R. intermedia* Jones and *R. bengalensis* Khan reported from Tropical Africa and East Pakistan respectively have been synonymised with *R. discolor* L. and *R. billardieri* Montin respectively. Udar (1959) described a new species, *Riccia pandei* Udar from Garhwal with a note on six other species of *Riccia viz.*, *R. hirta* (Austin) Underw., *R. pathenkotensis* Kashyap, *R. discolor* L. & L., *R. gangetica* Ahmad, *R. billardieri* Montin & L. and *R. aravalliensis* Pande & Udar collected from the

West Himalayan region. A detailed account on the sporeling germination and taxonomy of *Riccia pimodii* Kachroo (= *R. billardieri* Montin & Nees) was published by Kachroo (1959).

Pande *et al.* (1957) described four species of epiphyllous liverworts, viz., *Taeniolejeunea peraffinis* (Schiffn.) Zwickel, *T. pseudofloccosa* (Horik.) Hattori, *Leptolejeunea schiffneri* Steph. and *Drepanolejeunea foliicola* Horik. Srivastava (1957) worked on the spermatogenesis in *Notothylas levieri* Schiffn. and determined the haploid number of chromosome as $n=5$. Pande and Srivastava in 1957 made a review on the musci and liverworts known from India.

Proskeur (1957) carried out culture studies on *Phaeoceros* sp. from the monsoon flora of Mussoorie in the Western Himalayas. A systematic treatment of *Riccardia levieri* Schiffn. was carried out by Pande and Srivastava during 1958. Banerji (1958) published a note on the morphology and ecology of 23 liverworts of east Nepal. Kachroo (1958) presented an account on the morphology, development of sex organs, sporogonium and inter-relationships of various genera of the family Rebouliaceae. Bapna (1958) published a note on the hepatic flora of the Mt. Abu. Schiffner *et al.* (1959) gave a detailed account of *Riccardia palmatiformis* Schiffn. and *R. decolyana* Schiffn. in their series on the genus *Riccardia* Gray in India.

Pande *et al.* (1959) studied *Riccardia palmatiformis* and *R. decolyana*. Pande and Singh (1959) added *Jamesoniella microphylla* (Nees) Schiffn. to Indian bryoflora from Kodaikanal. Pillai (1961) reported the occurrence of the sporophyte of *Jungermannia viridis* Kashyap for the first time.

A detailed account of the Indian species of the genus *Chiloscyphus* and *Heteroscyphus* was provided by Pande *et al.* (1960). Srivastava (1960) made a detailed study on the species *Riccardia levieri* Schiffn. from India. In 1961 he studied *Pallavicinia lyellii* (Hook.) Carruth. and added further information on Indian Metzgerineae. Inoue (1960) discussed some species of *Plagiochila* from the Himalayas. Inoue (1965) gave a synopsis of *Plagiochila* in the Himalayan region including North-Western India, Nepal, Sikkim and Bhutan. Earlier account on about 70 species of the genus in this region are available in Mitten (1861), Schiffner (1899) and Stephani (1906, 1924).

Parihar (1961-1962) listed 38 species of *Anthoceros*, four species of *Notothylas* and one species each of *Megaceros* and *Dendroceros* from India. Of the 38 species of *Anthoceros*, seven were transferred to *Folioceros* and seven under *Phaeoceros* (Udar & Singh, 1981a). Kachroo (1967b) provided a comparative account of the under leaves of the genus *Schusteria*, proposed by him during 1957 with that of *Diplasiolejeunea*. Bapna (1961a) made a note on the validity of *Riccia media* Klingmuller. He described two new species of this genus from Jodhpur (Bapna, 1961b) and from Mt. Abu (Bapna, 1962). Bapna and Vyas (1962) studied the bryophytic vegetation in Mt. Abu and noted that this area was dominated by thalloid liverworts representing 6 genera of Marchantiales, 3 genera of Anthocerotales and 4 thalloid Jungermanniales. Bapna (1968) reported the genus *Petalophyllum* from Western Ghats and also the occurrence of abnormal female receptacles in *Plagiochasma appendiculatum* Lehm. & Lindenb. (Bapna, 1971).

The genus *Calobryum* was added to Indian liverwort flora by Udar and Chandra (1961) from Darjeeling. From the same locality *Haplomitrium hookeri* (Smith) Nees was also reported for the first time from Asia (Udar & Chandra, 1965b). Kachroo and Bapna (1963) in their extensive studies on *Riccia* in India recorded several species adding insight on the extended distribution of many species. A census of the Indian *Riccia* with annotated key was provided by Kachroo in 1969.

Chandra (1963) reported the occurrence of branched female receptacles in *Reboulia hemisphaerica* (L.) Raddi in a collection from Kodaikanal. Udar and Chandra (1964a) reported branched female receptacles in *Marchantia griesea* from Ootacamund and added *Exormotheca ceylonensis* Meijer as new to Indian bryophytic flora from Kodaikanal (1964b). Another species of *Exormotheca* viz., *E. tuberifera* reported by Kashyap in 1914 from western Himalaya has reported from South India by Joshi (1984) and from central India by Kaul *et al.*, in 1995.

Udar and Chandra (1964c) described one new species, *Plagiochasma pauriana* Udar & Chandra and in 1965a two novelties *Mannia foreaui* and *M. perssonii* from Garhwal Himalaya. A study of the genus *Athalamia* in South

India was carried out by Udar and Srivastava (1965) based on *A. pusilla* (Steph.) Kashyap collected from Nilgiri hills.

Bhardwaj contributed much to the group, Anthocerotales. He (1950, 1960a) published detailed accounts on the morphology of *Anthoceros crispulus* (Montin) Douin and *A. gemulosus* Steph., the latter now is treated as a synonym of *A. angustus* Steph. (Asthana & Srivastava, 1991). He (1960b) also studied *A. erectus* Kashyap in detail. In 1965a he gave a detailed account of *A. mamillisporus* (D.C.Bhardwaj) D.C.Bhardwaj and *A. dixitianus* (Mahabale) Prosk. The former was collected from the Kottayam district in Kerala by Mr. N. Pillai and the latter from Mangalore by Mr. A. Ramanatha Rao. He (1965b) studied some aspects of the morphology of *Phaeoceros*. Bhardwaj in 1971 established a new genus, *Folioceros* in Anthocerotales for some species, which now be referable to *Anthoceros*, having thickening in their elaters. In this he has also described a new species, *Folioceros assamicus* D.C.Bhardwaj and four new combinations. Bhardwaj (1973) while studying the taxonomy of some Indo-Pacific species, collected by Stephani and reported as *Aspiromitus*, transferred to *Folioceros* as *Folioceros mangaloreus* (Steph.) D.C.Bhardwaj, *F. spinisporus* (Steph.) D.C.Bhardwaj, *F. glandulosus* (L. & L.) D.C.Bhardwaj and *F. fuscus* (Steph.) D.C.Bhardwaj.

Mizutani (1967) studied 12 species of *Bazzania* from the Himalayas which includes the territories of Nepal, Sikkim, Bhutan and north eastern India and also gave an account of another five species of doubtful occurrence. Mizutani (1968) gave details of *Lepidozia flexuosa* Mitten from Darjeeling, Sikkim and Myanmar. Udar and Srivastava (1967) came across a remarkable *Metzgeria* in Stephani's Herbarium, with unusually prominent midrib and hairy sexual shoots on both sides.

Kachroo in 1954b reported *Anthoceros assamicus* and *Riccia kashyapii* from Assam and *Anthoceros shivanandini* from Kerala in 1967(a) with an account of *Phaeoceros laevis* L. and *Anthoceros carolianus* (L.) Prosk., now belonging to *Phaeoceros laevis* (L.) Prosk. subsp. *laevis* Prosk. and *P. laevis* (L.) Prosk. subsp. *carolianus* (Michx.) Prosk., respectively, and pointed out that

the two species might be conspecific. Asthana and Srivastava (1991) pointed out that the occurrence of *Anthoceros assamicus* Kachroo is doubtful. Kachroo (1968) described the history of the genus *Cheilolejeunea* and proposed four new genera viz., *Schusteria* Kachroo, *Cardiolejeunea* Schust. & Kachroo, *Cryptolejeunea* Schust. & Kachroo and *Cladocolea* Schust. & Kachroo. Kachroo (1969, 1970 a & b, 1973; Kachroo *et al.* 1977) in the taxonomic survey of the Indian Hepatics of India enumerated several species. In part-I the status of the problems and prospects of the taxonomy of Indian Hepaticae since Mitten, was discussed. In part-II, he dealt with families Takakiaceae through Marsupellaceae and in part-III with Plagiochilaceae through Pleuroziaceae. In these genera were listed with valid species and hitherto known synonyms, critical notes and keys to identification of species. In part-IV a taxonomic account of the family Lejeuneaceae was provided. Kachroo *et al.* (1977) continued the work and described taxonomy of Fossombroniaceae through Anthocerotaceae.

Udar and Srivastava (1969) reported *Fossombronia cristula* Austin from Kodaikanal of South India as a new record for India. Subsequently (1972a) they described a new species *Fossombronia foreaui* Udar & S.C.Srivast. from the same locality. Srivastava and Udar (1975b) have given a detailed account on the genus *Fossombronia* in India, including a note on the other taxa of the family Fossombroniaceae.

In a series of papers Hattori (1967, 1969, 1970, 1971a) described the Asiatic species of the genus *Porella*, which include accounts of several Indian species. Hattori (1972a) elaborately discussed the problems of *Frullania tamarisci* (L.) Dumort. Complex. Hattori (1971b, 1975 a-f) made detailed studies on the Anthocerotae and Hepaticae of eastern Himalaya. Hattori and Mizutani (1968) described the Asiatic species of *Pseudolepicolea* including two Indian species viz., *P. trollii* (Herzog) Grolle & Ando from Sikkim and East Nepal and its variety *darjeelingensis* S.Hatt. & Mizut. from Sandakphu and Tonglu in the Eastern Himalayas.

Mehra and Sokhi (1976) made a comparative morphological study of spermatozoids in the members of Hepaticae and Anthocerotae with a phylogenetic approach.

Udar and Srivastava carried out the sporeling development studies in *Exormotheca ceylonensis* Meijer (1968), *Preissia quadrata* (Scop.) Nees (1970b) and in *Fossombronia cristula* Austin (1972b) respectively.

Udar and Srivastava in 1970(a) described a new species of *Metzgeria* viz., *M. indica* Udar & S.C.Srivast., the only Indian species producing antical or dorsal gemmae. In 1971 they described a new species of *Cyathodium* viz., *C. denticulatum* Udar & S.C.Srivast. from Darjeeling. Srivastava (1972) gave a taxonomic account of *Riccardia platyclada* Schffn., including the sporophyte characters. Tayal and Saxena in 1973 described some liverworts from Dehra Dun and Bir in 1975 from Simla.

Udar and Nath (1973, 1975), during their studies on South Indian Hepaticae, reported *Cephalozia siamensis* and *Leucolejeunea xanthocarpa* (Lehm. & Lindenb) A.Evans as new records to India. Udar and Srivastava (1973a) in their series of *Notes on South Indian Hepaticae* gave a well illustrated taxonomic account of the three species of the genus *Herberta* in Southern India. Observations on the sporeling development in *Lophocolea bidentata* (L.) Dumort. (= *Chiloscyphus latifolius* (Nees) Engel & Schust.) were presented by Udar and Srivastava (1975a). Srivastava and Udar in 1975(a) also studied the sporeling development in *Fossombronia kashyapii*. In their study of the genus *Fossombronia* Raddi in India (Srivastava & Udar, 1975b) all the seven species occurring in India were dealt in detail, of which six were found in Southern India. Other outstanding contributions by them were the monographic studies on the families Metzgeriaceae 1975c) and Aneuraceae (1976).

Udar (1976b) presented a comprehensive account of the studies of Indian bryophytes in his highly appreciated work *Bryology in India*. He brought out the current trends in Indian bryology and attempted to update the information on a vast spectrum of topics such as cytology, physiology, etc. Udar and Kumar (1976) gave an account of five species of *Cephalozia* from Eastern

Himalayas, of which four were new to science viz., *C. darjeelingensis*, *C. pandei*, *C. laxifolia* and *C. indica*. Udar and Chandra in 1977 described *Notothylias pandei* Udar & Chandra from the vicinity of the Jog falls, Karnataka.

Studies on oil bodies in liverworts, which has been of great taxonomic significance in foliose forms, were started in India by Udar *et al.* (1970a). Udar and Nath (1971, 1976a, 1977) described the details of oil bodies in 12 South Indian Liverworts from Palni hills. Udar *et al.* (1978) described the oil bodies in 15 liverworts belonging to eight genera of Metzgeriales collected from various parts of India. The significance of oil bodies in the taxonomy of the family Frullaniaceae was discussed by Udar and Nath in 1979 based on a study in 10 species of *Frullania* and one species of *Jubula*.

Udar and Nath (1975) added *Leucolejeunea xanthocarpa* (Lehm. & Lindenb.) A.Evans to Indian flora. Udar and Srivastava (1975b) on their studies on South Indian Hepaticae gave an illustrated taxonomic account of *Trichocolea tomentella* (Ehrh.) Dumort. and *Notoscyphus lutescens*, which were also found in eastern Himalayas. Udar and Singh in 1977 described two new species of the genus *Trichocolea* viz., *T. indica* and *T. tenera* from Darjeeling.

Kumar and Udar in 1977 reported a new species of *Haplomitrium* viz., *H. grollei* from Darjeeling. Another species, *H. kashyapii* was described from the same locality by Udar and Kumar in 1982(b). Bapna (1977) studied *Anthoceros longii* Steph. (= *Phaeoceros laevis* subsp. *laevis*) from Mt. Abu, in Rajasthan and concluded that it as a distinct and valid species differing from *A. erectus* Kashyap in sexual and morphological characters.

Udar and Srivastava in 1978 studied the spore morphology and sporeling development in *Cyathodium aureonitens* (Griff.) Mitt. Srivastava in 1979 presented a list of Hepaticae of Kashmir Valley, including 43 species belonging to 24 genera and 14 families. Among these, *Frullania muscicola* Steph., *Lophocolea minor* Nees (= *Chiloscyphus minor* (Nees) Engel & Schust.), *C. polyanthus* (L.) Corda and *Riccia frostii* Austin were first reports for this Valley. Srivastava in 1995 conducted detailed studies on *Chiloscyphus polyanthus* (L.) Corda the only representative of *Chiloscyphus* in eastern Himalaya. Abnormal

elaters of phylogenetic importance in the liverwort, *Frullania grandistipula* Lindenb. have been observed by Nath in 1984. Nath and Udar (1984) described in detail, some species of *Frullania* from India having entire amphigastria such as *F. duthiana* Steph., *F. evelynae* S.Hatt. & Thaith., *F. hattoriantha* Udar & Nath, *F. physantha* Mitt., *F. sharpantha* Udar & Kumar and *F. yuennanensis* Steph.

Srivastava and Udar (1979) in their studies on the distribution of Metzgerials in India reveals that the Southern India hosts 25 species of which 13 are common to east Himalayan territory. Udar and Singh (1979a) added *Notothylas dissecta* Steph. from Agumbe of Karnataka to the Indian flora. The description of *Notothylas pflidereri* Udar & Singh from Mangalore (Udar & Singh, 1979b) was another significant contribution. Udar and Singh (1979c) described *Notothylas anaporata* based on specimens associated with *Cyathodium aureonitens* (Griff.) Mitt. collected by Pande during 1955.

Udar and Awasthi (1979) described *Leptolejeunea sikkimensis* from Sikkim. Lal (1979, 1980) reported *Frullania tuyamae* S.Hatt. & Thaith., with numerous marginal gemmae on the leaves, from Manipur and also reported *Colura ari* Steph. from Andamans, for the first time from Indian territory. Udar and Kumar (1980a) described *Cephaloziella indica* from Kalimpong in Eastern Himalayas.

The description of *Notothylas khasiana* from Shillong (Udar & Singh, 1981b) was followed by seven new combinations, made by them (Udar & Singh, 1981a) under *Phaeoceros*. Singh in 1995(a) made a revision of two species of *Notothylas* viz., *N. indica* Kashyap and *N. levieri* Schiffn. He in the same year (1995b) made a study on the distribution of Indian Notothylaceae and commented on their phytogeographical significance.

Sharma *et al.* (1981) carried out palynological studies on 20 species of liverworts of Garhwal Himalayas and noticed the diversity in sporomorphs. Gaur and Nautiyal (1981) listed 29 thallose liverworts from Srinagar and adjacent areas. The study of the genus *Archilejeunea* in India (Udar & Awasthi, 1981a) revealed two species viz., *A. apiculifolia* and *A. minutilobula* Udar &

U.S.Awasthi. Udar and Awasthi in 1981(b) described *Lejeunea indica* from Eastern Himalayas. Later they (Udar & Awasthi, 1982a) studied the genus *Schiffneriolejeunea* in India and found that out of the four species, *S. indica* (Steph.) Udar & U.S.Awasthi (= *S. pulopenangensis* (Gottsche) Gradst.) and *S. polycarpa* (Nees) Gradst. are restricted to Southern India, the former in Karnataka and the latter in Tamil Nadu.

The genus *Drepanolejeunea* in India was studied by Udar and Awasthi (1982b) and found that out of the five species of this genus, two species and a variety of the third species only were occurring in India. Udar and Awasthi (1982d) added *Dicranolejeunea yoshinagana* (S.Hatt.) Mizut. to Indian bryoflora, based on a specimen collected from Marcara of Karnataka. A detailed study of the genus *Notoscyphus* in India (Udar & Kumar, 1980b) revealed that the genus was represented by four species in India including two new species viz., *N. darjeelingensis* from Darjeeling and *N. pandei* from Gangtok, Kurseong and Shillong and all of them occurring in Southern India also.

Taxonomic details of *Jackiella javanica*, a rare and interesting liverwort, was another worth mentioning contribution of Udar and Kumar (1981a). The genus *Chandonanthus* in India was studied by them in 1982(a) and found that all the three species of this genus occurring only in Eastern Himalayas. *Gottschelia schizopleura* (Spruce) Grolle, a rare species and the lone representative of the genus in India were reported from Avalanche in Nilgiri hills (Udar & Kumar, 1982c). This was followed by the recording of *Chonocolea schusteri* (Udar & Kumar, 1982d) from Bandishola, in Tamil Nadu, extending the distribution from Neotropics to Paleotropics. *Cylindrocolea reticulata* was a remarkable member, described by Udar and Kumar (1982e) from Eastern India.

Udar and Shaheen (1982a) described a variety of *Porella chinensis* (Steph.) S.Hatt. viz., var. *crispata* Udar & Sharma from the Himalayas. *Marchantia kashyapii*, which was found commonly distributed in Nilgiri and Palni hills, was described by them (Udar & Shaheen, 1982b). This was followed by the report of *Folioceros pandei* from Kodaikanal, with its taxonomic details (Udar & Shaheen, 1982c). Later, they (Udar & Shaheen, 1982d) furnished the

details of Indian plants of *Porella gracillima* Mitt. var. *urogea* (Mass.) S.Hatt. (= *P. gracillima* Mitt. subsp. *urogea* (Mass.) S.Hatt. & Zhang.). Udar and Shaheen (1983a) gave a detailed account of *Porella perrottetiana* (Montin) Trev., a taxon originally described from Nilgiris. In 1983(b) they described another variety of *P. chinensis* (Steph.) S.Hatt. viz., var. *hattori* Udar & Shaheen from the Himalayas.

Based on the *Cololejeunea* collection from Agumbe of Karnataka Udar & Srivastava (1982, 1983a) described 3 new species viz., *C. pandei* Udar & G.Srivast., *C. dentifolia* Udar & G.Srivast. and *C. mizutaniana* Udar & G.Srivast. Udar *et al.* (1982) reported *Geocalyx*, a rare marsupial genus, from the Western Himalayas, for the first time from Indian territory. Morphological and anatomical details of the genus *Radula* Dumort. in India were worked out by Udar and Kumar (1982) based on the new species, *Radula nilgiriensis* Udar & Kumar and *R. tabularis* Steph., both collected from Nilgiri hills. Udar *et al.* in 1982 described *Caudolejeunea pluriplicata* Udar *et al.* and in 1983, *Lopholejeunea gradstenii* Udar, both from Agumbe in Karnataka.

The differentiation in development of the West Himalayan complex of *Targionia* was analysed in detail by Udar and Gupta (1981) and found that two morpho-forms exist in that area. Later, they (Udar & Gupta, 1983) studied the Himalayan as well as South Indian complex of this genus and described a new species, *T. indica*. According to them the South Indian complex consists of *T. lorbeeriana* Muell. and *T. indica*.

Udar and Awasthi (1983) studied the genus *Leucolejeunea* in India. Out of the three species of this genus represented in India, *L. xanthocarpa* (Lehm. & Lindenb.) A.Evans was the only one species reported from Southern India. Udar and Srivastava (1983a) worked out the reproductive biology of some Indian liverworts and found that reproductive limitations like non-viability of spores, etc. in several taxa impose great restriction on their distribution.

Jungermannia (Plectocolea) tetragona Lindenb. from Andaman Islands has been described with a note on its range of distribution in India by Udar and Kumar (1983a). Udar and Kumar (1983) described the South Indian endemic

species *Radula pandei* Udar & D.Kumar from Agumbe and Mercara of Karnataka and Mukkali-Silent Valley of Kerala. Udar and Awasthi (1984) reported *Schiffneriolejeunea indica* (Steph.) Udar & U.S.Awasthi (= *S. pulopenangensis* (Gottsche) Gradst.) from the bark of Rubber tree from Kottayam and Mannarkkad of Kerala State which was earlier reported from Karnataka. This was followed by the report of the *Acrolejeunea sikkimensis* (Mizut.) Gradst. from Kottayam as epiphytic on Rubber plants (Awasthi, 1984) which was known in India from the Western Himalayas only (Udar & Awasthi 1981c). Awasthi and Srivastava (1985) again reported the same species from Kerala.

Pant and Singh (1984) reported the unusual production of gametophytes from Carpocephala and rhizoidal furrow in *Marchantia polymorpha* L. and *M. palmata* Nees. Awasthi and Udar (1984) carried out detailed observations on the genus *Mastigolejeunea* in India and reported two species viz., *M. humilis* (Gottsche) Schiffn. and *M. repleta* (Taylor) A.Evans and described a new variety viz., *M. humilis* var. *ciliata* U.S.Awasthi & Udar. The former species was found having a wider distribution in Kerala. Udar and Jain (1984) listed 14 species of Marchantiales belonging to eight genera from Thrissur, Idukki, Wayanad and Kottayam districts of Kerala. This was the first exhaustive investigation on the liverworts of Kerala.

Udar and Asthana (1985) described *Anthoceros pandei* from Nagaland. Subsequently Udar and Agarwal (1985) studied the genus *Riccia* in Pachmarhi and provided the SEM details of spores of *R. cavernosa* Hoffm. and *R. stricta* Duthie & Arnell. *Colura acroloba* (Montin) S.Jovet-Ast. was reported by Udar and Awasthi in 1985 from Port Blair in Andaman Islands, as a new record to Indian territory.

Udar and Shaheen (1985) provided a detailed account of the rare genus *Ceratolejeunea* in India with its sole representative *C. singaporensis* (Lindenb.) Schiffn. collected from Lakkidi in Kerala. Udar *et al.* (1985) published a paper on the reproductive biology of *Stephensoniella brevipedunculata* Kashyap, an endemic liverwort in India along with its SEM details of spores.

Udar and Kumar (1985) reported two species of the family Cephaloziellaceae, *Cylindrocolea tagawae* (N.Kitag.) Schust. and *Cephaloziella kiaerii* (Austin) Arnell. In which *Cylindrocolea tagawae* is the sole representative of the genus described for the first time from India. Another one *Cephaloziella kiaerii* (Austin) Arnell is the only one species of *Cephaloziella* occurring in South India. Srivastava and Asthana (1986) described a new species of *Folioceros* viz., *F. udarii* from Silent Valley of Kerala.

Srivastava and Asthana (1987) studied the morpho-taxonomy of *Anthoceros crispulus* (Montin) Douin from South India. In 1988 Joshi and Desai reported the antimicrobial properties of *Fossombronia himalayensis* Kashyap. After examining in detail Awasthi and Srivastava (1988) reported that the genus *Brachiolejeunea* does not occur in India, and the species earlier known under this genus belongs to allied *Frullanoides* or *Tricholejeunea*.

Srivastava and Srivastava (1989) reported *Cololejeunea cardiocarpa* (Montin) Steph. as new record to India and described a new species, *C. foliicola* from Southern India (without precise locality). Asthana and Srivastava (1995) recorded the genus *Cololejeunea* subgenus *Leptocolea* viz., *C. longifolia* (Mitt.) Benedix and *C. minutissima* (Smith) Schiffn. from India. Recently Long and Grolle (1990) have enumerated 2 species of Anthocerotales and 235 species of Hepaticae collected by Dr. D.G. Long on two expeditions to Bhutan in 1979 and 1982, among these 37 species were new records for the Himalayas.

Possible anisospory is reported for the first time in four species of Hepaticae viz., *Targionia indica* Udar, *T. hypophylla* L., *Cyathodium aureonitens* (Griff.) Mitt. and *C. barodae* Chavan by Pant and Singh (1989). This report was based on observations of wide variations in size of spores comparable with those of anisosporous mosses of the family Orthotrichaceae.

Asthana and Srivastava in 1991 gave a detailed description regarding the taxonomy of Indian Anthocerotae. In this, they had given the history of Anthocerotae and a taxonomic account of Indian *Anthoceros* (9 species), *Folioceros* (12 species), *Phaeoceros* (3 species with 2 sub species), *Megaceros* (1 species) and *Notothylas* (8 species). Joshi *et al.* (1992) have studied the

hepatic flora of Andaman Islands. Nath and Asthana (1992) reported *Frullania neurota* Taylor from Western Himalaya. This species was known earlier from eastern Himalaya and South India. Singh (1994) epitomizes the causes of extinction and rarity of the Hornwort taxa. Asthana and Nath in 1994 provided a detailed account of five species *Phaeoceros* viz., *P. laevis* (L.) Prosk. subsp. *laevis*, *P. laevis* subsp. *carolinianus* (Michx.) Prosk., *P. himalayensis* (Kashyap) Prosk. ex Bapna & Vyas., *P. kashyapi* A.K.Asthana & S.C.Srivast. and *P. udari* A.K.Asthana & Nath collected by them from the Western Himalayas. This also contains ecological notes and distribution map.

Srivastava *et al.*, in 1994 studied the liverworts on Tea plantations in a Tea garden in Darjeeling hosting 6 species viz., *Plagiochila duthiana* Steph., *P. forficata* Schiffn., *Porella campylophylla* var. *lingulifera* (Tayl.) Hatt., *Frullania neurota* Tayl., *Lejeunea flava* (Sw.) Nees and *Microlejeunea punctifomis* (Tayl.) Spr.

Asthana *et al.* (1994) gave an illustrative account of the rare Indian liverwort, *Schiffneria hyalina* Steph. and discussed its taxonomic status and SEM details of spores and elaters. A morpho-taxonomic account of nine Indian species of *Cheilolejeunea* was provided by Asthana *et al.* (1995). In this they described two new species viz., *C. ghatensis* G.Asthana, *et al.* and *C. udarii* G.Asthana, *et al.* They have also provided details of phenotypic variation and reproductive structures for most taxa which was not adequately known to date. Srivastava and Srivastava in 1995 gave a taxonomic account of four species of the genus *Scapania* (Dumort.) Dumort., viz., *S. ciliatospinosa* Horik., *S. parva* Steph., *S. orientalis* Steph. and *S. verrucosa* Haeg. from Lilam in Kumaun region of western Himalayas.

Kapila and Kumar in 1995 made studies on morphology, cytology and chemical analysis of the long lost liverwort *Monoselenium tenerum* Griff. collected from Sundernagar and later from Baijnath. Srivastava and Singh (1995) gave detailed description of some species of *Jungermannia* subgenus *Solenostoma* from eastern Himalaya including a new species viz., *J. udarii*. Srivastava *et al.* (1995) described some rare and interesting liverworts such as

Acrobolbus ciliatus (Mitt.) Schiffn., *Delavayella serrata* Steph. and *Plagiochilion mayabarae* S.Hatt. from eastern Himalaya. Chaudhary and Bapna (1995) conducted regeneration studies on *Asterella angusta* Steph. Kaul *et al.* (1995b) reported *A. khasiana* (Griff.) Pande from Pachmarhi. Sarla and Chopra (1995) made studies on the *in vitro* induction of antheridia in the male clone of *Riccia discolor* Lehm. & Lindb and found that only few casein hydrolysate induce antheridia.

Nath and Asthana (1998) provided a detailed morpho-taxonomic account of twelve species of *Frullania* distributed in South India. The distributional pattern and altitudinal range of each taxon was also provided in addition to a key to species. Daniels (1998) gave ecological adaptation of some bryophytes of the Western Ghats based on their morphological and anatomical characters.

Bapna and Kachroo's (1999a & b) *Hepaticology in India* contains detailed description and general characters of Hepatics known in India. Kumar *et al.* (2000) reported that the Gaddi tribes of Kangra Valley of Himachal Pradesh use the liverwort *Plagiochasma appendiculatum* Lehm. & Lindb. for the cure of burns, boils and blisters of skin. Kaushik *et al.* (2000) tested the antibacterial potential of *Riccia* species against *Escherichia coli*, *Sarcina lutea* and *Bacillus megaterium*. They have also provided a detailed review of the literature related to antibacterial potential of bryophytes in general.

A new species, *Notothylas kashyapii* Singh has been described from Doon Valley of Uttaranchal by Singh and Semwal in 2000. They in 2001 described another new species of *Notothylas* viz., *N. udari* from Dehra Dun. Srivastava and Sharma (2000) enumerated 29 species including a new species, *Texilejeunea indica* from Silent Valley of Kerala. This preliminary account reports Liverworts and Hornworts belonging to Metzgeriales (4 spp.), Jungermanniales (17 spp.), Marchantiales (5 spp.) and Anthocerotales (3 spp.).

An account of the Indian species of the genus *Lopholejeunea* (Spruce) Schiffn. was given by Awasthi *et al.* (2000), which includes 10 species and two varieties. Of these two species viz., *L. kashyapii* and *L. nilgiriensis* were new to science, three species viz., *L. abortiva* (Mitt.) Steph., *L. javanica* (Nees) Schiffn.

and *L. nigricans* were new for India. Two new varieties, *L. sikkimensis* Steph. var. *dentata* and *L. abortiva* var. *doliiformis* Awasthi *et al.*, were also described.

Asthana (2001) provided an account of the present status of the Indian taxa of *Cololejeunea* which include 22 Indian species. Recent report by So and Grolle (2001a) on eight little known *Plagiochila* species in Asia includes six species from Himalayas.

Joshi (2001) presented the floristic analysis of the 45 taxa of liverworts from Andaman Islands and compared them with that of eastern Himalaya, western Himalaya, South India and neighbouring countries of India.

The first estimate of the diversity and abundance of the terricolous liverworts from the Indian subcontinent has been made by Negi *et al.* (2001) in some selected localities of Garhwal Himalayas. Negi and Gadgil in 2001 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.

Daniels (2001) reported *Cololejeunea furcilibulata* (Berrie & Jones) Schust. and *Heteroscyphus argutus* (Reinw. *et al.*) Schiffn. from Mahendragiri hills of Kanyakumari district for the first time. Singh *et al.* (2001) added *Porella hattorii* Udar & Shaheen to the bryoflora of eastern Himalayas, which was known earlier from Western Himalayas only. Srivastava in 2001 described the cytotaxonomy of 21 genera belonging to 8 families of Metzgerineae and commented on its evolutionary trends. Srivastava and Rawat (2001) re-located the long lost endemic liverwort, *Isotachis indica* Mitt., which was confined to a small pocket of Khasi hills. Sharma in 2001 recorded *Odontoschisma denudatum* (Nees) Dumort., a terricolous wide ranging but inadequately known species from eastern Himalayas.

An account of SEM studies carried out on the spores of different Indian liverworts has been reviewed by Nath and Asthana (2001). Banerji and Dixit (2001) revealed the presence of fatty acids and hydrocarbons in the ether extract of *Lepidozia reptans*. The GC-MS analysis of these liverworts *viz.*,

Jamesoniella microphylla (Nees) Schiffn., *Pallavicinia lyellii* (Hook) Gray, *Pellia epiphylla* (L.) Corda and *Plagiochila asplenoides* (L.) Dumort. are investigated chemically by Dixit *et al.* (2001a) revealed the presence of sesquiterpenes and fatty acids. Dixit *et al.* (2001b) made a review on the flavonoid pattern of liverworts in the orders Marchantiales, Metzgeriales, Jungermanniales, Takakiales and in Anthocerotales including about 5 species of different genera.

Singh and Narayan (2002) rediscovered *Folioceros glandulosus* (L. & L.) D.C.Bhardwaj from Arunachal Pradesh after a gap of 150 years. The species shows an interesting bicentric, transoceanic, disjunct distribution between India and Australia. Srivastava and Srivastava (2002) in their detailed study on the family Geocalycaceae from India described 27 taxa belonging to 4 genera viz., *Chiloscyphus* (5 species), *Heteroscyphus* (13 species), *Lophocolea* (7 species) and *Geocalyx* (1 species). In which *Chiloscyphus kashyapii*, *Heteroscyphus parvus*, *H. darjeelingensis*, *H. palniensis*, *H. orbiculatus*, *Lophocolea himalayensis* and *L. cuspidata* var. *asymmetrica* were new to science.

Kumar and Shukla (2003) revealed that the higher concentration of mineral nutrients in the *Riccia frostii* Austin and its habitat was directly related to the heavy pollution load of River Sai water in Rae Bareli.

Srivastava and Verma (2004) recorded the epiphytic diversity of hepaticae occurring in Cinchona plantation in Dodabetta, Nilgiri hills. They recorded a total of 13 species belonging to Jungermanniales and a single species or Metzgeriales.

3.2. Musci

The floristic study of the mosses, so richly distributed in the Indian subcontinent has received little attention throughout the past probably on account of non-availability of literature. Eventhough the Hepaticae received attention of Indian bryologists since Kashyap (1914), researchers on Indian mosses began only after a decade or two. However, contribution of scientists from abroad is continued even during the early half of this century.

During the first half of this century Dixon's contribution is notable. He has published a number of new species and genera. But most of his

contributions were based on collections made by others from different parts of the country. Dixon (1909a) described the species *Brachymenium turgidum* collected by L.J. Sedgewick from Lonavala in the Western Ghats. It was followed by the publication of a very valuable account of the mosses from the Western Ghats collected by G.B. Savery and sent to him by L.J. Sedgewick from various parts of the southern region of Bombay Presidency (Dixon, 1909b), this included two new species viz., *Pterobryopsis maxwelli* Cardot & Dixon and *P. kavarensis* Cardot & Dixon. In 1910 Dixon described the new genus *Merceyopsis* Broth. & Dixon, closely related to *Merceya* in the arrangement of cells in the nerve of the leaf. Sedgewick (1910, 1911, 1913) compiled a list of 71 mosses collected by him, Maxvel, Kirtikar and Woodrow from Mahabaleswar, Kanara, Panchgani and Purandhar in Western India and identified by Dixon. In 1911, Dixon proposed a new genus *Hyphilopsis*, based on a collection by Sedgewick from Purandhar and also described *Orthotrichum griffithii* Mitt. & Dixon, *Brachymenium fischeri* and *Bryum sachyadrense*. In 1912, the new genus *Bryosedgewickia* of Entodontaceae from Purandhar was proposed by Dixon and described three new species each of *Pogonatum*, *Forsstroemia* and *Lindbergia* alongwith a list of many mosses from various parts of India. He in 1914a enumerated 42 species belonging to 34 genera of mosses from Abor hills of Assam. Dixon (1914b) reported 58 species of mosses including 40 genera collected by C.E.C. Fischer and others from South India and Ceylon, which include three new species viz., *Campylopus pseudogracilis* Cardot & Dixon, *Taxithelium vivicolor* Broth. & Dixon, *Barbella questei* Cardot & Dixon, and two new varieties viz., *Stereophyllum ligulatum* (C.Muell.) A.Jaeger var. *sedgwickii* Broth. & Dixon and *Levierella fabroniaceae* var. *dilatinerve* Cardot & Dixon.

In 1921, Dixon assigned Sedgewick's collections from North Kanara into 43 species of mosses under 27 genera. During 1922, he proposed seven new genera of mosses of which *Beddomiella funarioides* Dixon was from the Nilgiri hills. Dixon (1925) described *Grimmia somervellii* Dixon from the Himalayas based on the collections made by T.H. Somervell, and later (Dixon, 1928) proposed a new genus *Homaliopsis* from Palni hills, collected by Foreau. In

1931 Dixon published six new genera, of which *Nanothecium* a member of Entodontaceae was collected by Foreau in 1929 from the Kannan Devan Hills in Travancore, *Orthotheciadelphus* (Entodontaceae) collected from North west Himalayas by R.L. Bardhwar in July 1928 and *Hydrocryphae* (Cryphaceae) from Abor hills in Assam, collected by F. Kingdon ward. In 1937, Dixon reported 208 species of mosses of Naga hills in Assam based on the collection made by Dr. N.L. Bor between 1933-1936 which include one new genus and 40 new species. Dixon and Badhwar (1938) described 17 new mosses from North-west Himalayas. In 1942, Dixon instituted 16 new species of acrocarpous mosses from North-western Himalayas.

Brotherus (1909-1910) described a new genus *Hageniella* Broth. with *H. sikkimensis* Broth. from Sikkim and later he (Brotherus, 1928) provided an account of 106 species and 6 varieties of the mosses of Kashmir collected by Borelli and Duthie.

Varde (1922, 1923a & b, 1924) published an account of mosses collected by Foreau, Andre, Roine and Velle from Madura in Southern India. Subsequently Varde (1925) described 14 new species and reported 32 mosses new to Southern India based on the collections made by Foreau from the then Madura district. Varde (1928) and Dixon and Varde (1927) described a large number of new species and proposed two new genera viz., *Foreauella* and *Trigonodictyon*.

In 1929, Bruehl and Sarkar described the mosses of Bengal. Blatter in 1929 listed the mosses collected from the Bombay Presidency. Fleischer (1929) while listing some mosses from Southern India, described the new species *Thuidium dodabettense*.

Foreau (1930, 1931) presented some notes of the bryological geography for the Presidency of Madras, which includes a family-wise list of 323 species and varieties, of which 4 genera, 95 species and 15 varieties were the new discoveries during 1908-1927 from this area. Later, he (1961, 1964) compiled the result of the survey on the Moss Flora of Palni hills and enumerated 424 species. Bruehl (1931) published a census of Indian mosses in which he enumerated 2,471 species including about 1,500 species of the Indian

continent.

Gupta (1933) studied the structure of *Physcomitriellopsis indica* Dixon collected from Banares. Sharma (1949) published an account of the Indian *Sphagnum* including the endemism of species and their economic importance. He enumerated 17 species of *Sphagnum*, out of this seven were indigenous. The majority of them occur in the eastern Himalayas, Sikkim, Bhutan and Khasi hills. Collections of mosses by Steward from North Western Himalayas were enumerated by Bartram (1955). Ochi in 1956 supplemented this list. Deb (1955) reported 35 species of mosses belonging to 28 genera and 17 families, from Manipur with a note on their habitats. Chopra *et al.* (1956) published a preliminary list of mosses of Mussorie consisting of 143 species belonging to 77 genera and 27 families.

Noguchi (1958) studied a collection of mosses from Southern India, made by T.S. Rao from Kodaikanal, Coonoor and Ootacamund and enumerated 27 taxa including a new variety in his revision of the family Trachypodaceae of India. Chopra and Sharma (1959) studied the life history of *Oligotrichum semilamellatum*.

Gangulee (1957, 1959, 1960, 1961) in his series of papers on the mosses of eastern India described the members of order Fissidentales in 1957, Ditrichaceae (1959), Dicranaceae (1960) and Leucobryaceae (1961) respectively. Gangulee (1985) in his *Handbook of Indian Mosses* enumerated 100 species including Acrocarpous and Pleurocarpous mosses with colour plates. Chopra in 1960 listed 158 species of mosses belonging to 68 genera under 25 families from Nainital. The genus *Alonia* was recorded for the first time from India by Wadhwa and Vohra (1963) from Garhwal with a detailed account of *A. rigida*. Foreau in 1964 reported *Bryum coronatum* Schwaegr. from Idukki district of Kerala and *B. curyphyllum* Dixon & P.Varde, *Philonotis subrigida* var. *adpressa* Cardot & P.Varde and *Physcomytrium insigne* Dixon & P.Varde from Kerala but without mentioning the precise localities.

Ochi (1964a) enumerated some species of the family Bryaceae and Bartramiaceae from Darjeeling and Sikkim including one new species and a

new variety. Robinson in 1956 described *Theriotia kashmirensis* Robinson and *Tortula websteri* Robinson together with a list of 60 species including 40 mosses and 20 liverworts collected from Kashmir. Srivastava (1966) listed 137 species of mosses belonging to 70 genera and 27 families from Kumaun. Chopra and Kanta (1966) reported 17 species of mosses from Delhi, of which *Bryum klinggraeffi* was a new record to India.

Vohra and Wadhwa in 1964 reported 60 species of mosses under 35 genera and 13 families collected from Nilkanth and Chaukhamb. Wadhwa and Vohra in 1965 reported 36 species of mosses under 26 genera and 15 families based on collections of expedition to Chooyu.

Chopra in 1967 studied the relationship between mosses and liverworts and concluded that the differences between the two groups outweigh the resemblances and hence neither of the taxa were derived from the other. Srinivasan in 1968 gave a general account of ecology and distribution of Indian liverworts and mosses. Further he listed species which are common with the various continents and insular areas. Dabhade in 1969 reinvestigated the four species of *Bryum* from Western India providing their taxonomic details, habit and range of distribution. Later, he (1970) reported *Funaria nutans* (Mitt.) Broth. from Khandala as a new record to Western India. Mohamed *et al.* (1986) reported 42 species of mosses from Mahabaleswar, Pune and Khandale in north Western Ghats.

Vohra (1969a) described the new species *Habrodon kashmiriensis* Vohra, along with illustrated account of six other species from Kashmir, Tehri and Dehra Dun. Subsequently Vohra (1969b, 1970) enumerated 165 species of mosses from Western Himalayas, of these three species were new to India and five were new to Western Himalayas.

Raghavan and Wadhawa (1968) reported 28 species of mosses belonging to 21 genera and 16 families from Agumbe-Hulical ranges in the Shimoga district of Karnataka state. This list included two new records to India and Southern India. They in 1970 studied and presented a key to mosses of Agumbe including two species *viz.*, *Bryosedgwickia densa* (Hook.) Bizot &

P.Vard and *Dendropogonella rufescens* (A.Schimp.) Britt., as new records for India.

The report of the genus *Buxbaumia* (Udar *et al.*, 1970b) from the Western Himalayas was an addition to the moss flora of India. They in the same year (1970c) described *B. himalayensis* Udar *et al.*, which was growing on rottenwood. Vohra in 1974 described a new species of *Plagiothecium* viz., *P. dehradunense* from the northwestern Himalayas. Srinivasan in 1974 published an account of the anatomical and morphological aspects of 64 species of mosses, collected from Palni, Gingi, Yercaud, Thirupathi, Kodaikanal, Nilgiris, Thiruvananthapuram and Mysore.

Chopra (1975) published his monumental work *Taxonomy of Indian Mosses* which includes nearly 2000 species belonging to 329 genera under 56 families. He also included the collections from the neighbouring regions such as Pakistan, Nepal, Bhutan and western and south eastern Tibet as most of the species extend to other regions also.

Vohra in 1977 critically reviewed the studies on bryophytes done in Botanical Survey of India with reference to Musci and provided the location of large number of collections of Indian mosses, deposited in foreign countries. During his study on the order Hypnobryales (Musci) in the Himalayas, Vohra (1978) described a new species, *Lescuraea darjeelingensis* and a new variety, *Haplocladium microphyllum* ssp. *capillatum* var. *bhutanicum*. Subsequently Vohra (1979) made a few new combinations in Hypnobryales and added two species to Indian bryophytic flora. Gangulee (1969-80) made valuable contributions on the mosses of eastern India and adjacent regions. His work, *Mosses of Eastern India and adjacent regions – A Monograph*, provided a well illustrated, detailed taxonomic account, and the distribution map of each species dealt with. This is the first of its kind in India and certainly forms the basic reference manual to study the Indian mosses.

Vohra (1981a) reported the Indian endemic species *Pogonatum hexagonum* Mitt. from Silent Valley of Kerala State. Subsequently, Vohra (1981b) mentioned about his 250 collections of mosses from Mulla Periyar and

its catchment area in the Idukki district of Kerala State. Chopra and Kumar in 1981 published a well illustrated taxonomic account of 65 mosses of Western Himalayas and adjacent plains. Bhatla in 1981 studied the effect of pH in gametangial formation in the moss *Bryum argenteum* Hedw. and found that the change in pH of the medium was one of the after-effects of the gametangial formation, rather than its cause *i.e.*, the change in pH has no role in the onset of reproduction phase.

Vohra *et al.* in 1982 published a list of 83 species of mosses collected from Silent Valley. They could also locate the fruiting material of *Handeliobryum setschwanicum* Broth. for the first time. Vohra in 1983 gave a detailed description on the Hypnobryales suborder Leskeineae of the Himlayas. He described and illustrated 42 genera and 161 species from Himalayas out of the 45 genera and 177 species occurring in India. Among the 161 species, 44 are endemic in this area. Buck in 1984 provided the taxonomical and nomenclatural notes on the west Indian Hypnaceae which also include two new species and three varietal combinations.

Pant and Tewari (1983, 1988) made an assessment of bryophytic vegetation of Nainital and surroundings based on substrate preferences of genera and species. Bapna in 1980 reported the occurrence of *Fissidens* in Rajasthan.

Chopra and Bhatla (1983) found that bryophytes exhibit maximal gametangial initiations in a definite pH range and the nutritional status of the medium has variable effect on gametangial induction. Vasishta and Chopra (1986) in the experimental studies on bryophytes in India provided a review of studies on gemmae, apogamy, apospory, callus induction and its differentiation and protoplast isolation and culture. Kumra (1995) conducted *in vitro* studies on *Bryum coronatum* and *Funaria hygrometrica* Hedw.

Cytochemical studies on the developing sporophyte in the moss *Physcomitrium cyathicarpum* Mitten were carried out by Ekalavya (1987). Mehra (1988) carried out studies on the effect of some growth regulators on the formation and behaviour of protonemal gemmae in the moss *Hyophila involuta*

(Hook.) A. Jaeger and found that the auxins delay the germination of gemmae. Babbar in the same year (1988) conducted similar studies in *Philonotis lancifolia* Mitt. and *Trematodon brevicalyx*. The development and behaviour of protonemal gemmae *in vitro* in two gemmiferous mosses, *Trematodon brevicalyx* and *Semibarbula orientalis* has been made by Babbar and Chopra in 1995. Mitra (1995) studied the morphology of moss protonema for understanding the morphogenetic changes, which occur during growth and development of protonema.

Ellis (1992a) made studies on the species *Fissidens ceylonensis* Dozy & Molke. and compared with related taxa such as *F. ceylonensis* var. *acutifolius* Dixon & P. Varde and *F. kawarensis* Dixon. He in the same year (1992b) studied the taxonomy of some taxa of Calymperaceae occurring in the Indian Peninsula.

Vohra and Kar (1996) reported 37 species of mosses from Great Nicobar Island. Among them *Taxithelium vermeiri* (Duby) Besch., was a new record for India and 17 species occurring in the mainland were new additions to the Island flora. *Leucophanes nicobaricum* C. Muell. & Gangulee and *Trichosteleum punctipapillosum* Gangulee, endemic to the Island so far represented by the type material only, have been recollected after more than a century. Ochyra (1998b) discussed the identity of two species of *Hygroamblystegium* endemic to northern India.

Narayan *et al.* (2001) illustrated, morphotaxonomic details of eight species of mosses belonging to six genera and six families from Great Himalayan National Park, Himachal Pradesh.

Fossil remains and fossil studies on this group are rare. Pant and Singh (1991) attempted to distinguish the spores of Hepaticae and Anthocerotales from iso- or microspores of Pteridophytes and pollen grains of Gymnosperms and Angiosperms for the identification of possible fossil spore dispersal of bryophytes reported from different geological horizons. Chandra (1995) recovered a good assemblage of bryophytes from the early Permian sediments of India as impressions along with the typical *Glossopteris* flora for the first time.

Both Hepaticae and Musci are represented by newly designated form genera and species. Remarks on the naming of the fossil bryophytes, the possibility of preservation, spore distribution, probable habitat and evolutionary aspects have also been discussed by him. Pant (1995) discussed the palynology of bryophytes.

Ecological studies on this group is very meager in India. Negi and Gadgil (1997) studied the species diversity and community ecology of mosses of Garhwal Himalaya and concluded that the microhabitat and altitude seem to be the major ecological factors governing species diversity and composition. Negi (2001) studied the ecology of bryophytes of Chopta-Tunganath in the Garhwal Himalaya.

Nath *et al.* (2000) discussed the role of bryophytes in soil management and in rock binding.

SEM studies of spores of two species of *Bryum* and seven species of *Fissidens* from the Western Ghats have been done by Dhabade and Patil (2001). Parihar (2001) presented a method of preparation of a perpetual taxonomic cross-reference dictionary of the bryophytes, for this a system of numeration of each taxon has been adopted. Chaudhary and Deora (2001) provided an illustrated account of 25 species of mosses belonging to 18 genera and 8 families from Mt. Abu. Among them 23 species occur in Western Himalaya, 19 in eastern Himalaya and 15 in South India. Pant (2001) highlighted the diverse habitat for bryophytes and given a checklist of the bryodiversity of Kumaun Himalaya pointing the need to explore and study the diverse species.

Saxena *et al.* (2001) highlighted the usefulness of bryophytes as subjects of biomonitoring studies and called for the establishment of bryophyte bank for environmental monitoring in India. Tewari (2001) described the distribution of "copper mosses" *Scopelophila ligulata* (Spruce) Spruce and *S. cataractae* (Mitt.) Broth. in Kumaun Himalaya and mentioned the plant–substrate relationship and indicator value of these two species. Kapoor and Bhatla (2001) studied the biochemical regulation of protonema differentiation in *Funaria hygrometrica*.

Pandey *et al.* (2001) studied the accumulation of heavy metals such as copper, chromium, lead, zinc, nickel and cadmium in bryophytes from the banks of Ganga. They found high concentration of heavy metals and which may be accumulated from the polluted waters of the river. Singh (2001) discussed the status, vulnerability and conservation of the Indian liverworts. An action plan for the conservation and monitoring has been suggested and need for capacity building in its taxonomy and integration of the regional herbaria is also emphasized. Vashistha (2001) reviewed the heavy metal pollution and the role of bryophytes in reducing the metal pollution. Saxena (2001) monitored the impact of heavy metals such as Pb, Ni, Cr and Hg using bryophytes in Nainital.

Saini and Vashistha (2001) studied the effects of some auxins (IAA, NAA, NDA, 2, 4-D) and cytokinins (BAP, 2iP & Kinetin) on the protonemal growth and bud formation in the moss *Anoetangium bicolor* Rev. & Cardot. Uniyal (2001) made cytological observations on 4 species of *Philonotis* viz., *P. angusta* Mitt., *P. falcata* (Hook.) Mitt., *P. fontana* (Hedw.) Brid. and *P. turneriana* (Schwaegr.) Mitt.

Banerjee (2001) made a review on the antimicrobial activities of bryophytes, which shows that nearly 200 species of bryophytes have been surveyed so far to detect such activity, of which 53-76% of the plants have shown positive results. Mosses are the most studied one followed by thalloid and leafy liverworts.

Daniel and Daniel (2003) added *Fissidens griffithii* to Indian bryoflora from Kanyakumari district of Tamil Nadu. He in the same year described six species viz., *Fissidens kalimpongensis* Gangulee, *F. leptopelma* Dixon, *Leptolejeunea sikkimensis* Udar & U.S.Awasthi, *L. himalayensis* Pande & Misra, *Radula madagascariensis* Gottsche and *Leucobryum juniperoideum* (Brid.) C.Muell. as new record to Peninsular India.

Nair *et al.* (2004) recorded *Bryum tuberosum* Mohamed & Damanhuri, which was known earlier from the Peninsular Malaysia, as a new record for India from Uduppi of Karnataka State. Singh and Nath (2004) added an epiphytic liverwort *Frullania rotundistipula* Steph. from Khasi hills, Meghalaya to

the Indian bryoflora. Singh and Singh (2004) added *Lejeunea flava* (Swartz) Nees to the bryoflora of Western Himalaya a species already known from Eastern Himalaya to Indian flora.

Pande and Joshi (2004) assessed the species composition, phytosociology, pattern of biomass and net primary production of bryoflora growing on decaying logs in the evergreen conifer forest of silver fir of Nanda Devi Biosphere reserve in Central Himalaya.

3.3. Bryophyte study with special reference to Kerala

The first record on the bryophytes of Kerala may be that appeared in Van Rheede's (1678-1703) monumental work on South Indian plants, *Hortus Malabaricus*. He described and illustrated one moss from Kerala as 'poovan-peda' (vol.12, t.37, p. 71, 1693). It was later identified by Nicolson *et al.* (1988) as *Bryum bicolor* Dickson, in contradiction to the earlier interpretation as *B. coronatum* Schwaegr which is now treated as synonym of *B. dichotomum* (Ochi, 1985). Dixon (1914b), while reporting the mosses collected by C.E.C.Fischer and others from South India and Sri Lanka, mentioned one species, *Erythrodonium julaceum* (Schwaegr.) Par. as collected from Attappadi (Palakkad district). Bruehl's (1931) exhaustive compilation, the *Census of Indian Mosses*, contain 2,471 species belonging to 371 genera of which three species are from Kerala *viz.*, *Fissidens zippelianus* Dozy & Molk. from the Travancore, *Webera rostrata* (C.Muell.) Broth. from the Malabar and *Brachymenium fischeri* Cardot & Dixon from the Attappadi hills. Dixon (1931) published six new genera of which *Nanothecium foreaui* Dixon & P.Varde was collected by Foreau in 1929 from the Kannan Devan hills in Travancore (Southern Kerala).

A new species *Anthoceros koshii*, was described by Khanna (1936) based on the collections made by T.K. Koshy from Peerumedu in Idukki district. Asthana and Srivastava (1991) opined that according to the taxonomic description and illustration made by Khanna (1936) this species approaches *A. bharadwajii* Udar & A.K.Asthana. Chopra (1938b) in his notes on South Indian Hepatics mentioned two species *viz.*, *Riccia cruciata* Kashyap and *Aspiromitus erectus* Kashyap from the Travancore without mentioning the precise locality.

Kachroo and Bapna (1963) also reported on the occurrence of *Riccia cruciata* Kashyap from the Travancore area. Kachroo (1956) while studying the morphology of the genus *Pallavicinia*, collected *P. ambigua* (Mitt.) Steph., from the Travancore area, but without mentioning the exact locality.

Foreau (1964) reported *Bryum coronatum* Schwaegr. from Idukki district and *B. curyphyllum* Dixon & P.Varde, *Philonotis subrigida* var. *adpressa* Cardot & P.Varde and *Physcomytrium insigne* Dixon & P.Varde from Kerala, without mentioning the precise localities. Bhardwaj (1965a) gave a detailed description of *Anthoceros mamillisporus* (D.C.Bhardwaj) D.C.Bhardwaj and *A. dixitianus* (Mahabale) Prosk. *A. mamillisporus* (D.C.Bhardwaj) D.C.Bhardwaj for the study was collected from the Kottayam district. Bhardwaj (1965b) studied the morphology of the genus *Phaeoceros* and compared it with *Anthoceros*. A new species of *Anthoceros* viz., *A. shivanandani* was described by Kachroo (1967a) from Kerala. Bhardwaj (1973) transferred the species collected and reported by Stephani as *Aspiromitus* to *Folioceros* of which *F. spinisporus* (Steph.) D.C.Bhardwaj was collected from Kottayam district.

Srinivasan's report (1974) on South Indian mosses, which contain 64 species, but include only one species viz., *Fissidens schmidii* C.Muell. from Thiruvananthapuram district of Kerala. Chopra's (1975) exhaustive study on Indian mosses dealing with nearly 2000 species, include a few species such as *Megalostylium brevisetum* Dozy & Molk., *Leucoloma brevifolium* Dixon & P.Varde, *Hymenostylium validinerve* Dixon & P.Varde, *Tortula schmidii* (C.Muell.) Broth., *Trichostomum minusculum* Dixon & P.Varde and the monotypic endemic genus *Nantheceium foreau* Dixon & P.Varde from the Kannan Devan hills of Travancore. Species such as *Homalothecium nilgheriense* (Montin) Robinson and *Stereophyllum subacuminatum* Dixon & P.Varde from the Travancore, *Leucoloma malabarens* Besch. ex Ren. & Cardot from the Malabar area and *Syrrhopodon leucophanoides* Cardot & P.Varde from Kerala were also mentioned but without precise locality.

Vohra (1981a) described *Pogonatum hexagonum* from Silent Valley as an endemic moss to India. Subsequently (1981b), he mentioned about his 250

collections of mosses from Mulla-Periyar and its catchment area, in the Idukki district. Vohra *et al.*, (1982) reported 83 species of mosses from the Silent Valley National Park. Among these, 43 were epiphytes, 37 grow on soil and rocks and three species seen both as epiphytic and epilithic. They also proposed about 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 Kumar (1983) described the South Indian endemic species *Radula pandei* Udar & Kumar from Agumbe and Mercara of Karnataka and Mukkali-Silent Valley of Kerala. Udar and Jain (1984) listed 14 species of Marchantiales belonging to eight genera from Thrissur, Idukki, Wayanad and Kottayam districts. This collection was the first investigation on the liverworts of Kerala. Udar and Awasthi (1984) collected *Schiffneriolejeunea indica* (Steph.) Udar & U.S.Awasthi (= *S. pulopenangensis* (Gottsche) Gradst.) from Kottayam and Mannarkkad in Kerala. This was followed by a report of *Acrolejeunea sikkimensis* (Mizut.) Gradst. from Kottayam (Awasthi, 1984). Awasthi and Srivastava (1985) also reported the same species from Kerala State.

Awasthi and Udar (1984) reported that *Mastigolejeunea humilis* (Gottsche) Schiffn. has a wide range of distribution in Kerala. 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. Recently Nair & Madhusoodanan (2001) collected this species from the Eravikulam National Park in the Idukki district of Kerala. A monotypic genus of the family, *Cylindrocolea tagawae* (N.Kitag.) Schust., has also been reported for the first time from Ponmudi of Thiruvananthapuram district by Udar and Kumar (1985). Udar and Shaheen (1985) studied the genus *Ceratolejeunea* in India and reported the occurrence of *C. singaporensis* (Lindenb.) Schiffn. from Lakkidi in Kerala.

Srivastava and Asthana (1986) described the new species *Folioceros udarii* from Silent Valley. A taxonomic revision of the genus *Calymperes* in Southern India and neighboring islands (Andaman & Nicobar Islands) by Ellis (1989) includes two species viz., *Calymperes lonchophyllum* Schwaegr. and *C. tenerum* C.Muell from Ponmudi.

The one and only Ph.D. thesis work on the taxonomy of bryophytes from Kerala is that of Rajeevan (1990) on the bryophyte flora of Idukki district. He has described 76 species of mosses and 19 species of liverworts from the high ranges of Idukki including five new species viz., *Diaphanodon ganguleei*, *Fissidens choprai*, *Macromitrium vohrai*, *Pohlia foreau* and *Pterobryopsis keralensis* and three new varieties *Entodon macroporus* var. *indica*, *Philonotis hastata* (Duby) Wijk. & Marg. var. *idukkiensis* and *Calycularia crispula* Mitt. var. *udarii* and one new record for India viz., *Fissidens hollianus* Dozy & Molk. (all awaiting publication). This work forms an important detailed study on the taxonomy and morphology of bryophytes in Kerala.

Asthana and Srivastava (1991) in their monographic studies on the Anthocerotales of India recorded *Anthoceros bharadwajii* Udar & A.K.Asthana, *A. subtilis*, *A. erectus* Kashyap, *Folioceros spinisporus* (Steph.) D.C.Bhardwaj and *Phaeoceros laevis* (L.) Prosk. subsp. *laevis* Prosk. from Idukki district. Ellis (1992a), while studying the family Fissidentaceae of South India reported *Fissidens ceylonensis* Dozy & Molk., from Kallar in Thiruvananthapuram district, a common species of Kerala and *F. ceylonensis* var. *acutifolius* Dixon & P.Varde from Kumali in Idukki district.

Asthana *et al.*, (1995) in their well illustrated morpho-taxonomic account of the genus *Cheilolejeunea* in India described a new species *C. ghatensis* from Ponmudi in the Thiruvananthapuram district. They also reported two species viz., *C. serpentina* (Mitt.) Mizut. and *C. imbricata* (Nees) S.Hatt. from Lakkidi of Wayanad district. Nath and Asthana (1998) recorded *Frullania squarrosa* (R.Bl. & Nees) Dumort., and *F. tamarisci* (L.) Dumort. respectively from Wayanad and Idukki districts.

Srivastava and Sharma (2000) enumerated 29 species of Liverworts and Hornworts including a new one, *Texilejeunea indica* from Silent Valley. This also includes four species of Metzgeriales, 17 Jungermanniales, 5 Marchantiales and 3 Anthocerotales. Awasthi *et al.* (2000) in the well illustrated and detailed account of the genus *Lopholejeunea* (Spruce) Schiffn. of India, recorded 5 species viz., *L. abortiva* (Mitt.) Steph., *L. indica* Udar & U.S.Awasthi, *L. sikkimensis* Steph., and *L. subfusca* (Nees) Steph. (all from the Lakkidi area of Wayanad district) and *L. javanica* (Nees) Schiffn., (from the Silent Valley of Palakkad district) from Kerala. They also described a new variety *L. abortiva* var. *doliiformis* Awasthi *et al.*, from Achilatti forest of Palakkad district.

A preliminary exploration made by Nair and Madhusoodanan (2001) for bryophytes in the Eravikulam National Park, Idukki district, situated in the high altitude mountainous areas with grassland and shola vegetation, reported 19 species including liverworts and mosses, of which, 6 were new records to Kerala. In an extended study by Madhusoodanan *et al.* (2002) reported 115 species including 87 mosses and 28 liverworts from the same area. As a baseline data for the studies on the bryophytes of Kerala, Nair and Madhusoodanan (2002) made a review on the bryophyte studies done in Kerala. A preliminary account on the diversity of the bryophytes of Kerala, with brief history, its importance and implications of conservation were discussed by Nair *et al.* (2002).

Easa (2003) in his compilation of flora and fauna of Kerala reported 232 species of bryophytes including 63 liverworts and 169 mosses.

Madhusoodanan and Nair (2003) reported *Ricciocarpos natans* (L.) Corda from Wayanad district and *Notothylas levieri* Schiffn. ex Steph. from Palakkad district of Kerala, as new records for South India. Nair and Madhusoodanan (2003) presented hitherto unexplored bryodiversity of Wayanad district giving a checklist of 100 species including 72 mosses, 25 liverworts and 3 hornworts. Among these 6 species viz., *Entodon flavescens* (Hook.) A.Jaeger. & Sauerb., *Eurhynchium vagans* (A.Jaeger) E.B.Bartram, *Floribundaria walkerii* (Ren. & Cardot) Broth., *Heteroscyphus coalitus* (Hook.) Schiffn., *Marchantia linearis* L. & L. and *Ricciocarpos natans* (L.) Corda were

new records for South India and 12 species viz., *Aerobryum speciosum* (Dozy & Molk.) Dozy & Molk., *Ectropothecium compressifolium* (Mitt.) A.Jaeger, *E. sikkimense* (Renauld & Cardot) Renauld & Cardot, *Hymenostylium recurvirostre* (Hedw.) Zant., *Hyophila nymaniana* (Fleisch.) Menzel, *Jungermannia (Plectocolea) macrocarpa* Steph., *Lejeunea obfusca* Mitt., *Macromitrium ferrei* Cardot & Ther., *Meteoriopsis divergens* (Mitt.) Broth., *Neckeropsis fimbriata* (Harv.) Fleisch., *Papillaria crocea* (Hampe) A.Jaeger and *Schoenobryum concavifolium* (Griff.) Gangulee were new for Kerala.

Nair *et al.* (in press) described seven little known species of *Plagiochila* (Dumort.) Dumort. viz., *P. arbuscula* (Brid. ex Lehm. & Lindenb.) Lindenb., *P. beddomei* Steph., *P. chinensis* Steph., *P. devexa* Steph., *P. fruticosa* Mitt., *P. parvifolia* Lindenb. and *P. sciophila* Nees. ex Lindenb. from Eravikulam National Park in South India. Among these, *P. arbuscula* (Brid. ex Lehm. & Lindenb.) Lindenb. is a new record for India and *P. chinensis* Steph., *P. devexa* Steph., *P. dorelii* Schiffn. and *P. fruticosa* Mitt. were new records for South India.

Madhusoodanan and Nair (2004) made an account of eight species of pleurocarpous mosses viz., *Chaetomitriopsis glaucocarpa* (Schwaegr.) Fleisch., *Cryptopapillaria fuscescens* (Hook.) A.Jaeger, *Diaphanodon blandus* (Harv.) Ren. & Cardot, *D. procumbens* (C.Muell) Ren. & Cardot, *Hedwigidium integrifolium* (P.Beauv.) Dixon, *Racopilum orthocarpum* Wils. & Mitt., *Symphiodon perrottetii* Montin and *Trachypus bicolor* Reinw. & Cardot, from the Eravikulam National Park. Among them *Chaetomitriopsis glaucocarpa* was a new record for South India and four species viz., *Hedwigidium integrifolium*, *Racopilum orthocarpum*, *Diaphanodon procumbens* and *Diaphanodon blandus* were new to Kerala. A checklist of bryophytes collected from the Vellarimala situated in the Western Ghat mountains of Kozhikode district, Kerala was presented by Nair and Madhosoodanan (in press). This preliminary survey reports the occurrence of 53 species of mosses and leafy liverworts and the need for conservation also was discussed.

From this overview it is evident that except for some sporadic collection reports, the Kerala state still remains bryologically almost unexplored or underexplored. A few publications in the first half of the century based on the

collections by others from Central Travancore, and the contributions by Udar and his associates at Lucknow (Udar & Awasthi, 1984a; Udar & Jain, 1984; Udar & Shaheen, 1985; Srivastava & Srivastava, 1989, Asthana *et al.*, 1995 and Srivastava & Sharma, 2000) are the only works on liverworts of this region. The collection of a moss by Foreau from Kannan Devan hills (Dixon, 1931), a few mosses worked out by Srinivasan (1974) from Thiruvananthapuram, 250 mosses collected from Mulla-Periyar by Vohra (1981a) followed by Vohra (1981b), Vohra *et al.* (1982) and Rajeevan (1990) are the only works on the moss flora of this State.

It is evident from this review that in the northern India the taxonomical study on the liverworts is rather comprehensive and for the past two decades they have also studied the applied aspects of bryophytes such as the antimicrobial activities, palynology, cytology, pollution detection, etc. in detail. The bryological studies in South India is meagre.

MATERIAL AND METHODS

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Material & Methods.....

The tiny moss, whose silken verdure clothes
The time-worn rock, and whose bright
Capsules rise
Like fairy urns on stalks of golden sheen,
Demands our admiration and our praise,
As much as cedar, kissing the blue sky

Anonymous

4. MATERIAL AND METHODS

4.1. Taxonomy

Systematic collection of bryophytes was done from the study area during 2000-2004, by conducting frequent trips covering all seasons. Plants were scraped out from the substrate with the help of a sharp-edged knife. Terrestrial species were collected with the substratum and the bulk of the soil particles were removed leaving a thin film. Epiphytic species were collected by climbing up the trees, as far as possible. The high canopy species, which were not easily accessible, were collected from the fallen branches. Corticolous and lithophytic species when strongly attached to the substratum were collected with a portion of the bark and rock respectively.

Most of the areas of the district were explored, giving special emphasis to the Wayanad Wildlife Sanctuary (WWLS) and adjacent reserved forests.

The field data were recorded in the field book, such as the locality, date, altitude, macrohabitat, microhabitat, substratum, associated species, etc. On examination the bulk of the specimen when contain more than one species, each one is separated with subnumbers for the ease of detailed taxonomic studies and for storage in herbaria.

The herbarium was prepared by air-drying the collected specimens. A small portion of the liverworts specimens were also kept in 70% alcohol or 4% formalin for detailed studies. The dried specimens were stored in brown paper packets of 5" x 4". The collected materials were processed following the standard procedures (Forman & Bridson, 1989). The properly labelled packets were arranged according to the classification systems of Gangulee (1969) and Crandall-Stotler & Stotler (2000) and were deposited in the Calicut University Herbarium (CALI).

Fresh materials were subjected for taxonomic treatment whenever possible. Otherwise dried specimens were soaked in cold water to regain its original shape before analysing. The external features of the specimens were studied using a stereo dissection microscope and the internal features using a

compound microscope. Line drawings were made for all species using Camera Lucida attaching a drawing tube to the microscope. Identification of the specimens was done referring the pertinent literature. The experts were also consulted in some doubtful cases. The specimens lodged in herbaria such as Madras Herbarium (MH) and National Botanical Research Institute (NBRI) were also referred. The authentic specimens of some species from Kew (K) and British Museum (BM) were also referred for identification.

4.2. Ecology

The microhabitats and altitudes of each species were noted to find out the distribution pattern. A handheld GPS receiver (Garmin 12) is used to record the altitude. The abundance and frequency of each species were also studied.

4.3. Plan of the thesis

The thesis is divided into six chapters as Introduction, Study area, Review of Literature, Materials and Methods, Results and Discussion appended with Bibliography.

Introduction - includes general characters of bryophytes, origin and evolution, importance, present status, objectives of the present study and relevance.

Study Area - gives detailed description of its geography, climate, vegetation, and is supported with a map.

Review of Literature - includes a general introduction on the work on bryophytes in the world, India and Kerala. This is followed by an elaborate review of literature on the liverworts and mosses of India. A special mention is given on the review of work done in Kerala.

Materials and Methods - describe the methodology adopted for collection, herbarium processing and a general outline on how the descriptions were prepared along with an ecological outline.

Results - The results are summarized under two different headings of Taxonomy and Ecology.

1. Taxonomic Description - which forms the major part of the thesis includes key to classes, characters of classes, key to families, family characters, key to genera, generic description, key to species, and species description. Occurrence of the number of species in each family, in India and in the study area are presented after each family description. Notes are given for the species, genus and families wherever it is needed. Authors of plant names are abbreviated based on Brummit and Powell (1992) and titles of journal are based on Taxonomic literature (Stafleu & Cowan, 1976-1986). Liverworts are arranged according to the latest revised classification by Crandall-Stotler and Stotler (2000) and for mosses, Gangulee (1969) has been followed. All the genera and species under the family are arranged alphabetically. Each species is described with illustration of habit together with details of available characters such as leaves, capsule, spores, etc. All the species are provided with up-to-date nomenclature including basionym and synonyms if any, pertaining to India and other parts of the world as far as possible. Dichotomous keys have been provided for families, genera and species on the basis of characters which are more reliable for identification.

2. Ecology gives a general introduction, species distribution in relation to vegetation, altitude and its microhabitat preferences.

Chapter VI (Discussion) discusses the general aspects of bryophytes of Wayanad, such as the species distribution, frequency, ecology, economic importance, classification and the need and problems of conservation.

A bibliography is given at the end citing all the references mentioned in the text and other relevant references pertaining to taxonomic identifications. An Index for scientific names were provided as Appendix I.

Photographs are provided for each species as far as possible and photographs for habitat preferences were also given.

4.4. Abbreviations used in the text

WWLS	: Wayanad Wildlife Sanctuary
ENP	: Eravikulam National Park
MCN	: Manju C. Nair
KPR	: K.P. Rajesh
PVM	: P.V. Madhusoodanan
SKA	: Saju K.A.
RF	: Reserve Forest
CU	: Calicut University
SEF	: Semi Evergreen Forest
MSSRF	: M.S. Swaminathan Research Foundation
NP	: National Park
mm	: Milli meter
µm	: Micro molar

RESULTS

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Results.....

“The mosses and liverworts are a marvellous display of
His craftsmanship”

M.L. So

13

60A

5. RESULTS

5.1. Systematic Treatment of Bryophytes of Wayanad

Plants free living, enjoy wide range of habitats, 1 mm to 40 m 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 gametophyte for nutrition, usually differentiated into foot, seta and capsule, elaters present in liverworts and absent in mosses.

Key to the Classes

- 1a. Rhizoids septate; capsule mouth, operculum and peristome usually present; elaters absent.....Musci
- 1b. Rhizoids aseptate; capsule mouth, operculum and peristome teeth absent; elaters present.....2
- 2a. Thallus with internal tissue differentiation; margin crumpled; cells with numerous chloroplasts, pyrenoids absent; elaters true type..... Hepaticae
- 2b. Thallus without internal tissue differentiation; margin not crumpled; cells with single chloroplasts, pyrenoid present, elaters pseudo type.....Anthocerotae

5.1.1. CLASS I: HEPATICAE (LIVERWORTS)

Plants thallose to foliose, prostrate, dorsiventral, branches usually dichotomous, when foliose distinctly 2 or 3 ranked, underleaves when present smaller, lamina cells larger, rounded or elongate; rhizoids aseptate; capsule rounded to cylindrical, seta elongated, mouth, operculum and peristome absent; elaters free or an elaterophore.

In general, the leafy liverworts possess fairly simple stems with 2 or 3 rows of unistratose, frequently divided leaves. Some taxa are isophyllous, with all the three rows of leaves transversely inserted, but commonly they are anisophyllous, with a small row of transversely inserted ventral leaves or amphigastria. In contrast to this, thalloid forms shows distinct multistratose midribs and unistratose wings or often strap-shaped thalli. The complex thallus is internally differentiated into an upper layer of air chambers, which open dorsally through air pores and a lower parenchymatous storage zone. The ventral surface of the thallus bears pegged rhizoids. In leafy liverworts the archegonia are borne either as apical clusters or on dorsal surface of the thallus, and are covered by leafy structures such as perianth or scales. In thalloid hepatics the archegonia are produced on the undersurface of erect highly specialized structures called archegoniophores.

The estimated diversity of liverworts is about 6000 to 8000 species, of which atleast 85% are leafy jungermannioids (Schuster, 1984a). Eventhough there is heterogeneity in gametophyte structure of its members, liverworts have been recognized to comprise a single natural unit.

Many classification schemes such as Grolle (1983), Vitt (1984), etc. are available for taxonomic treatment, the most recent one of Crandall-Stotler and Stotler's (2000) scheme is followed here with some modifications.

Key to the families of Hepaticae

- 1a. Plants thalloid, ribbon like.....2
- 1b. Thallus foliose, with rows of leaves along the stem.....7
- 2a. Ventral scales present.....3
- 2b. Ventral scales small or absent.....6
- 3a. Thallus with hexagonal air chambers; sporogonia exerted.....4
- 3b. Thallus without hexagonal air chambers; sporogonia embedded in thallus....
.....**Ricciaceae**
- 4a. Sporogonia produced ventrally in receptacles.....**Targioniaceae**
- 4b. Sporogonia produced dorsally in receptacles.....5

- 5a. Air chambers 2-to many layered; gemmae cup and gemmae absent
.....**Aytoniaceae**
- 5b. Air chambers one layered or absent; gemmae cup and gemmae present.....
.....**Marchantiaceae**
- 6a. Thallus with a distinct midrib; internally cells are uniseriate; branches when
present dichotomous.....**Pallaviciniaceae**
- 6b. Thallus without a midrib; cells multiseriate except at margin; branches
simple, pinnate, palmate or irregular.....**Aneuraceae**
- 7a. Leaves obliquely inserted in two lateral rows; each lobe having a single
mucilage papilla at the apex.....**Fossombroniaceae**
- 7b. Leaves alternate; mucilage papilla absent.....8
- 8a. Leaf lobules absent.....9
- 8b. Leaf lobules present.....10
- 9a. Leaves complanate; rhizoids restricted to underleaf bases; underleaves
bilobed with 2 lateral teeth.....**Geocalyceae**
- 9b. Leaves oblique to squarrose; rhizoids continuous on stem; underleaves
when present small.....**Jungermanniaceae**
- 9c. Leaves subequal to unequal; acute to subacute; rhizoids few, scattered;
underleaves absent.....**Cephaloziellaceae**
- 10a. Leaf lobules saccate to galeate; leaf apex rounded to pointed; ocelli
present in some.....**Jubulaceae**
- 10b. Leaf lobules strap shaped or rounded to elongate bifid; leaf apex ovate to
rounded to rectangular or elongate; ocelli absent.....11
- 11a. Leaf lobules strap shaped, parallel to stem; underleaves present.....
.....**Porellaceae**
- 11b. Leaf lobules inflated to elongate; underleaves present or absent.....12
- 12a. Underleaves completely absent; leaf lobes rectangular.....**Radulaceae**
- 12b. Underleaves present or vestigial or absent; leaf lobes ovate to oblong...13
- 13a. Leafy thallus very small, 0.5 mm- 2 cm long; leaves bilobed with lobes and
lobules**Lejeuneaceae**
- 13b. Leafy thallus large, 2-10 cm or more long; leaves with single lobe, lobules
absent14

- 14a. Leaves not divided into thread like segments, obliquely inserted;
paraphyllia present in some; underleaves vestigial; perianth present.....
.....**Plagiochilaceae**
- 14b. Leaves deeply divided into thread like segments; paraphyllia thread-like
outgrowth; underleaves smaller than lateral ones; perianth absent.....
.....**Trichocoleaceae**

Order MARCHANTIALES Limpr.

AYTONIACEAE Cavers

New Phytol. 10: 42. 1911.

Thallus prostrate, dichotomously branched; air chambers 2- to many layered, without assimilatory filaments, pores simple, delimited by a single layer of cells; ventral scales in two rows; gemmae cup and gemmae absent; sporophyte with bulbous foot, short seta and spherical capsule; elaters 2-4 spiraled; spores brownish, rounded.

This family includes five genera *viz.*, *Asterella*, *Cryptomitrium*, *Mannia*, *Plagiochasma* and *Reboulia*. All of which occur in India. Of which *Asterella* and *Reboulia* occur in the study area.

Key to the genera

- 1a. Thallus simple or 1-3 forked; pores simple, large, bounded by 2-3 concentric rings of 6-8 cells each.....**Asterella**
- 1b. Thallus dichotomously branched; pores a little elevated, with 3-5 concentric rings of 6-8 cells each.....**Reboulia**

Asterella P.Beauv.

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

Thallus light green to dark green, small, prostrate, forming rosettes in overlapping patches; simple or 1-3 forked, lobes linear or oblong, margin entire, innovations terminal or lateral from the costa; dorsal surface flat, margin wavy; air chambers irregular, empty, 1 or 2 rows in midrib, many layered towards wings, unistratose or 2-3 cell layered, assimilatory filaments absent; pores

simple, large, bounded by 2-3 concentric rings of 6-8 cells each; ventral surface dark, purplish, rhizoids both smooth and tuberculate; monoecious or dioecious, antheridia on dorsal surface, in whole length or in patches, receptacles bounded by small red papillae, each receptacle with 15-20 antheridia; female receptacle hemispherical or disciform, stalked, terminal, 2-8 lobed, involucre membranous, each with single archegonium; foot bulbous; seta short; capsule globose, opening by a lid; spores dark brown; elaters with single spiral band.

Asterella khasiana (Griff.) Grolle, *Ergebn. Forsch. Unter. Nepal Himalaya* 1(4): 267. 1966; Bapna & Kachroo, *Hepatic. India* 2: 406. 2000. *Octoskepos khasyanum* Griff., *Notul. Plant Asiat.* 2: 343. 1849. *Fimbriaria khasyana* (Griff.) Mitt., *J. Proc. Linn. Soc.* 5: 126. 1861; Steph. *Sp. Hepat.* 1: 118. 1900.

Thallus yellowish-green, 1.5 cm x 2 mm; thin, delicate, furcate, margin wavy, air chambers in 1 or 2 layer, empty; pores bounded by 3 or 4 concentric rings with 6 or 7 cells in each; scales purple with appendages; male receptacles behind the stalk of female receptacles, stalk with scales and one rhizoidal furrow, female receptacles terminal on the main thallus; spores yellowish, winged, 80-90 µm; elaters 200-250 µm long, bispiral. (Fig. 2: a-e & Plate 3a&b)
Habitat: On earth cuttings in shady regions of semi evergreen and shola forests.
Specimens examined: Chembra hills (1200 m) *MCN 120352*, Periya (850 m) *MCN 120355*.

Distribution: *Asterella khasiana* is a common species in Chembra hills. It has earlier recorded from North-east India (Himalaya, Darjeeling), Nepal and China. The present collection is a new record to Peninsular India.

Reboulia Raddi

Opusc. Scient. di Bologna 2: 357. 1818.

Thallus dichotomously branched, forming patches, without distinct areolae on the dorsal surface; pores simple, little elevated with 3-5 concentric rings of 6-8 cells each, air chambers in several layers, empty; ventral scales in two rows; male receptacle sessile, cushion-like, at apex of the lobe, oval to semi-circular, surrounded by small scales; female receptacles terminal on

ordinary lobes, stalked, stalk surrounded at the base and apex by narrow scales, with a single rhizoid furrow, receptacles conical or hemispherical, divided to the middle into 4-9 obtuse lobes, with air spaces and compound pores; involucre arising on the underside of the lobes from the margins, 2-valved, the margin of the valves involute when young, opening at maturity, each enclosing a single sporogonium filling only partially, perianth absent; foot large, capsule subglobose, irregularly dehiscent at the apex, shortly pedicellate; elaters 2-3 spiraled.

Reboulia hemisphaerica (L.) Raddi., Opusc. Scient. di Bologna 2: 357. 1818; Kashyap, Liv. W. Him. Punjab Pl. 1: 72. 1929; K.Muell., Robenh. Krypt. Fl. 6: 256. 1940; Bapna & Kachroo, Hepatic. India 2: 410. 2000. *Marchantia hemisphaerica* L., Sp. Pl. 1138. 1753. *Asterella hemisphaerica* (L.) P.Beauv., Encl. Meth. Suppl. 1: 502. 1802. *A. hemisphaerica* P.Beauv., Dict. Sci. Nat. 3: 257. 1805. *Reboulia sullivanti* Lehm., Nov. Stirp. Pug. 28. 1832. *R. javanica* Nees, Syn. Hepat. 549. 1845. *R. microcephala* (Taylor) Nees, Syn. Hepat. 790. 1845. *R. longipes* Sande-Lac. in Miquel, Prol. Fl. Jap. 373. 1866. *Asterella longipes* Mitt., Trans. Linn. Soc. Lond. ser. 1,3: 205. 1891. *Mindal pangiensis* Kashyap, J. Bombay Nat. Hist. Soc. 24: 346. 1916 & Liv. W. Himalayas Punjab. Pl. 1: 72. 1929; Tayal & V.Nath., J. Indian Bot. Soc. 44 (1): 23. 1965. *Reboulia hemisphaerica* var. *pangiensis* Kashyap, Liv. W. Him. Punjab Pl. 1: 74. 1929; Kachroo, J. Univ. Gauhati. 5: 121. 1954.

Thallus yellowish-green, margin purple, dense patches of overlapping individuals, 1-2 cm x 2.2-3.2 mm, lobes oblong, emarginate or bilobed at apex, margin ascending; dorsal epidermal cells 4-6 angled, walls slightly thickened, pores a little elevated with 3-5 concentric rings of 6-8 cells each; radial walls and trigones thickened; scales purple, in one row on either side of the midrib, appendages two, linear; midrib thick, gradually passing into the lamina ending in one cell thick margin; male receptacle not seen; female receptacles hemispherical, 4-lobed, about 4 mm long; capsule spherical; spores brown, rounded, reticulate with a broad wing; elaters 2-3 spiraled. (Fig. 2: f-h & Plate 3c)

Habitat: Seen as patches on earth cuttings alongwith *Philonotis mollis* and *Targionia hypophylla* in semi evergreen and evergreen forests.

Specimen examined: Soojipara (870 m) MCN 87085a.

Distribution: In Wayanad, this species is common in Soojipara area. Rajeevan (1990) reported this species from Idukki district of Kerala. Its distribution extends to other parts of South India (Tamil Nadu: Nilgiri hills, Madras, Palni hills, Tirunelvely hills), Central India (Mt. Abu), North-east India (Mussoorie, Simla, Kulu, Kashmir, Darjeeling, Pachmahri, Khasi hills), China, Japan, Korea, Nepal, Afganistan, Pakistan, Java, Bonin, New Zealand, Australia, North & South America, Tahiti, Europe and Africa.

MARCHANTIACEAE (Bisch.) Lindl.

Nat. Syst. Bot. ed 2, 26, 412. 1836.

Thallus greenish to dark greenish, dichotomously branched, prostrate; air pores dorsal, well defined, air chambers well developed or absent, with or without assimilatory filaments; gemmae cup present, sporogonia on receptacles, differentiated into foot, seta and capsule; capsule ovoid to globose.

This family includes five genera viz., *Bucegia*, *Dumortiera*, *Marchantia*, *Neohodgsonia* and *Preissia*. Of these *Dumortiera*, *Marchantia* and *Preissia* are reported from India. Of which *Dumortiera* and *Marchantia* occur in the study area.

Key to the genera

- 1a. Thallus 3-10 cm or more long; air chambers absent; gemmae cups absent on dorsal median line.....**Dumortiera**
- 1b. Thallus 1-2 cm long; air chambers in one layer; gemmae cups present on dorsal median line.....**Marchantia**

Dumortiera Nees

in Reinw. *et al.* Nova Acta Acad. Nat. Cur. 12: 410. 1824.

Thallus dark greenish, 3-10 cm or more long, prostrate in large expanded patches, repeatedly dichotomous or branching by apical innovations, apex

notched, midrib very prominent; air-chambers absent, outermost layer chlorophyllose, scales hyaline, reduced, attached to the thallus on either side of the midrib in one row; gemmae cup on surface of thallus at apex, absent in dorsal median line; male receptacles disciform, depressed in the centre, sessile with bristles along the margins; female receptacles disciform, convex with a few bristle-like hairs, sessile when young, stalked when mature, stalk 5 mm to 2.5 cm long, two-furrowed, top covered with scales; capsule with a short pedicel; spores tetrahedral, dark brown; elaters long, 2-4 spiraled, sometimes branched.

Dumortiera hirsuta (Sw.) Nees, Martius Fl. Ras. 1: 307. 1833; Kashyap, Liv. W. Him. Punjab. Pl. 1: 42. 1929; Kachroo, J. Univ. Gauhati 6: 127. 1955; Udar & Jain, Indian J. For. 7(4): 300. 1984; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 67. 2000; Bapna & Kachroo, Hepatic. India 2: 440. 2000. *Marchantia hirsuta* Sw., Prodr. Fl. Ind. Occid. 145. 1788. *M. irrigua* M.S.Wils. in Hook., Eng. Flora 106. 1833. *Dumortiera irrigua* Nees, Nat. Eur. Leberm. 4: 159. 1839.

Thallus dark greenish, in large patches of overlapping individuals, 5-10 cm x 1-1.5 cm, repeatedly dichotomous, margin undulate, midrib broad, dorsal surface sometimes with a faint network, covered densely with papillate cells, epidermal cells 4-6 angled, thin, ventral surface green, scales simple, hyaline, midrib more prominent below; male receptacles terminal, disciform, with bristles on the margin, resemble the female receptacles when young, female receptacles sessile when young, with a few bristle like hairs, stalked at maturity, stalk thick, with 2 rhizoid furrows; capsule globose; spores tetrahedral, dark brown at maturity, 22-26 μm in diameter; elaters 2-4 spiraled, some branched. (Plate 3d & e)

Habitat: Mostly seen in shady wet areas of forests, on rocks near water courses, on submerged rocks, on exposed roots of higher plants, etc. in semi evergreen, evergreen and shola forests.

Specimens examined: Begur RF (845 m) MCN 84595, Keeradamkolli, Muthanga range (915 m) MCN 76100, Chembra hills (1380-1560 m) MCN 120353.

Distribution: This species is widely distributed in the high altitude areas of Wayanad. It is also collected from the nearby areas such as Kakkayam and Vellarimala in Kozhikode and Aralam of Kannur district. Srivastava and Sharma (2000) had reported this species from Silent Valley NP. It has wide distribution in South India (Madras, Kotagiri, Kerala), North India (Simla, Mussoorie, Kumaon, Pachmahri), Nepal, Japan, Brazil, Mexico, Jamaica, North & South America, Europe, New Zealand, Hawaii and Africa.

Marchantia L.

Sp. Pl. 1137. 1753.

Thallus dichotomously branched, midrib broad, areolae hexagonal, gemmae globular on the dorsal surface, air-chambers in one layer, filaments in the chambers 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 lobed or entire; male receptacle long peduncled, stellately or palmately lobed, stalk with two rhizoid furrows on the anterior side, female receptacle stellate, with 4-10 cm 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 bi-spiraled.

Marchantia linearis Lehm. & Lindenb. in Lehm., Nov. Stirp. Pug. 4: 8. 1832; Mitt., J. Proc. Linn. Soc. 5: 125. 1861; Steph., Sp. Hepat. 1: 187. 1900; Bapna & Kachroo, Hepatic. India 2: 433. 2000.

Thallus dark greenish-black, 1.5-2 cm x 3 mm, dichotomously branched, crowded together; midrib narrow, prominent, black; pores scarce, small, not prominent, elevated with 5-8 concentric rings, ventral surface possess rhizoids and scales on either side of the midrib, scales in four rows; gemmae present at the apex of midrib, cup soft; photosynthetic filaments of air chambers highly branched, 2-3 cells high, air pores barrel-shaped, storage cells small, 0.1-0.2 x

0.1 mm; male and female reproductive structures not seen. (Fig. 2: i-k & Plate 3f).

Habitat: On soil cuttings near water courses in homestead areas of semi-shaded marshy area.

Specimens examined: Lakkidi palam (400 m) MCN 87112, 120357.

Distribution: This species could be collected from only one locality and has rare occurrence in the study area. It was earlier reported from North-east India (Darjeeling, Bengal, Assam, Sikkim, Khasi hills), Sri Lanka, Nepal and Malacca. The present collection is a new record to Peninsular India.

TARGIONIACEAE Dumort.

Anals. Fam. Pl. 68: 70. 1829.

Thallus pale green to yellowish-green or fluorescent green, dorsiventral, thin to thick and fleshy, air chambers empty or with assimilatory filaments, pores prominent; midrib slightly differentiated or not differentiated; branches dichotomous, rarely with ventral innovations; ventral scales abundant, in two rows or rarely absent; rhizoids numerous, hyaline; sporogonia usually found on the tip of ventral surface; capsule globose.

This family includes *Targionia* and *Cyathodium*, both occur in the study area.

Key to the genera

- 1a. Thallus greenish, thick, fleshy; air chambers distinct with full of assimilatory filaments.....**Targionia**
- 1b. Thallus fluorescent green, thin, not fleshy; air chambers in one layer, empty, or with assimilatory filaments.....**Cyathodium**

Cyathodium Kunze

in Lehm., Nov. Stirp. Pug. 6: 17. 1835.

Thallus fluorescent greenish, thin, tufted, dichotomously divided; air chambers in one layer, empty or with assimilatory filaments, pores when present large, bounded by concentric rings of cells; scales minute in two rows or

absent, rhizoids smooth; male receptacle terminal, lateral or in the forking of two branches, antheridia numerous, involucre smooth or hairy; archegonia few in a cluster; capsule globose, inserted by a small foot; seta short, slender, delicate; spores spherical; elaters fusiform, trispiraled.

Cyathodium cavernarum Kunze in Lehm., Nov. Stirp. Pug. 6: 18. 1834; Khanna, J. Myanmar Res. Soc. 16: 227. 1927; Schiffn., Ann. Bryol. 11: 132. 1938; Udar & Jain, Indian J. For. 7(4): 303. 1984; Bapna & Kachroo, Hepatic. India 2: 391. 2000. *C. africanum* Mitt., J. Linn. Soc. 298. 1887. *C. mexicanum* Steph., Sp. Hepat. 6: 4. 1917. *C. barodae* Chav., Bryologist 11: 57. 1937; Amer. J. Bot. 24: 484. 1937.

Thallus yellowish-green to light greenish or fluorescent green, thin, delicate, 4-10 x 4-5 mm, often dichotomously branched; dorsal epidermal cells thin walled, chlorophyllose; air chambers in single row, partition between air chambers 1-2 cells high with chloroplasts, pores on dorsal surface with 3-4 concentric rings of 4-6 cells; rhizoids smooth walled, scales minute in two rows.

Habitat: Occurs in moist areas of both forest and non-forest areas of the study area; on soil, wet rocks, walls and termite mount in the moist deciduous, semi-evergreen and evergreen forest and as well as in the pots and walls in the non-forested areas and homesteads. (Plate 3g).

Specimen examined: Hairpin area (480 m) MCN 120341.

Distribution: *Cyathodium cavernarum* is a widely distributed species usually growing in low altitude areas, in places of human habitation or in shady places of disturbed areas. It has earlier been reported from Peninsular India (Kerala, Gujarat), Central India (Maharashtra, Madhya Pradesh, Rajasthan), North-east India (Uttaranchal, Uttar Pradesh, West Bengal, Arunachal Pradesh, Sikkim, Assam, Meghalaya), Myanmar, Cuba, Africa, Java, Mexico and America.

Targionia L.

Sp. Pl. 1136. 1753.

Thallus green to yellowish green, simple with ventral innovations near the apex, prostrate, rarely dichotomously divided, with indistinct areolae on the

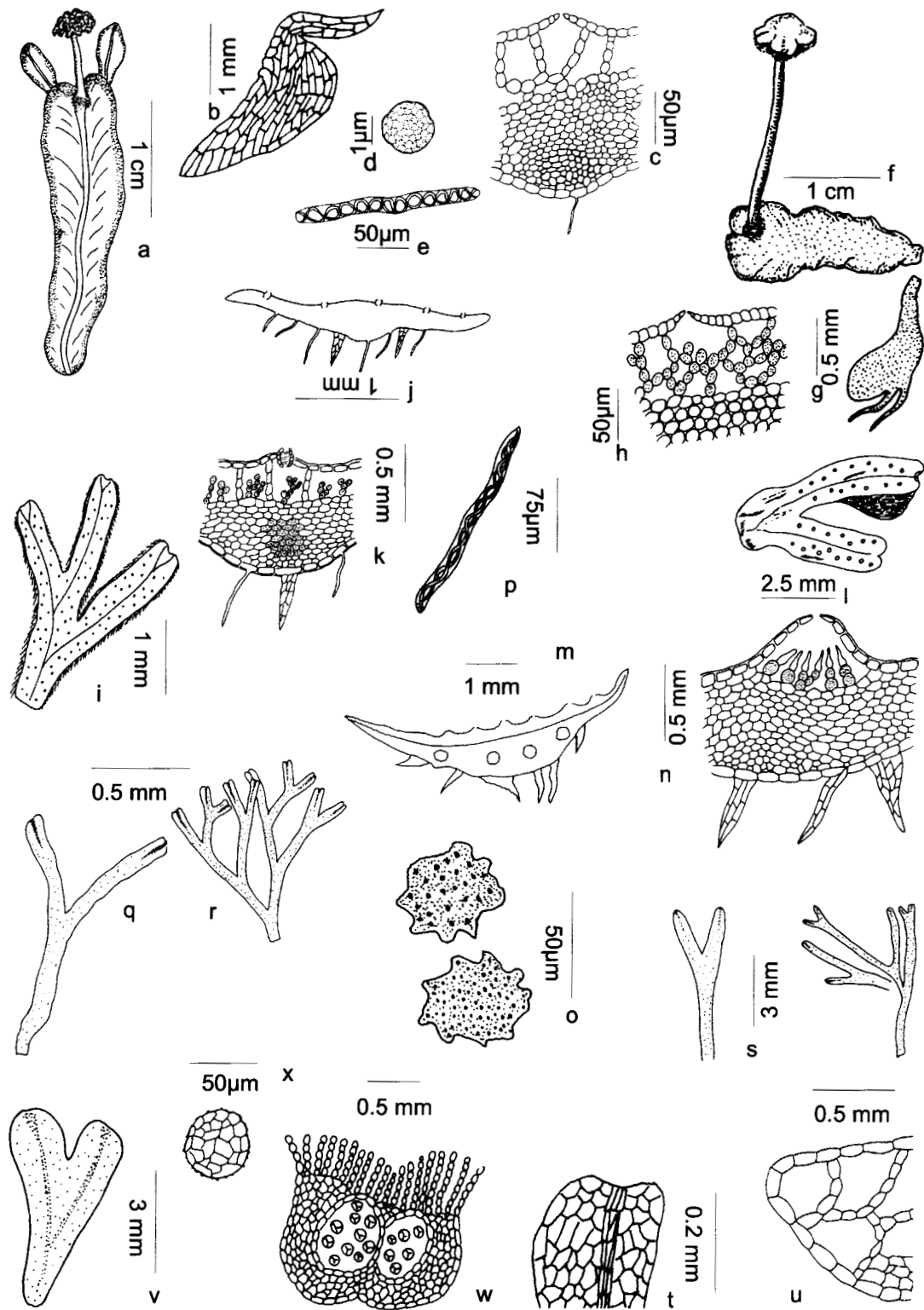


Fig. 2: a-e: *Asterella khasiana*; a: thallus, b: scale, c: section through thallus, d: spore, e: elaters; f-h: *Reboulia hemisphaerica*; f: thallus, g: scale, h: section through thallus; i-k: *Marchantia linearis*; i: thallus, j: diagrammatic view of thallus section, k: portion of thallus showing internal tissue; l-p: *Targionia hypophylla*; l: thallus, m: diagrammatic view of thallus section, n: portion of thallus showing internal tissue, o: spores, p: elater; q-u: *Riccia fluitans*; q&r: land thalli, s: aquatic thalli, t: cells at surface view, u: section through thallus; v-x: *Riccia frostii*; v: thallus, w: section through thallus, x: spore

dorsal surface, pores simple; air chambers distinct, full of filaments; ventral scales in two rows; antheridia on the dorsal surface of the disc-like ends of short ventral innovations arising from the midrib; archegonia several; sporogonium usually one in each involucre, rarely 2, the two valves of the involucre separating, leaving a slit like opening; capsule at length breaking through the calyptra, shortly pedicellate, with a well developed foot; spores spherical, reticulate; elaters bispiraled.

Targionia hypophylla L., Sp. Pl. 1136. 1753; Steph., Sp. Hepat. 1: 61. 1900; Macv., Std. Handb. Brit. Hepat. 1: 33. 1926; Kashyap, Liv. W. Him. Punjab Pl. 1: 57. 1929; Mahabale & Mahajan, J. Univ. Bombay 23: 24. 1955; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 68. 2000; Bapna & Kachroo, Hepatic. India 2: 388. 2000. *T. michellii* Corda in Opiz., Beitr. 1: 649.1829. *T. bifurca* Montin, Ann. Sci. Nat. Bot. 9: 113. 1852. *T. convoluta* Lindb. & Gottsche, Syn. Hepat. 576. 1852.

Thallus greenish, simple, rarely dichotomously divided, 5-10 mm x 2- 4 mm, fixed to the soil only at their base, margin entire, areolae indistinct, epidermal cells 5-6 angled, walls slightly thickened, angles much thickened; air chambers distinct, containing green filaments, terminal cells of the filaments under the pore hyaline with very few chloroplasts, pores simple, conspicuous, slightly elevated, with 4 concentric rings of 6 cells each; ventral surface purple, scales broadly triangular, long subulate at apex; involucre purple, subglobose, keeled; sporogonia single; capsule spherical; spores 42-55 µm in diameter, dark brown; elaters bispiraled, 80-200 x 7-10 µm. (Fig. 2: l-p & Plate 3h&i).

Habitat: Seen as patches on soil cuttings alongwith *Philonotis mollis* and *Reboulia hemisphaerica* in the moist and shady regions in tea estates, semi-evergreen and evergreen forests.

Specimens examined: Soojippara (765 m) MCN 87085b, Chembra estate (1055m) MCN 120251, Periya (880 m) MCN 120356.

Distribution: It is common in the study area. This species is distributed in South India (Kerala; Tamil Nadu: Madras; Karnataka: Mysore), Central India (Mt. Abu), North-east India (Western Himalayas, Mussoorie, Pachmahri, Simla, Sikkim,

Chirapunji, Khasi hills), Japan, Chile, Korea, Taiwan, China, Hawaii, Peru, Europe, N. & S. America and Australia.

Order **RICCIALES** Schljakov emend. Stotler & Crand.-Stotl.

RICCIACEAE Rehb.

Botanik fur Damen. Kunstler und Freunde 255. 1828.

Thallus yellowish-green to bluish or blackish green, prostrate, dichotomously branched; ventral scales in two rows; air spaces conspicuous, air pores rudimentary or absent; sex organs and sporogonia immersed within the thallus, sporogonia without foot, seta and capsule, spores surrounded by single or double layered spore wall, spores rounded, brownish.

This family includes two genera *viz.*, *Riccia* and *Ricciocarpos*, both occur in the study area.

Key to the genera

- 1a. Epidermis without pores; antheridia scattered in the thallus.....**Riccia**
- 1b. Epidermis with distinct minute pores; antheridia aggregated in a median furrow of the thallus.....**Ricciocarpos**

Riccia L.

Sp. Plant. 1138. 1753.

Thallus yellowish-green to bluish-green, dichotomously branched, usually forming rosettes on moist ground, rarely floating in water, with a distinct median furrow; ventral scales usually in one row at the apex, two rowed in the median line, hyaline, violet, light purple or brownish; rhizoids common on land forms, absent in aquatic forms, usually of two kinds, smooth walled and tuberculate; photosynthetic layer with narrow air spaces, or with large polyhedral air chambers, storage region compact; antheridia and archegonia scattered in monoecious species, arise in the dorsal surface, sporophyte without foot and seta, calyptra wall two layered; spores separating before maturity, usually tetrahedral, rarely isobilateral, in some species permanently united in tetrads, sterile cells absent.

Key to the species

- 1a. Thallus free floating or terrestrial, sterile; rhizoids pegged when present.....
.....*R. fluitans*
- 1b. Thallus terrestrial, fertile, rhizoids smooth walled.....*R. frostii*

Riccia fluitans L., Sp. Pl. 1139. 1753; K.Muell., Aufl. 6 Bd. 1. Abt. 204. f. 134. 1907; Kashyap, Liv. W. Him. Punjab Pl. 1: 96. 1929; Bapna, Bryologist 64: 250. 1961; Bapna & Kachroo, J. Indian Bot. Soc. 54: 221. 1975 & Hepatic. India 2: 452. 2000. *Ricciella fluitans* (L.) A.Braun, Sp. Pl. 1139. 1753. *Riccia canaliculata* Hoffm., Deutsch. Fl. 2: 96. 1795. *R. canaliculata* Hoffm. var. *fluitans* Schiffn., Oester. Bot. Zeitsch. 49: 387. 1899. *Fysonia tenera* Kashyap, Liv. W. Him. Punjab Pl. 1: 97. 1929. *Riccia duplex* Lorb. & K.Muell., Hedwigia 80: 100. 1941. *Riccia media* Klingmuller, Flora 146: 616. 1958.

Note: This species occurs in two forms, free floating form with delicate narrow thallus and terrestrial form with thicker and broader thallus than the floating form.

Thallus yellowish-green, narrow, thin, 1-5 cm x 0.5-2 mm, dichotomously branched; terrestrial thallus is much broader, rhizoids pegged, ventral scales rudimentary; both lacking in the free-floating form; thallus segments broadly channeled in free-floating form, spongy, large air chambers occur through out the thallus. (Fig. 2: q-u & Plate 3j&k).

Habitat: Floating form grows in ponds or in slow flowing streams, while the terrestrial form occurs along the muddy margins, or in wet sandy soils in moist deciduous and semi-evergreen forests.

Specimens Examined: Sulthanbathery (920 m) *MCN 84369*, Kurichiad range, Chikkanji (900 m) *MCN 84537a, 84538a* (terr.), Begur RF, Tholpetty range, (830-880 m) *MCN 84570, 84589* (terr.), Muthanga range, Keeradamkolli, (786m), *MCN 84511* (floating).

Distribution: The terrestrial form is widely distributed in the study area at 700-950 m altitudes. The floating form is seen only in Muthanga range. This species

has a wide distribution in South India (Tamil Nadu: Madras, Nilgiris), Central India (Mt. Abu), North-east India (Assam, Himalayas, Garhwal, Kashmir, Kumaun, Pachmahri), Bangladesh, China, Japan, Malaysia, Nepal, Taiwan, Korea, Siberia, Java, Borneo, New Zealand, South America, North America, Europe, West Indies and Britain. The present collection is a new record to Kerala.

Note: The status of *Riccia fluitans* L. has been controversial for a long time (Familler, 1920; Gaisberg, 1921; Evans, 1921; Carter, 1935). This was regarded either as a distinct species with aquatic as well as terrestrial forms or as a composite species comprising the aquatic forms of many terrestrial species. Mueller (1940 & 1941) shown that *R. fluitans* is a composite species consisting of four different species, viz., *R. fluitans* L. emend K. Muell., *R. canaliculata* Hoffm. and *R. duplex* Lorb. & K. Muell. This was accepted by most hepaticologists (Meijer, 1951; Schuster, 1953; Klingmueller, 1957 & 1959). The aquatic forms of the above mentioned species are more or less identical but the terrestrial forms are distinct. *R. fluitans* is mostly found as sterile. The plants collected from different parts of the present study area also were sterile and it usually reproduces by fragmentation and decay of the old thallus.

Riccia frostii Austin, Torrey Bull. Bot. Club 6: 17. 1875; Black, Ann. Bot. 27: 511. 1913; Pande & Udar, J. Indian Bot. Soc. 36: 577. 1957; Bapna & Kachroo, J. Indian Bot. Soc. 54: 219. 1975. *R. watsonii* Austin, Torrey Bull. 6: 17. 1875. *R. frostii* var. *major* Underw., Bot. Gaz. 19: 273. 1894. *R. beclaeriana* Steph., Sp. Hepat. 1: 43. 1898. *R. sanguinea* Kashyap, J. Bombay Nat. Hist. Soc. 24: 349. 1916 & Liv. W. Him. Punjab Pl. 1: 96. 1929; Pande, J. Indian Bot. Soc. 4: 117. 1924; Chopra, J. Indian Bot. Soc. 22: 238. 1943; Udar, Curr. Sci. 26: 22. 1957. *R. palestina* S. Arn., Bot. Not. 115: 311. 1962.

Thallus yellowish-green, in rosettes; female thallus larger than male, 4-10 x 1-1.5 mm, male thallus 3-5 x 1-1.2 mm; rhizoids thin, pinkish, smooth walled; air chambers elongated, epidermal cells thin walled, hyaline, assimilatory filaments loose, storage tissues 4-7 cells thick, spores rounded, 45-55 µm, brownish. (Fig. 2: v-x & Plate 3l).

Habitat: In marshy areas of moist deciduous forest.

Specimen examined: Kaimaram, Tholpetty range (870 m) MCN 120358.

