

ACB Field Guide Series No. 1

Guide to the Bryophytes in the Limestone Glass House of Queen Sirikit Botanic Garden

Ho Boon-Chuan
Benito C. Tan
Luong Thien Tam

Edwino S. Fernando, Hidetsugu Miwa, & Filiberto A. Pollisco Jr., *Editors*



Ministry of the Environment
Government of Japan





Cover

Eurhynchium savatieri Schimp. ex Besch.

Backcover

Dumortiera hirsuta (Sw.) Nees

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Guide to the Bryophytes in the Limestone Glass House of Queen Sirikit Botanic Garden

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FOREWORD

We all need to classify things so we can place them in their proper places. From spoons and plates or jeans and shirts, we know the importance of categorizing things. This also applies in biodiversity conservation through taxonomy, which is the science of describing, naming, and classifying living things. Unfortunately, the role of taxonomy seems underrated, not just in the ASEAN region, but anywhere else in the world.

The low appreciation of this field has resulted to lack of trained personnel, which has affected the achievement of country commitments to the Convention of Biological Diversity (CBD), especially in the ASEAN region. Taxonomy also serves as one of the most important tools to implement the Millennium Development Goals and to identify targets for the World Summit for Sustainable Development.

Through the support of Japan-ASEAN Integration Fund (JAIF), the Ministry of the Environment- Government of Japan, and the East and Southeast Asia Biodiversity Information Initiative (ESABII), ASEAN Centre for Biodiversity has implemented a taxonomic capacity initiative on “Extended Taxonomic Capacity Building for the Governance & Sustainable Use of Biodiversity: Bryophytes, Pteridophytes and Economically Important Insects (Predators & Parasitoids)”.

Part of the initiative is the publication of this *Guide to the Bryophytes in the Limestone Glass House of Queen Sirikit Botanic Garden* as an output of a capacity building workshop on “An Internship Programme on the Taxonomy of Bryophytes and Pteridophytes” held in Chiang Mai, Thailand on 20–30 January 2015. A total of 46 species and 40 genera in 25 families of bryophytes were identified, processed, and documented through a survey held during this workshop.

This guide is an important tool in implementing regional education programmes and conservation efforts on biodiversity, particularly on bryophytes. If we know what we have, we will know what to protect and conserve.

ATTY. ROBERTO V. OLIVA
Executive Director
ASEAN Centre for Biodiversity

FOREWORD

We would like to express to the authors in the various institutions and the staff in ASEAN Centre for Biodiversity (ACB) our gratitude for their wonderful contributions to these field guidebooks on Bryophytes and Pteridophytes.

The ASEAN region is home to a rich biological diversity. Despite its richness, it remains underexplored with many species still unidentified.

These publications are the special opportunities for capacity building in the ASEAN region, and are also anchored on the programme of work for the Global Taxonomy Initiative (GTI) under the Convention on Biological Diversity (CBD).

We are glad that we were able to support the capacity building on taxonomy through the East and Southeast Asia Biodiversity Information Initiative (ESABII) by Ministry of the Environment Government of Japan, with the Japan-ASEAN Integration Fund (JAIF) by Ministry of Foreign Affairs Japan.

We hope that we will be able to continue working with the authors and the ACB for biodiversity and taxonomy.

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The help of Dr Sahut Chantanaorrapint, PSU Herbarium, Prince of Songkla University for providing the updated number of liverwort and hornwort genera reported from Thailand, is much appreciated. We also thank colleagues who provided photos of moss species used in this field guide book.



The Bryophyte group from the workshop on the biodiversity of pteridophytes and bryophytes organized by the Japanese Ministry of Environment and ASEAN Centre for Biodiversity and held at Queen Sirikit Botanic Garden at Chiang Mai on 20–30 January 2015. From left to right, front squatting row: Dr Edwino S. Fernando, Mr Fulgent P. Coritico, Ms Khin Myo Htwe, Mr Sythat Setthavanxay, Ms Phetlasy Souladeth, Mr yoghi Budhiyanto, Mr Norihiro Matsushima. Back Standing Row: Ms Mai Ngoc Bich Nga, Dr Benito C. Tan, Mr Dek Vimeanreaksmey, Mr Parusuraman Athen, Ms Nootjaree Tathana, Ms Ummul-Nazrah Abdul Rahman, Dr Ho Boon-Chuan, Ms Henrietta P.M. Woo, Mr Wattana Tanming, Dr Manuel L. Castillo, Mr Athisone Silitham, Ms Syahida-Emiza Suhaimi, Mr Mon Samuth, Dr Miwa Hidetsugu, Dr Junko Kawai, Ms Luong Thien Tam.