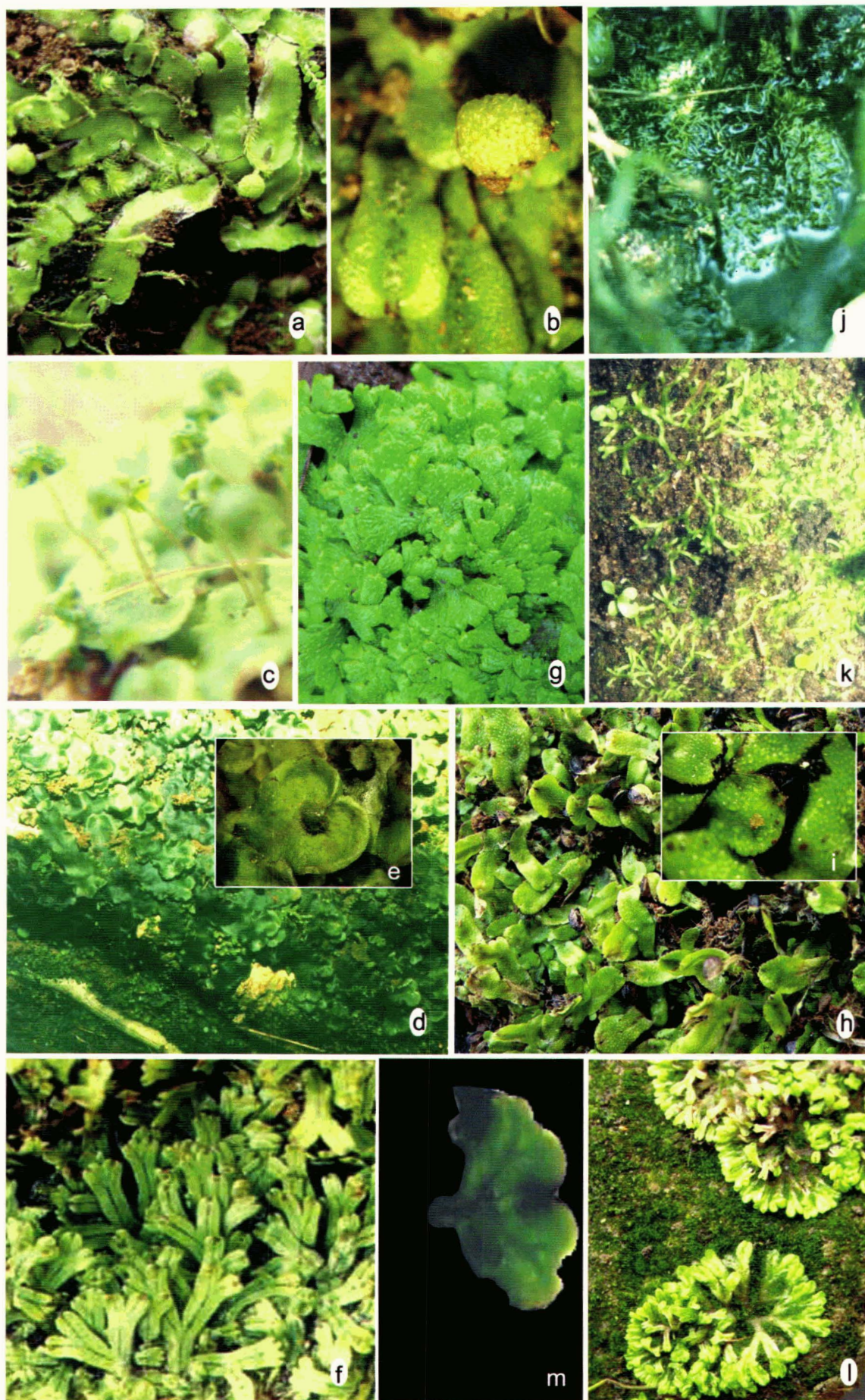


Plate.3. a: *Asterella khasiana*, b: male thalli, c: *Reboulia hemisphaerica*, d: *Dumortiera hirsuta*, e: enlarged view of thallus, f: *Marchantia linearis*, g: *Cyathodium cavernarum*, h: *Targionia hypophylla*, i: thallus with sporophyte, j: *Riccia fluitans*; aquatic thalli, k: land thalli, l: *Riccia frostii*, m: *Ricciocarpos natans*

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Distribution: In the study area it could be found in one locality in the Tholpetty range. It was also found in the nearby Kakkayam forests of Kozhikode district. The species has wide distribution in Peninsular India (Tamil Nadu: Coimbatore, Gujarat), North-east India (Kashmir, Sikkim, Gauhati, West Bengal, Lucknow, Allahabad, Manipur, Bihar), Bangladesh, Pakistan, North and South America, Africa, Europe and Turkey. The present collection is a new record to Kerala.

Ricciocarpos Corda

in Opiz., Beitrage. 1: 651. 1829.

Thallus greenish-black, thick, dichotomously branched, greater part of the thallus is with polyhedral air chambers, dorsal epidermis with minute pores, scales serrated, violet coloured; antheridia clustered together in the median dorsal furrow; archegonia in rows, dorsally each surrounded by a rudimentary cup-shaped involucre; capsule immersed in the thallus tissue; spores rounded, brownish.

Ricciocarpos natans (L.) Corda, Naturalient. 12: 651. 1829; Kashyap, J. Bombay Nat. Hist. Soc. 25: 347. 1916 & Liv. W. Him. Punjab Pl. 89. 1929; Srivastava, Bull. Nat. Bot. Gard. 104: 56. 1964; Bapna & Kachroo, Hepatic. India 2: 445. 2000; Nair & Madhus., Indian J. For. 26(3): 296. 2003. *Riccia natans* L., Syst. Nat. 10: 1339. 1759. *R. capillata* Schm., Icon. Pl. 276: 74. 1794. *R. lutescens* Schwein., Sp. Fl. Amer. Supl. 26. 1821. *R. velutina* Wils. in Hook., Icon. Pl. 249. 1849. *Ricciocarpos velutinus* (Wils.) Steph., Sp. Hepat. 1: 55. 1898.

Thallus dark greenish, ventral portion violet or brownish, free floating, 5-10 x 3-9 mm, dichotomously branched with obcordate lobes, median furrow distinct, dorsal surface leathery, distinctly reticulate; air chambers large, marked dorsally as hexagonal areolate; slightly convex on the ventral surface near median furrow, air pores surrounded by 6-8 cells with slightly thickened walls; ventral tissue thin, with large air chambers and oil cells; scales conspicuous, numerous, pendant, long, serrated, violet or brownish. (Fig. 3: a-f & Plate 3m).

Habitat: Free floating in small ponds in the moist deciduous forests.

Specimen examined: Tholpetty range (860 m) MCN 84615.

Distribution: It is rather rare in the study area and collected from one locality in the Tholpetty range. Nair and Madhusoodanan (2003) has reported this species as a new record to South India from the present locality. It has also been recorded from North-east India (Kashmir, Nainital, Gauhati, Manipur), New Zealand, Australia, North & South America.

Note: This species is characterized by the conspicuous furrow in the middle of each branch, evidently meant for vegetative reproduction by splitting of the thallus along the furrow. The halves separate and forms new plants.

Order FOSSOMBRONIALES Schljakov emend. Stotler & Crand.-Stotl.

FOSSOMBRONIACEAE Hazsl.

A Magyar Birodolom Moh. Florajazo 36. 1885.

Plants yellowish to greenish, prostrate to procumbent, delicate; leaves lobed, uniseriate, margins wavy, possess slime papillae; sporophyte differentiated into foot, seta and capsule, protected by a bell shaped pseudoperianth when young; capsule globose; spores numerous, rounded, yellowish-brown.

This family includes four genera viz., *Austrofossombronia*, *Fossombronia*, *Petalophyllum* and *Sewardiella*. Except *Austrofossombronia* all are present in India, of which only *Fossombronia* occur in the study area.

Fossombronia Raddi

Mem. Soc. Ital. Sci. Modena 18: 40. 1820.

Plants green to yellowish-green, delicate, solitary or in patches; stem simple, prostrate, sometimes slightly raised towards apex, dorsally flattened, with or without apical tubers; rhizoids hyaline or purple coloured; leaves simple, quadrate to subquadrate, usually broader than long, narrow at base, succubous, obliquely inserted in two lateral rows, each lobe having a single mucilage papilla at apex; cells thin walled, angular, filled with chloroplast; monoecious or dioecious, antheridia seen singly on the dorsal surface of the stem or sometimes aggregated towards apex at the base of young leaves,

archegonia dorsal on stem, usually solitary, sometimes mixed with antheridia towards apex, pseudoperianth distinct; seta short or long; capsule spherical, dark-brown to blackish, calyptra free; spores yellowish brown to dark brown; elaters small to large, branched or unbranched, rudimentary or well-developed, pale yellow or yellowish-brown spirals.

Key to the species

- 1a. Leaves quadrate, in two lateral rows; oil bodies few, restricted to cell margin
.....**F. foveolata** var. **cristula**
- 1b. Leaves ovate, overlapping; oil bodies few, dispersed in the cells.....
.....**F. indica**

Fossombronia foveolata Lindb. var. **cristula** (Austin) R.M.Schust., *Hepat. & Anthocerot. N. America* 5: 383. 1992. *F. cristula* Austin, *Proc. Acad. Nat. Sci. Philad.* 228: 1869; Steph., *Sp. Hepat.* 1: 385. 1900; Bapna & Kachroo, *Hepatic. India* 2: 338. 2000. *F. foveolata* Lindb. *Not. Fauna et Flora Fenn. Foerhand.* 13: 382. 1874. *F. japonica* Schiffn., *Oest. Bot. Zeitschr.* 389. 1899.

Plants greenish, prostrate, 6-10 mm long, dichotomously branched, branches 2-4 mm long, prostrate or the tip ascends toward the apex, dorsally flattened; rhizoids purple; leaves in two lateral rows, simple, quadrate, irregularly lobed, each lobe with mucilage papilla at apex; cells polygonal, apical cells 27-80 x 12-35 µm, submarginal cells 25-83 x 28-38 µm, middle cells 35-100 x 20-55 µm, oil bodies few restricted to cell margin; capsule spherical, dark brownish to blackish; seta short when young, emerges out of the perianth at maturity; capsule globose; spores small, ovoid, with conspicuous spine, 10-18 µm in diameter; elaters reduced with unispiral thickening. (Fig. 3: g-l & Plate 4a&b).

Habitat: On moist soil cuttings or rocks alongwith grasses and other mosses in semi-evergreen and evergreen forests.

Specimens examined: Chandanathode (950 m) *MCN 76067, 80075*, Soojippara (760 m) *MCN 87079*.

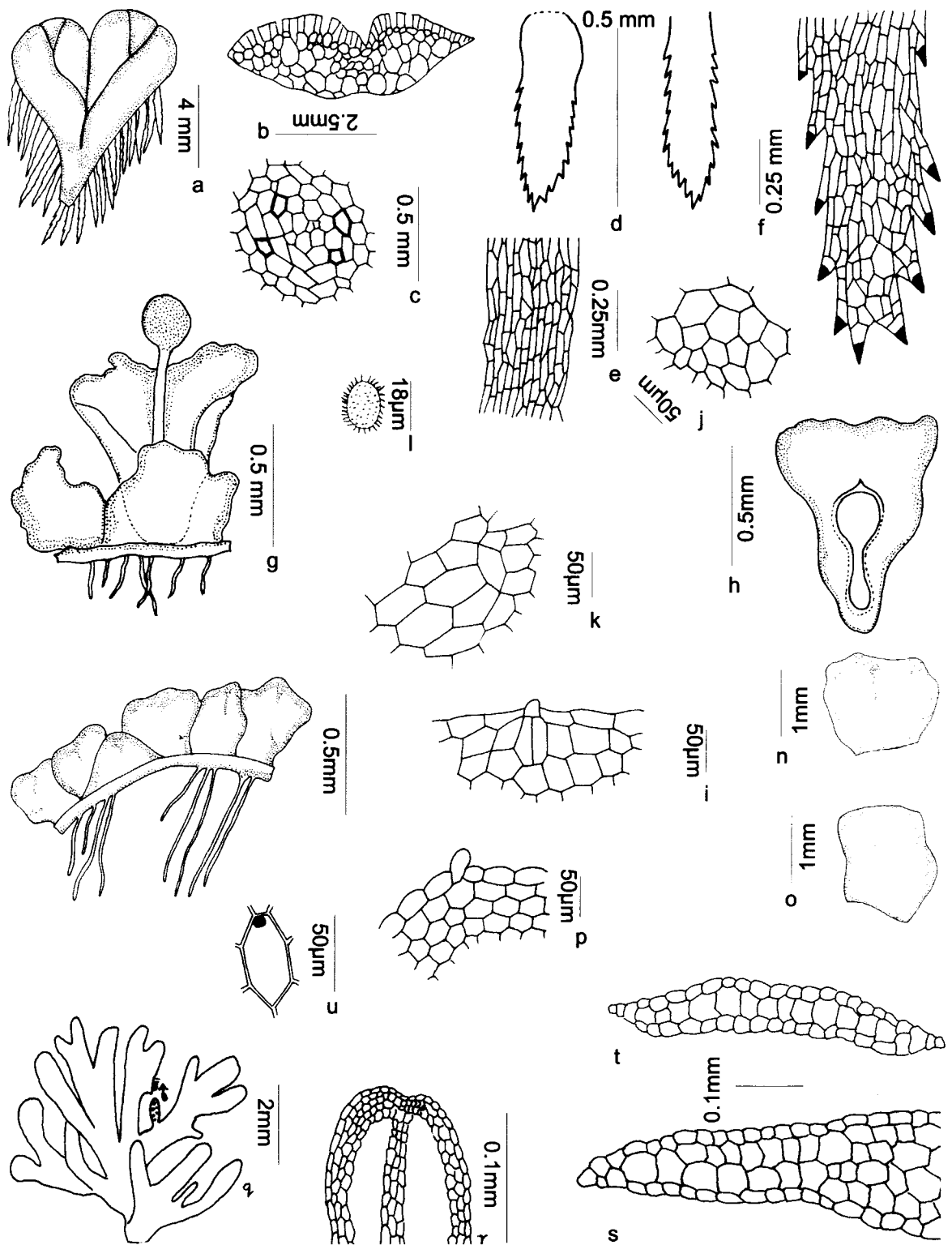


Fig. 3; a-f: *Ricciocarpos natans*; a: thallus, b: section through thallus, c: pores in surface view, d: ventral scales, e: upper part of ventral scale enlarged, f: lower part of ventral scale enlarged; g-l: *Fossombronia foveolata* var. *cristula*; g: habit, h: perianth with young sporophyte, i: marginal cells with papillae, j: middle cells, k: basal cells, l: spore; m-p: *Fossombronia indica*; m: habit, n&o: leaves, p: marginal cells with papillae; q-u: *Riccardia levierii*; q: habit, r: surface cell at margin, s: section through main branch, t: section through ultimate branch, u: single cell with oil body

Distribution: This is a common species distributed throughout the study area between 750-1100 m. Srivastava and Sharma (2000) reported this species from the Silent Valley National Park. It is distributed in South India (Kerala; Tamil Nadu: Kodaikanal, Palni hills, Ootacamund), Japan, Massachusetts, New York, North America and West Virginia.

Fossombronia indica Steph., Sp. Hepat. 6: 73. 1917; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 58. 2000.

Plants yellowish-green, delicate, prostrate, dichotomously branched, up to 1 mm long; rhizoids pinkish, smooth, arises in bunches from the ventral surface; leaves ovate, overlapping, as long as wide, 0.5-1.2 x 1 mm, margin wavy with single mucilage papillae; cells at margin 52-65 x 33-38 μm , basal cells 80-95 x 48-55 μm ; oil bodies few, dispersed in the cells. (Fig. 3: m-p & Plate 4c).

Habitat: On soil cuttings and on small rocks in grasslands.

Specimen examined: Chembra hills (1340 m) MCN 120286.

Distribution: This rare Peninsular Indian endemic species could be collected from Chembra hills of Wayanad. It was Stephani in 1917 described this species from Mangalore of Karnataka State. Srivastava and Sharma (2000) reported this species from Silent Valley National Park of Kerala. It is also distributed in Maharashtra.

Order METZGERIALES Schljakov emend. Stotler & Crand.-Stotl.

PALLAVICINIACEAE Migula

Krypt.-Fl. Deutschl 1: 423. 1904.

Thallus green, prostrate; midrib thick, wing unistratose towards margin, margin entire, undulate, branching dichotomous; ventral scales minute, filiform; antheridia on dorsal surface, hidden by scales or in pits without scales; archegonia on dorsal surface of midrib, surrounded by single or double involucre; seta massive; capsule elongate, cylindrical to ovoid; spores one celled; elaters 2-3 spiraled.

This family includes 10 genera viz., *Greeneothallus*, *Hattorianthus*, *Jensenia*, *Moerckia*, *Pallavicinia*, *Podomitrium*, *Seppeltia*, *Symphyogyna*, *Symphyogynopsis* and *Xenothallus*. Of which only one genus viz., *Pallavicinia* occur in India, and is present in the study area also.

***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 spiraled.

Pallavicinia lyellii (Hook.) S.Gray., Nat. Arr. Brit. Pl. 1: 775. 1821; Mitt., J. Proc. Linn. Soc. 5: 123. 1861; Carruth., J. Bot. Brit. Foreign 3: 302. 1865; Steph., Sp. Hepat. 1: 317. 1901; Kachroo, Proc. Nat. Acad. Sci. India 228. 1956; K.P.Srivast., Bull. Bot. Soc. Univ. Saugar 13: 83. 1961; Bapna & Kachroo, Hepatic. India 2: 349. 2000. *Jungermannia lyellii* Hook., Brit. Jung. Pl. 77. 1816. *Symphyogyna schweinitzii* Montin & Nees, Syn. Hepat. 484. 1845. *Pallavicinia Kanara* Steph., Sp. Hepat. 6: 62. 1924; Pande & K.P.Srivast., J. Indian Bot. Soc. 32: 179. 1953.

Thallus pale green, 3-8 cm x 4-5 mm, simple, innovations arise from the ventral side of midrib, margin entire, undulate; midrib with a central strand of narrow thick-walled cells; rhizoids brownish, arise from midrib, numerous; cells elongated; antheridia and archegonia not observed; capsule cylindrical, reddish-brown; spores 10-25 μ m, reddish-brown, reticulate, elaters bispiraled.

Habitat: On soil cuttings and rocky patches where water drips regularly in moist deciduous, semi-evergreen and evergreen forests. (Plate 4d).

Specimens examined: Hairpin area (450 m) MCN 76096, Kaimaram, Tholpetty range (880 m) MCN 120359.

Distribution: *P. lyellii* is rare in Wayanad. Srivastava in 1961 reported this

species from 'Travancore' but without precise locality. It is distributed in South India (Kerala; Karnataka: Kanara, Agumbe), North-east India (Assam, Gauhati, Shillong, Pachmahri), Sri Lanka, Europe, Jamaica, Cuba, Brazil, Java, Singapore, Philippines, Ryukyu, Japan, Moluccas, New Zealand, Africa and America.

ANEURACEAE Klinggr.

Die Hoeh. Cryptog. Preus. 11. 1858.

Plants thallose, greenish, thick, fleshy, branching pinnate to palmate or irregular; leaf margin entire or crenulate, apex obtuse to acute or emarginate; midrib absent; rhizoids few; sex organs on lateral branches, calyptra cylindrical; capsule ovoid to cylindrical; elaters simple or branched, unispiraled.

This family includes four genera viz., *Aneura*, *Cryptothallus*, *Lobatoriccardia* and *Riccardia*. Except *Lobatoriccardia* all are present in India, of which only *Riccardia* occur in the study area.

Riccardia S.Gray

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

Thallus narrow, delicate, 5-45 x 0.15-1.75 mm, irregularly or pinnately branched, branches slender with broad, emarginate or obtuse apex, margin entire or crenulate; rhizoids scarce, superficial cells polygonal, thin walled; 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 dioecious, 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.

Note: The species delimitation in *Riccardia* is bit problematic due to high variability and the fast

degrading nature of oil bodies in the dried specimens. The low percentage of occurrence of sexual stages, most of the time makes the condition more difficult.

Key to the species

- 1a. Thallus yellowish-green; variously branched.....2
- 1b. Thallus yellowish-brown; short pinnate branches.....3
- 2a. Main axis convex below, slightly concave above, thallus 6 cells thick in the middle; wing multistratose, gradually become thin towards margin.....
.....**R. levieri**
- 2b. Main axis biconvex; 4-6 cells thick in the middle; wing 3 cells thick, margin unistratose **R. multifida**
- 3a. Main axis slightly biconvex in cross section, 4-6 cells thick in the middle, wing multistratose, gradually thinning towards the margin, at branches 3-4 cells thick in the middle with multistratose wing ultimately becoming 2-cells wide, unistratose at the margin; oil bodies dispersed.....**R. tenuicostata**
- 3b. Main axis convex, 3-5 cells thick in the middle with multistratose wing, unistratose at the margin; oil bodies along margin.....**Riccardia sp.**

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; 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 & Madhus., J. Econ. Taxon. Bot. 25: 574. 2001. *Aneura levieri* Schiffn., Sp. Hepat. 1: 261. 1900.

Thallus yellowish-green, 25 mm or more long, 0.5-1 mm wide, variously branched, margin entire, apex thin, broad; rhizoids few, small; superficial cells polygonal, thin walled, without distinct trigones; main axis convex below, slightly concave above, 6 cells thick in the middle, wing multistratose, gradually become thin towards margin, ultimate branches with single or 3-4 cells thick in the middle with multistratose or unistratose wing, unistratose at the margin. (Fig. 3: q-u & Plate 4e).

Habitat: Plants grow in mats on moist and shady rocks and stones near streams above 800 m altitude in moist deciduous, semi-evergreen, evergreen and shola forests.

Specimens examined: Kurichiad range, Chikkanji (920 m) *MCN 84540*, Muthanga range, Mankolli (895 m) *MCN 84502*, Chembra hills (1220 m) *MCN 120228*.

Distribution: This is a common species in the riparian habitats of Wayanad district. It has a wide distribution in South India (Kerala, Tamil Nadu, Karnataka), Central and North India. Srivastava and Sharma (2000) had reported this species from Silent Valley and Nair and Madhusoodanan (2001) from Eravikulam National Park in Kerala.

Riccardia multifida (L.) S.Gray, Nat. Arr. Brit. Pl. 1: 684. 1821; S.C.Srivast. & Udar, Biol. Mem. 1: 137. 1976; Bapna & Kachroo, Hepatic. India 2: 355. 2000. *Jungermannia multifida* L., Sp. Plant. 1136. 1753. *Roemeria multifida* (L.) Raddi, Mem. Soc. Ital. Sci. Modena 18: 36. 1820. *Aneura multifida* (L.) Dumort., Comm. Bot. 115. 1822; R.S.Chopra, J. Indian Bot. Soc. 22: 240. 1943. *Gymnomitrium multifidum* (L.) Hub., Hepat. Germ. 37. 1834. *Sarcomitrium multifidum* (L.) Mitt., J. Proc. Linn. Soc. Bot. 5: 124. 1861. *Aneura crenulata* Steph., Bull. Herb. Boiss. 5: 85. 1897. *A. makinoana* Steph., Sp. Hepat. 1: 227. 1899. *A. decrescens* Steph., Sp. Hepat. 1: 227. 1899. *A. ambrasioides* Pears., Hepat. Brit. Isl. 453. 1902. *A. foreauna* Steph., Sp. Hepat. 6: 26. 1917. *Riccardia decrescens* S.Hatt., Bull. Tokyo Sci. Mus. 11: 164. 1944. *R. shimizuana* S.Hatt., J. Hattori Bot. Lab. 15: 81. 1955. *Riccardia foreauna* (Steph.) Pande & S.C.Srivast., J. Indian Bot. Soc. 37: 417. 1958.

Thallus yellowish-green, variously branched, 1 cm x 0.5-1 mm, margin entire, sometimes crenulate; superficial cells thin walled, polygonal; oil bodies single, ovoid; main axis biconvex in cross section, 4-6 cells thick in the middle, wing 3 cells thick and ultimate branch unistratose; monoecious, antheridial branches slender, embedded, globose; archegonial branches short, archegonia dorsal. (Fig. 4: a-f & Plate 4f).

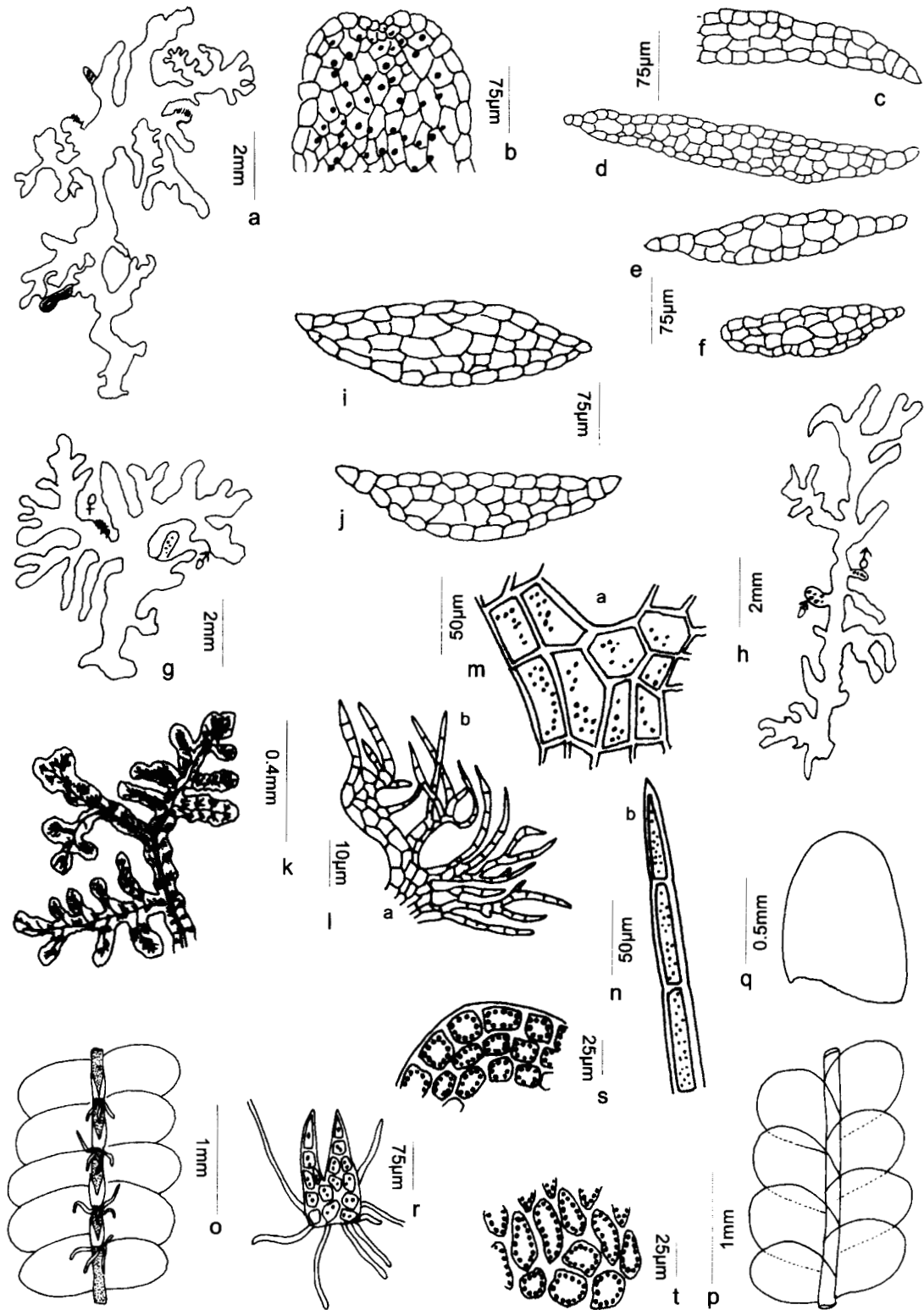


Fig.4: a-f: *Riccardia multifida*; a: thallus, b: cells at surface view, c&d: section through main branch, e&f: section through branches; g-j: *Riccardia tenuicostata*; g: bisexual thallus, h: unisexual thallus, i&j: section through branches; k-n: *Trichocolea tomentella*; k: single branch, l: branch cell enlarged, m: portion 'a' enlarged, n: portion 'b' enlarged, o-t: *Chiloscypus* sp.; o: portion of thallus ventral view, p: portion of thallus dorsal view, q: leaf, r: underleaf, s: marginal leaf cells, t: basal cells

Habitat: Growing in moist and shady places on rocks and on exposed roots of higher plants, where water drips regularly alongwith *Adiantum philippense* and *Utricularia* spp. in semi-evergreen and evergreen forests.

Specimens examined: Kuppadi (860 m) *MCN 84567*, Chandanathode (820 m) *MCN 80090*.

Distribution: This is a very common species of *Riccardia* and widely distributed in Wayanad. Srivastava and Sharma (2000) recorded this species from Silent Valley National Park. It is distributed in South India (Kerala; Tamil Nadu: Madura, Kodaikanal, Palni hills), North India (Eastern Himalayas, Darjeeling), Sri Lanka, China, North America, Europe, Alaska and Hawaii.

Riccardia tenuicostata Schiffn., Denkschr. Math. Nat. Cl. Kais. Akad. Wiss. Wien. 67: 166. 1898; S.C.Srivast. & Udar, Biol. Mem. 1(1/2): 128. 1976; Lindbergia 4: 129. 1977; S.C.Srivast., Bryologist 81: 168. 1978; Bapna & Kachroo, Hepatic. India 2: 357. 2000. *Riccardia crenulata* Schiffn., Denkschr. Math. Nat. Cl. Kais. Akad. Wiss. Wien. 67: 173. 1898. *Aneura tenuicostata* (Schiffn.) Steph., Sp. Hepat. 1: 245. 1899.

Thallus yellowish-brown, small, up to 6 x 0.5 mm, pinnately branched, branches short, apex obtuse, margin entire; main axis slightly biconvex in cross section, 4-6 cells thick in the middle, wing multistratose, gradually become thin towards the margin, branches 3-4 cells thick in the middle with multistratose wing, ultimately becoming 2-cells wide, margin unistratose; oil bodies dispersed; rhizoids small, faint; monoecious or dioecious, antheridial branches narrow or lanceolate, occasionally once or twice branched, margin crenulate; antheridia globose, embedded; archegonial branches short, margins papillose, archegonia dorsal. (Fig. 4: g-j & Plate 4g).

Habitat: On moist rocks and on exposed roots of higher plants and in fern rhizome in semi-shaded areas of moist deciduous and semi-evergreen forests.

Specimens examined: Ponkuzhi (900 m) *MCN 84378*, WWLS, Muthanga range, Mankolli (895 m) *MCN 84502*.

Distribution: This species is rare in Wayanad. Rajeevan (1990) commented that this species has of rare occurrence in Kerala. It is distributed in South India

(Kerala; Tamil Nadu: Kodaikanal), North India (Darjeeling, Western Himalayas), Singapore and Java.

Riccardia sp.

Thallus greenish, irregularly branched, fan-shaped, up to 4.5 mm x 1-2 mm, stoloniferous branches common, margin entire; main axis convex, 3-5 cells thick in the middle with multistratose wing, unistratose at the margin, branches flat; oil bodies on margin of the cells, apices broad, obtuse; superficial cells polygonal in surface, marginal cells 28-72 x 15-34 μm , middle cells 50-98 x 17-56 μm , cells thin walled without distinct trigones. (Plate 4h).

Habitat: Usually growing on moist rocks and soil alongwith *Phaeoceros laevis* subsp. *laevis* and *Fissidens* sp.

Specimen examined: Chembra hills (1310 m) MCN 120228.

Distribution: This species could be collected from only one locality and it is very rare.

Note: This plant does not match with any of the species known from India. Further studies are required to fix its identity.

Order LEPICOLEALES Stotler & Crand.-Stotl.

TRICHOLOLEACEAE Nakai

Ord. Fam. Trib. Nov. 200. 1943

This family includes two genera viz., *Eotrichocolea* and *Trichocolea*, of which only the *Trichocolea* occur in India and extends to Wayanad.

Trichocolea Dumort.

Plants yellowish-green, 4-14 cm long, twice or thrice pinnately branched, relatively broad and thick, bears a dense mass of leaves and paraphyllia; leaves deeply divided into thread like segments; paraphyllia thread-like outgrowth; each typical leaf deeply divided into four main segments, each segment about 3-cells wide at its base, bears a number of pinnately arranged, curved, filamentous outgrowths of one cell wide.

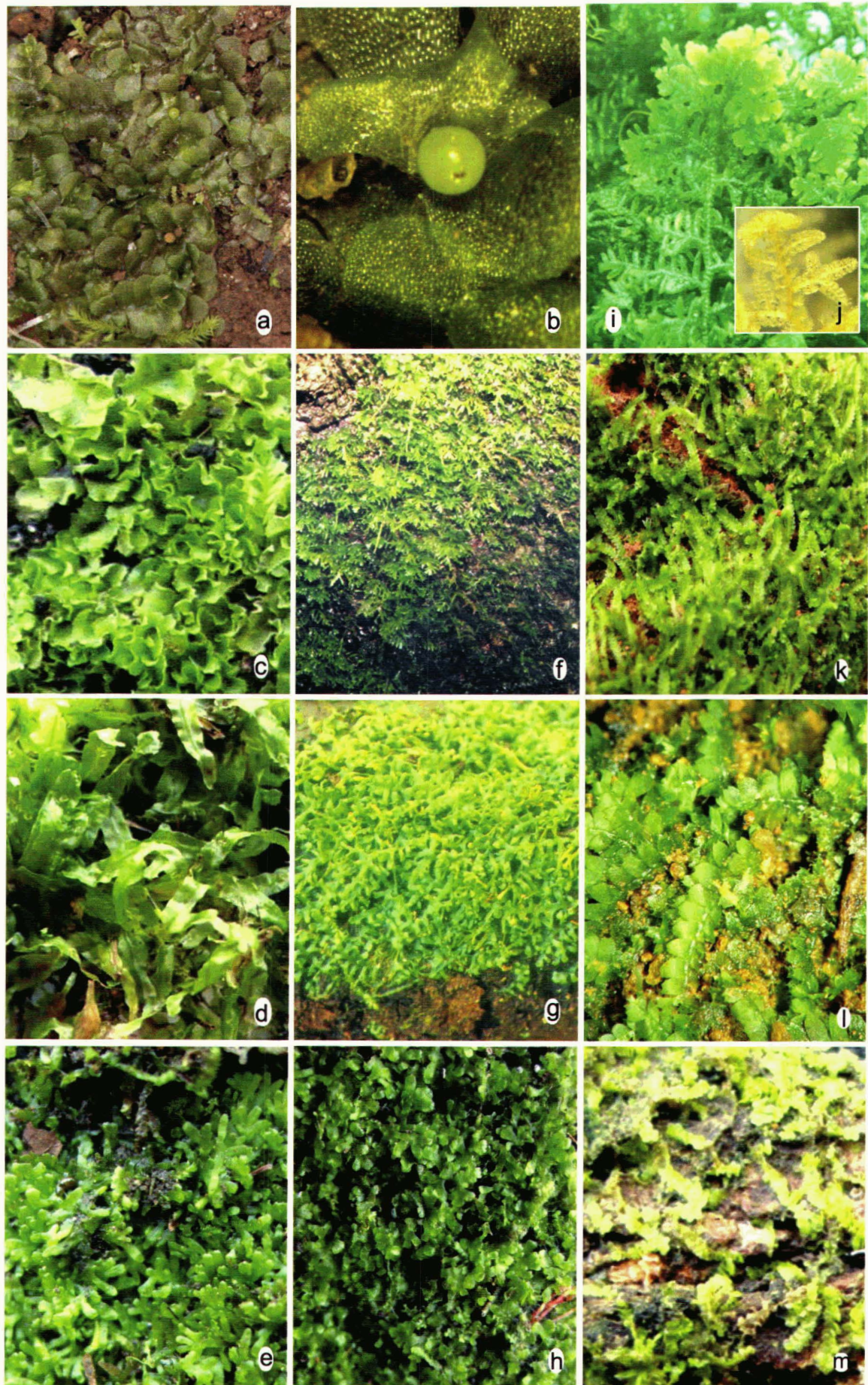


Plate. 4. a: *Fossombronia faveolata* var. *cristula*, b: thallus with sporophyte, c: *Fossombronia indica*, d: *Pallavicinia lyellii*, e: *Riccardia levieri*, f: *R. multifida*, g: *R. tenuicostata*, h: *Riccardia* sp., i: *Trichocolea tomentella*, j: branch enlarged, k: *Chiloscypus* sp., l: *Heteroscyphus argutus*, m: *H. coalitus*

Note: This genus resembles the branched moss *Thuidium* rather than a liverwort in its appearance and the filaments of leaves resemble some algal filaments.

Trichocolea tomentella (Ehrh.) Dumort., Syll. Jungerm. Europ. 67. 1831; R.S.Chopra, Proc. Indian Acad. Sci. 7: 247. 1938 & J. Indian Bot. Soc. 22: 247. 1943; Kachroo, J. Sci. Univ. Kashmir 7: 178. 1970; Udar & S.C.Srivast., J. Bombay Nat. Hist. Soc. 72: 401. 1975. *Jungermannia tomentella* Ehrh., Beitr. Naturk. 2: 150. 1788. *Jungermannia pluma* Reinw. et al., Nova Acta. (Hepat. Jav.) 12: 209. 1825. *Trichocolea biddlecomiae* Austin, Bot. Gaz. 3: 6. 1878.

Plants yellowish-green, 4-10 cm or more long, stems twice or thrice pinnately branched, relatively broad and thick, bears a dense mass of leaves and paraphyllia, leaves deeply divided into thread-like segments; paraphyllia thread like; typical leaf deeply divided into four main segments, each segment about 3 cells wide at its base, bears a number of pinnately arranged curved one cell wide filamentous outgrowths; cells of the filaments long and narrow, 50-70 x 8-10 μm , leaf base cells shorter and wider, ca. 45 μm . (Fig. 4: k-n & Plate 4i&j).

Habitat: Plants form extensive, pale whitish-green patches on very damp, shaded rocks in riverine areas of evergreen and shola forests.

Specimens examined: Chembra hills (1390-1400 m) MCN 120363, 99602.

Distribution: This is a high altitude species seen only in Chembra hills in the study area. It was also collected from Mlappara and Poovar in Idukki district. This species is distributed in South India (Tamil Nadu), Northern India (Western Himalaya) and China. The present collections are new record to Kerala.

Order JUNGERMANNIALES H.Klinggr. emend. Stotler & Crand.-Stotl.

GEOCALYCEAE H.Klinggr.

Die Hoeh. Cryptog. Preus. 34. 1858.

Plants light yellowish to greenish, delicate, prostrate, dorsiventral or laterally compressed; branching varies, ranging from lateral intercalary, lateral terminal to postical intercalary; leaves succubous, closely imbricate, sometimes distant, shape variable from ovate, oblong, ovate-rectangular, quadrate to orbicular, each pair dorsally free but sometimes united at antical lobe, margin

apex entire or apex bilobed or dentate with 1-10 small dentition; cells thin walled; oil bodies 2-25 per cells; underleaves well developed, distant or slightly to closely imbricate, usually shortly to deeply bilobed at apex; rhizoids rare to frequent, usually in tufts at underleaf bases; dioecious or monoecious, male inflorescence on lateral branches or on main shoot, female inflorescence terminal on main shoot or on lateral branches.

This family includes about 25 genera, of which four genera viz., *Chiloscyphus*, *Heteroscyphus*, *Lophocolea* and *Geocalyx* are present in India, of which two genera viz., *Chiloscyphus* and *Heteroscyphus* occur in the study area.

Key to the genera

- 1a. Leaves entire, shape varies, ovate, oblong, subquadrate, orbicular to semi orbicular, slightly to closely imbricate or even distant.....**Chiloscyphus**
- 1b. Leaves often toothed, squarrose or rectangular shaped, leaves arranged almost parallel to the axis.....**Heteroscyphus**

Chiloscyphus Corda

in Opiz. Beitrage 12: 651. 1828

Plants yellowish-green, delicate, prostrate, dorsi-ventral, sometimes laterally compressed; leaves variably arranged on stem, slightly to closely imbricate or even distant, alternate to subopposite, shape varies, ovate, oblong, subquadrate, orbicular to semi orbicular, margin entire, even bilobed towards base; cells usually thin walled, trigones usually absent, sometimes small tri-radiate trigones present, oil bodies fusiform to ovoid; underleaves distant, free, apex bifid; monoecious or dioecious; male inflorescence intercalary usually on main shoots, bracts 5-7 pairs, similar to vegetative leaves but with additional inflated lobule subtending one or two antheridia; female inflorescence terminal on short lateral-intercalary branches, bracts and bracteoles in one or two whorls, smaller than vegetative leaves, perianth without subfloral innovations; capsule ovoid, dehiscing into 4-valves, deep brown, spores yellowish brown, 10-18 µm in diameter, elaters slender, bispiraled.

Chiloscyphus sp.

Plants yellowish-green, delicate, in prostrate patches, dorsiventral, rarely laterally compressed; leaves ovate to oblong, up to 1 mm x 60-72 μm , closely imbricate, alternate or subopposite, margin entire; cells thin walled, trigones absent, cells at margin 20-28 x 25-30 μm , at middle rounded-elongate, 40-43 x 35-40 μm , basal cells 32-40 x 35-40 μm ; underleaves distant, smaller 0.35 mm long, bifid, 3-5 cells uniseriate in one and 2-3 cells in one lobe, 4-6 cells wide at base; rhizoids numerous, long, hyaline, arise from the underleaf bases. (Fig. 4: o-t & Plate 4k).

Habitat: On soil cuttings in semi-evergreen forests.

Specimen examined: Chandanathode (850 m) MCN 120334.

Distribution: This species is rare in Wayanad and could be collected from only one locality.

Heteroscyphus Schiffn.

Oesterr. Bot. Zeitschr. 60: 171. 1910.

Thallus pale yellowish-greenish or olive-green, leaves overlapping, almost parallel to the axis of the stem, often toothed, almost square or rectangular in shape, leaf tip slightly raised from the substrate, leaf margin dentate; underleaves in most taxa large, often reniform; monoecious or dioecious; androecia spicate, male bract entire, very small, androecia solitary, gynoecia on intercalary branches, female bracts large, shortly 2-lobed, enclosing perianth; capsule ovoid, light brown; spores small, rounded, 10-12 μm in diameter; elaters bispiraled.

Note: This genus can be easily recognized by the squarrose or rectangular shaped leaves arranged almost parallel to the axis. Each species differs in the number of teeth and sinus width of the underleaves.

Key to the species

- 1a. Thallus pale yellow to yellowish-green; leaf margin entire with 5-6 terminal dentitions; trigones absent; oil bodies 3-6 per cells.....**H. argutus**
- 1b. Thallus yellowish to olive green; leaf margin mostly smooth with dentitions

or dentitions absent; trigones present or absent; oil bodies 1-6 per cells....2

- 2a. Leaf margin with two distant teeth at the corners of leaf apex; trigones absent.....**H. coalitus**
- 3b. Leaf margin smooth; trigones nodulose.....**H. perfoliatus**

Heteroscyphus argutus (Nees) Schiffn., Osterr. Bot. Zeitschr. 60: 172. 1910; S.C.Srivast. & A.Srivast., Lindbergia 15: 201. 1989; Bapna & Kachroo, Hepatic. India 2: 62. 2000; A.E.D.Daniels in V.Nath & A.K.Asthana, Persp. Indian Bryol. 304. 2001; A.Srivast. & S.C.Srivast., Indian Geocalyc. 122. 2002. *Jungermannia arguta* Nees in Reinw. *et al.*, Hepat. Jav. 206: 14. 1825. *Chiloscyphus argutus* Nees in Gottsche *et al.*, Syn. Hepat. 183. 1845; Steph., Sp. Hepat. 3: 215. 1907; Kashyap, Liv. W. Him. Punjab Pl. 2: 14. 1932. *C. endlicherianus* Nees, Syn. Hepat. 184. 1844. *C. cubans* Taylor, J. Bot. London 5: 282. 1846; R.S.Chopra, J. Indian Bot. Soc. 22: 245. 1943. *Heteroschyphus cubanus* (Taylor) Schiffn., Oesterr. Bot. Zeitschr. 60: 172. 1910.

Thallus pale yellow to yellowish-green, delicate, prostrate, dorsi-ventral, 2-3 cm x 1.5 mm, irregularly branched; rhizoids hyaline, grouped at the base of small bifid under leaves; leaves quadrate to rectangular, flat, succubous, margin entire with 5-6 terminal dentitions; cell wall uniformly thickened, chloroplasts many, rounded, bead-like structures; marginal cells pentagonal, 15-20 µm, median and basal cells hexagonal, 40-54 x 30-36 µm, trigones usually absent; oil bodies 3-6 per cell, faintly grained; underleaves small, distant, deeply 4 lobed. (Fig. 5: a-d & Plate 4l).

Habitat: This is a very common species usually found on rotten logs, rocky patches, soil and roots of higher plants along stream banks in semi-evergreen and evergreen forests.

Specimen examined: Chandanathode (750 m) MCN 80085.

Distribution: This is a widely distributed species in South Asia. In India this is common in South India (Kerala, Karnataka, Palni hills), North-east India (Darjeeling, West Himalaya, Pachmahri, Assam, Sikkim, Manipur, Meghalaya). The present collection is a new record to Kerala. Its distribution extends to

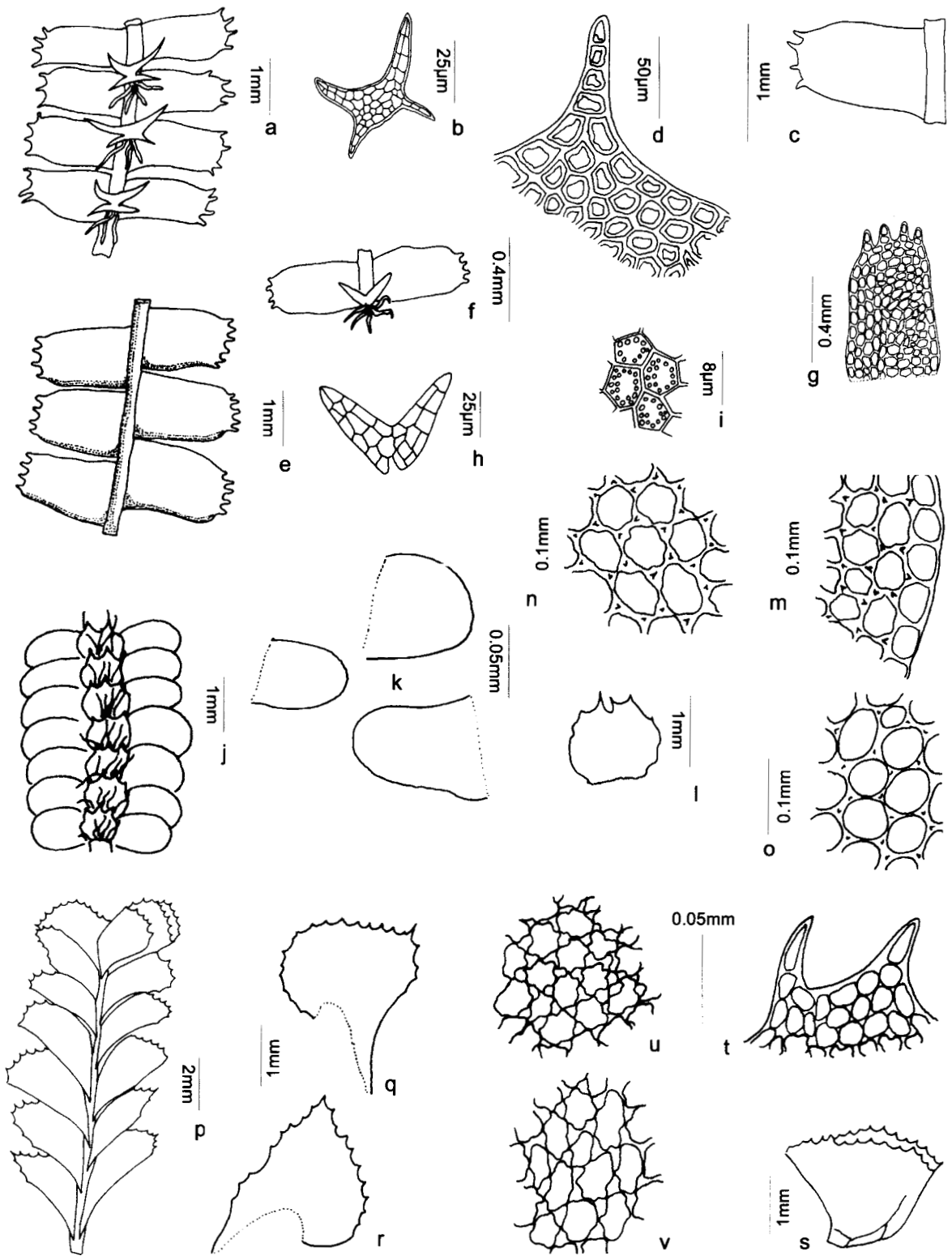


Fig.5: **a-d**: *Heteroscyphus argutus*; a: portion of thallus ventral view, b: underleaf, c: leaf attached to stem, d: marginal cells; **e-i**: *Heteroscyphus coalitus*; e: portion of thallus dorsal view, f: leaf with underleaf and rhizoids, g: leaf cells, h: underleaf, i: cells with oil bodies; **j-o**: *Heteroscyphus perfoliatus*; j: portion of thallus ventral view, k: leaves, l: underleaf, m: marginal leaf cells, n: middle cells, o: basal cells; **p-v**: *Plagiochila beddomei*; p: portion of thallus, q&r: leaves, s: perianth, t: marginal leaf cells, u: middle cells, v: basal cells

Borneo, Brazil, Myanmar, China, Java, Japan, New Guinea, New Zealand, the Philippines, Sumatra and Taiwan.

Heteroscyphus coalitus (Hook.) Schiffn., Oesterr. Bot. Zeitschr. 60: 172. 1910; Bapna & Kachroo, Hepatic. India 2: 62. 2000. *Jungermannia coalita* Hook., Musci. Exot. 2:123. 1818. *Chiloscyphus coalitus* (Hook.) Dumort., Rec. d Obs. 1835; Steph., Sp. Hepat. 3: 242. 1908. *C. bescherellei* Steph., Bull. Herb. Bioss. 5: 87. 1897; Hattori in Hara, Fl. East. Himalaya 512. 1966. *C. irregularis* Steph., Sp. Hepat. 2: 211. 1906. *Lophocolea savesiana* Yoshin, Bot. Mag. Tokyo 2: 54. 1906. *L. sendaica* Steph., Sp. Hepat. 6: 292. 1922. *Heteroscyphus bescherellei* (Steph.) S.Hatt., Bull. Tokyo Sci. Mus. 11: 45. 1944. *Heteroscyphus irregularis* S.Hatt., Bull. Tokyo Sci. Mus. 11: 43. 1944.

Thallus yellowish to olive green, glossy, slender, 1.5-2 cm x 2 mm, branches lateral, intercalary; leaves slightly imbricate, quadrate-rectangular, apex rounded to truncate, margin with two distant teeth at the corners of the leaf apex; cells at apex 10-23 x 10-14 μm , median cells 12-40 x 10-28 μm , at base 18-40 x 14-40 μm , trigones usually absent, oil bodies 1-6 per cell; underleaves small, 0.18-0.59 x 0.16-0.85 μm , distant, deeply bifid, cells uniseriate; antheridia and archegonia not observed; seta massive; capsule spherical; spores 10-15 μm in diameter, brown, granulate; elaters bispiraled, 6-10 μm long. (Fig. 5: e-i & Plate 4m).

Habitat: Occurring on rotten logs and moist soil often associated with other liverworts in semi-evergreen and evergreen forests.

Specimen examined: Chandanathode (920 m) MCN 80091.

Distribution: *Heteroscyphus coalitus* is rare in the study area, collected only from Chandanathode. It has wide distribution in North-east India (Himalayas, Sikkim, Khasi hills), Andaman Islands, Myanmar, Bhutan, China, Java, Sumatra, Borneo, Japan, New Guinea, Philippines and Australia. The present collection is a new record to Peninsular India.

Heteroscyphus perfoliatus (Montin) Schiffn., Oesterr. Bot. Zeitschr. 60: 171. 1910; S.C.Srivast. *et al.*, J. Bryol. 15(3): 559-564. 1989; Bapna & Kachroo,

Hepatic. India 2: 64. 2000; A.Srivast. & S.C.Srivast. Indian Geacalyc. 89. 2001. *Lophocolea perfoliata* Montin, Ann. Sc. Nat. 17: 12. 1842. *Chiloscyphus perfoliatus* (Montin) Nees, Syn. Hepat. 172. 1845.

Thallus yellowish to olive green, delicate, 4-6 cm long, branching lateral; leaves opposite, size varies, 0.04-1 mm, succubous, closely imbricate, ovate to oblong, margin entire, smooth, some leaves shortly bilobed at apex; oil bodies 1-2 per cell; cells thin walled, trigones nodulose, prominent at middle, 15-35 x 20-35 μm at apex, 20-45 x 20-40 μm in middle, 22-50 x 20-45 μm at base; underleaves large, 1 x 0.8 mm, imbricate, apex bifid, with tooth like projections. (Fig. 5: j-o & Plate 5a).

Habitat: Epiphytic on shola trees.

Specimen examined: Chembra hills (1380 m) MCN 120354.

Distribution: This Indian endemic species was collected from Chembra hills of the study area and also from ENP in the Idukki district of Kerala. It is also reported from other parts of South India (Tamil Nadu: Nilgiri hills) and North-east India (Sikkim).

PLAGIOCHILACEAE (Joerg.) C.Muell.

in Rabenh, Krypt.-Fl. ed. 3, 6(2): 877.1956.

Plants greenish to blackish-green, robust, prostrate, obliquely ascending to erect, 2-10 cm or more long, branching lateral, intercalary; rhizoids few; leaves succubous, alternate or opposite, margin entire or toothed; underleaves vestigial or absent; bracts much smaller than leaves, bracteoles absent; male inflorescence on main axis or on short branches; female inflorescence with one or two subfloral innovations; capsule ovoid; spores 15-28 μm in diameter; elaters 1 or 2 spiraled, 7-10 μm long.

This family includes eight genera viz., *Acrochila*, *Pedinophyllum*, *Plagiochila*, *Plagiochilidium*, *Plagiochilion*, *Steeerochila*, *Szweykowskia* and *Xenochila*. Of which about four are present in India, among them only one genus viz., *Plagiochila* occur in Wayanad.

Plagiochila (Dumort.) Dumort.

Rec. Obs. Jungerm. 14. 1835, *nom. cons.*

Plants large, robust, rarely small, caespitose, green to blackish, stem blackish, rarely pale, branches without rhizoids, ascending or procumbent, dichotomously branched or dendroid; leaves mostly larger, in some species smaller, succubous, alternate, widely spreading, margin dentate or ciliate, very rarely entire, underleaves usually absent; dioecious, androecia terminal or intercalary, bracts smaller than the leaves, loosely to closely imbricate, margin entire to strongly dentate; archegonia mostly terminal in long branches, female bracts and 3 or 4 pairs of subinvolucral leaves larger, more broadly ovate, densely toothed than stem leaves; capsule shortly pedicellate, globose; elaters bispiraled; spores small, smooth or rough.

Key to the species

- 1a. Plants dark brown; paraphyllia present; trigones large.....2
- 1b. Plants usually greenish brown; paraphyllia absent, trigones small.....3
- 2a. Leaves oblong-orbicular; cells with large nodulose trigones; paraphyllia in some dorsal leaf base, elongated.....**P. devexa**
- 2b. Leaves broadly ovate; cells with large trigones; paraphyllia broad, present in all leaves.....**P. beddomei**
- 3a. Leaves contiguous to remote, oblong-ovate; sparingly branched.....
.....**P. chinensis**
- 3b. Leaves close, ovate to rectangular; branching luxuriant**P. fruticosa**

Plagiochila beddomei Steph., Bull. Herb. Boissier, ser. 2, 3: 876. 1903 & Sp. Hepat. 2: 361. 1903; So, Syst. Bot. Monogr. 60: 149. 2001. *P. humicola* Steph., Sp. Hepat. 6: 168. 1918.

Plants dark brown, 4-6 cm x 4-5 mm, rarely branched, rhizoids infrequent; leaves imbricate, obliquely inserted, broadly ovate, 2-2.6 x 1.5-2.6 mm, leaf base long decurrent, apex broadly truncate, irregularly 7-11 toothed, ventral margin arched, overlap with opposite leaf base; terminal cell elongated, 50 µm long, median cells 35-40 µm long, basal cells 50-65 µm long, trigones

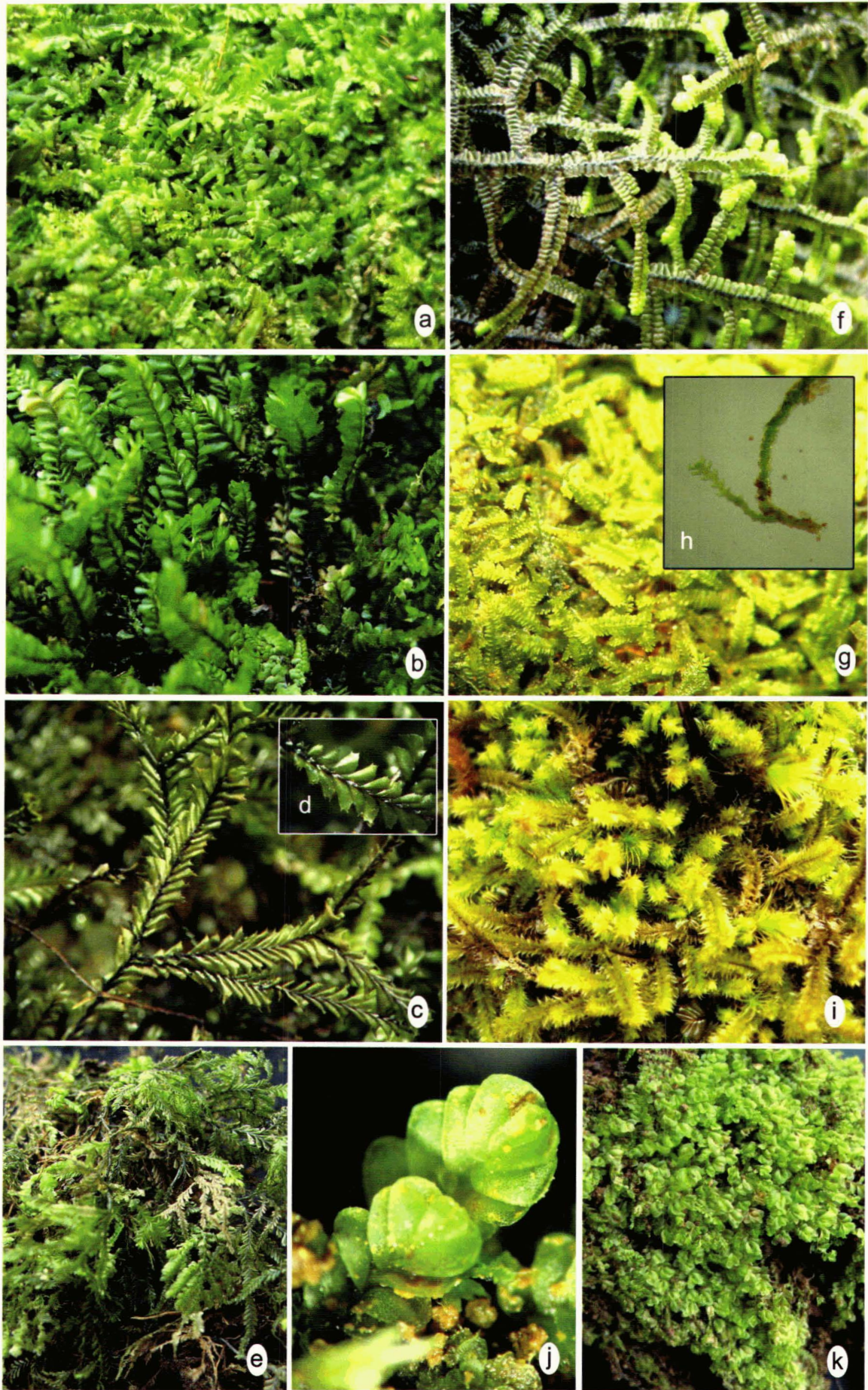


Plate.5. a: *Heteroscyphus perfoliatus* along with *Riccardia* sp., b: *Plagiochila beddomei*, c: *P. chinensis*, d: branch enlarged, e: *P. devexa*, f: *P. fruticosa*, g: *Cylindrocolea tagawae*, h: thallus enlarged, i: *Chandonanthus birmensis*, j: *Jungermannia appressifolia*, k: *J. macrocarpa*

large, nodulose; underleaves vestigial, paraphyllia broad; male plants not seen; gynoecia on apical shoot, bracts similar to stem leaves, spinose-dentate throughout. (Fig. 5: p-v & Plate 5b).

Habitat: Epiphytic and on small twigs on shola and evergreen species of *Syzygium wightianum*.

Specimen examined: Chembra hills (1770 m) MCN 120257.

Distribution: *Plagiochila beddomei* is distributed in the shola forests of Chembra hills and in Kuppadi forests. The species has also been collected from Vellarimala in Kozhikode and ENP in Idukki district of Kerala. It is also distributed in other parts of South India (Tamil Nadu), China and Thailand.

Note: As described by So (2001), this is a very poorly known species. It was described based on a collection from Nilgiri (South India) by Beddome in 18th century. Despite the large hepatic collections from Himalayas and adjoining areas, no recent collections of *P. beddomei* were obtained.

Plagiochila chinensis Steph., Mem. Soc. Sci. Nat. Cherbourg 29: 223. 1894; S.C.Srivast. & Dixit, Geophytology 25: 92. 1996; So, Syst. Bot. Monogr. 60: 179. 2001. *P. simplex* var. *parvifolia* C.Massari, Mem. Accad. Agric. Verona, ser. 3, 73(2): 12. 1897. *P. hokinensis* Steph., Bull. Herb. Boissier, ser. 2, 3: 116. 1903 & Sp. Hepat. 2: 296. 1903. *P. maireana* Steph., Sp. Hepat. 6: 185. 1921. *P. tongtschuana* Steph., ibid. 6: 232. 1921. *P. wilsoniana* Steph., ibid. 6: 242. 1921. *P. irrigata* Herzog in Handel- Mazzetti, Symb. Sin. 5: 18. 1930.

Plants greenish-brown, 2-3 cm long, sparingly branched, branches exclusively lateral intercalary, rhizoids scanty on basal part of shoot; leaves oblong-ovate, up to 1.5 x 1 mm, dorsal margin recurved, base long-decurrent, apex subtruncate, 15-25 teeth per leaf, 3-7 cells long, 1-2 cells wide at base; terminal cells of leaves elongated, 50 µm long, median cells 30 µm long, basal cells 50-60 µm long, trigones distinct, small; underleaves vestigial, paraphyllia absent; androecia terminal as well as intercalary, gynoecia terminal on main shoot, bracts broadly ovate, perianth long, irregularly toothed. (Fig. 6: a-e & Plate 5c&d).

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Habitat: Epiphytic and on small twigs on shola trees alongwith mosses and other leafy liverworts.

Specimen examined: Chembra hills (1765 m) MCN 120261.

Distribution: From Wayanad this species could be collected from Chembra hills only. *P. chinensis* Steph. was collected from India in 1892 from Uttar Pradesh. After a long gap Srivastava and Dixit (1996a) reported it from Kumaon, Western Himalayas. It was also collected from ENP of Idukki district. Here this species is seen associated with other pleurocarpous mosses and recorded it earlier from ENP as a new record for Peninsular India (Nair *et al.*, in press). The species is also reported from China, Vietnam, Thailand, Bhutan, Nepal and Pakistan.

Plagiochila devexa Steph., Bull. Herb. Boissier, ser. 2, 3: 340. 1903 & Sp. Hepat. 2: 324. 1903; So, Syst. Bot. Monogr. 60: 36. 2001; So & Grolle, J. Bryol. 23: 130. 2001. *P. deflexa* Mitt., J. Proc. Linn. Soc. Bot. 5: 97. 1860, *non* Montagne & Gottsche, 1856. *P. microphylla* Steph., Bull. Herb. Boissier, ser. 2, 3: 526. 1903 & Sp. Hepat. 2: 330. 1903. *P. runcinata* Herzog, Ann. Bryol. 12: 76. 1939. *P. pseudomicrophylla* Inoue in Hara, Fl. E. Himalaya 1: 518. 1967.

Plants dark brown, glossy, forming compact patches; shoots 1.5-2 cm long, simple, sometimes branched, branches lateral intercalary; leaves imbricate, becoming more distant towards the base, oblong-orbicular, 1-1.2 x 0.7-1 mm, dorsal margin slightly recurved, base entire, apex rounded, with 3-6 broad teeth, ventral margin arched, decurrent, marginal teeth usually 8-12 per leaf, 3-8 cells long, 2-4 cells wide at base, terminal cells elongated, 25 µm long, median cells 15-20 µm long, basal cells 30-45 µm long, trigones large, nodulose, walls moderately thickened; underleaves vestigial, paraphyllia present along some dorsal leaf base, elongated; androecia terminal on main and lateral shoots, gynoecia terminal on main shoot; bracts more densely toothed and slightly larger than the normal leaves, perianth obovate to cylindrical, highly dentate. (Fig. 6: f-k & Plate 5e).

Habitat: Upper part of tree trunks in evergreen forests.

Specimen examined: Periya (958 m) MCN 120360.

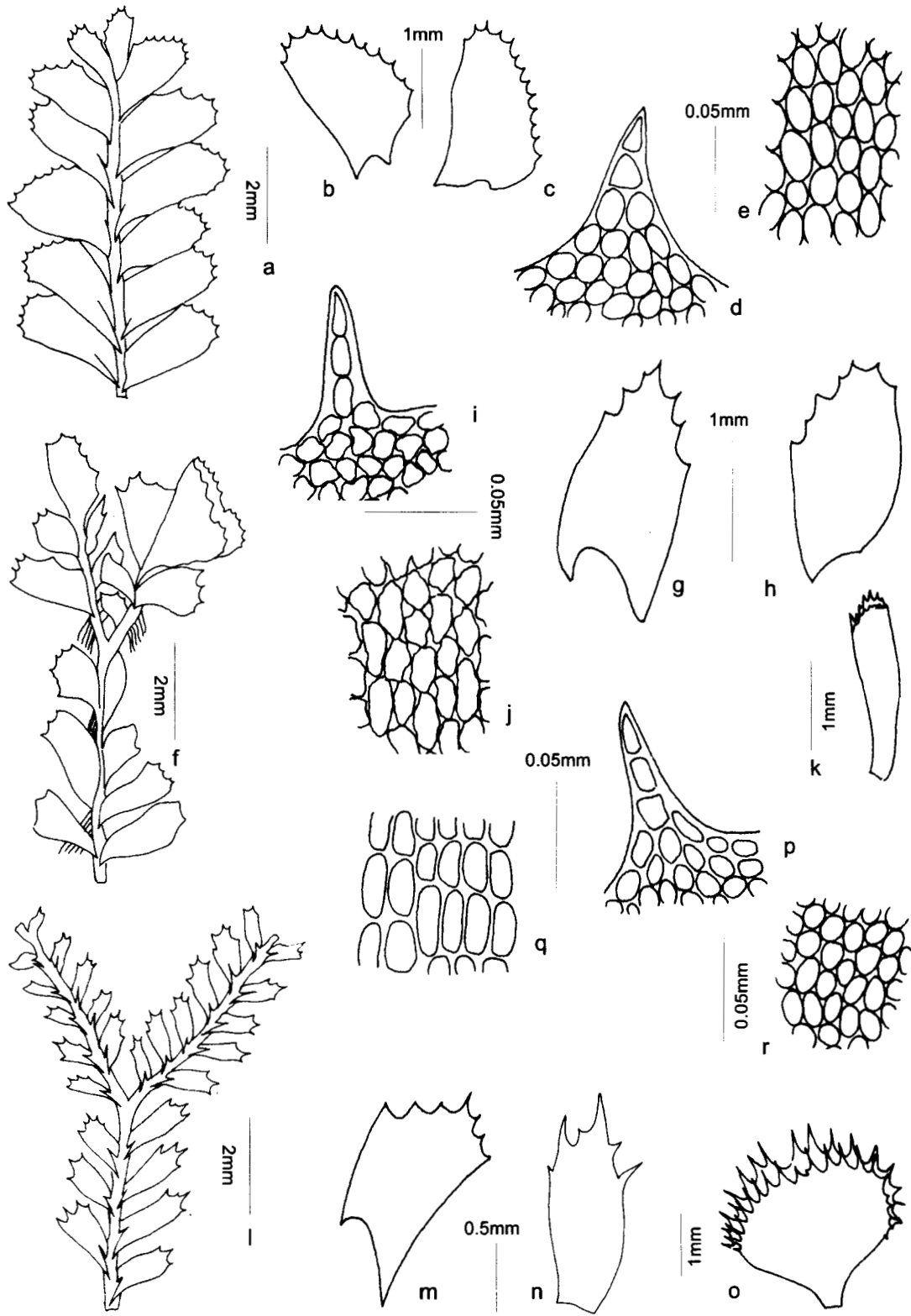


Fig.6: a-e; *Plagiochila chinensis*; a: portion of thallus, b&c: leaves, d: marginal cells, e: middle and basal cells; f-k: *Plagiochila devexa*; f: portion of thallus, g&h: leaves, i: marginal cells, j: basal cells, k: paraphyllia; l-r: *Plagiochila fruticosa*; l: portion of thallus, m&n: leaves, o: perianth, p: marginal cells, q: basal cells, r: middle cells

Distribution: It is rare in Wayanad. It was earlier recorded from North-east India (Sikkim, Himalaya), China, Bhutan, Nepal, and Sri Lanka. This student (Nair *et al.*, in press) recorded it earlier from ENP as a new record for Peninsular India.

Note: As stated by So (2001a) *P. devexa* Stephani is widespread in Himalayan region. But Inoue (1965) in the 'Synopsis of *Plagiochila* in the Himalayan region' had excluded this species alongwith several others. After the type collection from Himalaya, there was no recent report of this species in India.

Plagiochila fruticosa Mitt., J. Proc. Linn. Soc., Bot. 5: 94. 1860; So, Syst. Bot. Monogr. 60: 66. 2001. *P. bipinnata* Steph., Sp. Hepat. 6: 131. 1918. *P. tosana* Steph., *ibid.* 6: 227. 1921.

Plants greenish-brown, glossy, 3-10 cm x 2.1-2.6 mm, rhizome long creeping; leaves ovate to rectangular, stem leaves 1.5-1.7 x 0.5-0.8 mm, branch leaves 1-1.2 x 0.4-0.5 mm, dorsal margin slightly recurved, base long, decurrent, 6-8 teeth per leaf, 4-6 cells long, 4-6 cells wide at base; terminal cells 30 µm long, median cells 25-30 µm long, basal cells 45 µm long, trigones small; underleaves vestigial, paraphyllia absent; androecia intercalary, gynoecia terminal on branches, bracts irregularly toothed, perianth triangular, companulate, highly dentate. (Fig. 6: l-r & Plate 5f).

Habitat: Basal and upper part of tree trunks, on branches and twigs of shola trees and also on rocks.

Specimens examined: Chembra hills (1300-1400 m) MCN 120273, MCN 120292, MCN 120312, MCN 120313c.

Distribution: This species could be collected only in the shola forests of Chembra hills. It was also collected from the shola forests of Eravikulam National Park in Idukki district and Evergreen forests of Vellarimala of Kozhikode district. It is also distributed in North-east India (Assam, Sikkim, Himalaya, Darjeeling, West Bengal), China, Bhutan, Japan, Thailand and Philippines. Nair *et al.*, (in press) have reported this species as a new record to Peninsular India from ENP.

CEPHALOZIELLACEAE Douin

Bull. Soc. Bot. France, Mem. 29: 1, 5, 13. 1920.

Plants light yellowish to greenish, sometimes brown, delicate, prostrate, mostly microscopic, seen along with mosses; stem 6-8 cells across; branching abundant, flagelliferous; rhizoids few, scattered; leaves distant, obliquely inserted, bifid, lobes subequal to unequal, acute to subacute, margin normally entire; oil bodies seen in some, 1-5; underleaves absent; monoecious, male inflorescence terminal or intercalary; female inflorescence terminal or on short lateral branches; capsule ovoid; spores rounded, reddish-brown, papillate-vermiculate; elaters bispiraled.

This family includes nine genera viz., *Allisoniella*, *Amphicephalozia*, *Cephalojonesia*, *Cephalomitron*, *Cephaloziella*, *Cephaloziopsis*, *Cylindrocolea*, *Kymatocalyx* and *Stenorhipis*. Of which *Cephaloziella* and *Cylindrocolea* are present in India and also occur in Wayanad.

Key to the genera

- 1a. Flagelliferous branches present; leaves distant to contiguous, bifid, lobes subequal.....**Cephaloziella**
- 1b. Flagelliferous branches absent; leaves small, scaly at base, shortly bilobed, lobes equal or subequal.....**Cylindrocolea**

Cephaloziella (Spruc.) Steph.

Hedwigia 32: 318. 1893.

Plants greenish-yellow, prostrate, delicate; rhizoids few on the ventral surface of stem; leaves scaly at base, distant to crowded at apex, bifid, lobes equal to subequal; oil bodies and underleaves absent.

Cephaloziella kiaerii (Austin) S.Arnell, Bot. Not. 319. 1952; Udar & A.Kumar Geophytology 15(2): 141. 1985; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 61. 2000; Nair & Madhus., J. Econ. Taxon. Bot. 25: 574. 2001. *Cephalozia andreana* Steph., Sp. Hepat. 6: 434. 1924. *Cephaloziella willisana* (Steph.) Kitagawa, J. Hattori Bot. Lab. 32: 295. 1939.

Plants prostrate, light green, delicate, up to 15 mm long; branches abundant, flagelliferous branches present; rhizoids few, scattered on the basal part of stem, on the ventral side or on flagelliferous branch; leaves distant to contiguous, bifid, lobes subequal, margin entire, 130-240 x 120-200 μm , peripheral cells smaller, 5-15 x 6-15 μm , central larger 8-16 x 7-18 μm , thin walled; underleaves absent; monoecious, male inflorescence terminal on main or lateral branch, female inflorescence terminal or on short ventral branch, bracts 1-2 pairs, bifid, apex acute, perianth cylindrical, fusiform, exerted, 0.6-1.5 x 0.25-0.40 mm broad; capsule ovoid, spores reddish-brown, papillate vermiculate, 7-11 μm in diameter, elaters bispiraled, 150-200 x 7-9 μm . (Fig. 7: a-g).

Habitat: Seen on exposed soil alongwith *Anoetangium bicolor* in Tea estate.

Specimen examined: Chembra estate (1060 m) MCN 120239b.

Distribution: It is common in the high altitude areas of Chembra and Periya. Udar and Kumar (1983b) has reported this species from Lakkidi (Wayanad), Silent Valley (Palakkad), Vaguvarai (Idukki) and Ponmudi (Thiruvananthapuram) in Kerala State. *C. kiaerii* has also distributed in other parts of South India (Tamil Nadu: Nilgiri, Palni hills, Kodaikanal, Mahabaleswar), Sri Lanka and China.

Cylindrocolea R.M.Schust.

Bull. Nat. Sci. Mus. 12: 666. 1969.

Plants yellowish-green, minute up to 3 x 0.2 or 0.3 mm, creeping, attenuate; leaves distant to continuous, shortly bilobed; cells moderately thick walled without distinct trigones and intermediate thickening; underleaves and oil bodies absent.

Cylindrocolea tagawae (Kitag.) Schust., Nova Hedwigia 22: 174. 1971; Udar & Kumar, Proc. Indian Acad. Sci. 92: 2. 1983 & Geophytology 15(2): 143. 1985.

Plants robust, main stem creeping, delicate, up to 3 mm long, branches 1-2 mm long; leaves small, scaly at base, 35 μm long, upper leaves crowded, up to 50-110 x 60-100 μm , leaves shortly bilobed, obliquely attached to the

stem; cells irregular, 12-15 x 8-12 µm, trigones absent. (Fig. 7: h-l & Plate 5g&h).

Habitat: On soil cutting in semi-evergreen forest.

Specimen examined: Chandanathode (890 m) MCN 120389.

Distribution: *C. tagawae* is rare in the study area, collected from only one locality. The same species has collected from the Kakkayam RF in Kozhikode district. Udar and Kumar (1983b) has already reported this species from Ponmudi in Thiruvananthapuram district. It is also distributed in Pachmahri and Madhya Pradesh in India. *C. tagawae* was earlier reported as endemic to Thailand (Schuster, 1980). It was later reported from the Southern Island of Ryukyu Islands (Yamaguchi & Seki, 1983), India (Udar & Kumar, 1983b) and from Hong Kong (So & Zhu, 1997).

JUNGERMANNIACEAE Rchb.

Bot. Damen. P. 256. 1828.

Plants small to medium sized, yellowish-green or brownish-red, sometimes blackish; stem procumbent or erect, slender or rigid; rhizoids purple or hyaline; leaves obliquely spreading, orbicular to rounded, size varies from 0.5-1 mm or more long; cells mostly quadrate to elongate; underleaves usually absent, in rare cases it is present; dioecious or monoecious; female inflorescence mostly terminal, sometimes on short lateral branches; male inflorescence terminal or lateral; bracts and bracteoles present, larger than stem leaves, perianth exerted or inserted, oblong; capsule ovoid, greenish, blackish when mature; spores rounded, brownish black.

This family include about 38 genera in the world. In India this family is represented by about 10 genera of which only two genera viz., *Chandonanthus* and *Jungermannia* occur in the study area.

Key to the genera

- 1a. Plants erect to procumbent, robust; rhizoids simple, hyaline; leaves ovate to oblong serrated, deeply 2- 4 lobed, lobes equal or unequal
.....**Chandonanthus**

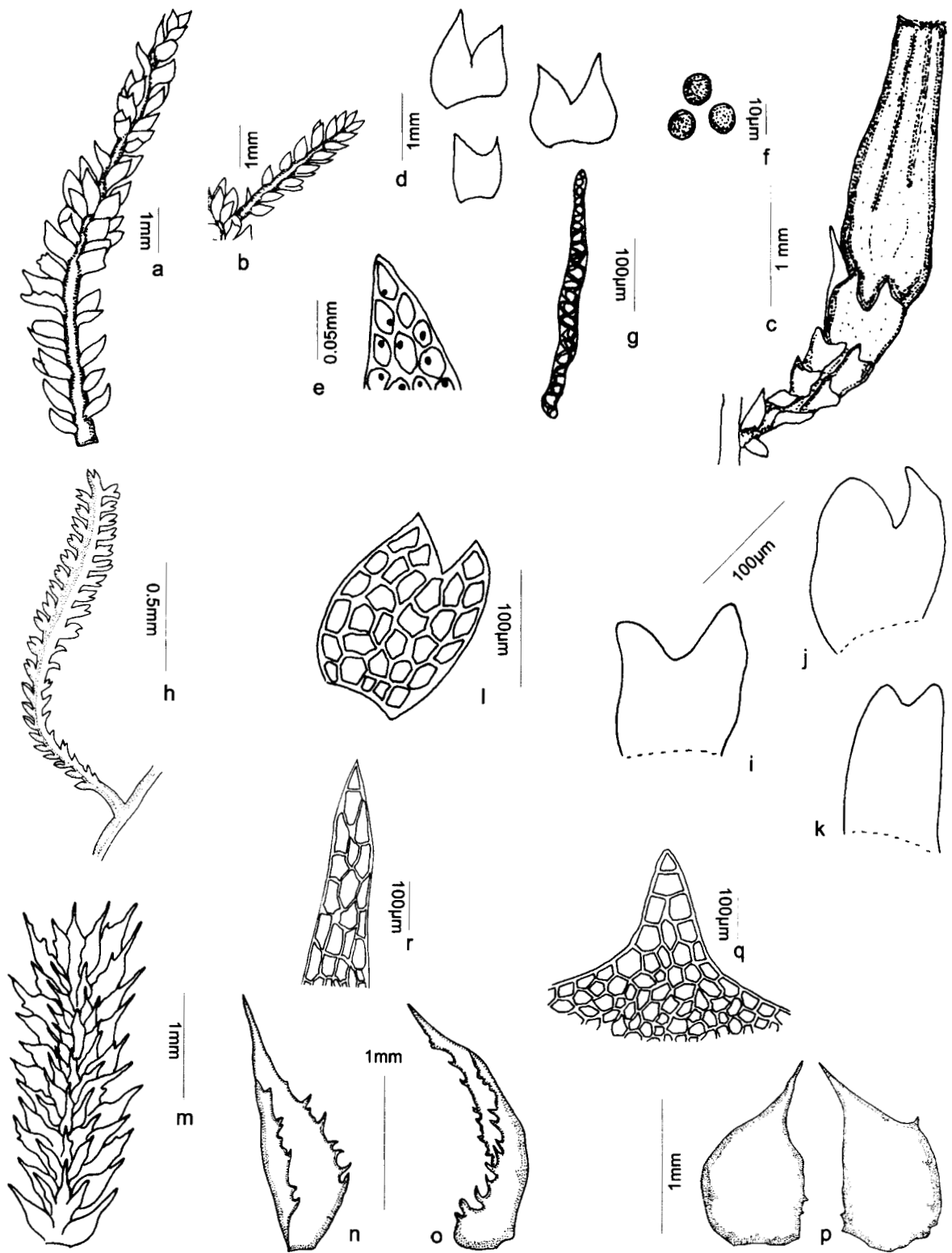


Fig. 7. **a-g:** *Cephaloziella kiaeri*; a: dorsal portion of plant, b: ventral portion of plant, c: female branch, d: leaves, e: leaf cell with oil bodies, f: spores, g: elater; **h-l:** *Cyndrocolea tagawae*; h: portion of plant, i, j & k: leaves, l: leaf cells; **m-r:** *Chandonanthus birmensis*; m: branch, n & o: underleaves, p: dorsal leaves, q: marginal cells, r: cells at spine

- 1b. Plants erect or prostrate, not robust; rhizoids whitish or purple coloured;
leaves rounded, entire, lobes equal.....**Jungermannia**

Chandonanthus Mitt.

in Hook., Handb. New Zealand Fl. 2: 750. 1867.

Plants dark green to yellowish or reddish-brown to deep brown; stem rigid, erect to procumbent, simple or sparingly branched, branches generally arise from axil of leaves, may be lateral, terminal *Frullania*-type or lateral intercalary; rhizoids few, scattered on ventral surface of stem; leaves imbricate, mostly transversely to obliquely inserted or succubous, deeply 2-4 lobed, lobes equal or unequal, adaxially convex with reflexed margins and teeth, underleaves large, deeply bilobed, toothed or ciliate at base; cells with thickened walls, trigones small and obscure or distinct; oil bodies 2-6 per cells; androecia intercalary with deeply lobed bracts, similar to leaves; gynoecia with single subfloral innovation, bracts and bracteoles almost similar, perianth terminal, large, exerted beyond bracts.

Chandonanthus birmensis Steph., Sp. Hepat. 3: 643. 1909; Kitagawa in Mizutani, J. Hattori Bot. Lab. 46: 314. 1979; Udar & Kumar, Geophytology 12(1): 60. 1982; Bapna & Kachroo, Hepatic. India 2: 3. 2000.

Plants yellowish-brown, in dense mats, procumbent, rigid; branches lateral intercalary; leaves imbricate, obliquely 2-3 lobed, lobes ovate to oblong, apex acuminate, dorsal lobe larger, strongly convex adaxially, ventral lobe smaller with few teeth; underleaves bifid up to the base, tip pointed, leaf margin with teeth; cells with thickened walls, trigones small, obscure, hexagonal-elongate, upper cells large, upto 90 x 40-60 μm , middle cells 50-60 x 30-38 μm ; oil bodies 2-6 per cells. (Fig. 7: m-r & Plate 5i).

Habitat: Upper part of tree trunk alongwith other mosses in shola forests.

Specimens examined: Chembra hills (1380-1740 m) *MCN 99605*, *MCN 120400*.

Distribution: It is a rare species in the study area. It was also collected from the evergreen forests of Vellarimala in Kozhikode district and reported as new record for South India (Nair & Madhusoodanan, in press). It is distributed in

North-east India (Sikkim, Darjeeling), China, Nepal, Myanmar, Java, Japan, Ryukyu, Taiwan, Madagascar, Canada, Pacific Islands and Africa.

Jungermannia L.

Sp. Plant. 1131. 1753.

Plants generally greenish-purple, small, prostrate or erect with numerous whitish or purple coloured rhizoids; leaves imbricate, obliquely spreading, concave, ovate or almost square, margin entire or slightly wavy; androecia long, spicate, bracts saccate at base, recurved above, involucre bracts larger, two to many pairs, perianth more or less ampliate, upper half plicate, mouth lobed or setulose, rarely broadly open; capsule globose or ovoid, cells of the inner wall with semi-annular bands; spores small, rounded; elaters small, bispiraled, ligulate.

Note: *Jungermannia* includes two-subgenera viz., *Solenostoma* and *Plectonema*. *J. macrocarpa* and *J. appressifolia* in the present collection comes under the subgenus *Solenostoma*.

Key to the species

- 1a. Leaves concave, imbricate, widely inserted; not appressed to the stem when dry.....**J. macrocarpa**
- 1b. Leaves rotundate, sinuately inserted; appressed to stem when dry.....
.....**J. appressifolia**

Jungermannia appressifolia Mitt., J. Proc. Linn. Soc. London 5: 91. 1861; Amak., J. Hattori Bot. Lab. 30: 187. 1967. *Jungermannia decolyana* Schiffn. ex. Steph., *Ibid.* 6: 85. 1917. *Solenostoma gollanii* Steph., Sp. Hepat., 6: 81. 1917. *Jungermannia monticola* var. *reniformis* S.Hatt., J. Hattori Bot. Lab. 3: 8. 1950. *J. pseudodecolyana* Amak., J. Hattori Bot. Lab. 30: 188. 1967. *Jungermannia kinabalensis* Amak., J. Hattori Bot. Lab. 32: 126. 1969.

Plants yellowish-green when young, dark brown to blackish-green when mature, up to 3 cm long, in tufts; stem erect, branches few at the tip, innovating; rhizoids throughout the stem, numerous below, purple; leaves imbricate, rotundate, sinuately inserted, decurrent on both sides, obliquely spreading,

when dried laterally appressed to the stem, up to 1 x 0.7 mm; cells along the leaf margin 20-22 x 10-12 μm , in the middle 42-48 x 30-35 μm , at base 45-50 x 30-36 μm , walls thin, cuticle smooth; dioecious, perianth pyriform when young; female bracts one pair, similar to the stem leaves. (Fig. 8: a-d & Plate 5j).

Habitat: It is seen near watercourses in soil, on small rocks and stones in grasslands alongwith *Utricularia* sp. and *Pilea microphylla* in semi-evergreen and evergreen forests.

Specimens examined: Chandanathode (920 m) MCN 80078a, MCN & PVM 80107, Chembra hills (1700 m) MCN 120361.

Distribution: It is rare in the study area. It was earlier recorded from China and Japan. The present collection is a new record to India.

Jungermannia macrocarpa Steph., Sp. Hepat. 6: 87.1917.

Plants light yellowish-brown, often tinged with red, up to 1 cm x 1.2-1.5mm, flaccid; stem fleshy, simple, erect, rarely with small lateral branches; rhizoids numerous, purple; leaves imbricate, widely inserted, more or less concave, 1-1.2 x 1.2-2 mm, leaf insertion wide and oblique; cells along the leaf margin and middle 30-50 x 20-35 μm , basal cells 45-65 x 25-38 μm , walls thin, trigones distinct. (Plate 5k).

Habitat: It is seen as mat in earth cuttings in semi-shaded areas in homestead.

Specimen examined: Lakkidi palam (450 m) MCN 80094.

Distribution: It is rare in Wayanad. This species has been reported to occur in Eastern Himalayas, East Nepal and Darjeeling. The present collection is a new record to Peninsular India.

Order PORELLALES (R.M.Schust.) Schljakov emend. Stotler & Crand.-Stotl.

PORELLACEAE Cavers

New Phytol. 9: 292. 1910, *nom. cons.*

Plants yellowish-green to greenish-brown, large, stem prostrate to suberect, rarely pendant, branches regularly bipinnate or tripinnate; rhizoids arising from the base of underleaves; leaves incubous, bilobed, obliquely ovate

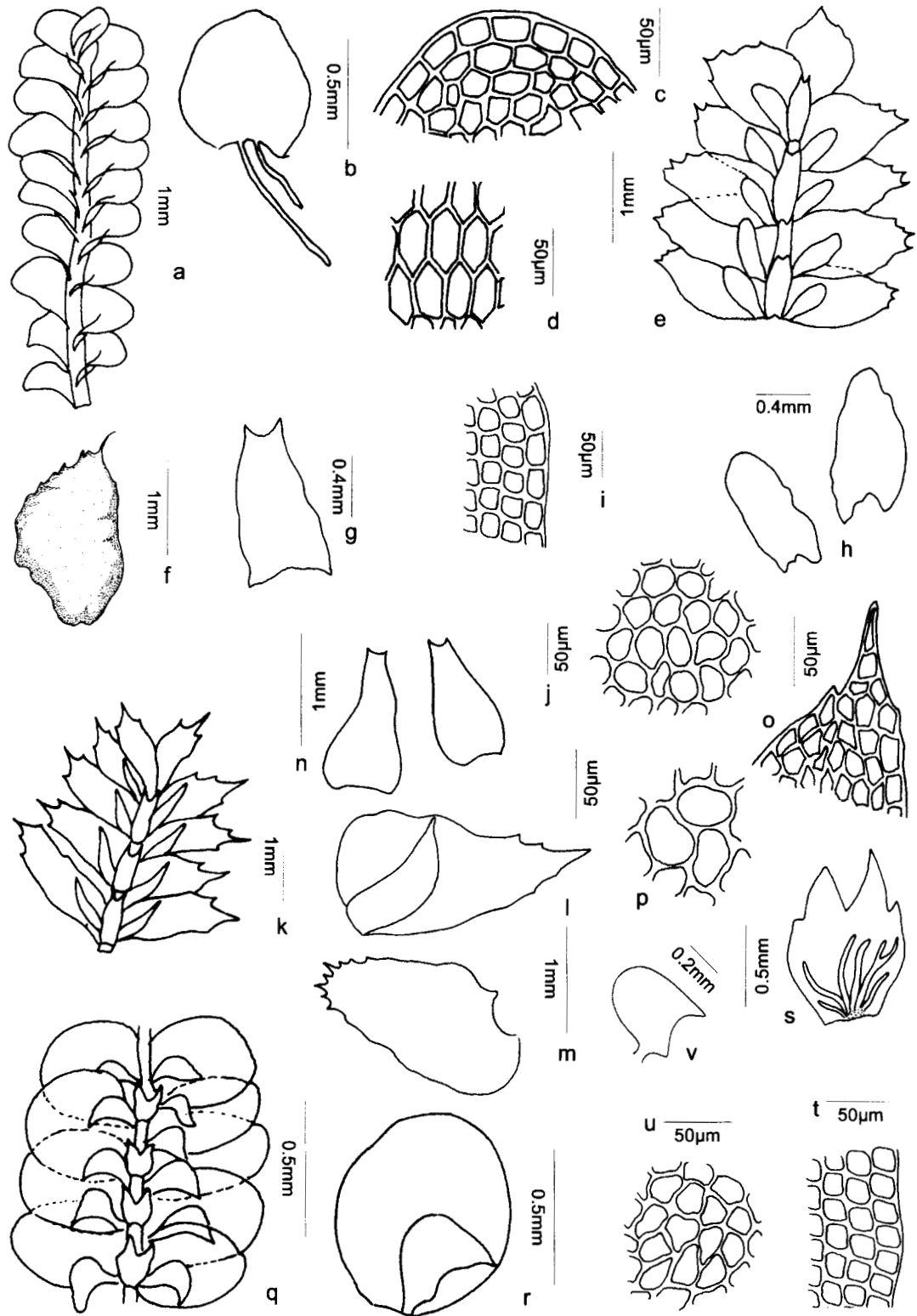


Fig. 8: a-d; *Jungermannia appressifolia*; a: plant, b: leaf with rhizoids, c: marginal cells, d: basal cells; e-j; *Porella acutifolia*; e: branch, f: leaf, g: underleaf, h: leaf lobule, i: leaf marginal cells, j: basal cells; k-p; *Porella campylophylla*; k: branch, l: leaf with lobule, m: leaf, n: underleaves, o: leaf marginal cells, p: basal cells; q-v; *Frullania acutiloba*; q: portion of plant, r: leaf with lobule, s: underleaf with rhizoids, t: leaf marginal cells, u: basal cells, v: leaf lobule

to circular, margin entire or dentate, postical lobe smaller, ovate, underleaves wider than stem; gemmae absent; male inflorescence on lateral or apical branch; female inflorescence on very short lateral branches; seta short; capsule spherical; spores small, spherical; elaters 2 or 3 spiraled.

Porellaceae includes three genera viz., *Ascidiota*, *Macvicaria* and *Porella*. Of which only one genus viz., *Porella* is present in India and which also occur in the study area.

Porella L.

Sp. Pl. 2: 1106. 1753.

Plants yellowish to dark green or reddish-brown, prostrate to pendant, 2-6 cm long, robust, loosely or tightly appressed to the substratum; stem irregularly to pinnately branched, leaf lobes imbricate, broadly ovate, margins reflexed with sharp teeth at apex, in some along the margins beset with spines, otherwise smooth; dorsal margin entire or rarely toothed; leaf lobules lingulate to tongue shaped, margin entire or toothed, base decurrent, small to slightly larger; underleaves small to medium sized, distant, similar to leaf lobules in shape, number of oil bodies varies, homogenous, spherical; cells of upper portion of lobe rounded, hexagonal or elongated, median cells thin walled with large trigones and without intermediate thickenings.

Key to the species

- 1a. Leaf lobes with 1 or 2 strong teeth at apex; underleaves irregularly lobed, almost toothed.....**P. acutifolia**
- 1b. Leaf lobes with 3-4 teeth with a single teeth at apex; underleaves broad at base with two spines at margin.....**P. campylophylla**

Porella acutifolia (Lehm. & Lindenb.) Trevis., Mem. Reale Ist. Lombardo Sci. ser. 3, 4: 408. 1877; Bapna & Kachroo, Hepatic. India 2: 149. 2000. *Madotheca acutifolia* Lehm. & Lindenb. in Lehm., Nov. Stirp. Pug. 8: 8. 1838. *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. *M. johannis-winkleri*

Herzog, Mitt. Inst. f. allgem Bot. Hamburg. 7(3): 195. 1931. *Porella lancifolia* (Steph.) Grolle, J. Hattori Bot. Lab. 28: 51. 1965. *P. johannis-winkleri* (Herzog) S.Hatt., *Ibid.* 3: 137. 1967. *P. stracheyana* (Gottsche ex Steph.) S.Hatt., *Ibid.* 30: 149. 1968. *P. plumosa* var. *stracheyana* (Steph.) Pocs, *Ibid.* 31: 82. 1968. *P. acutifolia* var. *elbertii* (Steph.) S.Hatt., *Ibid.* 32: 320. 1969. *P. acutifolia* var. *johannis-winkleri* (Herzog) S.Hatt., *Ibid.* 32: 323. 1969. *P. acutifolia* var. *lancifolia* (Steph.) S.Hatt., *Ibid.* 32: 325. 1969. *P. acutifolia* var. *subligulifera* S.Hatt., *Ibid.* 33: 41. 1970.

Plants yellowish-brown, up to 10 cm long, loosely branched, lobes of stem leaves densely imbricate, lobes 2-2.5 mm long, narrowly oblong, usually with 1 or 2 strong teeth at the apex; leaf lobules and underleaves irregularly lobed, angulate or almost toothed, apex obtuse to truncate, up to 1 mm ; cells at margin rounded to quadrate, 20-25 x 10-15 μm , central and basal cells rounded-elongated, 18-25 x 15-20 μm . (Fig. 8: e-j & Plate 6a&b).

Habitat: Epiphytic on evergreen and shola trees.

Specimen examined: Chembra hills (1380 m) MCN 99670.

Distribution: This is the most common species of *Porella*, in east and South-east Asia. In India it is known from South India only (Tamil Nadu: Madras, Nilgiri hills, Anamalai hills). The species extends to Malay Archipelago including New Guinea and tropical regions of Continental Asia, northward to Ryukyu Islands of Japan. The present collection is a new record to Kerala.

Porella campylophylla (Lehm. & Lindenb.) Trevis., Mem. Real. Ist. Lombardo Sci. ser. 3,4: 408. 1877; Hattori, J. Hattori Bot. Lab. 44: 101.1978; Shaheer & S.C.Srivast., Geophytology 19: 34. 1989; Bapna & Kachroo, Hepatic. India 2: 152. 2000. *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. *Porella plumosa* (Mitt.) Inoue var. *gollanii* (Steph.) Pocs, 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. *Madotheca denticulata* Kashyap, Liv.
W. Himalaya Punjab Pl. 2: 332. 1932; R.S.Chopra, J. Indian Bot. Soc. 22: 248.
1943.

Plants yellowish-green, 5-7 cm long, irregularly branched; leaf lobes widely spreading, widest at base, 2-2.2 x 1.2-1.5 mm, ovate to oblong-ovate, apex acuminate, 3-4 teeth at apex, with a prominent terminal tooth, dorsal margin arched towards the base; submarginal and median cells 10-20 μm , basal cells rounded-elongate, 20-25 μm , trigones small; leaf lobules elongated to lanceolate, entire, acuminate, 1 x 0.1-0.2 mm; underleaves broad at base, tip with two spines at margin. (Fig. 8: k-p & Plate 6c&d).

Habitat: Corticolous and on rocks in semi-evergreen, evergreen and shola forests.

Specimens examined: Muthanga range, Keeradamkolli (758 m) MCN 84516, Chembra hills (1360 m) MCN 120391.

Distribution: *Porella campylophylla* is a common species in high altitude areas. It is distributed in South India (Kerala; Tamil Nadu: Madurai, Shembaganur), North-east India (Darjeeling, Kumaon, Assam, Sikkim), Nepal, Myanmar and Vietnam.

JUBULACEAE H.Klinggr.

Die Hoh. Crypt. Preus. 40. 1858.

Plants greenish to reddish-brown, prostrate to suberect; rhizoids arise from the base or middle of underleaves; leaves incubous, bilobed, ventral lobule small, partially hidden under the large dorsal lobe, lobules saccate to galeate, rarely plane and linear; cells of dorsal lobe uniform, ocelli present in some; underleaves bifid or emarginate; male inflorescence on terminal short or long branches, bracts bilobed, lobes almost equal; female inflorescence terminal, bracts longer than leaves, bilobed, ventral lobes not saccate; capsule spherical, wall bistratose; spores rounded, brownish; elaters slender, unispiral or bispiraled.

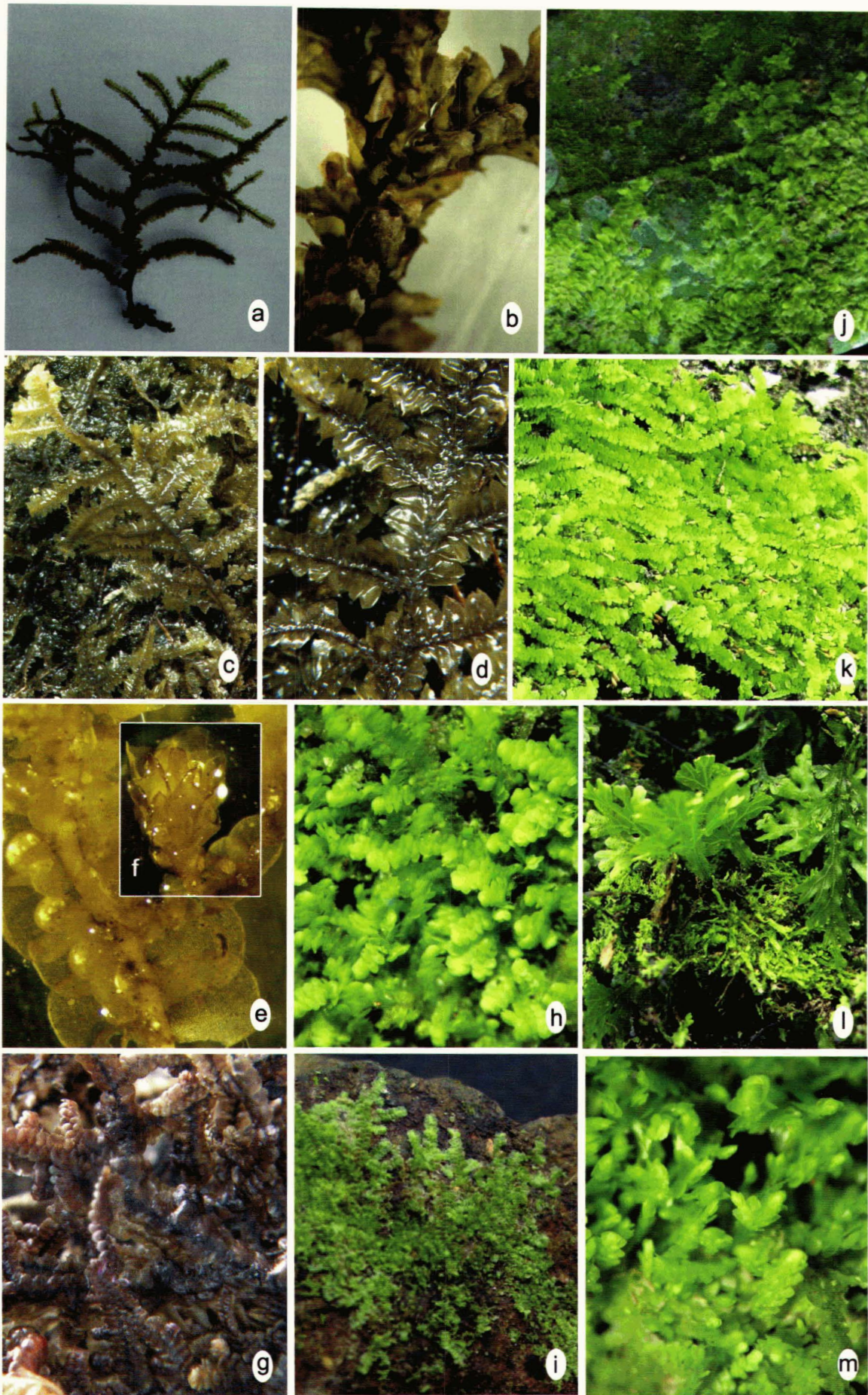


Plate. 6. a. *Porella acutifolia*, b: branch-ventral view, c: *Porella campylophylla*, d: branch-ventral view, e: *Frullania muscicola*, f: pericheatial leaves, g: *F. tamarisci*, h: *Cheilolejeunea giraldiana*, i: *C. intertexta*, j: *C. serpentina*, k: *Cheilolejeunea* sp., l: *Cololejeunea raduliloba*, m: *Lejeunea discreta*

The systematic position of the family Jubulaceae is a matter of dispute among bryologists. Grolle (1972) and Engel (1978, 1982) treated *Frullania* as a member of Jubulaceae based mainly on similarity of the saccate leaf lobules in *Frullania* and *Jubula*. Goerke (1978) in his monograph on *Jubula* considered Frullanioideae as a sub-family of Jubulaceae. Hattori (1979) pointed out several differences between *Frullania* and *Jubula* and placed in separate families, Frullaniaceae and Jubulaceae. Crandall-Stotler and Stotler (2000) in their recent classification based on morphological and molecular data treated *Frullania* and *Jubula* under the single family Jubulaceae, which is followed here.

Frullania Raddi

Mem. Soc. Italiana Sci. Modena 18: 20. 1820.

Plants green to dark brown and blackish, medium sized, pinnately branched, branches axillary; leaves in three rows, almost transversely inserted, dorsal leaves incubous, leaf lobe larger, ovate to suborbicular, apex decurved, margin entire; cells with thickened walls at corners, trigones prominent, ocelli present in some species; leaf lobule in various shapes, cucullate, saccate, helmet-shaped, cylindrical or club shaped; underleaves smaller than the leaves, base cordate, apex bifid or retuse; androecia terminal on short lateral branches, bracts closely imbricate; archegonia terminal on main branches, 2-4, rarely more, bracts in 2-5 pairs, dentate, larger than the leaves, bilobed, perianth with 1 or 2 ventral and lateral keels, surface smooth or with tubercles, lobules bladder like in some, open in others; foot haustorial; seta short, 6-9 cells thick; capsule globose; spores rounded, brownish; elaters few with 1 or 2 spirals, ends blunt; spores oblong, brownish.

Key to the species

- 1a. Ocelli in 1 or 2 rows, 10-20 cells long.....**F. tamarisci**
- 1b. Ocelli absent.....2
- 2a. Leaf lobules triangular with a blunt apex, not parallel.....**F. squarrosa**
- 2b. Leaf lobules helmet shaped, parallel to stem.....3
- 3a. Underleaves obovate to suborbicular, apex notched.....**F. muscicola**
- 3b. Underleaves broadly ovate, apex bilobed.....4

4a. Leaf lobules narrowly cucullate.....**F. calcarata**

4b. Leaf lobules helmet shaped with a piliferous beak.....**F. acutiloba**

Frullania acutiloba Mitt., J. Proc. Linn. Soc. 5: 120. 1861; Steph., Sp. Hepat. 4: 464. 1910; Verd., Ann. Bryol. Suppl. 1: 46. 1930; R.S.Chopra, J. Indian Bot. Soc. 22: 249. 1943; S.Hatt., J. Hattori Bot. Lab. 37: 99. 1973; Yuzawa & S.Hatt., J. Hattori Bot. Lab. 50: 253. 1981; V.Nath & A.K.Asthana, J. Hattori Bot. Lab. 85: 72. 1998; Bapna & Kachroo, Hepatic. India 2: 165. 2000.

Plants pale to deep green, 10-35 mm long, irregularly branched; leaf lobe ovate to cordate, imbricate, oblique to widely spreading, concave, apex incurved, basal appendages rounded to quadrate; lobules lanceolate to galeate (helmet-shaped) large with piliferous beak, up to 0.4 mm long, apical portion of rostrum with a row of 3-4 cells, acute to acuminate, rotundate, touching the base of underleaf, mouth wide, truncate; underleaves large, 0.8-1.2 mm long, sinus transversely inserted, margin entire, some leaves possess 1 or 2 teeth; dioecious, female inflorescence terminal on stem or main branches, pericheatial leaves entire, bracteoles often bear 1 or 2 teeth along margin; perianth exerted, 3-keeled, sharp, toothed with irregular spinous outgrowths. (Fig. 8: q-v).

Habitat: Upper part of tree trunk and on branches associated with *Cheilolejeunea* sp. in moist deciduous forests.

Specimens examined: Sulthan Bathery (933 m) *MCN 84364*, Begur RF (845 m) *MCN 84594*.

Distribution: *F. acutiloba* is common in the deciduous forests of the study area. It is distributed in South India (Tamil Nadu: Nilgiri hills), Eastern India (Khasi hills, Assam), Sri Lanka, China, Java and Japan. The present collection is a new record to Kerala.

Frullania calcarata Aongstr., Oepl. Vet.-Akad. Forh. Stockholm 30(5): 137. 1873; Steph., Sp. Hepat. 4: 460. 1910; Verd., Ann. Bryol. 2: 122. 1929; Suppl. 1: 62. 1930 & Nederl. Kruidk. Arch. Jaarg. Afl. 2: 165. 1930 & S. Hatt., J. Hattori Bot. Lab. 37: 128. 1973.

Plants yellowish-brown, 10-30 mm long, pinnately branched; lobes of stem leaves imbricate, horizontally spreading, distal margin incurved, oblong-ovate, 1 x 0.8 mm, apex obtuse or narrowly rounded, dorsal base arched and strongly appendiculate, the appendage narrowly triangular-lanceolate, elongate with an acute tip; leaf lobule narrowly cucullate, obtuse apices and wide with truncate mouth, mouth beak descending beyond the lobe margin; cells at margin 15-18 x 12-18 μm , middle cells 48-52 x 15-22 μm , basal cells thin, large, 40-55 x 30-40 μm , trigones elongate; stem underleaves continuous, flat, often narrowly incurved along lower lateral margins, widely obovate to cordate, bifid, lobes triangular, acute, base obtuse, non-appendaged; rhizoidal initial at the center of underleaves; cells irregular in shape, trigones large, elongate, 12-15 x 10-15 μm . (Fig. 9: a-f).

Habitat: On small branches of *Terminalia bellerica* and on logs in moist deciduous forests.

Specimen examined: Kurichiad range, Dhottakulachi (900 m) MCN 84546.

Distribution: This species is common in the deciduous trees such as *Terminalia bellerica*. It is distributed in North India (Pachmahri), Tahiti and New Guinea. The present collection is a new record to Peninsular India.

Frullania muscicola Steph., Hedwigia, 146. 1894 & Sp. Hepat. 4: 444. 1910; Kashyap, Liv. W. Himalaya Punjab Pl. 2: 14. 1932; Verd. in Handel-Mazzetti, Symb. Sinic. 5139. 1930; Inoue, J. Jap. Bot. 36: 187. 1961; S.Hatt., J. Hattori Bot. Lab. 38: 205. 1979; S.Hatt. & P.J.Lin., *Ibid.* 59: 139. 1985; V.Nath & A.K.Asthana, *Ibid.* 85: 75. 1998; Bapna & Kachroo, Hepatic. India 2: 175. 2000; Narayan *et al.*, Indian J. For. 24: 275. 2001. *Frullania dilata* auct. non (L.) Dumort. in Mitt., J. Proc. Linn. Soc. Ser 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 brownish-green, closely appressed to the bark, main stem up to 1 cm long, simple or pinnately branched; rhizoids dark brown; leaf lobes distant, horizontal, suborbicular, 0.7 x 0.5 mm long, base rounded, apex obtuse to

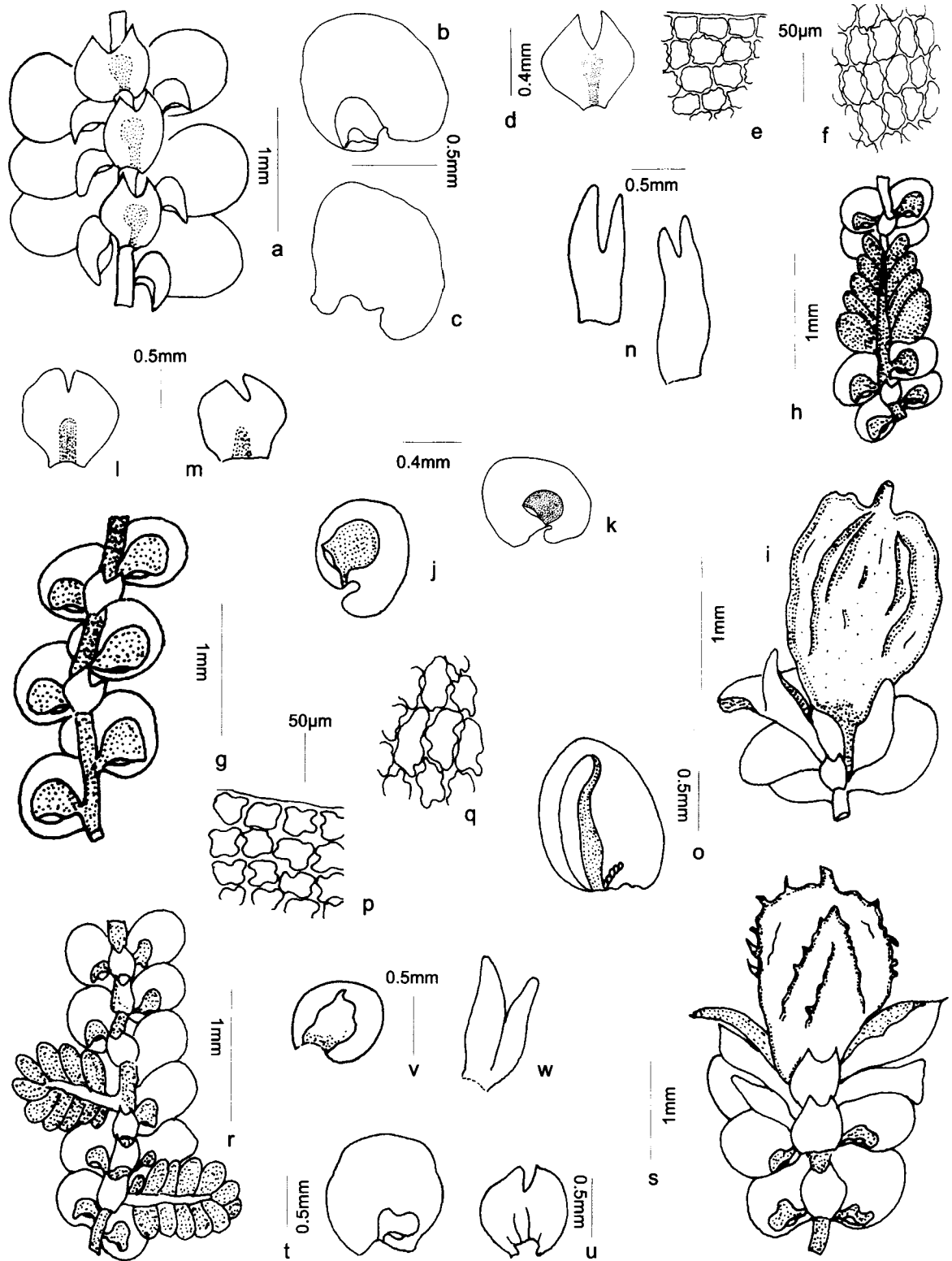


Fig. 9 a-f: *Frullania calcarata*; a: portion of branch, b: leaf with lobule, c: leaf, d: underleaf, e: leaf marginal cells, f: basal cells; g-q: *Frullania muscicola*; g: portion of branch, h: male branch, i: female branch, j&k: leaf with lobule, l&m: underleaves, n: female bracteole, o: female bract, p: leaf marginal cells, q: basal cells; r-w: *Frullania squarrosa*; r: male branch, s: female branch, t: leaf with lobule, u: underleaf, v: female bract, w: female bracteole

rounded; cells almost equal, upper cells 17 x 11-14 μm , trigones small, basal cells 25-32 x 21-18 μm , trigones thick, walls nodulose; leaf lobules on the older parts helmet-shaped, on the younger branches ovate-oblong, parallel to stem; underleaves about twice as large as lobule and 1/3 of the lobe, obovate to suborbicular, apex notched; dioecious, female bracts and bracteoles entire, perianth obovoid-oblong, 5-keeled, smooth, entire margin with prominent rostrum. (Fig. 9: g-q & Plate 6e&f).

Habitat: On logs and branches in moist deciduous forests.

Specimens examined: Muthanga range, Keeradamkolli (790 m) *MCN 84518b*, Kuppadi SEF (850 m) *MCN 84569*.

Distribution: *F. muscicola* is one of the most common Asian species and is common in the moist deciduous forests of Wayanad. Nath and Asthana (1998) reported its occurrence in Wayanad district. The species is widely distributed in South India (Kerala), Central India (locality unknown), North-east India (Mussorie, Garhwal), China, Japan, Korea, Manchuria, Mangolia and Nepal.

Frullania squarrosa (Reinw. *et. al.*) Nees in Gottsche *et al.*, Syn. Hep. 416. 1845; Steph., Sp. Hepat. 4: 388. 1910; V.Nath & A.K.Asthana, J. Hattori Bot. Lab. 85: 75. 1998

Plants green to deep brown, main stem 3-4 cm long, pinnately branched; rhizoids rare, small, brown, arising from the middle of the underleaves; leaf lobes imbricate, spreading, 0.7-0.4 x 1.1-0.7 mm long, base cordate, margin entire or wavy, apex rounded, upper cells 18 x 8-10 μm , basal 45 x 27 μm , trigones small, wall thick, nodulose; leaf lobule triangular with a blunt apex; underleaves large, broadly ovate, margin entire, apex bilobed; dioecious, female inflorescence terminal on the main axis or on the leading branches, bracts and bracteoles entire, perianth obovate to oblong, dorsally compressed, strongly 3-keeled with ornamentations on the surface and the margins. (Fig. 9: r-w).

Habitat: On bark of trees and on logs alongwith foliose lichens in moist deciduous and semi-evergreen forests.

Specimens examined: Sulthan Bathery (925 m) MCN 84359, MCN 84360, Begur RF (830 m) MCN 84592.

Distribution: This Indian endemic species is common in Begur, Sulthan Bathery and Kurichiad range of Wildlife Sanctuary. Nath and Asthana (1998) reported its occurrence in Wayanad and Tamil Nadu in South India. It is also reported from the Western Himalayas.

Frullania tamarisci (L.) Dumort., Rec. Obs. Jungerm. Tournay 13. 1835; Steph., Sp. Hepat. 4: 562. 1911; V.Nath & A.K.Asthana, J. Hattori Bot. Lab. 85: 68. 1998.

Plants greenish to brownish or blackish, varies in size, 10-30 mm long; leaf lobe ovate, strongly concave with acute, acuminate or apiculate apex, often incurved, ocelli in 1 or 2 rows, 10-20 cells long, rarely scattered or almost absent in some leaves; leaf lobules saccate, parallel or subparallel to stem with constricted mouth connected to a short stalk, sometimes bearing semicircular appendage; underleaves longer than wide, mostly with 1 or 2 marginal teeth, 0.5-0.6 x 0.48-0.58 mm; cell walls thickened with large nodulose trigones at base; dioecious, bracts and bracteoles often with spines at lateral margins, perianth oblong, strongly 3-keeled, surface smooth, rostrum prominent. (Fig. 10: a-f & Plate 6g).

Habitat: Epiphytic on a variety of trees such as *Ilex wightiana*, *Tectona grandis*, etc. in association with *Plagiochila* spp. and *Cheilolejeunea* spp. and on twigs in moist deciduous, semi-evergreen and evergreen forests

Specimens examined: Kurichiad range (840 m) MCN 120362, Periya (980 m) MCN 99609, Thirunelli RF (1180 m) MCN 99626.

Distribution: It is common in the deciduous and evergreen trees of Kurichiad, Meppadi, Tholpetty, Thirunelli and Periya. This South Indian endemic species is known to occur in Kerala and Tamil Nadu. Nath and Asthana (1998) reported the occurrence of this species in Wayanad and Idukki districts of Kerala.

LEJEUNEACEAE Casares-Gil

Fl. Iber. Hepat. 703. 1919.

Plants light yellowish to greenish, leafy, very small to medium sized, 0.5 mm - 2 cm long, prostrate, branching mostly *Frullania*-type, *Lejeunea*-type or *Radula*-type; leaves alternate, incubous, bilobed; leaf lobules distinctly saccate, attached to stem, inflated to elongate; underleaves present or absent, if present distinct; bracts, bracteoles and perianth prominent; capsule globose; elaters monospiral.

This is the largest family with about 94 genera in the world. About 30 genera are recorded from India, of which six genera viz., *Cheilolejeunea*, *Cololejeunea*, *Lejeunea*, *Lopholejeunea*, *Mastigolejeunea* and *Spruceanthus* occur in the study area

Key to the genera

- 1a. Underleaves absent; rhizoids clustered on stem; male and female bracteoles absent.....**Cololejeunea**
- 1b. Underleaves present; rhizoids clustered at underleaf bases or scattered; male and female bracteoles present.....2
- 2a. Underleaves deeply bilobed.....3
- 2b. Underleaves not deeply bilobed.....**Cheilolejeunea**
- 3a. Underleaves 3 or 4 times as broad as stem, orbicular, not plicate at base...4
- 3b. Underleaves thin or as broad as stem, entire or bifid, rarely absent, plicate at base.....**Lejeunea**
- 4a. Plants small, not robust, underleaves large, not plicate, orbicular to reniform5
- 4b. Plants large, robust, underleaves 2 times as broad as stem, orbicular, plicate at base.....**Spruceanthus**
- 5a. Leaf lobes imbricate to oblong, apex rounded to incurved....**Lopholejeunea**
- 5b. Leaf lobes ovate, concave, acute or obtuse at apex.....**Mastigolejeunea**

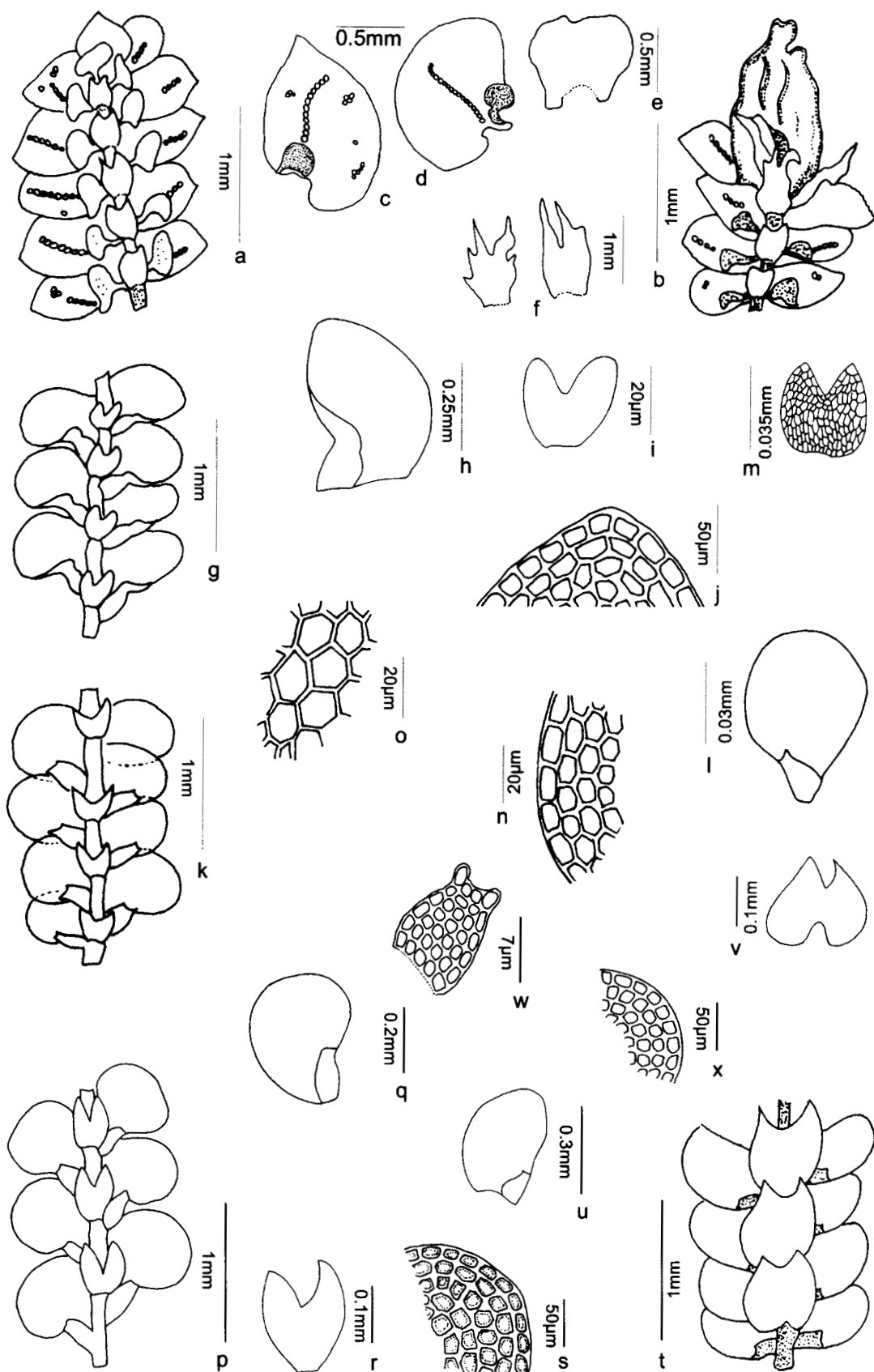


Fig. 10. **a-f:** *Frullania tamarisci*; a: branch, b: female branch, c&d: leaf lobules with ocelli, e: underleaf, f: female bract; **g-j:** *Cheilolejeunea giraladiana*; g: branch, h: leaf with lobule, i: underleaf, j: leaf marginal cells; **k-o:** *Cheilolejeunea intertexta*; k: branch, l: leaf with lobule, m: underleaf, n: leaf marginal cells, o: middle cells; **p-s:** *Cheilolejeunea serpentina*; p: branch, q: leaf with lobule, r: underleaf, s: marginal cells; **t-x:** *Cheilolejeunea* sp.; t: branch, u: leaf with lobule, v: underleaf, w: cells at lobule, x: leaf marginal cells

Cheilolejeunea (Spruce) Schiffn.

in Engl. & Prantl, Nat. Pflanzenfam. 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; monoecious or dioecious, 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 x 30-40 µm.

Key to the species

- 1a. Leaves oblong ovate.....2
- 1b. Leaves rotundate.....3
- 2a. Underleaves imbricate, covering $\frac{3}{4}$ of leaf lobule, bilobed..... **C. girdiana**
- 2b. Underleaves orbicular, covering whole of leaf lobule, entire.....
..... **Cheilolejeunea** sp.
- 3a. Branching Radula-Jubula type, trigones absent..... **C. intertexta**
- 3b. Branching Radula-Lejeunea type, trigones distinct without nodular thickening..... **C. serpentina**

Cheilolejeunea girdiana (Massari) Mizut., J. Hattori Bot. Lab. 27: 141. 1964 & 51: 166. 1982; G.Asthana *et al.*, Lindbergia 20: 139. 1995; Bapna & Kachroo, Hepatic. India 2: 218. 2000. *Euosmolejeunea girdiana* Massari, Mem. Acad. Agric. Art. Verona 37: 34. 1897. *Strepsilejeunea girdiana* (Massari) Steph., Sp. Hepat. 5: 288. 1913. *S. gomphocalyx* Herzog in Mazzetti, Symp. Sinic 5: 47. 1930. *Euosmolejeunea gomphocalyx* (Herzog) S.Hatt., Bull. Tokyo Sci. Mus.

11: 106. 1944. *E. ontakensis* (Steph.) S.Hatt., J. Hattori Bot. Lab. 5: 85. 1951. *Cheilolejeunea ontakensis* (Steph.) S.Hatt., Misc. Bryol. Lichenol. 1(14): 1. 1957.

Plants yellowish-brown, up to 2 cm long, irregularly branched; leaves wide spreading, imbricate, lobe convex, oblong to obtuse, 0.57-0.63 x 0.39-0.45 mm, margin entire; cells at the margin 10-17 x 10-14 μ m, median cells 17-20 x 13-17 μ m, basal cells slightly larger than the middle, 23-34 x 13-20 μ m, the first tooth an obtuse projecting cell, the second 1-3 celled, free margin incurved; leaf lobule small; underleaves slightly distant to imbricate, 3-4 times wide as the stem, covering leaf lobule, orbicular, 0.27-0.36 x 0.21-0.32 mm, bilobed, margin entire, base somewhat cordate; male inflorescence terminal on short lateral branches, 2-4 pairs of bracts, inflated, half the length of the stem leaf, 1-2 bracteoles confined to the base; female inflorescence on main branch as well as on lateral branches, capitate, with 1-2 subfloral innovations, female bracteoles large, ovate, 0.54 x 0.43 mm, apex bilobed, lobes obtuse. (Fig. 10: g-j & Plate 6h).

Habitat: Corticolous in semi-evergreen forests.

Specimen examined: Mananthavady (800 m) MCN & PVM 80132.

Distribution: *C. giraldiana* is rare in the area and could be collected from Mananthavady area. The species is distributed in South India (Tamil Nadu), North-east India (Darjeeling, Sikkim), China, Japan, Nepal and Philippines. The present collection is a new record to Kerala.

Cheilolejeunea intertexta (Lindenb.) Steph., Bull. Herb. Boiss 5: 79. 1897; Mizut., J. Hattori Bot. Lab. 30: 172. 1967; G.Asthana *et al.*, Lindbergia 20: 127. 1995; Bapna & Kachroo, Hepatic. India 2: 220. 2000. *Lejeunea intertexta* Lindenb. in Gottsche *et al.*, Syn. Hepat. 379. 1845. *Cheilolejeunea kurzii* Steph., Bot. Gazette 15: 284. 1890. *C. katschalliana* Steph., Hedwigia 34: 242. 1895. *C. grandiflora* Steph., Sp. Hepat. 5: 664. 1914. *C. subrotunda* Herzog, J. Hattori Bot. Lab. 14: 48. 1955.

Plants light greenish, 8-10 mm long, pinnately branched, branching *Radula-Jubula* type; leaves imbricate, apex rounded, margin entire, 0.06 x 0.06

mm; cells hexagonal, trigones absent, intermediate nodular thickening absent, cells at the margin 7-10 μm diagonally, middle cells long and wide, up to 25-20 x 15-19 μm , basal cells small, 20 μm diagonally; leaf lobule small, 0.10-0.15 x 0.6-0.9 mm, constricted at apex, tooth unicellular; underleaves distant, twice as wide as stem, bilobed, margin entire. (Fig. 10: k-o & Plate 6i).

Habitat: On rocky patches in semi-evergreen forests.

Specimen examined: Chandanathode (950 m) MCN 80083b.

Distribution: This species is rare in the study area. It has earlier been reported from South India (Tamil Nadu: Tirunelveli hills), Andaman & Nicobar Islands, Sri Lanka, Java, Japan, Malaya, Philippines, Samoa, Sumatra and Tahiti. The present collection is a new record to Kerala.

Note: The report of *Cheilolejeunea intertexta* from India is based on *C. katschalliana* Steph. and *C. kurzii* Steph., from Andaman & Nicobar Islands, which were synonymised under *C. intertexta* (Mizutani, 1967, 1982; Grolle, 1979).

Cheilolejeunea serpentina (Mitt.) Mizut., J. Hattori Bot. Lab. 26: 171. 1963; G.Asthana *et al.*, *Lindbergia* 20: 127. 1995; Bapna & Kachroo, *Hepatic. India* 2: 223. 2000. *Lejeunea serpentina* Mitt., J. Proc. Linn. Soc. (London) 5: 112. 1861. *Euosmolejeunea serpentina* (Mitt.) Steph., Sp. Hepat. 5: 590. 1914.

Plants yellowish-brown, stem 1-1.5 cm long, pinnately branched, branching *Radula-Lejeunea* type; leaves slightly imbricate, obliquely wide-spreading; leaf lobe convex to ovate, 0.36-0.54 x 0.27-0.36 mm, apex rounded, margin entire, marginal cells 10-17 μm , median cells 23-17 μm , basal cells 27-34 x 17-24 μm , trigones distinct, well developed, nodular thickenings absent, oil bodies large, rounded-elongated; leaf lobule small, 0.12-0.18 x 0.12-0.4 mm, constricted at apex, free margin incurved, first tooth indistinct, unicellular, second tooth obtuse, unicellular, keel arched, smooth; underleaves distant, about as wide as stem, orbicular 0.18-0.23 mm, bilobed, margin entire. (Fig. 10: p-s & Plate 6j).

Habitat: Epiphyllous in evergreen forests.

Specimen examined: Ponkuzhi (880 m) MCN 84384.

Distribution: The species is rare in the area. It is distributed in South India (Kerala; Tamil Nadu: Western Ghats of Kanyakumari, Madras), North India (Pachmahri), Andaman & Nicobar Islands, Sri Lanka, Cameroon, Caroline Islands, Java, Madagascar, Malacca, Philippines, Singapore, Sumatra, Seychelles and Thailand.

Cheilolejeunea sp.

Plants yellowish-green, highly branched, main stem creeping, 5-8 x 8 mm, appressed to the stem; leaf lobe ovate to rounded, 0.4-0.6 mm long, margin entire; underleaves large, orbicular, covering whole of leaf lobule, 0.2 mm wide, entire; lobule 15 μm long; cells small near margin, 7-10 μm diagonally, middle and basal cells 22-30 μm diagonally, trigones not distinct; oil bodies bead like towards margin. (Fig. 10: t-x & Plate 6k).

Habitat: Epiphytic on Tea bushes.

Specimen examined: Meppadi (750 m) MCN 87106.

Distribution: It is rare in the study area and could be collected from only one locality.

Note: This species shows resemblance to *C. girdiana* but differs in large size of underleaves which almost cover the entire leaf lobe of two sides and the oil bodies arranged towards the margin of the cells in bead like manner. It also resembles *C. trifaria*, but differs in the highly branched thallus and in the occurrence of oil bodies.

Cololejeunea (Spruce) Schiffn.

in Engl. & Prantl, Nat. Pfl-fam. 1, 3: 121. 1895.

Plants mostly minute, pale green to yellowish-green, creeping, irregularly branched, commonly epiphyllous, plants vary in shape and size depending on growth condition; leaf lobes ovate to oblong, elliptical, loosely imbricate, apex obtuse, in some margins densely spinose and apices rounded; leaf lobules variable, small, ovate, triangular, with two teeth at apex, in some with a median angular tooth which consists of a row of 3-6 cells, absent in some; underleaves absent; oil bodies 2-25, granular, rarely homogenous, spherical to elliptical; median leaf cells thin walled, in some with distinct trigones, one papilla per leaf

cell, spinose or absent; male inflorescence terminal, bracts 2-5 pairs, bilobed; female inflorescence terminal, mostly with one subfloral innovation, female bracts obovate, usually dorsiventrally compressed, perianth 5-keeled, male and female bracteoles absent; seta articulate; capsule globular; spores brown, irregular in shape, 30-35 x 20-28 μm ; elaters few, 200-280 μm long, colourless, wall thickened.

Cololejeunea raduliloba Steph., Hedwigia 34: 251. 1895.

Plants microscopic, yellowish-green, 2-4 x 0.06-0.08 mm, appressed to the substratum, branching irregularly pinnate; rhizoids hyaline, forked; leaves imbricate, ovate, margins entire; cells at the margin rectangular, median cells pentagonal to hexagonal, 15-25 μm long, uniformly thickened, devoid of trigones; oil bodies bead like, marginal; leaf-lobule single, furcate at the base. (Fig. 11: a-e & Plate 6l).

Habitat: Epiphyllous on *Trichomanes proliferum* Specimen examined: Chembra hills (1720 m) MCN 99681.

Distribution: *C. raduliloba* has already reported from Northeast India (locality unknown) China, Japan, Vietnam and Taiwan. The present collection is a new record to Peninsular India.

Lejeunea Libert.

Ann. Gen. Sc. Phys. 6: 372. 1820.

Plants minute and delicate, whitish-green to yellowish-green, stem prostrate, pinnately branched; leaves alternate, distant, incubous, margin entire or toothed, leaf lobe ovate, apex rounded or obtuse or rarely apiculate to acute; lobule plane, incurved or ventricose; cell walls thin, ocellii absent, trigones small or absent; oil bodies numerous, hyaline or with indistinct granules; underleaves entire or bifid, rarely absent, plicate at base, thin or as broad as stem; monoecious or dioecious, androecia usually on short branches, occasionally on the main stem; female branch with a single archegonium, usually with subinvolucral innovation, bracts different from the stem leaves in several pairs, bracteoles about the same size, perianth free from the bracts; capsule

pedicellate, globose, hyaline or pale brown; elaters fixed to the apex of the valves, monospiral.

Key to the species

- 1a. Leaf lobule small, not inflated, ¼ of leaf lobe.....2
- 1b. Leaf lobule large, inflated, ½ of leaf lobe.....**L. discreta**
- 2a. Leaf lobule toothed at apex.....**L. tuberculosa**
- 2b. Leaf lobule not toothed.....3
- 3a. Underleaves close, plicate at base.....**L. helenae**
- 3b. Underleaves distant, not plicate at base.....4
- 4a. Leaf lobe ovate-lanceolate, margin entire or slightly crenulate in a single branch; leaf cells with distinct trigones.....**L. exilis**
- 4b. Leaf lobe ovate-oblong, margin entire in whole leaves; leaf cells with minute trigones.....**L. obfusca**

Lejeunea discreta Lindenb., Syn. Hepat. 361. 1845; Mizutani, J. Hattori Bot. Lab. 34: 448. 1971; Bapna & Kachroo, Hepatic. India 2: 238. 2000. *Hygrolejeunea discreta* (Lindenb.) Schiffn., Consp. Hepat. Archip. Indici 266. 1898. *Eulejeunea ordinaria* Steph., Hedwigia 35: 92. 1896. *Lejeunea longiloba* Steph., Sp. Hepat. 5: 779. 1915. *L. ordinaria* (Steph.) Steph., Sp. Hepat. 5: 783. 1915. *L. stahlia* Steph., *Ibid.* 5: 791. 1915. *L. subdiversiloba* Horik., Bot. Mag. Tokyo. 48: 602. 1934. *Taxilejeunea discreta* (Lindenb.) Schust., Nova. Hedwigia 9: 138. 1963.

Plants small, yellowish-green, up to 10 mm long, irregularly branched; leaf lobe ovate to oblong, 0.25-0.30 mm long, obliquely to widely spreading, margin entire, not undulate; lobule large, inflated, ½ the length of leaf lobe, prominent; cells at margin 7-10 x 6-11 µm, central cells 10-12 x 9-12 µm, basal cells 25-30 x 12-15 µm. (Fig. 11: f-j & Plate 6m).

Habitat: Corticolous on riparian vegetation in moist deciduous forest.

Specimen examined: Ponkuzhi (880 m) **MCN 84383**.

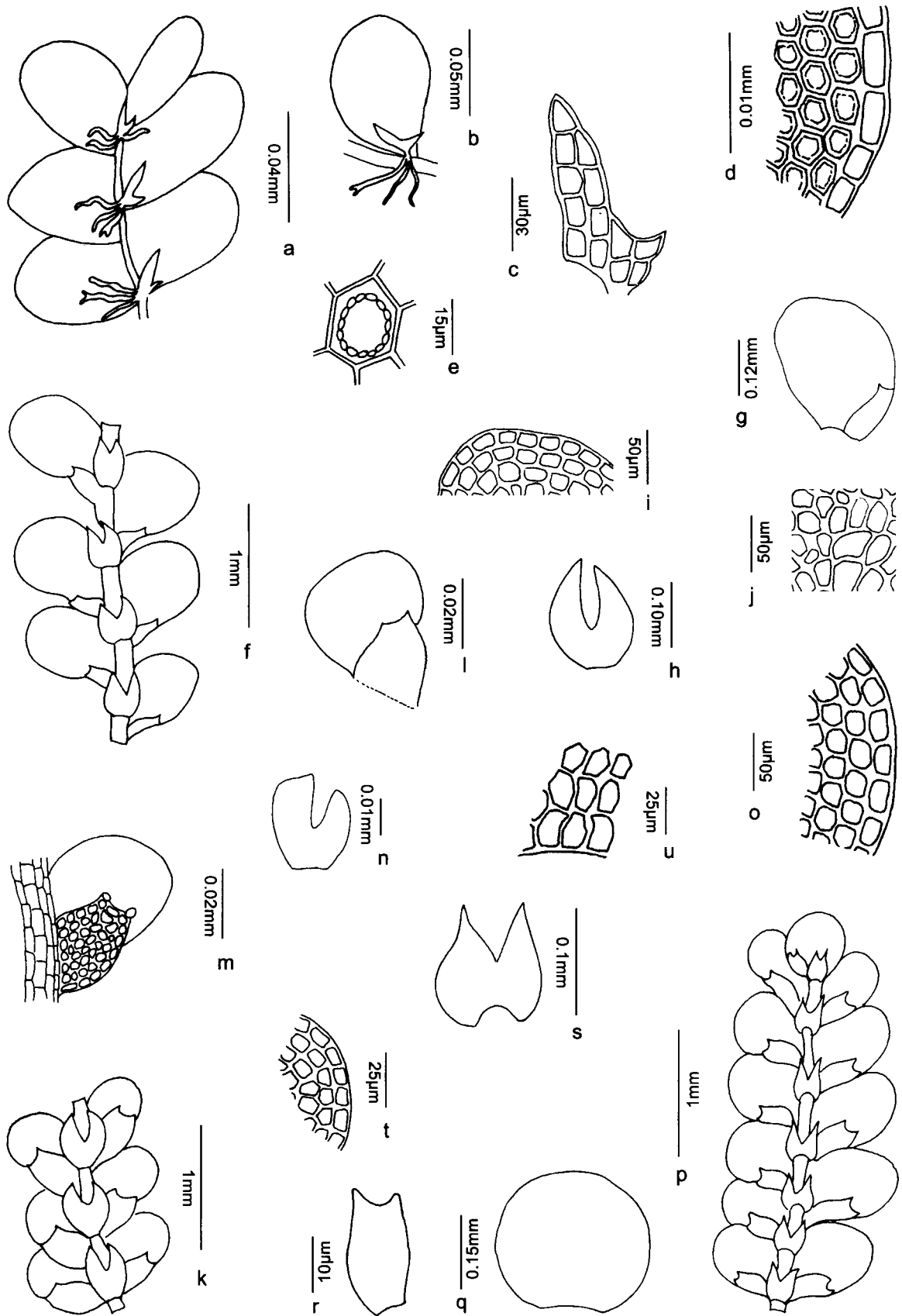


Fig. 11. **a-e**: *Cololejeunea raduliloba*; a: portion of branch ventral view, b: leaf with underleaf and rhizoids, c: underleaf cells, d: marginal cells, e: cell with oil bodies; **f-j**: *Lejeunea discreta*; f: portion of branch ventral view, g: leaf with lobule, h: underleaf, i: marginal cells, j: basal cells; **k-o**: *Lejeunea exilis*; k: branch ventral view, l: leaf with lobule, m: leaf attachment to the stem, n: underleaf, o: leaf marginal cells; **p-u**: *Lejeunea helena*; p: portion of branch ventral view, q: leaf, r: lobule, s: underleaf, t: leaf marginal cells, u: basal cells

Distribution: From the study area the species has collected from only one locality. The species is also collected from ENP of Idukki district. *L. discreta* is a widely distributed species earlier reported from South India (Tamil Nadu: Madras), North-east India (West Bengal, Himalayas, Sikkim), Sri Lanka, Bhutan, Borneo, Cambodia, Japan, Java, Kampuchea, Moluccas, Nepal, New Caledonia, Papua New Guinea, Philippines and Sumatra. The present collection is a new record to Kerala.

Lejeunea exilis (Reinw. *et al.*) Grolle, J. Hattori Bot. Lab. 46: 353. 1979. *Jungermannia exilis* Reinw. *et al.*, Nova Acta Caes. Leop. Nat. Cur. 12: 227. 1825. *J. cucullata* var. *exilis* (Reinw. *et al.*) Nees, Enumer. Pl. Crypt. Jav. Hepat. 57. 1830. *Lejeunea cucullata* var. *exilis* (Reinw. *et al.*) Gottsche *et al.*, Syn. Hepat. 390. 1845. *Eulejeunea cucullata* var. *exilis* (Reinw. *et al.*) Schiffn., Consp. Epat. Arch. Ind. 254. 1898. *Microlejeunea exilis* (Reinw. *et al.*) Bischl. *et al.*, Nova Hedwigia 3: 452. 1962. *M. lancistipula* Steph., Sp. Hepat. 5: 830. 1915. *Lejeunea lancistipula* (Steph.) H.A.Mill. *et al.*, Nova Hedwigia 14: 66. 1967. *Microlejeunea subacuta* Horik., Sci. Hiroshima Univ. ser. B, Div. 2, Bot. 2: 275. 1934. *Drepanolejeunea subacuta* (Horik.) H.A.Mill. *et al.*, Nova Hedwigia 4: 560. 1967 (1962). *Byssolejeunea abnormis* Herzog, Hedwigia 80: 84. 1941. *Lejeunea abnormis* (Herzog.) R.M.Schust., J. Hattori Bot. Lab. 25: 4. 1962, non (Gottsche) Steph. in Renauld & Cardot, Rev. Bryol. 18: 57. 1891. *Microlejeunea abnormis* (Herzog.) Inoue & H.A.Mill., Bull. Nat. Sci. Mus. Tokyo 11: 9. 1968. *Lejeunea byssiformis* Grolle & Mizut. in Mizutani, J. Hattori Bot. Lab. 43: 131. 1978 (1977).

Plants pale yellowish to greenish, scarcely irregularly branched, creeping up to 8 mm long, 0.36-0.40 mm wide with leaves, rhizoids at base of underleaves, hyaline, tufted; leaves distant, slightly caducous; leaf lobes ovate-lanceolate, highly variable in size, acute, margin entire or slightly crenulate, leaf lobules subquadrate to ovate-oblong, inflated, 2/5-3/5 as long as the leaf lobes, bordered by short rectangular cells; leaf cells thin walled, trigones small, marginal cells of leaf lobe quadrate to rectangular, 10-25 x 10-20 µm, median cells 14-32 x 10-25 µm, basal cells isodiametric to rectangular, 15-35 x 10-25 µm, intercellular space with distinct trigones; underleaves remote, dimorphic,

bilobed underleaves longer than wide, rarely as wide as long, wide as stem, sinus u-or v-shaped, lobes triangular to narrowly triangular, apex acute, 3-4 cells long, 2-3 cells wide at base, margin entire; unlobed underleaves lanceolate to subulate-ovate, 4-5 cells long, 2-3 cells wide at middle; leaf lobule ovate, about 0.05 x 0.04 mm wide, apex rounded to obtuse, ½ the length of the leaf-lobe. (Fig. 11: k-o & Plate 7a&b).

Habitat: Epiphytic alongwith *Heteroscyphus* sp. and *Cephaloziella kiaerii* in shola forests.

Specimen examined: Chembra hills (1770 m) MCN 99679.

Distribution: It was earlier recorded from China, Borneo, Carolines, Japan, Java, New Guinea and Philippines. The present collection is a new record to India.

Lejeunea helenae (Pears.) Pearson, Forh.Vidensk.-Selsk. Krist. 1886(3): 6. 1886.

Plants yellowish-green, up to 1 cm x 1 mm; rhizoids arise from underleaf base, hyaline; leaves rounded to oval, continuous, margin wavy, branching rare, if present pinnate, 0.3 x 0.4-0.6 mm, wider than long; lobule 0.13-0.15 x 0.1 mm, bilipped; underleaves bilipped, plicate at base, 120-122 x 100 µm, extreme tip of underleaf lobe with single cell; cells at margin small, irregularly rounded to quadrate, 4 x 4-6 µm, middle cells 16-20 x 15-18 µm, hexagonal, basal cells 20-22 x 10-12 µm, thin walled, trigones absent; cells at leaf lobule small, rounded to quadrate, 8-10 µm diagonally; oil bodies marginal. (Fig. 11: p-u & Plate 7c).

Habitat: On logs alongwith *Leucophanes octoblepharoides* in homestead.

Specimen examined: Kalpetta (450 m) MCN 99665b.

Distribution: The known distribution of *L. helenae* is from Uganda and Malawi in Africa. The present collection is a new record to India.

Lejeunea obfusca Mitt., J. Proc. Linn. Soc. London 5: 114. 1861; Mizutani, J. Hattori Bot. Lab. 26: 178. 1963; Bapna & Kachroo, Hepatic. India 2: 241. 2000.

Plants yellowish-green, small, appressed to the stem, up to 1 cm long, branching irregular; leaf lobe ovate-oblong, apex rounded or obtuse, margin

entire; cells without intermediate thickening, trigones minute; lobules small, 1/4 of the leaf lobe; underleaf distant, apex bilobed.

Habitat: Base of tree trunk on *Mangifera indica* in homestead area.

Specimen examined: Lakkidi (750 m) *MCN & PVM 80101*.

Distribution: It is rare in the study area and could be collected from only one locality. This was earlier known only from North India (Pachmahri) and Sri Lanka. The present collection is a new record to Peninsular India.

Lejeunea tuberculosa Steph., Sp. Hepat. 5: 790. 1915; Mizut., J. Hattori Bot. Lab. 34: 451. 1971; Bapna & Kachroo, Hepatic. India 2: 244. 2000.

Plants yellowish-green, small, up to 10 mm long, branches irregular, short; leaf lobe ovate, apex rounded, margin wavy, 0.22 x 0.25-0.27 μm ; leaf lobule small, 100 x 50 μm , ovate, apex toothed, inflated, 1/4 of the leaf lobe; underleaves distant, twice as wide as stem, 0.14 mm wide, bilobed, lobes acute, lateral margin entire, some with single tooth; cells at margin 5-8 x 13-15 μm , middle and basal cells 17-20 x 13-16 μm , oil bodies rounded to fusiform, 3-10 per cell. (Fig. 12: a-e).

Habitat: This species form large, loose patches on rocks, sometimes on tree trunks and logs in semi-evergreen forests.

Specimen examined: Mananthavady (700 m) *MCN 80113b*.

Distribution: The species is common in the study area. It is distributed in Eastern India (Assam, Mussoorie hills, Sikkim), Bhutan, Nepal and Philippines. The present collection is a new record to Peninsular India.

Note: So and Zhu (1998) commented that the distribution of this species appears to be disjunctive and every chance is there for the occurrence of it in Vietnam, Thailand, Laos and south-western China.

Lopholejeuneae (Spruce) Schiffn.

in Engl. & Prantl, Nat. Pfl.-fam. 1(3): 129. 1893.

Plants dark green, creeping, 20-40 mm long, irregularly branched; leaf lobes imbricate to oblong, apex rounded to incurved; leaf lobules small ovate, slightly inflated, in some there is small teeth at apex; underleaves imbricate,

orbicular to reniform, distant in some, entire; oil bodies per leaf varies, homogenous, elliptical; cells with large trigones and small intermediate thickenings; male bracts mostly ovate, 4-8 pairs, lobules oblong, obtuse at apex; female bracts ovate to acute and incurved at apex, irregularly dentate on margins, lobules rectangular, acute at apex, entire to irregularly dentate on upper margins, female bracteoles orbicular; seta short, 1-2 mm long; capsule globular; spores rounded, elaters numerous, brown, unispiral, rarely bispiral, 160-220 x 18 μm .

Lopholejeunea subfusca (Nees) Steph., Hedwigia 29: 16. 1890; R.S.Chopra, Proc. Indian Acad. Sci. 7: 249. 1938 & J. Indian Bot. Soc. 22: 250. 1943; Asthana *et al.*, Geophytology 29: 58. 2000; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 64. 2000; Bapna & Kachroo, Hepatic. India 2: 325. 2000. *Jungermannia subfusca* Nees, Hepat. Javan. 36. 1830. *Lejeunea subfusca* (Nees.) Gottsche *et al.*, Syn. Hepat. 315. 1845. *Phragmicoma cyclostipa* Taylor, London J. Bot. 5: 387. 1846. *Lejeunea cyclostipa* (Taylor) Gottsche *et al.*, Syn. Hepat. 749. 1848. *Lopholejeunea sagraeana* (Montin) Schiffn. in Engl. & Prantl, Nat. Pflanzenfam. 1,3: 129. 1895. *L. sagraeana* var. *subfusca* (Nees) Schiffn., Conspect. 294. 1898. *Mastigolejeunea andreana* Steph., Sp. Hepat. 4: 776. 1912. *Lopholejeunea asiatica* Steph., *Ibid.* 5: 82. 1912. *L. pyriformis* Steph., *Ibid.* 5: 88. 1912. *L. levierii* Schiffn., Ann. Bryol. 6: 134. 1933. *L. formosana* Horik., J. Sci. Hiroshima Univ. ser. 2, 2: 256. 1934.

Plants dark brown to black, up to 2 cm long, highly branched; leaf lobe rounded, widely spreading, margin entire, 60-65 x 45-50 μm ; cells thick walled with distinct radiate trigones and intermediate nodular thickenings, upper cells small, 10-15 x 10-12 μm , basal larger, 25-38 x 20-25 μm ; leaf lobule small, ovate, 15-18 μm long; underleaves wider than long, 28 x 35 μm , margin entire, apex rounded, rhizoids at the base of underleaves; male inflorescence on short lateral branch or on main branch, bracts distinctly saccate, lobe ovate, margin entire, apex obtuse or rounded, 0.32-0.48 x 0.21-0.32 mm, lobule 0.29-0.35 x 0.16-0.19 mm, margin entire, bracteole usually wider than long, 0.21-0.27 x

0.16-0.29 mm, margin entire; female inflorescence on terminal or on short lateral branches, bract-lobe orbicular, 0.67-1.05 x 0.64-0.91 mm, margin dentate, lobule rectangular to triangular, not extending beyond the keel, margin entire, bracteole 2/3 of the perianth length. (Fig. 12: f-h & Plate 7h).

Habitat: Base of tree trunk of *Tectona grandis* and *Terminalia bellerica* in semi-evergreen forests.

Specimen examined: Begur RF (845 m) MCN 84596.

Distribution: *L. subfusca* is rare in the present study area. From Kerala this species was reported from Silent Valley NP by Srivastava & Sharma in 2000 and from Wayanad, Idukki and Thiruvananthapuram by Awasthi *et al.* in 2000. It is distributed in Southern India (Kerala, Karnataka, Tamil Nadu), North-east India (West Bengal, Meghalaya, Sikkim), Andaman Islands, Sri Lanka, Borneo, Carolina Islands, China, Taiwan, Ryukyu Island, Japan, Java, Madagascar, Malaya, Marshal Island, New Guinea, New Caledonia, Philippines, Sumatra, Tahiti and Thailand.

Mastigolejeunea (Spruce) Schiffn.

in Engl. & Prantl, Nat. Pflanzenfam. 1,3: 129. 1895.

Plants small to medium sized, brown to blackish-green; leaf lobes ovate, concave, margin entire, acute or obtuse at apex, incubous; cell walls thick with intermediate thickening and trigones; oil bodies 2-3 per cell, cluster type; leaf lobule large, inflated with 1-2 teeth, rarely absent; underleaves large, orbicular, entire; male inflorescence terminal or on lateral branch or on main axis, bract and bracteole similar, smaller than leaves and underleaves; female bracts with entire margin, apex acute, bracteoles entire, perianth sharply 3-keeled, usually with 1-7 additional keels; seta small up to 2 mm long; capsule globular to elongated; spores rounded, blackish to brownish; elaters brown, unispiral.

Mastigolejeunea sp.

Thallus dark greenish, highly branched, irregular, leaves succubous, margin entire, dorsal margin arched; leaf lobes closely imbricate, ovate, 1 x 0.8 mm; cells irregular in shape; leaf lobule small, reach ¼ of the leaf; underleaves

small, closely arranged, double the width of the stem; male inflorescence on lateral branches, female inflorescence terminal. (Fig. 12: i-m).

Habitat: Epiphytic on Teak and on logs alongwith *Trachyphyllum inflexum* in moist deciduous forests.

Specimen examined: Ponkuzhi (921 m) MCN 84385c.

Distribution: It is rare in the study area and could be collected from only one locality.

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. 1934; Mizut., J. Hattori Bot. Lab. 24: 161. 1961; Udari & Awasthi, J. Indian Bot. Soc. 61: 184. 1982; Bapna & Kachroo, Hepatic. India 2: 315. 2000. *Jungermannia semirepanda* Nees, Hepat. Jav. 39. 1830. *Ptychanthus semirepandus* (Nees) Nees, Naturg. Eur. Laberm. 3: 212. 1839. *Phragmicoma semirepanda* (Nees) Gottsche in Gottsche, *et al.*, Syn. Hepat. 302. 1845. *Lejeunea semirepanda* (Nees) Mitt., J. Proc. Linn. Soc. Bot. 5: 111. 1861. *Thysananthus rotundistipulus* Steph., Sp. Hepat. 6: 566. 1924; Pande & Udari, Proc. Indian Sci. Cong. 3: 40.

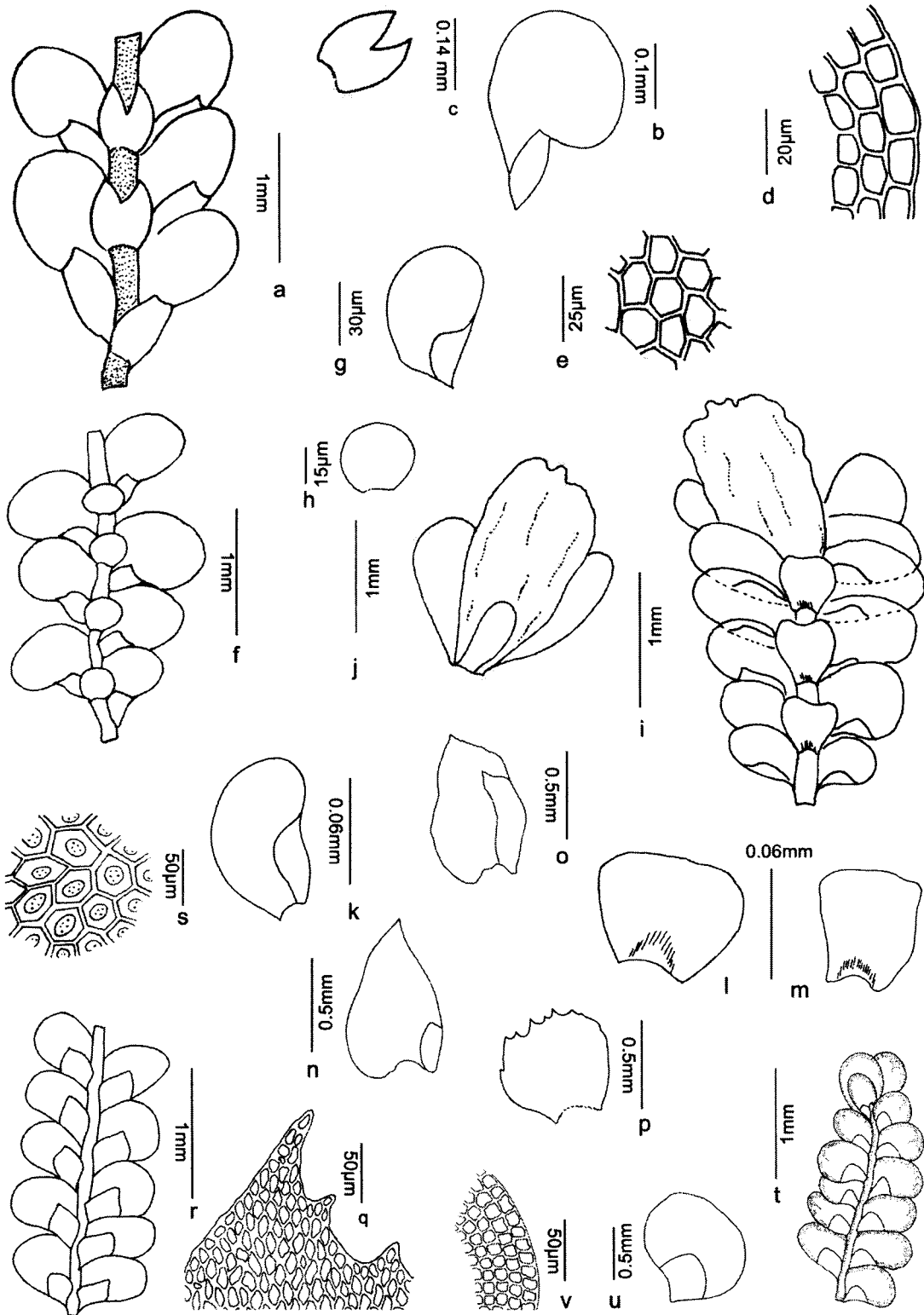


Fig. 12. a-e: *Lejeunea tuberculosa*; a: branch ventral view, b: leaf with lobule, c: underleaf, d: leaf marginal cells, e: basal cells; f-h: *Lopholejeunea subfusca*; f: branch ventral view, g: leaf with lobule, h: underleaf; i-m: *Mastigolejeunea* sp.: i: female branch ventral view, j: female inflorescence, k: leaf with lobule, l&m: underleaves; n-q: *Spruceanthus semirepundus*; n&o: leaf with lobule, p: underleaf, q: leaf tip cells; r-s: *Radula japonica*; r: branch ventral view, s: cells with oil bodies; t-v: *Radula kurzii*; t: branch ventral view, u: leaf with lobule, v: leaf marginal cells

1950. *T. fragillimus* Herzog in Mizut., Symb. Sinic. 5: 45. 1930. *Ptychanthus madothecoides* Horik., J. Sci. Hiroshima Univ. ser. B. 2: 248. 1934.

Plants greenish-brown, large, 6-9 cm long, robust, irregularly branched; leaf lobe elongate, with acute or apiculate apex, dorsal margin cordate at base; cells isodiametric, thick walled with intermediate nodular thickenings, triangular-radiate trigones distinct; oil bodies 30-40 per cell; lobule 1/4 or 3/4 of the length of the lobe, apex with 1-3 teeth, mostly one teeth; underleaves two times wide as stem; male inflorescence on terminal or on short lateral branches, with 1 or 2 subfloral innovations, bracteoles present; female inflorescence terminal on main branch, bracts oblong, more dentate than leaves, lobule smaller, 1/3 of the lobe, bracteoles oblong, apex bilobed, irregularly dentate, inflated, 5-9 keeled. (Fig. 12: n-q & Plate 7d&e).

Habitat: Epiphytic on shola trees as well as on rocky patches alongwith *Hypopterigium tenellum*, *Plagiochila fruticosa* and *Lejeunea* sp.

Specimens examined: Chembra hills (1380-1775 m) MCN 120260, 120282a, 120313a, MCN 120395.

Distribution: It is widely distributed on the shola trees of Chembra hills. This species was earlier reported from South India (Kerala: Malabar; Karnataka; Tamil Nadu: Nilgiri hills, Kodaikanal), Northeast India (Western Himalaya, Sikkim, Khasi hills, Meghalaya, Darjeeling), Sri Lanka, Japan, China, Java, Borneo, Philippines and Taiwan.

Order **RADULALES** (R.M.Schust.) Stotler & Crand.-Stotl.

RADULACEAE K.Muell.

Krypt. Fl. Deutschl. Ed. 2. 6(1): 404. 1909.

Plants green to dark greenish, closely attached to the substratum, prostrate, rarely pendant; stem closely or irregularly pinnate or bipinnate, branching terminal, *Radula* type; leaves incubous, widely ovate, rounded to rectangular, margin entire; lobule smaller with its free margin generally appressed to the underside of the dorsal lobe, single, inflated, margin entire; rhizoids arising from under surface of lobule or leaves; underleaves absent; androecia spicate, on terminal branches; gynoecia terminal on main stem,

perianth two lipped, mouth truncate, often entire, some times dentate; seta short; capsule ovoid.

This is a monotypic family.

Radula Dumort.

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

Plants yellowish-green, irregularly branched, branches prostrate or erect, easily detachable from the substratum; leaves incubous, usually ovate or falcate, with a broadly rounded anterior margin; lobule rectangular, persistent; rhizoids arising from the under surface of the lobule; underleaves absent; androecia terminal on the main stem, bracts imbricate, in several pairs, subequally lobed; gynoecia terminal, usually on the stem or main branch, female bracts 1-4 pairs, smaller than the stem leaves, lobes with toothed margin, perianth bilabiate, densely toothed in some, mouth wide, truncate; seta stout, not much exerted above perianth; capsule shortly and stoutly pedicelled, generally ovoid-cylindrical; spores globose, minutely granulate, 20-40 μm ; elaters long, 150-200 μm , slender, bispiraled.

Note: Radula is considered as an advanced genus in Jungermanniales. This genus can be easily recognized in the field, by its thallus structure, peculiar yellowish-green colour and quadrate or subquadrate lobule.

Key to the species

- 1a. Leaves imbricate, ovate with rounded apex.....2
- 1b. Leaves not imbricate, oblong or orbicular with rounded to elongate apex
.....**R. japonica**
- 2a. Lobules quadrate with a pointed apex; trigones small, without nodules.....
.....**R. javanica**
- 2b. Lobules subquadrate, obliquely spreading; trigones prominent, triangular,
nodulose.....**R. kurzii**



Plate. 7. a & b: *Lejeunea exilis*, c: *L. helenae*, d: *Spruceanthus semirepundus*, e: branch enlarged, f: *Radula japonica*, g: a portion enlarged, h: *Lopholejeunea subfusca*, i: *Radula javanica*, j: *R. kurzii*

Radula japonica Gottsche ex Steph. Hedwigia 23: 152. 1884.

Plants yellowish-green, creeping, irregularly branched, 1-1.5 mm wide with leaves, leaf lobes oblong or orbicular, 0.75 x 0.60 mm, leaf lobules quadrate; underleaves absent, oil bodies 1 per leaf cells, spherical or elliptical, median cells 10-20 x 12-22 μm , thin walled with minute trigones. (Fig. 12: r-s & Plate 7f&g).

Habitat: On branches as well as on soil and rocky patches alongwith *Plagiochila* sp. and *Cololejeunea* sp. in evergreen and shola forests.

Specimens examined: Thirunelli RF (1030 m) MCN 120364, Chembra hills (1220-1768 m) MCN 120390, MCN 120256.

Distribution: It is a rare species in the study area. It is also collected from the evergreen forests of Vellarimala in Kozhikkode district. It has earlier reported from North India (Himalayas), China, Japan and Korea. The present collection is a new record to Peninsular India.

Radula javanica Gottsche in Gottsche *et al.*, Syn. Hepat. 257. 1845; Yamada, J. Hattori Bot. Lab. 45: 235. 1979; Kitag, Acta Phytotax Geobot. 30: 39. 1979; Bapna & Kachroo, Hepatic. India 2: 139. 2000. *R. wallichiana* Lehm., Nov. Stirp. Pug. 10: 9. 1857. *R. colliculosa* Mitt., J. Proc. Linn. Soc. 5: 107. 1861. *R. ceramensis* Steph., Hedwigia 23: 132. 1884. *R. sandei* Steph., Hedwigia 23: 130. 1884. *R. ovalifolia* Steph., Hedwigia 23: 132. 1884. *R. nietneri* Steph., Sp. Hepat. 6: 512. 1924. *R. variabilis* S.Hatt., Bull. Tokyo Sci. Mus. 11: 86. 1944.

Plants pale yellowish-green, main stem 1-5 cm long, irregularly branched, branches small, bearing few rhizoids; leaves imbricate, ovate with rounded apex, slightly concave, margin smooth, postical lobe infolded towards the leaf, less than half the size of the broadly rounded antical lobe; lobules quadrate with a pointed apex; cells rounded hexagonal, about 20 μm wide, thin walled, trigones absent; underleaves absent. (Plate 7i).

Habitat: Corticolous on trees of semi-evergreen and evergreen forests.

Specimen examined: Kuppadi (865 m) MCN 120368.

Distribution: It is a common species in the semi evergreen forests of Kuppadi range. It is widely distributed in the Asian and Pacific tropics and was earlier reported from South India (Karnataka), North-east India (Assam, Khasi hills), Sri Lanka, Thailand, Vietnam, Sumatra, Java, Borneo, New Guinea, Philippines, Taiwan, China, Samoa, Japan and New Caledonia. The present collection is a new record to Kerala.

Note: This is one of the most common species of *Radula*, which shows variations in size and shape depending on growth conditions.

Radula kurzii Steph., Hedwigia 23: 153. 1884; Yamada, J. Hattori Bot. Lab. 45: 239. 1979; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res. 66. 2000; Bapna & Kachroo, Hepatic. India 2: 140. 2000. *Radula speciosa* Gottsche & Steph., Hedwigia 23: 155. 1884. *R. andreana* Steph., Sp. Hepat. 4: 182. 1910.

Plants yellowish-green, large, 5-7 cm long, branches irregular; leaf lobes imbricate, widely ovate, apex rounded, incurved along ventral margin; leaf lobules subquadrate, half the length of lobe, obliquely spreading; underleaves absent; cell walls thin, cells near margin small, 0.5-0.6 x 0.5 μm , median cells 13-20 μm diagonally, basal cells elongated, 23-32 x 17-23 μm , cells near leaf lobule small, rounded to irregular, 7-11 μm diagonally, trigones prominent, triangular, nodulose. (Fig. 12 t-v & Plate 7j).

Habitat: Corticolous, on rocky patches or on leaf litter alongwith *Spruceanthus semirepandus*, *Plagiochila fruticosa* and *Lejeunea* sp. in evergreen and shola forests.

Specimens examined: Chembra hills (1220-1768 m) MCN 120226, MCN 120256, MCN 120274, MCN 120315.

Distribution: This species is widely distributed in shola forests of the study area. It was also collected from evergreen forests of Kakkayam in Kozhikode and Silent Valley NP of Palakkad district of Kerala. Srivastava and Sharma (2000) reported this species from Silent Valley NP. The distribution extends to Andaman Islands, Sri Lanka, China, Caledonia and Australia.

5.1.2. CLASS II: ANTHOCEROTAE

Plants thallose, dorsiventral, lobed, without internal differentiation of tissues, oil bodies present, rhizoids smooth, sporogonium without seta, with bulbous foot and intercalary meristem, capsule cylindrical to elongate.

Recent cladistic analysis of morphological and ultrastructural data have helped to formulate phylogenetic hypotheses and these hypotheses have been used to propose alternate classification for anthocerotae (Hassel de Menendez, 1988; Hyvonen & Pippo, 1993; Hasegawa, 1994). All these classification recognize five to nine genera. In total 11 genera of hornworts have been named, of which only six have gained wide recognition viz., *Anthoceros*, *Phaeoceros*, *Folioceros*, *Notothylas*, *Megaceros* and *Dendroceros*, of these four genera such as *Anthoceros*, *Folioceros*, *Phaeoceros* and *Notothylas* have been collected from the study area. The classification system of Hyvonen and Pippo (1993) is followed here.

Classification system of Hyvonen & Pippo (1993)

Order Anthocerotales Limpr. in Cohn

Family **Anthocerotaceae** Dumort.

Anthoceros (P.Micheli.) L., ***Folioceros*** D.C.Bhardwaj, *Leiosporoceros* Hassel de Men., *Mesoceros* Piippo, ***Phaeoceros*** Prosk., *Sphaerosporoceros* Hassel

Family **Dendrocerotaceae** (Milde) Hassel de Men.

Dendroceros Nees, *Megaceros* Campbell

Family **Notothyladaceae** (Milde) Muell.

Notothylas Sull.

ANTHOCEROTALES Limpr. in Cohn

Key to the families

- 1a. Thallus spongy with schizogenous cavities, jacket cells of antheridium arranged in 4 tiers; capsule dorsal in position, erect, almost entirely projected out of the involucre at maturity; spores dark coloured
.....**Anthocerotaceae**

- 1b. Thallus compact without schizogenous cavities, jacket cells of antheridium irregularly arranged; capsule marginal in position, horizontal, almost entirely enclosed within the involucre until maturity; spores light coloured
**Notothyladaceae**

ANTHOCEROTACEAE Dumort.

Anal. Fam. Pl. 68. 1829.

Thallus usually spongy, bears numerous schizogenous cavities in 1-3 layers; antheridia club-shaped, numerous, per antheridial chamber, with 4-tired cells in the jacket layer; epidermal layer of capsule wall stomatiferous; spores brown to dark, sporoderm conspicuously sculptured; pseudoelaters 1-5 celled, short, thin walled or long, vermiform, thick walled bearing a central dark continuous lumen.

Key to the genera

- 1a. Pseudoelaters thick walled, vermiform, with a central dark lumen.....
**Folioceros**
- 1b. Pseudoelaters thin walled, frequently branched or some times branched....2
- 2a. Pseudoelaters long, 67-387 µm, sometimes branched, spores brown to dark brown**Anthoceros**
- 2b. Pseudoelaters stumpy, 123-255 µm, frequently branched, spores yellowish green **Phaeoceros**

Anthoceros (P.Micheli) L. *emend.* Prosk.

Bull. Torrey Bot. Club 78(4): 346. 1951.

Thallus spongy, lobed, suberect-erect, isolated or in rosettes of variable morpho-forms, margins deeply dissected, internally with 1-3 layers of mucilage chambers; upper epidermal layer with one subspherical or stellate chloroplast per cell, pyrenoid body composite, placed almost in the centre; *Nostoc* colony present; monoecious or dioecious, androecia intercalary, arranged along median line or throughout; capsule erect, bivalved, dehiscing longitudinally from apex to base; spores brown to dark brown, 28-65 µm in diameter;

pseudoelaters 1-4(-5) celled, 67-380 µm long, thin walled, sometimes branched.

Key to the species

- 1a. Thallus with smooth dorsal surface, gemmae present at the apical margin, chloroplast two per cell, spores light brown to brown.....**A. angustus**
- 1b. Thallus with lamellate or crispate dorsal surface, non gemmate, chloroplast single per cell, spores dark brown to black.....**A. crispulus**

Anthoceros angustus St., Spec. Hep. 5: 1001. 1916; Asthana & S.C.Srivast., Indian Hornworts 34. 1991. *Anthoceros formosae* St. Spec. Hep. 5: 1002. 1916. *A. grosseinvolucratu*s St., Spec. Hepat. 6: 426. 1923. *A. gemmulosus* (Hatt.) Pande ex D.C.Bhardwaj, J. Indian Bot. Soc. 37: 76. 1958; Nair and Madhus., J. Econ Tax. Bot. 25: 572. *A. cf. gemmulosus* (Hatt.) Pande ex. D.C.Bhardwaj J. Indian Bot. Soc. 37: 76. 1958.

Thallus light greenish, growing in dense cushions arranged as rosettes, up to 12 mm long, 1.5-4 mm wide, dorsal surface smooth, bears gemmae at the apical margin; epidermal cells usually contain two chloroplasts with its associated pyrenoids, a distinguishing character from other species of the genus, mucilage cavities large, separated each other by one cell thick partition; androecia arranged linearly along median lines; spores light brown, 31-40 µm, with spinulate blunt projections; pseudoelaters light brown, thin walled, sometimes branched. (Fig. 13: a-c & Plate 8a).

Habitat: In the rocky patches along the banks of stream in semi-evergreen forests.

Specimen examined: Chikkanji, Kurichiad range (920 m) MCN 120343.

Distribution: *A. angustus* has sparse occurrence in the study area. The species was located only in Kurichiad range. The species is distributed in North-east India (Sikkim, Western Himalayas, Eastern Himalayas) and Japan. The present collection is a new record to Peninsular India.

Anthoceros crispulus (Montin) Douin, Rev. Bryol. 32: 25. 1905; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends Bot. Res.

69. 2000. *Anthoceros punctatus* var. *crispulus* Montin in Webber & Berthelot, Hist. Ins. Can. Bot. 2(4): 64. 1840. *Anthoceros meeboldii* Steph., Spec. Hepat. 5: 1004. 1916. *Folioceros pandei* Udar & Shaheen, Geophytology 12: 78-80. 1982.

Thallus dark greenish, forming rosettes, up to 14 mm diameter, dorsal surface crispate to lamellate; epidermal cells contain single chloroplast with its associated pyrenoid, nearly ovoid, mucilage chambers 1-2 layered; seta long, up to 4 cm long; capsule split open by two valves; spores dark brown to black, 36-45 μm diameter; elaters thin walled, 100-235 μm long, 2-4 celled, sometimes branched. (Fig. 13: d-h & Plate 8b).

Habitat: In earth cuttings in semi-evergreen forests.

Specimen examined: Periya (920 m) MCN 80116.

Distribution: *A. crispulus* occur in Periya and Begur RF areas. The species is also distributed in the Western Himalayas, Eastern Himalayas, South India (Kerala; Tamil Nadu: Khandala, Kodaikanal, Shembaganur, Perumalmai, Ooty, Naduvattam), Sri Lanka, Japan, Korea, Malaysia, Europe and United States of America.

Folioceros D.C.Bhardwaj

Geophytology 1(1): 9. 1971.

Thallus spongy in nature, pinnately lobed, highly variable, long expanded with crenulate or deeply dissected margins; gemmae present on dorsal surface of the thallus; rhizoids simple and smooth walled; upper epidermal cells with usually one chloroplast per cell, variable in shape, pyrenoid body distinct, aggregated; schizogenous cavities large in 1-3 layers; spores brown to blackish, 25-50 μm in diameter; pseudoelaters thick walled, 1-5 celled, vermiform, up to 630 μm long with a continuous dark brown lumen, smooth or highly irregular, sometimes branched.

Folioceros sp.

Thallus dark greenish, spongy, up to 1 cm or more long, 1-2.5 mm wide, bearing narrow outgrowths; upper epidermal cells with single chloroplast,

pyrenoid region roughly globular with small darker area in the centre; androecia embedded along the median line, female thallus longer than male; spores yellowish brown, globose, spinulose, 35-42 µm diagonally; pseudoelaters 55-62 µm long, vermiform, thick walled with a central dark lumen. (Fig. 13: o-q & Plate 8c).

Habitat: On lateritic rocks as patches in grassland.

Specimen examined: Chembra hills (1330 m) MCN 120291b (CALI).

Note: This species resembles *Folioceros kashyapii* Srivasthava & Asthana but differs in apically linear outgrowth and smaller size of the elaters.

Phaeoceros Prosk.

Thallus dorsiventral, dorsal surface smooth, compact, internally 3-12 cells thick in the middle, without mucilage chambers, chloroplast in the epidermal layer usually one per cell, the shape and size varies from globular, pyrenoid to ring shaped; dioecious or monoecious, androecia on the dorsal surface of thallus, archegonia embedded in the thallus tissue, sporogonia same as those of *Anthoceros*; spores yellowish green; pseudoelaters frequently branched and thin walled, composed of 1-4(-5) cells, 123-257 µm long, sometimes stumpy.

Phaeoceros laevis (L.) Prosk. subsp. **laevis** Prosk., Rapp & Comm. VIII. Congr. Intern. Bot., Paris 14-16: 69. 1954; Asthana & S.C.Srivast., Indian Hornworts 122. 1991; Asthana & Nath, Cryptogamie, Bryol. Lichenol. 15(2): 130. 1994; S.C.Srivast. & Sharma in Chauhan, Prof. D.D. Nautiyal Comm. Vol. Recent Trends in Bot. Res. 71. 2000. *Anthoceros laevis* L., Spec. Plant 2: 1139. 1753. *A. major* Micheli, Nova Plant. Gen. 11. 1729. *A. indicus* Steph., Spec. Hep. 5: 1002. 1916. *A. longii* Steph., Spec. Hepat. 5: 1003. 1916. *Phaeoceros butleri* (Steph.) Udar & Singh, Geophytology 11(2): 257. 1981.

Thallus dioecious, greenish yellow, male thallus up to 6 mm or more, wide at apex, deeply lobed; female thallus fan shaped, expansive, long and branched, deeply lobed with smooth-wavy margin, up to 18 mm long and 16 mm wide at apex, cells 4-8 layers in the middle region, upper epidermal layer

with single globose chloroplast per cell; spores yellowish green, 35-55 μm in diameter, usually densely impregnated with minute papillae; pseudoelaters light yellowish, thin walled, short, sometimes branched. (Fig. 13: i-n & Plate 8d).

Habitat: On earth cuttings usually alongwith *Riccardia laevieri* and on moist rocks in semi-evergreen forests and grassland.

Specimens examined: Soojippara (760 m) MCN 87090, Chembra hills (1220 m) MCN 120229.

Distribution: This species is common in Soojippara and Chembra hills. It is a widely distributed species in South India (Tamil Nadu, Kerala, Karnataka) and Northern India (Eastern & Western Himalayas).

Note: *Phaeoceros laevis* (L.) Prosk. subsp. *laevis* Prosk. differs from *P. laevis* subsp. *carolinianus* in having dioeciousness, a thicker and more shortly tuberculated tri-radiate mark, rounded papillae on each triangular face. *Anthoceros chanbensis* Kashyap and *Phaeoceros dixiti* (Sane) Prosk. seems to agree in their description with *P. laevis* subsp. *laevis* in the compact nature of the thallus, dioeciousness and almost identical sporoderm ornamentation (Asthana and Srivasthava, 1991). The present collection also shows the same features.

NOTOTHYLADACEAE Prosk.

Phytomorphology 10: 1-19. 1960.

Thallus in rosettes, margin lobed, wavy or crenulate, 3-16 cell thick in the middle, dorsal surface smooth, ridged or lamellate; upper epidermal layer with 1-2 or more large chloroplasts per cell with a central pyrenoid region; *Nostoc* colonies irregularly distributed, sometimes absent; monoecious or dioecious, androecia scattered with 2-4 antheridia per antheridial chamber; archegonia embedded in the thallus tissue, undifferentiated from the vegetative cells of the thallus; capsule oblong, cylindrical or ellipsoidal, enclosed within involucre or slightly exerted beyond the mouth of the involucre, capsule bivalved, columella may be present or absent; pseudoelaters 1-2(-5) celled, subquadrate, elongated, with or without annular- spiral thickening bands.

Note: Notothyladaceae is a monotypic family with the genus *Notothylas* Sull.

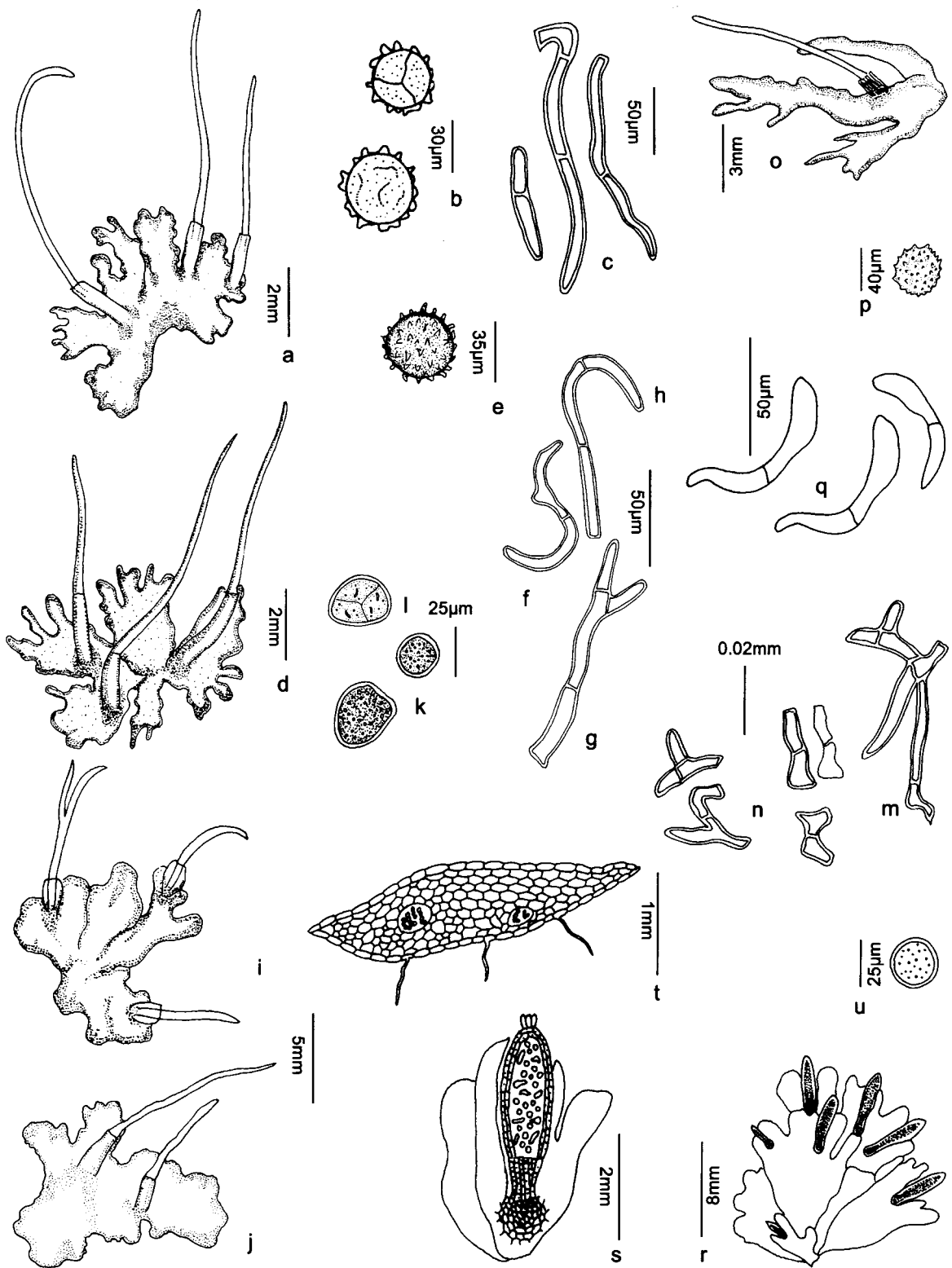


Fig.13: a-c: *Anthoceros angustus*; a: thallus, b: spores, c: elaters; d-h: *Anthoceros crispulus*; d: thallus, e: spore, f,g&h: elaters; i-n: *Phaeoceros laevis* subsp. *laevis*; i&j: thallus, k: spores, l: spore-distal view, m&n: elaters; o-q: *Folioceros* sp.; o: thallus, p: spore, q: elaters; r-u: *Notothylas levieri*; r: thallus, s: section through sporophyte, t: section through thallus, u: spore

Notothylas Sull.

Amer. Acad. of Arts & Sci. New Ser. Bd. 3: 1848.

Thallus prostrate, thick at the base, gradually thin towards margin, androecial chambers wide with 2-4 antheridia in each, capsule marginal, conical, with a large foot, never exerted, bi-valved, columella large or altogether absent; spores large, tetrahedral, elaters equal in size or longer than the spores, inflated, with spiral or simple oblique bands.

Notothylas levieri Schiffn. ex Steph., Sp. Hep. 5: 1021. 1917; Kashyap, Liverworts W. Himalayas & Punjab plain 129. 1929; Asthana & S.C.Srivast., Indian Hornworts 111. 1991; Singh, Notothylaceae India & Nepal 111. 2002; Nair & Madhus., Indian J. For. 26(3): 296. 2003.

Thallus monoecious, rosette forming in close overlapping masses, with smooth walled rhizoids on the ventral side, usually orbicular or suborbicular in outline, 5-7 cells thick in the middle, gradually thin out to one or two cells towards margin; cells chlorophyllose, similar, except the upper and lower epidermal cells, which are smaller than the inner; inner cells uniform, parenchymatous, mucilage cavities filled with *Nostoc*; antheridia in groups, usually of four on the dorsal side, archegonia on different lobes; sporogonia marginal, cylindrical, pointed; non columellate, outer wall layers surround the central mass of spores and elaters, arranged in alternating bands; spores globose, dark brown, minutely granular 25-35 μm in diameter; pseudoelaters with oblique thin bands or incomplete spirals up to 50 μm long. (Fig. 13: r-u & Plate 8e&f).

Habitat: Grows in shady rocky patches of semi-evergreen and evergreen forests where water drips regularly along with *Riccardia multifida*, *Utricularia* and *Pilea microphylla*.

Specimen examined: Wayanad Hairpin point (420-500 m) MCN 120342.

Distribution: It was located only in the hair pin area on the way to Wayanad. The species has wide distribution in northern and central India (Western Himalaya, Central Himalaya, Mussorie, Simla). From South India the species was first described from Palakkad of Kerala State by Madhusoodanan and Nair (2003).

Note: This species is characterized by the absence of columella, which differentiate it from *N. indica*.

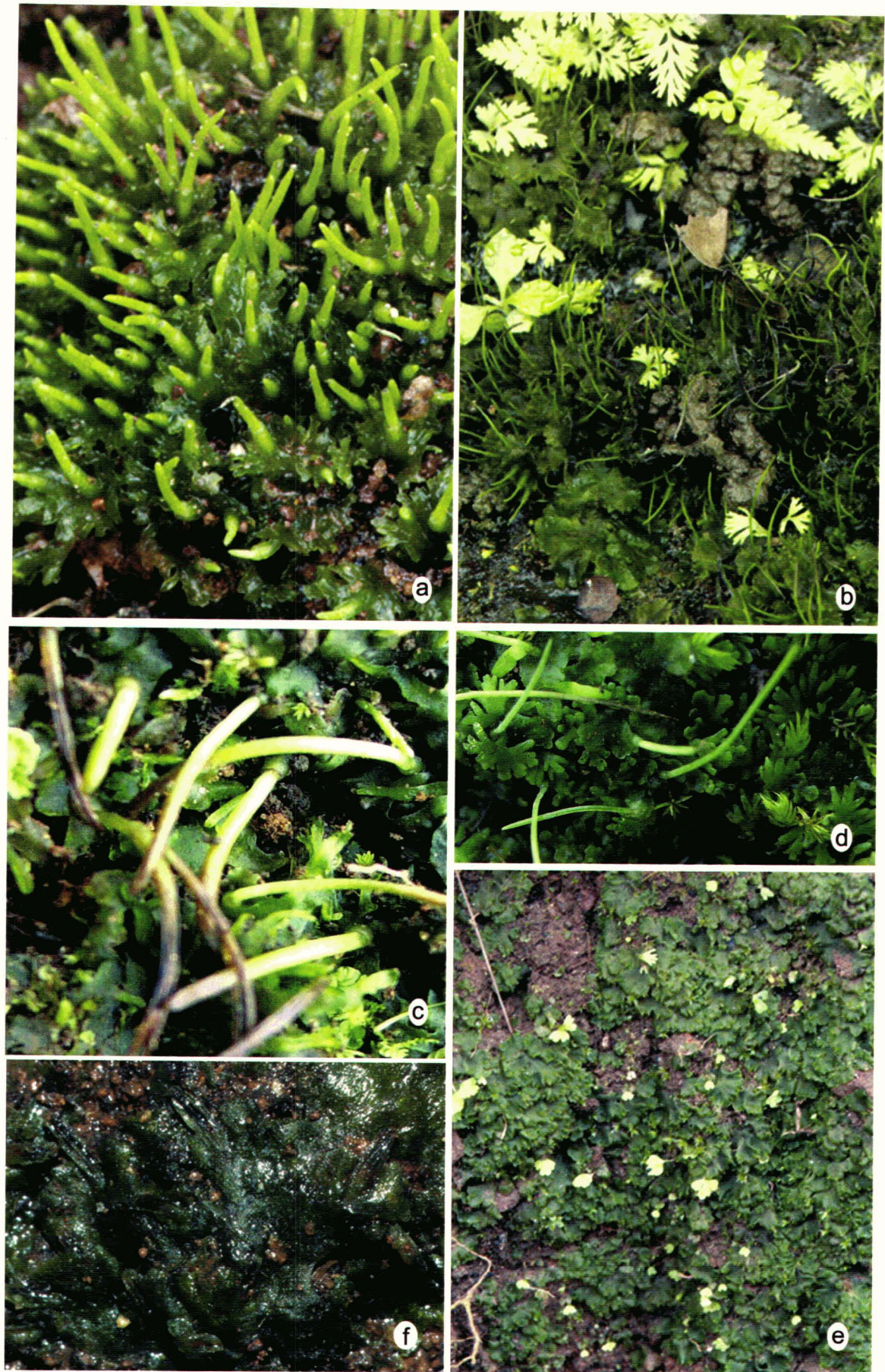


Plate. 8. a: *Anthoceros angustus*, b: *A. crispulus*, c: *Folioceros* sp., d: *Phaeoceros laevis* subsp. *laevis*, e: *Notothylas levieri*, f: *N. levieri* a portion enlarged

5.1.3. CLASS III: MUSCI

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 speciose group among bryophytes, comprising approximately 10,000 or more species. They differ from liverworts and hornworts in several characters such as gametophyte composed of stems with undivided and often costate leaves, and a sporophyte terminated by a capsule that is elevated by the elongation of seta prior to maturity. In their evolutionary history mosses are currently at the highest level of diversity (Kurschner & Parolly, 1999). Eventhough they are rather small in size, they show much variation in morphology. This diversity is highly correlated with the diversity of angiosperms of forests, which provide a wide range of habitats to colonize the bryophytes.

Key to the families

- 1a. Plants acrocarpic.....2
- 1b. Plants pleurocarpic.....14
- 2a. Leaves lamellose.....**Polytrichaceae**
- 2b. Leaves non lamellose.....3
- 3a. Capsule sessile, globose; spores 8-16 ... (no representation in the present study)
- 3b. Capsule stalked, not globose; peristome teeth dicranose; more than 16 spored.....4
- 4a. Peristome teeth split to the base.....**Ditrichaceae**
- 4b. Peristome teeth forked or simple.....5
- 5a. Peristome forked; leaf tip margin toothed; alar cells distinct.....**Dicranaceae**
- 5b. Peristome simple; leaf margin entire; alar small or absent.....6
- 6a. Leaves multistratose; cells differentiated into chlorocysts and leucocysts.....
.....**Leucobryaceae**
- 6b. Leaves unistratose; cells not differentiated as above.....7

7a. Leaves distichous; complanate with characteristic sheathing lamina	Fissidentaceae
7b. Leaves not distichous; without sheathing lamina.....	8
8a. Leaves differentiated into semisheathing hyaline zones.....	9
8b. Leaves not differentiated into semisheathing hyaline zone.....	10
9a. Hyaline zone bordered by green isodiametric cells; presence of gemmiferous and non gemmiferous leaves.....	Calymperaceae
9b. Hyaline zone not bordered by cells as above; leaves normal.....	Pottiaceae
10a. Leaves ovate, orbicular or lanceolate.....	11
10b. Leaves elongate, subulate.....	13
11a. Leaf cells not papillose; margin bordered by single layered elongated cells; rhizoids simple.....	Funariaceae
11b. Leaf cells papillose to mamilllose; leaf margin not bordered; rhizoids..... papillose.....	Splachnaceae
11c. Leaf cells thin walled; margin bordered by one or two layers of elongated cells; rhizoids simple or posses tubers.....	12
12a. Cells near leaf base quadrate to rectangular, above base rhomboid to hexagonal or linearly vermiform not in oblique rows; fertile and sterile branches erect.....	Bryaceae
12b. Cells near leaf base and above base similar, rounded to hexagonal; often in oblique rows; fertile branches erect and sterile prostrate.....	Mniaceae
13a. Leaf margin dentate or serrate by means of paired papillae, single ranked, laminar cells mamilllose or papillose.....	Bartramiaceae
13b. Leaf margin serrated, 2 ranked; laminar cells smooth.....	Rhizogoniaceae
14a. Leaves dimorphic	15
14b. Leaves monomorphic.....	16
15a. Plants prostrate; leaves aristate; amphigastrial leaves much smaller, erect with longer arista	Racopilaceae
15b. Plants erect; leaves acuminate; amphigastrial leaves smaller; more acuminate	Hypopterygiaceae
16a. Costa single, reach upto top or double or absent.....	17

- 16b. Costa double; reach up to middle or above midleaf..... **Hylocomiaceae**
- 17a. *Perichaecia radiculose*..... 18
- 17b. *Perichaecia* not radiculose.....20
- 18a. Branching often regularly pinnate; stem leaves and branch leaves distinct; paraphyllia present..... **Thuidiaceae**
- 18b. Branching irregular to pinnate; stem leaves and branch leaves indistinct; paraphyllia absent..... 19
- 19a. Leaves 4-8 ranked, crowded; leaves mostly bordered, minutely serrated at upper half; cells unipapillose **Hookeriaceae**
- 19b. Leaves alternate, simple; leaves not bordered, margin sharply ciliate dentate..... **Fabroniaceae**
- 20a. Main stem and branches radially symmetrical; mostly terrestrial or saxicolous.....21
- 20b. Main stem and branches not radially symmetrical, mostly corticolous.....22
- 21a. Alar cells large, vesicular and coloured..... **Sematophyllaceae**
- 21b. Alar cells small, quadrate to subquadrate, not coloured.....23
- 22a. Leaf cells elongate to rhomboid; alar cells differentiated..... **Entodontaceae**
- 22b. Leaf cells linear; alar cells poorly differentiated..... **Hypnaceae**
- 22c. Leaf cells at middle smooth or with projecting ends..... **Brachytheciaceae**
- 23a. Branches and leaves complanate; leaves mostly assymetrical.....
..... **Neckeraceae**
- 23b. Branches and leaves not complanate; leaves mostly symmetrical.....24
- 24a. Lamina cells papillose or incrassate.....25
- 24b. Lamina cells smooth.....26
- 25a. Leaves lanceolate or ovate lanceolate; cells rounded or 4-6 sided, often papillose, basal cells elongated..... **Orthotrichaceae**
- 25b. Leaves linear from auriculate ovate base; cells rhomboid to linear, papillose..... **Trachypodaceae**
- 25c. Leaves ovate but not auriculate; cells near costa elongate, apex rhomboid, basal cells rounded to transversely elongated..... **Cryphaeaceae**
- 26a. Secondary branches frondose to slenderly elongate; leaves neither recurved nor squarrose..... **Pterobryaceae**

26b. Secondary branches never frondose, slender and elongated; leaves either recurved or squarrose.....**Meteoriaceae**

Order **POLYTRICHALES**

POLYTRICHACEAE Schwaegr.

in Willd., Sp. Pl. ed. 4. 5(2): 1. 1830.

Plants erect, stiff, 2-12 cm or more high, microphyllous on basal part, in three rows, upper leaves larger; leaves lamellose, lingulate to linear-lanceolate, broader, differentiated into a sheathing proximal and a spreading distal part, toothed on back especially at apex; costa single, percurrent, strong; capsule erect, inclined, in some horizontal to pendulous, peristome single rowed, 32-64, rarely 16 or absent, short, triangular teeth attached to a shield-like membrane, covering the mouth of the capsule, calyptra hairy.

Out of the 15 genera distinguished within the family five genera viz., *Lyellia*, *Oligotrichum*, *Atrichum*, *Pogonatum* and *Polytrichum* occur in India. Among these *Pogonatum* is the only genus present in the study area.

Pogonatum P.Beauv.

in Mag., Encycl. 5: 329. 1804.

Plants greenish, erect, varying in size, often tall and showy, 2-10 cm 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; seta long, erect; capsule erect or suberect, grooved when dry, peristome teeth 32, one rowed, rarely 16, calyptra hairy, covers the entire capsule.

Pogonatum microstomum (Schwaegr.) Brid., Bryol. Univ. 2: 745. 1827; Gangulee, Moss. E. India 1(1): 143. 1969. *Polytrichum microstomum* Schwaegr., Sp. Musc. Suppl. 2(2): 10. 1826. *P. minutum* R.Br. & Brid., Bryol. Univ. 2: 127. 1827, *nom. nud. in synon. err. pro. P. microstomum*. *Pogonatum minutum* Brid., Bryol. Univ. 2: 127. 1827 *nom. illeg. P. paucidens* Besch., Rev.

Bryol. 18: 89. 1891. *Polytrichum paucidens* (Besch.) C.Muell., Gen. Musc. Fr. 175. 1900.

Plants dark green, stem simple, 5-8 cm x 0.6-1.5 mm, pale tomentum at the basal rhizomatous region; leaves at lower half small and scaly, upper leaves rigid, 8-12 x 1-2 mm, erect, incurved when dry, apex sharply acute; cells at lower half long, rectangular, becoming shorter, wider and thick walled in lamina; seta up to 3 cm long, usually one, sometimes more than one from each perichaetium; capsule erect to inclined, peristome teeth 32, solid with brown striations, calyptra white with dense hairs, covers entire capsule; spores rounded, 10-14 µm in diameter. (Fig. 14: a-f & Plate 9a-d).

Habitat: Along soil cuttings in grasslands, some times mixed with other mosses in semi-evergreen, evergreen forests and grassland area.

Specimens examined: Periya (940 m) MCN 99614, Chembra hills (1420 m) MCN 120397.

Distribution: The species was collected from the Chembra hills and Periya in the study area and has wide distribution in this area. This is a South-east Asiatic species reported from South India (Kerala: Eravikulam National park; Tamil Nadu: Nilgiri, Palni), North-east India (Darjeeling, Western Himalaya, Meghalaya, Sikkim), Sri Lanka, Bhutan, Taiwan, Nepal, Philippines, Szechwan, Tonkin and Yunnan.

Order DICRANALES

DITRICHACEAE Limpr.

in Rabenh., Kryptogamen-FI. ed. 2. 4: 482. 1887.

Plants small, tufted, with short, erect stems; leaves narrow-lanceolate, margin entire or slightly toothed near apex; costa strong, percurrent or excurrent; cells smooth, linear or subquadrate above, alar cells not differentiated; seta erect; capsule erect or inclined, peristome 16, split to the base, papillose or not papillose.

Three subfamilies are recognised in this family; Ditricheoideae with four genera viz., *Pleuridium*, *Pleuridiella*, *Garckea*, *Ditrichum*; Ceratodontoideae with one genus *Ceratodon* and Distichoideae with two genera *Distichum* and

Ditrichopsis in India. Among these only two genera viz., *Ditrichum* and *Garckea* occur in the study area.

Key to the genera

- 1a. Seta long, slender, 2-5 cm long; capsule erect or slightly inclined.....
.....**Ditrichum**
- 1b. Seta very short, 2-5 mm long; capsule immersed or emergent.....**Garckea**

***Ditrichum* Hamp.**

Flora 50: 181. 1867, *nom. cons.*

Plants tufted, slender, up to 3 cm long; leaves in several rows, lanceolate to subulate, smooth, very rarely papillose; costa broad, strong, usually percurrent or excurrent; cells at basal half rectangular, upper mostly elongate; seta long, slender; capsule erect or slightly inclined, ovoid to cylindrical, annulate, peristome teeth 16, erect, papillose or striate-pitted; spores small, smooth, 10-17 μm diagonally.

Ditrichum darjeelingense Renaud & Cardot, Bull. Soc. Bot. Belgium 41(1): 51. 1905; Gangulee, Moss. E. India 1(2): 199. 1969. *Fissidens darjeelingensis* (Renaud & Cardot) Syndow, Bot. Jahresber. 33: 61. 1906.

Plants yellowish-green, slender, dense caespitose, unbranched, up to 1 cm x 1-1.6 mm; leaves erecto-patent, lanceolate, appressed to stem when dry, up to 1.75 x 0.8 mm, base wide, margin smooth, slightly involute at base, denticulate at tip; costa light brown, percurrent; cells thin walled, at base shorter, irregular, 10-14 x 10 μm , mixed with longer cells, 30-35 x 3-5 μm , upper cells more regularly elongated and narrower, 30-35 x 4-5 μm . (Fig. 14: g-j & Plate 9e&f).

Habitat: On soil cuttings in moist deciduous forests.

Specimen examined: Tholpetty (850 m) *MCN 99664*.

Distribution: This Indian endemic species was known from Darjeeling only. Recently It was collected from the green lands of Madayippara in Kannur district and from Tholpetty of the study area. The present collection is a new record to Peninsular India.



Fig: 14. a-f: *Pogonatum microstomum*; a: habit, b: leaf, c: leaf marginal cells, d: section through leaf, e: capsule, f: spores; g-j: *Ditrichum darjeelingense*; g: habit, h: leaf, i: leaf tip cells, j: leaf basal cells; k-o: *Garckea flexuosa*; k: habit, l: sporophyte enclosed in comal leaves, m: leaf, n: leaf tip cells, o: leaf basal cells; p-s: *Campylopodium khasianum*; p: habit, q&r: leaves, s: spores; t-w: *Campylopus ericoides*; t: habit, u: leaf, v: basal marginal cells, w: upper marginal cells

Garckea C.Muell.

Bot. Zeit Regensburg 3: 865. 1845.

Plants pale-yellow or light-greenish, gregarious, stem erect, very thin, radiculose only at base; leaves lanceolate, more or less long acuminate, erecto-patent, lower leaves distant, smaller than the upper, upper aggregated into a comal tuft, upper leaves up to 2 mm long; costa strong, ending below apex; cells long, rectangular to linear, near the base wide, yellowish; capsule immersed or emergent, with very short seta, 0.5 mm long, ovate-cylindric to oblong-cylindric, calyptra campanulate, covering only the operculum, mostly very rough and crenate, rarely smooth.

Garckea flexuosa (Griff.) Margad. & Nork., J. Bryol. 7: 440. 1973. *Grimmia flexuosa* Griff., Calcutta J. Nat. Hist. 2(8): 492. 1842. *Dicranum phascoides* Hook., Misc. Bot. 1: 39. 1829. *Garckea comosa* Dozy & Molk., Ann. Sci. Nat. Bot. Ser. 3, 2: 304. 1844. *G. phascoides* (Hook.) C.Muell., Bot. Zeitung (Berlin) 3: 865. 1845; Gangulee, Moss. E. India 1(2): 185. 1969. *G. bescherelli* C.Muell. in Besch., Ann. Sci. Nat. Bot. Ser. 6, 9, 340. 1880. *G. hildebrandtii* C.Muell., Flora 69: 510. 1886.

Plants light green, gregarious; stem erect, very thin, radiculose only at the base; leaves narrow, basal portion broader, rectangular, elongated cells, margin smooth, 0.12 mm long, leaves at lower half distant, smaller, 1.3-1.6 mm, closely appressed when dry, upper leaves aggregated to form a coma, much larger with somewhat recurved margin, up to 2 mm long; costa thick, ending below the apex; cells prosenchymatous, long rectangular to linear, 60 x 10 μm , wider and yellow near the base, 40 x 20 μm ; capsule immersed or emergent, with a very short, up to 0.5 mm long, erect seta, peristome teeth 16, inserted below the mouth of the urn, operculum rostrate from a conical base, calyptra campanulate; spores spherical, brownish, 15-18 μm diagonally. (Fig. 14: k-o & Plate 9g&h).

Habitat: On the edges of earth cuttings and on brick walls in semi-shaded areas of homesteads, semi-evergreen, evergreen forests and in grasslands.

Specimens examined: Soojippara (760 m) MCN 80078b, 87083, 87095, Periya

(950 m) *MCN 80114*, Chembra hills (1300 m) *MCN 120243*, Thirunelli, Near Temple (1000 m) *MCN 99627*.

Distribution: It is a common species of the study area. It is widely distributed in South India (Kerala, Tamil Nadu, Karnataka), North-east India (West Bengal, Darjeeling, Khasi hills, Tripura), Andaman Islands, Sri Lanka, Bhutan, Myanmar, Indochina, Japan, Java, Madagascar, Malaysia, Nepal, New Guinea, Philippines, Sumatra, Thailand, Australia, Oceania and Central America.

Note: This species has wide distributional range. Gangulee (1968) described this species as *G. phascoides*. But Margadant & Norkett (1973) synonymised it under *G. flexuosa*. All the Indian species described as *G. phascoides* and *G. comosa* are *G. flexuosa*.

DICRANACEAE Schimp.

Coroll. Bryol. Eur. 11. 1855 [1856].

Plants small to robust, unbranched; leaves lanceolate, often acuminate, tip margin toothed; costa single, percurrent or excurrent; upper cells subquadrate or elongated, basal cells rectangular, alar cells differentiated; seta long; capsule ovoid or cylindrical, peristome teeth 16, forked, reddish, dicranate, operculum conic rostrate.

Six subfamilies are recognised within the family viz., Trematodontoideae with *Trematodon* and *Wilsoniella*, Rhabdoweisioideae with *Rhabdoweisia*, Anisothecioideae with *Anisothecium*, *Aongstroemia* and *Aongstroemiopsis*, Dicranoideae with ten genera, Campylopodioideae with eight genera, Paraleucobryoideae with two genera, *Paraleucobryum* and *Brothera*. Of which *Trematodon* of Trematodontoideae, *Campylopodium* and *Campylopus* of Campylopodioideae and *Leucoloma* of Dicranoideae are represented in the study area.

Key to the genera

- 1a. Plants very small, up to 5 mm long.....2
- 1b. Plants large, 1-5 cm long.....3
- 2a. Seta long, 2-4 cm; apophysis and urn long, cylindrical, prominent.....
.....**Trematodon**
- 2b. Seta short, up to 1 cm; apophysis and urn not prominent...**Campylopodium**

- 3a. Costa faint and narrow; cells along margin hyaline, forming a white border
 **Leucoloma**
- 3b. Costa broad 1/3 or more of leaf base; cells rhomboid to incrassate, not
 bordered **Campylopus**

Campylopodium (C.Muell.) Besch.

Ann. Sci. Nat. Bot. ser. 5, 18: 189. 1873.

Plants yellowish-green, very small; leaves abruptly linear-subulate from a linear sheathing base; costa long, excurrent, narrow from base to apex; alar cells not prominent; seta short, up to 1 cm long, strong, flexuose; capsule cylindrical to globose, apophysis and urn not prominent.

Campylopodium khasianum (Griff.) Paris, Index Bryol. Suppl. 237.1894; Gangulee, Moss. E. India 1(2): 166. 1969. *Dicranum khasianum* Griff., Calcutta J. Nat. Hist. 2: 496. 1842. *Campylopus tenuis* Wils., Kew J. Bot. 9: 296. 1857, nom. nud. *Leptotrichum khasianum* (Griff.) Mitt., Musc. Ind. Orient. 8. 1859. *Dicranella khasiana* (Griff.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1870-71: 372. 1872. *Aongstroemia khasiana* (Griff.) C.Muell., Gen. Musc. Fr. 318. 1900.

Plants greenish, in small loose tufted form; stem erect, 0.5-1.5 cm long, 0.3-0.5 mm wide, branches lateral; leaves narrow-elongated, curled and contorted when dry, lower leaves smaller, 1-3.5 x 0.2 mm, leaf tip pointed, almost hyaline; cells at basal part hyaline, rectangular, 20-25 x 7-9 μm , upper rounded, small, 10-12 μm diagonally, chlorophyllose; costa brown, strong, reach up to top, not very well-defined at base; seta 1 cm long, erect, flexuose; capsule cylindrical to globose, operculum beaked; spores 14-25 μm , yellowish-brown, highly warty papillose. (Fig. 14: p-s).

Habitat: On soil cuttings in semi-evergreen and evergreen forests.

Specimen examined: Soojippara (767 m) MCN & KPR 87078.

Distribution: This is an Indo Sri Lankan species earlier reported from South India (locality unknown), North-east India (Darjeeling, Khasi hills) and Sri Lanka.

Campylopus Brid.

Musc. Recent. Suppl. 4: 71. 1819.

Plants robust, 1-5 cm long; leaves with long, narrow, flexuose points; costa broad occupying 1/3 or more of leaf base; cells at upper half smaller, rhomboidal or incrassate, alar cells conspicuous, coloured; seta arcuate when moist; capsule usually furrowed when mature and dry, peristome dicranate.

Key to the species

- 1a. Leaves lanceolate-subulate from a wider base; margin serrate at tip.....2
- 1b. Leaves elongated with pointed tip; margin smooth to wavy.....**C. pilifer**
- 2a. Alar cells brownish, bulging; branching through proliferation from tips.....
.....**C. flexuosus**
- 2b. Alar cells colourless, inflated; branching from base.....**C. ericoides**

Campylopus ericoides (Griff.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1870-71: 424. 1872; P.Bruehl, Rec. Bot. Surv. India 13(1): 23. 1931; Gangulee, Moss. E. India 1(2): 296. 1969. *Dicranum ericoides* Griff., Calcutta J. Nat. Hist. 2: 499. 1842.

Plants yellowish-brown, caespitose, branching from base, stem reddish without a central strand, base black, up to 2 cm long; leaves narrow elongated, 4-6 x 0.4-0.6 mm, erecto-patent, margin smooth, extreme tip serrated; cells at margin 22-25 x 7-11 μ m, quadrate, upper cells 22-26 x 10-12 μ m, rhomboid, narrower, basal laminar cells up to 42-45 x 15-17 μ m, widest at alar region, alar cells inflated, colourless and distinct, rhizoids growing from leaf base; costa broad with elongated cells, light yellowish-brown, covering less than 1/3 of leaf breadth. (Fig. 14: t-w & Plate 9k).

Habitat: On rocky patches along with *Bryum* sp. and also on soil cuttings in grassland.

Specimen examined: Chembra hills (1420 m) MCN 120317.

Distribution: It is a South-east Asiatic species distributed in South India (Kerala: Chinnar WLS, Tamil Nadu: Western Ghats of Thirunelveli, Agasthyamala), North-east India (Darjeeling, Khasi hills, Manipur, Meghalaya, West Bengal), Sri Lanka, Nepal, Myanmar, Thailand, Vietnam, Java and Philippines.

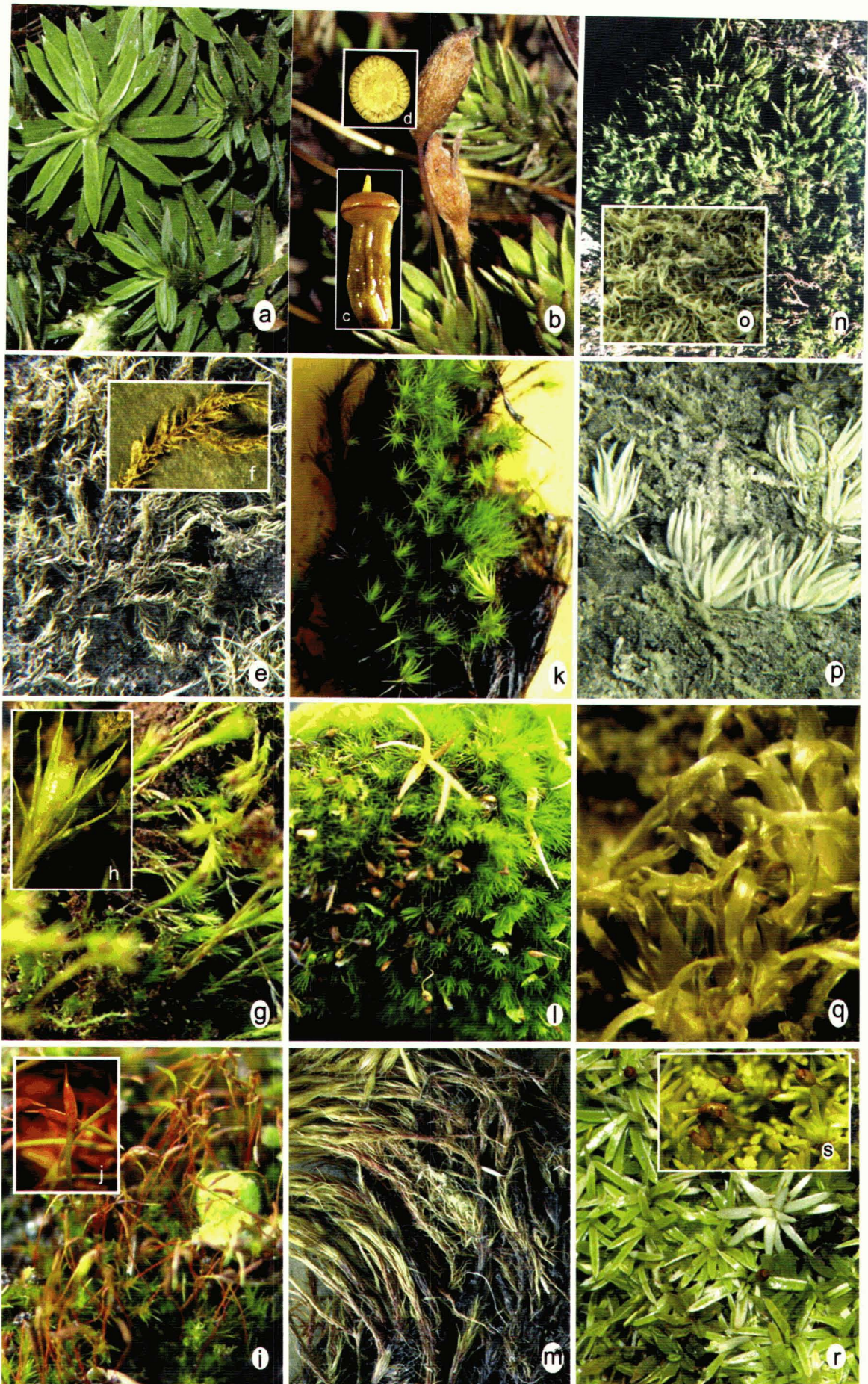


Plate 9. a-d: *Pogonatum microstomum* a: habit, b: habit with sporophyte, c: capsule, d: peristome teeth enlarged; e: *Ditrichum darjeelingense*, f: a portion enlarged, g: *Garckea flexuosa*, h: sporophyte, i: *Trematodon longicollis*, j: sporophyte, k: *Campylopus ericoides*, l: *Campylopus flexuosus*, m: *Campylopus pilifer*, n: *Leucoloma amoene-virens*, o: a portion enlarged, p: *Leucobryum juniperoideum*, q: *Leucophanes octoblepharoides* r: *Octoblepharum albidum*, s: plant with sporophyte

Campylopus flexuosus (Hedw.) Brid., Mant. Musc. 4: 71. 1819; Gangulee, Moss. E. India 1(2): 292. 1969. *Dicranum flexuosum* Hedw., Sp. Musc. 145. 1801. *Bryum flexuosum* (Hedw.) L. ex With., Syst. Arr. Brit. Pl. ed. 4, 3: 817. 1801. *B. immersum* Dicks., Pl. Crypt. Britt. fasc. 4: 15. 1801. *Weisia immersa* (Dicks.) Brid., Sp. Musc. 1: 124. 1806. *Dicranum palustre* La Pyl. in Brid., Bryol. Univ. 1: 814. 1827, *hom. illeg.* *Thysanomitrium flexuosum* (Hedw.) Arnott., Mem. Soc. Linn. Paris 5: 262. 1827. *Campylopus arduennae* Lib., Pl. Crypt. Arduenn. 106. 1831. *C. tallulensis* Sull. & Lesq., Musc. Bor. Am. 17. 1865. *C. paradoxus* Wils. in Hardy, Berwickshire Nat. Hist. Cl. 48. 1868. *Dicranum subleucogaster* C.Muell., Bull. Torrey Bot. Cl. 5: 49. 1874. *Campylopus subleucogaster* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-78: 381. 1880. *C. subcinereus* Stirt., Ann. Scot. Nat. Hist. 8: 105. 1899. *C. roellii* Renaud & Cardot, Bull. Soc. Bot. Belgium 38: 9. 1900. *C. melaphanus* Stirt., Ann. Scot. Nat. Hist. 12: 110. 1903. *C. rubiginosus* Stirt., Ann. Scot. Nat. Hist. 15: 1. 1906. *C. crenulatus* Stirt., Trans. Bot. Soc. Edinburgh 26: 244. 1914.