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INTRODUCTION

The Queen Sirikit Botanic Garden

The Queen Sirikit Botanic Garden (QSBG) is contoured into the foothills of the mist-shrouded Doi-Suthep-Pui Mountain in Chiang Mai, Thailand. It is Thailand's oldest and foremost botanic garden and major center for scientific research. Dedicated to the conservation of Thai flora, it holds collections of, and carries out research on rare, endemic and endangered species.

Although the main focus is on Northern Thai flora and surrounding regions, QSBG has an integrated programme of research and education with a global perspective. The QSBG has an extensive research facility housing the herbarium, micropropagation laboratories, and library. Research work covers a wide spectrum of morphological, entomological, biochemical, and molecular studies. Species recovery and ex-situ conservation projects include work with endangered native Thai orchids, cycads, and palms. In addition, QSBG protects a large area of unique tropical deciduous forest with its associated wildlife as a conservation zone.

Covering an area of about 1,000 hectares, the topography of QSBG topography consists of small plains alternating with interposing mountains with the highest point at approximately 1,200 meters. QSBG is situated within an important center for biodiversity, as well as, serving as a watershed for the Ping River tributaries and the Chaopraya region of Thailand. Three streams flow down to join the Mae Sa stream that runs through the garden. A combination of complex topography and high mountains composed of many ridge systems alternating with plains, combined with the seasonal climate, has resulted in an intricate mosaic of evergreen and deciduous forests.

The deciduous forest occurs below 1,000 meters, with evergreen hill forests at 1,000 meters upwards. The deciduous forest is further divided into two types: deciduous dipterocarp-oak (*Dipterocarpus*, *Shorea*,



Front entrance of the glass house complex (far right) at Queen Sirikit Botanic Garden. (Photo by Luong Thien Tam)



Interior of the Limestone Glass House showing the bryophyte-covered walls and rocks. (Photo by Luong Thien Tam)

Why publish the guidebook?

A training workshop on the biodiversity of pteridophytes and bryophytes, organized by the ASEAN Centre for Biodiversity (ACB) and the Japanese Ministry of Environment, was held at the Queen Sirikit Botanic Garden from 20–30 of January 2015. The workshop participants visited the Limestone Glass House to observe the diversity of bryophytes in cultivation. The original populations of different bryophytes were brought in from surrounding natural forests and transplanted onto the artificially constructed habitats inside the glass house. As a result, a total of 46 species and 40 genera in 25 families of bryophytes were documented during the workshop survey. Except for *Lunularia cruciata* (see page 29), none of the bryophytes identified are invasive or exotic species. Included are several uncommon moss species in Thailand, and three species represent new records for the Thai moss flora. They are *Cyclodictyon blumeanum*, *Physcomitrium eurystomum*, and *Symphyodon yuennannensis*.

With about 1,143 species of bryophytes being reported so far from Thailand, the country is still considered botanically underexplored for these obscure tiny plants. In response to the call for these plants to be protected for their diversity, an English guidebook with pictures was prepared to show and inform the public of the diverse bryophyte flora found at QSBG's glass house.

For easier referencing and locating of information, the bryophytes found in the Limestone Glass House were arranged into three Divisions, reflecting the three evolutionary lines of bryophytes. Within each Division, the listings of families and genera are done by alphabetical order. Since the species identification of a bryophyte specimen needs the use of a light compound microscope to see the distinguishing microscopic characters on a leaf or thallus, the guidebook focuses on the generic treatment with only side mention of the species collected and identified. The genera of bryophytes, unlike the species, are generally easier to recognize with the use of a 10x field magnifying lens.

As the diversity of bryophytes presented in this guidebook can also be found in similar elevation and vegetation type in other parts of Thailand, and even in the neighboring countries of Viet Nam, Laos, and Myanmar, the field guide book will be an important contribution of the Queen Sirikit Botanic Garden and the ACB to the regional public education program and conservation effort for the bryophytes.