Plants dark green to olive green, shiny, branching through proliferation from tips, 1-3 cm long, tomentose; leaves lanceolate-subulate from a wider base, 4-6 x 0.6-0.75 mm, erect to erecto-patent when moist, flexuose when dry, crowded in comal tufts, tip serrated; costa occurring half the leaf base, strong; cells rectangular at base, 25-28 x 10-12 μ m, yellowish-brown, upper shortly rectangular, 15-18 x 6-8 μ m, shorter towards margin, alar cells brownish, bulging, large, 30-35 x 22-28 μ m; sporophytes on comal tufts; seta inflexed, reddish-brown, 5-8 mm long; capsule reddish-brown. (Plate 9I).

Habitat: On rocks and soil in grasslands.

Specimens examined: Chembra hills (1340 m) MCN 120285, MCN 120288.

Distribution: This is a cosmopolitan species mostly occurring in high altitude areas. It has been reported earlier from South India (Kerala: Eravikulam National Park), North India (Western Himalaya), China, East Nepal, Algeria, Abyssinia, Madagascar, New Zealand, Oceania and Siberia.

Campylopus pilifer Brid., Musc. Rec. Suppl. 4: 72. 1819 [1818]. *Campylopus longipilus* Brid., Bryologia Universa 1: 477. 1826. *Campylopus atrovirens* De

Not., Syll. Musc. Italia 221. 1838. *Campylopus falcatus* Fergusson, Index Bryol. editio secunda 1: 307. 1904. *Campylopus yakushimensis* Sakurai, Bot. Mag. 47: 332. 1933.

Plants blackish to yellowish-green, prostrate, up to 5 cm long, 5-8 mm wide; stem brownish, smooth; leaves crowded at apex, leaves elongated, 3-5 x 0.07 mm, tip pointed, margin smooth to wavy; costa wide at base, 600 μm , at tip 80-100 μm wide; cells smooth, at apex elongate to quadrate, 5 x 4 μm , middle cells rhomboid, facing towards margin, 5-7 x 10 μm , basal cells quadrate, 25-30 x 8-10 μm , alar cells orange coloured at extreme base. (Fig. 15: a-c & Plate 9m).

Habitat: On soil cuttings in grasslands.

Specimens examined: Chembra hills (1400-1580 m) *MCN 99601*, *MCN 120314*.

Distribution: In the present study area this species was recorded from the grasslands of Chembra hills only. It was earlier recorded from Ireland, Mexico, Guatemala, Costa Rica, Nicaragua and South Africa. The present collection is a new record to India.

Leucoloma Brid.

Bryol. Univ. 2: 218. 1827, *nom. cons.*

Plants whitish-green to yellowish, slender, soft; stem sparsely radiculose below; leaves crisped when dry, erecto-patent when moist, lanceolate from a ovate base; costa rather faint and narrow, excurrent, alar cells differentiated, mostly coloured; cells very long near margin, narrow, hyaline, forming a broad whitish border, green cells small, mostly round or oblong, often densely papillose; seta erect, mostly short; capsule erect, symmetrical, mostly cylindrical, peristome teeth more or less deeply two-pronged, operculum long, calyptra conical, campanulate.

Leucoloma amoene-virens Mitt., Musc. Ind. Orient. 13. 1859; P.Bruehl, Rec. Bot. Surv. India 13(1): 28. 1931; Gangulee, Moss. E. India 1(2): 409. 1969;

Wadhwa, M.V.M. Patrika 6: 75. 1971; R.S.Chopra, Tax. Indian Mosses 86. 1975. *Dicranum amoene-virens* (Mitt.) C.Muell., Linnaea 36: 11. 1869.

Plant yellowish-green, caespitose, 2-3 cm long, densely covered with falcate leaves; leaves lanceolate, up to 2.5 x 0.3-0.5 mm, slowly narrowing from a wider elliptical sheathing base, tip narrow pointed, extreme tip serrated, leaves with a clear transparent border, $\pm 20 \times 1-3 \mu\text{m}$; costa narrow, brown to brownish-yellow, $\pm 45 \mu\text{m}$ at base, reach up to the tip; cells linear-rhomboid, whitish, towards the costa shorter, rounded-quadrangular, middle cells 8-10 x 3.5-5 μm , alar cells orange colored, 30-32 x 23-25 μm , near the costa yellowish. (Fig. 15: d-h & Plate 9n&o).

Habitat: Base of tree trunks and on logs in evergreen and shola forests.

Specimens examined: Thirunelli RF (880-1300 m) *MCN 84613*, *MCN 99619*, Chembra hills (1770 m) *MCN 120281*.

Distribution: It is an Indo-Sri Lankan species distributed in South India (Tamil Nadu: Madras, Thirunelveli, Agasthyamala, Kanyakumari, Upper Kodayar), East India (Khasi hills) and Sri Lanka. The present collection is a new record to Kerala.

Trematodon Michx.

Flora Bor. Amer. 2: 289. 1803.

Plants very small, up to 5 mm long, growing in patches; leaves narrow lanceolate from ovate-concave base; seta long, 2-4 cm, apophysis and urn long, cylindrical, apophysis prominent, spongy, peristome teeth 16, dicranate, flat, lanceolate, sometimes absent or rudimentary.

Trematodon longicollis Michx., Flora Bor. Amer. 2: 289. 1803. *Dicranum longicolle* (Michx.) Brid., Sp. Musc. 1: 223. 1806. *Trematodon squarrosus* C.Muell., Bot. Zeitung. Berlin 15: 381. 1857. *T. ceylonensis* C.Muell., Bot. Zeitung. Berlin 22: 350. 1864. *T. longicollis* Wils. & Mitt. in C.Muell., Bot. Zeitung. Berlin 22: 350. 1864, *nom. nud. in synonym.* *T. solmsii* Bolle, Verh. Bot. Ver. Brandenburg 7: 30. 1865. *T. cubensis* C.Muell., Hedwigia 37: 228. 1898. *T. drepanellus* Besch., J. de Bot. 12: 283. 1898. *T. atrovirens* Broth., Oefv. Finsk.

Vet. Soc. Foern. 62: 1. 1921. *T. drepanellus* Besch. var. *flaccidisetus* (Card.)
Dixon, Hong Kong Nat. Suppl. 2: 2. 1933.

Plants yellowish-green, 2 to 5 mm high; leaves erect spreading, suddenly tapering from a broad, ovate to rectangular sheathing base to a long narrow apex, margin slightly toothed at apex, entire below, 2-4 mm long; costa single, reach up to top, not filling below; cells at lamina rectangular, 11-24 x 5-8 μm , lax below, 20-54 x 11-14 μm ; seta pale yellow, erect, twisted when dry, 2-4 cm long; capsule yellowish-brown, peristome teeth reddish-brown, operculum conic rostrate, urn ovate-cylindrical, tapering into a long spongy cylindrical apophysis, calyptra cucullate; spores rounded, opaque, yellowish-brown, warty papillose, 15-22 μm in diameter. (Fig. 15: i-n & Plate 9i&j).

Habitat: On soil cuttings in evergreen forests.

Specimen examined: Hairpin area (550m) MCN 99663.

Distribution: It is a cosmopolitan species distributed in South India (Kerala: Chinnar WLS, Tamil nadu: Palni hills, Karnataka: Coorg), North-east India (Darjeeling, Bengal, Assam, Manipur, West Bengal, Western Himalaya), Sri Lanka, China, Japan, Ryukyu, Korea, Myanmar, Philippines, New Guinea, Taiwan, Siberia, South Africa, Europe and New Zealand.

LEUCOBRYACEAE Schimp.

Coroll. Bryol. Eur. 19. 1855 [1856].

Plants small to robust, whitish-green, often branched; leaves multilayered, with very broad costa, in which a median row of small chlorophyllose cells flanked on both sides by one or more layers of large hyaline leucocysts cells, margin entire, alar cells absent; seta erect; capsule erect or inclined, peristome teeth 8 or 16, simple, operculum rostrate, calyptra cucullate.

Four subfamilies are recognised within this family. Leucobryoideae with two genera viz., *Leucobryum* and *Ochrobryum*, Leucophanoideae with one genus viz., *Leucophanes*, Octoblepharoideae with *Octoblepharum* and Arthrocornioideae with *Exodictyon* are represented in India. Of these *Leucobryum*, *Leucophanes* and *Octoblepharum* are represented in the study area.

Key to the genera

- 1a. Costa broad and thin, smooth or toothed at abaxial near the apex;
peristome 16 teathed.....**Leucophanes**
- 1b. Costa broad and thick, not toothed; peristome 8 or 16 teathed.....2
- 2a. Limb of leaves flat or plano-convex on upper surface; base of leaves often
obovate concave base; peristome 8 teathed..**Octoblepharum**
- 2b. Limb of leaves not flat or plano-convex; base of leaves oblong; peristome
16 teathed.....**Leucobryum**

Leucobryum Hamp.

Linnaea 13: 42. 1839.

Plants whitish or pale green, in lax or dense cushions, brittle when dry; leaves long, spongy, mostly appressed when dry, straight or falcate when moist, lanceolate or subulate from an oblong base; costa flattened, very broad, occupying the whole width of the leaf except for a narrow margin of hyaline cells, margin entire; seta erect, elongate; peristome teeth 16, dicranoid; operculum rostrate, covering the urn.

Leucobryum juniperoideum (Brid.) C.Muell., Linnaea 18: 689. 1845; Gangulee, Moss. E. India 1(2): 420. 1969; A.E.D.Daniels & P.Daniel, Indian J. For. 26: 366. 2003. *Dicranum juniperoideum* Brid., Bryol. Univ. 1: 409. 1826.

Plant whitish-green, silky, 5-8 mm long, branches arise from the main stem and from basal portions; leaf varies in size, 1.2-2.2 mm long, spreading, flexuose, not much changed when dry, gradually narrowed to a tubular acute tip from a wider concave base; costa wide, uniform from base to apex, from base to apex one layer of chlorocyst cells, in between two layers of leucocyst cells; lamina cells hyaline, rectangular-elongated, 25-30 x 8-11 μm , margin entire, alar cells small. (Fig. 15: o-r & Plate 9p).

Habitat: Corticolous or on logs in moist deciduous, semi-evergreen, evergreen and shola forests.

Specimens examined: Ponkuzhi (900 m) *MCN 84371, 84381*, Muthanga range, Mankolli (893 m) *MCN 84520, 84521b*, Chembra hills (1372 m) *MCN 120273a*, Thirunelli RF (1220 m) *MCN 99621*.

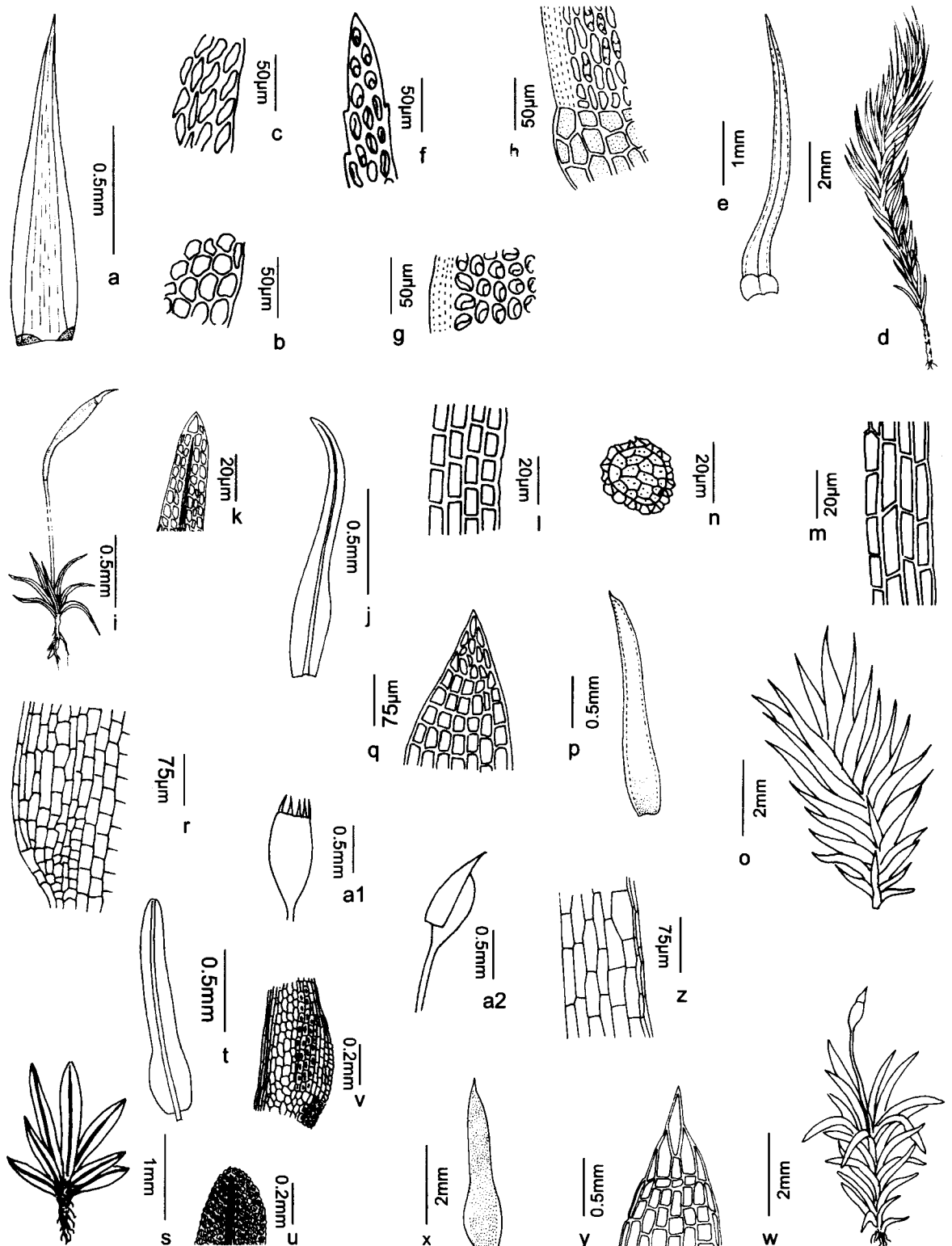


Fig. 15. a-c: *Campylopus pilifer*; a: leaf, b: basal marginal cells, c: upper marginal cells; d-h: *Leucoloma amoene-virens*; d: habit, e: leaf, f: leaf tip cells, g: middle cells, h: basal cells; i-n: *Trematodon longicollis*; i: habit, j: leaf, k: leaf tip cells, l: middle marginal cells, m: basal marginal cells, n: spores; o-r: *Leucobryum juniperoideum*; o: habit, p: leaf, q: leaf tip cells, r: leaf basal cells; s-v: *Leucophanes octoblepharoides*; s: habit, t: leaf, u: leaf tip cells, v: leaf basal cells; w-a2: *Octoblepharum albidum*; w: habit, x: leaf, y: leaf tip cells, z: basal cells, a1: capsule, a2: calyptra

Distribution: It is a common species in the study area. It was recorded earlier from South India (Tamil Nadu: Thirunelveli, Kalakkad), East India (Khasi hills) and Japan. The present collection is a new record to Kerala.

Leucophanes Besch.

Brid., Bryol. Univ. 1: 763. 1826.

Plants pale green or whitish, slender; leaves rather crowded, erect or widely spreading, narrowly lanceolate; costa broad and thin, smooth or toothed abaxially near the apex, bordered all around with a narrow band of very elongated cells with thickened, yellowish walls; cells at lamina few, usually confined to the marginal part of the leaf base; seta very slender terminal, but soon become lateral by the growth of the stem; capsule erect, cylindrical; peristome teeth 16, entire, papillose, calyptra cucullate.

Leucophanes octoblepharoides Brid., Bryol. Univ. 1: 763. 1826; Gangulee, Moss. E. India 1(2): 436. 1969. *Syrhopodon octoblepharis* Nees & Schwaegr., Sp. Musc. Suppl. 4: 311. 1842. *Octoblepharum octoblepharoides* (Brid.) Mitt., Rep. Sc. Res. Voyage Challenges 1(4): 259. 1885.

Plants pale green to whitish, glossy, densely covered with leaves, 2-4 mm long, erect to drooping, usually simple, without central strand; leaves rather crowded, erect or widely spreading, narrowly lanceolate, slightly concave at base, flat above, 1-3 mm long; costa broad at apex, covers whole surface, near base narrower, slightly toothed abaxially near the apex, stereidal cells towards the lower side, leucocyst occurs on the lower base of the leaves in 3 or more layers; lamina cells confined to the marginal part of the leaf base, hyaline, short rectangular, 20-25 μm wide, leaves bordered all around with 2-3 rows of very long narrow yellowish cells; sporophyte not common. (Fig. 15: s-v & Plate 9q).

Habitat: On logs along with *Lejeunea helenae* in homestead.

Specimen examined: Kalpetta (400 m) MCN 99665a.

Distribution: It is an Indo-Pacific species distributed in South India (Kerala), North-east India (Assam, Bengal), Sri Lanka, Bangladesh, Myanmar, Java, New Guinea, Nepal, Philippines, Sumatra, Tahiti, Admiral Island and Pacific Islands.

Octoblepharum Hedw.

Sp. Musc. 50. 1801.

Plants tufted, glossy, whitish-green, tinged with brown; leaves crowded, rigid, often fragile, lingulate, form an oblong or narrowly obovate, concave base, limb of leaves flat or plano-convex at upper half; costa broad and thick, occupying half of the leaf base and filling the upper part; central and basal laminal cells irregularly rectangular; seta erect, less than 1 cm long; capsule erect, ovoid, symmetrical; peristome 8 teathed, undivided, broadly lanceolate, perforated or teeth 16 in 8 pairs; calyptra cucullate.

Octoblepharum albidum Hedw., Sp. Musc. 50. 1801; Gangulee, Moss. E. India 1(2): 441. 1969; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986; M.C.Nair & Madhus., J. Econ. Taxon. Bot. 25: 573. 2001. *Bryum albidum* L., Sp. Pl. 1853. 1753, *nom. inval.* *B. albidum* (Hedw.) P.Beauv., Prodr. 45. 1805. *Octoblepharum minus* Hamp., Vid. Medd. Naturh. For. Kjobenh, ser. 4, 1: 83. 1879. *O. cuspidatum* C.Muell., Gen. Musc. Fr. 88. 1900. *O. martinicense* Mitt. in Cardot, Mem. Soc. Sc. Nat. Cherbourg 32: 41. 1901, *nom. nud.* *O. pallidum* Besch., *Ibid.* 32: 41. 1901, *nom. nud.* *O. ekmanii* Ther., Mem. Soc. Cubana Hist. Nat. 13: 220. 1939.

Plants whitish-green, up to 3 mm long; stem without central strand; leaves crowded, erect spreading on a very short stem; leaves lingulate, form an oblong or narrowly obovate, concave base; same in dry and normal condition, 3-5 mm long, sheathing base broad, apiculate at tip, minutely serrate, leaf base flanked by 5-8 rows of hyaline linear cells, outer two rows with narrow linear cells; seta straight, 5 mm long; capsule erect, ovoid, peristome 8 teathed; spores finely papillose, light brown, 18-20 μm in diameter. (Fig. 15: w-a2 & Plate 9r&s).

Habitat: It is a widely distributed species seen in a variety of habitats such as on exposed roots, branches, logs, on soil and rocks in scattered colonies, from lower to medium altitude (up to 900 m) mostly in all type of vegetations.

Specimens examined: Kurichiad range, Dhottakulachi (839 m) *MCN 84552*, Muthanga range, Mankolli (893 m) *MCN 84521a*, Mananthavady (700 m) *MCN*

PVM & KPR 80113a.

Distribution: It is a common species found in low altitude to higher altitudes and it has earlier reported from South India (Kerala, Karnataka, Tamil Nadu) North-east India (Kumaon, Sikkim), Sri Lanka, Java, New Guinea, China, Bolivia, Columbia, Indo-Malayan region, Madagascar, Myanmar, Nepal, Peru, Philippines and Venezuela.

Note: As the genus name suggests, the peristome of this species have 8 short blunt teeth. The species name refers to colour of this moss, which is waxy, greenish-white. It is fairly common locally.

Order FISSIDENTALES

FISSIDENTACEAE Schimp.

Coroll. Bryol. Eur. 20. 1855 [1856].

Plants yellowish-green; leaves distichous, vertically placed, equitant with a characteristic sheathing or vaginent lamina, complanate; capsule lateral or terminal, calyptra conical.

The order Fissidentales comprises a single family Fissidentaceae, members of which are distinguished easily by the peculiar duplicate nature of the sheathing lamina. There are four genera within the family of which the predominantly tropical genus, *Fissidens* only is known from India and which extends to the present study area.

Fissidens Hedw.

Sp. Musc. 152. 1801.

Plants yellowish-green, small to medium sized, simple or dimorphic, vertically placed; leaves distichous, differentiated into vaginant laminae (sheath like part), a dorsal (behind the costa) and a ventral lamina (above the vaginant lamina); capsule terminal or lateral, erect to inclined, peristome single; spores spherical, smooth to lightly papillose.

Key to the species

- 1a. Costa thin, ends far below tip; marginal cells of semilimbium 1-3 layers of elongated yellowish cells.....**F. flaccidus**

- 1b. Costa thin or thick, reach up to tip; marginal cells not demarcated as elongated hyaline cells 3
- 3a. Leaves narrow, up to 2 x 0.25 mm; costa excurrent in a minute apiculus.... 4
- 3b. Leaves broad; up to 2 x 0.4 mm; costa excurrent or percurrent..... 5
- 4a. Leaf cells papillose, sheathing lamina unequal; margin bordered by 1-2 layers of elongated hyaline cells, indistinct, near sheathing lamina 2-4 layers **F. subbryoides**
- 4b. Leaf cells not papillose, sheathing lamina equal; marginal cells not differentiated as above..... **F. zolligeri**
- 5a. Costa percurrent; dorsal lamina narrow at base..... 6
- 5b. Costa excurrent or percurrent; dorsal lamina rounded to wedge shaped at base..... (**F. crispulus**) 7
- 6a. Plants 5 mm or more long with more than 10 pairs of leaves; sheathing lamina usually equal, semilimbium present or not..... 8
- 6b. Plants very small, 1-6 mm long with up to 8 pairs of leaves; sheathing lamina equal or slightly unequal; semilimbium absent..... 10
- 7a. Central strand of stem not prominent; costa percurrent or ending a few cells below leaf apex; sheathing lamina equal, often terminating on the nerve..... **F. crispulus** var. **crispulus**
- 7b. Central strand of stem prominent; costa shortly excurrent; sheathing lamina unequal, not terminating on the nerve..... **F. crispulus** var. **robinsonii**
- 8a. Semilimbium absent..... **F. crenulatus**
- 8b. Semilimbium marginal or incomplete..... 9
- 9a. Semilimbium incomplete, 2-3 layers of simple, smooth cells bordering only the sheathing lamina..... **F. asperisetus**
- 9b. Semilimbium marginal, partially bordered by subrectangular elongated cells and at the margin of sheathing lamina with 2-3 layers of elongated cells..... **F. ceylonensis**
- 10a. Leaf margin crenulated by projection of cells; each cell show a single conical papillae on top..... **F. virens**
- 10b. Leaf margin wavy; conical papillae absent..... **Fissidens** sp.

Fissidens asperisetus Sande-Lac., *Naturk. Verh. Holl. Maatsch. Wetensch. Haarlem* 11: 2. 1872; P.Bruehl, *Rec. Bot. Surv. India* 13(1): 17. 1931; Gangulee, *Moss. E. India* 1(2): 507. 1969. *F. hollianus* Dozy & Molk. var. *asperisetus* (Sande-Lac.) M.Fleisch., *Die Musci Fl. Buitenz.* 1: 34. 1901. *F. asperisetus* var. *andamanensis* Gangulee, *Moss. E. India* 1(2): 507. 1971.

Plants yellowish-green, 5-8 x 2 mm, with 13-18 pairs of leaves; leaves curled and contorted when dry, oblong-lingulate, broader at base, tip symmetrical; semilimbium 2 or 3 layers, simple, smooth, bordering the sheathing lamina, rest of the leaf bordered by corrugated margin with sharp projections; costa brown, slightly excurrent; cells mamillate with surface projecting out conically; sheathing lamina unequal, cells on sheathing lamina base elongated; pericheatal leaves narrower, with 3-5 layers of semilimbium; seta reddish-orange, 4-6 mm long; capsule yellowish-brown; spores rounded, 7.5-12.5 µm in diameter. (Fig. 16: a-e & Plate 10a).

Habitat: On soil cuttings and also on concrete walls in homestead areas, semi-evergreen and evergreen forests.

Specimens examined: Way to Chandanathode from Periya (750 m) MCN 80103, 80104, Chandanathode (900-950 m) MCN & PVM 80073, 80077, Thirunelli RF (880 m), MCN 84609.

Distribution: It is a common species in Chandanathode and Thirunelli areas of Wayanad. This is a south-east Asiatic species earlier reported from South India (Tamil Nadu, Kerala), Andaman Islands, Sri Lanka, Celebes, Java and Philippines.

Fissidens ceylonensis Dozy & Molk., *Ann. Sci. Nat. Bot. ser.* 3(2): 304. 1844; P.Bruehl, *Rec. Bot. Surv. India* 13(1): 17. 1931; Wadhwa, M.V.K. *Patrika* 4: 90. 1969; Gangulee, *Moss. E. India* 1(2): 511. 1969; R.S.Chopra & Kumar, *Moss. W. Himalayas* 48. 1981; Mohamed *et al.*, *J. Bombay Nat. Hist. Soc.* 83: 689. 1986; Ellis, *Bull. Br. Mus. Nat. Hist. (Bot.)* 22: 153. 1992; M.C.Nair & Madhus., *J. Econ. Taxon. Bot.* 25: 571. 2001. *F. perpusillus* Wilson ex Mitt., *Musc. Ind. Orient.* 141. 1859; P.Bruehl, *Rec. Bot. Surv. India* 13(1): 17. 1931. *F. bicolor*

Thwaites & Mitt., Bot. J. Linn. Soc. 13: 322. 1873. *F. pennatulus* Thwaites & Mitt., Bot. J. Linn. Soc. 13: 325. 1873. *F. ceylonensis* Dozy & Molk. var. *jhargramii* Gangulee, Bull. Bot. Soc. Beng. 11: 72. 1937.

Plants yellowish-green, up to 5 mm long, with 12-16 pairs of leaves; leaves oblong-lanceolate, folded and curled, appressed to stem when dry, erecto-patent when moist, 0.8 x 0.25 mm, leaf tip variable from acute to widely acute, leaf margin shows constriction where sheathing lamina ends, sheathing lamina equal, dorsal lamina decurrent near base; costa yellowish-green, strongly excurrent; sheathing lamina nearly 2/3 of total leaf length, margin partially bordered, sub rectangular cells with marginal papillate cells or oblique end walls except at the base where sheathing lamina is seen, where 2-3 rows of elongate simple marginal cells; seta small, brownish to red; capsule erect, globular, elongated with orange calyptra; spores 14-18 μm , globose. (Fig. 16: f-i & Plate 10b,c&d).

Habitat: This species is common in laterite soil with sand or clay, rocks and stones, brick walls and on exposed roots of trees mostly on coconut trees in moist-deciduous forests and in homestead areas. It is a common species of Termite mounts.

Specimens examined: WWLS, Kurichiad range (880 m) *MCN 84558b*, Chandanathode (900 m) *MCN 80105*.

Distribution: It is a widely distributed species common in South India (Kerala, Tamil Nadu), North-east India (Darjeeling, Himalaya, Sikkim, Uttar Pradesh, West Bengal), Sri Lanka, Borneo, Iran, Java, Malaysia, Moluccas, Nepal, New Zealand, Philippines, Sumatra, Thailand, Vietnam and Yunnan.

Fissidens crenulatus Mitt., Musc. Ind. Orient. 140. 1859; Sedgwick, J. Bombay Nat. Hist. Soc. 19: 940. 1910; P.Bruehl, Rec. Bot. Surv. India 13(1): 17. 1931. *F. titalyanus* C.Muell. Linnaea 37: 165. 1872. *F. crenulatus* var. *crenulatus* Gangulee, Moss. E. India 1(2): 504. 1969.

Plants yellowish-green, small, up to 5 x 1.5 mm, with 12-15 pairs of leaves; leaves slightly curled when dry, oblong-lanceolate to oblong-lingulate, up to 1.3 x 0.3 mm, dorsal lamina narrowing down to base, sheathing lamina

open, usually equal in mature leaves, leaf broadest at base, tip acute, apical margin lightly serrulate by projection of cell edges; costa light brown, excurrent; cells irregularly rounded hexagonal, single, conical mamillate papillae, up to 6 µm wide at apex, slightly bigger near sheathing lamina base; perichaetial leaves narrower and slightly longer, 1.4 x 0.28 mm; seta orange-brown, up to 5 mm long; capsule brown, ovoid, erect; spores rounded, light brown, smooth, 8.5-11.5 µm in diameter. (Fig. 16: j-n & Plate 10e).

Habitat: On soil cuttings and on Termite mounts in baboo breaks in moist deciduous forest.

Specimens examined: Sulthanbathery, 1982 plantation (870 m) MCN 84350, 84351.

Distribution: An Indo-Pacific species distributed in South India (Tamil Nadu: Western Ghats of Kanyakumari), North-east India (Orissa), Myanmar and East Nepal. The present collection is a new record to Kerala.

Fissidens crispulus Brid., Musc. Rec. Suppl. 4: 187. 1819 [1818]. var **crispulus**: Musc. Rec. suppl. 4: 187. 1819. *Fissidens bryoides* var. *crispulus* (Brid.) Wijk & Margad., *Taxon* 8: 106. 1959. *F. tamarindifolius* (Turn.) Brid. var. *crispulus* (Brid.) Brid., *Bryol. Univ.* 2: 686. 1827. *F. zippelianus* Dozy & Molk., *Zoll. Syst. Verz.* 29. 1854. *F. incrassatus* Sull. & Lesq., *Proc. Amer. Acad. Arts Sci.* 4: 276. 1859. *F. auriculatus* C. Muell., *Linnaea* 37: 166. 1872. *F. sakourae* Paris & Broth., *Bull. Herb. Boissier*, ser. 2, 2: 921. 1902. *F. sylvaticus* (auct. non Griff.) Dix., *Hong Kong Nat. Suppl.* 2: 8. 1933. *F. pepuensis* P.C. Chen, *Sunyatsenia* 6(2): 189, 31. 1941. *F. sylvaticus* var. *zippelianus* (Dozy & Molk.) Gangulee, *Moss. E. India* 2: 537. 1971.

Plants yellowish-green, small, gregarious, 0.6-1.3 cm x 2 mm, with 10-16 pairs of leaves on stout orange-brown stem, central strand not prominent; leaves lanceolate to narrowly lanceolate, tip curled when dry, loosely arranged, apical part symmetrical, dorsal lamina rounded to wedge shaped; margins finely serrulate to crenulate above, entire below, sheathing lamina equal, often terminating on the nerve, leaf margin shows a bend where it leaves the sheathing lamina; costa orange-brown, percurrent or ending a few cells below

leaf apex; cells of apical and dorsal lamina rounded-quadrate to rounded hexagonal, 7-11 μm long, mamilllose, cells of sheathing lamina similar to those of apical and dorsal lamina, but larger and less mamilllose, with thicker walls towards the base; seta 5 mm long, erect, terminal; capcule erect-horizontal, brownish; spores rounded, 4-8 μm in diameter. (Fig. 16: o-u & Plate 10f).

Habitat: This species is very common and is frequently occur as dense mats on soil, rocks and bases of tree trunks in semi-evergreen forests.

Specimens examined: Chandanathode (920m) *MCN 80106*; WWLS, Kurichiad range, (860m) *MCN 80110, 84563*; Soojippara (760 m) *MCN & KPR 87087*.

Distribution: It is common in the study area. This species was earlier reported from North-east India (locality unknown), China, Malaysia, Madagascar, Reunion and Cameroon. The present collection is a new record to Peninsular India.

Fissidens crispulus Brid. var. **robinsonii** (Broth.) B.C.Tan & Choy, J. Bryol. 24: 47. 2002. *F. robinsonii* Broth., Philipp. J. Sci. 13: 204. 1918; Gangulee, Moss. E. India 1(2): 534. 1969.

Plants yellowish-green, brownish when old, minute, up to 2 mm long, with 5-7 pairs of leaves, central strand prominent; leaves narrowly lanceolate in the upper part, up to 1.5 mm, lowermost leaves much smaller, narrow-elongate, base of dorsal laminae rounded to wedge shaped, margins finely serrulate, sheathing lamina unequal, not terminating on the nerve; costa shortly excurrent, strong; cells of apical and dorsal laminae rounded-quadrate to rounded-hexagonal, 7-10.5 μm x 5-8 μm , thick walled, mamilllose, walls clear, cells of extreme base of sheathing lamina larger, 15-20 x 10-14 μm , thick walled. (Fig. 16: v-y & Plate 10g).

Habitat: On soil cuttings in plantations and moist deciduous forests.

Specimens examined: WWLS, 1978 plantation (883m) *MCN 84348*.

Distribution: It was earlier reported from North India (Himalaya), China and Philippines. The present collection is a new record to Peninsular India.

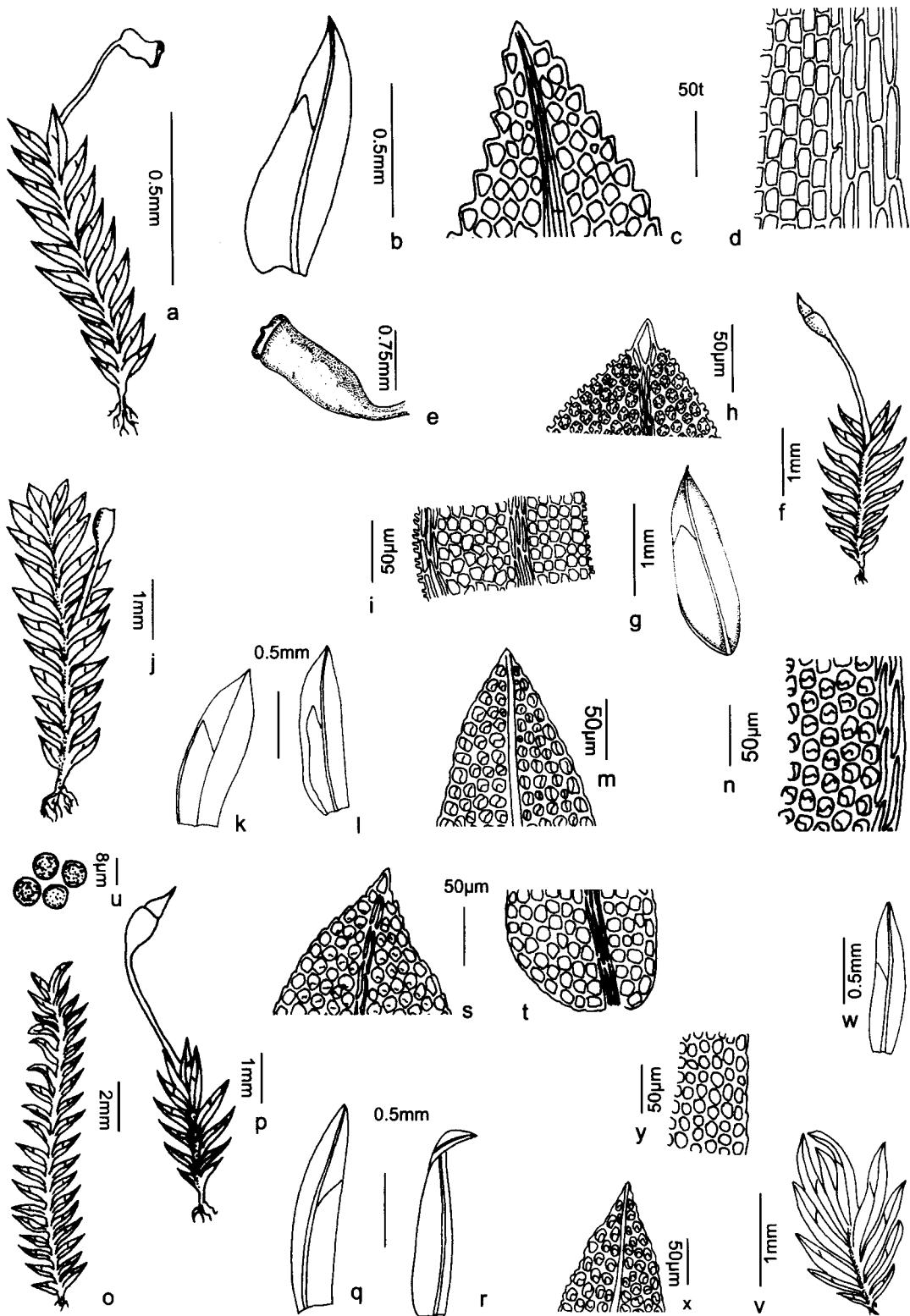


Fig. 16. a-e: *Fissidens asperisetus*; a: habit, b: leaf, c: leaf tip cells, d: leaf basal cells, e: capsule; f-i: *Fissidens ceylonensis*; f: habit, g: leaf, h: leaf tip cells, i: leaf basal cells; j-n: *Fissidens crenulatus*; j: habit, k&l: leaves, m: upper leaf cells, n: leaf basal cells; o-u: *Fissidens crispulus* var. *crispulus*; o&p: habit, q&r: leaves, s: leaf tip cells, t: leaf basal cells, u: spores; v-y: *Fissidens crispulus* var. *robinsonii*; v: habit, w: leaf, x: upper leaf cells, y: basal leaf cells

Fissidens flaccidus Mitt., Trans. Linn. Soc. Lond. 23: 56. 1860. *Fissidens maceratus* Mitt., Trans. Proc. Roy. Soc. Victoria 19: 91. 1882. *F. palmatulus* Besch., Rev. Bryol. 18: 50. 1891. *F. schwackeanus* Broth., Hedwigia 34: 119. 1895. *F. splachnobryoides* Broth., Fl. Deutsch. Schutz. Suedsee 81. 1900; Gangulee, Moss. E. India 1(2): 462. 1968; R.S.Chopra & Kumar, Moss. W. Himalayas 46. 1981; Sedgwick, J. Bombay Nat. Hist. Soc. 19: 939. 1910; P.Bruehl, Rec. Bot. Surv. India 13(1): 16. 1931. *F. megacistis* Pursell, Cryptog. Bryol. Lichenol. 7: 39. 1986.

Plants yellowish-green, gregarious on loamy soil, 6-8 x 3 mm, with 6-10 pairs of leaves, crowded at apex; leaves curled when dry, oblong-lanceolate, widely acuminate, up to 2 mm x 10 µm, leaves smaller below; dorsal lamina narrowing down at base; sheathing lamina usually equal, simple limbidium of 1 to 3 layers of elongated, yellowish cells; costa light yellowish, ending far below the tip; cells smooth, walls very thin, chlorophyllose with small bead like structure, 25 x 10 µm, cells towards the base of the sheathing lamina elongated and broad. (Fig. 17: a-c & Plate 10h).

Habitat: On soil, concrete walls and bricks in homesteads and in partially shady areas of moist deciduous forests.

Specimen examined: Muthanga range, Keeradam kolly (915m) MCN 76099, Begur RF (845 m) MCN 84597, Sulthan Bathery (900 m) MCN 84368.

Distribution: This species was reported earlier from South India (Tamil Nadu), Central India (Maharashtra, Madhya Pradesh), North-east India (Bengal, Haryana, Khandala, Western Himalaya), Sri Lanka, China, Indonesia, Borneo, Brazil, Myanmar, Taiwan, Japan, Java, Nepal, Mexico, New Guinea, Philippines and Ryukyus. The present collection is a new record to Kerala.

Fissidens subbryoides Gangulee, Nova Hedwigia 8: 141. 1964 & Moss. E. India 1(2): 467. 1969; Iwatzuki & Suzuki, *Frag. Flor. et Geobot.* 40: 154. 1995.

Plant yellowish-green, unbranched, 2 mm long with 6-8 pairs of leaves; leaves narrower, linear-lanceolate, curled and shrunk when dry, basal smaller and upper larger, sheathing lamina unequal, 0.5–1.2 mm long, margin bordered by 1-2 layers of elongated hyaline cells, indistinct, near sheathing lamina 2-4

layers; cells papillose, at sheathing lamina and at basal portion of ventral lamina broad, elongated-hexagonal, hyaline, 32-48 x 10-14 μm , upper and middle cells rounded to hexagonal, chlorophylose, papillose, 8-10 μm diagonally; costa strong, light brown, excurrent in a short apiculus. (Fig. 17: d-g & Plate 10i).

Habitat: On wet soil cuttings along with *Selaginella ciliaris* and *Asterella khasiana* in semi shaded road cuttings in semi-evergreen forests.

Specimens examined: Muthanga range (867 m) MCN 84395; Soojippara (757 m) MCN 87082b.

Distribution: This species is sparsely distributed in the study area. It was earlier reported from South India (Tamil Nadu: Western Ghats of Kanyakumari), North-east India (Assam), Andaman Islands and East Nepal. The present collection is a new record to Kerala.

Fissidens virens Thwait. ex Mitt., J. Linn. Soc. Bot. 13: 324. 1873; Gangulee, Moss. E. India. 1: 497. 1969. *F. asperifolius* Hedwigia 38: 126. 1899.

Plants very small, up to 1.2 mm long with 5-7 pairs of leaves; leaves crowded together, oblong ovate, up to 0.7-1.1 mm long, leaves equally broad at all side, the space where the sheathing lamina ends slight constriction occurs, 0.02 mm broad, leaf margin crenulated by projection of cells; sheathing lamina opened, reach above the midleaf; cells rounded hexagonal, chlorophyllose, regularly arranged, each cell show a single conical papillae on top, up to 7.5 μm diagonally; costa strong, ends below the apex; seta apical; capsule cylindrical to globose, short, 0.3 mm long; spores not observed. (Plate 10j).

Habitat: On soil cuttings in evergreen and semi-evergreen forests.

Specimens examined: Sulthan Batheri (907 m) MCN 84356, Thirunelli RF (880 m) MCN 84603.

Distribution: This species was earlier reported from North-east India (West Bengal, Assam), Sri Lanka, China, Malaysia and Vietnam. The present collection is a new record to Peninsular India.

Fissidens zollingeri Montin, Ann. Sci. Nat. Bot. ser. 3, 4: 114. 1845; Gangulee, Moss. E. India 1(2): 478. 1969; R.S.Chopra & Kumar, Moss. W. Himalayas 44.

1981; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986. *F. kegelianus* C.Muell., Linnaea 21:181. 1848. *F. biformis* Mitt., Musc. Ind. Orient. 141. 1859; Gangulee, Moss. E. India 1(2): 483. 1971; R.S.Chopra & Kumar, Moss. W. Himalayas 44. 1981. *Conomitrium caripense* Hampe & C.Muell., Linnaea 38: 574. 1874. *Fissidens caripensis* (Hampe & C.Muell) Paris, Index Bryol. Suppl. 463. 1896.

Plants yellowish-green, very small, 2-4.5 mm long with 3-6 pairs of leaves; leaves narrowly oblong-lanceolate, slightly curled and contorted when dry, 1.52 x 0.25 mm, widest at base, sheathing lamina equal, dorsal lamina narrowing down to base and meeting the vein at leaf base or may even end a little above; costa prominent, excurrent in a minute apiculus; cells quadrate to hexagonal, not papillose, 10-12 μm wide in apical part, becoming larger 20-30 μm long at the base of the sheathing lamina; pericheatial leaves longer than the normal leaves; seta terminal, erect, up to 5 mm long; capsule ovate-cylindrical, orange-brown; spores small, rounded, up to 10 μm in diameter.

Habitat: Terrestrial along with *Fossombronia foveolata* var. *cristula* on road cutting soil and also on logs in semi shaded areas of moist deciduous and semi-evergreen forests.

Specimens examined: Kurichiad range, Dottakulachi (920 m) MCN 84557, Lakkidi (750 m) MCN 80098.

Distribution: This species is common in the study area. It was earlier recorded from South India (Kerala, Tamil Nadu: Palni hills, Karnataka: Coorg, Kanara), Sri Lanka, Bolivia, Myanmar, Fiji, Java, Malaysia, New Guinea, Peru, Philippines, Samoa, Sumatra, Tahiti and North & Central Vietnam.

Fissidens sp.

Plants light green, very small, up to 4 x 1.5 mm; leaves up to 1.3 mm long, elongated, ovate-lingulate, 4-6 in pairs, curled when dry, tip acuminate, symmetrical all along, margin wavy; sheathing lamina half the length of the leaf, slightly unequal; costa light yellowish, ending near the tip; cells chlorophyllose, rounded-hexagonal, up to 7 μm diagonally; pericheatial leaves narrower and elongated up to 1.5 mm long. Sporophyte not seen.



Plate. 10. a: *Fissidens asperisetus*, b: *F. ceylonensis* c. plant with sporophyte, d: capsule, e: *F. crenulatus*, f: *F. crispulus* var. *crispulus* g: *F. crispulus* var. *robinsonii*, h: *F. flaccidus* i: *F. subbryoides* j: *F. virens*, k: *Calymperes afzelii*, l: gemmiferous leaf, m: *Calymperes erosum*, n: *Anoetangium bicolor*

Habitat: Growing on shaded humid earth bank on riverine area in moist deciduous forest.

Specimen examined: Kurichiad range, Chikkanji (900 m) *MCN 84538b*.

Distribution: It is rare in Wayanad and could be collected from only one locality.

Order SYRRHOPODONTALES

CALYMPERACEAE Kindb.

Genera Europe North Amer. Bryineae (Mosses) 11. 1897.

Plants small to fairly robust, mostly epiphytic, rarely growing on rocks and soil; stem erect, leaves linear-lanceolate to lingulate from a semi-sheathing broader base, sometimes with hyaline or thickened border, leaves mostly of two types: gemmiferous and non-gemmiferous; cells at upper half small, often papillose, basal hyaline, bordered by green, isodiametric cells; costa strong, often rough papillose; capsule erect, peristome absent or with 16 deeply inserted teeth, operculum conic-rostrate.

Three genera viz., *Calymperes*, *Syrrhodon* and *Thyridium* are present in India. Of which *Calymperes* and *Syrrhodon* are represented in the study area.

Key to the genera

- 1a. Gemmiferous leaves usually absent.....**Syrrhodon**
1b. Gemmiferous leaves usually present.....**Calymperes**

Calymperes Sw.

in F. Weber, Tab. Exhib. Calyptr. Operc. Musc. Frond. Gen. 2. 1813 (1814).

Plants small, yellowish-green, erect; stem simple or branched; leaves often dimorphic, gemmiferous and non-gemmiferous, narrow, broadly lingulate, lanceolate or linear with a hyaline, semi-sheathing base, apex narrow, sometimes abrupt; costa conspicuous, ending below apex to excurrent; cells at upper half chlorophyllose, small, mostly isodiametric, in some protrusions arise from the ventral surface, protrusions sometimes papillose, bearing dorsally 1(-2) papillae; cells at base hyaline, large, empty; gemmae produced in radial masses, often from the modified apices of specialised leaves, fusiform to clavate, sometimes filamentous and branched, multicellular, smooth; seta

normally exerted; capsule cylindrical with a conical operculum, enclosed in a persistent calyptra; peristome absent or rarely present but reduced.

Key to the species

- 1a. Non-gemmiferous leaves lingulate with obtuse-apiculate or denticulate apices; costa ending near the apex in a truncate to rounded dentate tip **C. afzelii**
- 1b. Non-gemmiferous leaves lingulate to narrowly lanceolate with acute, denticulate apices; costa ending near the apex or excurrent **C. erosum**

Calymperes afzelii Sw., Jahrb. Gewachsk. 1: 3. 1818. *C. thwaitesii* Besch., Annl. Sci. Nat. Bot. ser. 8, 1: 306. 1895. *C. microdictyon* Dixon & P.Varde, Ann. Crypt. Exot. 3: 172. 1930.

Plants yellowish-green, in tufts; leaves incurled when dry, erect when moist, dimorphic; non-gemmiferous leaves lingulate with obtuse or obtuse-apiculate or denticulate apices; costa ending just below the apex in a truncate to rounded, dentate tip; ventral superficial cells above leaf base quadrate to shortly rectangular, basal superficial cells hyaline, base subquadrate to rectangular; cells of chlorophyllose lamina mostly isodiametric or slightly longer than broad with 4-6 sided, cells of distal hyaline lamina mostly isodiametric; gemmiferous leaves lanceolate to lingulate with a narrow, gemma bearing proboscis; costa strong, extending into proboscis but ending below apex, lamina narrowing into proboscis, near the leaf apex forming rounded, dentate tip; gemmae arising in a radial mass from the ventral surface of the costal apex, fusiform, smooth, often red. (Fig. 17: h-l & Plate 10k&l).

Habitat: Commonly occurs on shaded tree trunks and logs including rotting stumps and fern rhizomes in moist deciduous forests.

Specimens examined: Mananthavady (700 m) *MCN, PVM & KPR 80113c*, Kurichiad range (880 m) *MCN 84558a*.

Distribution: It is a common species in the study area. This species is distributed in South India (Goa, Kerala, Tamil Nadu), Sri Lanka and China.

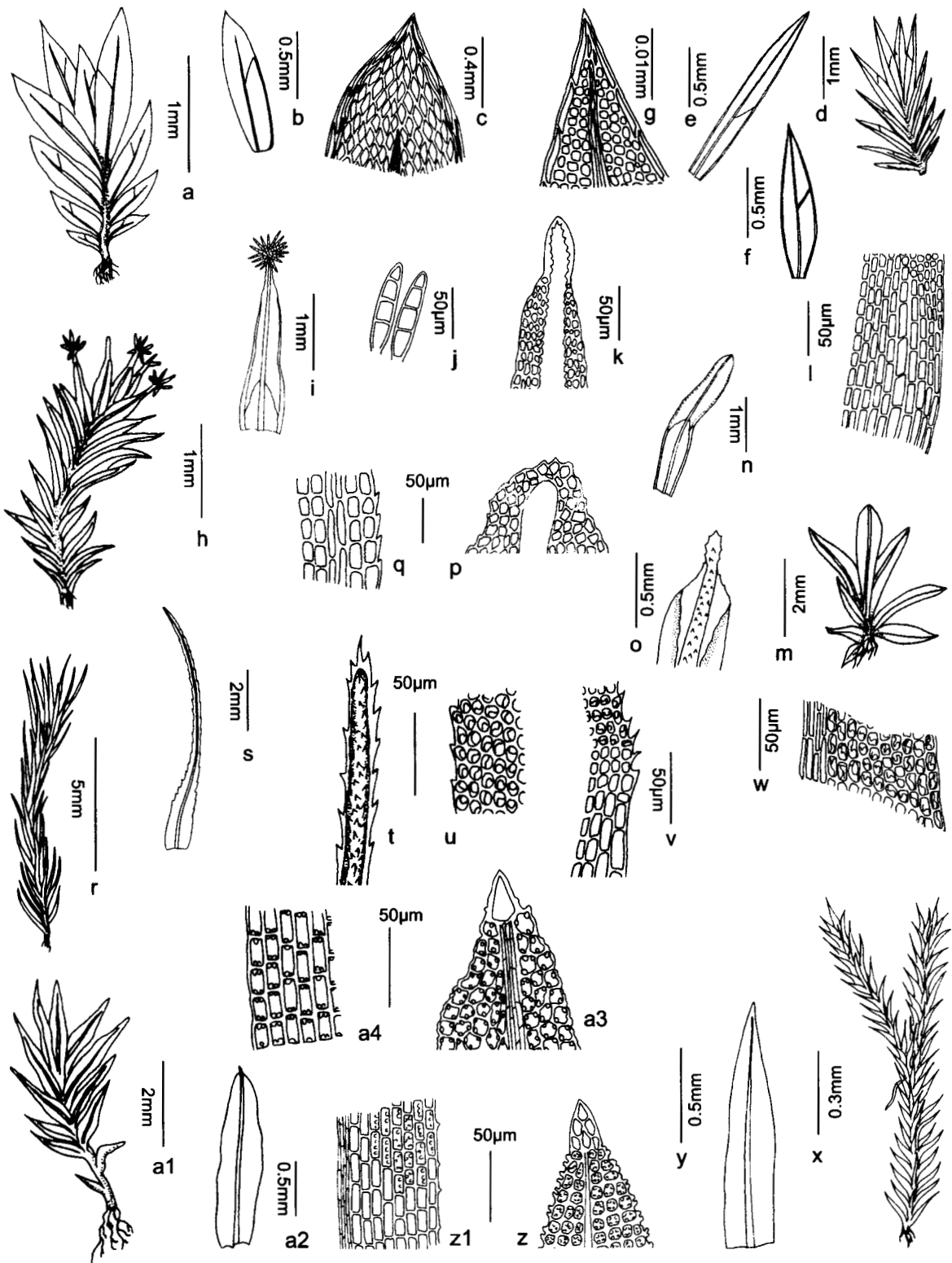


Fig. 17: **a-c**: *Fissidens flaccidus*; a: habit, b: leaf, c: upper leaf cells; **d-g**: *Fissidens subbryoides*; d: habit, e&f: leaves, g: upper leaf cells; **h-l**: *Calymperes afzelii*; h: habit, i: gemmiferous leaf, j: gemmae, k: upper leaf cells, l: leaf basal cells; **m-q**: *Calymperes erosum*; m: habit, n: leaf, o: upper part of gemmiferous leaf, p: upper cells of normal leaf, q: middle marginal cells; **r-w**: *Syrrhopodon gardnerii*; r: habit, s: leaf, t: leaf tip, u: middle marginal cells, v: basal marginal cells, w: cells above hyaline zone; **x-z1**: *Anoetangium bicolor*, x: habit, y: leaf, z: leaf tip cells, z1: leaf basal cells; **a1-a4**: *Barbula indica*; a1: habit, a2: leaf, a3: leaf tip cells, a4: leaf basal cells

Calymperes erosum C.Muell., *Linnaea* 21: 182. 1848. *Syrrhopodon heterophyllus* Mitt., *J. Linn. Soc. Bot. Suppl.* 1: 40.1859. *Calymperes burmense* Hamp. in Besch., *Annl. Sci. Nat. Bot. ser. 8, 1: 267, 279.* 1895. *C. fordii* Besch., *Annl. Sci. Nat. Bot. ser. 8, 1: 267, 284.* 1895. *C. exlimbatum* C.Muell. ex Besch., *Annl. Sci. Nat. Bot. ser. 8, 1: 267.* 1895. *C. manii* C.Muell. ex Besch., *Annl. Sci. Nat. Bot. ser. 8, 1: 267, 291.* 1895. *C. seychellarum* Besch., *Annl. Sci. Nat. Bot. Ser. 8, 1: 267, 304.* 1895. *C. thyridioides* C.Muell. in Paris, *Index Bryol. Suppl.* 86. 1900. *C. subcrassilimbatum* P.Varde, *Svensk Bot. Tidskr.* 51: 159. 1957.

Plants whitish-green, less than 1 cm high, in tufts; leaves incurled when dry, erecto-patent when moist, mostly 3-5 mm long, non-gemmiferous leaves lingulate to narrowly lanceolate with acute, denticulate apices; costa ending near the apex or excurrent; cells of chlorophyllose lamina mostly isodiametric to slightly longer than broad, with rounded hexagonal cells, two or more rows of small chlorocyst forming a unistratose, denticulate leaf margin; distal most cells of hyaline lamina (hyalocysts) ventrally protruding, protrusions acute and distally or laterally oriented, overlapping adjacent cells; lower hyaline basal cells long, narrowly rectangular, thin walled; gemmiferous leaves similar to non-gemmiferous leaves, often narrowly lanceolate; costa strongly excurrent, usually broadening slightly towards the tip, gemmae produced in superficial mass from all around the costal apex, pale to dark brownish to greenish-brown. (Fig. 17: m-q & Plate 10m).

Habitat: Epiphytic along with *Octoblepharum albidum* and *Lejeunea* sp. and also on logs and as epiphylls in homestead.

Specimen examined: Vythiri (750 m) MCN & PVM 80099.

Distribution: It is a common species distributed in South India (Goa, Kerala, Tamil Nadu), Sri Lanka, Myanmar, China, Africa and America.

Syrrhopodon Schwaegr.

in Hedw., *Sp. Musc. Suppl.* 2(1): 110. 1824.

Plants erect, small to medium sized in tufts or cushions; leaves crowded, contorted, lanceolate or linear-lanceolate from whitish, erect, sheathing bases, usually with a narrow hyaline border, gemmiferous leaves usually absent; costa

strong, ending below or in the apex; cells at upper half small, usually more or less papillose, demarcated from large hyaline cells at the base; capsule erect, cylindrical, peristome single, 16 papillose teeth, calyptra campanulate.

Syrrhopodon gardneri (Hook.) Schwaegr. in Hedw., Sp. Musc. Suppl. 2(1): 110. 131. 1824. *Calymperes gardneri* Hook., Musc. Exot. 2: 146. 1819. *C. hobsonii* Grev., Ann. Lyc. Nat. Hist. New York 1(2): 271. 23. 1825. *C. welwitschii* Duby, Mem. de la Soc. de Phys. et d'Hist. Natur. de Geneva 21: 444. 4 f.8. 1872. *Syrrhopodon strictus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 299. 1873. *S. aculeatoserratus* Besch., Annal. des Sci. Natur. Botanique ser. 6, 9: 349. 1880. *S. welwitschii* (Duby) Besch., Annal. des Sci. Natur. Botanique, ser. 8, 1: 307. 1896. *S. curranii* Broth., Philippine J. Sci. 5: 142. 1910.

Plants yellowish-green, erect to flexuose, up to 1 cm x 1 mm; leaves linear lanceolate, base sheathing, 6-8 x 0.8 mm, margin serrated almost from base to apex, teeth sharp; costa single, reach up to top, spiny throughout the costa, spines sharp at apex; cells at basal part hyaline, rectangular, 50-58 x 22-26 μm , sharp demarcation of hyaline cells upwards, cells chlorophyllose, rounded to elongate, upper and middle cells 10-12 x 8 μm . (Fig. 17: r-w).

Habitat: Upper part of tree trunk in semi-evergreen forests.

Specimen examined: Chembra hills (1720 m) MCN 99680.

Distribution: India (North-western Himalayas, West Bengal, Khasi hills), Sri Lanka, Bhutan, Borneo, Indonesia, Nepal, Philippines, Sumatra and Vietnam. The present collection is a new record to Peninsular India.

Order POTTIALES

POTTIACEAE Schimp.

Coroll. Bryol. Eur. 24. 1855 [1856].

Plants yellowish-green, erect, usually small, \pm 1-5 mm, densely tufted; leaves linear-lanceolate to spathulate, crowded, mostly crispate when dry; costa single, strong, percurrent or excurrent; cells usually thin walled, rectangular, hyaline at base, small, papillose, often obscure above, alar cells absent; seta

usually long, erect; capsule erect, cylindrical to ovate-cylindrical, calyptra narrow, cucullate, peristome usually absent.

Six subfamilies are recognised within this family. Of which Eucladioideae with four genera viz., *Anoetangium*, *Molendoa*, *Gymnostomum*, *Hymenostylium*; Trichostomoideae with five genera viz., *Oxystegus*, *Tortella*, *Scopelophila*, *Hymenostomum*, *Trichostomum*; Barbuloideae with nine genera viz., *Hyophila*, *Barbula*, *Geheebia*, *Bellibarbula*, *Semibarbula*, *Prionidium*, *Hydrogonium*, *Bryoerythrophyllum*, *Didymodon*, Pottioideae with three genera viz., *Merceya*, *Weisiopsis* and *Desmatodon* and Leptodontoideae with *Leptodontium* are represented in India. Of these Eucladioideae with two genera viz., *Anoetangium* and *Hymenostylium*, Trichostomoideae with two genera viz., *Trichostomum* and *Scopelophila*, Barbuloideae with three genera viz., *Hyophila*, *Barbula* and *Semibarbula* occur in the study area.

Key to the genera

- 1a. Plants 5 mm or more long.....2
- 1b. Plants 1 mm or even smaller..... **Scopelophila**
- 2a. Sporophytes on lateral shoots; costa weak, percurrent or very short
..... **Anoetangium**
- 2b. Sporophytes on main shoots; costa strong, excurrent or ends at tip.....4
- 4a. Leaves linear-lanceolate, acuminate.....5
- 4b. Leaves spatulate or lingulate, broad, apiculate..... **Hyophila**
- 5a. Leaf margin involute; upper cells papillose; basal cells rectangular, hyaline...
..... **Hymenostomum**
- 5b. Leaf margin flat; upper cells densely papillose, chlorophyllose; lower cells
rectangular with yellowish or hyaline walls.....6
- 6a. Leaf tip sharply acute, basal cells with rectangular yellow walls.....
..... **Hymenostylium**
- 6b. Leaf tip bluntly acute; basal cells hyaline.....7
- 7a. Leaf margin strongly involute when dry, leaves not brittle.....8
- 7b. Leaf margin flat even when dry; leaves brittle..... **Oxystegus**
- 8a. Peristome teeth divided to base into two filiform segments... **Trichostomum**
- 8b. Peristome teeth not as above.....9

- 9a. Leaves oval or ovate-oblong to lanceolate, obtuse or acuminate.....**Barbula**
9b. Leaves lingulate-lanceolate, obtuse from a broad base.....**Semibarbula**

Anoetangium Schwaegr.

Sp. Musc. Suppl. 1(1): 33. 1811, *nom. cons.*

Plants yellowish-green, tufted; leaves narrow, lanceolate, crispate when dry, margin flat; costa weak, percurrent or very short; cells at upper half ovate to irregularly quadrate, chlorophyllose, incrassate, papillose, often obscure, lower cells hyaline, rectangular; sporophyte on lateral shoots; seta erect to slender, long or short; capsule erect or horizontal, ovate-oblongoid, peristome absent, operculum conic-rostrate with a long beak.

Anoetangium bicolor Renauld & Cardot, Bull. Soc. Bot. Belgium 14(1): 19. 1905; Gangulee, Moss. E. India 1(3): 637. 1972.

Plants yellowish-green, caespitose, stem usually forked, 1-2 cm long, tomentose, densely covered with erect, spreading leaves; leaves lanceolate, curled when dry, reddish-brown below, yellowish-green above, up to 1.2 x 0.3 mm, apex acute, margin flat, papillate margin; costa prominent, extends into a short apiculus beyond tip; cells rectangular below, smooth, 40 x 8 μ m, shorter and slightly papillose near margin, upper lamellar cells chlorophyllose, highly papillose, quadrate to irregular, 5-8 μ m wide. (Fig. 17: x-z1 & Plate 10n).

Habitat: On soil and on rocky patches in Tea estates.

Specimen examined: Chembra estate (1060 m) *MCN 120239a*.

Distribution: This species was earlier recorded from the Western Himalayas only. The present collection is a new record to Peninsular India.

Barbula Hedw.

Sp. Musc. 115. 1801, *nom. cons.*

Plants green to brownish, small, slender to very robust; leaves ovate or ovate-oblong to lanceolate, obtuse or acuminate, margin revolute; costa strong, percurrent or sub-percurrent, smooth or only papillose at the back; cells at upper half small, more or less thick walled, densely papillose, basal cells

widened, quadrate to rectangular, hyaline, smooth; capsule erect, rarely inclined, ovate-oblongoid to cylindrical, calyptra cucullate.

Barbula indica (Hook.) Spreng., Syst. Veg. 2: 72. 1824; Broth., Rec. Bot. Surv. India 1(12): 317. 1899; P.Bruehl, *Ibid* 13(1): 40. 1931; Dixon, J. Indian Bot. Soc. 2: 183. 1921 & J. Bombay Nat. Hist. Soc. 39: 776. 1937; Foreau, J. Madras Univ. Sect. B. 2: 247. 1930 & J. Bombay Nat. Hist. Soc. 58: 21. 1961; Gangulee, Moss. E. India 1(3): 717. 1972; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986. *Tortula indica* Hook., Musci Exot. 2:135. 1819. *Trichostomum orientale* F. Weber, Arch. die Syst. Naturges. 1(1): 129. 4 f. 6. 1804. *Pottia muelleri* Duby, Mem. de la Soc. Phys. Hist. Natur. Geneve 20: 355. 1 f. 4. 1870. *Anoetangium stuhlmannii* Broth., Bot. Jahrb. Syst. Pflanzenges. Pflanzengeo. 20: 176. 1894. *Barbula dorrii* Renaud & Cardot, Bull. Soc. Bot. Belgique 35 (1): 310. 1896. *B. ferrinervis* C.Muell., Nuovo Gior. Bot. Italiano, new series 4: 255. 1897. *B. setschwanica* Broth., Wissensch. Wien Sitzung., Math.-naturwis. Abteilung 1 133: 566. 1924.

Plants greenish-brown, up to 10 mm long, more brownish below, lower part felted with rhizoids, branches equally high; leaves ovate-oblong to spatulate with incurved margins, arranged spirally around the stem, acuminate, margin revolute, entire; costa strong, light green, shortly excurrent; upper cells small, rounded, 5-8 μm diagonally, thick walled, with horse-shoe-shaped mamillae, basal cells somewhat widened and elongated, 25 x 10 μm , quadrate to rectangular, hyaline, smooth; seta smooth, long, up to 1.5 cm long, yellowish orange; capsule erect, yellowish orange, cylindrical, calyptra beaked; spores rounded. (Fig. 17: a1-a4 & Plate 11a&b).

Habitat: It is found almost everywhere, on roadsides, soil cuttings, rock crevices, moist bricks, rotten logs and on concrete walls in moist deciduous forests.

Specimens examined: Kurichiad range, Pavagadha (760 m) MCN 84522, Dottappalam (816 m) MCN 84528a, Sulthan Bathery (830-920 m) MCN 84363, MCN 84370.

Distribution: It was earlier recorded from India (locality unknown), China, Japan, Korea, Myanmar, Malaysia, Papua New Guinea, Philippines, Colombia, Mexico, Africa and America. The present collection is a new record to Peninsular India.

Hymenostomum R.Br.

Trans. Linn. Soc. Lond. 12(2): 572. 1819.

Plants yellowish-green, erect; leaves linear-lanceolate, margin involute; cells papillose above, rectangular, hyaline below; costa single, strong, ends up to tip; seta apical, slender, erect; capsule erect, ovoid, peristome absent, operculum conic-rostrate, calyptra cucullate.

Hymenostomum edentulum (Mitt.) Besch., Bull. Soc. Bot. Fr. 34: 95. 1887; Sedgwick, J. Bombay Nat. Hist. Soc. 19: 940. 1910; Dixon, J. Indian Bot. Soc. 2: 181. 1921; P.Bruehl, Rec. Bot. Surv. India 13(1): 35. 1931; Foreau, J. Madras Univ. Sect. B. 2: 246. 1930; Gangulee, Moss. E. India 1(3): 673. 1972; R.S.Chopra, Tax. Indian Mosses 128. 1975. *Weisia edentula* Mitt., Musc. Ind. Orient. 27. 1859. *W. leptotrichacea* C.Muell. in N.Giorn., Bot. Ital. 4: 259. 1897.

Plants yellowish-green, forming dense mats on soil; stem simple or branched, branches erect, 5-10 mm long, densely covered with leaves; leaves linear-lanceolate, erect, spreading when moist, crispate when dry, larger at top, up to 3 mm long, apex narrow pointed, margin unbroken; costa brownish, excurrent; cells at base yellowish, hyaline, up to 100 x 20 µm near costa, shorter towards margin, upper cells rounded-quadrate, up to 9 µm wide, densely papillose; seta apical, erect, 5-6 mm long; capsule erect or slightly nodding, calyptra cucullate, peristome absent; spores warty papillose, spinulose rounded, reddish-brown, 18-23 µm in diameter. (Fig. 18: a-g & Plate 11f).

Habitat: On soil cuttings in grasslands.

Specimen examined: Chembra hills (1300-1380 m) MCN 120242, 120263.

Distribution: *Hymenostomum edentulum* is common in the grasslands of Chembra hills. This is an Indo-Pacific species found distributed in South India (Nilgiri hills, Palni hills, Madras), Andaman & Nicobar Islands, Sri Lanka, China,

North Vietnam, Taiwan, Java, Philippines and New Caledonia. The present collection is a new record to Kerala.

Hymenostylium Brid.

Bryol. Univ. 2: 81. 1827.

Plants yellowish-green, in dense tufts; leaves erecto-patent, contorted and appressed when dry, linear-lanceolate, sharply acute; costa strong, ending below apex; cells at upper half chlorophyllose, rounded-quadrate, small, densely papillose, lower cells rectangular with yellow walls; seta long, erect; capsule ovoid, oblongoid or obovate, calyptra narrow.

Hymenostylium recurvirostre (Hedw.) Dixon, Rev. Bryol. Lichenol. 6: 96. 1933; Gangulee, Moss. E. India 1(3): 646. 1972. *Gymnostomum recurvirostrum* Hedw., Sp. Musc. 33. 1801. *G. curvirostre* Hedw. ex Brid. J. Bot. 1800(2): 273. 1801. *G. xanthocarpum* Hook., Musc. Exot. 2: 153. 1819. *G. pomiforme* Nees & Hornsch., Bryol. Germ. 1: 158. 1823. *Hymenostylium xanthocarpum* (Hook.) Brid., Bryol. Univ. 2: 82. 1827. *Gymnostomum atroviride* Griff., Calcutta J. Nat. Hist. 2: 479. 1842. *Weisia curvirostris* C.Muell., Synop. Musc. Frond. 1: 658. 1849. *Hymenostylium curvirostrum* Mitt., Musc. Ind. Orient. 32. 1859. *Barbula curvirostris* Lindb., Musc. Scand. 22: 1879. *Hymenostylium xanthangium* C.Muell. in Paris, Index Bryol. Suppl. 178. 1900, *nom.nud.* *Weisia recurvirostris* (Hedw.) Dixon, J. Bot. 40: 377. 1902, *hom. Illeg.* *Eucladium curvirostre* Hedw., Danm. Moss. 2: 315. 1923. *E. recurvirostre* (Hedw.) C.Jens., Skand. Bladmfl. 229. 1939.

Plants yellowish-green in tufts, up to 3 mm long, often branched by innovation; leaves curled when dry, linear-lanceolate, base broad, up to 1.6 mm long, margin wavy, acuminate; cells hyaline at base, middle and upper chlorophyllose, rounded, 6-8 μm diagonally; cells near costa at lower side rectangular, 40 x 15-20 μm , shorter towards margin, 20 x 10-13 μm ; costa strong, yellowish, ending below apex; seta long, erect, up to 5 mm long; capsule erect, calyptra cucullate; spores globose, dark brown, 12-15 μm diagonally. (Fig. 18: h-m).

Habitat: On rocky patches in semi-evergreen forests.

Specimen examined: Soojippara (760 m) MCN & KPR 87084.

Distribution: It is rare in the present study area. It was earlier reported from South India (locality unknown) North-east India (Western Himalaya, Kashmir, Kumaon, Khasi hills, Kangra, Ladakh, Mussoorie, Sikkim), Afghanistan, China, Japan, Korea, Myanmar, Caucasus, New Zealand, New Guinea, Philippines, Pakistan and Western Tibet.

Hyophila Brid.

Bryol. Univ. 1: 760. 1827.

Plants small to medium sized, forming mats; leaves oblong-lingulate to spatulate or lingulate, broad, apiculate, margin flat when moist, inrolled when dry, apex obtuse, often toothed at apex; cells at basal part rectangular, hyaline, upper cells small, rounded, papillose, chlorophyllose; costa percurrent to excurrent; seta apical, erect; capsule erect, peristome absent, calyptra cucullate, cylindrical.

Key to the species

- 1a. Leaves lingulate to spatulate, continuous, apex broadly pointed, denticulate, margin crenulate at apex.....**H. involuta**
- 1b. Leaves spatulate from a narrower base, in interrupted rosettes; apex ends in short apiculus; margin wavy at upper half.....**H. nymaniana**

Hyophila involuta (Hook.) A. Jaeger, Ber. Senckenberg. Naturf. Ges. 1871-72: 356. 1873; Broth., Rec. Bot. Surv. India 1(12): 317. 1899; P. Bruehl, Rec. Bot. Surv. India 13(1): 38. 1931; Dixon, J. Indian Bot. Soc. 2: 181. 1921 & J. Bombay Nat. Hist. Soc. 39: 776. 1937; Foreau, J. Madras Univ. Sect. B. 2: 247. 1930 & J. Bombay Nat. Hist. Soc. 58: 22. 1961; Sundararagh & Wadhwa, Bull. Bot. Surv. India 10: 345. 1968; Gangulee, Moss. E. India 1(3): 681. 1972; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986; *Gymnostomum involutum* Hook., Musc. Exot. 2: 154. 1819. *G. tortula* Schwaegr., Sp. Musc. Suppl. 2: 78, 175. 1826. *G. cylindricum* Hook., Icon. Pl. Rar. 1: 17. 1836. *Barbula spathulata* Dozy & Molk., Ann. Sci. Nat. Bot. ser. 3, 2: 300. 1844. *Hyophila hookeri* Hamp., Bot. Zeitung 4: 267. 1846, *nom. illeg.* *H. harveyana* Hamp., *Ibid.* 4: 267. 1846,

nom. illeg. H. tortula (Schwaeger.) Hamp., *ibid* 267. 1846. *Pottia involuta* (Hook.) C.Muell., Synop. Musc. Frond. 1: 560. 1849. *P. cylindrica* (Hook.) C.Muell., *ibid*. 562. 1849. *Desmatodon involutus* (Hook.) Mitt., Musc. Ind. Orient. 39. 1959. *Pottia zollingeri* C.Muell., Bot. Zeitung 14: 419. 1856. *P. circinata* C.Muell., Linnaea 36: 38. 1869. *P. riparia* Austin, Musc. Appal. 112. 1870. *Trichostomum bescherelli* Schimp. in Besch., Mem. Soc. Sc. Nat. Cherbourg. 16: 477. 1872. *Hyophila cylindrica* (Hook.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1871-72: 356. 1873. *H. circinnata* (C.Muell.) A.Jaeger, *ibid* 357. 1873. *H. bescherelli* (Schimp.) C.Muell., Flora 58: 538. 1875. *Trichostomum warnstorffii* Limpr., Laubm. Deutschl. 1: 587. 1888, *nom. illeg. Leptodontium riparium* (Austin) E.G.Britt., Bull. Torrey Bot. Club 19: 275. 1892. *L. canadense* Kindb., Macoun. Cat. Canad. Pl. 6: 45. 1892. *Hyophila micholitzii* Broth., Oefv. Finsk. Vet. Soc. Foerh. 35: 39. 1893. *Didymodon riparias* (Austin) Kindb., Eur. N. Am. Bryin. 2: 280. 1897. *Hyophila stenocarpa* Renauld & Cardot, Bull. Soc. Bot. Belgium 38(1): 10. 1900. *H. moutieri* Paris & Broth., Rev. Bryol. 28: 38. 1901. *H. commutata* Broth., Nat. Pflanzenfam. 1(3): 403. 1902. *H. riparia* (Austin) M.Fleisch., Bryologist 7: 69. 1904. *H. warnstorffii* (Limpr.) M.Fleisch., Musc. Fl. Buitenzorg. 1: 328. 1904. *H. tsunodae* Broth. ex Yas., Bot. Mag. Tokyo 29: 151. 1915. *H. attenuata* Broth., Symb. Sin. 4: 37. 1929. *H. subcylindrica* Broth. in P.Bruehl, Rec. Bot. Surv. India 13(1): 126. 1931, *nom. nud. H. sinensis* Dixon, Sci. Rep. Natl. Tsing Hua Univ. B. Biol. 2: 117. 1936, *nom. nud.*

Plants dark greenish, erect, simple or branched; shoots arise from a long, horizontal, radiculous part below, up to 1.8 cm long; upper leaves spreading in rosettes, leaves erect spreading, circinate-curved and inrolled when dry, up to 3.5 x 1 mm, lingulate to spatulate, apex broadly pointed, denticulate at apex; costa strong, reddish below, wider at base, percurrent; cells at upper half chlorophyllose, rounded-quadrate, mamillate, 6-10 µm in diameter, with a few larger cells at margin, basal cells pale, rectangular; seta long, reddish-brown, very thin, erect up to 1 cm long; capsule cylindrical, peristome teeth rudimentary or absent, calyptra cucullate; spores rounded, 10-18 µm diagonally. (Fig. 18: n-s & Plate 11c&d).

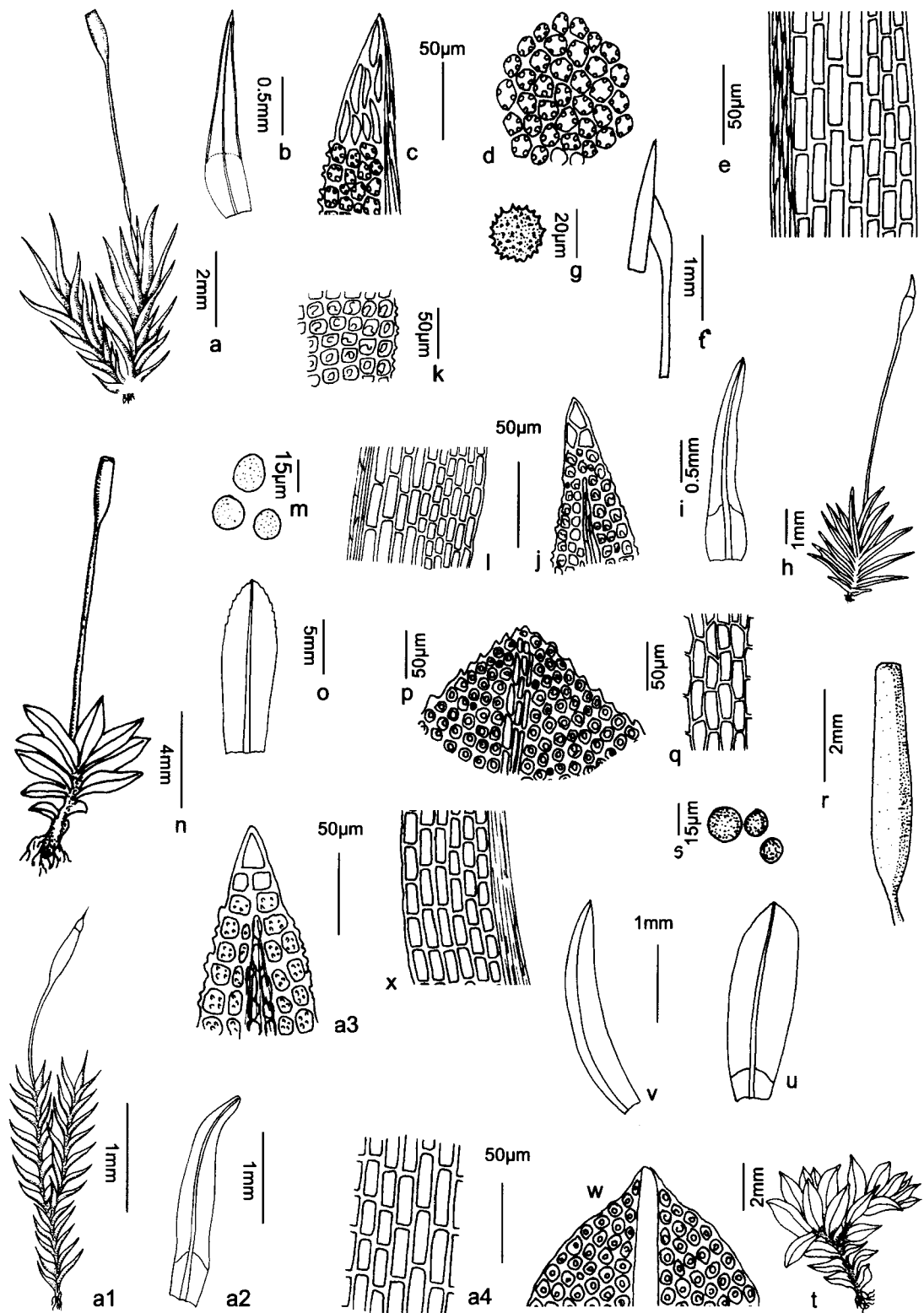


Fig. 18: **a-g:** *Hymenostomum edentulum*; a: habit, b: leaf, c: leaf tip cells, d: middle cells, e: basal cells, f: calyptra, g: spore; **h-m:** *Hymenostylium recurvirostre*; h: habit, i: leaf, j: leaf tip cells, k: middle cells, l: basal cells, m: spore; **n-s:** *Hyophila involuta*; n: habit, o: leaf, p: leaf tip cells, q: basal cells, r: capsule, s: spores; **t-x:** *Hyophila nymaniana*; t: habit, u&v: leaves, w: leaf tip cells, x: basal cells; **a1-a4:** *Oxystegus cylindricus*; a1: habit, a2: leaf, a3: leaf tip cells, a4: basal cells

Habitat: It is seen in a variety of habitats such as on soil, rocks, logs, crevices of rocks, walls, etc. from low to high altitudes. It is also found on Termite mount.

Specimens examined: Hairpin point (800 m) *MCN 80084*, Sulthan Bathery (929 m) *MCN 84362*, Thirunelli RF (880 m) *MCN 84600, 84607*, WWLS, Tholpetty range (875 m) *MCN 84577*, Begur (825 m) *MCN 84587*, Soojippara (760 m) *MCN & KPR 87080, 87102b*, Chembra hills (1200 m) *MCN 120224*, Near MSSRF, Manikkunnumala (950 m) *MCN 120303*.

Distribution: It is a widely distributed species from lower to high altitudes. It was earlier recorded from Peninsular India (Kerala; Karnataka: Mysore; Tamil Nadu: Palni hills, Nilgiri hills; Gujarat,), Central India (Madhya Pradesh, Orissa,), North-east India (Assam, Arunachal Pradesh, Bengal, Bihar, Chhotanagpur, Darjeeling, Khasi hills, Western Himalayas,), Sri Lanka, Nepal, China, Japan, Java, Korea, Borneo, Myanmar, Celebes, Manchuria, New Guinea, Oceania, Philippines, Sumatra, Taiwan, North & South Vietnam, North, Central & South America and Europe.

Note: *Hyophila* shows great variation in the size, colour, the cell structure, etc. according to the variation in microhabitats.

Hyophila nymaniana (M.Fleisch.) Menzel, *Willdenowia* 22: 198. 1992. *Glyphomitrium nymanianum* M.Fleisch., *Musci Fl. Buitenzorg* 1: 372. 1904. *Hyophila rosea* R.S.Williams, *Bull. N.Y. Bot. Gard.* 8: 341. 1914; Gangulee, *Moss. E. India* 1(3): 685. 1972.

Plants greenish, simple, sometimes branched, up to 8 mm long; leaves ovate-lanceolate or spatulate from a narrower base, in interrupted rosettes, erect spreading, inrolled when dry, 3 x 1 mm, papillate, margin wavy at upper half; costa strong, brown, percurrent or ends in short apiculus; cells rounded to hexagonal at upper half, chlorophyllose, highly multipapillose on both side, 5-8 µm wide, basal cells elongated, rectangular, incrassate, 20 x 10 µm, cells at extreme base thin walled, hyaline. (Fig. 18: t-x & Plate 11e).

Habitat: On earth cuttings and on cement walls in moist deciduous forests and in homestead areas.

Specimens examined: Kurichiad range (858 m) MCN 84550, Dottapalam (816 m) MCN 84528b.

Distribution: It is rare in the study area. This is an Indo-Pacific species distributed in Peninsular India (Kerala: Chinnar WLS, Tamil Nadu: Palni hills, Gujarat), North-east India (Western Himalaya, Orissa) and Philippines.

Oxystegus (Limpr.) Hilp.

Beih. Bot. Centralbl. 50(2): 666. 1933.

Plants yellowish-green, stem prostrate to erect, branched or not with indistinct or no central strand; leaves brittle, linear-lanceolate, apiculate, margin flat, wavy, not inrolled, flat even when dry, crenulate by papillae; lamina cells thin walled, coarse, rounded to quadrate, papillate above, smooth at base, rectangular, hyaline; capsule erect, ovoid-cylindric, peristome teeth usually undivided or irregularly split, deeply inserted, without basal membrane.

Oxystegus cylindricus (Bruch ex Brid.) Hilp., Beih. Bot. Centralbl. 50: 620. 1933; Gangulee, Moss. E. India 1(3): 655. 1972. *Weisia cylindrica* Bruch ex Brid., Bryol. Univ. 1: 806. 1827. *Weisia tenuirostris* Hook. & Tayl., Musc. Brit. ed. 2: 83. Suppl. 3. 1827. *Didymodon tenuirostris* (Hook. & Tayl.) Wils., Hook. J. Bot. 3: 378. 1841. *Barbula longifolia* Griff., Calcutta J. Nat. Hist. 2: 490. 1842. *Didymodon longifolius* Griff., *Ibid.* 2: 510. 1842. *D. cylindricus* (Brid.) Bruch, Schimp. & W.Guembel, Bryol. Eur. 2: 139. 1846. *D. calyptratus* Tayl., Lond. J. Bot. 7: 188. 1848. *Trichostomum cylindricum* (Bruch ex Brid.) C.Muell., Synop. Musc. Frond. 1: 586. 1849. *Tortula cylindrica* (Bruch ex Brid.) Mitt., Musc. Ind. Orient. 28. 1859. *T. longifolia* (Griff.) Mitt., *ibid.* 1859. *Trichostomum tenuirostre* (Hook. & Tayl.) Lindb., Oefv. K. Vet. Ak. Foerh. 21: 225. 1864. *Mollia tenuirostris* (Hook. & Tayl.) Lindb., Musc. Scand. 21: 1879. *Barbula leptotortuosa* C.Muell. in N.Giorn., Bot. Ital. 5: 179. 1898. *B. leptotortella* C.Muell., Hedwigia 38: 110. 1899. *Trichostomum leptotortuosum* (C.Muell.) Broth., Nat. Pflanzenfam. 1(3): 394. 1902. *T. longifolium* (Griff.) Broth., *Ibid.* 1(3): 394. 1902. *Tortella cylindrica* (Bruch ex Brid.) Loeske, Stud. Morph. Syst. Laubm. 97. 1910. *Oxystegus longifolius* (Griff.) Hilp. in Beih., Bot. Centralb.

50(2): 667. 1933. *O. leptotortella* (C.Muell.) Hilp., *ibid.* same page. *O. leptotortuosum* (C.Muell.) Hilp. *ibid.* same page.

Plants yellowish-green, in loose tufts; stem dark, slender, up to 3 mm long; leaves fragile, spreading, flexuose, elongate, curled when dry, lanceolate, 3-4.5 x 0.5 mm, base broad, margin flat, wavy, smooth below, somewhat crenulate with papillate above, tip acute with a short apiculus; costa yellowish, percurrent or excurrent in the apiculus; cells at base rectangular, hyaline, thin walled, 20-25 x 4-6 μm , shorter towards margin and gradually passing into shorter chlorophyllose cells above, upper lamina cells rounded-quadrate, multipapillate, 10-12 x 10 μm , obscure. (Fig. 18: a1-a4 & Plate 11g).

Habitat: On small rocky patches in semi-evergreen forests and grasslands.

Specimens examined: Soojippara (760 m) MCN 87086, MCN 87091, Chembra hills (1220, 1300 m) MCN 120230, 120271.

Distribution: This species is common in the study area at high altitudes. It is distributed in North-east India (Darjeeling, Naga hills, Khasi hills, Sikkim), Nepal. The present collection is a new record to Peninsular India.

Scopelophila (Mitt.) Lindb.

Acta Soc. Sci. Fenn. 10: 169. 1872.

Plants yellowish-green, very small, 1 mm long, leaves 5-7 per plants, tomentose; leaves at lower half smaller, upper larger, lingulate-lanceolate, acute; costa strong, reach up to tip; cells rounded hexagonal, lower cells larger than upper, papillate, margin entire.

Scopelophila cataractae (Mitt.) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 436. 1902.

Plant yellowish-green, up to 1 mm long, ca. 6 leaves per plant, stem often with red tomentum; lower leaves smaller, up to 12 mm long, lingulate-lanceolate, margin entire, acute to short-acuminate, constricted; costa single, reach up to top, strong, cells rounded-hexagonal, lower larger up to 10 x 5 μm , upper leaf cells very small, 3-5 μm diagonally, papillose. (Fig. 19: a-d & Plate 11h).

Habitat: Seen in sandy soil near riverine areas, mostly in mineral rich areas in semi-evergreen forests.

Specimen examined: Chandanathode (900 m) MCN 80112.

Distribution: It is widely distributed in all continents. In India, it is distributed in North India (Nainital, Kumaon Himalaya). The present collection is a new record to Peninsular India.

Note: Tewari (2001) commented that these plants are generally called as "Copper mosses" and are among the rarest plants on the earth. They are known to occur in high metal concentrated substrates. However *Scopelophila cataractae* is a fairly common moss in India and widespread in North, Central and South America, Africa and Asia through to China. It even grows on waste from copper mines in England.

Semibarbula Herzog ex Hilp.

Beih. Bot. Centralb. 50(2): 626. 1933.

Plants green to yellowish-green, in tufts; stem erect, simple or dichotomously branched; leaves lingulate-lanceolate, obtuse from a broad base, folded together when dry, twisted, closely appressed to the stem, erecto-patent when moist; costa strong, percurrent or projecting as small apiculus, rough at the back; cells thin walled, upper quadrate, densely papillose, basal cells translucent, pericheatial bracts longer; seta erect; capsule ovoid to oblong-cylindric, peristome lightly twisted, calyptra cucullate; spores small, brown, rounded.

Semibarbula orientalis (F.Weber) Wilk & Margad., Taxon 8(2): 75. 1959; Gangulee, Moss. E. India 1(3): 717. 1972; R.S.Chopra, Tax. Indian Mosses 142. 1975. *Trichostomum orientale* F.Weber, Arch. Syst. Naturgesch. 1: 129. 1804. *Dicranum orientale* (F.Weber) D.Mohr. Ann. Bot. 2: 546. 1806. *Tortula indica* Hook., Musc. Exot. 2: 135. 1819. *Semibarbula indica* (Hook.) Hezog ex Hilp., Bot. Centralbl. 50(2): 626. 1933.

Plants yellowish-green, in dense tufts, up to 7 mm long; rhizoids arise from the main and lateral branches; leaves crisped when dry, spreading when moist, distant below, forming a comal tuft above, long-narrow, up to 1.2 mm long, margin plane; costa strong, excurrent into a minute hyaline apiculus;

upper cells unistratose, small, rounded to quadrate, chlorophyllose, 5-8 μm wide, densely papillose on both sides, basal cells elongate, hyaline, 40-42 x 7.5-9 μm . (Fig. 19: e-h).

Habitat: Upper part of tree trunk along with *Pinnatella culcutensis* and on rocky patches in moist deciduous forests.

Specimens examined: Kurichiad range (858 m) *MCN 84653*, Tholpetty range, Begur, (830 m) *MCN 84591*, Begur (850 m) *MCN 84586*.

Distribution: It is a very common species in the study area earlier recorded from South India (locality unknown), North-east India (Darjeeling, Arunachal Pradesh, Bengal, Orissa), Sri Lanka, China, Nepal, New Guinea, Pakistan, Celebes, Taiwan, Madagascar, Malaysia, Siam and Central and Southern Africa.

Trichostomum Bruck

Flora 2: 295. 1829, *nom. cons.*

Plants yellowish-green; leaves usually narrow, elongate, basal cells lax, upper smaller, quadrate, papillose, leaves curled, incurved when dry; capsule oblong-cylindrical, peristome teeth divided to base into two filiform segments.

Trichostomum wayanadensis sp. nov.

Type: India, Kerala, Wayanad district, WWLS, Ponkuzhi (903 m) *MCN 84373* (CALI).

A lectotypo *Trichostomum brachydontio* in filo centrali indistincto, folii basi cellulis non incrassatis, apice apiculato differt. In *T. brachydontio* cellulae basales incrassatae, apex elongatus acuminatus. Haec species similitudines *T. brachydontio* solum in habitu et apice cellulae papillosis praebet 'cellulae structura' to 'cellulis papillosis'. Haec species quoque *T. minusculo* cellulis papillosis similis, sed folia angustiora fere aequaliter latiora e basi ad apicem, marginem apice crenulatum.

Plants yellowish-green, small, 3-5 x 1.5-2 mm, in dense tufts, branches arise by innovations, central strand indistinct, leaves crowded; leaves narrow, linear-lanceolate, apiculate, margin slightly crenulate above, basal margin entire, $\pm 2 \times 0.3-0.5$ mm, equally wide from base to apex, crisp in nature, curled

and contorted when dry; costa yellowish, strong, shortly excurrent, 50-62 μm wide; cells at upper part irregularly rounded to hexagonal, incrassate, covered with many small papillae, chlorophyllose, upper and middle cells up to 10-12 x 7-10 μm , basal cells hyaline, marginal cells near base more elongate than broad, 43-48 x 10-15 μm , near costa broad and elongate, 62-68 x 20-25 μm , above the hyaline cells $\pm 18 \times 15 \mu\text{m}$, leaf base attaching cells yellowish orange. Sporophyte not seen. (Fig. 24: a-g).

This species differs from the lectotype *T. brachydontium* Bruch, a widely distributed species in having central strand indistinct, leaf base cells not incrassate and leaf tip apiculate. In *T. brachydontium* the basal cells are incrassate and leaf tip is elongate and more acuminate. This species shows similarities with *T. brachydontium* only in the nature of the habit and cell structure at apex, which is papillose. This species also shows similarity with *T. minusculum* Dixon & P. de la Varde in having the papillose cells but the leaves are narrower and almost equally broad from base to apex and leaf margin crenulate at apex.

Habitat: On logs in moist deciduous forest.

Distribution: It is rare in Wayanad and could be collected from one locality.

Note: This species is named after the type locality

Order FUNARIALES

FUNARIACEAE Schwaegr.

in Willd., Sp. Pl., ed. 4. 5(2): 43. 1830.

Plants yellowish-green, erect, small to medium sized; rhizoids simple; leaves broad, soft, seen in comal tufts; costa slender, ending below tip; cells smooth, large, rhomboidal above, rectangular below, margin bordered by single layered elongated cells, undifferentiated; capsule globose, ovoid or pyriform, erect to inclined, peristome 16 teathed.

The family is represented by nine genera, of which *Entosthodon* has been considered as a subgenus of *Funaria* by Brotherus (1924a). But the modern bryologists considered *Entosthodon* as a separate genus. Only three

genera, *Physcomitrium*, *Entosthodon* and *Funaria* are represented in India. In the present study area two genera viz., *Funaria* and *Entosthodon* occur.

Key to the genera

- 1a. Capsule mostly symmetric and erect; peristome either single, rudimentary or absent **Entosthodon**
1b. Capsule asymmetric, erect to pendulous; peristome deeply inserted, single, double, or absent **Funaria**

Entosthodon Schwaegr.

Sp. Musc. Suppl. 2: 44. 1823.

Plants green, gregarious, tufted, small, up to 8 mm long; leaves at lower half small, larger at tip forming rosettes, ovate-lanceolate to oblong-lanceolate, up to 1.5 x 0.5 mm, margin usually dentate in the upper part; costa ending a little below apex; cells thin walled, narrower, hexagonal to rhomboidal at apex, rectangular at base; seta apical, erect, reddish-brown on top; capsule erect to slightly inclined, apophysis distinct, operculum conical, convex, peristome single, rudimentary or absent.

Entosthodon wichurae M.Fteisch., Die Musci Fl. Buitenz. 2: 481. 1904; Gangulee, Moss. E. India 2(4): 853. 1974; M.C.Nair & Madhus., J. Econ. Taxon. Bot. 25: 571. 2001. *Funaria wichurae* (M.Fleisch.) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1: 1204. 1909; P.Bruehl, Rec. Bot. Surv. India 13(1): 45. 1931. *F. lutschiana* Broth., Oefv. Finsk. Vet. Soc. Foerh. 62A: 15. 1921. *Physcomitrium kiushiuense* Sakurai, Bot. Mag. Tokyo 46: 738. 1932.

Plants yellowish-green, gregarious, small, 6-8 mm long; stem reddish-brown; leaves smaller at base, upper larger forming rosette, crumpled and clinging to stem when dry, ovate-lanceolate, 1.2 mm long, margin dentate at tip, bordered by a row of elongate cells, 90-150 x 5-15 µm with raised tips; costa percurrent; cells thin, rhomboidal at apex, rectangular at base; seta apical; capsule erect to slightly inclined, globose, apophysis distinct, calyptra cucullate; spores large, 15-20 µm in diameter, rough, reddish-brown. (Fig. 19: I-m & Plate 11i&j).

Habitat: On wet soil of stream banks of shola forests and on grasslands.

Specimens examined: Chembra hills (1120-1450 m) MCN 120247, MCN 120291, MCN 99604.

Distribution: It is a common species in the grasslands of high altitude areas. It is distributed in South India (Kerala: ENP; Tamil Nadu: Western Ghats of Kanyakumari), North-east India (Meghalaya, Uttar Pradesh), Sri Lanka, Indonesia and Myanmar.

Funaria Hedw.

Sp. Musc. 172. 1801.

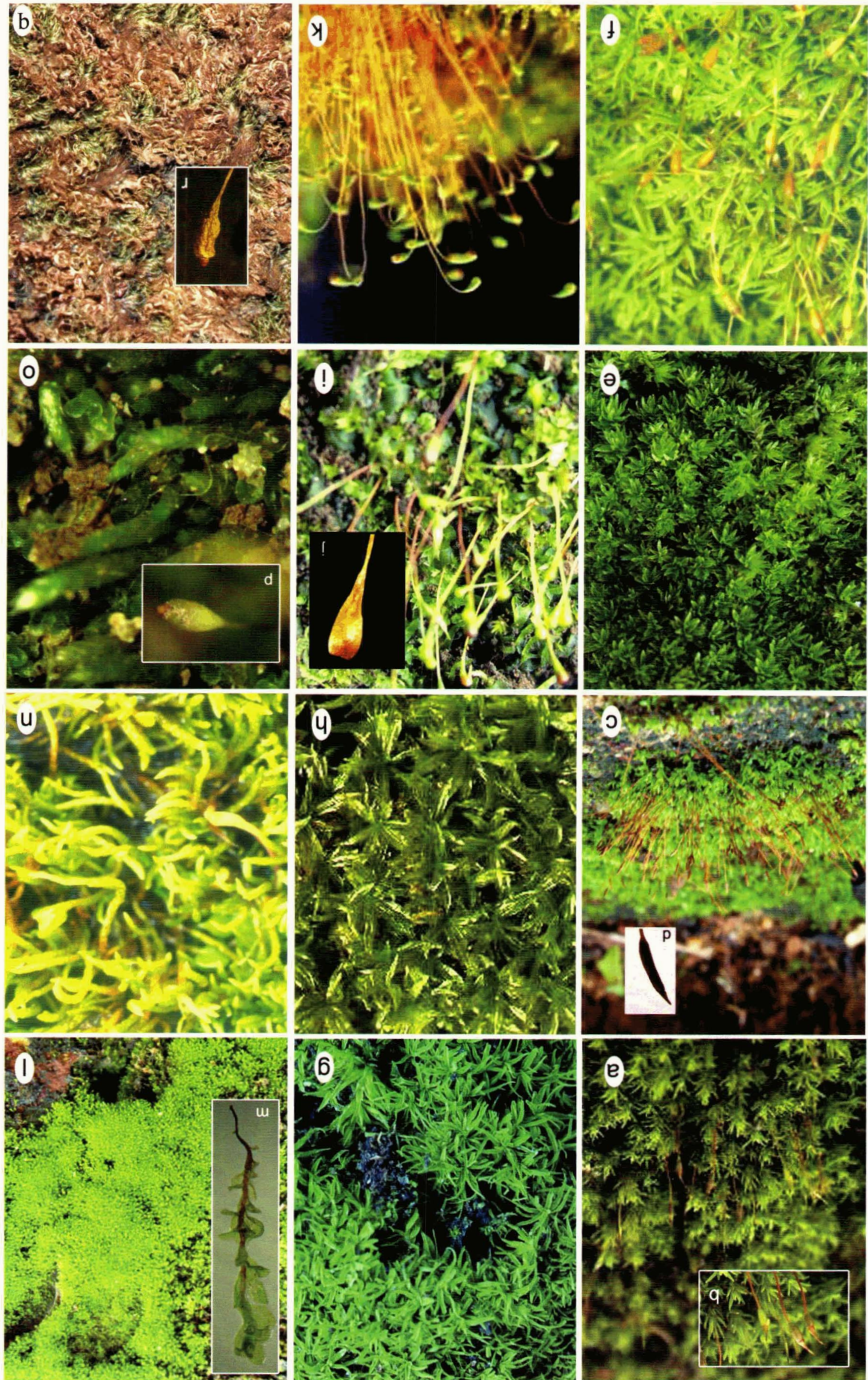
Plants yellowish, gregarious; leaves more or less erect to convolute, forming a bud like structure of various shapes, acuminate; costa ending below the apex to shortly excurrent; cells elongate, rectangular to rhomboidal, sometimes elongate towards the margin forming a narrow border; seta short or long, erect; capsule asymmetric, erect to pendulous, peristome deeply inserted, double, single or absent, reddish to brownish, mostly oblique, twisted towards right, inner peristome as long as outer or shorter, calyptra persistent, long beaked, smooth with entire margin; spores moderately large.

Funaria hygrometrica Hedw., Sp. Musc. 172. 1801; Gangulee, Moss. E. India 2(4): 856. 1974. *Mnium hygrometricum* (Hedw.) With., Syst. Arr. Br. 3: 787.1801. *Funaria angustifolia* Brid., Sp. Musc. 3: 71. 1817. *F. androgyna* Brid., Bryol. Univ. 2: 58. 1827. *F. ramificans* Brid., Bryol. Univ. 738. 1827. *F. campylopus* Brid., Bryol. Univ. 739. 1827. *F. gracilescens* Schimp. & C.Muell., Bot. Zeitung. Berlin 16: 154. 1858. *F. marginata* Kindb., Bih. K. Svensk. Vet. Ak. Handl. 7: 79. 1883. *F. megapoda* C.Muell., Bull. Herb. Boiss. 5: 175. 1897. *F. globicarpa* C.Muell., Nuov. Giorn. Bot. Ital. N. ser. 5: 161. 1898. *F. lonchopelma* C.Muell., Hedwigia 38: 61. 1899.

Plants green to yellowish-green, in loose to compact tufts, simple or branched; stem slender, erect, 1-1.5 mm long; leaves up to 3 x 1 mm, concave, obovate to lanceolate, acute, entire, at lower half small, leaves curved and folded when dry, spreading when moist; costa strong ending below apex; cells at upper half subhexagonal, elongated, 40-42 x 30-33 μm , cells at base rectangular, 33-77 x 20-25 μm , slightly narrower at margin; seta erect, terminal,

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Plate. 11. a: *Barbula indica*, b: sporophyte, c: *Hypophila involuta*, d: capsule, e: *Hypophila nymaniana*, f: *Hymenostomum edentulum*, g: *Oxysetegus cylindricus*, h: *Scopelophila cataractae*, i: *Entosthodon wichurae*, j: capsule, k: *Funaria hygrometrica*, l: *Gymnostomella verrucosa* var. *tenerum*, m: single plant, n: *Anomobryum auratum*, o: *Brachymerium exile*, p: capsule, q: *Brachymerium nepalense*, r: capsule



reddish at maturity, up to 3.5 cm long, twisted, hygroscopic; capsule horizontal to pendulous, curved, pyriform, mouth narrow, globose at back, orange-brown, operculum large, convex, mouth wide, bear two rows of teeth, closely and obliquely arranged in a spiral turn, each row of 16 teeth, calyptra persistent, cucullate, smooth; spores brownish, rounded, 13-16 μm in diameter. (Fig. 19: n-r & Plate 11k).

Habitat: Grow on moist soil, rocks and brick walls in large patches associated with other mosses in homestead areas.

Specimen examined: Hairpin point (550 m) MCN 80115a.

Distribution: A cosmopolitan species distributed in South India (Kerala: Chinnar WLS, Tamil Nadu: Nilgiri hills, Palni hills), North-east India (Himalayas, Kashmir, Manipur, Naga hills, Orissa), Sri Lanka, China, Japan, Korea, Myanmar, New Zealand, Siberia, Taiwan, Thailand, Tibet, Europe, North & South America, Africa, Australia and Oceania.

SPLACHNACEAE Grev. & Arn.

Mem. Wernerian Soc. 5: 442. 1824.

Plants small to medium sized, usually growing on decayed organic matter; rhizoids papillose; leaves broad, shrunk when dry, margin entire; cells papillose to mamilllose; costa ending below apex to long excurrent; capsule erect, columella persistent, peristome absent or in a single ring of 16 teeth, operculum conic rostrate.

This family is divided into four subfamilies viz., Splachnobryoideae, Voitioideae, Taylorioideae and Splachnoideae. In India it is represented by five genera viz., *Gymnostomiella* and *Splachnobryum* under Splachnobryoideae, *Voitia* under Voitioideae, *Tayloria* under Taylorioideae and *Tetraplodon* under Splachnaceae. Of which *Gymnostomiella* and *Splachnobryum* occur in the study area.

Key to the genera

- 1a. Cells at upper half irregularly rounded to hexagonal, papillose, lower cells rectangular, smooth.....**Gymnostomiella**

1b. Cells at upper half shorter, not papillose, lower cells elongate to hexagonal rhomboid.....**Splachnobryum**

Gymnostomiella M.Fleisch.

Die Musci Fl. Buitenz.1: 309. 1900.

Plants minute, soft, delicate, densely gregarious; stem filiform; leaves distant below, crowded in comal tufts, margin flat, entire; costa weak ending below apex or at midleaf; cells at upper half hexagonal, papillose, lower cells rectangular, smooth; seta long; capsule erect, ovoid, peristome absent; spores small, rounded.

Gymnostomiella vernicosa (Hook.) M.Fleisch. var. **tenerum** (C.Muell. ex Dusen) Arts, J. Bryol. 20(2): 424. 1998. *Splachnobryum tenerum* C.Muell. ex Dusen, K. Svensk. Vet. Handl. 28(3): 39. 1896.

Plants yellowish-green, up to 5mm long, delicate, stem filiform, radiculous at base, papillose, with a terminal rosette of leaves; leaves erect to nearly horizontal-spreading, concave, spatulate from a sheathing base, broad, rounded; costa faint, reach $\frac{1}{2}$ of leaf length; cells large, thin walled, upper rounded to hexagonal, papillose to mamilllose, basal cells rectangular, hyaline and smooth; plants remain sterile and propagate from the creeping rhizoids. (Fig. 19: s-x & Plate 11l&m).

Habitat: Seen along the concrete brick walls and painted walls in homestead areas.

Specimen examined: Kalpetta (400 m) MCN 99668.

Distribution: This variety is distributed in low altitude areas of the study area in concrete walls. This variety of *Gymnostomiella vernicosa* was reported from Saudi Arabia, Yemen, Oman, United Arab Emirates, Kuwait, Socotra, Qatar and Bahrain. The present collection is the first report of this variety from India.

Note: This plant looks like a hepatic (*Aplozia* sp.) but the presence of the nerve indicates it as a moss. Hexagonal cells in the lower half of the leaf indicate it as a member of the Funariales. The papillose rhizoids indicate its affinity with Splachnaceae.