What are bryophytes?

Bryophytes include about 20,000 species in nearly 1,500 genera worldwide. Three main groups of bryophytes representing three separate evolutionary lines are recognized: the liverworts or hepatics (Division Marchantiophyta), the hornworts (Division Anthocerotophyta), and the mosses (Division Bryophyta). Main differences between the three groups are shown in **Table 1**. Bryophytes are ancient groups of seedless land plants that have evolved from their aquatic green algae ancestors and have inhabited and colonized the land environment about 470 million years ago during the Ordovician geologic period. The oldest fossils known of the bryophytes are in many respects similar to the living taxa and it is for this reason that bryophytes are often looked upon as living fossils. Dispersed by spores instead of seeds and lacking true vascular bundles, bryophytes occupy a unique evolutionary position between the green algae and the vascular plants (ferns and seed plants). Thus, the study of bryophytes is essential for the understanding of plant evolution, especially their adaptations to the colonization of land.

Bryophytes are generally small and inconspicuous plants that are hardly noticed and appreciated by layman. However, the term “mosses” is sometimes misused to include non-bryophyte plants and misinterpreted by many people, even to those who have the basic knowledge of plant diversity. Common names such as “club-mosses” and “spike-mosses” belong to the Lycophyte genera *Lycopodium* and *Selaginella* respectively, which are non-flowering vascular plants more similar to ferns. “Irish moss” is a marine alga (*Chondrus crispus*), whereas “Reindeer moss” (*Cladonia* sp.) and “Beard moss” (*Usnea* sp.) are lichens, which are composite organisms consisting of a fungus and an alga living together. “Spanish moss” (*Tillandsia usneoides*) is, in fact, a monocot flowering plant in the same family as the pineapple (Family Bromeliaceae).

Ecological importance, economic, and potential uses of bryophytes

Ecologically speaking, bryophytes are important components of the forest ecosystem, especially in water and biogeochemical (e.g. nitrogen and carbon) cycling. The high water retention abilities of bryophytes help to keep the forest environment moist and prevent flash floods and soil erosion during storms which are common in the tropical forest ecosystem.

Although small in plant size, they are important pioneers in vegetation succession and soil formation. The populations of bryophytes on tree trunks act as footholds and water sources for many vascular epiphytes such as ferns and orchids. Colonial habits of bryophytes make excellent homes and shelters for many invertebrates, which are important parts of the food chains and food webs. Some vertebrate animals, such as amphibians and birds, also use the soft bryophytes to build nests for their eggs. It is known that in some flowering plants, seed germination and seedling establishments can only occur in bryophyte colonies, because of their acidic and antimicrobial properties.

The unique evolutionary position of bryophytes make them important illustrative organisms in botanical education. Being haploid dominant, bryophytes such as the moss *Physcomitrella patens* (Hedw.) Bruch & Schimp. and liverwort *Marchantia polymorpha* L. are today increasingly used as experimental model organisms in biotechnology and genetic research.

The dainty feel and look of bryophytes have made them suitable as ornamental plants for decorating mini floral arrangements, bonsai landscapes, aquariums, and terrariums. *Vesicularia dubyana* (Singapore moss) is popularly used in aquascaping in recent years. It and several other species of *Vesicularia* serve as a substrate and food source for shrimp and fish fry to live and survive in aquatic habitats.

The varying degree of sensitivity to the environment has made bryophytes good bioindicators of climate change. Epiphytic bryophytes have been used to access the level of air pollution. Meanwhile, the presence of some species can be a good indicator of the substrate it is growing on, like *Hyophila involuta* which are common on calcareous substrates, including man-made concrete.

Many species of leafy liverworts are known to produce special chemical compounds stored in the oil bodies of cells. These unique chemical compounds that are not known from other plant groups have been shown to have anti-microbial property. Therefore, it is not surprising that species of *Marchantia* and *Polytrichum* are used as medicine in China and Korea.