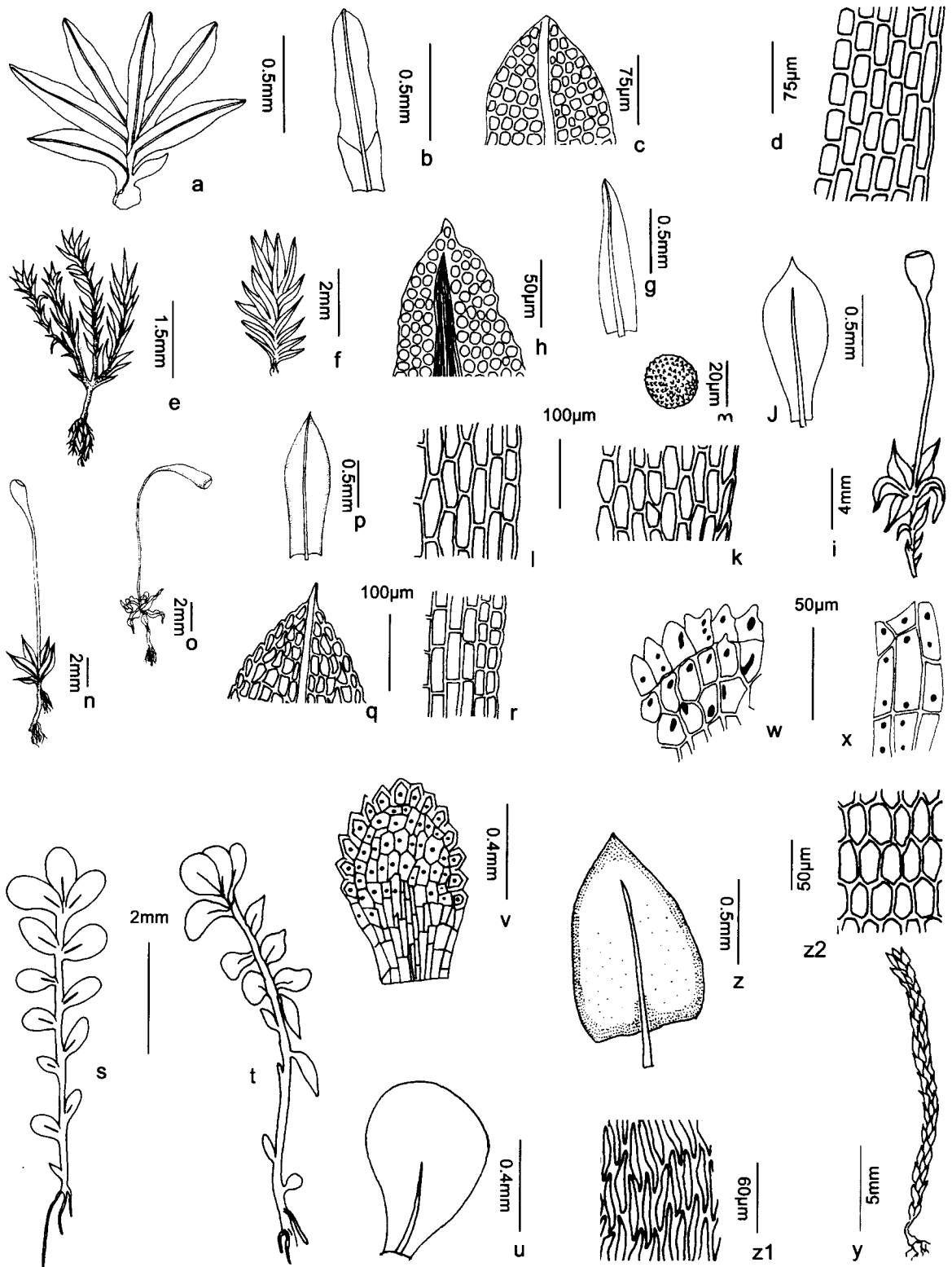


Fig. 19. **a-d**: *Scopelophila cataractae*; **a**: habit, **b**: leaf, **c**: upper leaf cells, **d**: middle cells; **e-h**: *Semibarbula orientalis*; **e&f**: habit, **g**: leaf, **h**: upper leaf cells; **i-m**: *Entosthodon wichurae*; **i**: habit, **j**: leaf, **k**: middle cells, **l**: basal cells, **m**: spore; **n-r**: *Funaria hygrometrica*; **n**: habit, **o**: dry habit, **p**: leaf, **q**: leaf tip cells, **r**: basal cells; **s-x**: *Gymnostomiella vernicosa var. tenerum*; **s&t**: habit, **u**: leaf, **v**: leaf cells, **w**: leaf tip cells enlarged, **x**: above basal cells enlarged; **y-z2**: *Anomobryum auratum*; **y**: habit, **z**: leaf, **z1**: leaf tip cells, **z2**: leaf basal cells

Splachnobryum C.Muell.

Verh. Zool. Bot. Ges. Wien. 19: 503. 1869.

Plants greenish, slender, gregarious; stem radiculose at base, simple or sparingly branched; leaves distant, lingulate to spatulate-lingulate, rounded to acuminate; costa indistinct, ending far below the apex; cells large, thin walled, lower cells elongate hexagonal to elongate rhomboid, shorter only near the apex; seta thin, elongate, twisted; capsule oblong, ovoid to narrowly cylindrical, calyptra conical, cucullate.

Splachnobryum obtusum (Brid.) C.Muell., Verh. Zool. Bot. Ges. Wien 19: 503. 1869. *Weissia obtusa* Brid., Sp. Musc. 1: 118. 1806. *Splachnobryum flaccidum* (Harv.) Braithw., Grevillea 1: 28. 1872; Gangulee, Moss. E. India 2: 867. 1974. *Weissia flaccida* Harv. in Hook., Icon. Pl. Rar. 1: 18f. 3. 1836. *Splachnobryum indicum* Hamp. & C.Muell., Linnaea 37: 174. 1872.

Plants green, soft, stem thin, simple or branched, 6-10 mm long, sparingly radiculose below; leaves concave, oblong to lingulate, thin, pellucid, $\pm 1 \times 0.2-0.3$ mm, apex rounded, margin flat, entire, except slight dentation at apex; costa yellowish-green, ending below apex; cells thin walled, long, rectangular to hexagonal, 50-65 x 8-10 μm , more chlorophyllose at tip, 15-20 x 6-8 μm , marginal cells smaller, subquadrate.

Habitat: Terrestrial in moist deciduous forests.

Specimen examined: Tholpetty (850 m) MCN 99666.

Distribution: It is a rare in Wayanad and was earlier recorded from Western Ghats of Tamil Nadu; North India (Delhi, Western Himalaya), Myanmar, Java and Philippines. The present collection is a new record to Kerala.

Oder EUBRYALES

BRYACEAE Schwaegr.

in Willd., Sp. Pl. ed. 4, 5(2): 47. 1830.

Plants yellowish to dark greenish or silvery, size varies, usually tufted, terrestrial or rupestrine, sometimes epiphytic; stem erect, radiculose, often with subfloral innovation; leaves thin, lanceolate, at lower half small and distantly

placed, upper larger usually forming comal tufts, shrunk when dry, mostly bordered by 2 or 3 layers of elongated cells; costa ending near apex or excurrent; cells near leaf base quadrate to rectangular, above base rhomboid to hexagonal or linearly vermiform not in oblique rows; seta long, smooth; capsule pendulous, erect in some, calyptra narrow, cucullate, smooth.

This family is represented by about 12 genera among these 10 genera occur in India under two subfamilies. Of these four genera viz., *Anomobryum*, *Bryum*, *Brachymenium* and *Rhodobryum* belongs to the subfamily Bryoideae occur in Wayanad.

Key to the genera

- 1a. Main stem erect, no subterranean rhizomatous growth; leaf marginal serration simple.....2
- 1b. Main stem creeping with subterranean rhizomatous growth**Rhodobryum**
- 2a. Capsule erect or suberect.....**Brachymenium**
- 2b. Capsule nodding.....3
- 3a. Plants slender, erect, julaceous to filiform; leaf cells linear-rhomboid above**Anomobryum**
- 3b. Plants strong, erect to prostrate, not julaceous or filiform; leaf cells rhomboid above but not linear**Bryum**

Anomobryum Schimp.

Synop. Musc. Eur. 1: 382. 1860.

Plants slender, julaceous to filiform, glossy, erect; leaves closely imbricate, ovate to oblong, obtuse or acute, flat, entire, appressed to the stem; costa ending well below apex to excurrent; cells of upper half firm walled, rhomboid to linear, lower cells wide, rhomboidal to hexagonal, thin walled; seta apical, erect; capsule horizontal to pendulous.

Note: This genus can be easily recognized by its filiform julaceous shoot.

Anomobryum auratum (Mitt.) A.Jaeger, Bericht. St. Gall. Naturw. Ges. 1873-74: 142. 1875; P.Bruehl, Rec. Bot. Surv. India 13: 49. 1931; Gangulee, Moss. E. India 2(4): 955. 1974; Chopra, Tax. Ind. Mosses 209. 1975; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986. *Bryum auratum* Mitt., Musc. Ind. Orient.

67. 1859. *Brachymenium filiforme* Griff., Calcutta J. Nat. Hist. 3: 58. 1843. *Bryum filiforme* (Griff.) Mitt., Musc. Ind. Orient. 67. 1859. *B. cymbifolium* Lindb., Not. Saellsk. Fauna Fl. Fenn. Forh. 11: 45. 1870. *Anomobryum filiforme* (Griff.) A. Jaeger, Ber. Senckenberg. Naturf. Ges. 1873-74: 142. 1875, *nom. illeg.* *A. cymbifolium* (Lindb.) Broth., Rec. Bot. Surv. India 1: 320. 1899. *Bryum benguetiae* Paris, Index Bryol. Suppl. 57. 1900. *Anomobryum sulcatum* Ther. & Vard., Rev. Bryol. 47: 50. 1920. *A. latifolium* Cardot & P. Vard., Rev. Bryol. 50: 19. 1923.

Plants shining yellowish-green, filiform, densely tufted, with catkin like branches, up to 3 cm long, 0.5-1 mm wide, densely radiculose below; leaves closely appressed to stem, 1-1.2 x 0.4-0.6 mm, cymbiform, ovate-elliptical, densely imbricate, to form a cylindrical appearance, apiculate; costa slender, pale brown, ending well below apex; cells elongated, 60 x 5 μm , upper cells with thickened walls, basal cells rhomboidal, ca 50 x 20 μm , thin walled, subrectangular to hexagonal, hyaline. (Fig. 19: y-z2 & Plate 11n).

Habitat: Plants grow on moist exposed rocks and moist soil in semi-evergreen and evergreen forests.

Specimens examined: Hairpin point (500 m) MCN 80082, Soojippara (760 m) MCN 87102a.

Distribution: Though locally abundant it is not much frequent. It is distributed in South India (Kerala: ENP; Karnataka: Mahabaleswar; Tamil Nadu), North-east India (Darjeeling, Western Himalayas, Kashmir, Meghalaya, Naga hills, Sikkim), Sri Lanka, China, Bhutan, Nepal, Korea, Japan, Philippines, Tanzania, Kenya and Madagascar.

Brachymenium Schwaegr.

in Hedw., Sp. Musc. Suppl. 2(1): 131. 1824.

Plant small to medium sized, erect, tufted with subfloral innovations; leaves ovate, acuminate; costa excurrent; cells smooth, at upper part rhomboid, basal shortly rectangular; seta long, erect, stiff; capsule erect or suberect, peristome 16 toothed, papillose, inner peristome without differentiated segments.

Key to the species

- 1a. Plants tomentose below; apophysis narrow.....**B. exile**
1b. Plants tomentose throughout; capsule with short tapering apophysis.....
.....**B. nepalense**

Brachymenium exile (Dozy & Molk.) Bosch & Sande-Lac., Bryol. Jav. 1: 139. 1860; P.Bruehl, Rec. Bot. Surv. India 13: 49. 1931; C.Sreeni., Mosses S. India 18. 1974; Gangulee, Moss. E. India 2(4): 947. 1974; Smith, J. Hattori Bot. Lab. 40: 71. 1976; Pursell & Reese, J. Hattori Bot. Lab. 53: 459. 1983. *Bryum exile* Dozy & Molk., Ann. Sc. Nat. Bot. ser. 3, 2: 300. 1844. *B. micans* Mitt., J. Proc. Linn. Soc. Bot. (Suppl.) 68. 1859. *Brachymenium micans* (Mitt.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1873-74: 121. 1875. *Bryum fisheri* Cardot & Dixon in Dixon, J. Bot. 49: 143. 1911; P.Bruehl, Rec. Bot. Surv. India 13(1): 49. 1931. *Microphilonotis gemmipara* Sakurai, J. Jap. Bot. 27: 279. 1982.

Plants yellowish-green, small, loosely tufted, up to 3 mm long, stem erect, tomentose below; leaves ovate, acuminate, not much changed or contorted when dry, imbricate when moist, up to 2 x 0.05 mm, entire, not bordered, leaves crowded above; costa strong, excurrent; cells rhomboid-hexagonal at upper and middle, up to 45 x 10 µm, lower cells quadrate, near midrib 50 x 15 µm; seta long, 1.3 cm high; capsule erect, bryum type, apophysis narrow; spores rounded, small, 15-20 µm diagonally. (Fig. 20: a-e & Plate 11o&p).

Habitat: This species is seen in a wide range of microhabitat such as on small stones, rocky patches, logs, soil, along with *Bryum argenteum*, *Hyophila involuta* etc. and also on muddy walls in moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Chandanathode (900 m) MCN & PVM 80074b, Kurichiad range, Dottappalam (816 m) MCN 84527, Soojippara (760 m) MCN & KPR 87094, MCN & KPR 87099, MCN & KPR 87103.

Distribution: A South and East Asiatic Pacific species distributed in South India (Kerala, Tamil Nadu), North-east India (Darjeeling, Western Himalayas, Naga

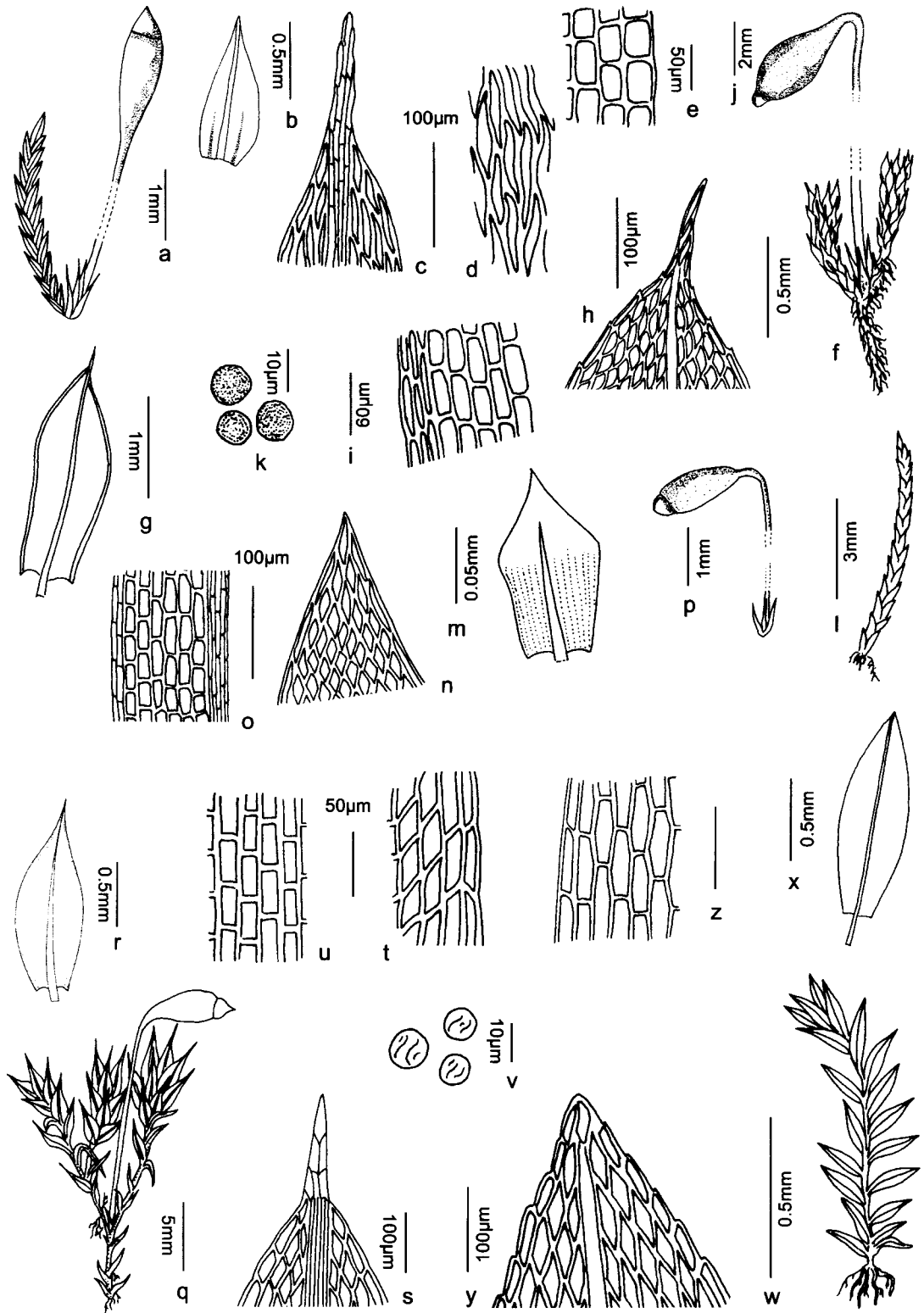


Fig. 20 a-e: *Brachymenium exile*; a: habit, b: leaf, c: leaf tip cells, d: middle cells, e: basal cells; f-k: *Brachymenium nepalense*; f: habit, g: leaf, h: leaf tip cells, i: basal cells, j: sporophyte, k: spores; l-p: *Bryum argenteum*; l: habit, m: leaf, n: leaf tip cells, o: basal cells, p: sporophyte; q-v: *Bryum capillare*; q: habit, r: leaf, s: leaf tip cells, t: middle cells, u: basal cells, v: spores; w-z: *Bryum cellulare*; w: habit, x: leaf, y: leaf tip cells, z: basal cells

hills), Sri Lanka, East Nepal, Japan, Korea, Java, Tonkin, Bolivia, Columbia and Peru.

Brachymerium nepalense Hook. in Schwaegr., Sp. Musc. Suppl. 2(1): 131. 1824; Gangulee, Moss. E. India 2(4): 937. 1974. *Bryum erectum* Brid., Bryol. Univ. 1: 602. 1826, *nom. inval.* *B. hookeri* Spreng., Syst. Veg. 4(1): 212. 1827. *Brachymerium contortum* Griff., Calcutta J. Nat. Hist. 3: 56. 1843. *Bryum brevicaule* Hamp. & C.Muell., Synop. Musc. Frond. 1: 323. 1848. *B. clavariaeforme* C.Muell., Bot. Zeitung 11: 24. 1853. *Brachymerium brevicaule* (Hamp. & C.Muell.) Mitt. & Wils, Kew J. Bot. 9: 330. 1857. *B. hookeri* (Spreng.) Bosch & Sande-Lac., Bryol. Jav. 1: 138. 1860. *Bryum orthopelma* C.Muell., Linnaea 38: 550. 1874. *Brachymerium clavariaeforme* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1873-'74: 119. 1875. *B. orthopelma* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-'78: 439. 1880. *B. clavulum* Mitt., Trans. Linn. Soc. Bot. ser. 2, 3: 165. 1891. *B. isochryroneuron* Cardot, Rev. Bryol. 28: 114. 1901. *B. parvulum* Broth., Symb. Sin. 4: 54. 1929. *B. sapoznikovi* Podp., Publ. Fac. Sc. Univ. Masaryk Brno. 116: 12. 1929. *B. nordenskioldii* Besch. f. *kiiense* Horik. & Ochi in Ochi, J. Jap. Bot. 28: 338. 1953.

Plants yellowish-green, tomentose throughout, 1-2 mm long, new shoots arises from the basal portion of the old ones; leaves ovate-lanceolate, margin bordered, acuminate, up to 2 x 0.3-0.5 mm, margin entire except at tip where minutely serrated; costa prominent, excurrent, arista long; cells at upper half linear-elongated to rhomboid, 35-40 x 12 μ m, lower quadrangular, 55-60 x 15-20 μ m, bordered by 2-3 layers of elongated cells; sporophyte arises from the basal portion; seta yellowish-brown, up to 1.5 cm long; capsule erect to drooping, 5 mm long, apophysis short, tapering, peristome orange; spores numerous, spherical, yellowish, 8-10 μ m. (Fig. 20: f-k & Plate 11q&r).

Habitat: Epiphytic on trunks of *Tectona grandis* in moist deciduous forests.

Specimen examined: Tholpetty (820 m) MCN 99667.

Distribution: *B. nepalense* is an Afro-Asiatic species distributed in South India (Kerala; Karnataka: Mahabaleswar; Tamil Nadu: Nilgiri hills), North-east India

(Simla, Kumaon, Garhwal), Sri Lanka, Thailand, Sumatra, Java, Borneo, Celebes, New Guinea, Myanmar, China, Taiwan, Indonesia, Japan, Philippines and Africa.

Bryum Hedw.

Sp. Musc. 178. 1801.

Plants small to robust, densely tufted, stem tomentose, mostly with subapical innovations, simple or branched; rhizoids numerous, brown, tubers present in some; leaves large, bordered or non bordered, ovate or ovate lanceolate, acuminate, lower leaves smaller, distant, upper larger; cells sub rectangular at base, narrow-rhomboidal above but not linear, smooth; seta long, erect, mostly red, arcuate at tip; capsule clavate, pyriform, with a distinct neck, sometimes broadly ovate, apophysis tapering, peristome usually double; spores rounded, 10-15 μm diagonally.

Key to the species

- 1a. Plants glossy, silvery green; leaves closely imbricate; costa faint, ending far below apex..... **B. argenteum**
- 1b. Plants yellowish-green, brown or reddish; leaves spreading; costa strong, percurrent or excurrent..... 2
- 2a. Costa percurrent..... **B. cellulare**
- 2b. Costa excurrent..... 3
- 3a. Leaves spirally twisted when dry..... **B. capillare**
- 3b. Leaves not spirally twisted when dry..... 4
- 4a. Leaves strongly concave; innovations not showing comal tufts..... 5
- 4b. Leaves not so strongly concave; innovations showing comal tufts..... **B. pseudotriquetrum**
- 5a. Capsule pendulous, apophysis thick spongy..... **B. coronatum**
- 5b. Capsule clavate, very wide mouthed..... 6
- 6a. Plants large, 2-12 cm high..... **B. wightii**
- 6b. Plants small, up to 2 cm high..... 7
- 7a. Leaves acuminate, closely overlapping **B. plumosum**
- 7b. Leaves acute, alternate, not closely overlapping..... **Bryum sp.**

Bryum argenteum Hedw., Sp. Musc. 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. Sect. B. 2: 249. 1930 & J. Bombay Nat. Hist. Soc. 58: 25. 1961. *Argyrobryum argenteum* (Hedw.) Kindb., Bih. Kong. Svensk. Vet.-Akad. Handlingar 7(9): 78. 1883. *Brachymenium argenteoides* Dixon, Notes Roy. Bot. Gard. Edinburgh 19: 289. 1938. *B. brachyphyllum* Taylor in Mitt., J. Linn. Soc. Bot. 12: 302. 1869. *B. candicans* Taylor in Mitt., J. Linn. Soc. Bot. 12: 303. 1869. *B. corrugatum* Hampe, Bot. Zeitung (Berlin) 27: 868. 1869. *B. leucurum* C.Muell., Linnaea 42: 479. 1879. *B. stenopyxis* C.Muell., Linnaea 42: 480. 1879. *B. niveum* Herzog, Biblioth. Bot. 88: 13. 1920.

Plants small, glossy, in silver tufts, 0.7-1.5 mm long; leaves closely imbricate, concave, obovate from a narrow base, margin entire, tip sharp-pointed; costa faint, ending far below the apex; cells rhomboid at upper half, poor in chlorophyll, thin walled, lower leaves chlorophyllose, bordered by small, linear cells, smaller than the inner quadrate cells; seta 2 cm long; capsule horizontal to hanging, brownish, 1.2 mm long; spores numerous, rounded, brownish, 7-10 µm in diameter. (Fig. 20: l-p & Plate 12a&b).

Habitat: On moist soil and on exposed rocks alongwith *Brachymenium exile* and *Hyophila involuta* in moist deciduous, semi-evergreen, evergreen forests and grasslands.

Specimens examined: Chandanathode (900 m) *MCN & PVM 80074a*, Near Chembra estate (1058 m) *MCN 120231*, Chembra hills (1340 m) *MCN 120287*, Thirunelli RF (1180 m) *MCN 99625*.

Distribution: It is a cosmopolitan species in the study area. It has earlier reported from South India (Kerala: Eravikulam National Park, Chinnar WLS; Tamil Nadu: Nilgiri, Palni hills), China, Japan, Malaysia, Papua New Guinea, Philippines, Taiwan, Thailand, Vietnam, Madagascar, America, Africa and Europe.

Note: This species can be easily identified from the field by its silvery glossy appearance, and the leaves resemble closely overlapping scale. It can be used in bonsai plantings as an adornment.

Bryum capillare Hedw., Sp. Musc. 182. 1801; P.Bruehl, Rec. Bot. Surv. India 13(1): 53. 1931; Gangulee, Moss. E. India 2(4): 987. 1974; Ochi, J. Fac. Educ. Tottori Univ. Nat. Sci. 34: 58. 1985. *Bryum squavidum* Brid., Musc. Rec. 2(3): 52. 1803. *B. torquescens* De Not., Syllab. Musc. 163. 1838. *B. philippianum* C.Muell., Linnaea 18 : 701. 1845. *B. capillare* var. *capense* C.Muell., Syn. Musc. Frond. 1: 281. 1848. *B. pyrothecium* C.Muell. & Hamp., Linnaea 26: 495. 1855. *B. cuspidatum* Wils., Kew J. Bot. 9: 364. 1857, *nom. illeg.* *B. thomsonii* Mitt., Musc. Ind. Orient. 75. 1859. *B. teneriffae* Hamp. in C.Muell., Bot. Zeitung. Berlin 20: 12. 1862. *Rhodobryum albo-limbatum* Hamp. & C.Muell., Linnaea 36: 517. 1870. *Bryum albo-limbatum* (Hamp. & C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1973-74: 191. 1875. *B. nanocoma* C.Muell., Linnaea 43: 365. 1882. *B. sawyeri* Renauld & Cardot, Rev. Bryol. 15: 71. 1888. *B. speirophyllum* Kindb., Bull. Soc. Bot. Ital. 1895: 17. 1895. *B. squarrosum* Kindb. in Roell, Hedwigia 35: 66. 1896, *nom. illeg.* *B. plebejum* C.Muell., Hedwigia 37: 94. 1898. *B. microsporum* Broth., Oefv. Finsk. Vet. Foerh. 42: 100. 1899, *nom. illeg.* *B. baileyi* Holz., Bryologist 8: 54. 1905, *nom. illeg.* *B. rubrolimbatum* Broth., Philipp. J. Sci. 5C: 147. 1910. *B. capense* (C.Muell.) Podp., Act. Sc. Nat. Moray. 22: 439. 1950.

Plant yellowish-green above, reddish below, up to 1.5 cm long, branched, rhizomatous; leaves ovate, acuminate, concave, 1-1.2 x 0.5 mm, margin smooth, 1-2 layers of marginal cells elongated, 90-100 µm long, leaves spirally twisted when dry; costa thick below, tapering upwards, excurrent; cells thin walled, upper cells rhomboid-hexagonal, 35-50 x 10-15 µm, middle cells 50-58 x 15-18 µm, lower cells rectangular, 40-55 x 15-28 µm, leaf attachment cells coloured; seta long, up to 2.8 cm long; capsule erect to horizontal, 1.8-2.2 mm long, calyptra cucullate; spores small, numerous, hyaline, up to 10 µm diagonally. (Fig. 20: q-v).

Habitat: On damp soil or on small rocks in semishaded areas of semi-evergreen forests.

Specimen examined: Manikkunnumala (940 m) MCN 120306.

Distribution: It was collected from only one locality in the study area. It is a cosmopolitan species found distributed in South India (Tamil Nadu: Palni hills),

North India (Western Himalaya, Kashmir), China, Thailand, Vietnam, Taiwan, Korea, Japan, Siberia, Central Asia, Europe, North & Central Africa, North & South America, Australia and New Zealand. The present collection is a new record to Kerala.

Bryum cellulare Hook., Sp. Musc. Suppl. 3(1): 214a. 1827; Gangulee, Moss. E. India 2(4): 969. 1974. *Brachymenium cellulare* (Hook.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1873-74: 111. 1875. *Pohlia turbinata* Schwaegr., Sp. Musc. Suppl. 2(2): 150. 1827. *Brachymenium splachnoides* Harv. in Hook., Icon. Pl. Rar. 1 : 19. 1836. *Bryum splachnoides* (Harv.) C.Muell., Synop. Musc. Frond. 1: 291. 1848. *B. compressidens* C.Muell., Synop. Musc. Frond. 1: 290. 1848. *Plagiobryum wildii* Broth., Oefv. Vet. Soc. Foerh. 33 : 101. 1891. *Brachymenium japonense* Besch., Ann. Sc. Nat. Bot. ser. 7, 17 : 340. 1893. *Bryum japonicum* C.Muell., Gen. Musc. Fr. 204. 1900. *B. wildii* (Broth.) C.Muell., Gen. Musc. Fr. 204. 1900. *Webera thermalis* Besch., Oefv. K. Vet. Ak. Foerh. 57: 291. 1900. *Epipterygium thermale* (Besch.) Broth., Nat. Pflanzenfam. 1(3): 555. 1903. *Bryum japonense* (Besch.) Broth., Nat. Pflanzenfam. I (3): 576. 1903. *B. calabricum* Warnst. & M.Fleisch., Roth Eur. Laubm. 2: 68. 1904. *B. diversifolium* Broth., Philipp. J. Sci. 5 : 147. 1910. *B. formosanum* Broth., Oefv. Finsk. Vet. Soc. Foerh. 62A(9): 17. 1921. *Brachymenium cumingii* Ther., Bull. Soc. Bot. Gen. 26: 85. 1936. *Bryum epipterygoides* Ochi, J. Jap. Bot. 29: 212. 1954.

Plants light green to purplish brown, up to 1 cm long, tomentose at the base, arise from protonemal filaments, not crowded, slightly glossy; leaves ovate to oblong, tip obtuse, closely overlapping, 1 mm long, arranged in three tiers, bordered all around, slightly serrated by the elongation of the marginal cells, leaf insertion to the stem deep; costa prominent, purplish brown, percurrent or ending below apex; cells elongated, rhomboid at apex, 75-80 x 12-15 μm , basal subquadrangular to hexagonal, 88-92 x 15-20 μm ; seta erect, brownish, up to 2 cm or more long; capsule erect to pendulous, globose; spores numerous, brownish, rounded, 15-20 μm (Fig. 20: w-z & Plate 12c).

Habitat: On soil cuttings along with other mosses in semi-evergreen forests.

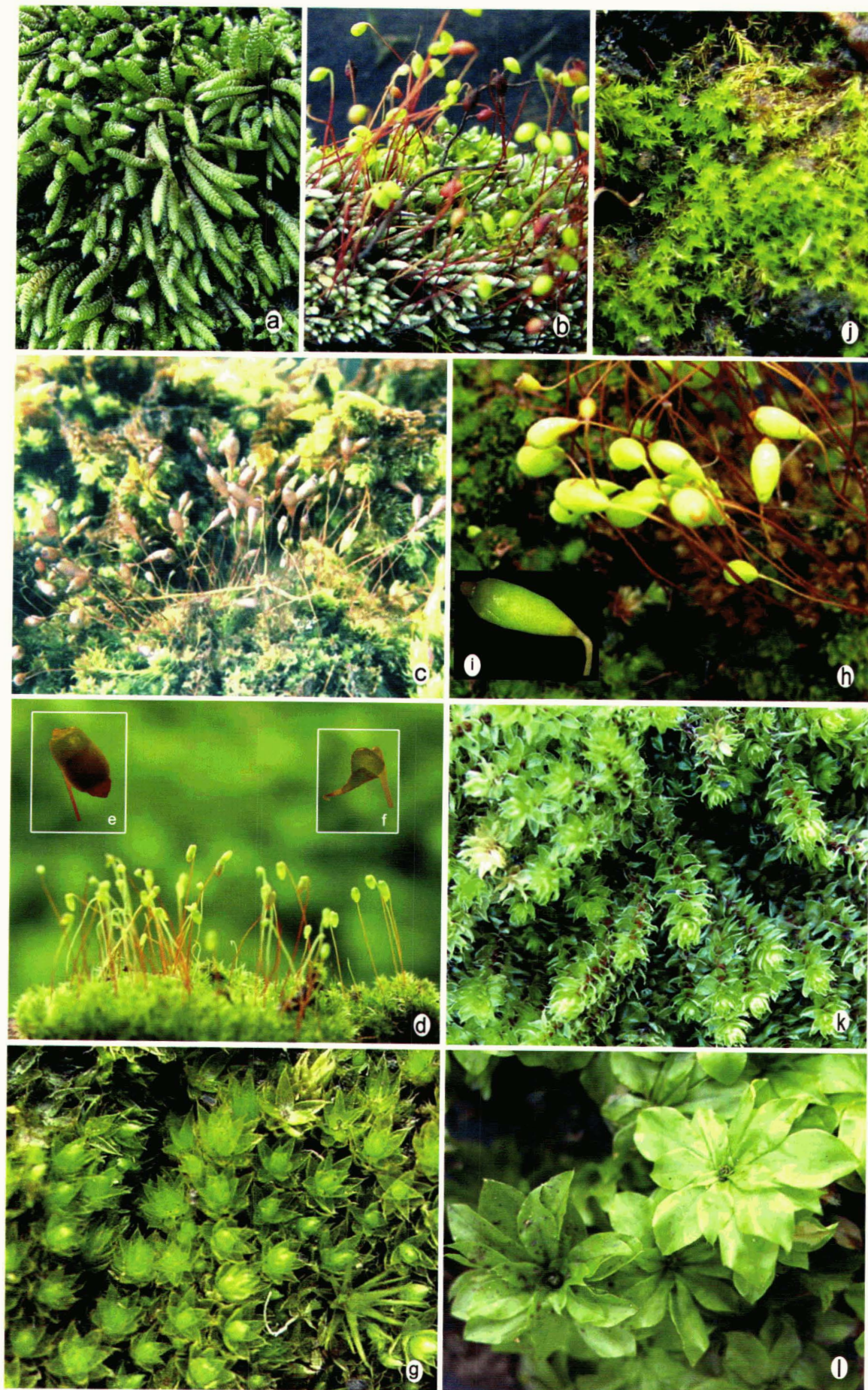


Plate. 12. a: *Bryum argenteum*, b: plant with sporophyte, c: *Bryum cellulare*, d: *B. coronatum*, e: mature capsule, f: young capsule, g: *Bryum plumosum*, h: *B. pseudotriquetrum*, i: capsule, j: *Bryum* sp., k: *B. wightii*, l: *Rhodobryum giganteum*

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Specimen examined: Chandanathode (750 m) MCN 80102.

Distribution: A wide spread species distributed in North India (Western Himalayas), Myanmar, China, Japan, Sumatra, Java, Philippines, Taiwan, Europe, North & Central Africa and Australia. The present collection is a new record to Peninsular India.

Bryum coronatum Schwaegr., Sp. Musc. Suppl. 7(2): 103. 1816; Gangulee, Moss. E. India 2(4): 1002. 1974; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986. *Bryum angustifolium* Brid., Sp. Musc. 3: 31. 1817. *B. doliolum* Dub. in Moritzi, Syst. Verz. Zoll. Pfl. 133. 1846. *B. brevicaule* Hamp., Linnaea 36: 518. 1870, *nom. Illeg.* *B. macropelma* C.Muell., Linnaea 37: 149. 1872, *nom. Illeg.* *B. gracilifolium* C.Muell., Linnaea 38: 390. 1875. *B. barbulateum* C.Muell., Linnaea 39: 389. 1875. *B. convolutaceum* C.Muell., Linnaea 39: 388. 1875. *B. zygodontoides* C.Muell., Bot. Jahrb. 5: 83. 1883. *B. balanocarpum* Besch., Bull. Soc. Bot. Fr. 41: 82. 1894. *B. curtum* Paris, Index Bryol. Suppl. 176. 1894.

Plant bright to dull greenish, densely tufted, 1-3 mm long, tomentose at base; stem erect, branched from base, tomentose at base; leaves ovate to oblong-lanceolate, lower leaves smaller, $\pm 3 \times 1$ mm, erect spreading when moist, contorted when dry, acuminate; costa strong, reddish, excurrent; cells at upper part thin, rhomboid to hexagonal, 50-58 x 8 μ m, basal cells shorter, rectangular, thin walled, 35-40 x 15-19 μ m, one layer of elongated cells as marginal border, tip serrated; seta apical, erect, reddish, 2-3 cm long; capsule pendulous, shaped like a cup in another cup, up to 2 mm long, apophysis thick, spongy, peristome reddish. (Fig. 21: a-f & Plate 12d,e&f).

Habitat: On calcareous soils or walls and also on rocks alongwith *Funaria hygrometrica* and *Hyophila involuta* in homesteads and in semi-evergreen forests.

Specimens examined: Hairpin point (550 m) MCN 80115b, Soojippara (767 m) MCN & KPR 87077.

Distribution: It is common throughout the study area, mostly in the mid altitudinal range from 500-800 m. It is widely distributed in India, China, Borneo, Philippines, Thailand, Brazil, Bolivia, Peru and Mexico.

Bryum plumosum Dozy. & Molk., Ann. Sci. Nat. Bot. Ser. 3, 3(2): 301. 1844; Gangulee, Moss. E. India 2(4): 1010. 1974; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986. *Bryum pachypoma* Montin, Ann. Sci. Nat. Bot. Ser. 3, 4: 104. 1845. *B. apiculatum* Dozy & Molk., M.Frond. Ined. Archip. 24. 1845, *nom. Illeg.* *B. levilleanum* Dozy & Molk., *Ibid.* 16. 1845. *B. ambiguum* Dub. in Moritzi, Syst. Verz. Zolling. Pfl. 132. 1846. *B. baileyi* Broth., Oefv. Finsk. Vet. Ak. Foerh. 33: 100. 1890. *B. subplumosum* Broth. & Paris, Rev. Bryol. 27: 77. 1900. *Pohlia saxensis* Williams, Bull. N.Y. Bot. Gard. 8: 347. 1914. *Bryum kurandae* Broth. & Watts, Proc. Linn. Soc. N.S. Wales 43: 554. 1918. *B. rubridens* Dixon & Sak., Bot. Mag. Tokyo 51: 10. 1937.

Plants yellowish-green, slender, 5 mm - 2 cm long, variously branched; leaves lanceolate to ovate, lower leaves small, scattered at base, 1-1.5 x 0.2-0.4 mm, upper leaves larger, crowded, 2-3 x 0.4-0.6 mm, strongly acuminate, margin entire, border not differentiated; costa excurrent; cells thin walled, narrow-rhomboid, 80-95 x 10-12 μm at tip, shorter and broader below, 50-60 x 18-22 μm , irregularly rhomboid to hexagonal, large rectangular to quadrate cells at base; seta reddish, apical, erect to suberect; capsule pendulous, reddish brown, wide mouthed, with a slender tapering apophysis, peristome normal. (Fig. 21: g-j & Plate 12g).

Habitat: On earth cuttings in moist deciduous forests.

Specimen examined: Muthanga (878 m) MCN 84510.

Distribution: This species has been located only in one locality. It was reported earlier from South India but without mentioning the precise locality. Also recorded from North-east India (Assam, Calcutta, Orissa, Western Himalaya), Sri Lanka, China, Japan, Sumatra, Java, Celebes, Borneo, Philippines, Taiwan, Australia and New Caledonia. The present collection is a new record to Kerala.

Bryum pseudotriquetrum (Hedw.) Schwaegr., Sp. Suppl. 1(2): 110. 1816; Gangulee, Moss. E. India 2(4): 991. 1974. *Mnium pseudotriquetrum* Hedw., Sp. Musc. 190. 1801. *Bryum cubitale* Dicks. & With., Syst. Arr. Brit. Pl. ed. 4, 3: 823. 1801. *B. ventricosum* Relh., Fl. Cantrabr ed. 2: 427. 1802. *Mnium bimum* Schreb., Bot. Zeitung. Berlin Regensburg 1: 79. 1802. *Bryum bimum* (Schreb.)

Turn., Musc. Hib. 127. 1804. *B. tasmanicum* Hamp., Linnaea 25: 714. 1853. *B. ellipticum* Lac., Ned. Kruidk. Arch. 5: 294. 1861, *nom. illeg.* *B. physcomitrioides* C.Muell. in A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-78: 446. 1880, *nom. nud.* *B. gracilens* Cardot, Bull. Soc. Bot. Gen. ser. 2, 1: 128. 1909. *B. austroaffine* Broth., Proc. Linn. Soc. N.S. Wales 42: 487. 1916. *B. subventricosum* Broth., *ibid.* 586. 1916. *B. samuelssonii* Ther., Rev. Bryol. Lichen 14: 17. 1944.

Plants green above, reddish below, tomentose below; leaves crowded together, ovate to lanceolate, 1.2-2.2 x 0.6 mm, margin plane, faintly serrated at tip, bordered by 1-2 layers of elongated yellowish cells, base wide, often reddish; costa stout, reach far above the tip, pointed, reddish; cells at upper half hexagonal-rhomboid, 50-60 x 10 μ m, lower broad and rectangular, 60 x 10-15 μ m; seta arises from the base of the branches, 2.5 cm long, reddish-brown; capsule elongated, cylindrical, pendulous with a distinct tapering apophysis, 3-5 mm long; spores hyaline, 30-45 μ m diagonally. (Fig. 21: k-q & Plate 12h&i).

Habitat: Seen in a variety of habitats such as on soil in grasslands, on rocky patches, bark of *Cycas circinalis* and on other trees in semi-evergreen, shola forests and in plantations.

Specimens examined: Soojippara (760 m) MCN 87092, Chembra hills (1220 m) MCN 120221, Chembra estate (1100) MCN 120234.

Distribution: A cosmopolitan species distributed in North-east India (Kumaon Himalaya, Sikkim, Kashmir), Nepal, Korea, Columbia, Ecuador, Siberia, Venezuela; Europe, Australia, Africa and Antartica. The present collection is a new record to Peninsular India.

Bryum wightii Mitt., J. Linn. Soc. Bot. Suppl. 1: 74. 1859; Gangulee, Moss. E. India 2(4): 983. 1974; Mohamed, J. Bryol. 12: 24. 1982; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986. *Rhodobryum strigosum* Paris, Index Bryol. Suppl. 300. 1900. *Bryum bohnhoffii* C.Muell. & 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 subfloral innovations, 2-12 cm high, tomentose; leaves light green to reddish, often reddish-brown, loosely spreading when

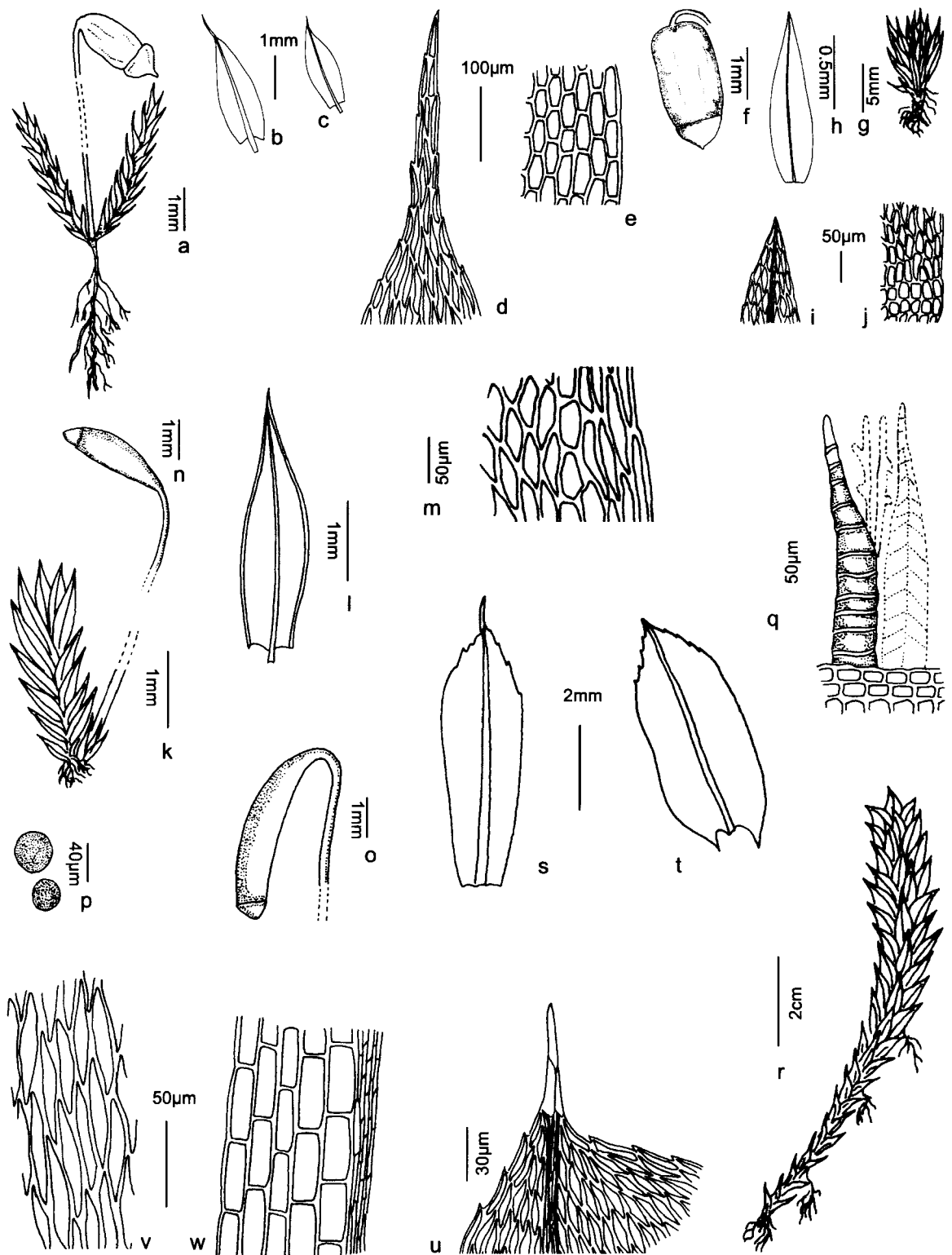


Fig. 21. a-f: *Bryum coronatum*; a: habit, b&c: leaves, d: leaf tip cells, e: basal cells, f: capsule; g-j: *Bryum plumosum*; g: habit, h: leaf, i: leaf tip cells, j: basal cells; k-q: *Bryum pseudotriquetrum*; k: habit, l: leaf, m: upper and middle marginal cells, n&o: capsule from different collection, p: spores, q: peristome; r-w: *Bryum wightii*; r: habit, s&t: leaves, u: leaf tip cells, v: middle cells, w: basal cells

moist, not shrinking and appressed to stem when dry, lower margin reflexed, margin crenulate at apex, 2-3 rows of elongated cells forms the border, triangular to broadly ovate; costa strong, wider at base, narrower towards apex, brownish in older leaves, shortly excurrent; cells at upper half elongate to rhomboid, 60-65 x 8-12 μm , incrassate, basal rectangular, 100-135 x 20-35 μm , porose. (Fig. 21: r-w & Plate 12k).

Habitat: Grows moderately at high altitude regions, near wet areas such as waterfalls, often on moist rocky substratum, mostly associated with *Utricularia* sp. and *Campylopus* sp. in semi-evergreen, evergreen, shola forests and in grasslands.

Specimens examined: Lakkidi (450 m) MCN 80095, Soojippara (760 m) MCN 87101, Chembra hills (1220-1380 m) MCN 120225, MCN 120308, Manikkunnumala, Near MSSRF (970) MCN 120297.

Distribution: This Indo-Sri Lankan species is common in the study area at higher altitudes. This species is also collected from the adjacent areas such as Vellarimala in Kozhikode and Aralam WLS in Kannur districts. It has also reported from other areas of South India (Mahabaleswar, Nilgiri, Palni, Kodaikanal, Maharashtra).

Bryum sp.

Plants yellowish-brown, tomentose below, up to 1 cm x 0.5 mm; leaves linear, up to 3 mm long, extreme tip serrated, acute; costa strong, reach up to the tip; cells at the tip linear-elongated, 50 x 5 μm , basal cells quadrangular, 50 x 25 μm ; seta 2- 3.8 cm; capsule 2-4 mm long, slightly nodding, light yellowish; spores rounded, brownish, 10-14 μm diagonally. (Plate 12j).

Habitat: On soil cuttings in grasslands.

Specimen examined: Kurichiad range, (830 m) MCN 84553a.

Distribution: It is rare in Wayanad and could be collected from only one locality.

Rhodobryum (Schimp.) Limpr.

in Laubm., Deutsch. Oester. Schweiz 2: 444. 1892.

Plants robust in loose tufts, with subterranean rhizomatous growth, leaves at terminal half larger forming rosettes, spreading, lower leaves distant, scale-like, bordered and toothed, teeth mostly two ranked; costa strong, reach up to top; cells at upper side rhomboidal to elongate six sided, basal cells elongate to rectangular; seta apical, long; capsule horizontal to pendulous, operculum convex; spores 14-24 μm diagonally.

Rhodobryum giganteum (Schwaegr.) Paris, Index Bryol. Suppl. 1116. 1898; Gangulee, Moss. E. India 2(4): 1020. 1974; Mohamed, J. Hattori Bot. Lab. 55: 282. 1984; M.C.Nair & Madhus., J. Econ. Taxon. Bot. 25: 573. 2001. *Mnium giganteum* Schwaegr., Sp. Musc. Suppl. 2(2): 20, 158. 1826. *Bryum giganteum* (Schwaegr.) Arnott, Mem. Soc. Linn. Paris 5: 279. 1827. *B. sollyanum* Griff., Calcutta J. Nat. Hist. Sci. 3: 61. 1843 [1842]. *B. pseudogiganteum* C.Muell., Flora 82: 439. 1896. *Rhodobryum pseudogiganteum* (C.Muell.) Paris, Index Bryol. 1119. 1898.

Plants dark greenish-brown, large and robust; stem stoloniferous, branched by subfloral innovations; leaves at upper forming rosettes of large crown, spreading, spatulate from a narrow base, 15 x 2.5 mm, bordered by two layers of elongated cells, teeth in pairs, lower leaves distant, scale-like; costa strong, excurrent, stout below; cells rhomboidal at upper, thin walled, 80-100 x 15-20 μm , basal cells elongate to rectangular, 85-100 x 15-22 μm ; seta long, up to 5 cm long, usually more than one arises from the same perichaetium; capsule horizontal to pendulous, reddish below, 1 mm long; spores rounded, 12-16 μm diagonally. (Fig. 22: a-e & Plate 12l).

Habitat: Seen at high altitude areas mostly on wet rocks, humus rich soils and logs near streams in shola forests.

Specimens examined: Chembra hills (1760 m) MCN 120392.

Distribution: This species is rare in the study area, confined to the shola forests of Chembra hills. Nair and Madhusoodanan (2001) reported this species from the shola forests of ENP of Idukki district of Kerala. It is wide spread in the

tropical and sub tropical region and was earlier reported from South India (Tamil Nadu: Palni hills), North-east India (Darjeeling, Khasi hills, Arunachal Pradesh, Manipur, Sikkim), Sri Lanka, China, Japan, Nepal, Madagascar, Sumatra, Java, Myanmar, Thailand and Oceanic Islands.

MNIACEAE Schwaegr.

in Willd., Sp. Pl. ed. 4. 5(2): 25. 1830.

Plants robust, forming loose mats, fertile stems erect, with terminal large leaves forming a rosette; sterile branches usually prostrate, rooting at the ends and form new foliate branches; leaves curled and crispate when dry, margin biserrate, uniserrate or smooth, usually bordered, ovate-spathulate, to almost rounded-ovate; costa percurrent or ending below tip; cells smooth, usually rounded to hexagonal, often in oblique rows; seta terminal on fertile shoots, long; capsule pendulous or horizontal, Occasionally erect, ovoid-oblong or cylindrical, calyptra small, cucullate.

Brotherus (1925) included seven genera within the family, of which three genera viz., *Orthomnium*, *Orthomniopsis* and *Mnium* are represented in India. Only one genus viz., *Mnium* is represented in the present study area.

Mnium Hedw.

Sp. Musc. 188. 1801, *nom. cons.*

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 in pairs, single or double ranked; cells rounded hexagonal, rarely rhombic; seta erect, long; capsule inclined, rarely erect, mostly oblong-ovoid, sometimes curved.

Mnium rostratum Schrad., Bot. Zeitung. Berlin Regensburg 1: 79. 1802; Gangulee, Moss. E. India 2(4): 1042. 1974; M.C.Nair & Madhus., J. Econ. Taxon. Bot. 25: 573. 2001; Narayan *et al.*, Indian J. For. 24: 269. 2001. *Hypnum rostratum* (Schrad.) F.Weber & Mohr, Ind. Mus. Pl. Crypt. 3. 1803. *Mnium*

longirostre Brid., Musc. Rec. 2(3): 106. 1803. *Bryum rostratum* (Schrad.) Sm., Fl. Brit. 3: 1369. 1804. *Mnium cylindricum* Hoffm. & Brid., Bryol. Univ. 1: 70. 1826, *nom. nud.* *M. rhynchophorum* Hook., Icon. Pl. Rar. 1: 20. 1836. *Bryum coriaceum* Griff., Calcutta J. Nat. Hist. 3: 60. 1843. *Astrophyllum rostratum* (Schrad.) Lindb., Musc. Scand. 13. 1879. *Mnium madagascariense* Kiaier in Wright, J. Bot. 26: 265. 1888, *nom. nud.* *M. prorepens* C.Muell., Flora 82: 437. 1896. *M. orbifolium* C.Muell., Bull. Herb. Boiss. 5: 176. 1897. *M. spathulatulum* Sak., Bot. Mag. Tokyo 49: 769. 1935. *Plagiomnium maximovickzii* (Lindb.) Kop., Ann. Bot. Fenn. 5:147. 1968. *P. rostratum* (Hook.) Kop., *ibid.* same page 1968. *P. rhynchophorum* (Hook.) Kop., Hikobia 6: 57. 1971.

Plants yellowish-green to dark greenish, forming compact creeping mats, crisped and contorted when dry; main stem erect, lateral sterile branches arise from the comal regions or from the stoloniferous base, fertile shoot more crowded at apex, 2-3 cm long, simple or branched; leaves on the prostrate stem complanate, distant, oblong-elliptical, 2-4 x 1.5-2 mm, apex rounded and apiculate, those on the erect fertile stem similar but longer and more acuminate, 5-6 x 2-3 mm; cells thick walled to collenchymatous, irregularly quadrate to hexagonal at top and middle, 15-28 μ m wide, rectangular at base, 55 x 26 μ m, margin prominent, 3 or 4 rows of linear partly free cells; costa strong on the under side, ends in an apiculus; seta strong, reddish, erect to flexuose, about 2 cm long; capsule erect when young, horizontal or pendulous at maturity, yellow to light-brown, ovoid-cylindrical, 2.5-5 x 1.5-2 mm, operculum long-rostrate, beak reddish, peristome normal. (Fig. 22: f-m & Plate 13a&b).

Habitat: On wet rocks, earth cuttings and base of trees near streams in evergreen and shola forests.

Specimens examined: Thirunelli RF (1350 m) MCN 99616, Chembra hills (1760 m) MCN 120396.

Distribution: It is a common species of high altitude region in the study area. Nair and Madhusoodanan (2001) reported this species from the shola forests of ENP of Idukki district. Almost a cosmopolitan species distributed in South India (Kerala; Tamil Nadu: Palni hills, Nilgiri), North-east India (Arunachal Pradesh, Assam, Himalaya, Manipur, Meghalaya, Nagaland), Sri Lanka, China, Japan,

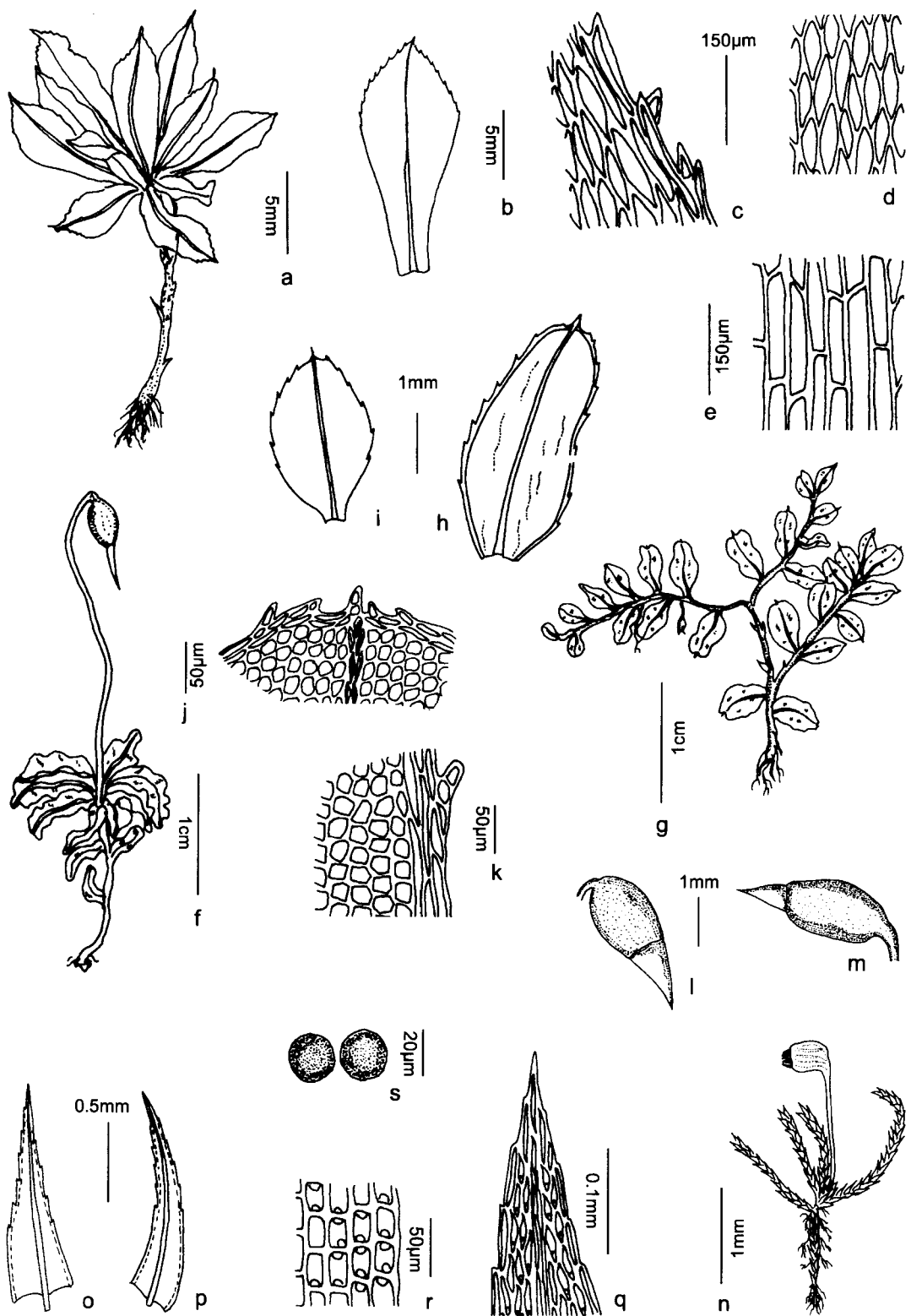


Fig. 22. **a-e:** *Rhodobryum giganteum*; a: habit, b: leaf, c: leaf marginal cells, d: middle cells, e: basal cell; **f-m:** *Mnium rostratum*; f: fertile plant, g: sterile plant, h&i: leaves, j: leaf tip cells, k: leaf marginal cells, l&m: capsule from different plant; **n-s:** *Philonotis fontana*; n: habit, o&p: leaves, q: leaf tip cells, r: basal cells, s: spores

Java, Korea, Myanmar, Nepal, New Guinea, New Zealand, Pakistan, Philippines, Taiwan and Tibet.

RHIZOGONIACEAE Broth.

Nat. Pflanzenfam 1(3): 614. 1904.

Plants greenish to brownish, robust, with erect or flexuose shoots, densely tomentose below; leaves linear-lanceolate, margin flat, usually dentate, 2-ranked, thickened at the border; costa single, strong, excurrent, often spinose on back; cells smooth, thick walled, small, rounded to irregularly hexagonal; seta long, erect to flexuose, arises from the base of branches; capsule suberect to horizontal.

Of the seven genera included within the family by Brotherus (1925) only *Pyrrhobryum* is present in India, which extend to Wayanad.

Pyrrhobryum Mitt.

J. Linn. Soc. Bot. 10: 174. 1868.

Plants greenish above, brownish below; leaves linear-lanceolate, tip incurved when dry, border thick, serrated, teeth often in pairs; costa percurrent, toothed on back above; cells incrassate, rounded to elongate, smooth.

Pyrrhobryum spiniforme (L. ex Hedw.) Mitt., J. Linn. Soc. Bot. 10: 174. 1868. *Hypnum spiniforme* L. ex Hedw., Sp. Musc. 236. 1801. *Rhizogonium spiniforme* (L. ex Hedw.) Bruch in Krauss, Flora 29: 134. 1846; Gangulee, Moss. E. India 2(4): 1068. 1974. *Mnium spiniforme* (L. ex Hedw.) C. Muell., Syn. Musc. Frond. 1: 175. 1848. *Rhynchostegium latifolium* Aongstr., Oefv. K. Vet. Ak. Foerh. 29(4): 18. 1872. *Rhizogonium pervilleanum* Besch., Ann. Sc. Nat. Bor. Ser. 6, 10: 242. 1880. *R. pervillei* Kindb., Enum. Bryin. Exot. 94. 1889.

Plants greenish-brown, in dense tufts, tomentose below, 2.5-4 cm long, flexuose, generally branched from base; leaves flexuose when dry, lower leaves smaller, upper larger, linear-lanceolate, acuminate, 5-8 x 2 mm, margin thicker, serrated with paired teeth; costa strong, excurrent, toothed on back above; cells smooth, ovate to quadrate-hexagonal, 10-12 μ m at top, 12-20 x 5-7 μ m at base; seta brown, erect-flexuose, arises lateral from base, 2-5 cm long; capsule

horizontal to inclined, ovate-cylindrical, peristome large, outer peristome yellowish-brown, inner hyaline; spores yellowish, finely papillose, 15-20 µm diagonally. (Fig. 23: a-f & Plate 13c).

Habitat: On rocky patches and base of tree trunks in evergreen and shola forests.

Specimen examined: Chembra hills (1560 m) MCN 99607.

Distribution: It is distributed in South India (Tamil Nadu: Palni hills), North-east India (Darjeeling, Sikkim, Khasi hills, Assam, Arunachal Pradesh), Sri Lanka, Japan, China, Korea, New Guinea, Java, Borneo, Vietnam, New Caledonia and Philippines. The present collection is a new record to Kerala.

BARTRAMIACEAE Schwaegr.

in Willd., Sp. Pl. ed. 4, 5(2): 90. 1830.

Plants densely tufted, usually robust; leaves lanceolate, acuminate, dentate or serrate; costa percurrent or excurrent, often toothed on back; cells narrow, rectangular, usually mamilllose or papillose; seta lateral or terminal; capsule subglobose, mostly furrowed.

Of the nine genera included under this family, seven *viz.*, *Plagiopus*, *Anacolia*, *Bartramia*, *Bartramidula*, *Philonotis*, *Breutelia* and *Fleischerobryum* are known from India. Among these only one genus *Philonotis*, occur in the study area.

Philonotis Brid.

Bryol. Univ. 2: 15. 1827.

Plants light yellowish to greenish, very slender, in dense tufts, interwoven with smooth or faintly papillose rhizoids, dichotomously branched, with whorled subfloral innovations; leaves elongate-linear, acuminate, serrate or denticulate often by means of paired papillae; costa percurrent to excurrent; cells near the apex elongate to shortly rectangular, 5-6 sided, basal cells large, thin walled, mamilllose on the upper or on both ends; seta elongate, erect; capsule inclined to horizontal, nearly globose, striate, mostly compressed in the middle.

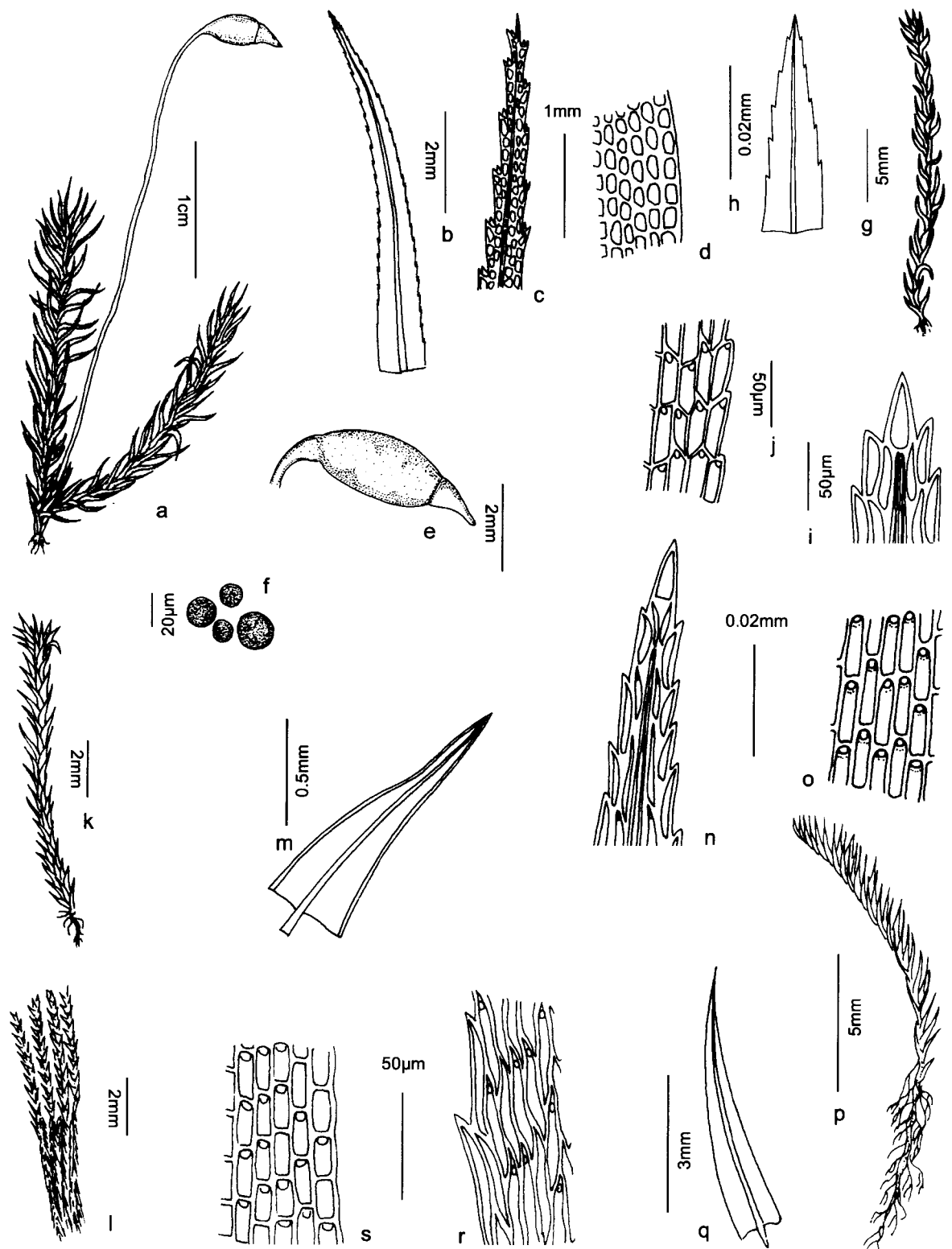


Fig. 23. **a-f:** *Pyrrhobryum spiniforme*; **a:** habit, **b:** leaf, **c:** leaf tip cells, **d:** leaf basal cells, **e:** capsule, **f:** spores; **g-j:** *Philonotis hastata*; **g:** habit, **h:** leaf, **i:** leaf tip cells, **j:** leaf basal cells; **k-o:** *Philonotis mollis*; **k&l:** habit, **m:** leaf, **n:** leaf tip cells, **o:** leaf basal cells; **p-s:** *Philonotis secunda*; **p:** habit, **q:** leaf, **r:** upper marginal cells, **s:** basal cells

Key to the species

- 1a. Leaves narrow-linear, margin rolled inwards.....2
1b. Leaves almost triangular, margin flat.....3
2a. Plants soft; dry leaves not appressed to stem.....**P. mollis**
2b. Plants rough; dry leaves appressed to stem.....4
3a. Leaf cell mamillae never at centre; leaf margin entire at base, serrate
towards apex with paired teeth-like projection.....**P. fontana**
3b. Leaf cell mamillae almost at centre, leaf margin serrated.....
.....not in present collection
4a. Leaves stiff, erect; stem dichotomously branched with whorled leaves;
rhizoids papillose.**P. thwaitesii**
4b. Leaves lax, falcate; stem not dichotomously branched, leaves alternate,
erect; rhizoids smooth.....5
5a. Costa ends below tip; leaf margin biserrated by upturned tip.....**P. hastata**
5b. Costa reach up to tip; leaf margin serration single by upturned marginal cells
.....**P. secunda**

Philonotis fontana (Hedw.) Brid., Bryol. Univ. 2: 18. 1827; Mitt., Musc. Ind. Orient. 63. 1859; P.Bruehl, Rec. Bot. Surv. India 13(1): 58. 1931; Gangulee, Moss. E. India 2(4): 1114. 1974; R.S.Chopra, Tax. Indian Mosses 257. 1975. *Mnium fontanum* Hedw., Sp. Musc. 195. 1801. *Bartramia macrocarpa* C.Muell., Bot. Zeitung. Berlin 11: 57. 1853. *B. crassinervis* Wils., Kew J. Bot. 9: 370. 1857, *nom. nud.* *Philonotis lutea* Mitt., J. Linn. Soc. Bot. Suppl. 1: 63. 1859. *P. macrocarpa* (C.Muell.) Mitt., Musc. Ind. Orient. 62. 1859. *P. tomentella* Mol. in Lor., Moosstud. 170. 1864. *Bartramia heleniana* Mitt. in C.Muell., S. Helena 361. 1875. *Didymodon mollis* Schimp. in C.Muell., Synop. Musc. Frond. 2: 167. 1876. *Philonotis emodi-fontana* C.Muell. in Paris, Index Bryol. Suppl. 266. 1900, *nom. nud.* *P. heleniana* (Mitt.) Herz., Biblioth. Bot. 73: 51. 1901. *P. seriata* Mitt. var. *mollis* (Schimp.) Loeske, Hedwigia 45: 196. 1906. *P. tomentella-fontana* Loeske, Hedwigia 45: 205. 1906, *nom. nud.*

Plants yellowish-green, up to 2 cm long; stem slender, with whorls of subfloral innovations, tomentose, branches up to 6 mm long; leaves lanceolate, leaf margins rolled inwards, margin entire at base, serrate towards apex with

paired teeth-like projection; costa strong, reach up to top; cells quadrangular, basal larger, up to 40 x 15-20 μm , upper smaller, 25-30 x 10-15 μm , mamilllose except in the middle; seta apical, up to 2 cm long; capsule globose, erect or horizontal; spores round, 18-22 μm diagonally. (Fig. 22: n-s & Plate 13d).

Habitat: On soil cutting in semi-evergreen forests.

Specimens examined: Soojippara (760 m) MCN & KPR 87077a, MCN 87093.

Distribution: It is a rare species in the study area and has collected from the Soojippara area only. Earlier it was recorded from South India (Tamil Nadu: Palni hills), North India (Kumaon himalaya), China, Japan, Korea, Iran, Tibet, Taiwan, Philippines, Europe, Central & South Africa, Central & South America and New Zealand. The present collection is a new record to Kerala.

Philonotis hastata (Duby) Wijk & Marg., Taxon 8: 74.1959; Gangulee, Moss. E. India 2(4): 1127. 1974; R.S.Chopra, Tax. Indian Mosses 252.1975; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690.1986. *Hypnum hastatum* Duby in Moritzi, Syst. Verz. 132. 1846. *Bartramia laxissima* C.Muell., Synop. Musc. Frond. I: 480. 1849, *nom. illeg.* *Philonotis laxissima* Mitt., Musc. Ind. Orient. 61. 1859. *Bartramia wallisii* C.Muell., Linnaea 38: 554.1874. *Philonotis wallisii* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-78: 437. 1880. *Fleischerobryum wallisii* (C.Muell.) Loeske, Morph. Syst. Stud. Laubm. 127. 1910.

Plants pale to yellowish-green, radiculose at base; stem erect, up to 2 cm long, spongy in appearance; leaves curled and appressed to stem when dry, lanceolate-lingulate, shortly acuminate, narrow, small, 0.04-0.05 mm long, marginal teeth biranked by upturned tips or mamillae of the cells; costa prominent, papillose at the back, neds below tip; cells thin walled, mamillae at the anterior end, rhomboidal to hexagonal, basal cells 20-35 x 10-15 μm , upper smaller; mostly found as sterile. (Fig. 23: g-j & Plate 13e).

Habitat: On soil and rocky patches in homestead, moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Chandanathode (900 m) *MCN 80305*, Sulthan Bathery (830 m) *MCN 84370a*, Kurichiad range, Chethalayam (956 m) *MCN 84530*, Tholpetty range (875 m) *MCN 84574*.

Distribution: It is a common species of shady garden soil and flower pots from the low altitudes to higher altitudes in the shaded forest floor of the study area. A pantropical species earlier reported from South India (Kerala), North-east India (Calcutta, Assam, Sikkim), Sri Lanka, Borneo, Bolivia, Java, Thailand, Celebes, Philippines, Japan, Taiwan, Chile, Oceanic Island, Peru, Venezuela, Africa, South America and Australia.

Philonotis mollis (Dozy & Molk.) Mitt., *Musc. Ind. Orient.* 60. 1859; Broth., *Rec. Bot. Surv. India* 1(12): 322. 1899; P.Bruehl, *Rec. Bot. Surv. India* 13(1): 58. 1931; Gangulee, *Moss. E. India* 2(4): 1120. 1974; R.S.Chopra, *Tax. Indian Mosses* 253. 1975; Mohamed *et al.*, *J. Bombay Nat. Hist. Soc.* 83: 690. 1986. *Bartramia mollis* Dozy & Molk., *Ann. Sci. Nat. Bot. Ser.* 3, 2: 300. 1844. *B. sphaerocarpa* Montin in C.Muell., *Synop. Musc. Frond.* 1: 484. 1849, *nom. nud.* *Philonotis stolonacea* C.Muell. in Paris, *Index Bryol. Suppl.* 268. 1900, *nom. nud.*

Plants yellowish-green, in loose tufts; stem soft, delicate, 1.5-2 cm x 0.3-0.5 mm, unbranched; leaves lanceolate, crowded below, spreading above, erecto-patent below, shrink and erect when dry, ending in filiform point, 1.8-2 x 0.4 mm, margin entire, serrate above with paired teeth like projections; costa excurrent; cells at upper part narrow elongated, mamilllose, 30-45 x 5-10 μm , basal smooth, rectangular, 16-35 x 20 μm ; mostly found as sterile. (Fig. 23: k-o).

Habitat: On moist rocks covered with soil or on moist soil associated with *Bryum wightii*, *Utricularia* sp. and grasses in moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Tholpetty range (860 m) *MCN 84580*, Hairpin point (550 m) *MCN 80092*.

Distribution: *P. mollis* was reported earlier from South India (Karnataka: Kanara, Coorg), Central India (Rajasthan), Andaman Islands, Sri Lanka, Borneo, Java,

Indonesia, Japan, Madagascar, Philippines, Sumatra and Tonkin. The present collection is a new record to Kerala.

Philonotis secunda (Dozy & Molk.) Bosch & Sande-Lac., *Bryol. Jav.* 1: 156. 1861. *Bartramia secunda* Dozy & Molk. *Plantae Junghuhnianae* 3: 332. 1854. *Breutelia neocaledonica* Broth. & Paris, *Ibid*, same page. 1854.

Plant yellowish-green, tufted, up to 2 x 0.3-0.5 mm; leaves lanceolate, up to 8 x .025 mm, margin bordered by single row of cells, serrated by upturned marginal cells; costa slightly excurrent or percurrent; cells at upper part linear-elongated, 20-30 x 5-8 μm , basal cells 30-38 x 5-10 μm quadrangular to hexagonal; sporophyte not seen. (Fig. 23: p-s & Plate 13f).

Habitat: On rocky patches in homesteads and in evergreen forests.

Specimens examined: Lakkidi (360 m) MCN 80096, Periya (960 m) MCN 99611.

Distribution: This species was earlier recorded from South India (locality unknown), Sri Lanka and Indonesia.

Philonotis thwaitesii Mitt., *Musc. Ind. Orient.* 60. 1859; *Gangulee Moss. E. India* 2: 1121. 1974; M.C.Nair & Madhus. *J. Econ. Taxon. Bot.* 25: 574. 2001. *Philonotis revoluta* Bosch & Sande-Lac., *Bryol. Jav.* 1: 158. 128. 1861. *P. socia* Mitt., *J. Linn. Soc. Bot.* 8: 151. 1864. *Philonotula savatieriana* Besch., *Ann. Soc. Nat. Bot. ser. 7, 17*: 349. 1893. *P. stricta* Schimp. in Besch., *Ann. Soc. Nat. Bot. Ser. 7, 17*: 350. 1893, *nom. nud. in synonym. Philonotis stricta* Paris, *Index Bryol. Suppl.* 927. 1897, *nom. nud. P. savatieriana* (Besch) Broth., *Hedwigia* 38: 222. 1899. *P. wichurae* Broth., *Hedwigia* 38: 223. 1899. *P. tosana* Cardot, *Bull. Soc. Bot. Gen. ser. 2, 1*: 123. 1909. *P. sumatrana* Dixon, *Ann. Bryol.* 5: 32. 1932. *Microphilonotis iwasaki* (Sak.) Sak., *J. Jap. Bot.* 26: 199. 1951. *Philonotis tenuicarpa* Dixon & Ochi, *J. Jap. Bot.* 45: 25. 1970.

Plants yellowish-green, slender to robust, in dense tufts, rhizoids papillose; stem erect or flexuose, ± 1 cm, dichotomously branched with whorled leaves; leaves appressed to stem when dry, dense, erect, stiff, lanceolate, ± 1.5 x 0.3-0.5 mm, apex acute, margin faintly denticulate; costa ending below the

apex; cells near the apex shortly rectangular-elongate, 50-70 x 3-5 μm , at the base rectangular, thin walled, less papillose, 20-28 x 10-15 μm , at extreme base cells are quadrate, 15-20 μm wide, hyaline; seta apical, erect, ± 2 cm long; capsule erect to horizontal, brown, subglobose, strongly furrowed when dry; spores brownish, rounded, 15-20 μm diagonally. (Fig. 25: a-f & Plate 13g&h).
Habitat: Seen on soil cuttings and moist rocks in semi-evergreen, evergreen and shola forests.

Specimens examined: Lakkidi (750 m) MCN 80129, Chembra hills (1780 m) MCN 120310.

Distribution: It is a widely distributed species in the study area. Earlier it was reported from South India (Kerala; Tamil Nadu: Palni hills), North India (Western Himalaya), Sri Lanka, China, Borneo, Bolivia, Colombia, Japan, Korea, New Guinea and Taiwan.

Order ISOBRYALES

ORTHOTRICHACEAE Arn.

Disp. Meth. Mousses 13. 1825.

Plants usually dark coloured, dense tufts or cushions on tree trunks, rarely on rocks; stem long, creeping, sometimes erect; leaves dense, appressed or curled when dry, widely spreading when moist, lanceolate to ovate-lanceolate, margin usually entire; costa strong, single; cells at upper half rounded, often papillose, basal cells elongated; capsule erect, smooth, ovoid to cylindrical; calyptra smooth or hairy.

Four subfamilies are recognized within the family by Brotherus (1925) viz., Zygodontoideae, Orthotrichoideae, Macromitrioideae and Pseudomacromitrioideae, which includes 10 genera in India. Of these *Amphidium* of the subfamily Zygodontoideae and *Macromitrium* of Macromitrioideae are represented in the study area.

Key to the genera

- 1a. Stem erect, leaf cells usually with thick wall, rounded, warty papillose on both sides at apex, hyaline rectangular cells below.....**Amphidium**

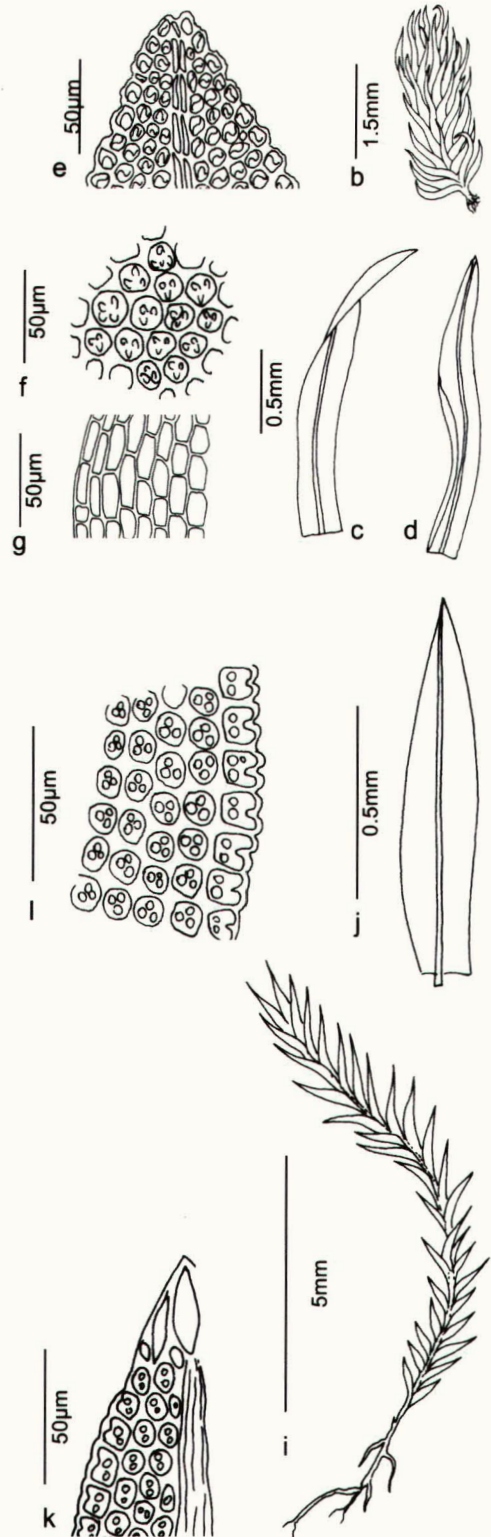


Fig. 24. **a-g**: *Trichostomum wayanadensis*; **a**&**b**: habit, **c**&**d**: leaves, **e**: leaf tip cells, **f**: middle cells, **g**: basal cells; **h-l**: *Amphidium gangulii*; **h**&**i**: habit, **j**: leaf, **k**: leaf tip cells, **l**: leaf basal cells

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1b. Stem long, creeping, leaf base cells elongated, upper rounded, smooth papillae in some, basal elongate, hyaline cells**Macromitrium**

Amphidium Schimp.

Coroll. 39. 1856, *nom. cons.*

Plants yellowish-green, in dense tufts, stem simple or branched; leaves curled when dry, linear lanceolate; costa strong, ends at tip; cells thick walled, warty papillose on both sides, rounded-quadrate, basal cells elongated, rectangular, smooth; seta short, erect; capsule pear shaped, peristome absent, operculum rostrate, calyptra cucullate.

Amphidium gangulii sp. nov.

Type: India, Kerala, Wayanad district, Chandanathode (900 m) *Manju C Nair 80088* (CALI).

Amphidium mougeotii similis specie in India orientali communi in foliis linearilanceolatis crispatis, costa percurrenti. Autem ab illi valde in cellulis omnino papillis verrucosis, habitu minore et simplici differt, dum in *A. mougeotii* cellulae epapillosae nec verrucosis, statura ad 2 mm vel plus. Haec species quoque differentias a *A. lapponico* specie asiatica communi praebet. In *A. lapponico* folii margo planus cellulae in dimidio superiore papillosae, basin rectangulares hyalinae, sed in habitu and foliorum natura similitudo praebet.

Plants yellowish-green, in tufts, branches arises from basal part, shoot 0.6 mm - 1 cm long; leaves distant, linear-lanceolate, up to 1 mm x 0.2-0.3 mm, erect when moist, flexuose, crispate when dry, tapering to an acute point, margin crenulate by the warty papillose cells from base to apex; cells papillose, rounded to hexagonal, upper smaller up to 5 μ m diagonally, lower larger up to 10 μ m diagonally; costa strong, single, yellowish, percurrent. Sporophyte not seen. (Fig. 24: h-l).

This species shows similarity with *A. mougeotii*, a common eastern Indian species in its linear-lanceolate leaves, percurrent nerve and crispate nature. But it strongly differs from the later species in having the papillose cells throughout and smaller and simple habit, whereas in *A. mougeotii* cells are not papillose and the habit reach upto 2 mm or more. This species also shows

differences from the common Asiatic species *A. lapponicum*. In *A. lapponicum* the leaf margin is plane and the cells at upper half is papillose and at base rectangular hyaline. But shows similarity in plant habit and nature of the leaves.

Habitat: Terrestrial in semi-evergreen forests.

Distribution: This species is rare in Wayanad and could be collected from only one locality.

Note: The species is named after Dr. H.C. Gangulee, the famous bryologist of India.

Macromitrium Brid.

Mant. Musc. 4: 132. 1819.

Plants yellowish-green or brownish, slender to robust, in dense tufts; stem long creeping, erect or ascending, simple or fasciculately branched; leaves appressed when dry, sometimes spirally twisted around the stem, erect 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; cells rounded to quadrate or rounded hexagonal at upper half, rich in chlorophyll, papillose to smooth, near the base elongate, thickened, smooth to strongly papillose on the plicae, sometimes all cells elongated; seta erect, usually elongate, rough; capsule nearly spherical to oblong-ovoid, calyptra campanulate, plicate, mostly covering the capsule, smooth or hairy, lobed; spores large of uneven size, papillose.

Key to the species

- 1a. Leaves spirally twisted when dry; capsule sulcate.....**M. sulcatum**
- 1b. Leaves curled when dry; capsule not sulcate2
- 2a. Leaf cells not papillose.....**M. tenerum**
- 2b. Leaf cells with few large papillae.....**M. nepalense**
- 2c. Leaf cells with single large papillae.....**M. moorcroftii**

Macromitrium moorcroftii (Hook. & Grev.) Schwaegr., Sp. Musc. Suppl. 2(2): 67. 1826; Gangulee, Moss. E. India 2(5): 1180. 1976. *Orthotrichum moorcroftii* Hook. & Grev., Edinburgh J. Sci. 1: 116. 1824. *Leiotheca moorcroftii* (Hook. &

Grev.) Brid., Bryol. Univ. 1: 727. 1826. *Orthodon moorcroftii* (Hook. & Grev.) Griff., Icon. Pl. As. 1: 76. 1849. *Macromitrium pileatum* Wils., Kew J. Bot. 9: 327. 1857, *nom nud.* *M. tortuosum* Wild., *ibid.* 1857, *nom. nud.*

Plants yellowish-brown, main stem creeping, curled inwards when dry, erecto-patent when moist, branches up to 1 cm long; leaves linear-lanceolate, up to 2.5 x 0.6 mm, margin entire below, serrated at apex; costa brownish, ends below apex; cells small, rounded to elongate, upper cells 5-8 μm diagonally, single large papillae, middle cells 8-10 μm , lower cells elongated, 25-33 x 2-5 μm , cells minutely pegged outwards in two sides at basal half, marginal cells at extreme base rectangular elongated; seta apical, erect; capsule erect, ovoid, calyptra hairy, covering entire capsule; spores rounded, 18-25 μm . (Fig. 25: g-l & Plate 13i).

Habitat: Corticolous in evergreen and shola forests.

Specimens examined: Thirunelli (1000 m) MCN & KPR 99661, Chembra hills (1230 m) MCN 120220, 120289.

Distribution: It was earlier reported from South India (Karnataka: Coorg), North-east India (Western Himalaya, Khasi hills, Sikkim, Darjeeling), Andaman and Nicobar Islands, China, Nepal, Myanmar, Bhutan and Bangladesh. The present collection is a new record to Kerala.

Macromitrium nepalense (Hook. & Grev.) Schwaegr., Sp. Musc. Suppl. 2(2): 134. 1827; Gangulee, Moss. E. India 2(5): 991. 1976. *Orthotrichum nepalense* Hook. & Grev., Edinburgh J. Sc. 1: 117. 1824. *Leiotheca nepalensis* (Hook. & Grev.) Brid., Bryol. Univ. 1: 732. 1826. *Orthotrichum assamicum* Griff., Calcutta J. Nat. Hist. 2: 485. 1842. *Macromitrium assamicum* (Griff.) Mitt., Musci. Ind. Orient. 50. 1859.

Plants brownish-green in dense tufts, main stem ± 4 cm, produce erect secondary branches; leaves dense, 2-3 x 0.5 mm, curled when dry, with hook-like incurving, lanceolate, base broader, apex acute, margin entire; costa single, reach up to tip; cells thick walled, rounded to ovate, ± 10 x 7 μm , few large papillae, middle cells rectangular, ± 10 x 8 μm , large rectangular cells at base towards inner side, ± 19 x 9 μm , papillae tubercular, margin with linear cells, at

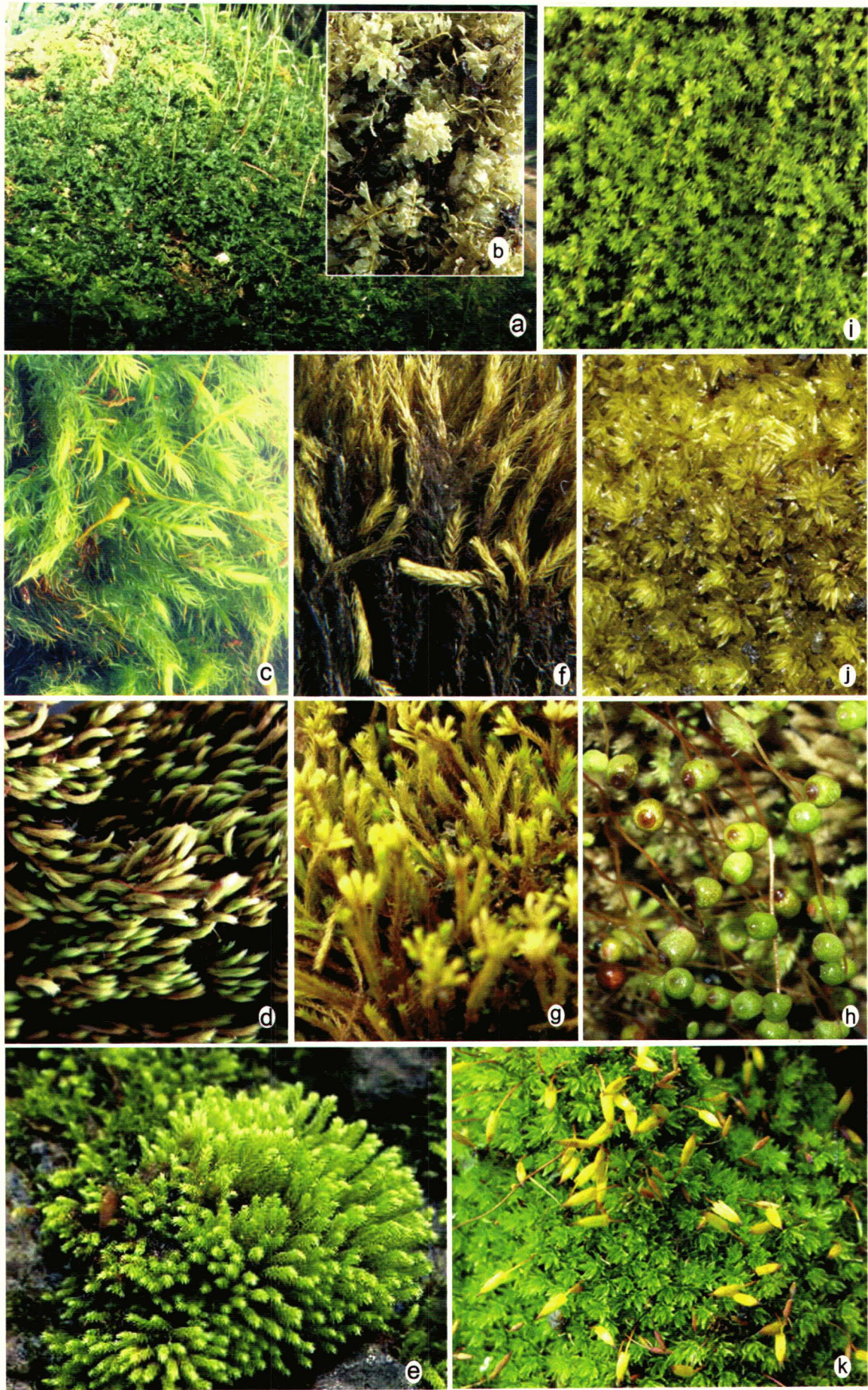


Plate. 13. a: *Mnium rostratum*, b: enlarged view of plant, c: *Pyrrhobryum spiniforme*, d: *Philonotis fontana*, e: *P. hastata*, f: *P. secunda*, g: *P. thwaitesii*, h: plant with sporophyte, i: *Macromitrium moorcroftii*, j: *M. nepalense*, k: *M. sulcatum*

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extreme base cells smooth, thin walled, larger rectangular, 40-45 x 7-10 μm ; seta on short lateral shoots, erect; capsule erect, ovoid, up to 2.5 mm long, calyptra hairy, covering the entire capsule. (Fig. 25: m-t & Plate 13j).

Habitat: Base of tree trunk on *Mangifera indica* on marshy areas in moist deciduous forests.

Specimen examined: Muthanga, Nalloor vayal (896 m) MCN 84507.

Distribution: A Southeast Asiatic species earlier reported from South India (Tamil Nadu: Palni hills), North-east India (Darjeeling, Arunachal Pradesh, Assam, Khasi hills, Naga hills), Myanmar, Thailand, North Vietnam, Yunnan, Hongkong and Philippines. The present collection is a new record to Kerala.

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, Moss. E. India 2(5): 1181. 1976; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 690. 1986. *Schlotheimia sulcata* Hook., Musc. Exot. 2: 156. 1819. *Macromitrium neelgheriense* C.Muell., Synop. Musc. Frond. 1: 737. 1849. *M. nilghiriense* C.Muell. & Mitt., Musc. Ind. Orient. 52. 1859. *M. ceylanicum* Mitt., Musc. Ind. Orient. 52. 1859. *M. ramentosum* Thwait. & Mitt., J. Linn. Soc. Bot. 13: 301. 1873.

Plants dark greenish to brownish, robust, in dense tufts; stem long prostrate, erect, fasciculately branched secondary shoot system; leaves dense, spirally twisted when dry, stiff, erect to spreading when moist, lanceolate to oblong-lanceolate, 0.5 x 0.04 mm; costa strong, ending below apex or percurrent; cells towards the apex rounded or quadrate, 4-8 x 3-6 μm , with irregularly rounded or ovate lumen, rich in chlorophyll, papillose, median cells 6-10 x 4-7 μm , basal cells elongate, 20-40 x 10-12 μm , some times rounded, hyaline, with thick walls, above basal cells elongate, surrounded by thin walled hexagonal cells, margin bordered with 5-6 smooth thin walled cells; seta erect, rough; capsule spherical to oblong-ovoid, sulcate, peristome absent; spores large of uneven size, 12-25 μm diagonally, papillose, green. (Fig. 26: a-e & Plate 13k).

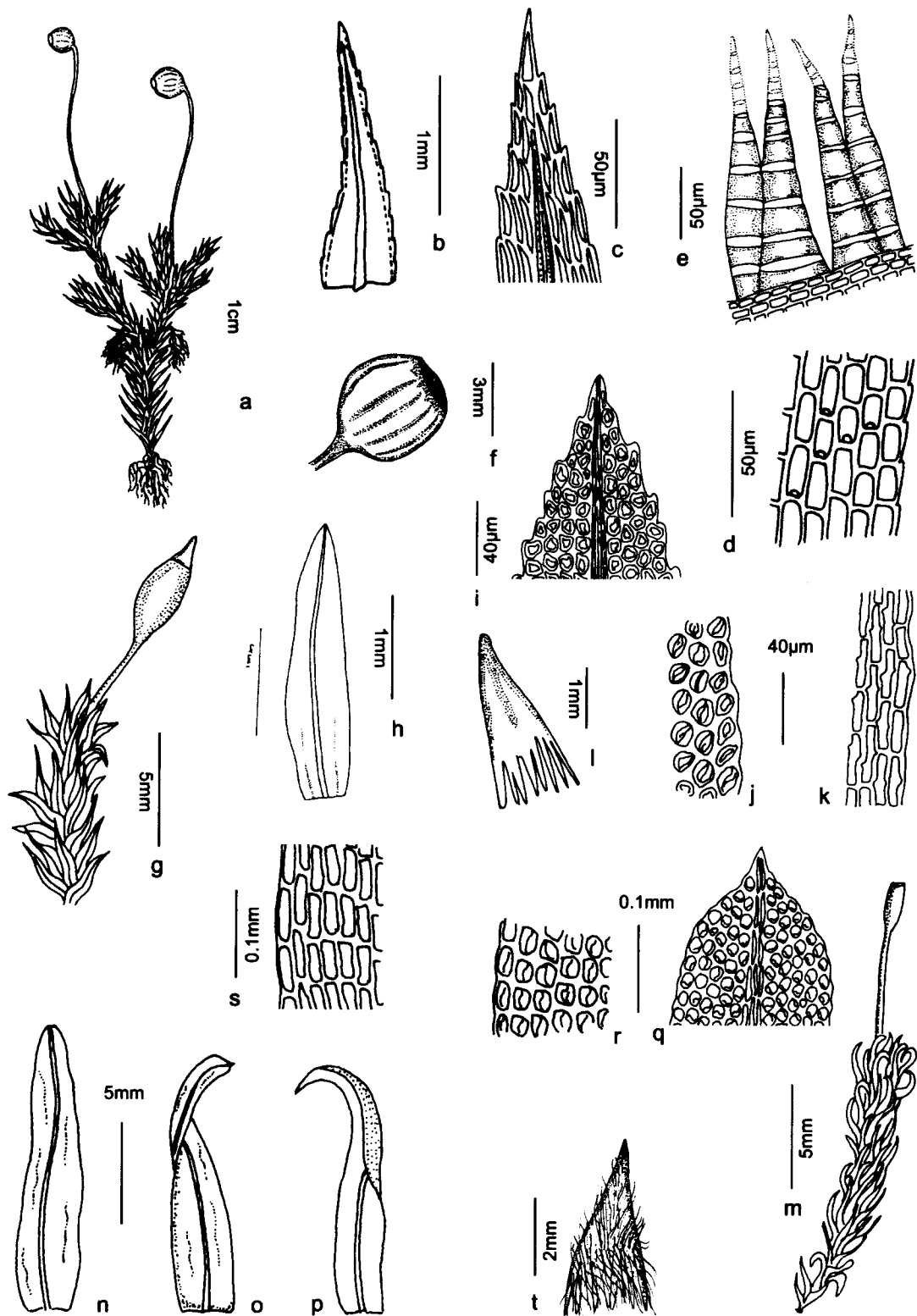


Fig. 25. a-f: *Philonotis thwaitesii*; a: habit, b: leaf, c: leaf tip cells, d: basal cells, e: peristome teeth, f: capsule; g-l: *Macromitrium moorcroftii*; g: branch, h: leaf, i: leaf tip cells, j: middle marginal cells, k: basal cells, l: calyptra; m-t: *Macromitrium nepalense*; m: habit, n,o&p: leaves, q: leaf tip cells, r: middle cells, s: basal cells, t: calyptra

Habitat: This is a common species in evergreen and shola forests as corticolous along with other leafy liverworts, sometimes on rocks.

Specimen examined: Chembra hills (1220 m) MCN 120222.

Distribution: *M. sulcatum* is common in the high altitude evergreen and shola forests. This species is widely distributed in South India (Kerala; Western Ghats of Maharashtra; Tamil Nadu: Nilgiri hills, Chennai; Karnataka: Coorg), Sri Lanka, Nepal, Borneo, Kampuchea, Madagascar, Malaysia, Myanmar, Philippines, Thailand and Vietnam.

Macromitrium tenerum Kurz, Flora 13: 373. 1830. *Ptychomitrium nigrescens* C.Muell., Syn. Musc. Frond. 1, 1849.

Plants yellowish-green, long, creeping, crowded, tomentose below; branches very small, 6 mm long, crowded; leaves linear-lanceolate, up to 1.5 mm long, curled when dry, tip pointed, margin entire, upper portion wavy; costa yellowish-brown, strong, ending below the tip; cells rounded to elongated, upper rounded-hexagonal, 7.5 μm diagonally, not papillose, basal cells elongated, 12.5 x 2-4 μm ; sporophyte not seen. (Fig. 26: f-i & Plate 14a).

Habitat: On logs in semi-evergreen and evergreen forests.

Specimens examined: Ponkuzhi (900 m) MCN 84377, Kurichiad range, Pavagadha (750 m, 900 m) MCN 84535, 84537b, Begur RF (845 m) MCN 99671.

Distribution: This species has earlier recorded from China, Japan and Sri Lanka. The occurrence of this species in India is unknown. Here this species is reported as new record to India.

RACOPIACEAE Kindb.

Bot. Centralbl. 76: 85. 1898.

Plants olive 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, rhomboidal below; amphigastral leaves much smaller, erect with longer arista;

seta long; capsule erect or inclined, furrowed when dry, calyptra cucullate, hairy.

The family includes two genera viz., *Powellia* and *Racopilum*. Of these *Powellia* is limited to Australia and Oceania while *Racopilum* has a wide distribution.

Racopilum P.Beauv.

Prodr. 36. 1805.

Plants olive green to brown tinged, prostrate, radiculose; leaves dimorphic, large lateral leaves in two rows, dorsal leaves much smaller, resembling amphigastria; costa strong, usually excurrent; cells rounded or hexagonal, chlorophyllose; seta elongate; capsule inclined, peristome double, calyptra cucullate, hairy.

Key to the species

- 1a. Leaf dentation not strong in lateral and amphigastrial leaves; arista long; capsule erect.....**R. orthocarpum**
1b. Leaves show strong dentation in lateral and amphigastrial leaves; arista not long; capsule horizontal.....**R. cuspidigerum**

Racopilum cuspidigerum (Schwaegr.) Angstr., Ofvers. Foerh. Kongl. Svenska Vetensk.-Akad. 29: 10. 1872; Gangulee, Moss. E. India 2(5): 1200. 1976. *Hypnum cuspidigerum* Schwaegr., Gaud. Freyc. Voyage Aut. Monde Oranie Phys. Bot. 229. 1828. *Hookeria tomentosa* (Hedw.) Arn. var. *subintegrifolia* Arn., Mem. Soc. Hist. Nat. Paris 5: 250. 1897. *Racopilum demissum* Bosch & Sande-Lac., Bryol. Jav. 2: 18. 1861; P.Bruehl, Rec. Bot. Surv. India 13(1): 64. 1931.

Plants greenish, glossy, creeping, 2-6 cm x 0.5-0.7 mm, highly branched, branches pinnate, tomentose throughout; leaves two types, lateral and amphigastrial, lateral leaves oblong-ovate, 1-1.5 mm long, amphigastria small, 0.7-1 mm long, margin strongly serrated at upper half in both the leaves; costa prominent, percurrent; cells rounded-hexagonal, chlorophyllose, marginal leaf cells hyaline; seta long, erect, capsule horizontal to inclined, calyptra cucullate;

spores 10-15 μm . (Sporophyte not seen in the present specimen, described after Fleischer, 1929). (Fig. 27: e-i & Plate 14b).

Habitat: On sandy soil and rocks in moist deciduous, semi-evergreen, evergreen and shola forests.

Specimens examined: Muthanga range (890 m) *MCN 84501, 84515*, Sulthan Bathery (870-907 m) *MCN 84352, MCN 84357*, Kurichiad (929 m) *MCN 84560*, Chembra hills (1380 m) *MCN 120262*, Manikkunnumala, near MSSRF (980 m) *MCN 120293, 120302*.

Distribution: It was earlier recorded from South India (Tamil Nadu: Nilgiri hills), Myanmar, Thailand, Philippines, Vietnam, Borneo, Indonesia, Malaysia and Papua New Guinea. The present collection is a new record to Kerala.

Note: Though the sporophyte differs, the gametophyte of this species does not differ much from *R. orthocarpum*. *R. cuspidigerum* differs from *R. orthocarpum* on strong dentation in both the leaves and nerve so long than the former species.

Racopilum orthocarpum Wils. & Mitt., J. Linn. Soc. Bot. Suppl. 1: 136. 1859; Gangulee, Moss. E. India 2(5): 1199. 1976; Madhus. & M.C.Nair, J. Econ. Taxon. Bot. 28: 341. 2004.

Plants olive green, glossy, prostrate, 1.5 cm long, radiculose throughout; leaves oblong-ovate, dimorphic, large lateral leaves in two rows, up to 2 mm long, strongly contorted when dry, asymmetrical, ovate, tip acute, margin flat, dentate at tip, dorsal leaves much smaller, up to 1 mm long, resembling amphigastria, unbordered, appressed to the stem, erect or drooping; costa strong, excurrent; cells distinct, ovate to elongate, smooth, chlorophyllose, unipapillose, basal cells irregularly quadrate rectangular; seta erect, spirally twisted when dry, ca. 1.2 cm long; capsule erect, cylindrical, peristome double, hypnoid, calyptra cucullate, sparsely hairy; spores small, 8-10 μm diagonally. (sporophyte characters after Gangulee, 1974). (Fig. 27: a-d & Plate 14c).

Habitat: On a wide variety of habitats such as bark of trees, logs, bare rocks and soil in moist deciduous, semi-evergreen and evergreen forests.

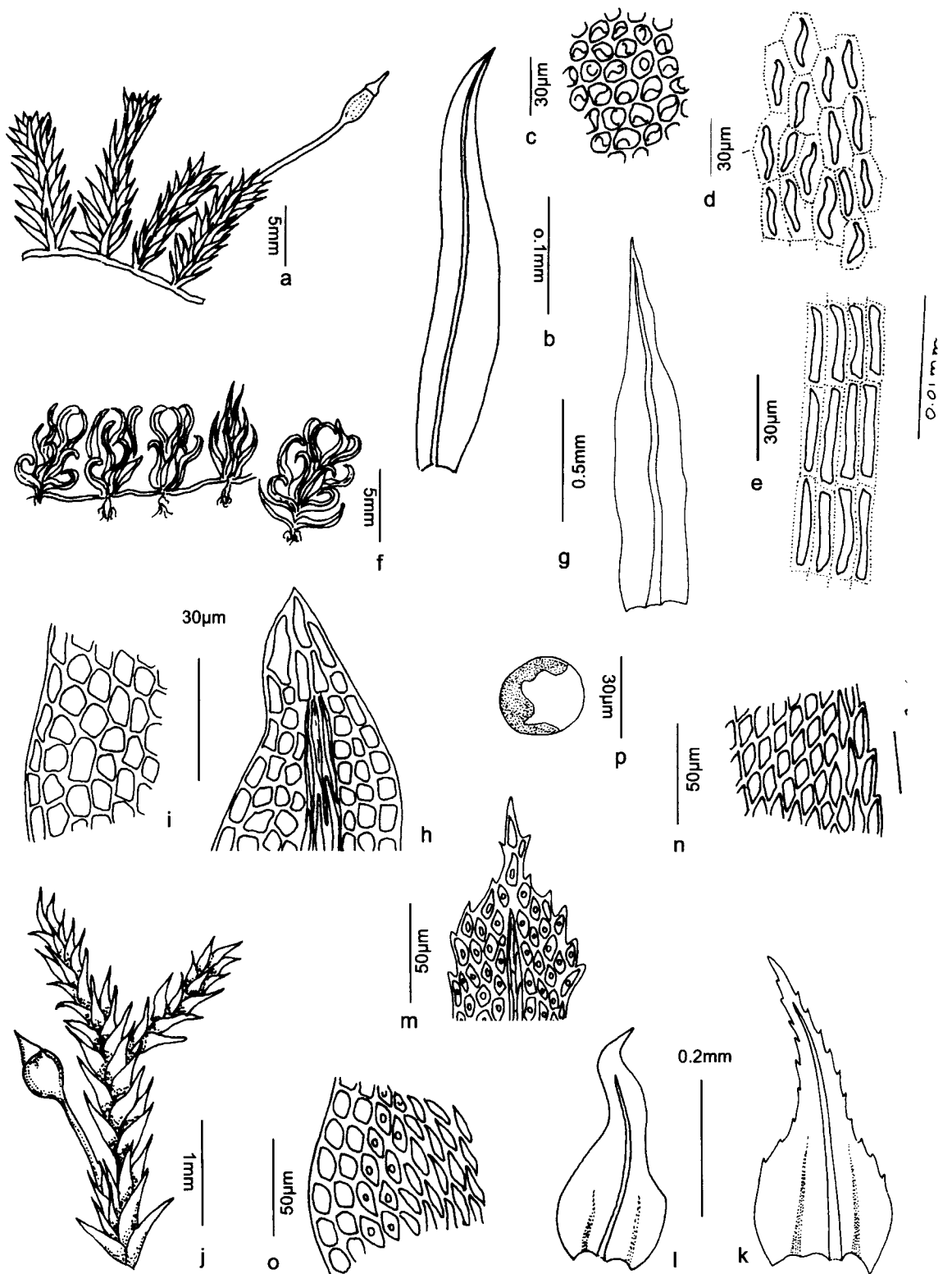


Fig. 26. **a-e**: *Macromitrium sulcatum*; a: habit, b: leaf, c: upper and middle cells, d: above basal cells, e: basal cells; **f-i**: *Macromitrium tenera*; f: habit, g: leaf, h: leaf tip cells, i: basal marginal cells; **j-p**: *Diaphanodon blandus*; j: branch with sporophyte, k&l: leaves, m: leaf tip cells, n: middle marginal cells, o: basal cells, p: spore

Specimens examined: Kurichiad range (715 m, 830 m) *MCN 84523, 84553b*, Tholpetty range (880 m) *MCN 84573*, Muthanga range, Keeradam kolli (786-915 m) *SKA 76098, MCN 84513*, Chembra hills (1383 m) *MCN 120265*.

Distribution: It is a widely distributed species in the high altitude areas of the study area. A South East Asiatic continental species earlier reported from South India (Kerala; Tamil Nadu: Kodaikanal), North-east India (Western Himalaya, Khasi hills, Sikkim), Sri Lanka, Nepal, Vietnam and Myanmar.

CRYPHAEACEAE Schimp.

Coroll. Bryol. Eur. 97. 1855 [1856].

Plants mostly hanging, slender to robust; main stem creeping, secondary stems branched; leaves imbricate, erect and appressed when dry, ovate acuminate; costa single, ending below apex; cells incrassate, ovoid, elongate near costa, alar cells rounded, transversely elongated; capsule with a very short seta, usually completely hidden, sometimes exerted, peristome single or double, calyptra small, campanulate or cucullate.

Two subfamilies are recognized within the family. Cryphaeoidae with three genera, *Schoenobryum*, *Sphaerotheciella* and *Pilotrichopsis* and Alsidioideae with one genus *Forsstroemia*, are found in India. Only one genus, *Schoenobryum* occur in Wayanad.

Schoenobryum Dozy & Molk.

Musc. Frond. Ined. Archip. 6: 183. 1848.

Plants slender, secondary stem ascending; leaves imbricate when dry, spreading when moist, ovate, acute to narrowly acuminate, entire or toothed towards apex; costa ceasing a little above the middle; cells parenchymatous, thick walled, smooth or finely papillose, with ovate lumina, basal adjoining the costa linear; alar cells rounded or transversely elongated; capsule fully immersed, ovoid-oblong with a truncate base, peristome teeth white, densely papillose, inner peristome absent, calyptra conical; spores rounded, 20-25 µm diagonally.

Schoenobryum concavifolium (Griff.) Gangulee, Moss. E. India 2(5): 1209. 1976. *Orthotrichum concavifolium* Griff., Calcutta J. Nat. Hist. 2: 484. 1842.

Schoenobryum julaceum Dozy & Molk., Musc. Fr. Ined. Archip. Indici 6: 184. 1848. *Acrocryphaea javanica* Bruch, Schimp. & W.Guembel, Bryol. Eur. 5: 32. 1850, *nom. nud.* *Cryphaea gardner* Mitt., J. Linn. Soc. Bot. Suppl. 1: 125. 1859. *C. concavifolia* (Griff.) Mitt., Musc. Ind. Orient. 125. 1859. *Acrocryphaea concavifolia* (Griff.) Bosch & Sande-Lac., Bryol. Jav. 2: 106. 1864. *A. gardneri* (Mitt.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1874-75: 178. 1876. *Schoenobryum gardneri* (Mitt.) Manuel, Bryologist 80: 523. 1977.

Plant yellowish-green to blackish-green, creeping, primary branches up to 2.5 cm long, secondary branches small; leaves oblong-ovate, up to 2 mm long, apex acute, margin flat, feebly serrated at tip; costa yellowish, strong, reach up to middle; cells ovate to elliptical, papillate at middle, basal elongate, 18-20 x 6-8 μm , upper shorter, oblique rows towards margin, marginal cells transeversely placed; capsule immersed, ovoid, calyptra conical; spores rounded to ovate, 15-25 μm diagonally. (Fig. 27: j-p & Plate 14d&e).

Habitat: On twigs and on logs in moist deciduous forests.

Specimens examined: Muthanga range, Keeradamkolli (790 m) *MCN 84518 a*, Begur RF (831 m) *MCN 84588, 84590*.

Distribution: It is widely distributed in the Wildlife Sanctuary of the study area. Earlier it was recorded from South India (Karnataka: Coorg), East India (Manipur), Sri Lanka, Bangladesh, Myanmar, Thailand, Vietnam, Celebes, New Guinea, Philippines, Columbia, Bolivia and Ecuador. The present collection is a new record to Kerala.

TRACHYPODACEAE M.Fleisch.

Hedwigia 45: 63. 1906 [1905].

Plants dark greenish to blackish, primary stem creeping, rhizoids very few, secondary stem densely plicate, irregularly branched, erect or prostrate; leaves linear from auriculate ovate base, shortly or longly acuminate, smooth or plicate, margin toothed; costa single, ending below apex; cells rhomboid to linear, mostly papillose; sporophyte on lateral branches; seta small; capsule ovoid, smooth, peristome double, operculum conical.

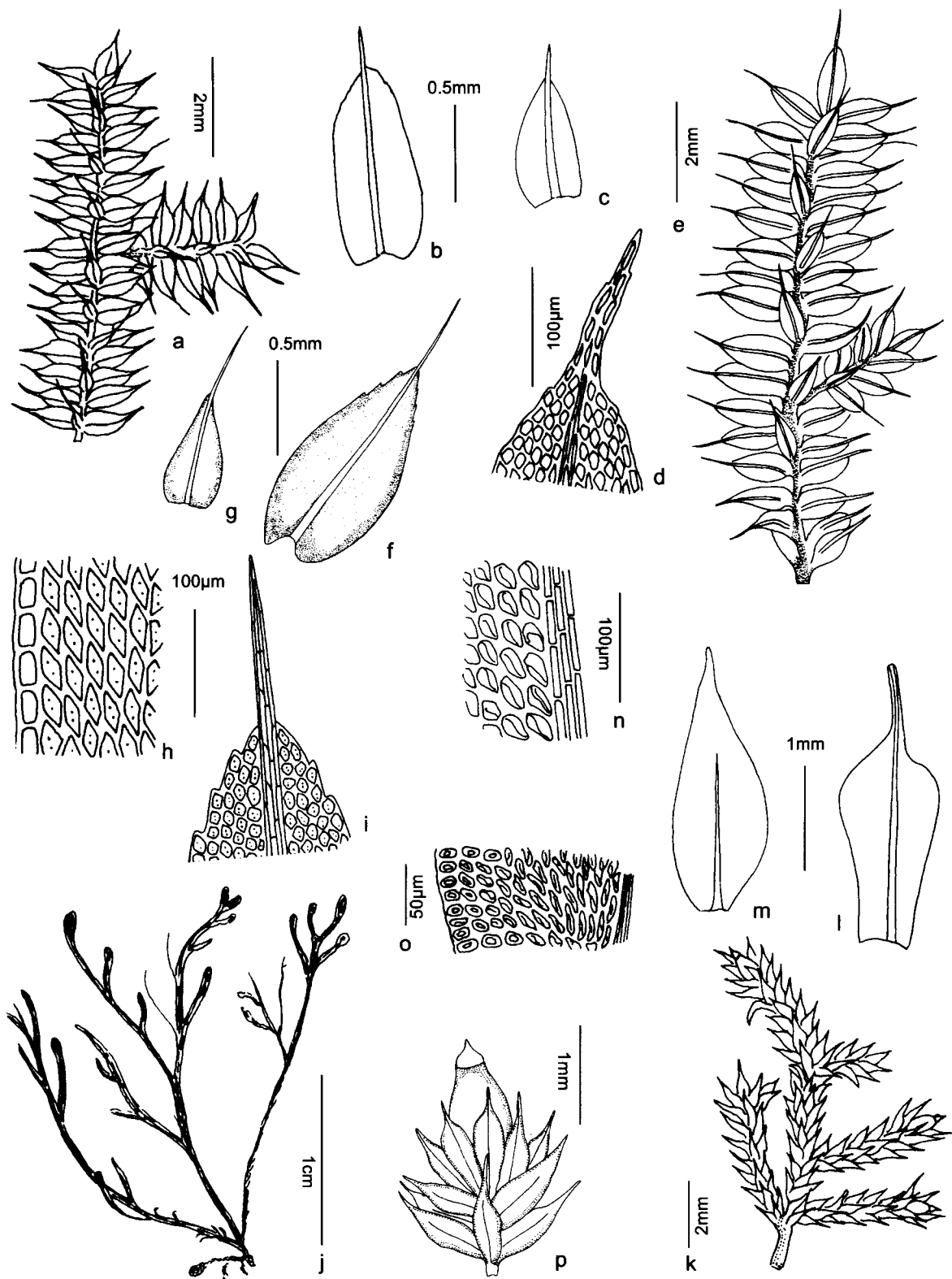


Fig. 27. a-d: *Racopilum orthocarpum*; a: habit, b: leaf, c: amphigastrial leaf, d: leaf tip cells; e-i: *Racopilum cuspidigerum*; e: habit, f: leaf, g: amphigastrial leaf, h: leaf tip cells, i: basal cells; j-p: *Schoenobryum concavifolium*; j: habit, k: branch enlarged, l: pericheatial leaf, m: branch leaf, n: upper and middle cells, o: basal cells, p: sporophyte enclosed in pericheatial leaves

Five genera are recognized within the family viz., *Pseudospiridentopsis*, *Duthiella*, *Trachypus*, *Diaphanodon* and *Trachypodopsis*. Of these *Duthiella*, *Trachypus* and *Trachypodopsis* are represented in the study area.

Key to the genera

- 1a. Seta smooth, capsule inclined or horizontal.....**Duthiella**
- 1b. Seta papillose, capsule erect.....2
- 2a. Leaf cells hexagonal to elongate-linear, with characteristic seriate papillae...
.....**Trachypus**
- 2b. Leaf cells elongated with single papillae.....3
- 3a. Leaves bordered.....**Diaphanodon**
- 3b. Leaves unbordered.....**Trachypodopsis**

Diaphanodon Renauld & Cardot

Rev. Bryol. 22: 33. 1895.

Plants light yellowish-green, moderately robust, dense or loose tufted; secondary stem pendant, pinnate or bipinnate, branches curved, often elongated, flagelliform; stem leaves appressed when dry, erect spreading when moist, base decurrent, tapering gradually or abruptly to form a long and narrow acumen, margin entire or strongly toothed; costa strong, ending below apex; cells thickened, oblong to linear, both sides unipapillose over the lumen; alar cells small, irregular, quadrate, smooth; branch leaves smaller, shortly acuminate from broad ovate base, margin minutely serrate, near the base recurved; costa ending below the apex or double in some; cells similar to stem leaves; seta very short, papillose; capsule raised, erect, spherical, brown, operculum conical, calyptra cucullate, small; spores large, faintly papillose, 30-45 µm diagonally.

Diaphanodon blandus (Harv.) Renauld & Cardot, Bull. Soc. Bot. Belgium 38(1): 23. 1900; Gangulee, Moss. E. India 2(5): 1224. 1976; Madhus. & M.C.Nair, J. Econ. Taxon. Bot. 28: 344. 2004. *Neckera blanda* Harv. in Hook., Icones Plantarum 1: 22. 1836. *Trachypus blandus* (Harv.) Mitt., Musc. Ind. Orient. 127. 1859. *Cryptopapillaria blanda* (Harv.) A.Jaeger, Ber. Senckenberg.

Naturf. Ges. 1875-'76: 271. 1877. *Diaphanodon thuidioides* Renaud & Cardot, Rev. Bryol. 22: 33. 1895. *D. brotheri* Renaud & Cardot, Bull. Soc. Bot. Belgium 38: 23. 1900. *D. javanicus* Renaud & Cardot, Rev. Bryol. 28: 117. 1901. *Thuidium javense* Broth. in M.Fleisch., Die Musci Fl. Buitenz. 3: 747. 1908, nom. nud. *Trachypodopsis blanda* (Harv.) Sedgw., J. Bombay Nat. Hist. Soc. 19: 841. 1910. *Pseudothuidium ceramicum* Herz., Hedwigia 57: 239. 1916. *Trachypodopsis tereticaulis* Froehl., Ann. Naturh. Mus. Wien. 59: 90. 1953.

Plants yellowish-green, robust in loose tufts; secondary stems slightly pendant, pinnate or bipinnate, branches densely foliate; leaves isophyllous, stem leaves appressed, erect to spreading when dry, erect to horizontally spreading when moist, acuminate, dentate at the tip, 1.3-1.6 x 0.7 mm, branch leaves 1 x 0.3 mm, base ovate, acuminate, margin incurved at base; costa single, ends far below tip; cells isodiametric, thick walled, oblong to linear, apex 15-19 x 6-8 μm , middle cells rhomboidal, 5-8 x 7 μm , basal cells 8 x 7 μm , bordered, alar cells small; seta 2-5 mm long, rough; capsule erect, ovoid, smooth; spores large, faintly papillose, 30-45 μm diagonally. (Fig. 26: j-p).

Habitat: On tree trunks along the stream banks and logs in evergreen forests.

Specimen examined: Thirunelli RF (880) MCN 84606.

Distribution: This species has collected from only one locality in Thirunelli Reserve Forest. This was also collected from the shola forests of ENP of Idukki district. It has earlier described from South India (Kerala: ENP; Karnataka: Coorg; Tamil Nadu: Nilgiri), North-east India (Mussoorie, Simla, Kumaon, West Bengal, Sikkim, Assam, Darjeeling), Sri Lanka, Nepal, Bhutan, Borneo, Ceram, Halmahera, Indonesia, Myanmar, Taiwan, Sumatra and Yunnan.

Note: This species is extremely variable and occur in many ecological forms, particularly with regard to branching and papillosity of the leaf cells. The papillosity of the leaves varies considerably from one collection to another. In the present collection also the specimens from Eravikulam and Thirunelli varies greatly. This widely distributed species has been described by several authors under different names. But according to Wijk *et al.* (1962, 1969) this genus comprises only 4 species.

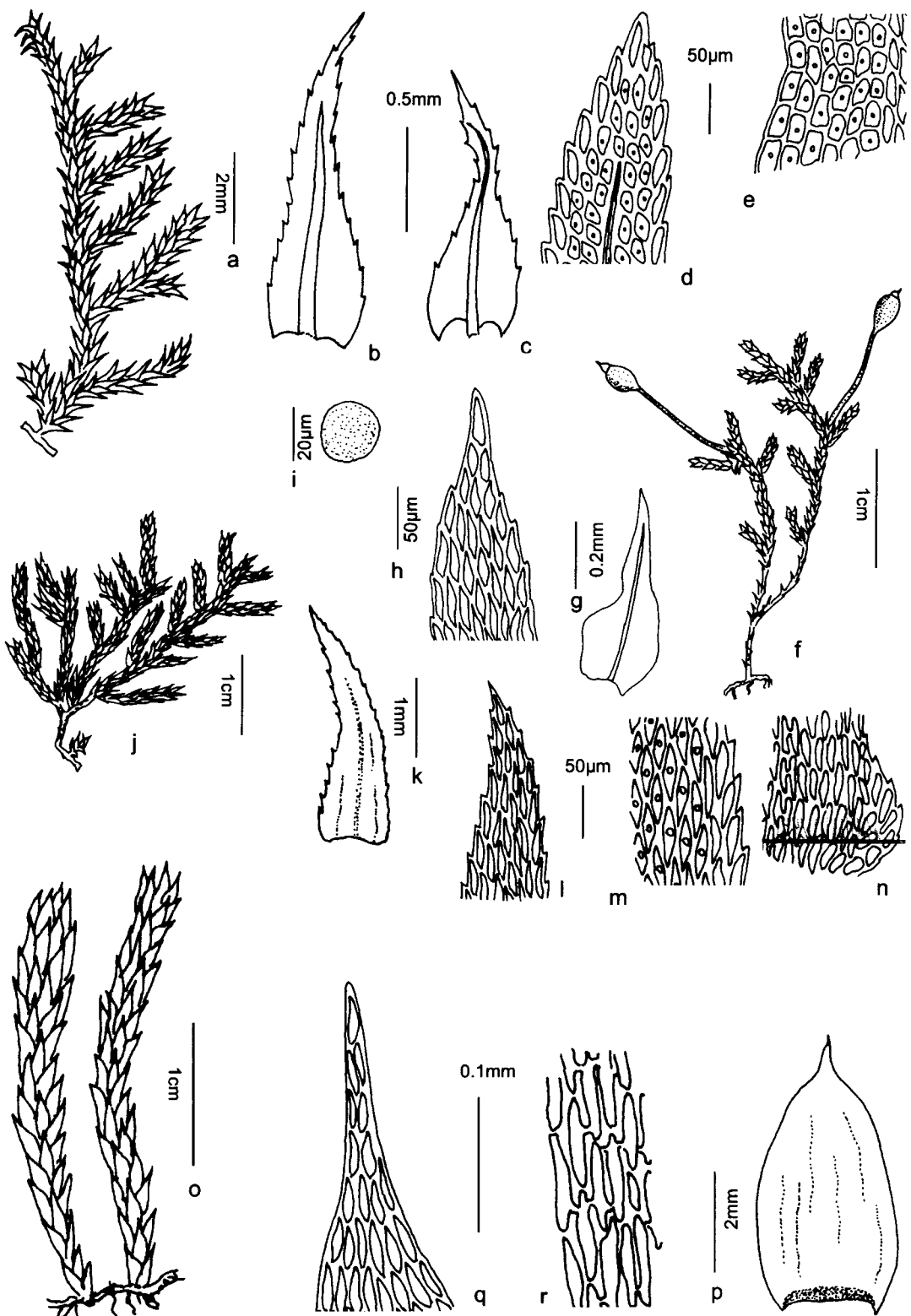


Fig. 28. **a-e**: *Duthiella declinata*; a: habit, b&c: leaves, d: leaf tip cells, e: basal cells; **f-i**: *Trachypus bicolor*; f: habit, g: leaf, h: leaf tip cells, i: spore; **j-n**: *Trachypodopsis serrulata*; j: habit, k: leaf, l: leaf tip cells, m: middle cells, n: basal cells; **o-r**: *Garovaglia plicata*; o: habit, p: leaf, q: leaf tip cells, r: middle and basal cells

Duthiella C. Muell.

in 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, appressed to the stem when dry, erecto-patent when moist, stem leaves linear-lanceolate, acuminate from ovate-lanceolate base, margin serrate, narrowly bordered, branch leaves with shorter acumen; costa single, strong, ending below apex; cells rhomboid to hexagonal, thin, mostly with one, sometimes with many small papillae, marginal cells long and narrow, translucent, smooth, forming a narrow border, basal cells elongate, smooth; alar cells large, thin walled, ovate-six sided; seta elongate, red, smooth; capsule inclined or horizontal, oblong-cylindrical, slightly curved, calyptra cucullate, naked; spores small, smooth, up to 12 μm diagonally.

Duthiella declinata (Mitt.) Zant., Blumea 9(2): 559. 1959; Gangulee, Moss. E. India 2(5): 1240. 1976. *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, robust, main stem creeping, secondary stems many, ascending upwards, regularly pinnate, very small, up to 0.5 mm long, branches of unequal length; leaves dense, 1.2 x 0.5 mm, stem leaf linear-lanceolate, acuminate from ovate-lanceolate base, margin sharply serrate, branch leaves with short acumen; costa single, strong, ending below tip; cells rhomboid to hexagonal, thick walled, with one papillae except in smooth marginal cells, small at apex, 10-15 x 10 μm , basal cells smooth, 40-48 x 8 μm , alar cells quadrate, distinct, 10-12 x 11 μm , walls of basal cells thin; seta smooth, long; capsule inclined or horizontal, oblong cylindrical, calyptra cucullate; spores rounded, smooth, 10-12 μm diagonally. (Fig. 28: a-e).

Habitat: Corticolous in moist deciduous forests.

Specimen examined: Tholpetty range (875 m) MCN 84578.

Distribution: It is rare in the study area, already reported from North-east India (Mussoorie, Naga hills, Simla), China, Indonesia and Philippines. The present collection is a new record to Peninsular India.

Trachypus Reinw. & Hornsch.

Nova Acta Leop. Carol. 14(2): 708. 1829.

Plants greenish-brown to blackish, slender to dense in loose tufts; secondary stem usually elongate, erect to almost pendant; leaves ovate to lanceolate, shortly or longly acuminate from a slightly auricled base, entire or toothed in the upper half; costa reach above midleaf, sometimes ending in or below midleaf, branch leaves sometimes ecostate; cells hexagonal to elongate-linear, striate papillose on the walls, more elongated near the base, smooth, small, rounded in the auricles; seta up to 2.5 cm long, papillose; capsule erect, ovoid, operculum long rostrate from a conical base, calyptra cucullate; spores yellowish, rounded, papillose.

Trachypus bicolor Reinw. & Hornsch., Nov. Act. Ac. Leop. Car. 14 (2): 708. 1829; Gangulee, Moss. E. India 2(5): 1227. 1976; Madhus. & M.C.Nair, J. Econ. Taxon. Bot. 28: 344. 2004. *Pilotrichum trachypus* C.Muell., Syn. Musc. Frond. 2: 162.1851. *Neckera trachypus* (C. Muell.) C.Muell., Syn. Musc. Frond. 2: 672. 1851. *N. viridula* Mitt., Kew J. Bot. 3: 351. 1851. *N. hispida* C.Muell., Bot. Zeitung. Berlin 12: 570 1854. *Meteorium hispidum* (C.Muell.) Mitt., Musci Ind. Orient. 89. 1859. *Neckera nietneri* C.Muell., Linnaea 36: 25. 1869. *Meteorium viridulum* (Mitt.) Mitt., J. Linn. Soc. Bot. 12: 443. 1869. *Papillaria viridula* (Mitt.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1875-'76: 267. 1877. *P. bicolor* (Reinw. & Hornsch.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1875-'76: 273. 1877. *P. nietneri* (C.Muell.) A.Jaeger, *ibid.* same page. 1877. *P. hispida* (C.Muell.) A.Jaeger, *ibid.* same page. 1877. *Trachypus hispidus* (C.Muell.) Paris, Index Bryol. Suppl. 1303. 1898. *T. nietneri* (C.Muell.) Paris, *ibid.* same page. 1898. *T. subbicolor* C.Muell. ex Card. in Paris, *ibid.* 1304. 1898, *nom. nud.* *T. rigidus* Broth. & Paris, Bull. Herb. Boiss. ser. 2. 2: 926. 1902. *T. appressus* M.Fleisch., Musci Fl. Buitenz. 3: 737. 1908. *T. cuspidatus* Fleisch., *ibid.* 741. 1908. *T. bicolor* var. *pilifer* M.Fleisch., *ibid.* same page. 1908. *T. bicolor* var. *tenellus* M.Fleisch.,

ibid. 741. 1908. *Brachydon patens* Hornsch. in M.Fleisch., *ibid.* 738. 1908, *nom. nud.* *Trachypus cuspidatus* var. *brevifolia* M.Fleisch., Musci Fl. Buitenz. 3: 743. 1908. *T. bicolor* var. *sinensis* (C.Muell.) Broth., Nat. Pflanzenfam. ed. 2, 11: 119. 1925. *T. annamensis* Broth., Nav. Rev. Bryol. n. ser. 1: 40. 1928, *nom. nud.* *T. bicolor* var. *brevifolius* Broth, Symb. Sin. 4: 76. 1929. *T. bicolor* var. *simplicicaulis* Dixon, Bryologist 46: 20. 1943. *T. bicolor* var. *viridulus* (Mitt.) Zant., Blumea 9: 499. 1959. *T. mexicanus* Broth, in Zanten, Blumea 9: 500. 1959, *nom. nud. in synon.*

Plants yellowish-green to blackish, slender to robust, in dense to loose mats; stem highly branched, small, horizontal; leaves ovate to lanceolate, dense, up to 0.5 mm long, broad at base, acuminate, toothed in the upper half; costa single, ending near the midleaf; cells elongate or linear papillose on the walls, near the base more elongated; seta up to 2 cm long; capsule erect, globose-ovoid, small-necked, dark brown, peristome teeth white; spores large, brown, 17.5 -25.5 μm diagonally. (Fig. 28: f-i & Plate 14f&g).

Habitat: Common on basal and upper part of tree trunks and branches in semi-evergreen, evergreen and shola forests.

Specimens examined: Chembra hills (1380 m) MCN 99603, Thirunelli RF (1350 m) MCN 99617.

Distribution: It is widely distributed in the study area. It was reported earlier from South India (Tamil Nadu: Palni hills, Nilgiri hills; Kerala: Vellarimala, Chinnar WLS, ENP), North-east India (Western Himalayas, Assam, Sikkim), Sri Lanka, China, Nepal, Barnes, Brazil, Celebes, French Guinea, Guatemala, Indonesia, Japan, Korea, Mexico, Myanmar, Thailand, New Guinea, Philippines and Sumatra.

Trachypodopsis M.Fleisch.

Hedwigia 45: 64. 1905.

Plants greenish, slender to robust, secondary stems many, mostly elongated, prostrate to pendant, irregularly pinnate, usually with simple branches; leaves appressed to stem when dry, erecto-patent when moist, lanceolate from an auriculate, ovate base, auricles sometimes large, crenulate

to sharply toothed, long acuminate; costa long, but never percurrent; cells linear or widely elliptic, each with a papilla from the middle of the lumen, cells in the auricles mostly quadrate to rectangular; seta 3-18 mm, papillose; capsule erect, short, oblong-ovoid, operculum conical, calyptra small, cucullate, smooth or with one celled hairs; spores small, about 25 μm diagonally, slightly papillose.

Trachypodopsis serrulata (P.Beauv.) M.Fleisch., Hedwigia 45: 67. 1905; Gangulee, Moss. E. India 2(5): 1234. 1976. *Pilotrichum serrulatum* P.Beauv., Prodr. 83. 1805. *Neckera serrulata* (P.Beauv.) Brid., Sp. Musc. 2: 29. 1812. *Meterium serrulatum* (P.Beauv.) Mitt., J. Linn. Soc. Bot. 7: 156. 1863. *Papillaria serrulata* (P.Beauv.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 274. 1877. *Trachypus serrulatus* (P.Beauv.) Besch., Ann. Sci. Nat. Bot. Ser. 6, 10: 269. 1880. *Trachypodopsis nodicaulis* (C.Muell.) M.Fleisch., Hedwigia 45: 67. 1906. *T. pintasiana* M.Fleisch., *ibid.* same page. 1906. *T. rutenbergii* (C.Muell.) M.Fleisch., *ibid.* 68. 1906. *Trachypus quintasianus* C.Muell. in Broth., Nat. Pflanzenfam. 1(3): 832. 1906, *nom. nud. in synon.*

Plants dark greenish, robust, in dense mats; secondary stem ascending or hanging, up to 10 cm or more long, pinnately branched; leaves erect spreading when moist, appressed to stem when dry, plicate, lanceolate, acuminate, margin serrulate, base auricled; costa single, faint or strong ending far below apex; cells thick walled, rhomboid to linear, 35-40 x 5-8 μm , smooth at apex, basal cells rhomboid with a single papilla at centre, 15-20 x 5-9 μm , juxtacostal cells broader rectangular, alar cells quadrate-rhomboid, 10-12 x 6-8 μm ; sporophyte not seen. (Fig. 28: j-n & Plate 14h).

Habitat: Basal and upper part of tree trunk on evergreen forests.

Specimen examined: Thirunelli RF (1220 m) MCN 99624.

Distribution: It is common in the study area. It was earlier recorded from South India (Tamil Nadu: Palni hills), North-east India (Calcutta, Mussoorie, Arunachal Pradesh, Khasi hills, Naga hills, Sikkim, Simla,), Andaman Islands, Sri Lanka, Myanmar, Thailand, Laos, Sumatra, Java, Borneo, Celebes, Taiwan, Central & South Africa and Madagascar. The present collection is a new record to Kerala.

PTEROBRYACEAE Kindb.

Genera Europ. North Amer. Bryineae (Mosses) 15. 1896.

Plants yellowish-green, slender to robust, secondary branches elongate; leaves dense, ovate, acuminate, neither recurved nor squarrose; costa single, double or none; cells thick walled, elongate, usually smooth, alar often differentiated, coloured; seta usually short; capsule immersed or exerted, smooth, peristome double, operculum short, calyptra small, not hairy.

Brotherus (1925) recognized four subfamilies within this family. Of these Trachylomoideae with three genera viz., *Trachyloma*, *Penzigiella* and *Osterwaldiella*; Garovaglioideae with two genera, *Garovaglia* and *Entotrichella* and Pterobryoideae with three genera, *Pterobryopsis*, *Symphysodontella* and *Horikawaea* are found in India. In the present treatment only two genera viz., *Garovaglia* and *Pterobryopsis* are recognized.

Key to the genera

- 1a. Leaves broadly ovate to oblong; costa scarcely distinct, double or absent
.....**Garovaglia**
- 1b. Leaves ovate-cordate, costa single mostly ending in the middle, rarely double or absent.....**Pterobryopsis**

Garovaglia Endl.

Gen. Pl. 57. 1836.

Plants rigid, robust; leaves large, octofarious, broadly ovate to oblong-ovate, rarely spreading on all sides, asymmetric, from a narrow, half sheathing auriculate base, upper narrower, abruptly passing into a subulate, often twisted and curved acumen, mostly deeply plicate, concave, margin plane or revolute, usually toothed above; costa scarcely distinct, double or absent; cells oblong or elongate-linear, firm walled, wider at the base, strongly pitted, alar cells often differentiated; capsule completely immersed, ovoid to oblong, smooth, brown, operculum with short and straight beak from a nearly flat base, calyptra mitriform, many lobed, hardly covering the operculum; spores of unequal size, 10-30 μm diagonally.

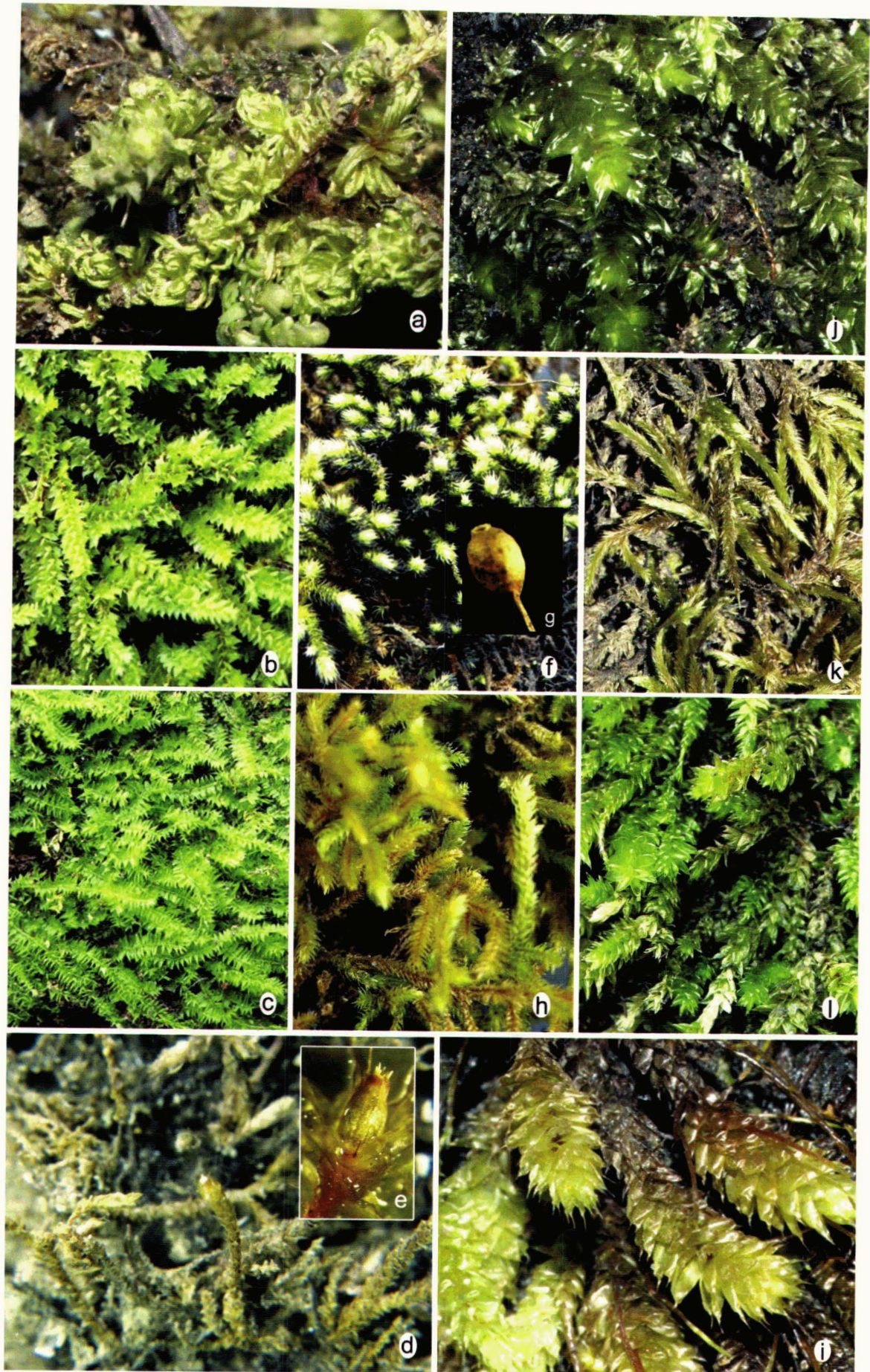


Plate. 14. a: *Macromitrium tenerum*, b: *Racopilum cuspidigerum*, c: *R. orthocarpum*, d: *Schoenobryum concavifolium*, e: capsule, f: *Trachypus bicolor*, g: capsule, h: *Trachypodopsis serrulata*, i: *Garovaglia plicata*, j: *Pterobryopsis acuminata*, k: *P. orientalis*, l: *Pterobryopsis* sp.

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Garovaglia plicata (Brid.) Bosch & Sande-Lac., Bryol. Jav. 2: 79. 1863; Gangulee, Moss. E. India 2(5): 1256. 1976. *Esenbeckia plicata* Brid., Bryol. Univ. 2: 754. 1827. *Neckera plicata* (Brid.) Schwaeger. in Hedw., Sp. Musc. Suppl. 3(2): 268. 1829. *Pilotrichum plicatum* (Brid.) C.Muell., Synop. Musc. Frond. 2: 158. 1850. *Meteorium plicatum* (Brid.) Mitt., J. Linn. Soc. Bot. Suppl. 1: 84. 1859. *Endotrichum plicatum* (Brid.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 231. 1877.

Plants golden greenish to dark greenish, primary stem thick, blackish, rhizomatous, secondary stem erect to drooping, some branches flagelliform; leaves dense, $\pm 4 \times 2.2$ mm, ovate-lanceolate, sharply acuminate, plicate, margin slightly dentate at apex; cells with porose walls, lamellae at basal cells, $\pm 50 \times 9$ μm at tip, lower cells $75\text{-}80 \times 8\text{-}11$ μm , short wider, cells at leaf insertion yellowish-brown; mostly seen as sterile. (Fig. 28: o-r & Plate 14i).

Habitat: Upper part of tree trunk in evergreen and shola forests.

Specimens examined: Chembra hills (1370-1770 m) MCN 120253, MCN 120399, Thirunelli RF (1280 m) MCN 99620.

Distribution: It is an Indo-Malesian species distributed in East India (Sikkim); Sumatra, Indonesia, Java, Malaya, Borneo, Taiwan, Cera and Philippines. The present collection is a new record to Peninsular India.

Pterobryopsis M.Fleisch.

Hedwigia 45: 56. 1906.

Plants golden-yellowish to greenish, slender to robust, glossy; leaves ovate-cordate, appressed to stem when dry, shortly and narrowly acuminate from an ovate base, entire or toothed in the apical part; costa single, mostly ending in the middle, rarely double or absent; cells smooth, rhomboid to narrowly linear, at the base large, brown, pitted; alar cells large, thick walled, often reddish-brown; capsule mostly raised, oblong, orange-brown, operculum rostrate; spores large, rounded, $40\text{-}50$ μm , papillose.

Key to the species

1a. Costa strong, not flexuose; 7-11 celled filamentous gemmae

.....**Pterobryopsis** sp.

- 1b. Costa strong, flexuose, gemmae absent.....2
 2a. Leaves ovate-cordate, tip apiculate.....**P. acuminata**
 2b. Leaves elongate-ovate, shortly acuminate.....**P. orientalis**

Pterobryopsis acuminata (Hook.) M.Fleisch., Hedwigia 45: 59. 1905; Gangulee, Moss. E. India 2(5): 1273. 1976. *Neckera acuminata* Hook., Musci. Exot. 2: 15. 1819. *Meteorium acuminatum* (Hook.) Mitt., Musci. Ind. Orient. 86. 1859. *Endotrichum acuminatum* (Hook.) A.Jaeger., Ber. Senckenberg. Naturf. Ges. 1875-'76: 233. 1877. *Garovaglia acuminata* (Hook.) Paris, Index. Bryol. 507. 1896.

Plants yellowish-green, primary stem creeping, up to 5 cm long, blackish; secondary shoot rigid, 1-1.5 cm x 3-5 mm; leaves dense, imbricate, ovate-cordate, tip apiculate, plicate, 2 x 1 mm, margin flat; costa single, reach above midleaf, flexuose above; cells thick walled, elongate, walls porose at base, stem attached cells coloured, alar cells deep reddish brown, rectangular, 25-48 x 18-20 µm, middle cells 120-130 x 3-5 µm, upper cells 120-125 x 5 µm, shorter at base margin. (Fig. 29: a-d & Plate 14j).

Habitat: Upper part of tree trunk on semi-evergreen and evergreen forests.

Specimen examined: Mananthavady puzha (1100 m) MCN 99648.

Distribution: It is rare in Wayanad. This species is distributed in South India (Tamil Nadu: Nilgiri hills), North-east India (Sikkim, Khasi hills), Nepal and Myanmar. The present collection is a new record to Kerala.

Pterobryopsis orientalis (C.Muell.) M.Fleisch., Hedwigia 59: 217. 1917; Gangulee, Moss. E. India 2(5): 1272. 1976. *Neckera orientalis* C.Muell., Bot. Zeitung. Berlin 14: 437. 1856. *Meteorium foulkesianum* Mitt., Musc. Ind. Orient. 85. 1859. *Leucodon orientalis* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 217. 1877. *Endotrichum foulkesianum* (Mitt.) A.Jaeger, *ibid.* 76: 233. 1877. *Garovaglia foulkesiana* (Mitt.) Paris, Index Bryol. Suppl. 508. 1896. *Pterobryopsis foulkesiana* (Mitt.) M.Fleisch., Hedwigia 45: 60. 1905. *P. yuennanensis* Broth., Sitz. Ak. Wiss. Wien Math. Nat. Kl. Abtl. 133. 573. 1924.

Plants golden-yellowish to green, robust, stiff, 6-8 cm long, main stem creeping, secondary stem irregularly branched, branches sometimes flagelliform, erect; leaves elongate-ovate, shortly acuminate, up to 1.4 mm long, serrate above, plicate; costa strong, flexuose above, ends well below the tip; cells at the upper portion elongated to rhomboid, small, up to 22-30 x 4-9 μm , middle and basal cells 28-40 x 4-9 μm , alar cells rounded-quadrate, smooth, yellowish-orange to dark brownish, 10-15 μm diagonally. (Fig. 29: e-g & Plate 14k).

Habitat: Corticolous along with other mosses and leafy liverworts and also on logs in moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Arupunji (876 m) *MCN 84389*, Kurichiad range (750-858 m) *MCN 84531*, *MCN 84555*, Chandanathode (950 m) *MCN 80108*.

Distribution: It is common in the study area. A South-east Asiatic species found distributed in South India (Nilgiri hills), North-east India (Mussoorie, Kumaon, Darjeeling, Sikkim, Naga hills), Myanmar, Thailand, North Vietnam and Yunnan. The present collection is a new record to Kerala.

Pterobryopsis sp.

Plant light to dark greenish, main stem creeping, up to 5 cm or more long, branches erect, 1-3.5 cm long, stiff, dendroid; leaves dense, erecto-patent to spreading, $\pm 2.6 \times 1-1.2$ mm, concave, plicate, tip acuminate, margin flat, faintly denticulate above; costa single reaching half of leaf; cells linear, thick walled, 65-75 x 4-6 μm , middle cells 50-55 x 4-6 μm , cells at stem insertion coloured, alar cells deep yellowish-red, rectangular, 25-28 x 20-22 μm ; numerous, 7-11 celled, $\pm 250 \times 15-22$ μm , filamentous gemmae scattered on the upper leaves. (Fig. 29: h-j & Plate 14l).

Habitat: Upper part of tree trunk in semi-shaded areas of moist deciduous forests.

Specimen examined: Manikunnumala, Near MSSRF (950 m) *MCN 120294*.

Distribution: It is rare in Wayanad and could only be collected from one locality.

METEORACEAE Kindb.

Gen. Eur. N.-Amer. Bryin. 7. 1897.

Plants glossy, robust, usually hanging from trees, primary stem creeping, filiform, 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 short; capsule exerted, peristome double, calyptra small, cucullate; spores very small; fruiting not common.

This family is represented by about 20 genera of which 12 genera are found in India. Among these six genera viz., *Papillaria*, *Cryptopapillaria*, *Floribundaria*, *Aerobryum*, *Aerobryopsis* and *Meteoriopsis* occur in the study area.

Key to the genera

- 1a. Leaves usually squarrose; cells papillose or not.....3
- 1b. Leaves usually not squarrose; cells papillate.....2
- 2a. Cells with two rows of papillae on the laminal cells.....**Cryptopapillaria**
- 2b. Cells with one central line of papillae on the laminal cells.....**Papillaria**
- 3a. Plants not glossy, very delicate, feather-like; cells multipapillate; alar cells distinct.....**Floribundaria**
- 3b. Plants glossy, thick, strong; cells smooth or papillate; alar cells not differentiated.....4
- 4a. Plants not robust, slender, stem leafless; cells uniformly unipapillate.....**Aerobryopsis**
- 4b. Plants robust; stem leafy, cells smooth.....5
- 5a. Leaves sheathing; costa single, faint, ending near midleaf.....**Aerobryum**
- 5b. Leaves half sheathing; costa single, prominent, ends at upper half of leaf.....**Meteoriopsis**

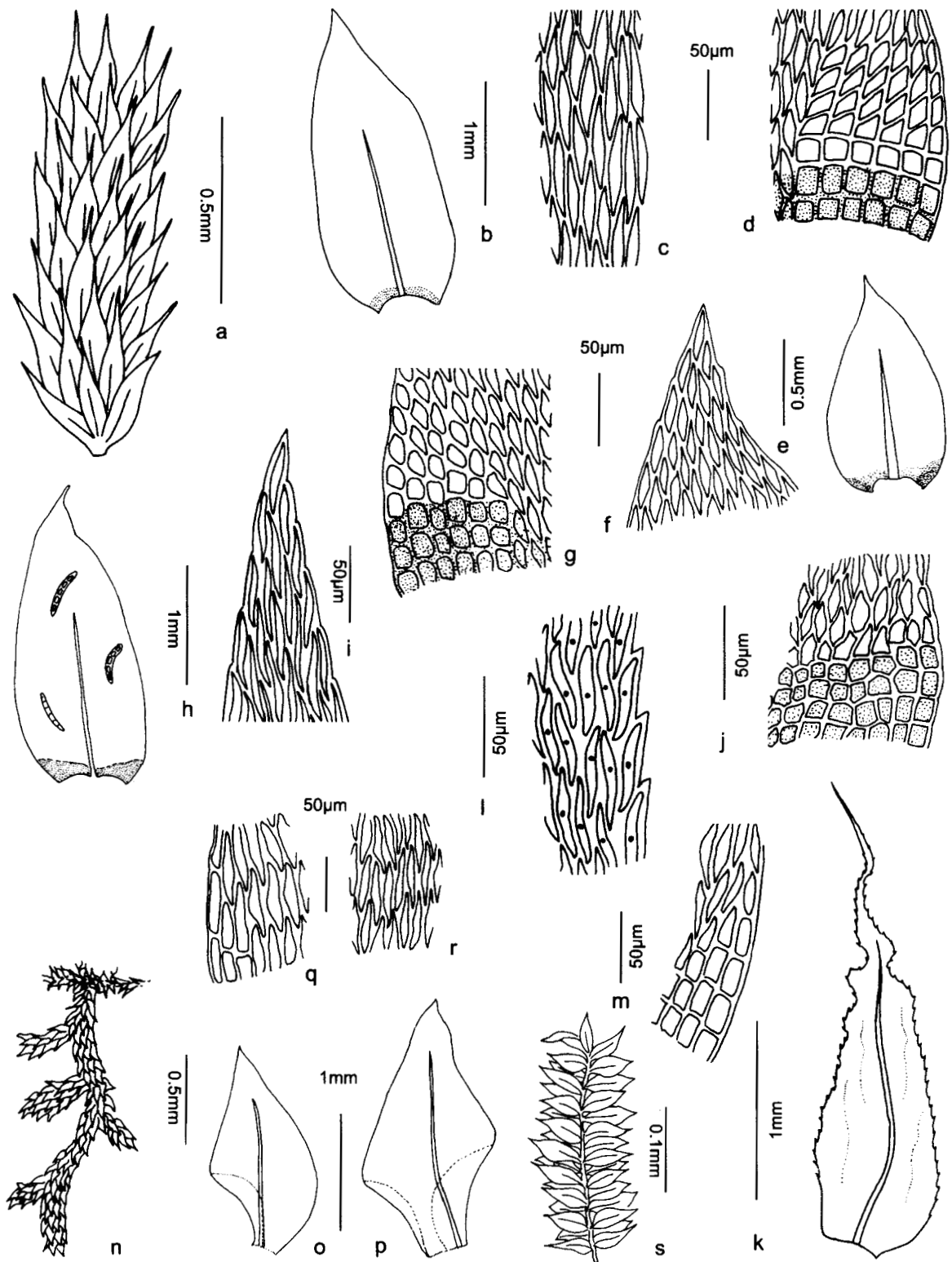


Fig. 29. a-d: *Pterobryopsis acuminata*; a: single branch, b: leaf, c: upper and middle cells, d: basal cells; e-g: *Pterobryopsis orientalis*; e: leaf, f: leaf tip cells, g: basal cells; h-j: *Pterobryopsis* sp.; h: leaf, i: leaf tip cells, j: basal cells; k-m: *Aerobryopsis longissima*; k: leaf, l: leaf tip cells, m: basal cells; n-r: *Aerobryum speciosum*; n: habit, o&p: leaves, q: upper and middle cells, r: basal cells, s: single branch

Aerobryopsis M.Fleisch.

Hedwigia 44: 304. 1905.

Plants glossy, slender; stem leafless, irregularly branched, branches pinnate, pendant; leaf concave, smooth or narrowly ovate-lanceolate with shorter or longer acumen, minutely toothed; costa thin, reaching above the midleaf; 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, more or less rough; capsule erect or inclined, brown, straight or curved, calyptra cucullate, sparsely hairy; spores 10-20 μm , brownish, finely papillose.

Aerobryopsis longissima (Dozy & Molk.) M.Fleisch., Hedwigia 44: 305. 1905; P.Bruehl, Rec. Bot. Surv. India 13(1): 72. 1931; Foreau, J. Madras Univ. Sect. B. 3: 120. 1931 & J. Bombay Nat. Hist. Soc. 58: 32. 1961; Wadhwa, M.V.M. Patrika 4: 76. 1969; R.S.Chopra, Tax. Indian Mosses: 337. 1975; Gangulee, Moss. E. India 2(5): 1318. 1976. *Neckera longissima* Dozy & Molk., Ann. Sc. Nat. Bot. ser. 3,2: 313. 1844. *Meteorium longissimum* (Dozy & Molk.) Dozy & Molk., Musc. Fr. Inediti Archipelago Indici 6: 159. 1848. *Neckera dozyana* C.Muell., Synop. Musc. Frond. 2: 141. 1850. *Meteorium lanosum* Mitt., Musc. Ind. Orient. 90. 1859. *Pilotrichum griffithianum* Wils. in Mitt., Musc. Ind. Orient. 90. 1859. *Aerobryum lanosum* (Mitt.) Mitt., J. Linn. Soc. Bot. 10: 170. 1868. *A. longissimum* (Dozy & Molk.) C.Muell., Linnaea 40: 260. 1876. *A. pseudo-lanosum* Broth. & Geh., Biblioth. Bot. 44: 17. 1898. *Eriocladium beccarii* C.Muell. in M.Fleisch., Hedwigia 44: 306. 1905.

Plant yellowish-green, stem blackish, up to 6 cm long, branches short, pinnate; branch leaf 3.5 x 0.6 mm; stem leaf wider, 2-2.3 x 1 mm, leaves mostly radially disposed in a symmetrical manner, broad below, becoming narrow towards the tip, pointed, margin denticulate; costa yellowish, reach above mid leaf; cells narrow elongate, with one papilla on top, except at extreme tip and base, 40-45 x 5-7 μm at tip, 60-65 x 6 μm below; sporophyte not seen. (Fig. 29: k-m).

Habitat: Base of tree trunk in moist deciduous forests.

Specimen examined: Sulthan Bathery (870 m) MCN 84353b.

Distribution: It is distributed in South India (Tamil Nadu: Palni hills; Karnataka: Coorg) East India (Sikkim), Sri Lanka, China, Caroline Islands, Indian Archeipelago, Madagascar, Malacca, New Guinea, Philippines, Pacific Ocean Islands, Sumatra, Taiwan, Tonkin, Australia and Yunnan. The present collection is a new record to Kerala.

Aerobryum Dozy & Molk.

Ned. Kruidk. Arch. 2(4): 279. 1851.

Plants robust, glossy with long, sparingly branched, secondary stems pendant, whole stem leafy; leaves squarrose, widely spreading, broadly ovate, acuminate, margin serrate; costa single, faint, ending near the midleaf; cells thin to thick walled, rhomboid-linear to elliptic-ovate, smooth; alar cells absent or indistinct; sporophyte on ultimate branches; seta slender smooth; capsule suberect, exerted, peristome double; spores rounded, 15-20 μm diagonally.

Aerobryum speciosum Dozy & Molk., Ned. Kruidk. Arch. 2(4): 280. 1851; Gangulee, Moss. E. India 2(5): 1347. 1976. *Meteorium specium* (Dozy & Molk.) Mitt., J. Linn. Soc., Bot. Suppl. 1: 87. 1859. *Aerobryum nipponicum* (Nog.) Sak., Musc. Jap. 105. 1954. *A. speciosum* var. *nipponicum* Nog., J. Hattori Bot. Lab. 3: 98. 42 f. 3. 1948.

Plants robust, glossy with long, sparingly branched, laxly leafy, pendant secondary stems; leaves squarrose, widely spreading, broadly ovate, narrowed to a short acuminate tip, inflexed, distinctly serrate; costa single, faint, ending near the midleaf; cells thin to thick walled, rhomboid-linear to elliptic-ovate, smooth, upper cells 35-40 x 6 μm , middle cells 75-80 x 7 μm ; alar cells indistinct; sporophyte not seen. (Fig. 29: n-r).

Habitat: Base of tree trunk along with mosses near streams in moist deciduous and semi-evergreen forests, also epiphytic on Coffee tree in Plantations.

Specimens examined: Chandanathode (950 m) MCN 80081a, MCN 80111, Lakkidi (400 m) MCN 80086, MCN & PVM 80100b, Tholpetty range (860 m) MCN 84582.

Distribution: This species is common in the study area. An east and southeast Asiatic species earlier reported from South India (Western Ghats of Tamil Nadu), North-east India (Darjeeling, Arunachal Pradesh, Khasi hills, Manipur, Meghalaya, Sikkim), Sri Lanka, Bhutan, Celebes, China, Taiwan, Indonesia, Japan, Philippines, New Guinea and Tonkin. The present collection is a new record to Kerala.

Cryptopapillaria M.Menzel

Willdenowia 22: 181. 1992.

Plants yellowish-green, robust; secondary stems many, elongate; leaves closely or distantly imbricate when dry, erecto-patent from a cordate or auriculate base when moist, oblong to lanceolate, apex shortly or longly acuminate or hair pointed, margin entire or minutely toothed, two rows of papillae on the laminal cells; costa narrow, single, not percurrent; cells rhomboidal to linear, two rows of papillae on the wall, at the base adjoining the costa hyaline, smooth, auricular in oblique rows, alar cells not distinct; seta very short, rough; capsule completely immersed or exerted, ovoid to oblong-ovoid; peristome teeth yellowish-white, calyptra small, more or less papillose.

Note: The genus *Cryptopapillaria* was created by Menzel (1992) to include those species of *Papillaria* having two rows of papillae on the laminal cells (which line up along the edges of the cells, making the cell walls difficult to see), rather than one central line of papillae. He included five species viz., *C. fuscescens* (Hook.) A.Jaeger, *C. feae* (C.Muell. ex M.Fleisch) M.Menzel, *C. chrysoclada* (C.Muell.) M.Menzel, *C. helictophylla* (Montin) M.Menzel, and *C. penicillata* (Dozy & Molk.) M.Menzel. The first 3 occur in India, the fourth only in the Pacific Ocean area and the fifth only in Central and South America. Among these *C. fuscescens* is cosmopolitan in distribution.

Cryptopapillaria fuscescens (Hook.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 270. 1877; 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; Sundararagh & Wadhwa, Bull. Bot. Surv. India 10: 346. 1968; R.S.Chopra, Tax. Indian Mosses 333. 1975; Gangulee, Moss. E. India 2(5): 1284. 1976; Madhus. & Nair, M.C. J. Econ. Tax. Bot. 28: 341.2004.

Neckera fuscescens Hook., Musc. Exot. 2: 157. 1819. *Daltonia fuscescens* (Hook.) Arn., Mem. Soc. Linn. Paris 5: 296. 1827. *Pilotrichum fuscescens* (Hook.) Brid., Bryol. Univ. 2: 264. 1827. *Neckera chrysoclada* C.Muell., Syn. Musc. Frond. 2: 139. 1850. *Trachypus fuscescens* (Hook.) Mitt., Musc. Ind. Orient. 128. 1859. *Meteorium fuscescens* (Hook.) Bosch & Sande-Lac., Bryol. Jav. 2: 93. 1864. *Papillaria chrysoclada* (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 270. 1877. *P. fuscescens* (C.Muell.) A.Jaeger, var. *crassiramea* Renaud & Cardot, Bull. Soc. Bot. Belgium 38: 19. 1900. *P. feae* C.Muell. ex M.Fleisch., Die Musci Fl. Buitenz. 3: 761. 1908; P.Bruehl, Rec. Bot. Surv. India 13(1): 23. 1931. *P. fuscescens* (C.Muell.) A.Jaeger var. *gracilis* M.Fleisch., Die Musci Fl. Buitenz. 3: 761. 1908. *P. bamfothiae* Broth. ex Dixon, J. Bot. (Morot) 50: 148. 1912.

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 to lanceolate, up to 0.13 mm long, apex acuminate or hair pointed, margin toothed; costa single, ending well below apex; cells rhomboidal to linear, with elliptic lumina, two rows of seriate papillose on the walls, at the base adjoining the costa hyaline, smooth, auricular cells in oblique rows, cells $\pm 25 \times 3-5 \mu\text{m}$ at apex, $40-48 \times 8-12 \mu\text{m}$ at base, alar cells not distinct; mostly remain as sterile. (Fig. 30: a-d & Plate 15a).

Habitat: On tree trunks and on logs in moist deciduous, semi-evergreen, evergreen and shola forests.

Specimens examined: Begur RF (840 m) MCN 84593, Chembra hills (1394 m) MCN 120316a, Periya (985 m) MCN 99610, Nalukettumchola (1050 m) SKA 120215.

Distribution: It is a common species in the high altitude zones of the study area. It is widely distributed in South India (Kerala, Goa, Karnataka, Tamil Nadu), North-east India (Kumaon Hiamalaya, West Bengal, Arunachal Pradesh, Manipur, Meghalaya, Sikkim), Sri Lanka, Bhutan, Indonesia, Indian Archeipelago, Myanmar, Nepal, Philippines, Thailand, Tonkin and Yunnan.

Floribundaria M.Fleisch.

Hedwigia 44: 301. 1905.

Plants slender, in loose tufts, main stem prostrate, pinnately branched, branches short or elongate; branch and branchlet leaves distichous, widened from a small decurrent, rounded base, narrowly lanceolate, hyaline, acuminate, margin plane or recurved near the base, serrate; costa single, thin; cells narrow, linear-rhomboid, usually more or less papillose, near the base wider, alar cells nearly quadrate, smooth, sometimes absent; stem leaves and those near the base smaller, base broad, long acumen, alar cells distinct; seta 2-4 mm; capsule erect, inclined, ovoid or oblong-ovoid, calyptra cucullate, small, mostly sparsely hairy; spores rounded, 15-25 μm diagonally.

Floribundaria walkeri (Renauld & Cardot) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 822. 1906; P.Bruehl, Rec. Bot. Surv. India 13(1): 73. 1931; R.S.Chopra, Tax. Indian Mosses 346. 1975; Gangulee, Moss. E. India 2(5): 1306. 1976. *Papillaria walkeri* Renauld & Cardot, Bull. Bot. Soc. Belgique 34(2): 70. 1896.

Plants yellowish-green, very delicate, in tufts, not much branched, up to 5 cm long; leaves wide-spreading, feather like, small, 0.5 x 0.16 mm, ovate-lanceolate, apex acuminate, margin smooth, flat; costa weak, covering less than half of leaf length, some times indistinct; cells narrow, linear, multipapillate, 25-30 x 3-5 μm at apex, ± 25 x 3-5 μm at base; sporophyte not seen. (Fig. 30: e-g & Plate 15b).

Habitat: On rocky patches and as epiphytes along with other leafy liverworts in semi-evergreen, evergreen and shola forests.

Specimens examined: Chandanathode (950 m) MCN 80083a, 80109, Chembra hills (1394-1775 m) MCN 120282b, Manikkunnumala (920 m) MCN 120304.

Distribution: *Floribundaria walkeri* is an Indian endemic species distributed in Eastern Himalayas and West Bengal. The present collection is a new record to Peninsular India.

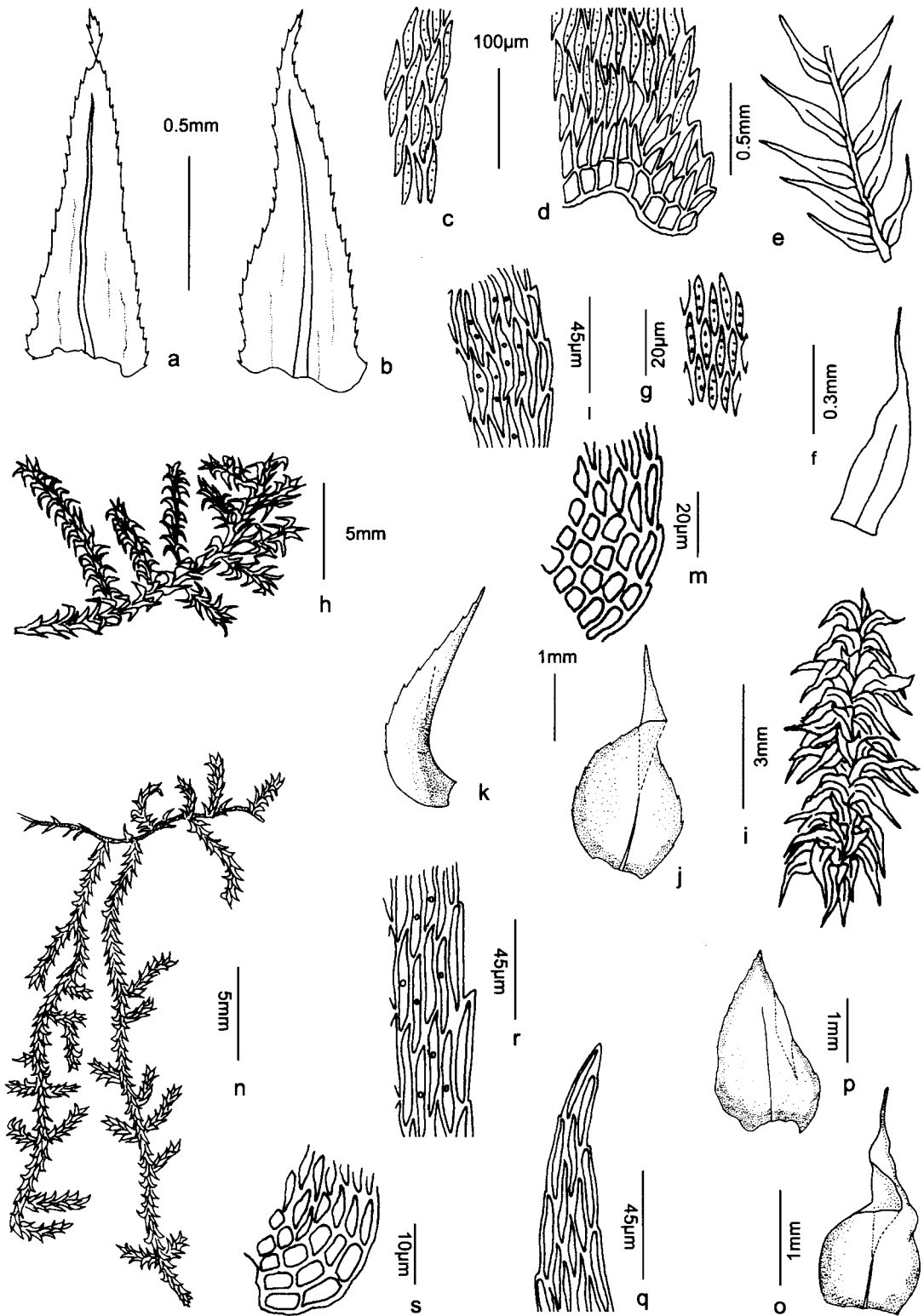


Fig. 30. **a-d:** *Cryptopapillaria fuscescens*; a&b: leaves, c: upper and middle cells, d: leaf basal cells; **e-g:** *Floribundaria walkerii*; e: portion of branch, f: leaf, g: leaf cells; **h-m:** *Meteriopsis reclinata*; h: habit, i: single branch, j&k: leaves, l: upper and middle leaf cells, m: leaf basal cells; **n-s:** *Meteriopsis squarrosa*; n: habit, o&p: leaves, q: leaf tip cells, r: middle marginal cells, s: leaf basal cells

Meteoriopsis M.Fleisch ex Broth.

Nat. Pflanzenfam. 1(3): 825. 1906.

Plants slender to robust, secondary stems many, long, pendant, pinnate, whole stem leafy; leaves ovate to nearly orbicular, arises from half-sheathing or squarrose-spreading base, shortly pointed to long and narrowly acuminate, whole margin minutely to strongly serrate; costa single, ending in the upper half of the leaf; cells narrowly rhomboid to linear, uni to multi papillose, sometimes smooth, near the base wider, alar cells not differentiated; seta short; capsule erect, ovoid to oblong, brown, smooth, peristome teeth lanceolate or linear-lanceolate, long and narrowly subulate, operculum with straight or oblique beak, calyptra covering only on the upper part of the urn, many lobed and usually hairy, or rough near the tip; fruiting not common.

Key to the species

- 1a. Leaf tip more reflexed, suddenly acuminate; cells with papillae except at extreme tip and base **M. reclinata**
1b. Leaf tip deflexed, short pilose; cells with two small papillae..... **M. squarrosa**

Meteoriopsis reclinata (C.Muell.) M.Fleisch. in Broth., Nat. Pflanzenfam. 1(3): 826. 1906; P.Bruehl, Rec. Bot. Surv. India 13(1): 74. 1931; Dixon, J. Bombay Nat. Hist. Soc. 58: 17. 1961; R.S.Chopra, Tax. Indian Mosses 351. 1975; Gangulee, Moss. E. India 2(5): 1354. 1976. *Pilotrichum reclinatum* C.Muell., Bot. Zeitung 12: 572. 1854. *Meteorium reclinatum* (C.Muell.) Mitt., Musc. Ind. Orient. 87. 1859; Broth., Rec. Bot. Surv. India 1(12): 322. 1899. *M. phaeum* Bosch. & Sande-Lac., Bryol. Jav. 2: 86. 1864.

Plants yellowish-green, variously branched, branches small; leaves oblong-ovate, faintly serrated all around, leaves plicate, 2-3 x 1.4 mm, curled backwards both in fresh and dried; costa faint, single, ending far below the apex; cells narrow elongate, 35-40 x 5 µm at apex, cells at basal half irregularly rectangular, smooth, 60-75 x 5-7 µm, 2-3 small papillae, except at extreme base and tip; sporophyte not seen. (Fig. 30: h-m & Plate 15c).

Habitat: It is a common species seen on the trunks and branches of trees and shrubs in coffee and teak plantations, moist deciduous, semi-evergreen,

evergreen and shola forests.

Specimens examined: Kurichiad range, Dhottakulachi, (890 m) *MCN 84556*, Chandanathode (900 m) *MCN 80081b*, Sulthan Bathery (600-925 m) *MCN 84347*, *MCN 84367*, near Lakkidi palam (700 m) *MCN 80080a*, Soojippara (760 m) *MCN & KPR 87097*, Chembra hills (1394 m) *MCN 120316*.

Distribution: It is a widely distributed species in the study area. It was earlier recorded from South India (Tamil Nadu: Nilgiri, Palni hills, Tirunelveli; Karnataka: Coorg), North-east India (Mussoorie, Kumaon, Bihar, Meghalaya, Sikkim), Sri Lanka, China, Japan, Indonesia, Malacca, Myanmar, Thailand, Laos, Celebes, Nepal, New Guinea, Sumatra and Australia. The present collection is a new record to Kerala.

Meteoriopsis squarrosa (Hook.) M.Fleisch. in Broth., Nat. Pflanzenfam. 1(3): 826. 1906; Gangulee, Moss. E. India 2(5): 1349. 1976; Mohamed *et al.*, J. Bombay Nat. Hist. Soc. 83: 689. 1986. *Neckera squarrosa* Hook., Icon. Pl. Rar. 1: 22. 1836. *Pilotrichum squarrosom* (Hook.) C.Muell., Syn. Musc. Frond. 2: 154. 1850. *Meteorium squarrosom* (Hook.) Mitt., Musci. Ind. Orient. 87. 1859.

Plants yellowish-green, in dense mats, secondary shoots pendulous, irregularly branched; leaves dense squarrose with tip deflexed, not twisted, $\pm 2 \times 1.4$ mm, ovate-lanceolate, folded, base semi-sheathing, cordate, quickly narrowed to sharp point; costa single, ending above midleaf; cells linear-rhomboid, $\pm 100 \times 5-8 \mu\text{m}$ at tip, $50-60 \times 5-8 \mu\text{m}$ at midleaf, near base $30-40 \times 7-10 \mu\text{m}$, more rhomboid with two small papillae, cells on the auricle smooth, rectangular in the alar region; mostly remain as sterile. (Fig. 30: n-s & Plate 15d).

Habitat: Corticolous as well as on small branches of shrubs in moist deciduous semi-evergreen, evergreen and shola forests.

Specimens examined: Sulthan Bathery (900 m) *MCN 84358*, *MCN 84367*, Chembra hills (1380 m) *MCN 120264*.

Distribution: It is widely distributed in the study area. It was earlier recorded from South India (Tamil Nadu: Nilgiri hills, Palni hills; Karnataka: Coorg), North-east India (Sikkim, Darjeeling, Himalaya, Arunachal Pradesh, Khasi hills,

Manipur), Sri Lanka, Nepal, Bhutan, Myanmar, Thailand, Vietnam, Sumatra, Java, New Guinea, Philippines, Taiwan and Yunnan.

Papillaria (C.Muell.) C.Muell.

Aongstr. Oefv. K. Vetensk Akad. Foerh. 33(4): 34. 1876.

Plants yellowish-green, robust; secondary stems many, elongate; leaves closely or distantly imbricate when dry, erecto-patent from a cordate or auriculate base when moist, oblong to lanceolate, apex shortly or longly acuminate or hair pointed, margin entire; costa narrow, single, excurrent; cells rhomboidal to linear, one central line of papillae on the wall, cells adjoining the costa at basal part hyaline, near the margin cells are parallel, smooth, auricular cells in oblique rows, alar cells not distinct; seta very short, rough; capsule completely immersed or exerted, ovoid to oblong-ovoid; peristome teeth yellowish-white, calyptra small, more or less papillose.

Papillaria crocea (Hamp.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 267. 1877. *Pilotrichum croceum* Hamp., Linnaea 25: 715. 1853. *Trachyloma taylorii* Mitt., J. Linn. Soc. Bot. Suppl. 1: 92. 1859. *Trachypus cuspidiferus* (Wils.) Mitt., J. Linn. Soc. Bot. Suppl. 1: 128. 1859. *Papillaria cuspidata* (Hook.f. & Wils.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1875-'76: 272. 1877.

Plant yellowish-green, main stem up to 16 cm long, branches lateral, short or long; leaves linear-lanceolate, up to 1.6 mm long, basal part short auriculate, apex acuminate; costa strong, percurrent; cells at the upper portion elongate, colourless, 15-20 μm long, middle half parallel to the leaf margin, rhomboid, chlorophyllose, basal cells near costa elongate, hyaline and broadened, 15-20 μm , as much wider, near the margin cells are parallel, small rhomboid, margin serrulate, one central line of papillae on the cell walls. (Fig. 31: a-e & Plate 15e).

Habitat: On small branches of trees as well as on logs in moist deciduous forests.

Specimen examined: Muthanga range (890 m) MCN 84509.

Distribution: This species was collected from only one locality in the study area.

It has earlier reported from South India (Tamil Nadu: Palni hills), Sri Lanka, China, Japan, New Zealand and Australia. The present collection is a new record to Kerala.

NECKERACEAE Schimp.

Coroll. Bryol. Eur. 99. 1855 [1856].

Plants yellowish-green, usually glossy, primary stem creeping, filiform, secondary stem erect or pendulous, branches and leaves complanate; leaves linear, short pointed, mostly assymmetrical; costa usually single, rarely double, short; cells smooth, rhomboidal towards apex, linear towards base, alar cells differentiated; sporophyte lateral on branches of secondary shoots; capsule immersed or exerted, peristome double.

Three subfamilies are recognized within the family by Brotherus (1925). Leptodontoideae with one genus, Neckeroideae with six genera and Thamnioideae with four genera in India. Of these Neckeroideae with four genera viz., *Calyptothecium*, *Neckeropsis*, *Himantocladium*, *Homaliiodendron* and Thamnioideae with one genus *Pinnatella* occur in Wayanad.

Key to the genera

- 1a. Plants glossy; leaf cells mostly prosenchymatous; papillae absent; costa feeble, rarely above midleaf(subfam. **Neckeroideae**).....2
- 1b. Plants generally not glossy; leaf cells incrassate; rough papillae on lumen; costa strong, vanishes near leaf tip.....(subfam. **Thamnoideae**)
..... **Pinnatella**
- 2a. Leaves not undulate; leaf base auriculate or cordate, ovate to oblong, margin concave, denticulate at tip;**Calyptothecium**
- 2b. Leaves undulate; leaf base faintly auriculate or cordate, crenulate at apex or entire.....3
- 3a. Leaves transversely undulate, plicate; costa reach above midleaf.....
.....**Neckeropsis**
- 3b. Leaves not transversely undulate; not plicate; costa, ending well below apex
.....4
- 4a. Leaf base not inflexed; alar cells absent; basal cells broadly rhomboidal to

ovate, apical and middle cells irregularly rounded, polygonal

.....**Himantocladium**

- 4b. Leaf base reflexed on one side; alar cells rectangular to ovate or quadrate, basal cells elongate, upper regularly rounded polygonal, middle cells rhomboid.....**Homaliodendron**

Calyptothecium Mitt.

J. Linn. Soc. Bot. 10: 190. 1868.

Plants robust, glossy; main stem creeping, long in fascicles, small scale-leaves throughout; secondary stem elongate, pendant, regularly pinnate, branches usually short and blunt tipped; leaves ovate-oblong or ovate-lingulate, shortly acuminate from a cordate, strongly auricled base, entire or minutely denticulate near apex; costa single, reaching above midleaf; cells smooth, rhomboid to linear, towards the apex shorter, near the base wider, alar cells not differentiated; capsule completely immersed, ovoid or oblong-ovoid, peristome lanceolate, calyptra small, covering only the operculum; spores large, finely papillose.

Calyptothecium wightii (Mitt.) M.Fleisch., Hedwigia 45: 62. 1905; Gangulee, Moss. E. India 2(5): 1377. 1976. *Meteorium wightii* Mitt., Musc. Ind. Orient. 85. 1859. *Pterobryopsis wightii* (Mitt.) Broth., Nat. Pflanzenfam. 1(3): 803. 1906. *P. subacuminata* Broth. & Paris, Rev. Bryol. 34: 45. 1907. *Calyptothecium formosanum* Broth., Oefv. Finsk. Vet. Soc. Foerh. 62(9): 23. 1921. *C. subacuminatum* (Broth. & Paris) Broth., Nat. Pflanzenfam. ed. 2, 11: 184. 1925.

Plants yellowish-green, robust, long, creeping, covered with minute leaves, producing erect frond like branches at regular intervals, primary branches 8-10 cm long; secondary branches shorter, usually pendulous; leaves dark green, stem leaves small, wide spreading, branch leaves imbricate, 2.2 x 1.1 mm, ovate to oblong, glossy, margin concave, incurved and entire, denticulate at tip, pointed, elongate, broadly ovate at base, auriculate; costa single, reach above mid leaf, plicate near the base; cells irregularly rhomboid, incrassate, basal cells 40-60 x 4-7 μm , leaf attachment cells coloured, deep

reddish-brown, shorter and wider, auricular cells short, narrow, irregularly rhomboid; alar cells not differentiated; sporophyte not seen. (Fig. 31: f-h).

Habitat: Epiphytic and also terrestrial in evergreen and shola forests.

Specimens examined: Thirunelli RF (870 m) MCN 84612, Chembra hills (1220 m) MCN 120225.

Distribution: It is rare in the study area. An Asiatic species distributed in North-east India (Darjeeling), Bangladesh, Sri Lanka, Myanmar, Laos, Thailand, Vietnam, Yunnan and Taiwan. The present collection is a new record to Peninsular India.

Himantocladium (Mitt.) M.Fleisch.

Die Musci Fl. Buitenz.3: 883. 1908.

Plants robust, glossy, secondary stems more or less regularly miniature-dendroid, distantly to closely pinnate; leaves many or 8-ranked, mostly transversely undulate, nearly lingulate, base broad, obtuse, often with an apiculus; costa single, strong, usually ending well below the apex; cells near the base generally broadly rhomboid to ovate, upper and middle cells irregularly rounded, polygonal, alar cells absent; seta short; capsule exerted, small, peristome teeth smooth or papillose, calyptra small, sparsely hairy.

Himantocladium plumula (Nees) M.Fleisch., Die Musci Fl. Buitenz. 3: 889. 1908; Gangulee, Moss. E. India 2(5): 1406. 1976. *Pilotrichum plumula* Nees in Brid., Bryol. Univ. 2: 759. 1827. *Neckera hookeri* Dozy & Molk., Ann. Sc. Nat. Bot. Ser 3, 2: 313. 1844. *Pilotrichum hookeri* (Dozy & Molk.) Dozy & Molk., Musc. Fr. Ined. Archip. Indici 5: 155. 1847. *Neckera plumula* (Nees) C.Muell., Synop. Musc. Frond. 2: 53. 1850. *N. acutata* Mitt., Musc. Ind. Orient. 121. 1859. *N. arbuscula* Hamp. ex C.Muell., Flora 61: 83. 1878. *Neckeropsis acutata* (Mitt.) M.Fleisch., Die Musci Fl. Buitenz. 3: 878. 1908.

Plants dark greenish to yellowish; main stem creeping, with scale leaves, secondary shoots erect; leaves erecto-patent, up to 2 x 1 mm, longitudinally plicate, apex rounded with an abruptly acute apiculus, base wider, auriculate, margin minutely denticulate at tip, inflexed on one side covering stem; costa

strong, ending below apex; cells irregularly quadrate, hexagonal above, 5-8 μm wide, in the middle border with 2 or 3 rows of narrower or shorter cells, basal cells elongate-rectangular, incrassate, 30-35 x 5-8 μm , few shorter cells at extreme base; seta erect, orange brown, up to 1.5 cm long; capsule globose, orange brown, peristome teeth normal, whitish; spores small, rounded (Fig. 31: i-n & Plate 15f).

Habitat: Base of tree trunk in evergreen forests.

Specimen examined: Thirunelli RF (1180 m) MCN 99623.

Distribution: It is rare in the study area. An Indo-Pacific species found distributed in North-east India (Arunachal Pradesh, Assam, Khasi hills), Bangladesh, China, Taiwan, Japan, Sumatra, Indonesia, Borneo, Philippines, New Caledonia, New Guinea, Australia and Pacific Ocean Islands. The present collection is a new record to Peninsular India.

Homaliodendron M.Fleisch.

Hedwigia 45: 74. 1906.

Plants yellowish-green, robust, main stem creeping, microphyllous, branched and often with stolons, secondary stems ascending, usually complanate and flagelliform; leaves polymorphic, the lower stem leaves small, appressed, lanceolate, apiculate, upper normal, leaves on small branches complanate, 2-ranked, spreading, broad or oblong to spatulate-lingulate, crenulate or coarsely toothed at the extreme apex, near the base nearly revolute on one side; costa single, feeble, ending in the mid leaf; cells smooth, firm walled, small, upper rounded polygonal, rhomboid in the middle, near the base elongated, often pitted; alar cells rectangular to ovate or quadrate, thick walled near the insertion; seta short, 2-3 mm long; capsule erect to slightly inclined, symmetrical, ovoid, peristome teeth narrow, lanceolate, pale greenish, papillose, calyptra cucullate, mostly small with long hairs, sometimes naked; spores small, rounded.

Key to the species

- 1a. Leaf tip obtuse, suddenly narrowed into a apiculus.....**H. exiguum**
- 1b. Leaf tip rounded, shortly acuminate.....**H. flabellatum**

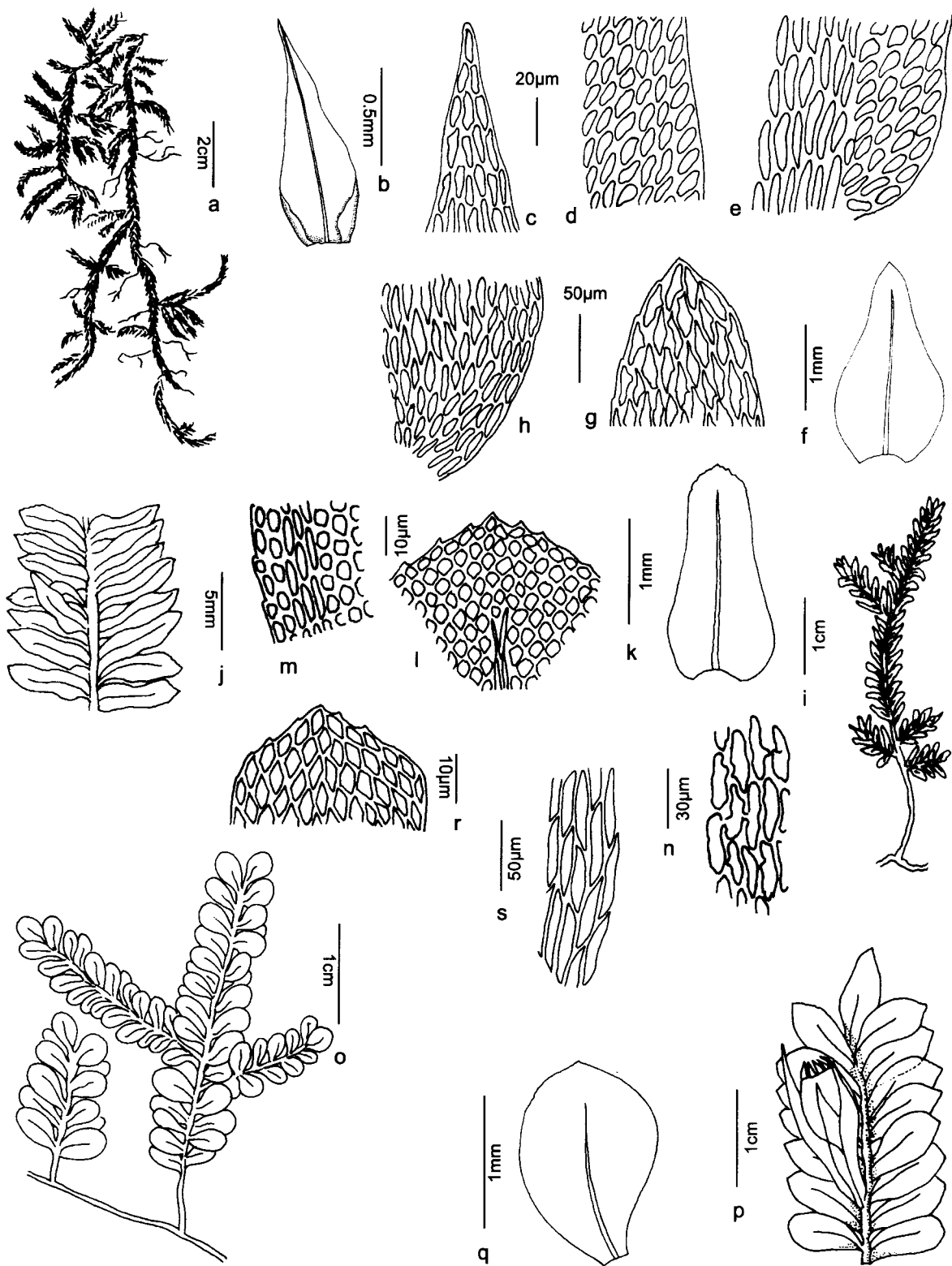


Fig. 31. **a-e:** *Papillaria crocea*; a: habit, b: leaf, c: leaf tip cells, d: middle cells, e: basal cells; **f-h:** *Calyptothecium wightii*; f: leaf, g: leaf tip cells, h: basal cells; **i-n:** *Himantocladium plumula*; i: habit, j: branch enlarged, k: leaf, l: leaf tip cells, m: middle cells, n: basal cells; **o-s:** *Homaliodendron exiguum*; o: habit, p: branch bearing sporophyte, q: leaf, r: leaf tip cells, s: extreme basal cells

Homaliodendron exiguum (Bosch. & Sande-Lac.) M.Fleisch., Musci Fl. Buitenz. 3: 897. 1908; Gangulee, Moss. E. India 2(5): 1413. 1976. *Homalia exigua* Bosch. & Sande-Lac., Bryol. Jav. 2: 55. 1862. *H. valentinii* Besch., Ann. Sci. Nat. Bot. Ser. 6, 10: 274. 1880. *Hypnum bibrachiatum* C.Muell., Bot. Jahrb. 5: 86. 1883. *Homalia bibrachiata* (C.Muell.) Geheeb, Biblioth. Bot. 13: 6. 1889. *Neckeropsis pseudonitidula* Okam., J. Coll. Sc. Imp. Univ. Tokyo 38(4): 39. 1916. *Homaliodendron pseudonitidulum* (Okam.) Nog., Trans. Nat. Hist. Soc. Formosa 24: 291. 1934. *Homalia laxiretis* Sak., Bot. Mag. Tokyo 50: 618. 1935.

Plants pale greenish, glossy, secondary shoots rigid, erect, up to 5 cm long, basal leaves minute, appressed; leaves on main branches horizontally spreading, longitudinally plicate when dry, tip obtuse but suddenly narrowed into a small apiculus, margin minutely serrate at tip, reflexed on one side at base; costa single, reach up to midleaf; cells smooth, rhomboidal towards apex, 15-20 x 10 µm, at base linear-elongate, 40-45 x 7-8 µm; sporophyte on short lateral branches; seta short, up to 2 mm long; capsule erect, brownish, ovoid, immersed, up to 1 x 0.5 mm; calyptra beaked. (Fig. 31: o-s & Plate 15g).

Habitat: On rocky patches near streams in moist deciduous forests.

Specimen examined: Sulthan Bathery (907 m) MCN 84355.

Distribution: It is not common in the study area. It was earlier reported from South India (Kerala; Tamil Nadu: Palni hills), North-east India (Garhwal, Mussoorie, Arunachal Pradesh, Khasi hills), Sri Lanka, Japan, Myanmar, Thailand, Vietnam, Sumatra, Java, Celebes, New Guinea, Philippines, Taiwan, Tahiti, Fiji and Australia.

Homaliodendron flabellatum (Sm.) M.Fleisch., Hedwigia 45: 74. 1906; Foreau in P.Bruehl, Rec. Bot. Surv. India 13(1): 77. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 785. 1937; J. Madras Univ. Sect. B. 3: 121. 1931 & J. Bombay Nat. Hist. Soc. 58: 34. 1961; Wadhwa, M.V.M. Patrika 6: 72. 1971; R.S.Chopra, Tax. Indian Mosses 369. 1975; Gangulee, Moss. E. India 2(5): 1426. 1976; M.C.Nair & Madhus. J. Econ. Taxon. Bot. 25: 574. 2001. *Hookeria flabellata* Sm., Trans. Linn. Soc. 9: 280. 1808. *Leskea flabellata* (Sm.) Schwaegr., Sp. Musc. Frond. Suppl. 1(2): 164. 1816. *Neckera dentata* Griff., Not. Pl. Asiat. 2: 463. 1849. N.

australasica C.Muell., Syn. Musc. Frond. 2: 42. 1850. *Hypnum flabellatum* (Sm.) Dixon ex C.Muell., Syn. Musc. Frond. 2: 225. 1850. *Neckera flabellata* (Sm.) Mitt., Musc. Ind. Orient. 118. 1859. *Homalia flabellata* (Sm.) Bosch. & Sande-Lac., Bryol. Jav. 2: 58. 1863; Broth., Rec. Bot. Surv. India 1(12): 325. 1899. *Homaliodendron dentatum* (Griff.) M.Fleisch., Hedwigia 45: 75. 1906.

Plants yellowish-green, robust, main stem creeping, 2-5 cm long, branched and often with stolons, secondary stem pinnately branched; leaves lanceolate to oblong lingulate, branch leaves ovate, shortly acuminate, toothed at the extreme tip, near the base revolute on one side, longitudinally plicate when dry, perichaetial bracts lanceolate with unicellular teeth, the lower stem leaves smaller; costa single, ending below apex, sometimes bifurcate at apex; cells smooth, upper leaf cells polygonal, middle cells rhomboidal, 10-30 x 5-15 μm , basal cells elongated, 45-60 x 15-18 μm ; seta 2-3 mm long; capsule erect to slightly inclined; spores rounded, smooth, 12-15 μm diagonally. (Fig. 32: a-g & Plate 15h&i).

Habitat: Epiphytic on shady tree trunks and on rocks near stream in shola forests.

Specimen examined: Chembra hills (1762 m) MCN 120393.

Distribution: It is common in the shola forests of the study area. It was earlier reported from South India (Kerala; Tamil Nadu: Nilgiri hills, Madurai, Tirunelveli, Kanyakumari; Karnataka), North-east India (West Bengal, Sikkim, Darjeeling, Arunachal Pradesh, Meghalay), Sri Lanka, Java, Borneo, Philippines, Japan, Pacific Ocean Islands, Sumatra, Thailand and Australia.

Neckeropsis Reichdt.

Oesterr. Freg. Novara Bot. 1(3): 181. 1870.

Plants glossy, yellowish-green, robust, pendant or procumbent; primary stem creeping, microphyllous, secondary stems 5-15 mm long, Occasionally simple, subpinnately branched, branches right angles to the stem; leaves widely spreading, slightly dimorphous, usually transversely undulate, at base strongly curved away from the stem, base shortly decurrent, usually with small auricles, apex truncate to rounded-truncate, often with small blunt apiculus, crenulate at

apex or almost entire; costa usually single, strong, reaching far above the midleaf, Occasionally shorter, sometimes forked; cells pellucid to opaque, rhomboid to oblong-rectangular, basal cells elongate and porose, faintly bordered; seta yellowish-brown, 0.2-0.5 mm long; capsule ovoid to shortly cylindrical, erect, calyptra cucullate; spores globose, 13-30 μm diagonally, pale green.

Neckeropsis fimbriata (Harv.) M.Fleisch., Die Musci Fl. Buitenz. 3: 878. 1908; Gangulee, Moss. E. India 2(5): 1403. 1976. *Neckera fimbriata* Harv. in Hook., Icon. Pl. Rar. 1: 21. 1836. *Neckera parishiana* Mitt., Musci Ind. Orient. 121. 1859. *N. parishii* Mitt. ex Kindb., Enum. Bryin. Exot. 26. 1888, *nom. illeg.* *N. nigrescens* Broth., Bot. Tids. 24: 122. 1901, *nom. Illeg.* *Neckeropsis parishiana* (Mitt.) M.Fleisch., Die Musci Fl. Buitenz. 3: 878. 1908. *N. nigrescens* Broth., Nat. Pflanzenfam. ed. 2, 11: 187. 1925. *N. auriculata* Dixon, J. Siam. Soc. Nat. Hist. Suppl. 9(1): 29. 1932.

Plants yellowish-green, robust, primary stem creeping, secondary branches pendant, irregularly pinnately branched, branches coiled when dry; leaves lingulate, horizontally spreading, asymmetric, 1-1.5 x 0.5 mm, transversely undulate when dry, apex obtuse, acuminate, margin minutely crenulate, incurved on one side, covering stem; costa single, strong, reaching far above midleaf; cells 15 x 7 μm at apex, middle cells 25-30 x 7-8 μm , narrower at base, 25-28 x 3-5 μm , incrassate, irregularly rhomboid to elongate-rhomboid; sporophyte not seen. (Fig. 32: h-l & Plate 15j&k).

Habitat: Base of tree trunk in semi-evergreen forests.

Specimen examined: Kuppadi (860 m) MCN 84564.

Distribution: This species is located only in one locality in the study area. It is an Indo-Malesian species distributed in North-east India (Darjeeling, Sikkim, Khasi hills), Nepal, Bhutan, Myanmar, Thailand, Cambodia, Vietnam, Malaysia and Philippines. The present collection is a new record to Peninsular India.

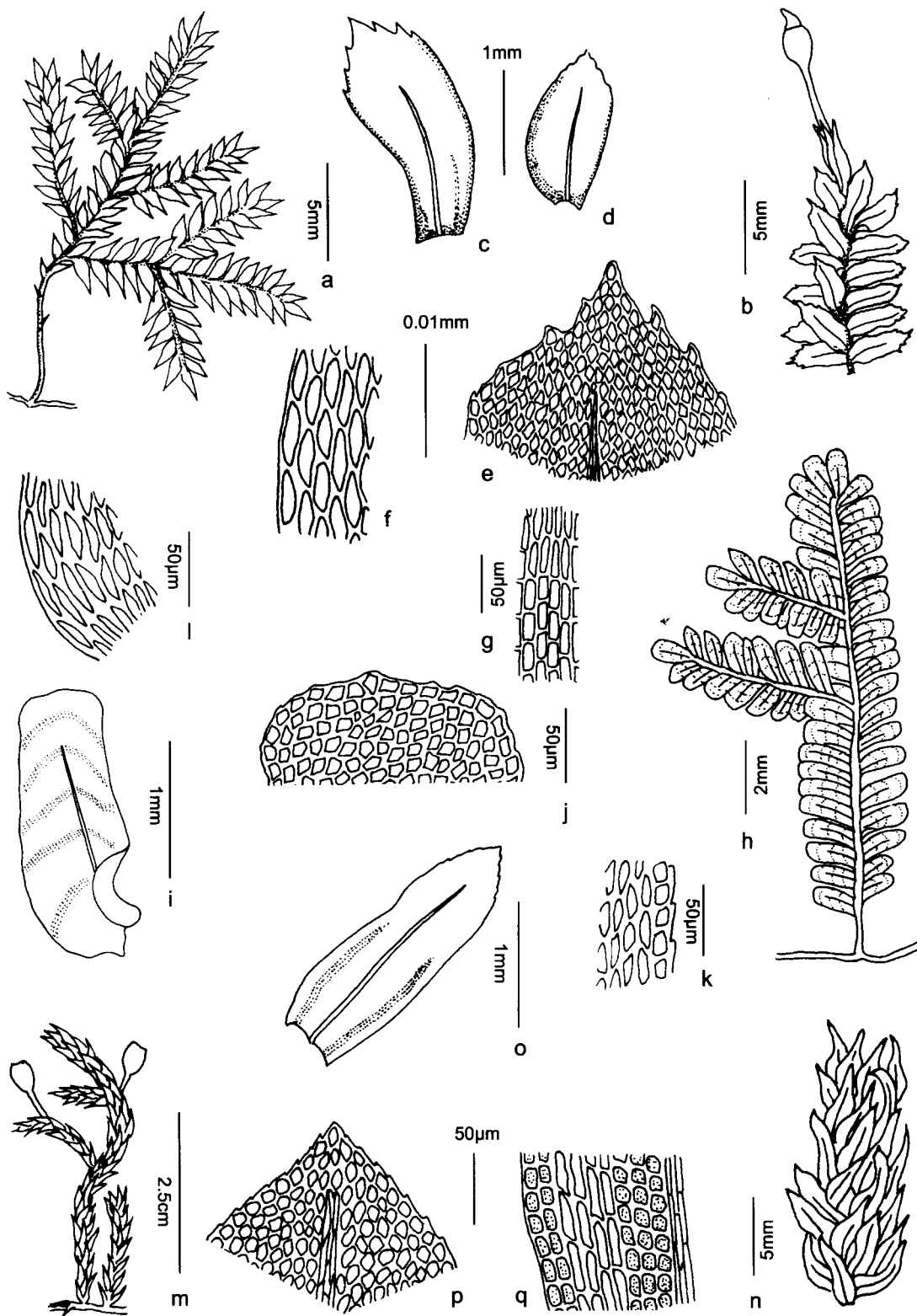


Fig. 32. **a-g:** *Homaliodendron flabellatum*; a: habit, b: branch with sporophyte, c&d: leaves, e: upper leaf cells, f: middle cells, g: basal cells; **h-l:** *Neckeropsis fimbriata*; h: habit, i: leaf, j: leaf tip cells, k: middle marginal cells, l: basal cells; **m-q:** *Pinnatella culcutensis*; m: habit, n: branch enlarged, o: leaf, p: leaf tip cells, q: basal cells

Pinnatella M.Fleisch.

Hedwigia 45: 79. 1906.

Plants slender to robust, not glossy, main stem creeping, secondary stem usually erect, sometimes pendant, bipinnately branched to form a dendroid form; leaves spreading, concave, broadly-ovate, short or long, apiculate, upper often minutely toothed; costa strong, mostly ending near the apex; cells thick walled, small, rounded-quadrate to hexagonal or rhomboid, upper unipapillose, rough, near the edge often in several rows of elongated cells; seta 3-5 mm long, yellow, somewhat rough; capsule erect, ovoid; spores rounded, about 20 µm diagonally.

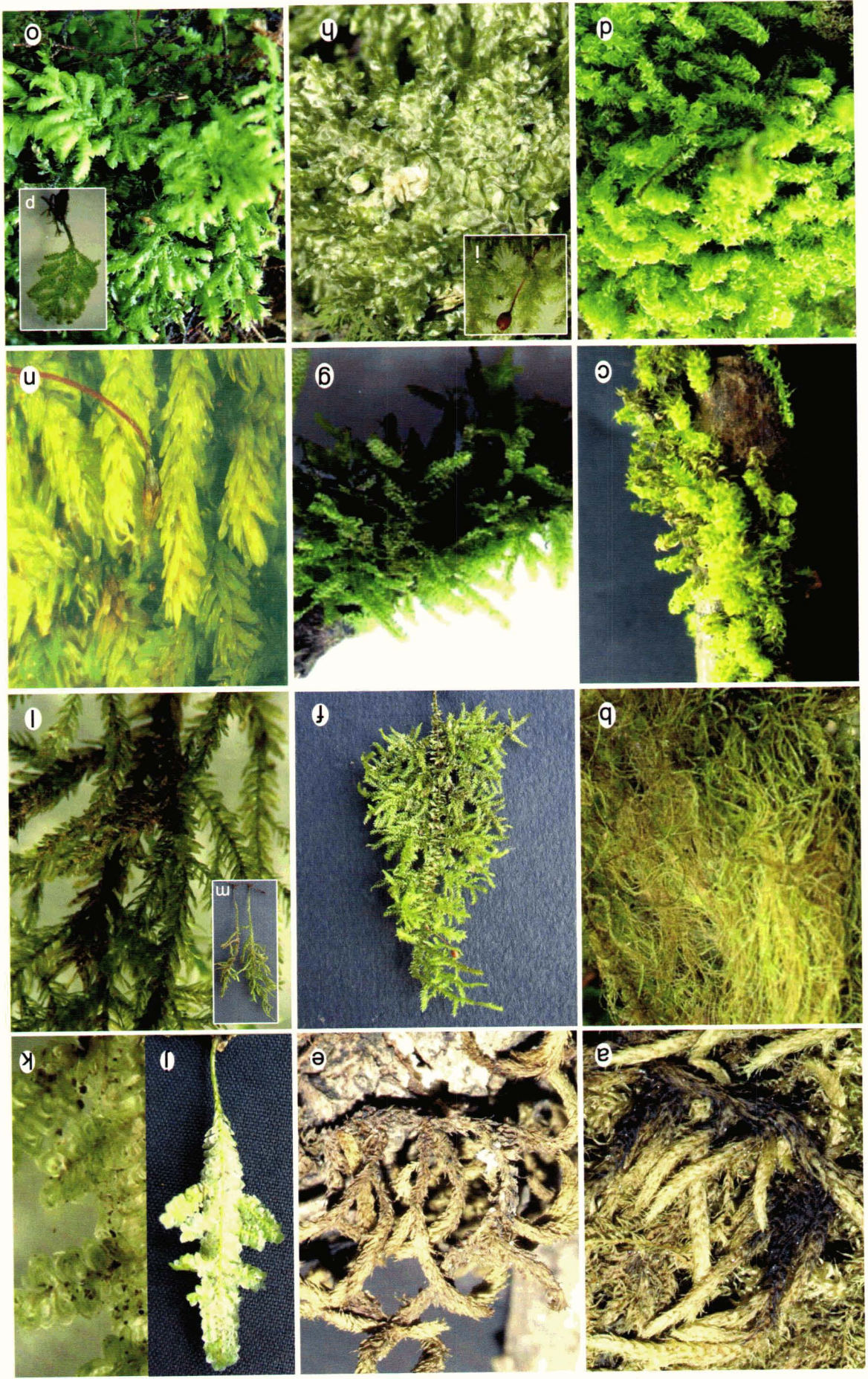
Pinnatella calcutensis M.Fleisch., Hedwigia 45: 84. 1906. *Neckeropsis calcutensis* (M. Fleisch.) Enroth., Acta Bryolichenol. Asiatica 2: 9. 1990 [1991]. *Pinnatella alopecuroides* var. *calcutensis* (M. Fleisch.) Gangulee, Moss. E. India 2(5): 1440. 1976.

Plants dark greenish, main stem creeping, branches weak, never erect, having scale leaves, secondary stem up to 8 cm long, no central strand in the stem, branching regular and closely pinnate; leaves flaccid when dry, wavy, ovate-lingulate, up to 2.5 mm long, base broad, obtuse with an apiculus, at the insertion point it is orange, apex dentate; costa single, strong, usually ending well below the apex; cells incrassate, rough papillae on lumen, marginal and basal cells broadly rhomboid to ovate, a conspicuous intramarginal zone of elongated cells near the base, 40-50 x 5-10 µm, covering more than two third of leaf length, flanked by a border of 2 or 3 rows of very small cells, upper cells irregularly rounded, 11-13 x 7-8 µm, alar cells distinct, orange colored; seta short; capsule exerted, small; spores small, rounded. (Fig. 32: m-q & Plate 15l&m).

Habitat: Basal and upper part of tree trunk in moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Tholpetty range (835-870 m) MCN 84571b, 84579, Thirunelli RF (880 m) MCN 84614.

Plate 15. a: *Cryptopapillaria fuscescens*, b: *Floribundaria walkeri*, c: *Meteropsis reclinata*, d: *M. squarrosa*, e: *Papillaria crocea*, f: *Himantocladium plumula*, g: *Homaliodendron exiguum*, h: *H. fiabellatum*, i: capsule, j: *Neckeropsis fimbriata*, k: a portion enlarged, l: *Pinnatella culcensis*-enlarged view, m: habit, n: *Calliostella papillata*, o: *Hypopterygium aristatum*, p: single plant



Distribution: It is a South-east Asiatic species reported from South India (Karnataka: Kanara, Mahabaleswar), North-east India (West Bengal, Darjeeling, Orissa) and Thailand. The present collection is a new record to Kerala.

HOOKERiaceae Schimp.

Coroll. Bryol. Eur. 101. 1855 [1856].

Plants yellowish-dark greenish, irregularly to pinnately branched; leaves 4-8 rowed, shape varies, mostly bordered, minutely serrated at upper half; costa single, double or absent; cells smooth or papillose, wide, alar cells not differentiated; seta on lateral branches; capsule inclined or horizontal, peristome double, calyptra conical, lobed or fringed at base, scabrous or pilose.

A total of 10 genera viz., *Daltonia*, *Distichophyllum*, *Hookeria*, *Eriopsus*, *Chaetomitrium*, *Chaetomitriopsis*, *Orontobryum*, *Actinodontium*, *Callicostella* and *Hookeriopsis* are found in India. Of these only one genus viz., *Callicostella* occur in Wayanad.

Callicostella (C.Muell.) Mitt.

Musc. Ind. Orient. 136. 1859.

Plants yellowish to dark greenish, medium sized, stem creeping, prostrate, usually flattened in one plane, irregularly branched; leaves oblong, short acute to acuminate, margin serrate upwards, rarely entire; costa double, strong, protrude abaxially just below the apex; cells firm, ovate-hexagonal, usually unipapillose on the lumen; seta elongate, rough or smooth; capsule inclined to horizontal, somewhat asymmetrical, ovoid with long thick neck, brownish-red, inner peristome yellow, finely papillose, cilia absent, operculum obliquely rostrate to subulate, calyptra conical, cucullate; spores small, rounded.

Callicostella papillata (Montin) Mitt., Musc. Ind. Orient. 136. 1859; Gangulee, Moss. E. India 2(6): 1510. 1977; Mohamed & H.Rob., Smithsonian Contr. Bot. 80: 6. 1991. *Hookeria papillata* Montin, Lond. J. Bot. 3: 632. 1844. *H. andamania* Paris, Index Bryol. Suppl. 1: 184. 1900, *nom. nud.* *Callicostella andamana* C.Muell., Die Musci Fl. Buitenz. 3: 1023. 1908, *nom. nud. in synon.*

Plants yellowish to dark greenish, in flat mats, stem creeping, prostrate, usually flattened in one plane; leaves in several rows, complanate, plicate when dry, sometimes crispate, flat to very concave when moist, oblong or ovate-oblong, rounded, abruptly short apiculate from a broad tip, margin serrate upwards; costa double, strong; cells ovate-hexagonal, 6-14 x 6-9 μm , basal cells elongate, smooth, 30-50 x 8-10 μm , usually unipapillose on the middle; sporophyte on lateral shoots, seta erect, up to 1.5 cm long, smooth; seta erect, 1.5 cm long, smooth; capsule erect to nodding, ovate-cylindrical, calyptra myriform, peristome double, normal; spores small 10-15 μm diagonally . (Fig. 33: a-d & Plate 15n).

Habitat: Epiphytic on base of trunk as well as on logs in homestead areas.

Specimen examined: Vythiri (750 m) MCN 80079.

Distribution: It is rare in the study area. It is reported as distributed in South India (locality unknown), North India (West Bengal), Andaman Islands, Sri Lanka, Borneo, Fiji, Taiwan, Indonesia, Java, Malaya, Madagascar, New Guinea, New Caledonia, Ryukyus, Samoa, Sumatra, Tahiti, Taiwan, Thailand, Philippines and Vietnam.

HYOPTERYGIACEAE Kindberg

Hedwigia 40: 277. 1901.

Plants erect, robust, with brownish rhizomatous primary stem, elongate or creeping; secondary setm mostly dendroid; leaves dimorphous, lateral rows complanate, ovate, serrate; ventral row amphigastrial, smaller, more acuminate; costa single, cells rhomboid-hexagonal, mostly bordered; seta short or long; capsule exerted, usually inclined or horizontal, peristome double.

Two subfamilies *viz.*, Cyathophoroideae and Hypopterygioideae with three genera are found in India, of these only one genus *viz.*, *Hypopterygium* occur in the study area.

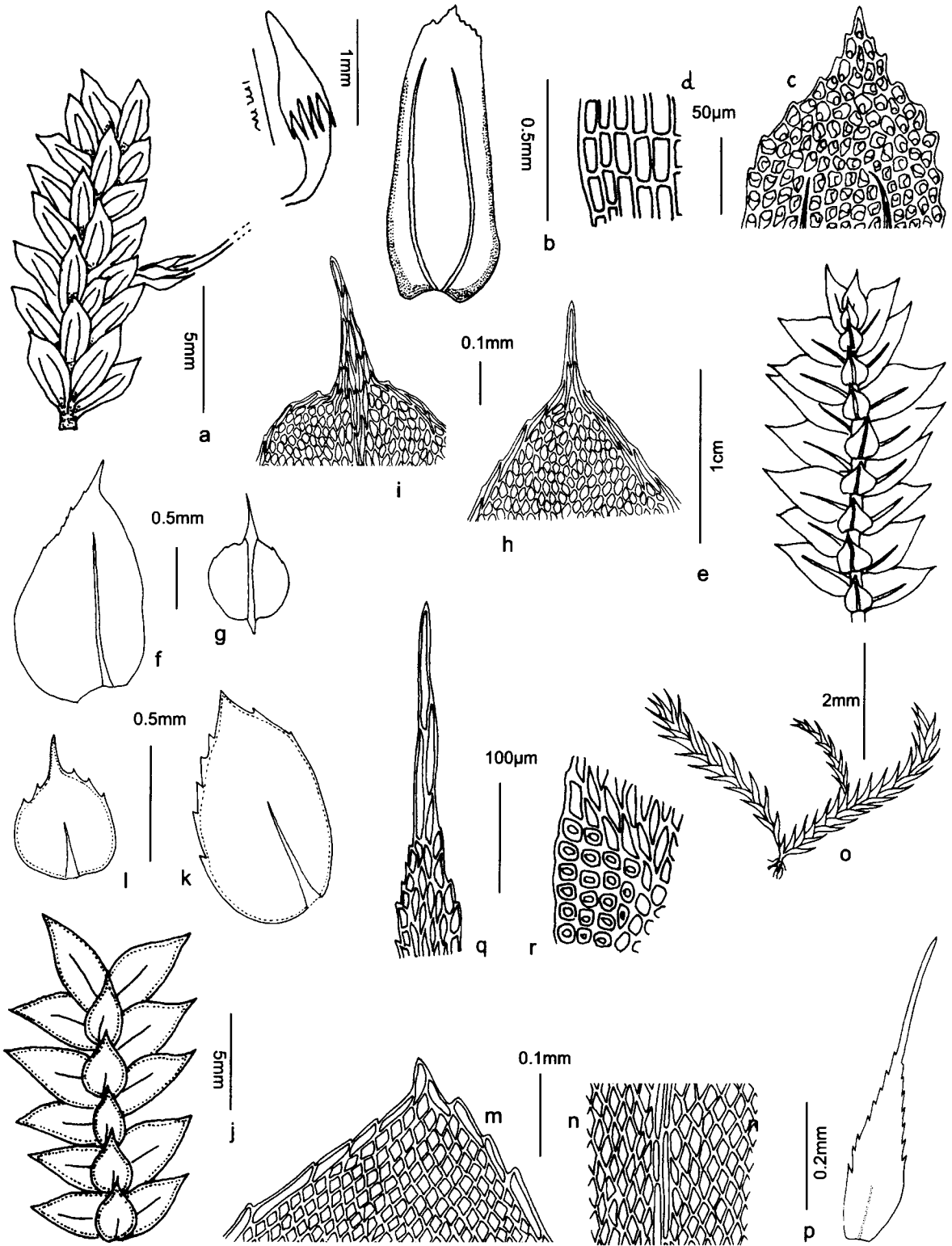


Fig. 33. **a-d:** *Callicostella papillata*; **a:** branch with sporophyte, **b:** leaf, **c:** leaf tip cells, **d:** basal cells; **e-i:** *Hypopterygium aristatum*; **e:** branch, **f:** lateral leaf, **g:** amphigastrial leaf, **h:** lateral leaf tip cells, **i:** amphigastrial leaf tip cells; **j-n:** *Hypopterygium tamarisci*; **j:** branch, **k:** lateral leaf, **l:** amphigastrial leaf, **m:** leaf tip cells, **n:** middle and basal cells; **o-r:** *Fabronia schensiana*; **o:** habit, **p:** leaf, **q:** leaf tip cells, **r:** basal cells

Hypopterygium Brid.

Bryol. Univ. 2: 709. 1827.

Plants slender to robust, main stem creeping, long, secondary stem frondose or irregularly pinnately branched; leaves often recurved when dry, sometimes strongly crumpled to one side, spreading when moist, lateral leaves broadly ovate, ovate-oblong or ovate-lingulate, bordered, tip serrated; amphigastrial leaves smaller, broadly ovate or suborbicular, with narrow acumen, bordered, margin serrate or entire above; costa single, ending well below the apex, excurrent in the amphigastrial leaf; cells rhomboid or rounded six sided, smooth, near the base longer and wider; seta elongate, smooth; capsule inclined to horizontal, ovoid to cylindrical, thick necked, calyptra naked, cucullate or conical; spores small, rounded.

Key to the species

- 1a. Lateral leaves long acuminate; faintly toothed at apex; costa of amphigastria distinct and excurrent.....**H. aristatum**
- 1b. Lateral leaves short-acuminate; strongly toothed at apex; costa faint, percurrent; costa of amphigastria weakly defined, ending well below apex**H. tamarisci**

Hypopterygium aristatum Bosch. & Sande-Lac., Bryol. Jav. 2: 12, 141. 1861; P.Bruehl, Rec. Bot. Surv. India 13(1): 84. 1931; R.S.Chopra, Tax. Indian Mosses 397. 1975; Mohamed & H.Rob., Smithsonian Contr. Bot. 80: 37. 1991.

Plant pale greenish to yellowish, stem creeping, densely tomentose, 1.5-3 cm long, secondary stem erect, 1-2.5 cm long, dendroid; leaves 3-rowed, 2 lateral, one amphigastrial; lateral leaves asymmetric, ovate-lanceolate, 0.5-1 x 0.5-0.6 mm, long-acuminate, faintly toothed at apex, margin entire below, bordered by two rows of linear elongate hyaline cells, arista long; costa reaching $\frac{3}{4}$ of leaf length; amphigastrial leaves small, costa distinct, excurrent.

Habitat: On rocky patches near streams in evergreen and shola forests. (Fig. 33: e-i & Plate 15o&p).

Specimens examined: Chembra hills (1390-1770 m) *MCN 120267*, *MCN 120258*, Thirunelli RF (1200 m) *MCN 99622*.

Distribution: This species is rare in Wayanad and was earlier recorded from South India (Tamil Nadu: Tirunelveli), Northern India (Himalayas), China, Java, New Guinea and Indo-Malayan region. The present collection is a new record to Kerala.

Hypopterygium tamarisci (Sw.) Brid. & C.Muell., Syn. Musc. Frond. 2: 8. 1850; P.Bruehl, Rec. Bot. Surv. India 13(1): 84. 1931; Foreau, Madras Univ. 3: 121. 1931 & J. Bombay Nat. Hist. Soc. 58: 36. 1961; Wadhwa, M.V.M.Patrika 6: 74. 1971; R.S.Chopra Tax. Indian Mosses 397. 1975; Mohamed & H.Rob., Smith. Contr. Bot. 80: 37. 1991. *Hypnum tamarisci* Sw., Fl. Ind. Occ. 3: 1825. 1806. *H. laricinum* Hook., Musc. Exot. 2(1): 35. 1818. *Hypopterygium laricinum* (Hook.) Brid., Bryol. Univ. 2: 714. 1827. *Hypnum scutellatum* Taylor, London J. Bot. 6: 338. 1847. *Hypopterygium flavescens* Hampe, Linnaea 20: 95. 1847. *H. scutellatum* (Taylor) C.Muell., Syn. Musc. Frond. 2: 7. 1850. *H. tenellum* C.Muell., Bot. Ztg. Regensburg 12: 557. 1854; Mohamed & H.Rob., Smithsonian Contr. Bot. 80: 37. 1991. *H. rigidulum* Mitt., J. Linn. Soc. Bot. 12: 329. 1869. *H. sylvaticum* Mitt., J. Linn. Soc., Bot. 12: 329. 1869. *H. argentinicum* Lorentz & C.Muell., Linnaea 42: 404. 1879. *H. lehmannii* Besch., Bull. Herb. Boissier 2: 399. 1894. *H. bolivianum* Herzog, Beih. Bot. Centralbl. 26(2): 81. 1909.

Plants dull green to brownish, stem creeping, densely tomentose, 2.5-3.3 cm long, secondary stem erect, dendroid, 1.2 cm long; lateral leaves 1-1.3 x 0.6-0.9 mm, ovate, short-acuminate, margin toothed at upper part, entire below, bordered all around by 1-2 rows of elongate hyaline cells, 40-140 x 6-10 μ m; costa single, reach up to midleaf; cells at middle hexagonal, 20-45 x 12-15 μ m; amphigastria 0.8 x 0.6-0.8 mm, orbicular, sharply apiculate, margin entire below, distantly toothed above, bordered all around by 1-2 rows of elongate hyaline cells; costa faint, extends $\frac{1}{2}$ of leaf length; median cells hexagonal, 20-35 x 13-20 μ m; seta elongate, smooth; capsule inclined to horizontal, ovoid to oblong, thick necked, orange-brown, calyptra naked, conical; spores very small, 8-10 μ m diagonally. (Fig. 33: j-n & Plate 16a).

Habitat: In moist shady areas on rocks, logs, over humus or leaf litter; Occassionally on bases of tree trunks and soil in evergreen and shola forests.

Specimens examined: Chembra hills (1380 m) MCN 120313b, Thirunelli (1300 m) MCN 99615.

Distribution: It is common in the high altitude areas of the study area and is a common species of the montane temperate forest of the tropical area. Earlier reported from South India (Kerala; Tamil Nadu: Nilgiri hills, Tirunelveli hills, Madura, Palni hills, Kanyakumari), Sri Lanka, Brazil, Columbia, Ecuador, Java, Madagascar, Malaya, Mexico, New Guinea, Pacific Ocean Islands, Argentina, Bolivia, Borneo, Peru, Philippines, Sumatra and West Indies.

Order HYPNOBRYALES

FABRONIACEAE Schimp.

Coroll. Bryol. Eur. 102. 1855 [1856].

Plants delicate, soft, forming thin mats on the bark of trees or on rocks; main stem creeping, irregularly branched; leaves ovate, tip long-acuminate, margin sharply serrated; costa single, slender or absent; cells more or less rhomboid, smooth, quadrate at basal part, marginal cells prominent, hyaline; capsule long, peristome single or double, operculum conical or short rostrate, calyptra cucullate, smooth.

This family is represented by about five genera. Among these two genera viz., *Fabronia* and *Schwetskeopsis* are represented in India, of which only *Fabronia* occur in Wayanad.

Fabronia Raddi.

Atti Accad. Sci. Siena 9: 230. 1808.

Plants very slender, soft, silky, stem prostrate, irregularly branched, branches often dimorphic, leafy shoot and stolons; leafy shoot very short to elongate, leaves more or less concave, ovate or ovate-lanceolate, mostly subulate or filiform-acuminate, margin smooth to sharply ciliate-dentate; costa short, weak, sometimes indistinct; cells thin to firm walled, mostly elongate-rhombic to hexagonal, alar cells in several series, quadrate; seta 1-7 mm long,

thin, twisted; capsule erect, obovate-oblong to pyriform, short necked, peristome single, sometimes absent, calyptra narrowly cucullate, smooth; spores small to medium sized, mostly strongly papillose.

Fabronia schensiana C.Muell., Nuov. Giorn. Bot. Ital. ser. 4: 262. 1897; Gangulee, Moss. E. India 3(7): 1555. 1978.

Plants yellowish-green, small, soft silky, stem prostrate, up to 4 mm long, irregularly branched; leaves loosely arranged, erect when dry, oblong-lanceolate, up to 0.6 x 0.1 mm, tip filiform-acuminate, margin sharply dentate; costa single, indistinct, about half the leaf; cells thin, elongate rhomboid, 35-40 x 5-8 μm at apex, with very few linear cells at extreme tip, two-three rows of quadrate rectangular cells at the basal angles; sporophyte not seen. (Fig. 33: o-r & Plate 16b).

Habitat: On logs in Tea estates.

Specimen examined: Chembra estate (1054 m) MCN 120233.

Distribution: It is a rare species in the study area located only in Chembra. It was also collected from Munnar of Idukki district. It has earlier reported from Eastern India (Sikkim) and China. The present collections are new record to Peninsular India.

THUIDIACEAE Schimp.

Syn. Musc. Eur. 493. 1890.

Plants yellowish-green, slender to robust; main stem creeping, secondary stems regularly once, twice or more branched, branches in plane with paraphyllia; stem leaves and branch leaves distinct, leaves small, distant, usually dimorphic, small and scale like and large and chlorophyllose; large leaves ovate, broadly acuminate; costa single, strong, ending below apex; cells smooth or papillose; seta long, smooth; capsule horizontal, peristome double, hypnoid.

Four subfamilies with nine genera are recognized in this family. Heterocladioideae with one genus, Anomodontoideae with five genera, Thuidioideae with three genera and Helodioideae with one genus is represented

in India. Of these *Thuidium* and *Pelekium* of Thuidioideae occur in the study area.

Key to the genera

- 1a. Branches slender, short, filamentous in appearance; cells uni-or
multipapillose.....**Pelekium**
- 1b. Branches robust, long filamentous in appearance; cells unipapillose
.....**Thuidium**

Thuidium Bruch, *et al.*

Bryol. Eur. 5: 177. 1852.

Plants yellowish-green, robust; stem creeping, stiff, changing into elongated stolons and again becoming leafy, bi-or tripinnate, often flabellate; stem leaves strongly plicate, triangular to ovate-cordate, mostly with recurved margin, upwards serrate; costa strong, broad in the basal part, percurrent or ending below the apex, sometimes excurrent; branch leaves ovate-lanceolate with shorter and fainter costa, never crumpled; cells more or less thickened and mostly oblong to ovate six-sided, unipapillose over the lumen; seta long, smooth or rough, yellowish-orange; capsule inclined to horizontal, ovoid-oblong, yellowish orange, smooth or faintly papillose; spores brown, small, 8-16 μm diagonally.

Thuidium pristocalyx (C.Muell.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 257. 1878. *Hypnum pristocalyx* C.Muell., Bot. Zeitung. Berlin 12: 573. 1854. *Leskea glaucina* Mitt., J. Linn. Soc. Bot. Suppl. 2: 133. 1859. *Hypnum glaucinum* (Mitt.) C.Muell., Linnaea 36: 7. 1869. *Thuidium glaucinum* (Mitt.) Bosch & Sande-Lac., J. Linn. Soc. Bot. Suppl. 2: 133. 1859.

Plants yellowish green, main stem creeping, thick, highly tomentose, variously branched, branching pinnate to bipinnate or tripinnate; leaves at stem large, up to 1 x 0.5 mm, leaves arranged in three tiers, ovate-acuminate, branch leaves ovate acute, 0.3-0.5 x 0.2 mm, margin crenulated, leaf back toothed; costa thin, faint, reach up to midleaf, in stem leaf costa reach up to tip; cells not

pegged, almost rounded at tip, up to 6-10 μm diagonally, basal cells rounded to elongate-hexagonal, 10-16 x 4-6 μm . (Fig. 34: a-d & Plate 16c).

Habitat: On rocks near streams in evergreen and shola forests.

Specimen examined: Chembra hills (1340 m) *MCN 99606*.

Distribution: It was earlier recorded from Thailand, Vietnam, Indonesia, Malaysia and Philippines. The present collection is a new record to India.

Thuidium tamariscellum (C.Muell.) Bosch. & Sande-Lac., Bryol. Jav. 2: 20. 1865; Gangulee, Moss. E. India 2(7): 1637. 1978. *Hypnum tamariscellum* C.Muell., Bot. Zeitung. Berlin 12: 573. 1854. *Leskea tamariscella* (C.Muell.) Mitt., J. Proc. Linn. Soc. 2: 134. 1859.

Plants yellowish-green, forming mats, robust, long, filamentous in appearance; main stem creeping, branches irregular to pinnate, paraphyllia numerous, filamentous; stem leaves distant, larger, base cordate, acuminate, up to 0.5 mm long; branch leaves dense, ovate-lanceolate, 0.20-0.30 x 0.10 mm, apex acute, margin crenulate; costa single, ending just below apex, faint; cells rounded-rhomboid, 6-9 μm wide, single papilla on both sides of lumen. (Fig. 34: e-h & Plate 16d).

Habitat: Occur in wide range of habitats such as rocks, bases of trees and leaf litter in evergreen and shola forests.

Specimens examined: Periya (940 m) *MCN 99613*, Thirunelli RF (1320 m) *MCN 99618*, Chembra hills (1760 m) *MCN 120268*, *MCN 120394*.

Distribution: It is a common species in the high altitudes of the study area. This is a south and east Asiatic species, earlier reported from South India (Kerala; Tamil Nadu: Nilgiri hills, Palni hills; Karnataka: Coorg), North-east India (Himalaya, Sikkim), Butan, Nepal, Myanmar, Thailand, Tonkin, Yunnan, Taiwan, Sumatra, Java and Philippines.

Pelekium Mitt.

J. Linn. Soc., Bot. 10: 176. 1868.

Plants very delicate, stem creeping, elongate, irregularly bipinnate; stem leaves triangular-ovate, abruptly tapering into a fine acumen, margin crenulate;

costa strong, ceasing below apex; cells quadrate-hexagonal to oblong-hexagonal, uni- or pluripapillose over the lumen; branch leaves oblong-lanceolate, obtuse or acute, margin crenulate; seta densely papillose; capsule horizontal to pendulous, ovoid; spores finely papillose, calyptra campanulate.

Pelekium gratum (P.Beauv.) Touw, J. Hatt. Bot. Lab. 90: 203. 2001. *Hypnum gratum* P.Beauv., Prodr. Cinqui. Fam. Aethe. 64. 1805. *Hypnum kuripanum* Dozy & Molk., Syst. Verz. Indisc. Archipel 32. 1854. *Thuidium bandaicum* C.Muell., Bull. Soc. Bot. Belgique 41(1): 89. 1906. *T. erosulum* Mitt., J. Linn. Soc., Bot. 10: 186. 1868. *T. pelekinooides* P.C. Chen, Sunyatsenia 6: 190. f. 23. 1941. *T. pelekiooides* Broth., Bot. Jahrb. Syst. Pflanzenges. Pflanzengeo. 17: 479. 1893. *T. subscissum* C.Muell., ex Besch., Annal. Sci. Natur.; Bot., ser. 6, 10: 290. 1880.

Plants dark greenish, slender, creeping, short filamentose, highly branched, pinnate, branches up to 4 mm long; leaves very small, stem leaves up to 150 x 100 µm, margin serrated, pegged; cells chlorophyllose, rounded, hexagonal, 8-10 µm diagonally, uni- or multipapillose, pegged; sporophyte arises from the main stem; seta long, slender, 1 cm long; spores large rounded, brownish, 30-60 µm diagonally, calyptra conical when young. (Fig. 34: i-n & Plate 16e&f).

Habitat: On leaf litter where soil is seen and on logs in semi-evergreen and evergreen forests.

Specimen examined: WWLS, Kuppadi (861 m) MCN 84565.

Distribution: It was earlier reported from Sri Lanka, Indonesia, Malaysia, Papua New Guinea and Philippines. The present collection is a new record to India.

BRACHYTHECIACEAE Schimp.

Syn. Musc. Eur., ed. 2. XCV: 637. 1876.

Plants yellowish-green, generally glossy, prostrate, irregularly branched; leaves often plicate, costate, sometimes strongly concave; cells at median half smooth or with projecting ends, leaf base usually with differentiated or few alar cells; seta long, rough; capsule inclined, rarely erect, operculum long-rostrate.

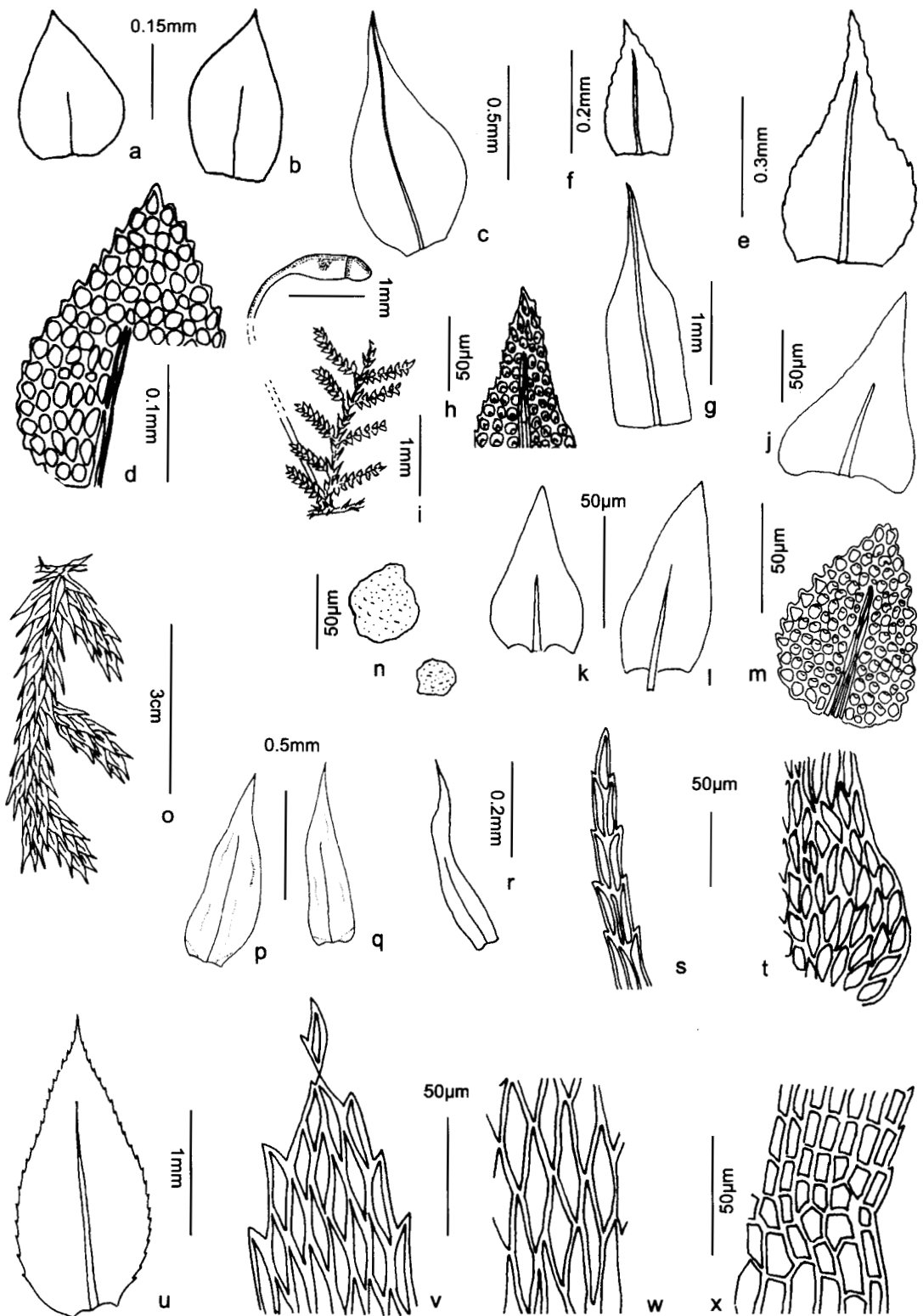


Fig. 34. **a-d**: *Thuidium pristocalyx*; **a**&**b**: branch leaves, **c**: stem leaf, **d**: leaf cells; **e-h**: *Thuidium tamariiscellum*; **e**: stem leaf, **f**: branch leaves, **g**: pericheatal leaf, **h**: leaf tip cells; **i-n**: *Pelekium gratum*; **i**: habit, **j**: stem leaf, **k**&**l**: branch leaves, **m**: leaf cells, **n**: spores; **o-t**: *Brachythecium buchananii*; **o**: habit, **p**&**q**: branch leaves, **r**: leaf at extreme branch tip, **s**: leaf tip cells, **t**: leaf basal cells; **u-x**: *Bryhnia nepalensis*; **u**: leaf, **v**: leaf tip cells, **w**: middle cells, **x**: basal cells

Six genera are represented in India within the family, viz., *Homalothecium*, *Bryhnia*, *Brachythecium*, *Rhynchostegiella*, *Eurhynchium* and *Rhynchostegium*. Of these four genera viz., *Bryhnia*, *Brachythecium*, *Eurhynchium* and *Rhynchostegium* occur in the study area.

Key to the genera

- 1a. Plants glossy in soft tufts; leaves homophyllose; leaf margin usually dentate2
- 1b. Plants not so glossy and robust; leaves heterophyllose; leaf margin entire ...3
- 2a. Plants never rolled inwards when dry; leaves acute to short or long acuminate, apex twisted one half turn.....**Bryhnia**
- 2b. Plants rolled inwards when dry; leaf tip acute to acuminate, apex not twisted**Rhynchostegium**
- 3a. Leaves mostly plicate, loosely imbricate; alar distinct with quadrate or rectangular cells.....**Brachythecium**
- 3b. Leaves not plicate; closely imbricate; alar not strongly differentiated.....**Eurhynchium**

Brachythecium Bruch, Schimp. & W. Guembel

Bryol. Eur. 6: 5. 1853.

Plants yellowish-green, prostrate, creeping, in large loose tufts; leaves heterophyllous, mostly plicate, loosely imbricate to somewhat erect, ovate to broadly triangular, apex acute, sometimes very long-acuminate; costa strong, ends below apex; median cells long or short, elongate-rhombic to linear; alar cells distinct with quadrate or rectangular cells; seta rough, sometimes partially or entirely smooth, 1.5-2 cm; capsule inclined to horizontal, brownish to reddish-brown; spores rounded, brownish, 11-16 µm diagonally.

Brachythecium buchananii (Hook.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 341. 1878; Takaki, J. Hattori Bot. Lab. 15: 18. 1955; Gangulee, Moss. E. India 3(7): 1711. 1978. *Hypnum buchananii* Hook., Trans. Linn. Soc. Lond. 9: 320. 1808. *Brachythecium pilicuspis* C.Muell. in Paris, Index Bryol. Suppl. 97. 1900, *nom. nud.*

Plants yellowish-green to pale green, slender, in dense mats; stem up to 6 cm long, branches rigid, irregularly pinnate, up to 5-8 cm long, obtuse; leaves erect to erect spreading, linear-lanceolate, crisped at apices, strongly plicate, margin serrated, apex acuminate, leaves at branches 0.7-0.9 x 0.25 mm, at flagellate tip up to 0.4-0.5 x 25 μ m; costa faint, reach above midleaf; cells papillose, tightly packed, linear-rhomboid, difficult to distinguish individual cells, 18-25 x 5-9 μ m, alar cells subquadrate, thickened at corners. (Fig. 34: o-t & Plate 16g).

Habitat: On soil, rocks, also as epiphytic on trunks, or on short branches in evergreen forests.

Specimens examined: Thirunelli RF (870-880 m) MCN 84608, MCN 84611.

Distribution: It is rare in the study area but wide spread species in Eastern Asia. Earlier reported from South India (Tamil Nadu: Nilgiri hills), North-east India (Himachal Pradesh, Mussorie, Garhwal, Meghalaya, Naga Hills), Nepal, Bhutan, China, Japan, Korea, Myanmar, Pakistan, Thailand, Vietnam, Laos and Philippines. The present collection is a new record to Kerala.

Bryhnia Kaur.

Bot. Not. 1892: 61. 1892.

Plants green to yellowish-green, small to large, erect to prostrate, regularly or irregularly pinnately branched, main stem creeping, not curled when dry; leaves imbricate, often plicate, dentate, decurrent at base, acute to short or long acuminate, apex twisted one half turn, ovate, broadly triangular; costa single, strong, ends far below tip; cells linear-rhomboid, alar cells wider; seta rough; capsule inclined to horizontal, peristome hypnoid.

Bryhnia nepalensis Takaki, Bull. Nat. Sc. Musc. Tok. 9: 374. 1966; Gangulee, Moss. E. India 3(7): 1701. 1978.

Plants yellowish-green, robust, rigid, glossy, main stem creeping, secondary stem 4-6 cm long; leaves crispy when dry, cordate to rotund, apex long, acuminate, twisted one half turn, base decurrent, 1.4-1.7 x 1.4 mm, concave, margin denticulate all along; costa strong, covers $\frac{3}{4}$ of leaf length;

cells narrow, rhomboid, upper 20-25 μm long, at middle 32-35 μm long, basal cells rectangular, 15 x 10 μm . (Fig. 34: u-x & Plate 16h).

Habitat: Epiphytic on shola trees.

Specimen examined: Chembra hills (1720 m) MCN 120278.

Distribution: It is rare in the study area. This species was earlier recorded from east Nepal only. The present collection is a new record to India.

Note: Gangulee (1972) has not examined this species and descriptions were given after Takaki. The present collection differs from Takaki's description by twisted leaf tip. All other characters are same.

Eurhynchium Bruch, *et al.*

Bryol. Eur. 5: 217. 1854.

Plants dark to yellowish-green, forming mats, branches erect; leaves heterophyllous, closely imbricate, not plicate, broadly triangular to orbicular, apex acute in stem leaves, obtuse in branch leaves; costa reach above mid leaf; cells at basal half thick walled, porose, median cells longer than broad; alar cells not strongly differentiated, small and quadrate; seta smooth or rough; capsule inclined to horizontal, operculum long rostrate.

Eurhynchium vagans (A.Jaeger) E.B.Bartram, Bishop Mus. Bull. 101. 213. 1933. *Rhynchostegium vagans* A.Jaeger, Ber. S. Gall. Naturw. Ges. 1876-77: 369. 1878; Gangulee, Moss. E. India 3(7): 1751. 1978. *Hypnum vagans* Harv. in Hook., Icon. Pl. Rar. 1: 24. 1836, *nom. illeg.* *Rhynchostegium subvagans* Hamp. in A.Jaeger, Icon. Pl. Rar. 369. 1878, *nom. nud.* *Oxyrrhynchium distantifolium* Williams, Bull. N.Y. Bot. Gard. 8: 375. 1914.

Plants yellowish-green, ceeping, delicate, radiculose below, main stem up to 12 cm long, branches irregular, some flagelliform; leaves distant, alternate, 1-1.2 x 1 mm, ovate to oblong, margin entire, tip acute; costa ends much below the tip, faint, yellowish; cells narrow elongate to rhomboid, tightly packed, up to 52-68 μm long, slightly wavy walls, cells at extreme tip elongate, 30-50 μm long, rectangular at extreme base, 35-38 x 20-22 μm . (Fig. 35: a-e & Plate 16i, j&k).



Plate. 16. a: *Hypopterygium tamarisci*, b: *Fabronia schensiana*, c: *Thuidium pristocalyx*, d: *T. tamariscellum*, e: *Pelekium gratum* on rock, f: *P. gratum* on leaf litter, g: *Brachythecium buchananii*, h: *Bryhnia nepalensis*, i: *Eurhynchium vagans*, j: single branch enlarged, k: habit, l: *Rhynchostegium herbaceum*, m: *Entodon flavescens*, n: capsule

Habitat: Epiphytic near riverine areas in moist deciduous forests.

Specimens examined: Ponkuzhi (900 m) MCN 84375, Kurichiad range, Thottapalam (715 m) MCN 84525a.

Distribution: It is rare in the study area. Earlier recorded from South India (Karnataka: Coorg; Tamil Nadu: Palni hills), North-east India (Darjeeling, Dehradun, Garhwal), Sri Lanka, Myanmar, Thailand, Laos, Java, Borneo, Philippines, Taiwan, Japan and Hawaii. The present collection is a new record to Kerala.

Rhynchostegium Bruch & Schimp.

Bryol. Eur. 5: 197. 1852.

Plants pale or yellowish-green, glossy in soft dense tufts, rolled inwards when dry, main stem creeping, ± 10 cm long, irregularly branched; leaves erecto-patent to spreading, ovate to ovate-lanceolate, tip acute to acuminate, margin usually dentate; costa ends below tip, alar cells few; seta long, smooth; capsule inclined or horizontal, operculum rostrate.

Rhynchostegium herbaceum (Mitt.) A. Jaeger, Ber S. Gall Naturw. Ges. 1876-77: 368. 1878; Gangulee, Moss. E. India 3(7): 1749. 1978. *Hypnum herbaceum* Mitt., Musc. Ind. Orient. 81. 1859.

Plants yellowish-green to blackish, main stem creeping, thick, hard and black, primary stem erect to pendant, up to 10 cm or more long, branches arise from the primary stem, leaves and branches curled inwards on drying, scale leaves on main stem; primary stem leaves ovate to linear, up to 1.8 x 0.8 mm, tip narrow elongate to acute, margin yellowish, entire; costa strong, percurrent; cells at upper narrow, rhomboid, 10-15 μm x 5-7 μm , middle cells narrow, elongate, 15-22 x 4-7 μm , basal cells more elongate, 30-52 x 4-6 μm ; branch leaves spreading, 1.4-1.6 x 1 mm, widely acute, margin faintly serrated below, sharply serrated at tip, apex pointed, cells same as stem leaves. (Fig. 35: f-g & Plate 16l).

Habitat: On rocky patches and on short branches in evergreen and shola forests.

Specimen examined: Chembra hills (1390 m) MCN 120244.

Distribution: It is rare in the study area. An Indo-Sri Lankan species earlier reported from South India (Karnataka: Coorg), North-east India (Darjeeling, Sikkim, Khasi hills, Arunachal Pradesh, Dehradun, Mussoorie hills) and Sri Lanka. The present collection is a new record to Kerala.

ENTODONTACEAE Kindb.

Gen. Eur. N.-Amer. Bryin. 7. 1897.

Plants glossy, slender to robust; main stem prostrate, branches irregularly pinnate, julaceous; costa short or absent, double or single; cells elongate-rhomboid with projecting ends, alar differentiated; seta elongate, smooth; capsule cylindrical, mostly erect, operculum conic, rostrate, calyptra cucullate.

This family includes nine genera viz., *Rozea*, *Levierella*, *Pleurozium*, *Trachyphyllum*, *Pterigynandrum*, *Entodon*, *Orthothecium*, *Erythrodontium* and *Campylodontium*. Of these three genera viz., *Trachyphyllum*, *Entodon* and *Erythrodontium* occur in Wayanad.

Key to the genera

- 1a. Alar cells transverse, reach half of the leaf, thick walled.....**Erythrodontium**
- 1b. Alar cells in many series in basal region, thin walled.....2
- 2a. Upper leaf cells linear, elliptic, thick walled, papillose.....**Trachyphyllum**
- 2b. Upper leaf cells elongate, thin walled, not papillose.....**Entodon**

Entodon C.Muell.

Linnaea 18: 704. 1844.

Plants yellowish-green, slender to robust, branched; stem leaves close set, slightly decurrent, concave from narrow bases, ovate to ovate-oblong, or ovate-lanceolate, obtuse or acute, rarely hair pointed, margin plane or recurved near the base, entire or minutely toothed in the upper part; costa double, short or absent; cells elongate, thin walled, not papillose, basal cells large and strongly thickened, alar cells quadrate, thin walled and hyaline; seta 1-3 cm,

reddish or yellowish, when dry twisted; capsule erect, straight or faintly curved; spores rounded, 12-20 μm diagonally.

Key to the species

- 1a. Plants robust; costa usually absent on branch leaves, two short costa on stem leaves **E. flavescens**
- 1b. Plants delicate; costa indistinct in both stem and branch leaves **E. plicatus**

Entodon flavescens (Hook.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 293. 1879; Gangulee, Moss. E. India 3(8): 1775. 1980. *Neckera flavescens* Hook., Trans. Linn. Soc. Lond. 9: 314. 1808. *Stereodon schwaegricheni* Mitt., Musc. Ind. Orient. 108. 1859. *S. rubicundus* Mitt., Musc. Ind. Orient. 108. 1859. *S. griffithii* Mitt., *ibid.* 108. 1859. *Entodon rubicundus* (Mitt.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 285. 1878; Gangulee, Moss. E. India 3(8): 1781. 1980. *Entodon griffithii* (Mitt.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 293. 1878. *E. ramulosus* Mitt., Trans. Linn. Soc. Bot. Ser. 2, 3: 179. 1891. *Cylindrothecium flavescens* (Hook.) Paris, Index Bryol. Suppl. 298. 1894. *Entodon schwaegrichenii* (Mitt.) Broth. in Paris, Index Bryol. Suppl. ed. 2, 5: 151. 1906. *E. rubrissimus* Sak., J. Jap. Bot. 28: 59. 1953.

Plant dark greenish, glossy, branches pinnate, flattened, robust; leaves triangular, ovate-lanceolate, stem leaves up to 2 x 1 mm, branch leaves up to 1.3 x 0.6 mm, erect spreading, margin almost smooth; costa usually absent on branch leaves, two short costa on stem leaves, sometimes indistinct; cells at basal part round and broad, upper elongated, 100 x 15-20 μm , thin walled, cells closely packed, margin entire; seta up to 1.5 cm, erect, yellowish orange; capsule erect to horizontal, peristome normal, double; spores 13-20 μm diagonally. (Fig. 35: h-l & Plate 16m&n).

Habitat: On rocks and rotten logs in moist deciduous, semi-evergreen and evergreen forests.

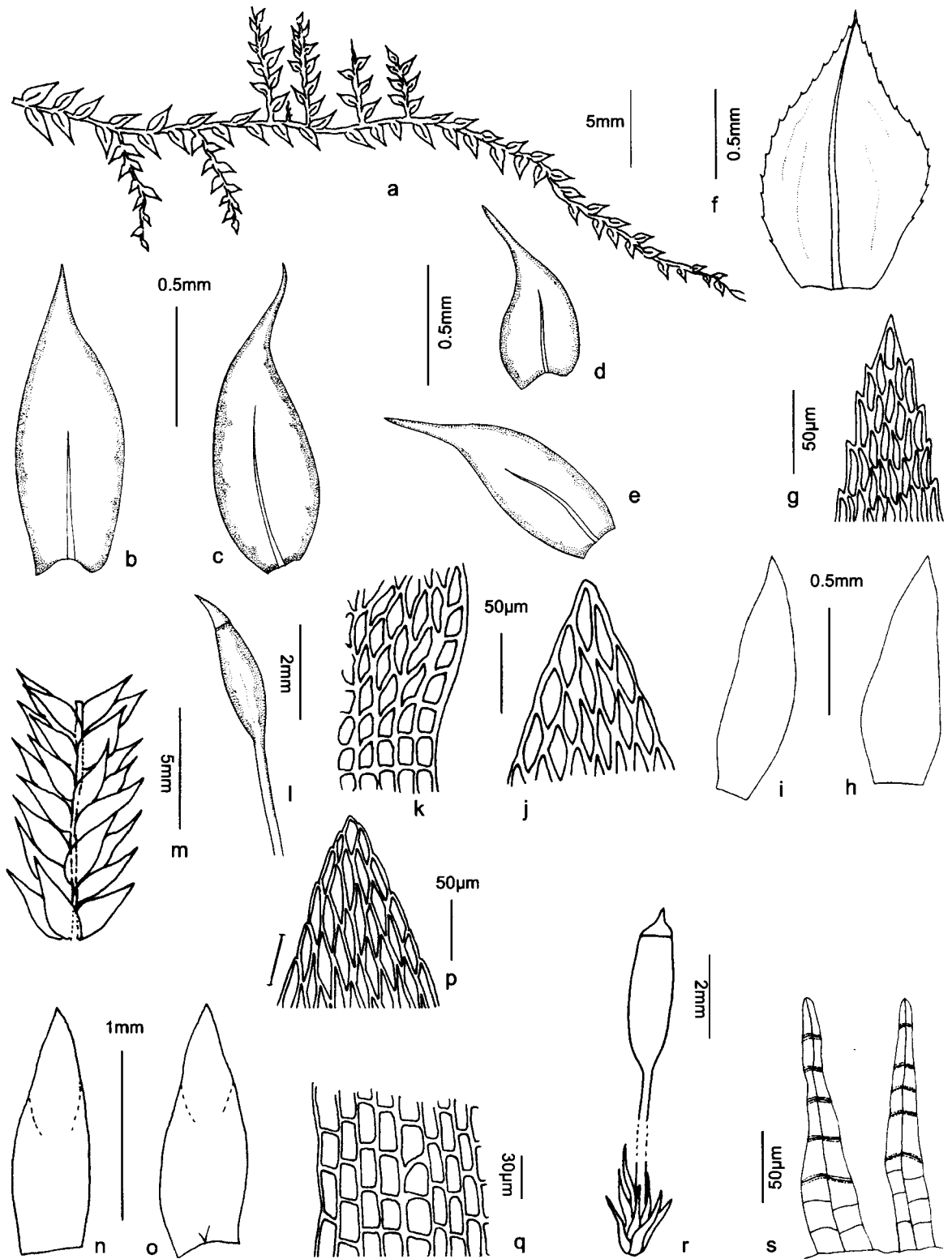


Fig. 35. a-e: *Eurhynchium vagans*; a: branch, b,c,d&e: leaves; f-g: *Rhynchoszegium herbaceum*; f: leaf, g: leaf tip cells; h-l: *Entodon flavescens*; h&i: leaves, j: leaf tip cells, k: basal cells, l: capsule; m-s: *Entodon plicatus*; m: branch, n&o: leaves, p: leaf tip cells, q: basal cells, r: sporophyte, s: peristome teeth

Specimens examined: Muthanga (860-915 m) *MCN 76097b*, *MCN 84394*, Sulthan Bathery (830 m) *MCN 84366*, Kurichiad (929 m) *MCN 84536*, Dottakulachi (856 m) *MCN 84548*, Soojippara (760 m) *MCN 87096*.

Distribution: It is widely distributed in the shady regions of the study area. This east Asiatic species is distributed in South India (locality unknown), North-east India (Darjeeling, Mussoorie, Assam, Khasi hills, Sikkim), Nepal, Bhutan, Korea, Japan, Philippines, Yunnan and Eastern Siberia.

Entodon plicatus C.Muell., *Linnaea* 18: 706. 1845; Gangulee, 3(8): 1791. 1980. *Neckera plicata* (C.Muell.) C.Muell., *Synop. Musc. Frond.* 2: 60. 1850. *Stereodon plicatus* (C.Muell.) Mitt., *Musc. Ind. Orient.* 106. 1859. *Entodon longidens* Broth., *Oefv. Finsk. Vet. Soc. Foerh.* 47(14): 8. 1905. *E. longidus* Broth. in Engl. & Prantl, *Nat. Pflanzenfam.* 1(3): 881. 1907, *nom. err.*

Plants light yellowish-green, creeping, delicate, branches opposite, small, up to 1.5 cm long; branch leaves small, ovate-lanceolate, concave, acute, 1 x 0.5 mm, stem leaves 1.5 x 0.5 mm, margin faintly serrated towards tip; costa not visible; cells linear-rhomboid, 45-55 x 5 µm, thin walled on top, basal cells rectangular to quadrate, 25-28 x 15-19 µm; sporophyte at the base of the main branch; seta yellowish, up to 2 cm; capsule yellowish-orange, cylindrical, 3 mm long, peristome double. (Fig. 35: m-s & Plate 17a).

Habitat: Corticolous in moist deciduous forests.

Specimen examined: Tholpetty range, Kaimaram (880 m) *MCN 84583*.

Distribution: A Southeast Asiatic species distributed in South India (Tamil Nadu: Nilgiri, Palni; Karnataka: Kanara), North-east India (Kumaon Himalaya), Sri Lanka, China, Myanmar, Thailand, Celebes, Philippines. The present collection is a new record to Kerala.

Erythrodontium Hamp.

Vidensk. Medd. Naturh. For. Kjobenh. ser. 3, 2: 279. 1870.

Plants slender, stem elongate, prostrate, branches julaceous, regularly and closely pinnate; leaves broadly ovate to ovate-oblong, small, narrowly acuminate, margin plane or narrowly incurved near the base, minutely serrate

or entire in the upper region; costa double, strong, very short or absent; cells narrowly elliptic, alar cells in oblique series, rounded-quadrate or transversely rectangular, forming a large conspicuous group extending obliquely about half way up the margins; seta 1-2.5 cm long, reddish or yellowish, twisted above; capsule erect, oblong-cylindric; spores 25-30 μm , papillose.

Erythrodonium julaceum (Hook. ex Schwaegr.) Paris, Index Bryol. Suppl. 436, 1896; Gangulee, Moss. E. India 3(8): 1796. 1980. *Neckera julacea* Hook. ex Schwaegr., Sp. Musc. Suppl. 3(1): 245. 1828. *Leptohyemium julaceum* (Hook. ex Schwaegr.) Hamp., Linnaea 20: 83. 1847. *Pterogonium squarrosulum* Griff., Calcutta J. Nat. Hist. 3: 63. 1843. *P. squarrosulum* Montin, Lond. J. Bot. 4: 9. 1845. *P. julaceum* (Hook. ex Schwaegr.) Hook. in C.Muell., Synop. Musc. Frond. 2: 101. 1850. *Neckera squarrosula* C.Muell., Synop. Musc. Frond. 2: 101. 1850. *Pterogonium squarrosulum* Montin, Syll. 21. 1856, ortho. err. *Stereodon juliformis* Mitt., Musc. Ind. Orient. 92. 1859. *Platygyrium julaceum* (Hook. ex Schwaegr.) Bosch & Sande-Lac., Bryol. Jav. 2: 107. 217. 1864. *P. squarrosulum* (Montin) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 277. 1878. *Entodon julaceus* (Hook. ex Schwaegr.) C.Muell., Linnaea 42: 435. 1879. *Erythrodonium juliforme* (Mitt.) Paris, Index Bryol. Suppl. 436. 1896. *E. squarrosulum* (Montin) Paris, Index Bryol. Suppl. 437. 1896.

Plants golden-greenish to brownish, robust, main stem creeping, secondary branches numerous, crowded, 4-6 cm long, branches julaceous, dense, erect; leaves broad, ovate, slightly concave, 1-1.5 x 0.6-0.8 mm, apex acuminate, margin smooth, faintly denticulate at tip; ecostate; cells smooth, narrow, elliptical to linear, 50-58 x 5-7 μm at tip, marginal and sub marginal ones ovate to quadrate, wider than the inner cells, inner cells elongate and rhomboid, 60-70 x 7-10 μm at base, at basal angle on both sides there are large triangular patches of transverse, ovate-rectangular cells reaching to considerable height along two margin; seta 2 cm long, twisted in the upper half; capsule cylindrical, erect, calyptra cucullate; spores papillose, large, 20-30 μm diagonally. (Fig. 36: a-e & Plate 17b&b1).

Habitat: On logs and on moist soil in Teak plantations and in moist deciduous forests.

Specimens examined: Ponkuzhi (900 m) MCN 84374, Kurichiad range, Chikkanji (900 m) MCN 84538c, Tholpetty range (880-893 m) MCN 84576, MCN 84584.

Distribution: It is very common in the study area and it is widespread in the tropical and subtropical regions of the world. It was earlier reported from South India (Kerala; Karnataka: Coorg; Tamil Nadu: Palni hills, Nilgiri hills), North-east India (Assam, Dehradun, Khasi hills, Mussoorie, Sikkim), Sri Lanka, Celebes, Java, Nepal, Philippines, Myanmar, Tonkin, Sumatra, Yunnan and South & Central Africa.

Trachyphyllum A.Gepp.

Cat. Welw. Afr. Pl. 2(2): 298. 1901.

Plants slender, stem very long, prostrate, regularly and densely pinnate, branches short, julaceous; branch leaves squarrose-spreading, concave, broadly ovate, narrowly acuminate, margin toothed above owing to the extended ends of the marginal cells; costa double, short, strong near the base; cells at upper half linear, elliptic, thick walled, upper ends projected as papillae on the back, near the leaf base adjoining the costa in oblique series, rhombic six-sided; alar cells in many series, quadrate or broader than long; seta strong, yellowish red; capsule horizontal, symmetrical; spores ca. 15 μm diagonally.

Note: *Erythrodonium*, *Pterygynandrum* and *Trachyphyllum* form a complex of closely related genera. In *Erythrodonium* the alae extend half way up to the margins and the cells are smooth, while in the other two genera the alae do not extend so high. In *Pterygynandrum* the papillae are on the lamina, while in *Trachyphyllum* the papillae form the extended angles.

Trachyphyllum inflexum (Harv.) Gepp in Hiern., Cat. Welw. Afr. Pl. 2(2): 299. 1901. Gangulee, Moss. E. India 3(8): 1762. 1980. *Hypnum inflexum* Harv. in Hook., Icon. Pl. Rar. 1: 24. 1836. *Stereodon inflexus* (Harv.) Mitt., Musci Ind. Orient. 92. 1859. *Platygyrium inflexum* (Harv.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1876-77: 276. 1878. *Leptohymenium ferriezii* Marie in Besch., Ann. Sc.

Nat. Bot. Ser. 7, 2: 95. 1885. *Trachyphyllum ferriezii* (Marie) A. Gepp., *Ibid.* 300. 1901.

Plants yellowish-green, slender, creeping in extensive thin mat, giving rise to short, erect or ascending julaceous branches; stem leaves cordate, ecostate; branch leaves dense, concave, cordate-ovate, short apiculate, margin smooth; costa short, forked or in some indistinct; cells elongated to rhomboid, papillose at tip and lamina, basal median cells ovate-rectangular, basal angle cells transversely elongated, chlorophyllose, 8-12 μm diagonally, at extreme base angle few larger quadrate cells, 14 x 14 μm , smooth, upper cells elongated; mostly remain as sterile. (Fig. 36: f-k & Plate 17c).

Habitat: On logs in plantations and moist deciduous forests.

Specimens examined: Ponkuzhi (900-925 m) MCN 84372, MCN 84385, MCN 84388, Kurichiad range, Dottakulachi (839-920 m) MCN 84545, MCN 84547, MCN 84552, MCN 84562, Pavagadha (759 m) MCN 84534, Muthanga (878 m) MCN 84503, Tholpetty range, Kaimaram (850-880 m) MCN 84581, MCN 84585.

Distribution: It is a widely distributed species in the study area. This species was earlier reported from South India (Karnataka: Kanara), Central India (Madhya Pradesh), North-east India (Sikkim, Darjeeling, Orissa), China, Nepal, Bangladesh, Myanmar, Thailand, Cambodia, Java, Moluccas, Philippines, Australia, New Caledonia and Madagascar. The present collection is a new record to Kerala.

SEMATOPHYLLACEAE Broth.

in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 1098. 1908.

Plants slender to robust, glossy; stem prostrate or erect, irregularly or pinnately branched; leaves ovate, acuminate; costa short, double or absent; cells linear, smooth or papillose, alar cells few, large vesicular and differentiated, mostly coloured; seta long, smooth or papillose; capsule small, horizontal to inclined, operculum rostrate, calyptra cucullate, smooth.

Fleischer and Brotherus recognized four subfamilies in this family, viz., Clastobryoideae with six genera, Heterophylloideae with five genera,

Sematophylloideae with 11 genera and Macrohymenoideae with one genus. Of these Sematophylloideae with *Sematophyllum* and *Foreauella* occur in the study area.

Key to the genera

- 1a. Dry leaves characteristically secund; normal leaves falcate; costa double, short.....**Foreauella**
1b. Dry leaves not as above; leaves erect; costa absent.....**Sematophyllum**

Foreauella Dixon & P.Varde.

Archs Bot. Bull. Mens 1(8-9): 175. 1927.

This is a monotypic genus.

Foreauella orthothecia (Schwaegr.) Dixon. & P.Varde., J. Bot. 75: 129. 1937; Gangulee, Moss. E. India 3(8): 1886. 1980. *Hypnum orthothecium* Schwaegr., Sp. Musc. Suppl. 3(1): 220. 1827. *Stereodon orthothecius* (Schwaegr.) Mitt., Musc. Ind. Orient. 101. 1859. *Leskea secunda* Harv. in Hook., Icon Pl. Rar. 1: 23. 1836, *nom. Illeg.* *Pylasia secunda* (Harv.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 306. 1878. *Foreauella indica* Dixon & P.Varde., Arch. Bot. 1(8-9): 175. 1927. *Hypnum curvatirameum* Hamp. in Dixon, Rev. Bryol. ser. 2: 24. 1929, *nom. nud.*

Plants yellowish-green, in caespitose mats, main stem prostrate, densely branched, branches pinnate, short, simple, curled inwards in dry condition; leaves dimorphic, stem leaves appressed, broadly deltoid from an obovate base, acuminate, up to 1 x 0.28 mm, margin entire, faintly denticulate by the projecting marginal cells; costa double, short; branch leaves spreading, ovate-lanceolate, broadly acuminate, bicostate, upper part longitudinally plicate, denticulate; cells at the base strongly chlorophyllose, hexagonal, 28-40 µm long, middle and upper cells rhomboid, 18-25 x 3-5 µm; alar cells a row of two or three large hyaline cells, ±18 x 10-15 µm, below the alar cells form a row of attachment cells. (Fig. 36: l-o & Plate 17d).

Habitat: On logs, roots and bark, strongly attached to the substratum in the plantations, moist deciduous, semi evergreen and evergreen forests.

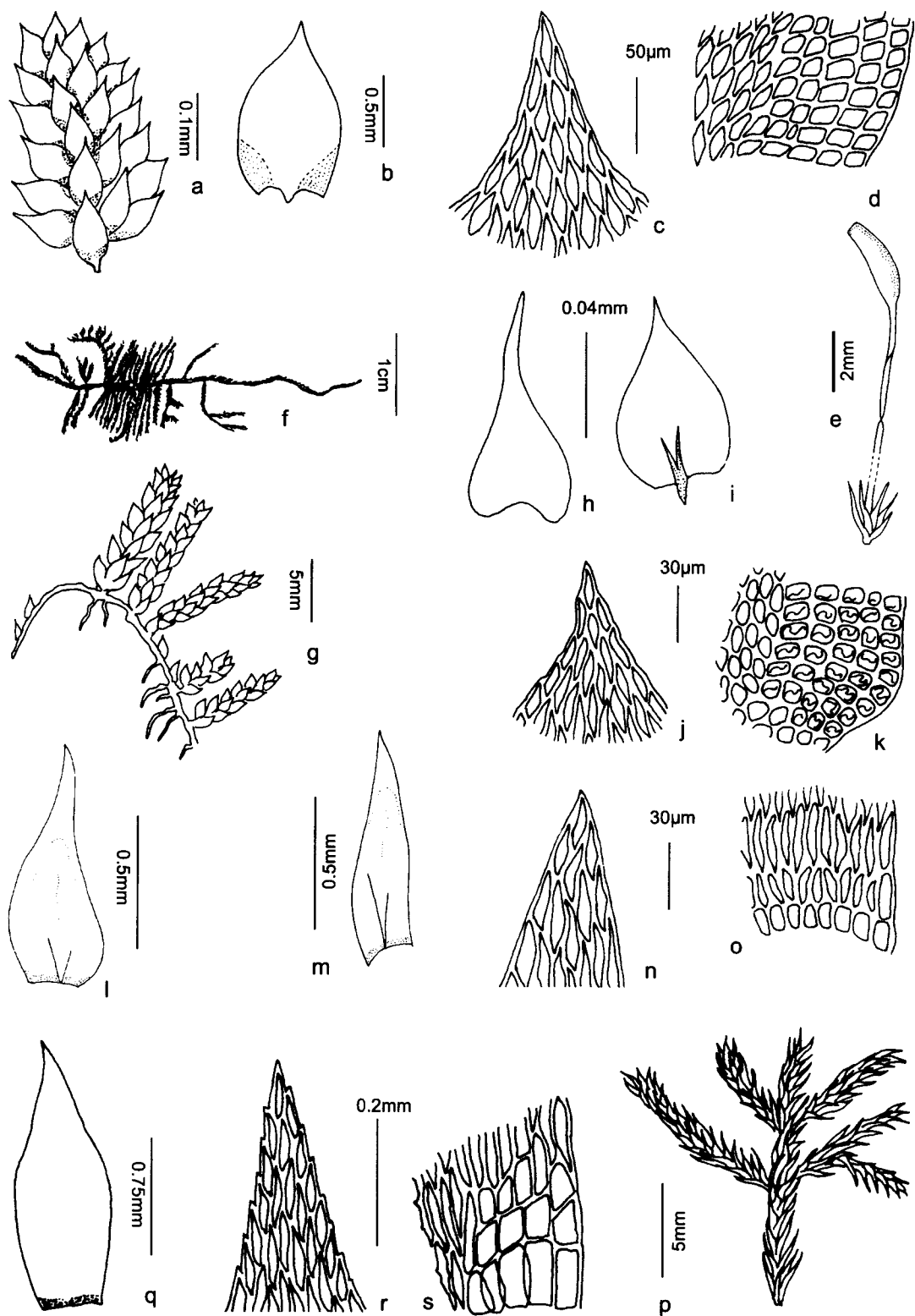


Fig. 36. **a-e**: *Erythrodontium julaceum*; a: branch, b: leaf, c: leaf tip cells, d: basal cells, e: sporophyte; **f-k**: *Trachyphyllum inflexum*; f: dry habit, g: enlarged view of habit, h: stem leaf, i: branch leaf, j: leaf tip cells, k: basal cells; **l-o**: *Foreauella orthothecia*; l&m: leaves, n: leaf tip cells, o: basal cells; **p-s**: *Sematophyllum subpinnatum*; p: branch, q: leaf, r: leaf tip cells, s: basal cells

Specimens examined: Ponkuzhi (920 m) *MCN 84386, MCN 84387*, Muthanga range, Keeradamkolli (878 m) *MCN 84396, MCN 84398*, Nalloor vayal (896 m) *MCN 84508*, Kurichiad range (781-925 m) *MCN 84529, 84539*, Kuppadi (869 m) *MCN 84568*, Soojippara (760 m) *MCN 87104*, Mananthavady puzha (1100 m) *MCN 99641*.

Distribution: It is common in the study area. This Indo-Malesian species was earlier recorded from South India (Tamil Nadu: Palni hills), North-east India (Darjeeling, Assam, Khasi hills, Orissa), Nepal, Thailand, Philippines and the Pacific Ocean Islands. The present collection is a new record to Kerala.

Note: This species is easily recognizable in the field, by its peculiar type of curling of branches and the falcate leaves.

Sematophyllum Mitt.

J. Linn. Soc., Bot. 8: 5. 1864.

Plants small to robust, glossy in dense mats; stem creeping, branches crowded, densely foliate; leaves erect to spreading, ovate to oblong-elliptic, obtuse, apiculate, gradually or abruptly long acuminate, sometimes hair pointed, weakly toothed above; costa absent; cells rhombic, alar cells large, oblong inflated, coloured; seta usually elongate, reddish; capsule erect to horizontal, ovoid to oblong; spores small to medium sized.

Sematophyllum subpinnatum (Brid.) E.G.Britton, *Bryologist* 21: 28. 1918. *Leskea subpinnata* Brid., *Sp. Musc.* 2: 54. 1812. *Hypnum loxense* Hook. in Kunth., *Syn. Pl. Aequin.* 1: 62. 1822. *H. subsecundum* Arnott, *Mem. Soc. Linn. Paris* 1: 350. 1823. *H. densifolium* Spreng. in Brid., *Bryol. Univ.* 2: 591. 1827, *nom. nud. in synon.* *H. pallidisetum* Brid., *ibid.* 591. 1827. *Hookeria leduceana* Montin, *Ann. Sc. Nat. Bot. ser. 2*, 16: 275. 1841. *Leskea circinalis* Hamp., *Icon. Musc.* 5. 1844. *L. kegeliana* C.Muell., *Linnaea* 21: 19. 1848. *Hypnum galipense* C.Muell., *Bot. Zeitung. Berlin* 6: 780. 1848. *H. hampeanum* C.Muell., *Syn. Musc. Frond.* 2: 326. 1851. *H. sphaerotheca* C.Muell., *ibid.* 333. 1851. *Sematophyllum caespitosum* (Hedw.) Mitt., *J. Linn. Soc. Bot.* 12: 479. 1869; Gangulee, *Moss. E. India* 3: 1880. 1980. *S. galipense* (C.Muell.) Mitt., *J. Linn. Soc. Bot.* 12: 480. 1869. *S. lamprophyllum* Mitt., *ibid.* 12: 496. 1869. *S. leptothecium* Mitt., *ibid.*

12: 482. 1869. *S. subnervatum* Mitt., *ibid.* 12: 483. 1869. *Rhynchostegium hampei* Besch., Mem. Soc. Bot. Cherbourg 16: 249. 1872. *Hypnum lecoultriae* Dub., Flora 60: 91. 1877. *H. robillardii* Dub., *ibid.* 91. 1877. *Rhaphidostegium fallax* Besch., Mem. Soc. Sc. Nat. Cherbourg 21: 270. 1877. *R. tristiculum* (Mitt.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1876-'77: 392. 1878. *R. barnesii* Renaud & Cardot, Bull. Soc. Bot. Belgium 29(I): 182. 1890. *Aptychus concinnus* C.Muell., Malpighia 10: 516. 1896. *A. grammicarpus* C.Muell., *ibid.* 5: 7. 1896. *A. longicollis* Hamp. ex C.Muell., Bull. Herb. Boiss. 5: 213. 1897. *A. semitortulus* C.Muell., *ibid.* 213. 1897. *Rhaphidostegium concinnum* (C.Muell.) Paris, Index Bryol. Suppl. 1090. 1898. *R. grammicarpum* (C.Muell.) Paris, *ibid.* 1095. 1898. *R. perlaxum* Paris, *ibid.* 1102. 1898, *nom. nud.* *Pterogoniella stuhlmanii* Broth. in Paris, Index Bryol. Suppl. 1048. 1898. *Semaptophyllum tristiculum* (Mitt.) M.Fleisch., Musci Fl. Buitenz. 4: 1262. 1923.

Plants glossy, brownish-green, main stem creeping, branching irregular; leaves on branches erecto-patent, appressed to stem when dry, broad ovate-lanceolate, 1-1.5 x 0.5 mm, apex acute, margin dentate at apex; ecostate; cells narrow-rhomboid, 40-55 x 5-8 μ m at apex, basal cells narrow, longer, 70-85 x 5-8 μ m, alar differentiated by four large vesicular cells, cells joining the alar highly porose. (Fig. 36: p-s).

Habitat: Base of tree trunk and also on logs of *Tectona grandis* in plantations.

Specimen examined: WWLS, Muthanga range (870 m) MCN 84504.

Distribution: This species is rare in the study area. It has been reported earlier from South India (Tamil Nadu: Palni hills), North-east India (Darjeeling, Assam, Khasi hills), Sri Lanka, Japan, Sumatra, Java, Philippines, Australia, Central & South Africa, Madagascar and America. The present collection is a new record to Kerala.

HYPNACEAE Schimp.

Coroll. Bryol. Eur. 113. 1855.

Plants slender to moderately robust, usually glossy; main stem creeping, branching regularly to irregularly pinnate, paraphyllia mostly absent; leaves ovate or ovate-lanceolate, acuminate; costa short, double or none; cells linear,

rarely papillose, alar cells poorly differentiated; monoecious or dioecious; seta long, slender, smooth; capsule mostly horizontal, ovoid, operculum conical, calyptra cucullate; spores small, smooth.

Three subfamilies with 13 genera are recognized within this family. Pylaisioideae with three genera, Hypnoideae with six genera and Ctenioideae with four genera are represented in India. Of these *Taxiphyllum*, *Isopterygium*, *Ectropothecium* and *Vesicularia* under the subfamily Hypnoideae and *Ctenidium* under Ctenioideae occur in the study area.

Key to the genera

- 1a. Leaves slightly or not differentiated, symmetrical or asymmetrical; capsule inclined or hanging(subfam. **Hypnoideae**) 2
- 1b. Leaves distinctly differentiated into stem and branch leaves, symmetrical; capsule inclined to nearly horizontal.(subfam. **Ctenioideae**) **Ctenidium**
- 2a. Branches more or less complanate.....3
- 2b. Branches not complanate.....4
- 3a. Leaves in two rows; pseudoparaphyllia foliose.....**Taxiphyllum**
- 3b. Leaves not distinctly in two rows; pseudoparaphyllia filamentous.....
.....**Isopterygium**
- 4a. Leaf narrow acuminate; cells narrow-linear.....**Ectropothecium**
- 4b. Leaf with short or long hair-like acumen; cells broader, rhomboid six sided
.....**Vesicularia**

Ctenidium (Schimp.) Mitt.

J. Linn. Soc., Bot. 12(1): 509. 1869.

Plant slender, soft, branches small, horizontal, prostrate; leaves closely crowded, differentiated into stem and branch leaves, long decurrent, non-plicate to faintly plicate, abruptly lanceolate-subulate from broad, cordate base, serrate throughout; costa double, very short or absent; cells narrow, linear, alar cells a group of quadrate and rectangular, small cells; branch leaves narrower, ovate-lanceolate; seta 1-2.5 cm long, reddish; capsule inclined to nearly horizontal, broadly ovoid, calyptra hairy.

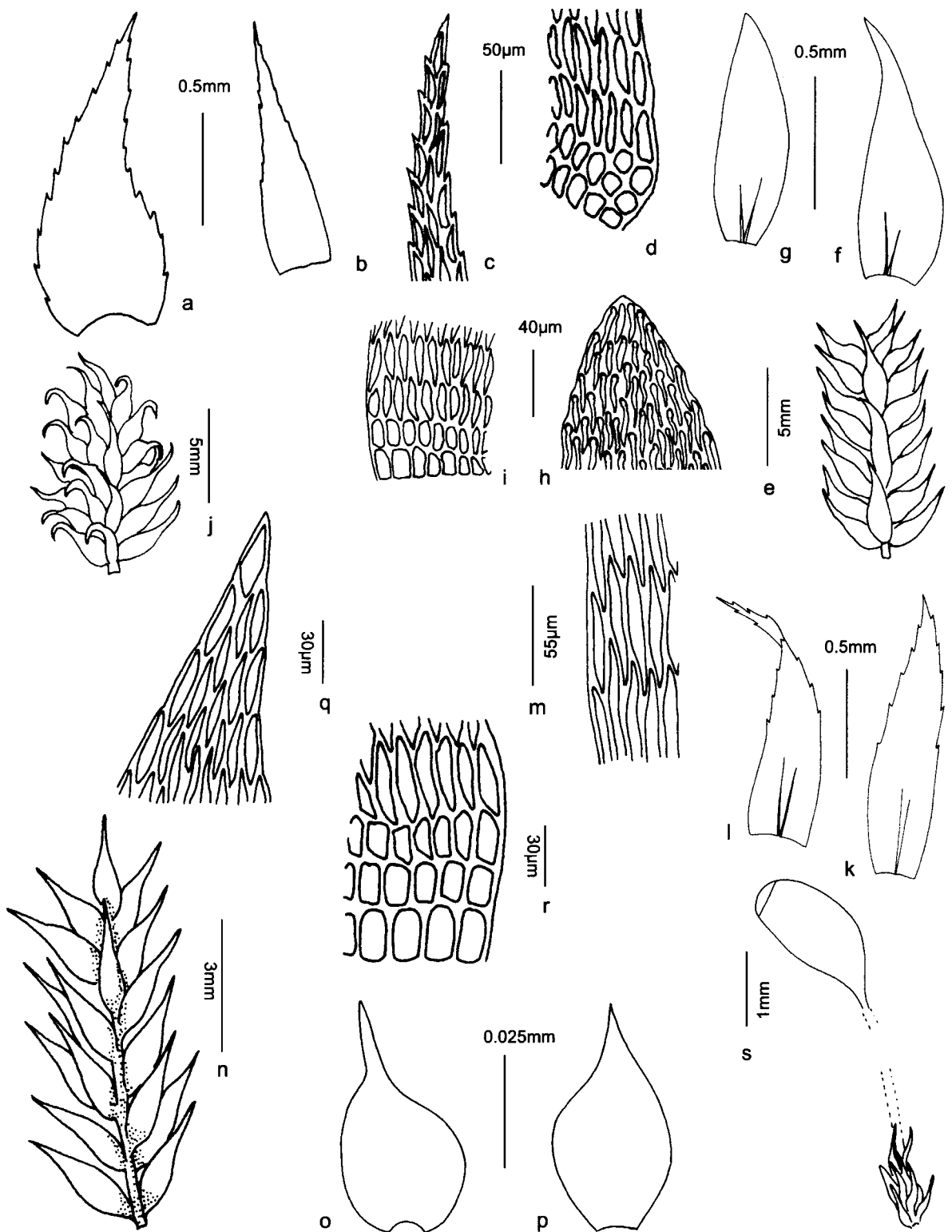


Fig. 37. a-d *Ctenidium lychnitis*; a: stem leaf, b: branch leaf, c: leaf tip cells, d: basal cells; e-i: *Ectropothecium compressifolium*; e: branch, f&g: leaves, h: leaf tip cells, i: basal cells; j-m: *Ectropothecium sikkimense*; j: branch, k&l: leaves, m: leaf cells; n-s: *Isopterygium albescens*; n: branch, o&p: leaves, q: leaf tip cells, r: basal cells, s: sporophyte

Ctenidium lychnites (Mitt.) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 1048. 1909. *Stereodon lychnites* Mitt., Musc. Ind. Orient. 114. 1859. *Hyocomium lychnites* (Mitt.) Mitt., Trans. Linn. Soc. Bot. Lond. ser. 2,3: 177. 1899. *Hypnum lychnites* (Mitt.) C.Muell., Linnaea 36: 8. 1869.

Plants yellowish-green, silky, in dense tufts; main stem creeping, branching pinnate; stem leaves larger, 1.25 x 0.5 mm, base cordate, slightly auriculate, narrowed into a fine acumen; branch leaves spreading, narrower than stem leaves, 0.8-1.2 x 0.20-0.25 mm, margin dentate at apex towards middle; costa single; cells linear, at apex 35-40 x 5 µm, lower cells 55-60 x 5-7 µm; alar cells hyaline, quadrate and rectangular, most prominent are quadrate cells, 10-12 µm wide. (Fig. 37: a-d & Plate 17e).

Habitat: Terrestrial in evergreen forests.

Specimen examined: Thirunelli (1150 m) MCN 99669.

Distribution: This species is rather rare in the study area and could be collected from the evergreen forests of Thirunelli and also collected from the Vellarimala in Kozhikode district adjacent to the study area. It is an Indo-Philippine species distributed in South India (Kerala; Tamil Nadu: Nilgiri hills, Palni hills), North-east India (Khasi hills), Sri Lanka and Philippines.

Ectropothecium Mitt.

J. Linn. Soc., Bot. 10: 180. 1868.

Plants slender to robust, stem elongated, prostrate, simple or branched, branches spreading, pinnate; leaves shortly decurrent, symmetrical, differentiated into dorsal, ventral and lateral; stem leaves ovate to ovate-lanceolate, acuminate; costa short, double or absent; cells narrow-linear, generally distinctly papillose, extend towards the apex, near the base short and somewhat wider, alar cells small, rectangular to quadrate or sometimes poorly differentiated; seta elongate; capsule horizontal to pendulous, peristome double, calyptra cucullate.

Key to the species

- 1a. Alar cells not distinct, one row of rectangular cells at extreme base above that another row of smaller cells.....**E. compressifolium**
1b. Alar cells distinct, small, rectangular to quadrate.....**E. sikkimense**

Ectropothecium compressifolium (Mitt.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1877-78: 290. 1880; Gangulee, Moss. E. India 3(8): 1992. 1980. *Stereodon compressifolius* Mitt., Musci. Ind. Orient. 99: 1859.

Plants yellowish-green, main stem creeping, irregularly branched, branches complanate; leaves ovate, tip acute, erecto-patent when moist, 5-8 x 0.35 mm, margin dentate at tip; costa short, double, sometimes indistinct; cells narrow-rhomboid, 25-30 x 5-8 μm at apex, 35-45 x 5-7 μm at lower side, papillae at cell tip, alar cells not distinct, one row of rectangular cells at extreme base, above that another row of smaller cells, alar cells not distinct. (Fig. 37: e-i & Plate 17f).

Habitat: On soil cuttings in evergreen forests.

Specimen examined: Thirunelli RF (880 m) MCN 84602.

Distribution: It is rare in the study area. It was earlier recorded from North-east India (Assam, Khasi hills) and Myanmar. The present collection is a new record to Peninsular India.

Ectropothecium sikkimense (Renauld & Cardot) Renauld & Cardot, Bull. Soc. Bot. Belgium 41(1): 109. 1905; Gangulee, Moss. E. India 3: 1996. 1974. *Hypnum humulosum* var. *sikkimense* Renauld & Cardot, Bull. Soc. Bot. Belgium 34(2): 78. 1896. *Cupressina lonchopteris* C.Muell. in Paris, Index Bryol. Suppl. 106. 1900, *nom. nud. in synon. C. mussooriensis* C.Muell. in Renauld & Cardot, Bull. Soc. Bot. Belgium 41(1): 109. 1905, *nom. nud. in synon. Ectropothecium mussuriense* Broth., *ibid.*, *nom. nud. in synon. Hypnum darjeelingense* Ando, Hikobia 6: 41. 1971.

Plants yellowish-green, very small, silky, creeping, appressed to the soil, highly branched, branches short; leaves linear-lanceolate, crowded, decurrent, acuminate, narrowed at base, up to 1.2 mm long, margin faintly serrated at the tip; costa double, short; cells all alike, linear-rhomboid, longer than broad, 50-58

x 5-7 µm, small papillae on projected cell tips at midleaf, alar cells small, rectangular to quadrate, 15-20 µm wide. (Fig. 37: j-m).

Habitat: Terrestrial in moist deciduous, semi-evergreen and evergreen forests.

Specimens examined: Ponkuzhi (900 m) MCN 84380, Thirunelli RF (880 m) MCN 84604.

Distribution: This species is rare in the study area. It has earlier reported from North-east India (Darjeeling, Sikkim), Bhutan and Thailand. Gangulee (1974) recorded this species as endemic to Western Himalayas. However occurrence in Thailand and Bhutan shows its range of distribution. The present collection is a new record to Peninsular India.

Isopterygium Mitt.

J. Linn. Soc. Bot. 12(1): 21, 497. 1869.

Plants slender, glossy, flat mats; stem prostrate to ascending, scarcely erect; leaves of branches and main stem alike, complanate, dorsal and ventral leaves obliquely appressed, usually asymmetric, not in distinct rows; leaves spreading in two rows in same plane, ovate-oblong or ovate-lanceolate, short or long piliform acumen, margin entire or faintly toothed; costa short or absent; cells narrow prosenchymatous, near the insertion short and thick walled, alar cells not differentiated, pseudoparaphyllia filamentous; seta long, twisted in dried condition; capsule suberect to horizontal, ovoid to oblong-ovoid, operculum convex.

Key to the species

- 1a. Costa absent.....**I. albescens**
1b. Costa double, faint, one longer than the other, merge with leaf cells.....
.....**Isopterygium sp.**

Isopterygium albescens (Hook.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1877-78: 433. 1878. *Hypnum albescens* Hook. in Schwaeger., Sp. Musc. Suppl. 3(1): 226. 1828. *Stereodon albescens* (Hook.) Mitt., Musci Ind. Orient. 104. 1859.

Plants slender, yellowish-green, glossy, forming thick mat; main stem creeping, 1-3 cm x 0.03-0.08 mm, branches pinnate, short, up to 6 mm long; leaves ovate, short acuminate, concave, margin smooth, minutely dentate at tip; costa absent; cells elongate, upper cells 30-38 x 3-5 μm , basal cells 68-76 x 6-8 μm , at extreme base a row of rectangular cells, 35-38 x 10-13 μm , with some irregular cells above; seta slender, erect, up to 2 cm long; capsule horizontal to drooping, ovoid-cylindrical, curved at base, operculum conic rostrate; spores rounded, small, 10-13 μm diagonally. (Fig. 37: n-s & Plate 17j).

Habitat: On bark, rotten logs and on the surface of polypores in shola forests.

Specimens examined: Chembra hills (1770 m) *MCN 120277*, *MCN 120280*

Distribution: This species is common in the shola forests of the study area. It was earlier recorded from South India (Tamil Nadu: Nilgiri hills, Palni hills), North-east India (Khasi hills), Sri Lanka, Myanmar, Thailand, Vietnam, Singapore, Sumatra, Java, Borneo, Celebes, Philippines, Japan and New Zealand.

***Isopterygium* sp.**

Plant yellowish-green in loose tufts, main stem creeping, long, up to 10 cm or more, tomentose below at intervals, bipinnately branched, branches small, up to 5 mm long; leaves broadly ovate, acute, margin smooth, stem leaves up to 1.5 x 0.7 mm, tip broadly pointed than branch leaves, branch leaves up to 1.3 mm long; costa double, faint, one longer than the other, merge with leaf cells; cells chlorophyllose throughout, elongate, rhomboid to hexagonal, marginal cells hyaline, 50-75 μm ; seta long, slender, yellowish; capsule pyriform, yellowish brown; spores small, rounded, ca. 10 μm diagonally. (Fig. 38: a-c & Plate 17i).

Habitat: On ground floor in semi-evergreen forests.

Specimen examined: Kurichiad range (760 m) *MCN 84533*.

Distribution: This species is rare in Wayanad and could be collected from one locality.

Taxiphyllum M.Fleisch.

Die Musci Fl. Buitenz.4: 1434. 1923.

Plants green, soft, glossy, branching irregular, pseudoparaphyllia triangular to lanceolate in outline; leaves of branches and of main stem alike, mostly complanate, leaves spreading in two rows, oblong or sometimes ovate or oblong-lanceolate with short or long acumen, margin faintly toothed, pseudoparaphyllia foliose; costa very short, double and indistinct; cells narrow elongate or rhomboid, near the base thick walled; alar cells not differentiated; seta long; capsule erect to suberect, with a distinct neck, ovoid to oblong-ovoid or cylindrical; spores rounded, dark brown.

Taxiphyllum taxirameum (Mitt.) M.Fleisch., Die Musci Fl. Buitenz. 4: 1435. 1923; Gangulee, Moss. E. India 3(8): 1945. 1980. *Stereodon taxirameus* Mitt., Musc. Ind. Orient. 105. 1859. *Hypnum teysmanni* Sande-Lac., Bryol. Jav. 2: 102, 290. 1869. *Isopterygium planissimum* Mitt., J. Linn. Soc. Bot. 12: 498. 1869. *I. taxirameum* (Mitt.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1876-77: 439. 1878. *Plagiothecium taxirameoides* C.Muell. in Paris, Index Bryol. Suppl. 968. 1898, *nom. nud.* *Isopterygium taxirameoides* C.Muell., Lev. Rev. Bryol. 34: 55. 1907, *nom. nud.* *Plagiothecium planissimum* (Mitt.) Bartram, Bryologist 49: 122. 1946.

Plant glossy-green, prostrate, variously branched; main stem up to 6 cm long, branches small, 0.5-1 cm long; stem and branch leaves alike, oblong-lanceolate, gradually tapering to a pointed tip, margin serrated near the tip, up to 1.5 x 0.04 mm; cells linear to rhomboid-linear, cell tips papillose, upper cells 30-32 x 5-7 μ m, extreme leaf base cells rectangular, hyaline, 65-72 x 5-7 μ m, pseudoparaphyllia triangular, foliar; costa double, indistinct; seta 10 mm long; capsule cylindrical, erect; spores 15-20 μ m diagonally. (Fig. 38: d-h & Plate 17h).

Habitat: Commonly found in shaded sites, on rocks or soil banks, on logs; often near riparian habitat in Teak plantations, moist deciduous, semi-evergreen and evergreen forests.

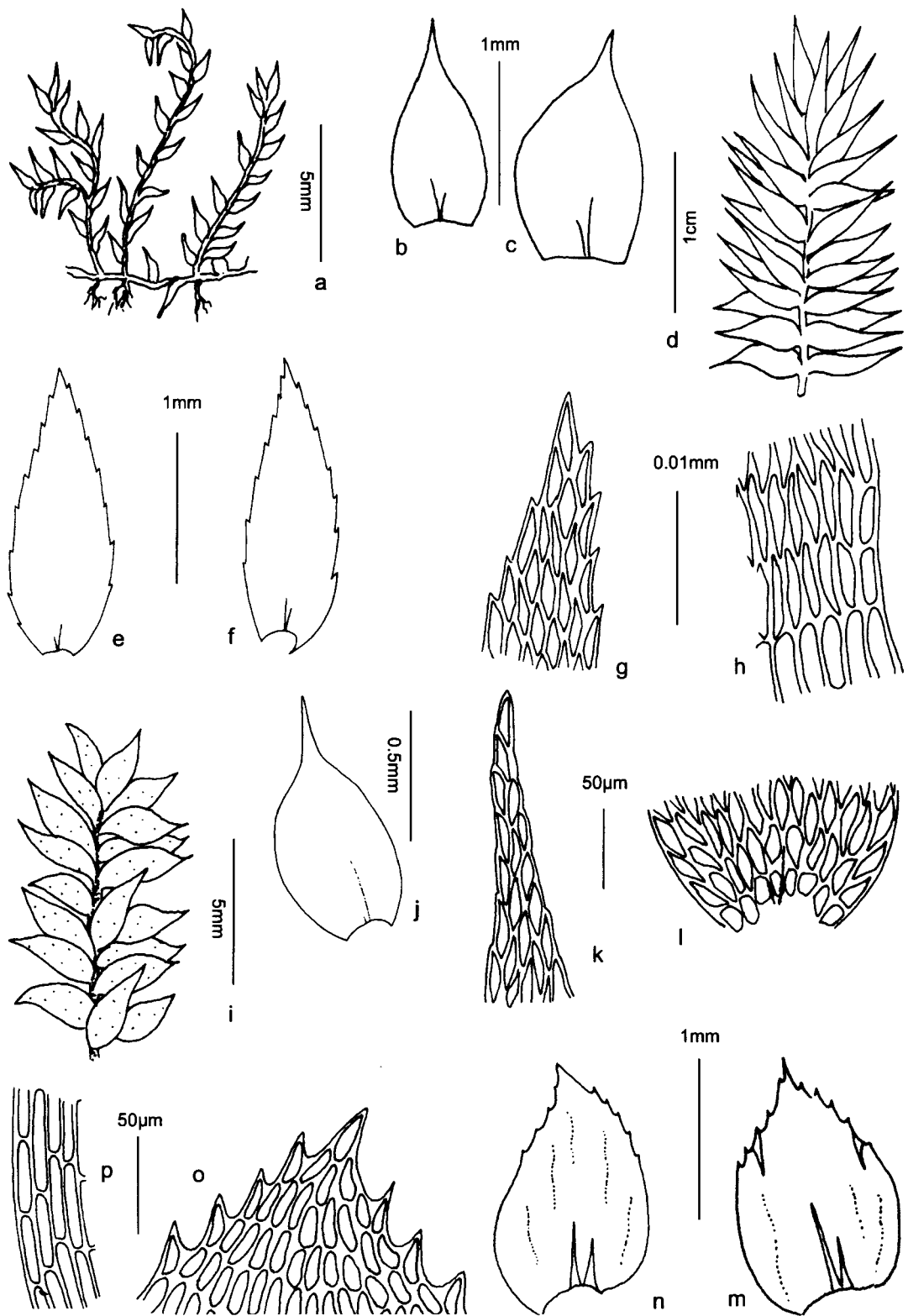


Fig. 38. **a-c:** *Isopterygium* sp.; a: habit, b&c: leaves; **d-h:** *Taxiphyllum taxirameum*; d: branch, e&f: leaves, g: leaf tip cells, h: basal cells; **i-l:** *Vesicularia vesicularis*; i: branch, j: leaf, k: leaf tip cells, l: basal cells; **m-p:** *Macrothamnium macrocarpum*; m&n: leaves, o: leaf tip cells, p: basal cells

Specimens examined: Sulthan Bathery, 1978 Plantation (883 m) MCN 84349, Ponkuzhi (900 m) MCN 84376, Arupunji (876 m) MCN 84390, MCN 84391, Edathara (889 m) MCN 84393, Thirunelli RF (875 m) MCN 84599, MCN 84601, MCN 84605, Kurichiad range (715-900 m) MCN 84525b, MCN 84541.

Distribution: It is a common species in the evergreen and deciduous forests of high altitude areas. This is widely distributed in the tropics and earlier reported from South India (Tamil Nadu: Palni; Karnataka: Coorg), North-east India (Mussoorie, Simla, Nainital, Almora), Sri Lanka, Myanmar, Sumatra, Java, New Guinea, Philippines, Taiwan, Yunnan, Korea, Japan, Siberia, Oceania and Australia. The present collection is a new record to Kerala.

Note: Iwatsuki (1963) pointed out that this genus is similar to *Isopterigium* in almost all aspects except that the latter has filamentous pseudoparaphyllia whereas *Taxiphyllum* has foliose ones and the leaves are strongly complanate and appear to be in two neat rows. Many species of Japanese *Isopterigium* bear filamentous pseudoparaphyllia. These usually consist of a single row of narrow thin walled cells.

Vesicularia (C.Muell.) C.Muell.

Bot. Jahrb. 23: 330. 1896.

Plants yellowish-green, slender to robust; stem elongate, prostrate, simple or branched, mostly regularly pinnate, branches spreading, mostly small and simple; leaves broadly ovate or oblong-lanceolate, with short or long hair like acumen, margin entire except apical part where it is distinctly toothed; costa double, very short or absent; cells ovate or oblong to elongate or rhomboid-six sided, smooth, chlorophyllose; alar cells not differentiated; seta 1-2.5 cm long; capsule horizontal to pendulous, shortly ovoid to oblong-ovoid, peristome normal, operculum apiculate or shortly rostrate.

Vesicularia vesicularis (Schwaegr.) Broth., Nat. Pflanzenfam. 1(3): 1094. 1908. *Hypnum vesiculare* Schwaegr., Sp. Musc. Suppl. 2(2): 167. 1827. *Vesicularia montagnei* (Bel.) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 1094. 1908; Gangulee, Moss. E. India 3(8): 2001. 1980. *Pterygophyllum montagnei* Bel., Voyag. Ind. Or. Bot. 2: 85. 1834. *Hookeria meyeniana* Hamp., Icon. Musc. 3. 1844. *Hypnum montagnei* Schimp. in Montin, Ramon de la

Sagra, Hist. Fis. Cuba Bot. Pl. Cell. 9: 530. 1845. *H. meyenianum* (Hamp.) C.Muell., Synop. Musc. Frond. 2: 233. 1851. *Ectropothecium meyenianum* (Hamp.) A.Jaeger, Ber. Senckenberg. Naturf. Ges. 1877-78: 268. 1880. *E. montagnei* (Bel.) A.Jaeger, *ibid.* 269. 1880. *Vesicularia meyeniana* (Hamp.) Broth. in Engl. & Prantl, Nat. Pflanzenfam. 1(3): 1094. 1908.

Plant yellowish-green, prostrate, creeping in extensive mat, up to 7-10 cm long, main branches irregular, secondary branches pinnate, 0.5 -1 cm long, rhizoids numerous at nodes; leaves ovate to ovate-oblong, erecto-patent when moist, tip acute, margin smooth, faintly denticulate at apex, up to 1-1.2 x 0.5 mm; ecostate; cells rhomboid to hexagonal, longer than wide, 62-73 x 12-18 μ m at apex, at base 70-75 x 18-20 μ m, alar cells not distinct. (Fig. 38: i-l & Plate 17g).

Habitat: On rocks near riparian habitat in semi-evergreen and evergreen forests.

Specimens examined: Keeradamkolli (370 m), MCN & SKA 84400, Kuppadi (860 m) MCN 84566.

Distribution: It is rare in the study area. This south & east Asiatic-Pacific species distributed in North-east India (Western Himalaya, West Bengal, Arunachal Pradesh), China, Thailand, Vietnam, Sumatra, Java, Borneo, Philippines, Australia and Oceania. The present collection is a new record to Peninsular India.

HYLOCOMIACEAE (Broth.) M.Fleisch.

Nova Guinea 12: 125. 1914.

Plants rigid, robust, regularly pinnate or bipinnate, glossy, densely foliate in loose tufts, stem and branch leaves often differentiated; leaves acuminate, serrated at tip; costa double, rarely single; alar cells well differentiated, sometimes indistinct; seta long, smooth; capsule large, ovoid, mostly horizontal, sometimes erect, operculum short, conical

About 13 genera are represented in this family. Of these Five genera *viz.*, *Hylocomium*, *Macrothamnium*, *Leptohymerium*, *Stenetheciopsis* and

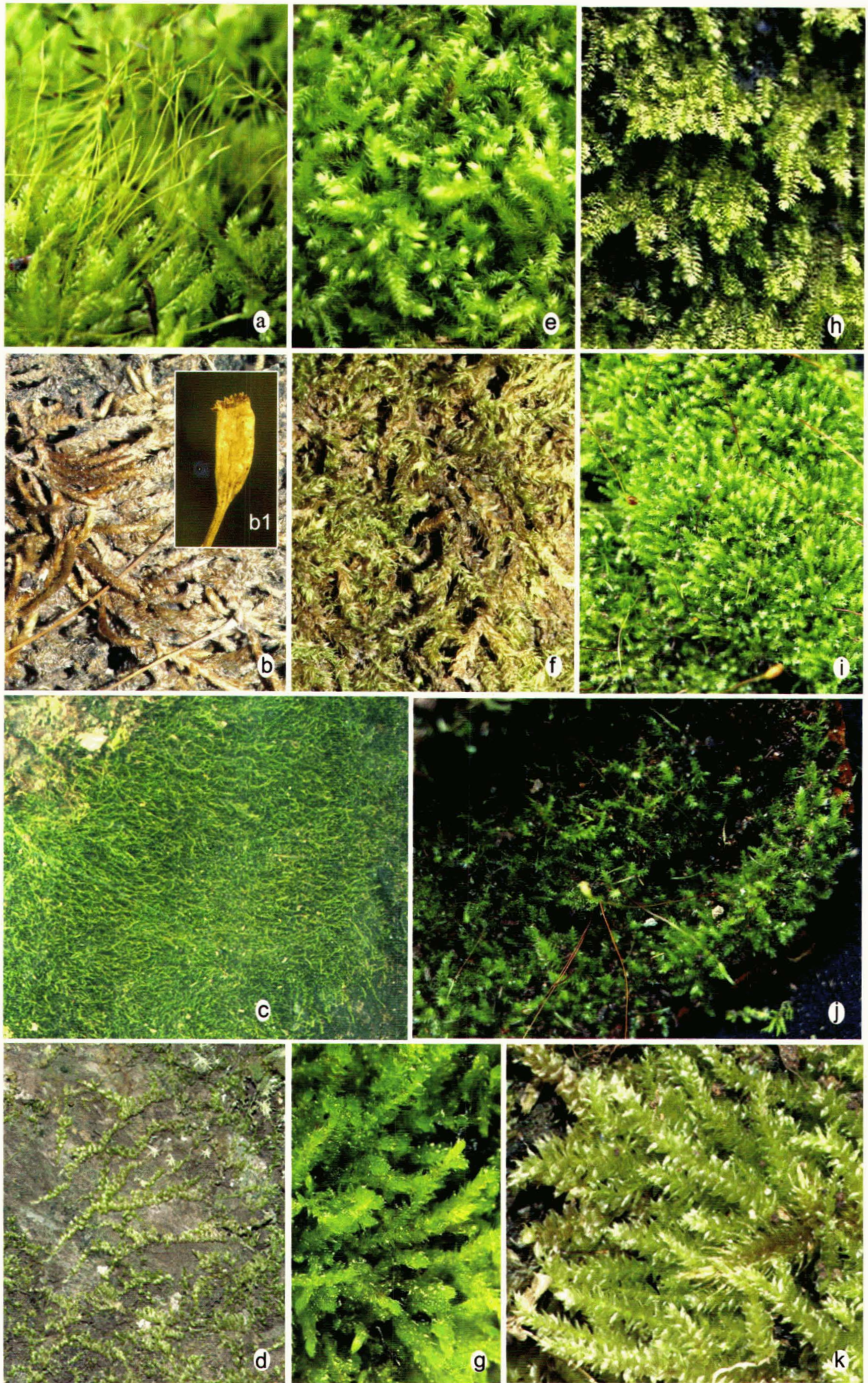


Plate. 17. a: *Entodon plicatus*, b: *Erythrodonium julaceum*, b1: capsule, c: *Trachyphyllum inflexum*, d: *Foreauella orthothecia*, e: *Ctenidium lychnitis*, f: *Ectropothecium compressifolium*, g: *Vesicularia vesicularis*, h: *Taxiphyllum taxirameum*, i: *Isopterygium* sp., j: *Isopterygium albescens*, k: *Macrothamnium macrocarpum*

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Macrothamniella are represented in India. Of which only *Macrothamnium* occur in Wayanad.

Macrothamnium M.Fleisch.

Hedwigia 44: 307. 1905.

Plants glossy, moderately slender, stem prostrate, with curved, ascending branches, near the base unbranched or with small branches, leaves distant, but above densely beset with fasciculate branches, rarely tripinnate; 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 and oblong ovate, acuminate, much smaller, mostly loosely imbricate; seta about 6 cm long; capsule inclined to pendulous, ovoid-oblong to thick-cylindric, shining brown, annulus differentiated, peristome normal, operculum convex with a short beak.

Macrothamnium macrocarpum (Reinw. & Hornsch.) M.Fleisch., Hedwigia 44: 308, 1905; Gangulee, Moss. E. India 3(8): 2029. 1980. *Hypnum macrocarpum* Reinw. & Hornsch., Nov. Act. Leop. Car. 14(2): 725. 1829. *Hypnum discriminatum* Montin in C.Muell., Synop. Musc. Frond. 2: 452. 1851. *H. paraphysale* C.Muell., Bot. Zeitung. Berlin 12: 572. 1854. *Stereodon macrocarpus* (Reinw. & Hornsch.) Mitt., Musc. Ind. Orient. 113. 1859. *S. pseudostratus* (C.Muell.) Mitt., *ibid.* 114. 1859. *Macrothamnium discriminatum* (Montin) A.Jaeger, *ibid.* 431. 1878. *Plicatella microcarpa* C.Muell., Hedwigia 41: 308. 1905. *Macrothamnium setschwanicum* Broth., Ak. Wiss. Wien Math. Nat. kl. Abt. 131: 218. 1923.

Plants yellowish-green to golden-green; main stem wiry, slender, prostrate, curved, branches ascending, leaves distant at base, above fasciculate; leaves on main stem spreading, wide based, triangular, plicate, up to 0.9 x 0.8 mm, margin denticulate, leaves on primary branches larger, 1-1.2 x 0.7-0.8 mm, cordate, narrowed below, acute on top, margin denticulate; costa

double, one reaching the midleaf and other short; cells linear-rhomboid to elliptic, apical cells 20 x 11 μm , lower cells 65-80 x 8 μm ; alar cells not distinct; seta erect, slender, up to 5 cm long; capsule horizontal, cylindrical, up to 1.5 mm long, peristome hypnoid. (Fig. 38: m-p & Plate 17k).

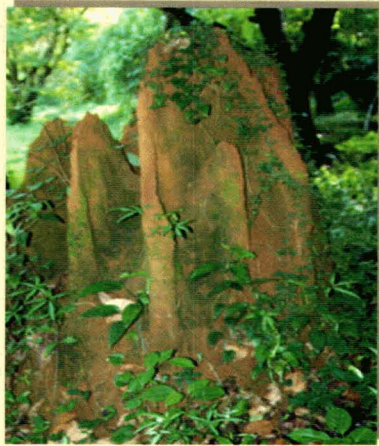
Habitat: Basal and upper part of tree trunk in evergreen and shola forests.

Specimens examined: Chembra hills (1560-1760 m) *MCN 99608*, *MCN 120398*, Periya (960 m) *MCN 99612*.

Distribution: It is common in the study area. A widespread Indo-Pacific species distributed in South India (Nilgiri hills, Palni hills), North-east India (Abor, Khasi, Kumaon, Sikkim), Sri Lanka, Java, Thailand, Borneo, Yunnan, Japan, Hawaii, Myanmar, Pacific Ocean Islands, Taiwan, Philippines and Siam. The present collection is a new record to Kerala.

ECOLOGY OF BRYOPHYTES OF WAYANAD

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Ecology.....

The silver brook
From its full cover pours the white cascade,
And babbling low amid the tangled woods,
Slips down the moss-grown stones with
Endless laughter

Long Fellow

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5.2. ECOLOGY OF BRYOPHYTES OF WAYANAD

From the ecological point of view, bryophytes form an important element of diverse vegetations. They play an important role in the terrestrial ecosystems, such as modification of habitat, nutrient cycling, maintenance of nutrient status of the soil and primary production (Brown, 1982, Pocs, 1982). They provide suitable environment for seed and spore germination and subsequent seedling and sporeling growth (Withner, 1974). Some of them also provide refuge to certain hibernating invertebrates (Gerson, 1982). They have been utilized in pollution detection, environmental monitoring and as climatic indicators (Crum, 1973; Pippo, 1982; Saxena, 2001). They also harbour nitrogen fixing cyanobacteria in some species (Madhusoodanan and Dominic, 1996).

Many species of bryophytes are used in land conservation. Pleurocarpous mosses such as *Hygrohypnum*, *Thuidium*, *Brachymenium*, etc. form a covering over stones and soil densely packing it. Another important role of bryophytes in soil management is their ability to build up rocks. Emig (1918) observed the rock building in a stream where the dense tufts of *Didymon* sp. are more commonly distributed along moist ledges extending across the shallow streams. His observation explains that mosses act indirectly in the precipitation of CaCO₃ mainly by providing a larger absorptive and adsorptive surface for the evaporation of calcareous water. Some mosses play an important role in slope formation (Marsh & Koerner, 1972). *Barbula unguiculata* Hedw., *Weissia controversa* Hedw. and *Bryum* sp. are valuable in erosion control (Conard, 1935).

In addition to these, bryophytes play an important role as pioneer plants in occupying primary habitats as well as secondary habitats after disturbance. They serve as home for many invertebrates, (Plate 27c) and often provide construction material for bird's nest. Pant and Tewari (1989) reported that in the remote villages in the Almora district, on the way to Pindari Glacier, mosses, locally known as 'muk', are utilized for making comfortable beddings and cushions by the nomadic herdsmen.

Until 1950, very little was known concerning the ecology of bryophytes. Pessin (1922) and Allorge (1938) studied on epiphyllous communities of bryophytes. The classic work of tropical rain forest bryophyte vegetation are those of Giesenhagen (1910), Herzog (1926) and Richards (1932). The other works dealing with tropical and subtropical bryophyte communities are Richards (1954, 1957), Horikawa (1950) and Thorold (1955).

From 1950 onwards the situation changed. A series of works dealing with epiphytic bryophyte communities in the subtropical forests were done (Iwatsuki, 1985; Lindlar and Frahm (2002), Gonzalez-Mancebo, *et al.* 2003). The work of, Tixier (1966), Longman and Jenik (1974), Hietz (1998), Stuntz *et al.* (2002) in tropical Asia on the epiphytic communities is worth mentioning. Trujillo and Balslev (1993) studied the distribution and abundance of terrestrial mosses of Costa Rica in association with different life-forms of vascular plants, In tropical America, Harrington (1967) studied the ecology of epiphyllous communities in Sierra Leone. The foliicolous communities have been studied by Pocs (1974, 1978) and Daniels (1998). Bates (1982) explained the quantitative approaches in bryophyte ecology. The distribution of bryophytes based on the altitudinal worked out by several authors such as van Reenen and Gradstein (1983), Frahm (1990), Frahm and Gradstein (1991) and Wolf (1993). Schmitt and Slack (1990) have studied the host specificity of epiphytic lichen and bryophytes. This study reports that only very few species are host specific, but most communities of lichens or bryophyte and of both combined were specific to particular tree species. Franks and Bergstrom (2000) studied the corticolous bryophytes in microphyll fern forests of south-east Queensland. Analysis of the variation revealed that the composition and structure of the community altered with both the height above ground level and the direction of exposure.

While there are extensive studies on the biology and taxonomy of the rich flora of bryophytes in India, the issues on investigating their ecology has begun only recently by Negi (1999). Nagi and Pant (1994) given a general account of the bryophyte association, their habitat and species communities associated with mineral enrichment in Kumaon Himalaya. The first estimate of the diversity and abundance of the terricolous liverworts from the Indian

subcontinent has been made by Negi *et al.* (2001) in some selected localities of Garhwal Himalayas. Negi and Gadgil (2001) 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. Tewari (2001) described the distribution of “copper mosses” *Scopelophila ligulata* (Spruce) Spruce and *S. cataractae* (Mitt.) Broth. in Kumaun Himalaya and mentioned the plant–substrate relationship and indicator value of these two species.

In Kerala, there are no reports on the ecological studies of this group. Pleurocarpous mosses are being used as a substratum for higher plants in nurseries (Plate 27a). Some species such as *Campylopus* and *Sphagnum* are used for air layering (personal observation). The most important role played by this group of plants is in the ecosystem development and sustenance. But there are no reports on such studies in Kerala.

5.2.1. DISTRIBUTION OF BRYOPHYTES ALONG VEGETATION GRADIENT

The study area is unique in having the diverse vegetation types. Except for the coastal vegetation almost all vegetation types such as forests, paddy fields, plantations, homesteads, etc. occur in the study area. The area being in the hilly tract of the Western Ghats, the major vegetation types are the forests, ranging from moist deciduous to montane shola through evergreen and semi-evergreen forests.

The vast extent of tea, coffee and teak plantations are characteristic features of this area. Once densely covered by the tropical forests, this area is now fast degrading due to heavy anthropogenic activities. Isolated homesteads and urban areas occur in this area. The homesteads however, in most cases are still remaining green with some trees, while the towns or cities have less plant cover. The bryophyte flora also changes according to the vegetation types.

The major part of the area is occupied by semi-evergreen forests. Vast extend of forest plantations, simulating the moist deciduous forests occur in the area. The evergreen forests with highly humid climate under the thick canopy

cover are the bryophyte rich areas. The montane shola forests of high altitudes with unique vegetation and humid climate also provide suitable habitats for bryophytes.

5.2.1.1. Vegetation types and the Bryophyte distribution

The major vegetations of the study area are:

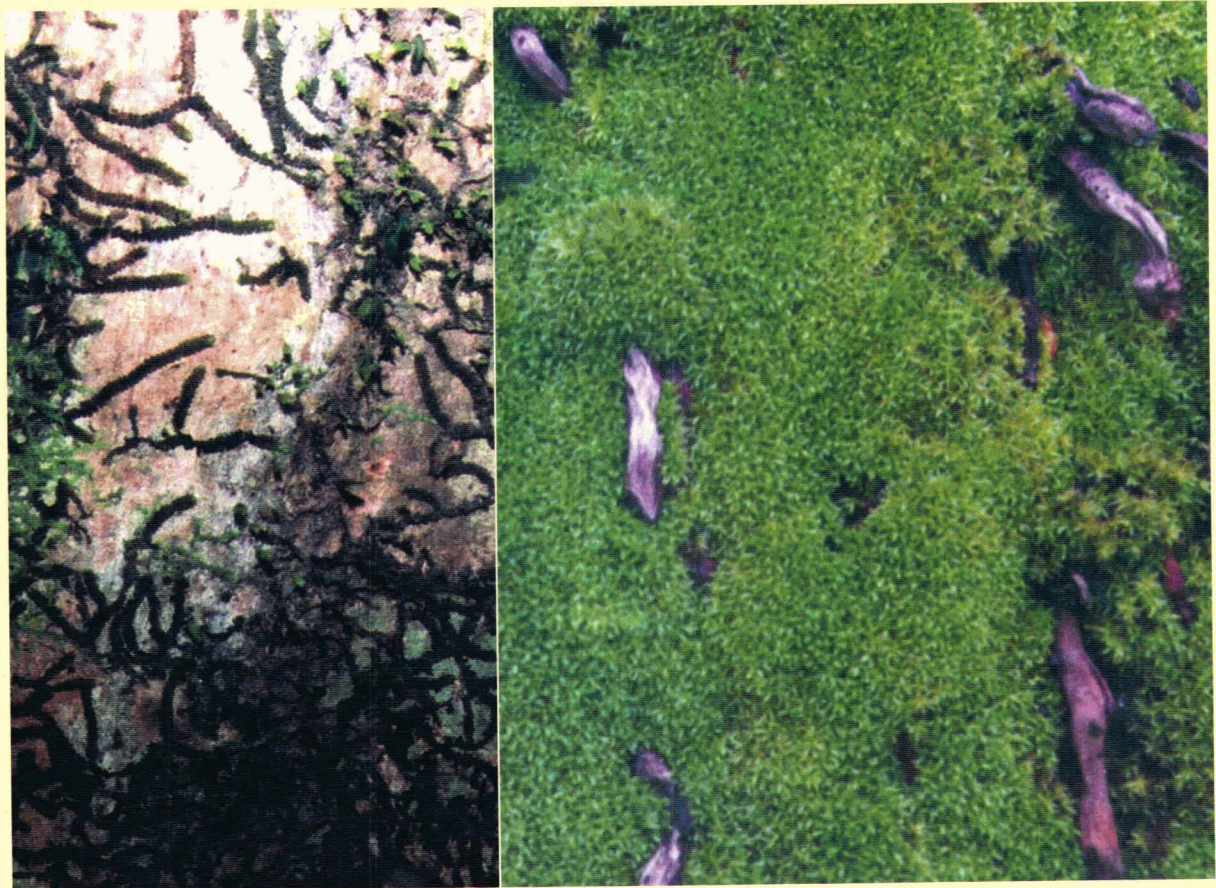
Vegetation types		
Forest areas	Non forest areas	
Evergreen	Plantations	Tea Coffee Teak
Semi-evergreen	Homesteads	Settlements near forests Settlements near towns
Moist deciduous	Cultivated lands	Paddy field Plantain
Shola	Urban areas	
	Wastelands	
	Canals, artificial structures	

FOREST AREAS:

Evergreen forests: This type is the climax of the tropical rain forest formation and is found usually at elevations above 700 m. It descends to 350 m in the Kottiyoor valley. The tropical rain forest formation is characterized by a very large number of inhabiting species. It is also characterized by a luxuriant growth of evergreen trees of different size and shape arranged in three different stories. The main blocks of the evergreen forests occur in Periya, Kannoth, Kottiyoor, Meppadi and Begur Reserves. The common liverworts in this type of forests include *Dumortiera hirsuta*, *Riccardia multifida* and *Asterella khasiana* and the mosses, *Garckea flexuosa*, *Hyophila involuta* and *Cryptopapillaria fuscescens*. *Trematodon longicollis*, *Mnium rostratum*, *Rhodobryum giganteum*, *Philonotis thwaitesii*, etc. also occur in the this zone. Riparian habitat is the common



a: Thick growth of bryophytes on buttress of tree b: Pleurocarpous mosses growing along with orchid on base of tree trunk



c: *Frullania tamarisci* growing on the upper part of tree trunk, d: Thick growth of *Leucobryum juniperoideum* among exposed roots

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feature in this type of forests and harbour a good number of species (Plate 2b). The diversity and frequency of the bryophytes are maximum here. A detailed list of species occurring in this vegetation is given in Table 2.

Semi-evergreen forests: This is an intermediate type between the wet evergreen and moist deciduous forests and therefore supports heterogenous mixture of two major types. Most of the study area falls in this vegetation zone. The semi evergreen forests are confined to portions of Kannoth, Kottiyoor, Tirunelli and Kalpetta Reserves and Kurichiad range of the Sanctuary. The bryophytes occurring in these forests is the mixture of evergreen and moist deciduous forests and diversity is also high in this region. The common species of this area are *Philonotis* spp., *Bryum* spp., *Floribundaria walkerii*, etc. Some rare species of the area such as *Scopelophila cataractae*, *Bryum cellulare*, *Chiloscyphus* sp., *Heteroscyphus coalitus*, etc. occur in this vegetation only. *Amphidium gangulii*, a new species has collected from this vegetation. A detailed list of species occurring at this vegetation is given in Table 2.

Moist deciduous forests: A major portion of the WLS falls under this category. During the dry season, most of the trees shed leaves and canopy cover is comparatively less. Bamboo brakes are distributed sporadically all over the habitat. It is also found all along the perennial streams and in the wet areas. The species composition of bryophytes in these forests varies from that of Wet evergreen and semi evergreen forests. But some species occurring in these vegetation are also found in the semi-evergreen forests. The species diversity is maximum near to riparian habitat and some species such as *Frullania acutiloba*, *Frullania tamarisci*, *Lejeunea discreta*, *Floribundaria walkeri*, *Fissides ceylonensis*, etc. are common. A notable feature in this forest is the occurrence of Termite mounts, which harbours a variety of mosses such as *Fissidens ceylonensis*, *Hyophila involuta* and *Cyathodium cavernarum*. A detailed list of species occurring at this vegetation is given in Table 2.

Shola forests: This type of forest is seen in the upper reaches of Thirunelli area, Periya in north division and in Chembra hills in southern division. The forest type of Chembra hills ranges from tropical wet evergreen to montane subtropical forest, associated with vast areas of grassland. The shola patches



a. Thick growth of *Octoblepharum albidum* on the bark



b. *Entodon flavescens* on base of tree trunk

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are seen from about 1,500 m extending up to 1,800 m. The vegetation is characterized by trees, shrubs, ferns and orchids. In sholas the bryophyte diversity is maximum and the species composition is unique compared to other types of forests. The diversity of the liverwort genus *Plagiochila* is maximum in these forests. *Dumortiera hirsuta*, *Thuidium tamariscellum*, *Hypopterigium aristatum*, *Racopilum orthocarpum*, etc. are common in sholas. Some rare species such as *Trichocolea tomentella* and *Jungermannia appressifolia* are seen here. In grasslands the habitat specific species such as *Entosthodon wichurae*, *Campylopus flexuosus*, *C. ericoides*, etc. are common with maximum frequency. A detailed list of species occurring in this vegetation is given in Table 2.

NON-FOREST AREAS:

Plantations: The major plantations in the study area are teak, tea and coffee. The area is occupied by the weed *Lantana camara*. Most of these plantations have a belt of natural forests and good undergrowth of shrubs, herbs and grass species. The bryophyte species diversity and abundance is minimum in these forests. The common bryophyte species found in these areas are *Fissidens ceylonensis*, *Garckea comosa*, *Hyophila involuta* and *Bryum argenteum*. A detailed list of species occurring at this vegetation is given in Table 2.

Homesteads: The study area is occupied by large number of settlements where cultivation is practised. These settlements are near to the moist deciduous forests and teak plantations. People occupy almost all the 'vayals' having perennial water sources. The species composition in these zones is same as those occurring in the moist deciduous forests. But the species occurring in the homestead areas near towns are different and the area is occupied by species such as *Cyathodium cavernarum*, *Garckea flexuosa*, *Hyophila involuta*, and *Bryum argenteum*. A detailed list of species occurring at this area are given in Table 2.

Cultivated lands: The cultivated lands such as paddy fields and plantain fields are occupied by the common moss species such as *Hyophila involuta* and *Philonotis hastata*. In some plantain fields the species such as *Bryum*

pseudotriquetrum, *Macromitrium tenerum*, etc. are seen. Here the diversity and frequency are very less.

Urban areas: The towns in Wayanad district are small. This zone is also occupied by the common species such as *Hyophila involuta*, *Philonotis hastata* and *Cyathodium cavernarum*.

Waste lands, canals and artificial structures: The waste lands in the study area are occupied by the common species such as *Bryum argenteum*, *Hyophila involuta* and *Fissidens ceylonensis*. The rare species *Marchantia linearis* has been collected from a canal near Lakkidi. The artificial structures such as brick walls, mud walls, concrete walls, etc. are occupied by the common species such as *Cyathodium cavernarum*, *Garckea flexuosa*, *Hyophila involuta* and *Gymnostomiella vernicosa* var. *tenerum*. Fig. 39a. shows the percentage distribution of bryophytes in each vegetation.

5.2.2. ALTITUDE AND BRYOPHYTE DISTRIBUTION

The altitude of the study area ranges from 700 to 2,100 m above sea level. Around the boundary it may even come below 100 m. In the present treatment the areas including the boundary were also included. It is observed that the bryophyte species assemblage, species diversity and frequency vary in accordance with the altitude. Frahm and Gradstein (1991) opined that bryophytes are suitable to describe the altitudinal zonation of tropical mountains. In the lower elevation it is very difficult to obtain floristically defined altitudinal zonation because of the lack of dominant species and phytogeographic difference. Based on the species occurrence in the various altitudes, the study area can be classified into three regions. viz., low altitude zone (up to 400 m), mid altitude zone (between 400-900 m) and high altitude (above 900 m). The species composition and occurrence vary in these three zones. Fig. 39b. shows the percentage distribution of bryophytes in relation to altitude.



a. Profuse growth of bryophytes on bark, branches and twigs in shola forest



b. *Rhynchosstegium herbaceum* hanging from branches and twigs

Low altitude zone (up to 400 m)

The low altitude zone is comparatively very low in the study area. The area is limited to the boundary near Lakkidi and near Thalassery pass. This zone is hotter and comparatively dry. The canopy cover is less and also the humidity. On the way from Kozhikode, through the western slopes of Wayanad, the altitude ranges from 50 m at base and goes up to 550 m on the top (Lakkidi) and here the vegetation is of the tropical evergreen forests. The earth cuttings of this area favours the diversity and abundance of bryoflora. Here, up to 400 m the diversity of bryophytes is less similar to the same altitude of other areas where the canopy is semi open. A detailed list of species occurring at this altitudinal zone is given in Table 2. The common species of this zone is *Bryum coronatum*, *Cyathodium cavernarum* and *Garckea flexuosa*.

Mid altitude zone (between 400-900 m)

Major part of the study area falls within this region, which include the Wayanad Wildlife Sanctuary. Maximum natural vegetation cover in this zone provide diverse microhabitats for bryophytes. A total of 116 species of bryophytes are recorded from this zone. This diversity is due to the mixing up of low altitude and high altitude species. Among the various microhabitats, earth cuttings and abundance of porophytes provide maximum surface area for the bryophytes to colonise. Some species such as *Aerobryopsis longissima*, *Brachymerium exile*, *B. nepalense*, *Cheilolejeunea girdiana*, *Ditrichum darjeelingense*, etc. are confined to this zone. A list of species occurring in this altitudinal zone is given in Table 2.

High altitude zone (above 900 m)

The major portion of high altitude zone lies in the Meppadi range, Thirunelli and Periya. The temperature fluctuation is low in the high altitude zone, where it is very humid and moist during most part of the year. The species diversity is higher due to the presence of many microhabitats with ideal microclimate for the bryophytes. The unique vegetation of sholas, which is a paradise for the bryophytes. *Plagiochila chinensis*, *P. fruticosa*, , *Porella campylophylla*, *Riccardia* spp., *Heteroscyphus* spp., etc are the common

species of this zone. Some species such as *Dumortiera hirsuta*, *Cryptopapillaria fuscescens*, *Entodon flavescens*, etc. of this zone extend to mid altitudes also. A list of species occurring in this altitudinal range is given in Table 2. The occurrence of sporophytes and extensive vegetative growth is maximum in this zone. Some species such as *Rhodobryum giganteum*, *Rhynchostegium herbaceum*, *Thuidium pristocalyx*, *T. tamariscellum*, *Trachypodopsis serrulata*, *Trichocolea tomentella*, etc. are confined to this zone only.

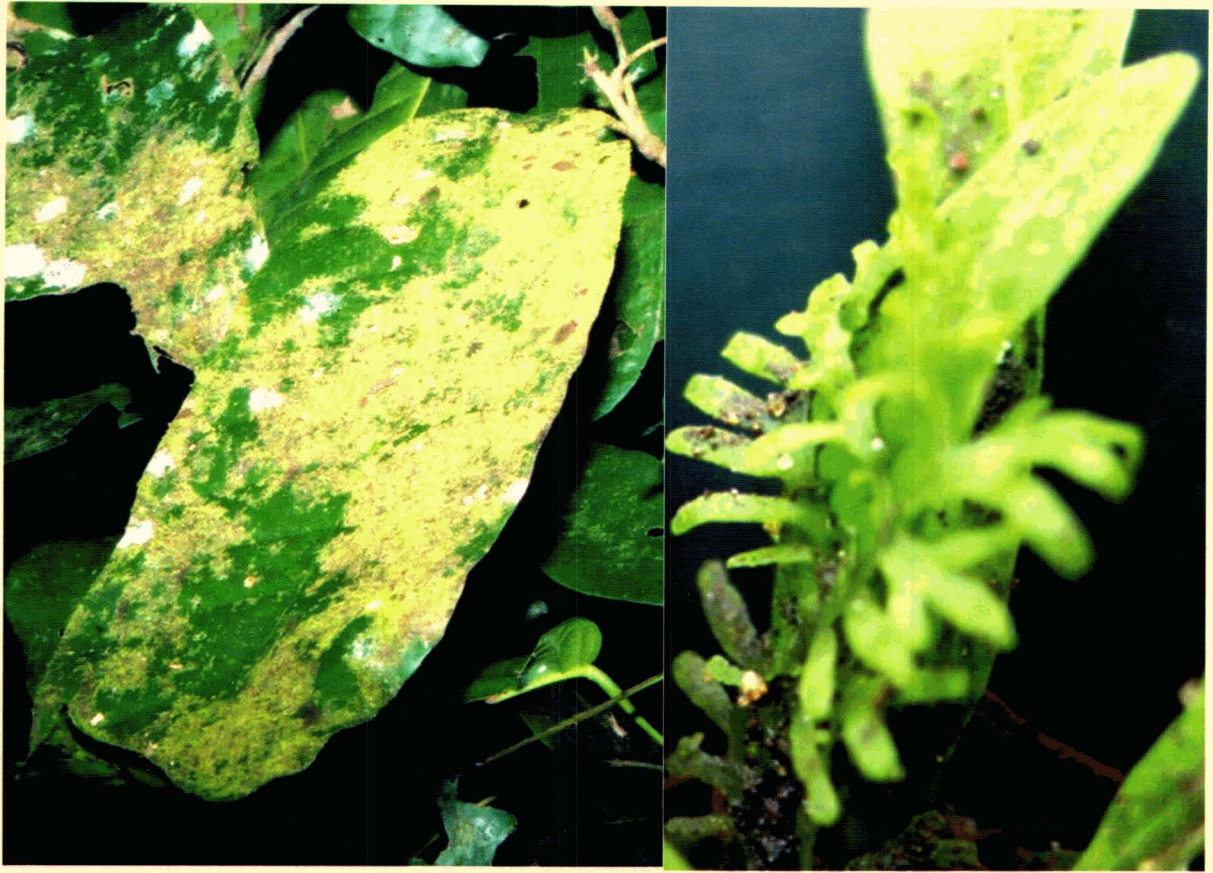
The most widely distributed species occurring in all the three zones is *Hyophila involuta*.

5.2.3. HABITAT'S AND BRYOPHYTE ASSOCIATIONS

Pocs (1982) suggested a classification of bryophyte communities of tropical forests and some adjoining vegetation types based on the microhabitat preferences. The microhabitats of bryophyte communities are determined by the different amounts of direct or indirect light, availability of water, nutrients from direct rainfall, stem flow, mist and dew and ground water. The relative humidity and the physical and chemical character of substrate, such as roots, stems, leaves of living and dead plants, underlying rocks, soil substrate, etc, also play significant roles.

Though the bryophytes are cosmopolitan in distribution, most of them exhibit strong preference to specific microhabitats/ecological niches. Usually they do not exist as isolated populations but are found growing mixed with other species of bryophytes, ferns, seed plants, etc. as biological associations of communities.

Wayanad, characterized by diverse vegetation, mountainous topography, valleys, water falls, forest streams with wide altitudinal gradients and consequent climatic variations (high annual rainfall, over 3,000 mm, short summer and high humidity) provide a highly congenial environment for the luxuriant growth and diversity of bryophytes. They occupy almost all conceivable habitats with almost omnipresent distribution.



a: Epiphyllous growth in evergreen forests b: *Riccardia* growing on the leaf of *Pyrosia porosa*



c. *Cololejuenea raduliloba* growing among filmy fern *Trichomanes proliferum*

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The bryophytes in the study area exhibit differential distribution according to localities, depending on various features such as altitude, microclimate, vegetation, disturbance of the substrata, etc.

Longman and Jenik (1987) divided the tall, forest canopy tree into five micro-climatic zones, which include top of the crown, the protected part of the crown, upper part of the trunk, lower part of the trunk and the buttresses at the base of the trunk. The microhabitat classification of Pocs (1982) is adopted here incorporating the Longman and Jenik (1987) with some modifications to deal with ecology and distribution of bryophytes of the study area. The bryophyte communities can be generally categorised under three ecological types viz., epiphytic, terrestrial and aquatic. Epiphytic and Terrestrial communities include several microhabitats (Table 1). A diagrammatic representation of the bryophyte microhabitats of the study area is provided in Fig. 40.

5.2.3.1. EPIPHYTES

Evergreen, moist deciduous and montane forests, which occupy the large extent of the study area are characterized by a complex structure composed of tall trees with closed upper canopy and a second stratum by the crowns of smaller trees, the shrubby layer and ground layer. Except for the shola forests, the stratification is prominent where as in sholas, the trees being short, the stratification is not prominent. The evergreen and shola plants are usually composed of a large number of woody species. Lianas, climbers and other macro epiphytes add complexity to the vegetation structure. These macrohabitats provide abode for diverse bryophytes depending on light intensity and relative humidity. The distribution of bryophytes also depends on the physical and chemical characteristics of the host trees as well as other external and inherent factors (Smith, 1982). In open areas and in the moist deciduous forests the canopy structure and the prevailing climate varies considerably, so as the bryophytes also. The cultivated trees such as coffee, tea, teak, etc. also provide microhabitats to bryophytes to colonise but the composition is different when compared to the forest trees. These habitats are usually inhabited by Meteoriaceae and Lejeuneaceae members. Tree as a habitat is well marked by

three vertical zones such as base of trees, upper part of trees and branches and twigs.

Table 1: Microhabitat types

Major types	Sub types	
Epiphytes	Base of trees (buttress), shrubs (1-2 m)	
	Lower part of trunk	
	Upper part of trunks of trees and shrubs	
	Branches and twigs	
	Epiphyllous (on leaf surfaces)	living leaves
		dead leaves
	Rhizome of ferns	
Dead and decomposing wood (logs)		
Terrestrial	Disturbed soil	road sides
		forest floor
		grasslands
	Rocks and stones	large rocks and stones of forest areas
		submerged rocks and stones
		creeks and crevices of rocks
	On building blocks of retaining walls (brick walls, mud walls, concrete walls, etc.)	
Termite mount		
Aquatic	Stagnant water	
	Streams	



a: Greenish mat on log



b: *Philonotis hastata* on rotten log

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Base of large trees

Tree bases in the Evergreen, Semi-evergreen and Shola forests provide the moist shady habitat for epiphytes. The buttresses add more space for bryophytes to colonise. The species composition differs considerably among the forest types depending upon the microhabitat availability. The buttresses and the large exposed roots of the trees are usually colourfully covered by the bryophytes (Plate 18a&d). How far the species grows above the tree trunk depends upon the humidity and physical conditions of the bark. Under wet conditions, especially in the shola forests, it might reach to the base of main branches as the shola trees do not reach more than 10 m. But usually it is restricted to 1 m at the base of main branches in the trees and shrubs of evergreen forests and poorly developed in moist deciduous trees.

The area is usually inhabited by different mat and weft forming species such as *Thuidium tamariscellum*, *T. pristocalyx*, *Entodon plicatus*, *Rhodobryum giganteum*, *Mnium rostratum* and some *Fissidens* spp. giving the appearance of a miniature forest.

Lower part of the tree trunk

The large surface of tree trunks provide suitable surface for corticolous bryophytes, often associated with filmy ferns and crustose lichens. Usually this area is restricted to 1-3 m (Plate 18b & 19b). The rough barked trees facilitate more room to bryophytes than the smooth barked. On porous barks, *Leucobryum juniperoideum*, *Calymperes afzelii*, *Leucophanes octoblepharoides*, *Pterobryopsis orientalis*, etc are common. In very shady wet habitats, especially near streams and rivulets, the bark of trees are usually occupied by *Homaliodendron flabellatum*, *H. exiguum*, *Leucoloma amoenevirens* and *Pyrrhobryum spiniforme*. On the deciduous trees such as *Terminalia bellerica*, *Tectona grandis*, etc. the basal portion is usually occupied by tolerant species such as *Foreauella orthothecia*, *Frullania acutiloba*, *Frullania calcarata*, etc. The variation of species diversity and density among the vegetation types is due to the differences in the available host trees, microhabitats and the prevalent microclimatic conditions.

Upper part of tree trunk

Above the tree base, the trunk is relatively more shady but comparatively drier. This part is either bare or occupied by crustose lichens associated with smaller or larger hepatics, which are strongly attached to the substratum (Plate.18.c & 19.a). The liverworts such as *Frullania tamarisci*, *Frullania squarrosa*, *Chandonanthus birmensis*, Lejeuneaceae members and mosses such as *Garovaglia plicata*, *Cryptopapillaria fuscescens*, *Syrhodon gardnerii*, etc. are common. In this zone the posture of the trunk is very much influential with regard to microhabitats. If the trunk is inclined, it holds a relatively good number of pleurocarpous mosses mixed with leafy liverworts towards the lower part. This may be due to the retention of more moisture and shade towards the lower part in inclined trees. The erect trunks especially in humid forests, is covered almost uniformly with appressed leafy liverworts and some pleurocarpous mosses, as the trunk receives the same microclimate throughout. Members of Orthotrichaceae with creeping branches are typical of this microhabitat.

Branches and twigs

The branches and twigs are mostly exposed to direct sunlight and are subjected to temporary desiccation. This area is occupied by many Orchidaceae members alongwith crustose and foliose lichens and bryophytes. The macro-epiphytes occur mainly on the branches while the micro-epiphytes occur both on branches and also on the fully exposed terminal twigs. The species composition found on the branches generally do not differ much from the upper trunk but are exposed to more light, hence include different dense mat forming species such as *Macromitrium tenerum*, *M. sulcatum*, *Sematophyllum subpinnatum*, *Erythrodontium julaceum*, appressed mats of *Frullania*, Lejeuneaceae members, etc. The species found on the terminal twigs are feathery in appearance. Leafy liverworts such as *Plagiochila fruticosa*, *P. chinensis*, *Spruceanthus semirepandus*, *Porella acutiloba*, *P. campylophylla* and hanging mosses such as *Meteoriopsis reclinata*, *M. squarrosa*, *Floribundaria walkerii*, *Cryptopapillaria fuscescens*, *Rhynchostegium*

herbaceum, etc. are common in this zone (Plate 20a&b). The feathery nature in this layer may be an adaptation for direct rain absorption. In the highly humid evergreen and shola trees, the branches and twigs are inhabited by large number of species. In the deciduous species, the bryophytes develop only on the crowns of the second tree layers. Here appressed liverworts such as *Frullania tamarisci*, *F. acutiloba*, *Lejeuneaceae* members are most frequent.

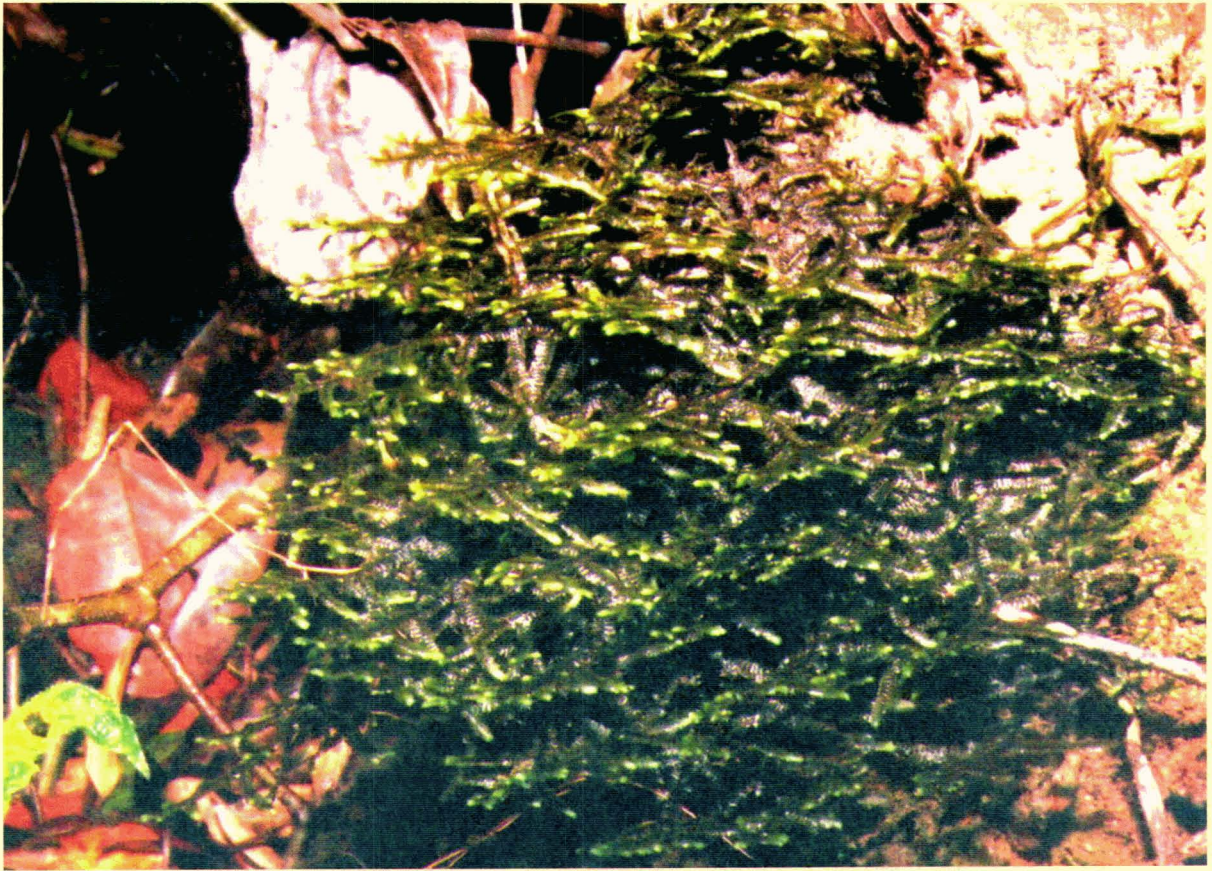
Branches and twigs of understorey shrubs provide a very good substratum for the hanging or rough mat forming species, owing to the very shady atmosphere and high humidity. Mosses are common on the understorey shola and evergreen trees and shrubs. These area are commonly occupied by members of *Meteoriaceae* and *Pterobryaceae*.

Epiphyllous communities

The leaves of trees, shrubs and herbs provide another suitable microhabitat for the bryophytes. They are most typical of tropical rain forests. Epiphyllous bryophytes are found on the leaves of young trees, shrubs and of long-lived herbs of the lowest layer of forests. Generally this type of microhabitat is near forest streams and in the highly humid inner forests. The nature of the leaves is an important factor. They usually colonise on leaves with long life span. Mostly they do not occur on deciduous plants. The evergreen trees and shrubs and the leaves of ferns, orchids and other herbs are occupied by epiphyllous species. The water and nutrient supply of the occupants of this microhabitat is derived from precipitation. The leafy liverworts form the most common vegetation in the epiphyllous communities. In the present study area *Octoblepharum albidum* and members of *Lejeuneaceae* are common in epiphyllous communities. Some species thrive even after the leaves had fallen to the ground. (Plate 21a,b&c; Plate 23a).

Rhizome of ferns

Rhizomes of many ferns are usually densely wrapped in a felt-like mass of roots, and hold large amount of moisture. The leaf bases and leaf scars provide good sites for bryophyte to colonize. In the present study area *Riccardia*



a: *Radula kurzii* among leaf litter in evergreen forests



b: *Riccia frostii* on marshy area

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tenuicostata, *Cololejeunea* sp., etc. are seen growing on the rhizome of ferns such as *Angiopteris evecta*, *Diplazium esculentum*, *Alsophila gigantea*, etc.

Dead and decomposing wood

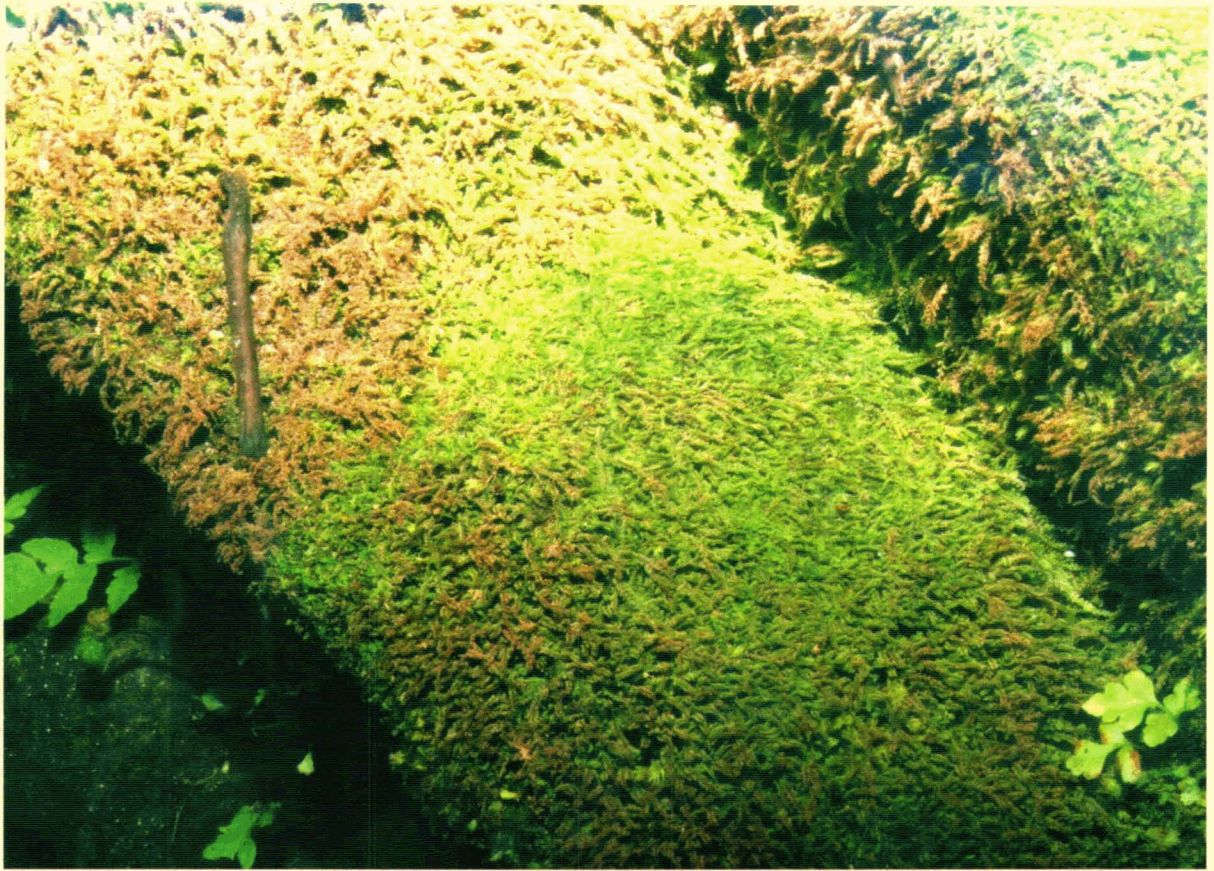
Dead and decomposing wood of fallen trees, twigs, logs, etc. with soft and absorbent surface are typical feature of tropical forests, and is common in the study area. These provide good microhabitat for many species such as *Barbula indica*, *Racopilum orthocarpum*, *Schoenobryum concavifolium*, *Papillaria crocea*, *Fabronia schensiana*, *Trachyphyllum inflexum*, *Frullania muscicola*, *Heteroscyphus argutus* and *H. coalitus*. Among these *Fabronia schensiana* and *Trachyphyllum inflexum* are confined to decomposing woods only. These bryophytes can utilize the nutrients of the decomposed wood and they also take the advantage of good water absorbing and retaining property of dead wood. Some species are also found growing on the surface of Polyporous fungi, which grown on logs. (Plate 22a&b).

Cultivated trees

Bryophytes are less diverse on cultivated trees of homesteads and plantations than forest trees. In the present study area, the major portion of the Wildlife Sanctuary is occupied by Teak plantations, where the bryophytes such as *Frullania tamarisci*, *Lopholejeunea subfusca* and *Mastigolejeunea* sp., etc are common. Another major part of the study area is occupied by tea and coffee plantations owned by private sectors. Members of Lejeuneaceae, Meteoriaceae and mosses such as *Macromitrium moorcrofti*, *Bryum pseudotriquetrum* were noted on coffee and tea plantations.

5.2.3.2. TERRESTRIAL

Terrestrial communities are the most common in the study area. This habitat includes, forest floor, soil cuttings, rocks, termite mount, etc. The characteristics of the soil is the main factor determining the bryophyte distribution in this zone. The degree of shade also plays the crucial role. The hard and tightly bound soil is more promising site for the bryophytes than the loose sand. Soil cuttings, where moisture and shade is comparatively more, are



a: *Heteroscyphus* sp. growing along the banks of river forming thick bed



b: *Philonotis hastata* on soil cutting

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more species rich than the flat forest floor. Some species may grow well in marshy area (Plate 23b). The wet pebbles, stones and rocks of the forest floor also provide immense space for the bryophytes to colonise.

Terrestrial microhabitats of the study area can be described under the following categories.

Disturbed soil and soil cuttings

In this microhabitat the large thalloid species such as *Targionia hypophylla*, *Asterella khasiana*, etc alongwith many cushion forming mosses like *Fissidens* spp., *Bryum* spp., *Hyophila involuta*, *Trematodon longicollis*, *Pogonatum microstomum*, *Philonotis* spp., etc and small leafy liverworts such as *Fossombronia* spp., *Jungermannia macrocarpa*, *Cylindrocolea tagawae*, etc are common (Plate 24b). Soil cuttings along the roads and stream banks are very interesting, as the soil in this area is more acidic and wetter. Here the species such as *Hyophila involuta*, *Philonotis* spp., *Jungermannia* spp., *Marchantia linearis*, etc. are common. The soil among grasslands in high altitude areas hold different species such as *Entosthodon wichurae*, *Campylopus ericoides*, *C. flexuosus* and *C. pilifer* in the study area, which are not common in other areas.

Rocks and stones

Huge rocky patches in the shady areas of forests and exposed areas hold diverse groups of bryophytes (Plate 25a). The species found on rocks are mostly found as epiphytes also. In most cases the bryophytes on the rocks and stones of the shady areas are found associated with filmy ferns. The rocky patches near streams are very rich, holding thick mats of bryophytes such as *Dumortiera hirsuta*, *Fissidens* spp., *Thuidium tamariscellum*, *Rhodobryum giganteum*, *Mnium rostratum*, *Bryum wightii*, etc. The submerged rocks and emergent rocks hold different species. Some species of *Fissidens* and *Riccardia levieri* are usually found on the submerged rocks and stones. The species occurring on the large rocky patches are different from those of small stones. Small stones in the forests and open areas are inhabited by *Hyophila involuta*, *Bryum argenteum*, *Pelekium gratum* and *Brachymenium exile* (Plate

25.b). The rocks among grasslands and open places hold species such as *Hyophila involuta*, *H. nymaniana*, *Brachymenium exile*, *Bryum argenteum*, *B. cappillare*, *Fossombronia indica*, *Campylopus flexuosus*, etc. Most of the corticolous species occur on rocky patches also. The shady cliffs near streamlets are rich in bryophytes where they usually grow together with filmy ferns (Plate 24a).

Creeks and Crevices of rocks

This area provides cool, shady microhabitat for bryophytes, especially for liverworts. The bryophytes found in this type of shady areas are *Cyathodium cavemarum*, *Bryum argenteum* and *Hyophila involuta*. Here the overlying rocks provide a shady and humid region for bryophytes to colonise.

Building blocks of retaining walls

Moist stones of the retaining walls are occupied by *Cyathodium cavemarum*, *Gymnostomiella vermicosa* var. *tenerum*, *Hyophila involuta* and Pottiaceae Members (Plate 26a). The surfaces of these structures are rough having minute cavities or crevices, where the dust and humus deposited usually provide substratum for bryophytes. Concrete walls of buildings, roofs and other structures are also colonised by the common bryophytes such as *Garckea flexuosa*, *Bryum argenteum*, *Hyophila involuta* and *Bryum coronatum*.

Termite mount

Many living and abandoned termite mounts are observed in the moist deciduous forests of the study area. It is found densely colonized by *Fissidens ceylonensis*, *Hyophila involuta* and *Cyathodium cavemarum* (Plate 26b&c).

5.2.3.4. AQUATIC

Bryophytes are often conspicuous elements of the macrophyte vegetation of flowing water and ponds. They may be either free floating or submerged attached forms. The free-floating forms are more common in stagnant water bodies such as ponds. *Ricciocarpos natans* is a typical example for this. *Riccia fluitans* also occur in this kind of habitat (Plate 26c). It also occurs in slow flowing water courses and stagnant muddy water areas. The



a: *Campylopus* sp. tightly packing the rocky patch



b: *Pelekium gratum* growing on small rocks

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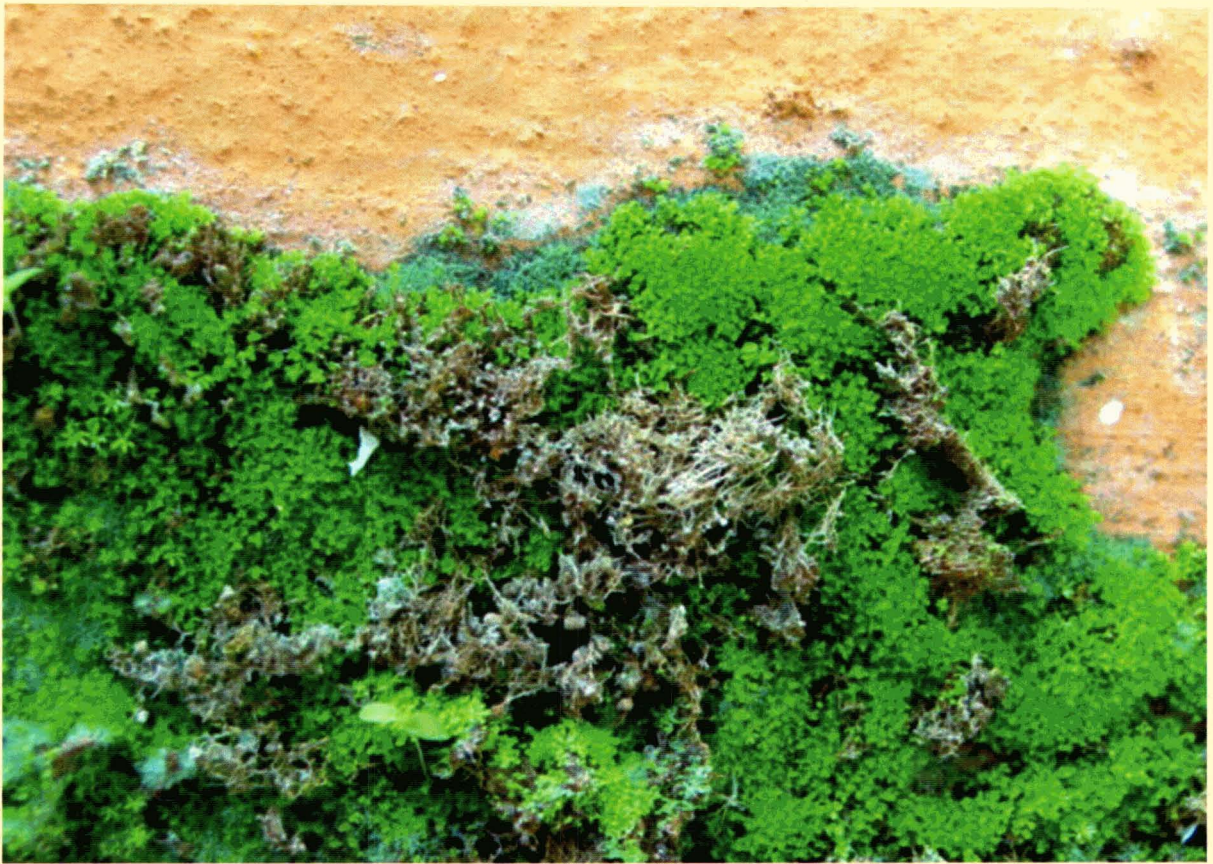
submerged forms are attached to the rocks. They may remain submerged throughout, or may be exposed when the water recedes. These species become sexually reproductive during the emerged phase only. Some species such as *Fissidens* sp., *Mnium rostratum*, etc. are submerged in streams, they partially prefer aquatic life for vegetative and wholly for reproductive growth.

5.2.4. HOST SPECIFICITY

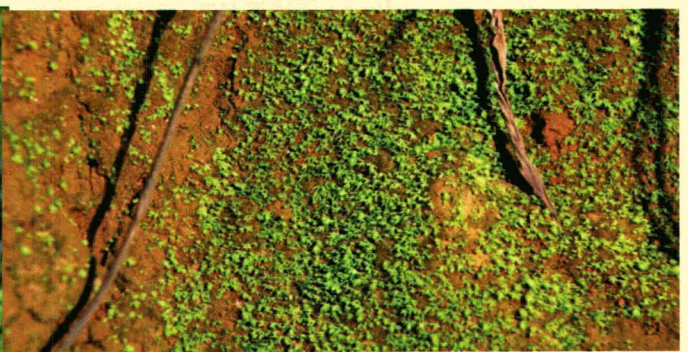
The host specificity of bryophytes is a long debated topic. There exists differences of opinion on this. Iwatzuki (1960) and Slack (1976) considered that the identity of the host species is of great importance in this matter. But Philips (1951) opined that the specificity of the host tree is not an important factor whereas, the microclimate of the prevailing area of the species is very significant. The moisture is the main factor for the bryophytes to colonize in a specific microhabitat. The other factors such as pH, smoothness of the surface, etc. will be satisfied by the amount of water available on the host tree. In Wayanad, except for some, most of the epiphytic species are not host specific. Species such as *Syrhopodon gardnerii* is confined to *Litsea floribunda* and *Plagiochila beddomei* is found restricted to *Syzygium wightianum*. Except some terrestrial species, most of the shola bryophytes are confined to the shola vegetation. However, shola bryophytes extend to evergreen forests also. Little host specificity exists among the bryophytes of shola, grows on almost all plants. This may be due to the most congenial climate of the shola forests that support the luxuriant bryophyte growth.

5.2.5. NEW HABITAT RECORDS

Most of the bryophytes are habitat specific. Some are facultative in extending the distribution to more than one habitats and ensuring their better survival. *Octoblepharum albidum* is reported generally occurring as epiphytic or corticolous. However, the epiphyllous occurrence was observed during the present study. *Frullania muscicola* generally occurs as epiphytic on trunks and small branches. The luxuriant growth of the species was noted on rotting logs from the study area. *Fissidens crispulus* var. *robinsonii* has been recorded earlier as occurring on bark of trees and on rocks. But the occurrence of this



a: *Gymnostomiella vernicosa* var. *tenerum* along with *Hyophila involuta* growing on the painted wall



b: Bryophytes on Termite mount c: portion of termite mount on which *Fissidens ceylonensis* is growing c: *Riccia fluitans* in aquatic habitat

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species as thick mat on soil cutting is observed here. These show the wide range of adaptability of these plants.

5.2.6. BRYOPHYTES IN BIRD'S NESTS

Many birds are known to choose green, leafy liverworts and mosses for nest building. The most commonly used bryophytes are, pleurocarpous mosses and some leafy liverworts. In the Indian subcontinent, Waxwings, Silky flycatchers (family Bombycillidae), Dippers (family Cinclidae) and Buntings (family Emberizidae) are reported to use mosses in nest building (Ali & Ripley, 1982).

One abandoned nest was observed in the evergreen forests of the study area (Plate 27b). Species such as *Himantocladium plumula* and *Meteoriopsis reclinata* are the common mosses found on this nest.

Interestingly, only the pleurocarpous mosses are mainly gathered by the birds for nest building. This maybe due to their extensive branching system which is commonly prostrate and can be easily twisted and woven into a desired pattern compared to acrocarpous mosses. The pleurocarpous mosses are light weight in dry state but resurrect in damp and wet conditions. Thus, birds help in the dispersal of these mosses from one habitat to another. Thus an epilithic species may get transferred to an epiphytic habitat or vice versa.



a: Substratum for higher plants



c. Protection for invertebrates



b: Bird's nest

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Table: 2 Distribution of bryophytes in relation to vegetation and altitude

H: Habitat, **E:** Epiphytic, **bt:** base of large trees, **ut:** upper part of tree trunk, **br:** branches, **tw:** twigs, **ep:** epiphyllous, **rh:** rhizome of ferns, **lg:** logs, **lt:** leaf litter, **T:** Terrestrial, **sc:** soil and soil cuttings, **rc:** rocks, **st:** stones, **sr:** submerged rocks, **cr:** crevices of rocks, **wl:** walls, **tm:** termite mount, **aq:** aquatic, **MD:** Moist deciduous, **SE:** Semi Evergreen, **E:** Evergreen, **S:** Shola, **GL:** Grassland, **P:** Plantation, **H:** Homestead

Species	H	Vegetation types							Altitude zones		
		MD	SE	E	S	GL	P	H	Low	Mid	High
<i>Aerobryopsis longissima</i>	E: bt	+	-	-	-	-	-	-	-	+	-
<i>Aerobryum speciosum</i>	E: bt	+	+	-	-	-	+		+	+	-
<i>Amphidium gangulii</i>	T: sc	-	+					-	-	+	
<i>Anoetangium bicolor</i>	T: sc, rc	-	-	-	-	-	+		-		+
<i>Anomobryum auratum</i>	T: sc, rc	-	+	+	-	-	-	-	-	+	-
<i>Anthoceros angustus</i>	T: rc	-	+	-	-	-	-	-	-	+	-
<i>Anthoceros crispulus</i>	T: sc	-	+	+	-	-	-	-	-	+	-
<i>Asterella khasiana</i>	T: sc	-	+	+	+	-	-	-	-	+	+
<i>Barbula indica</i>	T: sc, rc, wl	+	-	-	-	-	-	-	-	+	+
<i>Brachymerium exile</i>	T: sc, rc, st, wl, E: lg	+	+	+	-	-	-	-	-	+	-
<i>Brachymerium nepalense</i>	E: ut	+	-	-	-	-	-	-	-	+	-
<i>Brachythecium buchananii</i>	T: sc, rc, E: ut, br	-	-	+	-	-	-	-	-	+	-

<i>Bryhnia nepalensis</i>	E: bt, ut	-	-	-	+	-	-	-	-	-	+
<i>Bryum argenteum</i>	T: sc, rc	+	+	+	-	+	-	-	-	+	+
<i>Bryum capillare</i>	T: sc, rc	-	+	-	-	-	-	-	-	+	-
<i>Bryum cellulare</i>	T: sc	-	+	-	-	-	-	-	-	+	-
<i>Bryum coronatum</i>	T: sc, rc, wl	-	+	-	-	-	-	+	+	+	-
<i>Bryum plumosum</i>	T: sc	+		-	-	-	-	-	-	+	-
<i>Bryum pseudotriquetrum</i>	T: sc, rc, E: bt	-	+	+	-	-	+	-	-	+	+
<i>Bryum wightii</i>	T: rc	-	+	+	+	+		-	-	+	+
<i>Bryum</i> sp.	T: sc	-	-	-	-	+	-	-	-	+	
<i>Callicostella papillata</i>	E: bt, lg	-	-	-	-	-	-	+	-	+	-
<i>Calymperes afzelii</i>	E: ut, lg, rh	+	-	-	-	-	-	-	-	+	-
<i>Calymperes erosum</i>	E: bt, ut, lg, ep	-	-	-	-	-	-	+	-	+	-
<i>Calypothecium wightii</i>	T: rc	-	-	+	+	-	-	-	-	+	+
<i>Campylopodium khasianum</i>	T: sc	-	+	+	-	-	-	-	-	+	-
<i>Campylopus ericoides</i>	T: sc, rc	-	-	-	-	+	-	-	-	-	+
<i>Campylopus flexuosus</i>	T: sc, rc	-	-	-	-	+	-	-	-	-	+
<i>Campylopus pilifer</i>	T: sc	-	-	-	-	+	-	-	-	-	+
<i>Cephaloziella kiaerii</i>	T: sc	-	-	-	-	-	+	-	-	-	+
<i>Chandonanthus birmensis</i>	E: ut	-	-	-	+	-	-	-	-	-	+
<i>Cheilolejeunea giraldiana</i>	E: ut	-	+	-	-	-	-	-	-	+	
<i>Cheilolejeunea intertexta</i>	T: rc	-	+	-	-	-	-	-	-	-	+
<i>Cheilolejeunea serpentina</i>	E: ep	-	-	+	-	-	-	-	-	+	-
<i>Cheilolejeunea</i> sp.	E: bt, ut	-	-	-	-	-	+	-	-	+	-

<i>Chiloscyphus</i> sp.	T: sc	-	+	-	-	-	-	-	-	+	-
<i>Cololejeunea raduiloba</i>	E: ep	-	+	-	-	-	-	-	-	*****	*****
<i>Cryptopapillaria fuscescens</i>	E: ut, lg	+	+	+	+	-	-	-	-	+	+
<i>Ctenidium lychnites</i>	T: sc	-	-	+	-	-	-	-	-	-	+
<i>Cyathodium cavernarum</i>	T: sc, cr, wl, tm	+	+	+	-	-	-	-	+	+	-
<i>Cylindrocolea tagawae</i>	T: sc	-	+	-	-	-	-	-	-	+	-
<i>Diaphanodon blandus</i>	E: ut, lg	-	-	+	-	-	-	-	-	+	-
<i>Ditrichum darjeelingense</i>	T: sc	+	-	-	-	-	-	-	-	+	-
<i>Dumortiera hirsuta</i>	T: sc, rc, sr, E: bt,	-	+	+	+	-	-	-	-	+	+
<i>Duthiella declinata</i>	E: bt, ut	+	-	-	-	-	-	-	-	+	-
<i>Ectropothecium compressifolium</i>	T: sc	-	-	+	-	-	-	-	-	+	-
<i>Ectropothecium sikkimense</i>	T: sc	+	+	+	-	-	-	-	-	+	-
<i>Entodon flavescens</i>	T: rc, E: lg	+	+	+	-	-	-	-	-	+	+
<i>Entodon plicatus</i>	E: bt, ut	+	-	-	-	-	-	-	-	+	-
<i>Entosthodon wichurae</i>	T: sc	-	-	-	+	+	-	-	-	-	+
<i>Erythrodonium julaceum</i>	T: sc, E: lg	+	-	-	-	-	+	-	-	+	-
<i>Eurhynchium vagans</i>	E: bt, ut	+	-	-	-	-	-	-	-	+	-
<i>Fabronia schensiana</i>	E: lg	-	-	-	-	-	+	-	-	-	+
<i>Fissidens asperisetus</i>	T: sc, wl,	-	+	+	-	-	-	+	-	+	+
<i>Fissidens ceylonensis</i>	T: sc, rc, st, wl, E: bt, lg,	+	-	-	-	-	-	+	-	+	-
<i>Fissidens crenulatus</i>	T: sc, tm	+	-	-	-	-	-	-	-	+	-

<i>Fissidens crispulus</i> var. <i>crispulus</i>	T: sc, rc, E: bt	-	+	-	-	-	+	-	-	+	-
<i>Fissidens crispulus</i> var. <i>robinsonii</i>	T: sc	+	-	-	-	-	-	-	-	+	-
<i>Fissidens flaccidus</i>	T: sc, wl	+	-	-	-	-	-	+	-	+	-
<i>Fissidens subbryoides</i>	T: sc		+	-	-	-	-	-	-	+	-
<i>Fissidens virens</i>	T: sc		+	+	-	-	-	-	-	+	-
<i>Fissidens zollingeri</i>	T: sc, E: lg	+	+	-	-	-	-	-	-	+	-
<i>Fissidens</i> sp.	T: sc	+			-	-	-	-	-	+	-
<i>Floribundaria walkeri</i>	T: rc, E: bt	-	+	+	+	-	-	-	-	-	+
<i>Folioceros</i> sp.	T: rc	-	-	-	-	+	-	-	-		+
<i>Foreauella orthothecia</i>	E: bt, ut, lg	+	+	+	-	-	+	-	-	+	+
<i>Fossombronia foveolata</i> var. <i>cristula</i>	T: sc, rc	-	+	+	-	-	-	-	-	+	+
<i>Fossombronia indica</i>	T: sc, rc	-	-	-	-	+	-	-	-	-	+
<i>Frullania acutiloba</i>	E: ut, br	+	-	-	-	-	-	-	-	+	+
<i>Frullania calcarata</i>	E: br, lg	+	-	-	-	-	-	-	-	+	-
<i>Frullania muscicola</i>	E: br, lg	+	-	-	-	-	-	-	-	+	-
<i>Frullania squarrosa</i>	E: ut, lg	+	+	-	-	-	-	-	-	+	+
<i>Frullania tamarisci</i>	E: ut, tw	+	+	+		-	-	-	-	+	+
<i>Funaria hygrometrica</i>	T: sc, rc, wl	-	-	-	-	-	-	+	-	+	-
<i>Garckea flexuosa</i>	T: sc, wl	+	+	+	-	+	-	+	+	+	+
<i>Garovaglia plicata</i>	E: ut	-	-	+	+	-	-	-	-	-	+
<i>Gymnostomiella vernicosa</i> var. <i>tenerum</i>	T: wl	-	-	-	-	-	-	+	+	-	-
<i>Heteroscyphus argutus</i>	T: sc, rc, wl, E: bt	-	+	+	-	-	-	-	-	+	-
<i>Heteroscyphus coalitus</i>	T: sc, E: lg	-	+	+	-	-	-	-	-	-	+

<i>Heteroscyphus perfoliatus</i>	E: bt, ut	-	-	-	+	-	-	-	-	-	+
<i>Himantocladium plumula</i>	E: bt	-	-	+	-	-	-	-	-	-	+
<i>Homaliodendron exiguum</i>	T: rc	+	-	-	-	-	-	-	-	-	+
<i>Homaliodendron flabellatum</i>	T: rc, E: bt, ut	-	-	-	+	-	-	-	-	-	+
<i>Hymenostomum edentulum</i>	T: sc	-	-	-	-	+	-	-	-	-	+
<i>Hymenostylium recurvirostre</i>	T: rc	-	+	-	-	-	-	-	-	+	-
<i>Hyophila involuta</i>	T: sc, rc, cr, wl, E: lg	+	+	+	+	+	+	+	+	+	+
<i>Hyophila nymaniana</i>	T: sc, wl	+	-	-	-	-	-	+	-	+	-
<i>Hypopterygium aristatum</i>	T: rc	-	-	+	+	-	-	-	-	-	+
<i>Hypopterygium tamarisci</i>	T: rc, sc, E: lg, lt	-	-	+	+	-	-	-	-	-	+
<i>Isopterygium albescens</i>	E: bt, ut, lg	-	-	-	+	-	-	-	-	-	+
<i>Isopterygium sp.</i>	T: sc	-	+	-	-	-	-	-	-	+	-
<i>Jungermannia appressifolia</i>	T: sc, rc, st	-	+	+	-	+	-	-	-	-	+
<i>Jungermannia macrocarpa</i>	T: sc	-	-	-	-	-	-	+	-	+	-
<i>Lejeunea discreta</i>	E: bt, ut	+	-	-	-	-	-	-	-	+	-
<i>Lejeunea exilis</i>	E: bt, ut	-	-	-	+	-	-	-	-	-	+
<i>Lejeunea helenae</i>	E: lg	-	-	-	-	-	-	+	-	+	-
<i>Lejeunea obfusca</i>	E: bt	-	-	-	-	-	-	+	-	+	-
<i>Lejeunea tuberculosa</i>	T: rc, bt, E: lg	-	+	-	-	-	-	-	-	+	-
<i>Leucobryum juniperoideum</i>	E: bt, ut, lg	+	+	+	+	-	-	-	-	+	+
<i>Leucoloma amoene-virens</i>	E: bt, lg	-	-	+	+	-	-	-	-	+	+
<i>Leucophanes octoblepharoides</i>	E: lg	-	-	-	-	-	-	+	+	-	-

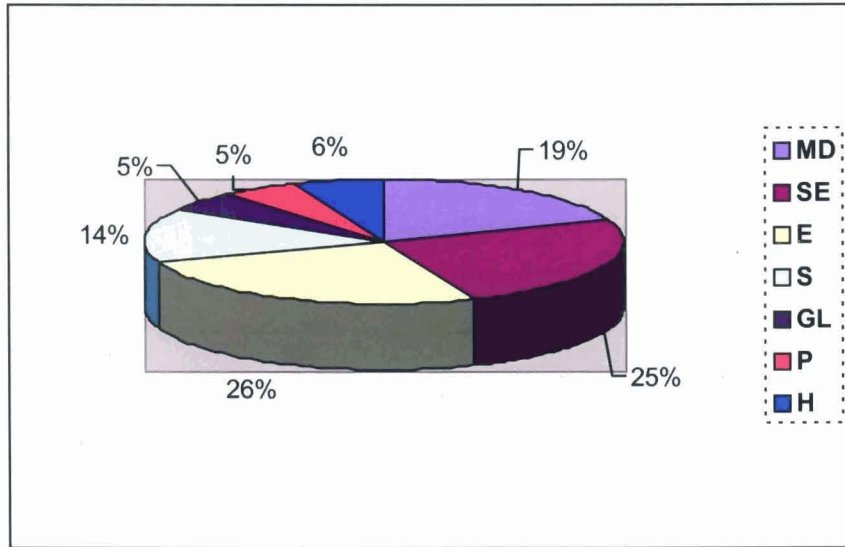
Lopholejeunea subfusca	E: bt	-	+	-	-	-	-	-	-	+	-
Macromitrium moorcroftii	E: bt, ut	-	-	+	+	-	-	-	-	-	+
Macromitrium nepalense	E: bt	+	-	-	-	-	-	-	-	+	-
Macromitrium sulcatum	E: bt, ut, T: rc	-	-	+	+	-	-	-	-	-	+
Macromitrium tenerum	E: lg	-	+	+	-	-	-	-	-	+	-
Macrothamnium macrocarpum	E: bt, ut	-	-	+	+	-	-	-	-	-	+
Marchantia linearis	T: sc	-	-	-	-	-	-	+	+	-	-
Mastigolejeunea sp.	E: bt, lg	+	-	-	-	-	-	-	-	+	-
Meteoriopsis reclinata	E: ut, br	+	+	+	+		+	-	-	+	+
Meteoriopsis squarrosa	E: bt, br	+	+	+	+	-	-	-	-	+	+
Mnium rostratum	T: sc, rc, E: bt	-	-	+	+	-	-	-	-		+
Neckeropsis fimbriata	E: bt	-	+	-	-	-	-	-	-	+	-
Notothylas levieri	T: rc	-	+	-	-	-	-	-	-	+	-
Octoblepharum albidum	E: bt, ut, lg, br, ep	+	+	+	-	-	+	+	-	+	-
Oxystegus cylindricus	T: rc	-	+	-	-	+	-	-	-	+	+
Pallavicinia lyellii	T: sc, rc	+	+	+	-	-	-	-	-	+	-
Papillaria crocea	E: br, lg	+	-	-	-	-	-	-	-	+	-
Pelekium gratum	E: lt, lg	-	+	+	-	-	-	-	-	+	-
Phaeoceros laevis	T: sc, rc	-	+	-	-	+	-	-	-	+	+
Philonotis fontana	T: sc	-	+	-	-	-	-	-	-	+	-

<i>Philonotis hastata</i>	T: sc, rc	+	+	+	-	-	-	+		+	+
<i>Philonotis mollis</i>	T: sc, rc	+	+	+	-	-	-			+	-
<i>Philonotis secunda</i>	T: rc	-	-	+	-	-	-	+	+	-	+
<i>Philonotis thwaitesii</i>	T: sc, rc		+	+	+	-	-	-	-	+	+
<i>Pinnatella calcutensis</i>	E: bt, ut	+	+	+		-	-	-	-	+	-
<i>Plagiochila beddomei</i>	E: bt, ut, tw	-	-	+	+	-	-	-	-	-	+
<i>Plagiochila chinensis</i>	E: bt, ut, tw	-	-	-	+	-	-	-	-	-	+
<i>Plagiochila devexa</i>	E: ut	-	-	+	-	-	-	-	-	-	+
<i>Plagiochila fruticosa</i>	E: bt, ut, br, tw	-	-	-	+	-	-	-	-	-	+
<i>Pogonatum microstomum</i>	T: sc	-	+	+	-	+	-	-	-	+	+
<i>Porella acutifolia</i>	E: bt, ut, br, tw	-	-	-	+	-	-	-	-	-	+
<i>Porella campylophylla</i>	E: bt, ut, rc	-	+	+	+	-	-	-	-	+	+
<i>Pterobryopsis acuminata</i>	E: ut	-	+	+	-	-	-	-	-	-	+
<i>Pterobryopsis orientalis</i>	E: bt, ut, lg	+	+	+	-	-	-	-	-	+	+
<i>Pterobryopsis</i> sp.	E: ut	-	+	-	-	-	-	-	-	-	+
<i>Pyrrhobryum spiniforme</i>	E: bt, T: rc	-	-	-	+	-	-	-	-		+
<i>Racopilum cuspidigerum</i>	T: sc, rc	+	+	+	+	-	-	-	-	+	+
<i>Racopilum orthocarpum</i>	E: bt, ut, lg, T: sc, rc	+	+	+	-	-	-	-	-	+	+
<i>Radula japonica</i>	T: sc, rc, E: br	-	-	+	+	-	-	-	-		+
<i>Radula javanica</i>	E: bt, ut	-	+	+		-	-	-	-	+	-
<i>Radula kurzii</i>	E: bt, ut, T: rc	-	-	+	+	-	-	-	-		+

Reboulia hemisphaerica	T: sc	-	+	+	-	-	-	-	-	+	-
Rhodobryum giganteum	T: sc, rc, E: lg	-	-	+	+	-	-	-	-		+
Rhynchostegium herbaceum	T: rc	-	-	+	+	-	-	-	-	-	+
Riccardia levieri	T: rc, st	+	+	+	+	-	-	-	-	+	+
Riccardia multifida	T: rc, E: bt	-	+	+	-	-	-	-	-	+	
Riccardia tenuicostata	T: rc, E: bt	+	+	-	-	-	-	-	-	+	-
Riccardia sp.	T: sc, rc	-	-	-	-	-	-	-	-		+
Riccia fluitans	aq, T: sc	+	+	-	-	-	-	-	-	+	+
Riccia frostii	T: sc	+	-	-	-	-	-	-	-	+	-
Ricciocarpus natans	aq	+	-	-	-	-	-	-	-	+	-
Schoenobryum concavifolium	E: tw, lg	+	-	-	-	-	-	-	-	+	-
Scopelophila cataractae	T: sc	-	+	-	-	-	-	-	-	+	
Sematophyllum subpinnatum	E: bt, lg	-	-	-	-	-	+	-	-	+	-
Semibarbula orientalis	E: ut, T: rc	+	-	-	-	-	-	-	-	+	
Splachnobryum obtusum	T: sc	+	-	-	-	-	-	-	-	+	-
Spruceanthus semirepandus	E: bt, ut, T: rc	-	-	-	+	-	-	-	-		+
Syrrhopodon gardneri	E: ut	-		+	-	-	-	-	-	***	****
Targionia hypophylla	T: sc	-	+	+	-	-	+	-	-	+	+
Taxiphyllum taxirameum	T: sc, rc, E: lg	+	+	+	-	-	+	-	-	+	-
Thuidium pristocalyx	T: rc	-	-	-	+	-	-	-	-	-	+
Thuidium tamariscellum	E: bt, lt, T: rc	-	-	+	+	-	-	-	-	-	+

<i>Trachyphyllum inflexum</i>	E: lg	+	-	-	-	-	+	-	-	+	+
<i>Trachypodopsis serrulata</i>	E: bt, ut	-	-	+	-	-	-	-	-	-	+
<i>Trachypus bicolor</i>	E: bt, ut, br	-	+	+	+	-	-	-	-	-	+
<i>Trematodon longicollis</i>	T: sc	-	-	+	-	-	-	-	-	+	-
<i>Trichocolea tomentella</i>	T: rc	-	-	-	+	-	-	-	-	-	+
<i>Trichostomum wayanadensis</i>	E: lg	+	-	-	-	-	-	-	-	+	-
<i>Vesicularia vesicularis</i>	T: rc	-	+	+	-	-	-	-	+	+	-

Fig.39. a. Percentage distribution of Bryophytes in relation to vegetation



MD: Moist Deciduous, SE: Semi-evergreen, E: Evergreen, S: Shola, GL: Grassland, P: Plantation, H: Homesteads

Fig.39. b. Percentage distribution of bryophytes in relation to altitude

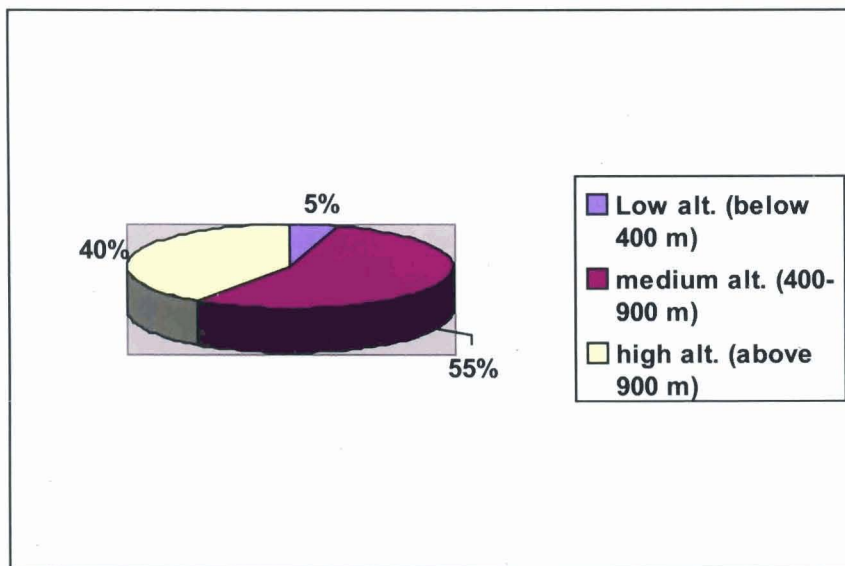




Fig. 40. A diagrammatic representation of the bryophyte microhabitats of the study area a. base of trees, b: lower part of trunk, c: upper part of trunks of trees and shrubs, d: branches and twigs, e: on leaf surfaces, f: rhizome of ferns, g: dead and decomposing wood, h: forest floor, i: on soil cuttings, j: large rocks and stones of forest areas, k: submerged rocks and stones, l: termite mount

DISCUSSION

Manju C. Nair “Eco-systematic studies on bryophytes of Wayanad, Kerala”
Thesis. Department of Botany , University of Calicut, 2005



Discussion.....

"The smallest natural population permanently separated from each other by a discontinuity in the series of biotypes".....

Du Røitz

6. DISCUSSION

Eventhough the Indian subcontinent is rich in bryophytes, the information on this group is meagre. It is evident from the fact that, there are no good manuals or monographs on the bryophytes of India. The main reason for this is, probably the limited number of researchers in bryology compared to the enormous diversity of the group. It is nearly impossible to bring out the bryophyte flora of India single handily, considering the vast extent of our country and geographical diversity.

The South Indian scenario is not different. It is more pathetic when compared to the Northern Indian bryophytic studies. The reason behind is the low number of active researchers and research centres engaged in the bryophytic studies in India. The review of literature on South Indian bryology reveals that except for some sporadic collections, it is limited. The South Indian bryology needs urgent detailed studies on this ecologically important group.

The regional approaches of studying the smaller areas with deeper intensity is probably the best method in developing a national database. The present work is significant in this aspect. The present study is aimed mainly to document the bryophyte diversity of a biodiversity rich area in the Western Ghats of Wayanad district. This study, the second of this kind in South India has brought out 170 species of bryophytes from an area of 540 km², including many new distributional records and novelties. This figure is great when compared with the list of 232 species of bryophytes from the entire Kerala State recorded by Easa (2003). The present figure is nearly 73 % of species from an area of 4% of Kerala State. This is also significant when formulating conservation measures for the area.

The present study reports 168 species and two varieties belonging to 105 genera and 47 families. Of these, mosses comprise 109 species and two varieties belonging to 74 genera and 29 families. Liverworts comprise 53 species, belonging to 28 genera and 16 families and hornworts comprise 5 species belonging to four genera and two families. Bryaceae is the largest family with 11 species followed by Fissidentaceae and Pottiaceae with 10

species each among mosses and Lejeuneaceae with 13 species is the largest liverwort family. Of these two species viz., *Trichostomum wayanadensis* and *Amphidium gangulii* are new to science. Five species and one variety are new records to India, 30 species and one variety are new records to Peninsular India and 43 are new records to Kerala (Listed below). Out of the endemic species recorded from the area, four are mosses and two are liverworts. Some taxa described as *Bryum* sp., *Cheilolejeunea* sp., *Chiloscyphus* sp., *Fissidens* sp., *Folioceros* sp., *Isopterygium* sp., *Mastigolejeunea* sp., *Pterobryopsis* sp. and *Riccardia* sp. may turn to be new to science or become new distributional records. All these show richness of the bryo-diversity of the area.

In the present study area the evergreen forests shows the richest species diversity followed by semi-evergreen forests eventhough the area is less in extent compared to the moist deciduous forests. This is mainly due to the availability of more suitable microhabitats, which support a variety of bryophytes. The diversity in semi-evergreen forests is high due to the mixing up of species from evergreen and moist deciduous forests. In homesteads, plantations and in the grasslands the diversity is very less due to the unavailability of suitable microhabitat and more disturbance. The grassland area supports minimum number of species. This is because of the dryness, exposure to wind, lack of shade and occurrence of fire. The soil moisture which play the key role in the sustenance of the bryophytes is lesser in grasslands, compared to other vegetation types. These areas are more prone to stress due to lack of shade and exposure to sun and wind. Moreover, the species present in grasslands such as *Pogonatum microstomum*, *Campylopus* spp., *Entosthodon wichurae*, etc. are adapted to grassland life with their subterranean rhizoids and high regenerating capacity. Only those species which can withstand the extreme conditions of grassland could survive here. Hitherto unrecorded new habitats for some species such as *Octoblepharum albidum*, *Frullania muscicola*, *Fissidens crispulus* var. *robinsonii*, etc. are recorded during the present study.

The maximum diversity of species is seen in the medium altitude. This may be due to the mixing of low and high altitude species in the mid altitude zone.

Species new to Science

1. *Trichostomum wayanadensis* sp. nov.
2. *Amphidium gangulii* sp. nov.

Species recorded new to India

1. *Bryhnia nepalensis*
2. *Campylopus pilifer*
3. *Gymnostomiella vernicosa* var. *tenerum*
4. *Jungermannia appressifolia*
5. *Lejeunea exilis*
6. *Lejeunea helenae*
7. *Macromitrium tenerum*
8. *Pelekium gratum*
9. *Thuidium pristocalyx*

Species recorded new to Peninsular India

- | | |
|---|------------------------------------|
| 1. <i>Anoetangium bicolour</i> | 17. <i>Floribundaria walkeri</i> |
| 2. <i>Anthoceros angustus</i> | 18. <i>Frullania calcarata</i> |
| 3. <i>Asterella khasiana</i> | 19. <i>Garovaglia plicata</i> |
| 4. <i>Barbula indica</i> | 20. <i>Heteroscyphus coalitus</i> |
| 5. <i>Bryum cellulare</i> | 21. <i>Himantocladium plumula</i> |
| 6. <i>Bryum pseudotriquetrum</i> | 22. <i>Jungermannia macrocarpa</i> |
| 7. <i>Calyptothecium wightii</i> | 23. <i>Lejeunea obfusca</i> |
| 8. <i>Cololejeunea raduliloba</i> | 24. <i>Lejeunea tuberculosa</i> |
| 9. <i>Ditrichum darjeelingense</i> | 25. <i>Marchantia linearis</i> |
| 10. <i>Duthiella declinata</i> | 26. <i>Neckeropsis fimbriata</i> |
| 11. <i>Ectropothecium compressifolium</i> | 27. <i>Oxystegus cylindricus</i> |
| 12. <i>Ectropothecium sikkimense</i> | 28. <i>Radula japonica</i> |
| 13. <i>Fabronia schensiana</i> | 29. <i>Scopelophila cataractae</i> |
| 14. <i>Fissidens crispulus</i> var. <i>crispulus</i> | 30. <i>Syrhropodon gardneri</i> |
| 15. <i>Fissidens crispulus</i> var. <i>robinsonii</i> | 31. <i>Vesicularia vesicularis</i> |
| 16. <i>Fissidens virens</i> | |

Species recorded new to Kerala

- | | |
|--------------------------------------|---------------------------------------|
| 1. <i>Aerobryopsis longissima</i> | 23. <i>Meteoriopsis reclinata</i> |
| 2. <i>Aerobryum speciosum</i> | 24. <i>Papillaria crocea</i> |
| 3. <i>Brachythecium buchananii</i> | 25. <i>Philonotis fontana</i> |
| 4. <i>Bryum capillare</i> | 26. <i>Philonotis mollis</i> |
| 5. <i>Bryum plumosum</i> | 27. <i>Pinnatella culcutensis</i> |
| 6. <i>Cheilolejeunea giraladiana</i> | 28. <i>Porella acutifolia</i> |
| 7. <i>Cheilolejeunea intertexta</i> | 29. <i>Pterobryopsis acuminata</i> |
| 8. <i>Entodon plicatus</i> | 30. <i>Pterobryopsis orientalis</i> |
| 9. <i>Eurhynchium vagans</i> | 31. <i>Pyrrhobryum spiniforme</i> |
| 10. <i>Fissidens crenulatus</i> | 32. <i>Racopilum cuspidigerum</i> |
| 11. <i>Fissidens flaccidus</i> | 33. <i>Radula javanica</i> |
| 12. <i>Fissidens subbryoides</i> | 34. <i>Rhynchostegium herbaceum</i> |
| 13. <i>Foreauella orthothecia</i> | 35. <i>Riccia fluitans</i> |
| 14. <i>Frullania acutiloba</i> | 36. <i>Riccia frostii</i> |
| 15. <i>Hymenostomum edentulum</i> | 37. <i>Schoenobryum concavifolium</i> |
| 16. <i>Hypopterygium aristatum</i> | 38. <i>Sematophyllum subpinnatum</i> |
| 17. <i>Lejeunea discreta</i> | 39. <i>Splachnobryum obtusum</i> |
| 18. <i>Leucobryum juniperoideum</i> | 40. <i>Taxiphyllum taxirameum</i> |
| 19. <i>Leucoloma amoene-virens</i> | 41. <i>Trachyphyllum inflexum</i> |
| 20. <i>Macromitrium moorcroftii</i> | 42. <i>Trachypodopsis serrulata</i> |
| 21. <i>Macromitrium nepalense</i> | 43. <i>Trichocolea tomentella</i> |
| 22. <i>Macrothamnium macrocarpum</i> | |

Endemic species recorded from the study area

Species	Endemic Area
1. <i>Ditrichum darjeelingense</i>	India
2. <i>Floribundaria walkerii</i>	India
3. <i>Fossombronia indica</i>	Peninsular India
4. <i>Frullania squarrosa</i>	India
5. <i>Frullania tamarisci</i>	South India
6. <i>Heteroscyphus perfoliatus</i>	India

6.1. FUTURE PROSPECTS

The present study in a less explored area of the Western Ghats, one among the hotspots of biodiversity, reveals its bryological potentials. It opens new vistas for more studies related to the development on pharmacological and other relevant medicinal aspects of bryophytes. The lack of an easy to use identification manual is the main reason that made most of the teachers and students as bryophobic. The present study may fill this gap to certain extent and could ignite more bryological studies.

The ecological adaptability and the occurrence of rare and threatened species in the area call for conservation of the species as a whole and thereby in the conservation of area.

6.2. CONSERVATION

Generally, the conservation strategy is meant for higher group of organisms only. In the case of lower groups, the conservationists and policy makers give no significance. This neglect is the main reason for the lack of proper information base on the lower group of plants in the country.

Among the 17 protected areas in Kerala state, the Wayanad district constitutes one Wildlife Sanctuary. The area is protected by law and hence experience less threat. There are many areas of rich and unique biodiversity other than the protected area, which deserve better conservation status. Reserved forest areas in the Wayanad north and South hold a good vegetation of evergreen, semi evergreen and shola forests, which abode a good number of rare and threatened species. Now these areas are subjected to indiscriminative anthropogenic interference by tourists. If the present situation is continued, the area with its rich biodiversity will be degraded in the near future itself. *Ex-situ* conservation, by introducing into gardens may also be attempted.

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Publications

**RICCIOCARPUS NATANS (L.) CORDA (RICCIACEAE) AND
NOTOTHYLAS LEVIERI SCHIFFN. EX STEPH. (NOTOTHYLACEAE),
TWO NEW BRYOPHYTE RECORDS FOR SOUTH INDIA**

P.V. Madhusoodanan and Manju C. Nair

Department of Botany, Calicut University, Kerala- 673 635, India.

Abstract: *Ricciocarpus natans* (L.) Corda and *Notothylas levieri* Schiffn. ex Steph. are reported from the Western Ghats of Kerala, as new records for South India.

INTRODUCTION

Studies on the bryophytes of Kerala are scant and limited to documentation of limited number of species. Our recent exploration on the bryophyte flora of Kerala State yielded many interesting species such as *Rhodobryum giganteum* (Schwaegr.) Par., *Racopilum orthocarpum* Wilson ex Mitt., *Diaphanodon blandus* (Harvey) Renault & Cardot., *Rhytidiadelphus triquetrus* (Hedw.) Warnst., *Aneura pinguis* (L.) Dum., *Heteroscyphus perfoliatus* (Mont.) Schiffn., *Conocephalum conicum* (L.) Dum., *Dumortiera hirsuta* (Swartz) Nees, etc. (Madhusoodanan *et al.*, 2002; Nair and Madhusoodanan, 2001). Here we report two interesting bryophytes, as new records for South India.

The monotypic genus *Ricciocarpus* Corda with its single species *R. natans* (L.) Corda, enjoys a world-wide distribution. Earlier the generic status of *Ricciocarpus* Corda has been challenged by many bryologists (Garber, 1904; Lewis, 1906; Duthie & Garside, 1936). But now the generic rank of *Ricciocarpus* Corda is more or less universally accepted (Pearson, 1902; Macvicar, 1926; Verdoon, 1932; Evans, 1939; Steere, 1940; Howe, 1947).

In India, *Ricciocarpus natans* (L.) Corda was reported from Dal Lake in Kashmir (Kashyap, 1916; Biswas & Calder, 1936), Loktak Lake in Manipur (Biswas & Calder, 1936; Deb, 1956), Kapurthala in Punjab (Kachroo and Deb, 1954) and from Kumaon

Himalaya (Pant, 2001). Srivastava (1964), while describing the Ricciaceae of India mentioned the occurrence of this species from various parts of Northern India, but not from South India. Recently we could collect this species from a natural pond in the moist deciduous forests of Tholpetty range of Wayanad Wildlife Sanctuary situated in the northern part of Kerala State between 11° 20' and 21° 7' N latitude and between 75° 28' and 76° 36' E longitude.

The genus *Notothylas* Sull. is represented in tropical and temperate regions of the world by 18 species, of these nine are reported to occur in India. Among these, six species, viz., *N. anaporata* Udar & Singh, *N. himalayensis* Udar & Singh, *N. khasiana* Udar & Singh, *N. pandei* Udar & Chandra, *N. pfeleidereri* Udar & Singh and *N. udarii* Singh & Semwal are confined to India. *N. indica* Kashyap extends its distribution to Pakistan and Myanmar. *N. dissecta* Steph. is known also from Guatemala. *N. levieri* Schiffn. ex Steph. is reported from Brazil, Nepal and India. In India *N. levieri* Schiffn. ex Steph. was reported from Eastern Himalaya, Western Himalaya and Central India (Kashyap, 1929; Singh, 1995; Singh & Semwal, 2000, 2001; Udar, 1976; Udar & Chandra, 1977), but not from South India. Recently we have collected *N. levieri* Schiffn. ex Steph. from the moist deciduous forest of Dhoni hills (400 m alt.) in the Western Ghats of the Palakkad Dt. of Kerala State between 10° 15' to 11° 15' N latitude and 76° 21' to 77° 18' E longitude. The present collection of *Ricciocarpus natans* (L.) Corda and *Notothylas levieri* Schiffn. ex Steph. are new records of

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occurrence to South India, hence are described here with illustrations and other relevant notes.

Ricciocarpus natans (L.) Corda, Opiz. Beitrage. 651. 1829; Kashyap, J. Bombay nat. Hist. Soc. 25: 347. 1916; Liverworts W. Himalayas & Punjab plain 89. 1929; Srivastava, Bull. Nat. Bot. Gard. 104: 56. 1964. (Fig. 1. a-f). *Riccia natans* L., Syst. Nat. 10: 1339. 1759. *R. capillata* Schmidel, Ic. Pl. 276. 1794. *R. lutescens* Schweinitz, Specim. Fl. Amer. Supl. 26. 1821. *R. velutina* Wils., Hook. Ic. Pl. 249. 1849. *Ricciocarpus velutinus* Steph., Spec. Hepat. 1: 55. 1898.

Thallus free floating, 5-10 mm long, 3-9 mm broad, dichotomously branched with obcordate lobes and distinct median furrow, dorsal surface leathery, distinctly reticulate, dark green; ventral scales conspicuous numerous, pendant, long, dentate with violet or brownish green. Air chambers large, visible through the dorsal surface as hexagonal areolate. Transverse section shows slightly convex margin on the ventral surface and near median furrow. Dorsal epidermis of one layer cells. Air pores surrounded by 6-8 cells with slightly thickened walls. Ventral tissue thin, with large air chambers and oil cells; scales conspicuous, numerous, pendant, long, serrated, violet or brownish. All plants collected were sterile.

Note: Specific name 'natans' is derived from the latin word, meaning floating, which is the usual habit of the plant. This species is characterized by the conspicuous furrow in the middle of each branch, evidently meant for vegetative reproduction by splitting the thallus along the furrow. The halves separate and forms new plants.

Specimen examined: Tholpetty range, Wayanad Wildlife Sanctuary, Wayanad District, Kerala, India (alt. 860 m), Manju C. Nair CU 84615 (CALI).

Notothylas levieri Schiffn. ex Steph., Sp. Hep. 5: 1021. 1917; Kashyap, Liverworts W. Himalayas & Punjab plain 129. 1929. (Fig. 1. g-k).

Thallus monoecious, rosette forming in close overlapping masses, with smooth walled rhizoids on

the ventral side, usually orbicular or suborbicular in outline, 5-7 cells thick in the middle, gradually thin out to one or two cells towards margin. Cells chlorophyllose, similar, except the upper and lower epidermal cells, which are smaller than inner; inner cells uniform, parenchymatous. Mucilage cavities filled with endophytic cyanobacterium, *Nostoc*. Antheridia in groups, usually of four on the dorsal side. Archegonia on different lobes. Sporogonia marginal, cylindrical, pointed, non columellate; outer wall layers surround the central mass of spores and elaters, arranged in alternating bands. Spores globose, dark brown, minutely granular, 25-35 µm in diameter; elaters with oblique thin bands or incomplete spirals up to 50 µm length.

Specimen examined: India, Kerala, Palakkad Dt., Dhoni hills (alt. 400 m), Manju C. Nair CU 80022 (CALI).

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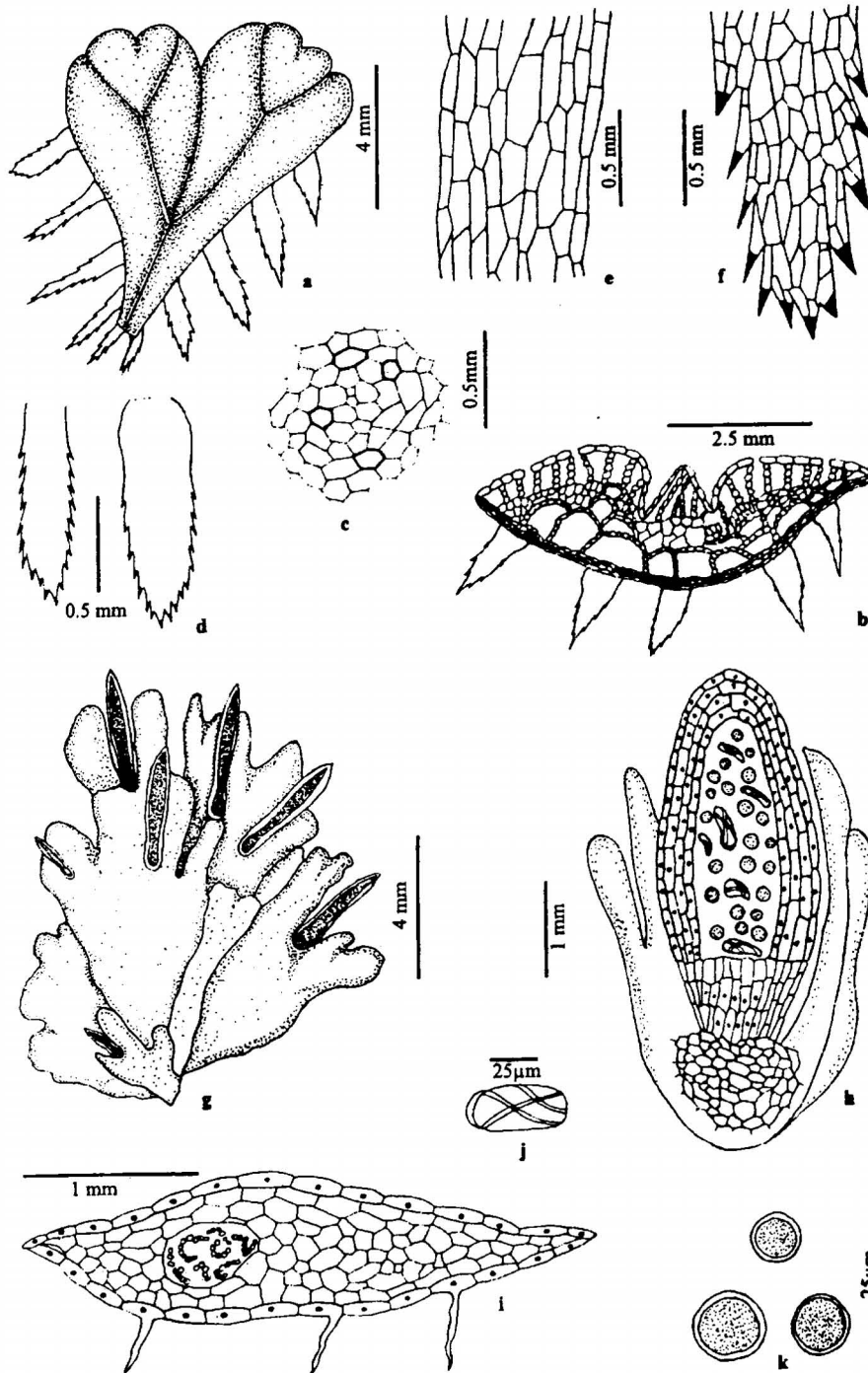


Fig. 1. a-f: *Ricciocarpus natans* a- Habit, b- T.S. of Thallus, c- Pores in surface view, d- Ventral scales, e- A portion of upper part of ventral scale enlarged, f- Lower part of ventral scale enlarged; g-k: *Notothylas levieri* g- Habit with Sporogonia, h- L.S. of Capsule, i- T.S. of Thallus, j- Elater, k- Spores.

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STUDIES ON THE BRYOPHYTE FLORA OF KERALA (SOUTH INDIA) — AN INTRODUCTION

MANJU C. NAIR & P.V. MADHUSOODANAN
Department of Botany, Calicut University, Kerala- 673 635, India

ABSTRACT

The work on bryophytes of Kerala state has been reviewed in chronological order. The need for detailed study emphasized.

INTRODUCTION

The Kerala State, located in the Southwest corner of the Indian Peninsula, is one among the notable areas of rich biodiversity in the world. Its unique location and long geological history as the part of Gondwanaland, moulded its ideal climate and diverse vegetation types that support rich flora including bryophytes. Eventhough the bryophytes form an important component in the forest ecosystems of Kerala, it was not subjected to thorough studies. Except for some sporadic collections, no serious effort has been made to explore the rich bryoflora of the state. Our recent explorations as part of the detailed study on the bryophyte flora of the State yielded about 250 species (Nair & Madhusoodanan, 2001, Madhusoodanan *et al.*, 2002, some unpublished data). The present paper aims to provide a review on the earlier works on this group of plants from the State.

The amphibious adaptation and the

characteristic life cycle with less prominent sporophyte generation parasitic on the gametophyte makes the bryophytes a unique and fascinating group of plants. Never-the-less, the study on bryophytes has been badly neglected in this area. Multidimensional aspects of bryophyte ecology have received attention all over the world in the last 50 years. The studies include quantitative estimation of bryophyte communities, defining bryophyte growth forms, species diversity, correlation with environment and multivariate techniques, statistical methods such as regression, cluster and niche analysis and the use of these in epiphytic, epilithic, mountain and aquatic bryophytic communities, mineral nutrition and molecular genetic studies (Watson, 1980; Bates, 1982, 2001; Slack & Glime, 1985; Russel, 1988; Nash & Wirth, 1988 and Cove, 2001). In contrast to such important breakthroughs made elsewhere, our studies in this field appear to be meagre, and there is hardly

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any authentic work on this line.

PHYSIOGRAPHY OF THE AREA

Kerala forms a 550 km long and 50-80 km broad strip of land on the west coast of Peninsular India between 8°18' to 12°18' N latitude and 74°50' to 77°22' E longitude. Topographically, Kerala falls into three regions, *viz.*, the mountainous highland, the undulating midland, and the coastal low land.

In the 17th century, the present Kerala State was under three small Kingdoms/regions *viz.*, the Malabar region (including the Kolathunadu and Kozhikode kingdoms), the Cochin Kingdom (central Kerala) and the Travancore Kingdom (southern Kerala). Van Rheede (1678-1703) was the first to mention the term 'Malabar' as a geographical area in a scientific work. His Malabar constituted of Cochin and adjoining parts of Travancore Kingdom (northwards) and part of Malabar region (northern Kerala, Tanur-southwards) according to Heniger (1986). Hooker and Thomson (1855) stated that the "Malabar botanical province" is the mountain range of the western Ghats, extending along the western side of the western Peninsula, from the Tapti river of Gujarat to Cape Comorin (Kanyakumari). For many centuries almost all the colonial explorers such as Dutch, French and British had used the term 'Malabar' of Hooker and Thomson (1855) for denoting their collection sites. Many collections of the bryophytes made by earlier workers are from Malabar and Travancore area without specifying the exact locality.

Presently the area is divided into 14 districts. The land is slopping from the mountainous Western Ghats on the East

with the highest peak Anamudi (2697 m) followed by Kattumala (2500 m), and Agasthyarkudam (*ca.* 1900 m) to the sea shore of Arabian Sea in the west with 41 west flowing and three east flowing rivers. About 56% of the total area of Kerala is occupied by the Western Ghat mountains, one among the 25 biodiversity hot spots of the world. This small state has two National Parks and 12 Wildlife Sanctuaries including a Tiger Reserve.

Kerala has tropical humid climate with high moisture and over 3000 mm annual rainfall. The area receives south-west monsoon from June to September. The maximum rainfall is obtained during July and August. The temperature varies between 15°C to 40°C. December to January is the coolest period. The soil is mainly lateritic and acidic (pH. 2.5-6.5). The forest area is occupied by West coast tropical evergreen forests, West coast semi-evergreen forests, Southern moist deciduous forests, Southern tropical broad leaved hill forests, Southern montane wet temperate forests, Southern tropical dry deciduous forests, Grasslands, and Mangroves. These areas have never been explored bryologically. The topography and climate of Kerala are highly congenial for the growth and proliferation of liverworts and mosses and hence the degree of diversity is very high.

BRIEF HISTORY OF BRYOPHYTE STUDIES IN INDIA

Studies on Indian bryology are comparatively few and have not equated the progress made on other groups of plants. The first ever work dealing exclusively with mosses was by Dillenius (1741). Linnaeus (1753) in his "Species

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Plantarum" included some Indian mosses. This work is considered as the starting point for the principle of priority for *Sphagnum*, but for other mosses Hedwig's (1801) "Species Muscorum" is the starting point.

The studies on the mosses of India may be said to have commenced when the road to Nepal was opened. The first step towards our knowledge of the moss flora of this region was by Buchanan Hamilton, a Medical Officer in British Embassy in 1802, who collected mosses from Nepal. The first paper on the mosses of this region "Musci Nepalensis" was published in 1808 by Hooker, who later (1818-20) described several new species. This was followed by two papers on Indian muscology jointly published by Hooker and Greville (1825). Schwaegrichen (1826- 1827) included some Indian mosses in his supplement to Hedwig's "Species Muscorum". Mitten (1859) published "Musci Indiae Orientalis", it was the most important comprehensive work embodying all the Indian species known at that time. He recorded nearly 775 species belonging to 85 genera and 18 families. Wallich (1828-32), Harvey and Hooker (1840), Montagne (1842), Griffith (1842, 1843), Mueller (1853-54) and Mitten, (1860, 1861) made valuable contributions. In the post-Mitten period much progress has been made through direct and indirect contributions, like those of Brotherus (1898), Stephani (1900, 1906-1924), Dixon (1910, 1930, 1942), Bruehl (1931), Bartram (1955, 1960) and Robinson (1956).

The wealth of Indian liverworts described by Kashyap (1914, 1919, 1929, 1932) appeared so impressive. In India, the liverworts received more attention than mosses by Indian botanists. Following Kashyap; Pande (1936, 1958), Pande and Bhardwaj (1952), Pande and Srivastava

(1957), Mahabale (1958) and Udar (1976a, 1976b, 1980) made valuable contributions. In later years excellent work on Indian hepatics was continued by late Professor Ram Udar and his students (Udar & Nath (1976), Udar & Singh (1977, 1978, 1981), Udar & Srivastava (1981, 1983), Udar & Awasthi (1981), Udar & Kumar (1982, 1984), Udar *et al.*, (1983) and Tewari & Pant (1994)).

The floristic study of the mosses so richly distributed in the Indian subcontinent has received little attention throughout the past on account of non- availability of workable manuals for proper identifications. Initially, they were not interested in this group and made random collections. Professor H.C. Gangulee's comprehensive treatment of Indian mosses the "*Moss Flora of Eastern India and Adjacent Regions*" appeared in a series of fascicles (1969-1980) giving a resurgence of interest in mosses. Followed by him, Chopra (1975), Chopra and Kumar (1981), Vohra (1983), and Gangulee (1985) contributed valuable works on Indian moss.

The first close attention on the South Indian mosses came from some of the earliest who settled in the Nilgiri hills. Brotherus reported mosses collected in Coorg, J.H. Darrell and C.E.C. Fischer in Southern India, Dixon reported all these collections in 1914.

BRYOLOGY IN KERALA

The first record on the bryophytes of Kerala may be that appeared in Van Rheedes (1678-1703) monumental work on South Indian plants, *Hortus Indicus Malabaricus*. He described and illustrated one moss from Kerala as 'poovan-peda' (vol. 12, t.37, p. 71, 1693). It was later identified

by Nicolson *et al.* (1988) as *Bryum bicolor* Dickson, in contradiction to earlier interpretation as *B. coronatum* Schwaegr. Dixon (1914), while reporting the mosses collected by C.E.C. Fischer and others from South India and Ceylon, mentioned one species, *Erythrodonium julaceum* (Schwaegr.) Par. from Attappadi (Palakkad district). Bruehl (1931) compiled the *Census of Indian Mosses*, including genera and species from some of the neighbouring countries. He listed 2,471 species belonging to 371 genera. In this census he recorded three species, *viz.*, *Fissidens zippelianus* Bryol from the Travancore, *Webera rostrata* (C.Mull.) Broth. from the Malabar and *Brachymenium fischeri* Cardot & Dixon from the Attappadi hills.

Chopra (1938) in his notes on South Indian Hepatics mentioned two species *viz.*, *Riccia cruciata* Kashyap and *Aspiromitus erectus* Kashyap from the Travancore without mentioning precise locality. Kachroo and Bapna (1962) also reported on the occurrence of *Riccia cruciata* Kashyap from the Travancore area. Kachroo (1956) while studying the morphology of the genus *Pallavicinia* collected *P. ambigua* (Mitt.) Steph., from the Travancore area but without mentioning the exact locality.

Foreau (1964) reported *Bryum coronatum* Schwaegr. from Idukki district and *B. curyphyllum* Dix. & P.Varde, *Philonotis subrigida* var. *adpressa* Card. & P. Varde and *Physcomytrium insigne* Dix. & P. Varde from Kerala without mentioning the precise localities. Bhardwaj (1965) gave a detailed description of *Anthoceros mamillisporus* (D.C. Bhardw.) D.C. Bhardw. and *A. dixitianus* (Mahabale) Prosk. The species *A. mamillisporus* (D.C. Bhardw.) D.C. Bhardw. for the study was

collected from the Kottayam district. Bhardwaj (1973-74) while studying the taxonomy of some Indo-Pacific species collected by Stephani and reported as *Aspiromitus*, transferred to *Folioceros*. The herbarium specimens of the species *F. spinisporus* (Steph.) Bhardwaj was collected from Kottayam district.

Srinivasan (1974) in his studies on the South Indian mosses recorded only one species *Fissidens schmidii* C.Muell. from Thiruvananthapuram district. A detailed study on the taxonomy of Indian mosses including the collections from Indo-Pakistan subcontinent, Nepal, Bhutan and western and south eastern Tibet were made by Chopra (1975). Although the title mentions only the Indian mosses he included other areas because many of the mosses found in India extends to other regions. The species *Megalostylium brevisetum* Doz. & Molk., *Leucoloma brevifolium* Dix. & P. Varde, *Hymenostylium validinerve* Dix. & P. Varde, *Tortula schmidii* (C. Muell.) Broth., *Trichostomum minusculum* Dix. & P.Varde and the monotypic endemic genus *Nanotechnology foreaui* Dix. & P. Varde are reported from the Kannan Devan hills of Travancore. Species such as *Homalothecium nilghe-riense* (Mont.) Rob. and *Stereophyllum subacuminatum* Dix. & P. Varde are also reported from the Travancore, but without precise locality. The species *Leucoloma malabarensense* Besch. ex Ren. & Card. from Malabar and *Syrrhopodon leucophanoides* Card. & P.Varde from Kerala are also mentioned without precise locality.

Vohra *et al.*, (1981) reported 83 species of mosses from the Silent Valley National Park. Among these, 43 are epiphytes, 37 grow on soil and rocks and three species

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seen both as epiphytic and epilithic. They mentioned about the occurrence of three new species, one in the genus *Pinnatella* and two in *Fissidens* but not found described till now. Another interesting finding of the work was the recording of the sporophytes of *Handeliobryum setschwanicum* Broth. from the area.

Udar and Kumar (1983) described the South Indian endemic species *Radula pandei* Udar & Kumar from Agumbe and Mercaca of Karnataka and Mukkali-Silent Valley of Kerala. Udar and Jain (1984) listed 14 species of Marchantiales belonging to eight genera from Thrissur, Idukki, Wayanad and Kottayam districts. This collection was the first investigation on the liverworts of Kerala. Awasthi and Srivastava (1985) reported *Acrolejeunea sikkimensis* (Mizut.) Gradst. from Kerala State. Udar and Kumar (1985) while studying the family Cephalociellaceae in South India recorded *Cephalociella kieri* (Aust.) Arnell., the sole representative of the genus in South India, from Silent Valley, Munnar and Ponmudi areas. Presently we could collect this species from the Eravikulam National Park (Nair & Madhusoodanan (2001). Another species of the family, *Cylindrocolea tagawae* (Kitag.) Schust., a monotypic species has also been reported for the first time from Ponmudi of Thiruvananthapuram district by Udar and Kumar (1985). Srivastava and Asthana (1986) (not seen) reported a new species of *Folioceros* from Silent Valley. A taxonomic revision of the genus *Calymperes* in Southern India and neighbouring islands (Andaman & Nicobar Islands) by Ellis in 1989 reported two species from Ponmudi viz., *Calymperes lonchophyllum* Schwaegr and *C. tenerum* C.Muell.

One and the only thesis work regarding taxonomy of this group of plants

from Kerala is those of Rajeevan (1990) on the bryophyte flora of Idukki district. He has described 76 species of mosses and 19 species of liverworts from the high ranges of Idukki including three new species viz., *Fissidens choprai*, *Macromitrium vohrai* and *Pterobryopsis keralensis* and one variety *Entodon macroporus* var. *indica* (all awaiting publication). This work forms an important detailed study on the taxonomy and morphology of bryophytes in Kerala. Ellis (1992), while studying the family Fissidentaceae of South India reported *Fissidens ceylonensis* Dozy & Molkeb, from Kallar, Thiruvananthapuram district and *F. ceylonensis* var. *acutifolius* Dixon & P. Varde from Kumali, Idukki district.

Asthana *et al.*, (1995) in their well illustrated morpho-taxonomic account of the genus *Cheilolejeunea* in India described a new species *C. ghatensis* from Ponmudi in the Thiruvananthapuram district. They also reported two species viz., *C. serpentina* (Mitt.) Mizut. and *C. imbricata* (Nees) Hatt. from Lakkidi of Wayanad district. Nath and Asthana (1998) recorded *Frullania squarrosa* (R.Bl. & Nees) Dum., and *F. tamarisci* (L.) Dum. respectively from Wayanad and Idukki districts.

Srivastava and Sharma (2000) enumerated 29 species including a new species *Texilejeunea indica* from Silent Valley. This preliminary collection reports only Liverworts and Hornworts belonging to Metzgeriales (4 spp.), Jungermanniales (17 spp.), Marchantiales (5 spp.) and Anthocerotales (3 spp.). In the well illustrated and detailed account on the genus *Lopholejeunea* (Spruce) Schiffn. of India, Awasthi *et al.*, (2000) recorded 5 species viz., *L. abortiva* (Mitt.) Steph., *L. indica* Udar & Awasthi, *L. sikkimensis* Steph., and *L. subfusca* (Nees) Steph. (all

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from the Lakkidi area of Wayanad district) and *L. javanica* (Nees) Schiffn., (from the Silent Valley of Palakkad district). They also described a new variety *L. abortiva* var. *doliiformis* Awasthi *et al.*, from Achilatti forest of Palakkad district at 2000 m alt. (but we are not aware of such a place in this area).

A preliminary exploration made by Nair and Madhusoodanan (2001) for bryophytes in the Eravikulam National Park, Idukki district, situated in the high altitude mountainous areas with grassland shola vegetation, revealed 19 species including liverworts and mosses, of which, 6 are new records to Kerala. Among the new records one species *Fissidens ceylonensis* Dozy & Molkeb. is found recorded from Kallar area, Thiruvananthapuram district, earlier by Ellis (1992). Madhusoodanan *et al.* (2002) reported 115 species including 87 mosses and 28 liverworts from the same area. The bryological studies done in Kerala are given in chronological order.

DISCUSSION

In general, studies on the bryophytes of Kerala are scant and limited to documentation of limited number of species. Much attention should be given to update the earlier studies, taxonomy, morphology, details of ecology, economic aspects and diversity in different habitats. This review and the preliminary collection by the authors give an insight into the necessity of further work on the taxonomy and ecology of bryophytes. It is essential that we have a precise knowledge of the floristic wealth of the country, current extent of its economic utilization and possibilities of extended utilization. Such information is essential also for the preservation of available genetic diversity

of living organisms and to understand the extent of availability of bioresources. The 12 Wildlife sanctuaries and two National Parks are the sites of *in situ* conservation of the flora and fauna including the bryophytes. The two National Parks *viz.*, Silent Valley and Eravikulam are the areas of richest diversity as far as the bryophytes are concerned. When compared to the estimated diversity of the bryophyte flora of Kerala (*ca.* 500 spp.) the present review reveals the pathetically poor condition of the bryological studies. There was no concerted effort to document the bryowealth of this State. As now we are, well aware of the importance of biodiversity, there is no reason to neglect this ecologically highly significant group further. It is high time to plan for a systematic documentation of the bryophyte flora of the Kerala State.

CHRONOLOGICAL SUMMARY OF THE BRYOLOGICAL STUDIES DONE IN KERALA STATE

(Author - Year - Area concerned - Type of Study)

Van Rhee - 1678 - Malabar - In his studies on South Indian plants, *Hortus Indicus Malabaricus*, described and illustrated one moss which later identified as *Bryum bicolor* Dickson.

Dixon - 1914 - Attappady (Palakkad district) - Reported 58 species of mosses collected by C.E.C. Fischer from South India and Ceylon (Sri Lanka), mentioned one species *Erythrodontium julaceum* (Schwaegr.) Par. from Attappady.

Bruehl - 1931 - Attappady (Palakkad district), Malabar and Travancore - Census of mosses from Indian empire, Ceylon, Malay Peninsula, Malay Archipelago, Siam, Cochin China, Anam, Tonkin, Formosa, Turkestan, Caucasus, Kurdistan, Persia, and

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- Afghanistan listed 2,471 species in which three species viz., *Fissidens zippelianus* Bryol, *Webera rostrata* (C.Mull.) Broth. and *Brachymenium fischeri* Cardot & Dixon are reported from Kerala State.
- Chopra - 1938 - Travancore - An examination of herbarium specimens of Punjab University, which are, send by different authors from South India, reports about 103 species. This include three new species and several new records. *Riccia cruciata* Kashyap and *Aspiromitus erectus* Kashyap are recorded from Kerala.
- Kachroo - 1956 - Travancore - Morphological account of *Pallavicinia ambigua* (Mitt.) Steph., *P. lyelli* (Hook.) Gray and *P. longispina* Steph., collected from India and Japan were studied in detail. *P. ambigua* (Mitt.) Steph. for the study was collected from Kerala State.
- Kachroo & Bapna - 1962 - Travancore - 31 Indian species of *Riccia* and their distribution in various zones of the Indian subcontinent has been presented on the basis of literature. In this they mentioned the occurrence of *R. cruciata* Kashyap from Kerala.
- Foreau - 1964 - Kerala - *Bryum coronatum* Schwaegr. from Idukki district and *B. curyphyllum* Dix. & P.Varde, *Philonotis subrigida* var. *adpressa* Card. & P.Varde and *Physcomytrium insigne* Dix. & P.Varde were reported from Kerala.
- Bhardwaj - 1965 - Kottayam district - Morphology and Anatomy of *Anthoceros mamillisporus* (Bharadw.) Bharadw. and *A. dixitianus* (Mahabale) Prosk. collected from India have been illustrated. *A. mamillisporus* (Bharadw.) Bharadw. for the study was collected from Kerala.
- Bhardwaj - 1973-1974 - Kottayam district - Morphology and anatomy of *Folioceros* sp. earlier reported as *Aspiromitus* by Stephani from Indo-Pacific region. *A. spinisporus* were collected from the Kerala State.
- Srinivasan - 1974 - Thiruvananthapuram district (earlier Trivandrum) - Taxonomy and anatomy of the 64 South Indian mosses with illustrations, ecological, and physiological characters are presented. Only one species, *Fissidens schmidii* C.Mull., was collected from Kerala.
- Chopra - 1975 - Travancore and Malabar - Taxonomy and anatomy of 2000 Indian species belonging to 329 genera under 56 families were illustrated. About 10 species viz., *Homalothecium nilgheriense* (Mont.) Rob., *Hymenostylium validinerve* Dix. & P.Varde, *Leucoloma brevifolium* Dix. & P.Varde, *L. malabarens* Besch. ex Ren. & Card. *Megalostylium brevisetum* Doz. & Molk., *Nanothecium foreaui* Dix. & P.Varde, *Stereophyllum subacuminatum* Dix. & P.Varde, *Syrrhopodon leucophanoides* Card. & P.Varde, *Tortula schmidii* (C.Muell.) Broth. and *Trichostomum minusculum* Dix. & P.Varde are reported from Kerala.
- Vohra et al. - 1981 - Silent Valley National Park (Palakkad district) - Enumeration of 83 species of mosses from the area, including three new species; one in the genus *Pinnatella* and two in *Fissidens*, but not found described till now.
- Udar & Kumar - 1983 - Mukkali - Silent Valley (Palakkad district) - Described *Radula pandei* Udar & Kumar.
- Udar & Jain - 1984 - Thrissur, Idukki, Kottayam and Wayanad districts - Distribution of 14 species of Marchantiales belonging to eight genera viz., *Asterella wallichiana* Steph., *A. leptophylla* Mont., *Cyathodium cavernarum* Kunze., *Dumortiera hirsuta* Reinw., *Marchantia kashyapii* Udar & Shaheen, *M. palmata* Nees., *Plagiochasma intermedium* L. & G., *Reboulia hemisphaerica* (L.) Raddi, *Riccia billardieri* Mont. & N., *R. crystallina* L., *R. discolor* L. & L., *R. huebeneriana* Lindenb., *R. stricta* Duthie ex Arnell, *Targionia hypophylla* L., and *T. indica* Udar & Gupta are reported from Kerala.

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- Awasthi & Srivastava - 1985 - Kerala - *Acrolejeunea sikkimensis* (Mizut) Gradst. reported
- Udar & Kumar - 1985 - Silent Valley (Palakkad district), Munnar (Idukki district) and Ponmudi (Thiruvananthapuram district) - Distribution of the two species of the family Cephalociellaceae, *Cephaloziella kierii* (Aust.) Arnell, and *Cylindrocolea tagawae* (Kitag.) Schust. reported.
- Srivastava & Asthana - 1986 - Silent Valley (Palakkad district) - New species of the genus *Folioceros*.
- Ellis - 1989 - Ponmudi (Thiruvananthapuram district) - Taxonomic revision of the genus *Calymperes* from South India and neighbouring Islands (Andaman & Nicobar) reports 12 species, of which *C. lonchophyllum* Schwaegr. and *C. tenerum* C. Muell were collected from Kerala.
- Rajeevan - 1990 - High ranges of Idukki district - Illustrative account of 76 mosses and 19 liverworts including three new species viz., *Fissidens choprai*, *Macromitrium vohrai* and *Pterobryopsis keralensis* and one variety, *Entodon macroporus* var. *indica*. (all in editing)
- Ellis - 1992 - Kallar (Thiruvananthapuram district), Kumali (Idukki district) - *Fissidens ceylonensis* Dozy & Molkeb. is described and compared with some related taxa. *F. pennatulus* Thwaites & Mitt. and *F. perpusillus* Wilson ex Mitt. are regarded as forms of *F. ceylonensis* and *F. ceylonensis* var. *acutifolius* Dixon & P. Varde is considered to be a distinct taxon.
- Asthana et al. - 1995 - Ponmudi (Thiruvananthapuram district), Lakkidi (Wayanad district) - A morphotaxonomic account of nine species of *Cheilolejeunea* including two new species viz., *C. ghatensis* Asthana et al., and *C. udarii* Asthana et al., of which the species *C. ghatensis* Asthana et al., is reported from Ponmudi in the Thiruvananthapuram district and *C. udarii* Asthana et al., from Tamil Nadu. They also reported two species viz., *C. serpentina* (Mitt.) Mizut. and *C. imbricata* (Nees) Hatt. from Kerala.
- Nath & Asthana - 1998 - Wayanad and Idukki districts - Occurrence of 12 species of *Frullania* from South India is discussed. Morphological diversity among vegetative and reproductive parts of each species, the distribution pattern and altitudinal range of each taxon in South India is discussed. Among these they recorded *Frullania squarrosa* (R. Bl. & Nees) Dum. and *F. tamarisci* (L.) Dum. from Kerala.
- Awasthi et al. - 2000 - Lakkidi (Wayanad district), Achilatti, Silent Valley (Palakkad district) - An account of the Indian species of the genus *Lopholejeunea* (Spruce) Schiffn. is provided with ten species and two varieties. Among these two species (*L. kashyapii* and *L. nilgiriensis*) are described as new. Three species (*L. abortiva*, *L. javanica* and *L. nigricans*) are new for India. Two new varieties, *L. sikkimensis* var. *dentata* and *L. abortiva* var. *doliiformis* are also described. Among these *L. abortiva* (Mitt.) Steph., *L. indica* Udar & Awasthi, *L. sikkimensis* Steph., *L. subfusca* (Nees) Steph., *L. javanica* (Nees) Schiffn., and *L. abortiva* var. *doliiformis* Awasthi et al., are recorded from Kerala.
- Srivastava & Sharma - 2000 - Silent Valley (Palakkad district) - Diversity and ecology of liverwort and hornwort flora of the area were described, which include 29 species including a new species *Texilejeunea indica* Agarwal (inedit) from Silent Valley. This preliminary collection includes only liverworts and hornworts belonging to Metzgeriales (four species viz. *Fossombronia cristula* Aust., *F. indica* Steph., *Riccardia levieri* Schiffn., *R. multifida* (L.) Gray.), Jungermanniales (17 species viz., *Archilejeunea apiculifolia* Steph., *Cephaloziella kiaerii* (Aust.) Amell., *Dicranolejeunea gilva* Steph., *Frullania acutiloba* Mitt., *Jungermannia tetragona* Lindenb., *Jungermannia truncata* Nees., *Lejeunea flava* (Sw) Nees.,

Lopholejeunea abortiva (Mitt) Steph., *L. abortiva* var. *doliformis* Awasthi et al., *L. indica* Udar & Awasthi, *L. javanica* (Nees) Schiffn., *L. sikkimensis* Steph., *L. subfusca* (Nees) Steph., *Microlejeunea ulicina* Evans., *Radula kurzii* Steph., *R. pendei* Udar & Kumar and *Texilejeunea indica* Agarwal (inedit), Marchantiales (five species viz., *Asterella leptophylla* (Mont.) Pande et al., *Cyathodium cavernarum* Kunze., *Dumortiera hirsuta* (Sw.) Reinw., *Targionia hypophylla* L., and *T. indica* Udar & Gupta) and Anthocerotales (three species viz., *Anthoceros cripulus* (Mont.) Douin., *Folioceros udarii* Asthana & Srivastava, and *Phaeoceros laevis* (L.) Prosk. subsp. *laevis* Prosk. & Comm.

Nair & Madhusoodanan - 2001 - Eravikulam National Park (Idukki district) - A preliminary exploration of bryophytes of the area revealed 16 genera with 19 species of mosses and liverworts viz., *Campylopus flexuosus* (Hedw.) Brid., *Ditrichum difficile* (Dub.) Fleisch., *Entosthodon wichuriae* Fleisch., *Fissidens anomalus* Mont., *F. ceylonensis* Doz. & Molke., *F. cristatus* Wilson & Mitt., *Garckea phascoides* (Hook.) C. Muell., *Homaliodendron flabellatum* (Sm.) Fleisch., *Mnium rostratum* Schrad., *Octoblepharum albidum* Hedw., *Philonotis thawaitesii* Mitt., *Pogonatum microstomum* (Schwaegr.) Brid., *Rhodobryum giganteum* (Schwaegr.) Par., *Syrrhopodon leucophanoides* Card & Vard., *Trichostomum minusculum* Dix. & Vard., *Anthoceros erectus* Kashyap, *Anthoceros gemmulosus* (Hatt.) Schiffn. & Pande ex Kachroo et al., *Cephaloziella kiaerii* (Aust.) Amell. and *Riccardia levieri* Schiffn. Among these *Ditrichum difficile* (Dub.) Fleisch., *Fissidens cristatus* Wilson & Mitt., *Mnium rostratum* Schrad., *Pogonatum microstomum* (Schwaegr.) Brid., and *Rhodobryum giganteum* (Schwaegr.) Par. are new records for Kerala.

Madhusoodanan et al. - 2002 - Eravikulam National Park (Idukki district) - Diversity of

the species of the area based on altitudinal ranges and general ecology of the species were described in brief. Detailed account of 105 species of mosses and liverworts under preparation.

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