Table 1. Selected key differences between liverworts, hornworts, and mosses.

| Features | LIVERWORTS |
|--|---|
| Dominant plant body (gametophyte) | - leaves when present, in 2–3 neat rows or not differentiated into stems and leaves (thalloid) |
| Leaves | undivided or lobed, without midrib |
| Cells | - with numerous chloroplasts - trigones usually present |
| Oil bodies | - usually present |
| Rhizoids | - unicellular |
| Protonema | - very small, thalloid, producing only 1 gametophyte |
| Sporophyte (diploid) | - growing by an apical cell - during development entirely surrounded by a calyptra and other protective organs (perianth, marsupium, involucre, etc.) |
| Spore maturation | - synchronous, before elongation of seta |
| Capsule (sporangium) | - rounded to cylindrical, supported by a short-lived, fragile, colorless seta (or seta lacking) - opens at once, by (1–)4 valves - lacking columella, stomata, and peristome; elaters present |

| HORNWORTS | MOSESSES |
|---|--|
| - not differentiated into stems and leaves (thalloid) | - leaves spirally arranged, rarely in 2–3 neat rows |
| - | - always undivided, with or without midrib |
| - with 1–4 large chloroplasts - trigones lacking | - with numerous chloroplasts - trigones usually lacking |
| - lacking | - lacking |
| - unicellular | - multicellular |
| - very small, thalloid, producing only 1 gametophyte | - filamentous, usually producing more than one gametophyte |
| - growing by a basal meristem - during development partially surrounded by involucre, a calyptra lacking | - growing by an apical cell - during development upper part covered by calyptra; additional protective organs lacking |
| - asynchronous (seta lacking) | - synchronous, after elongation of seta |
| - cylindrical to long filiform, seta lacking - opens gradually from top to bottom, by 2 valves - with columella, with or without stomata, peristome lacking; pseudo-elaters present | - rounded to cylindrical, generally supported by a longer-lived, firm, pigmented seta - opens at once, usually by an operculum - with columella and stomata, often with a peristome; elaters lacking |

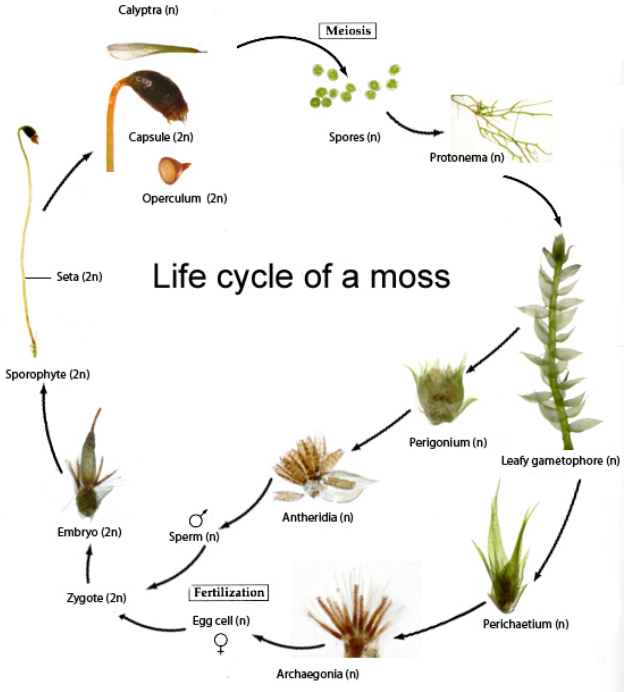
Morphology and life cycle

Like all land plants, bryophytes also go through two stages of life cycle: the **gametophyte** and the **sporophyte**. But unlike the vascular plants, the gametophyte of bryophytes is the dominant generation. The sporophyte of mosses, and those of liverworts and hornworts, is attached and dependent entirely or partially on the gametophyte body for nutrition. Also, unlike the vascular plants, the sporophytic body of bryophytes is quite short-lived. In other words, the life cycle of bryophytes includes a dominant, complex, haploid (1n) gametophytic body and a less differentiated, diploid (2n) sporophytic body.

Taxonomically, bryophyte species and genera are classified and named based mainly on the morphology of gametophytic characters. For hornworts and thalloid liverworts, those features observed on the **thallus**, such as branching, ventral scales, presence/absence of air pores, midrib, margin of thallus, etc. are used. For mosses and leafy liverworts, the leaves and stems are observed under light microscope for characters, such as leaf shape, leaf margins, differentiation of a leaf border, leaf cells shape, size, and ornamentation. Moreover, for leafy liverworts, **lobule** shape and size (when present), presence/absence of **trigones**, **oil bodies** (type, color, distribution and number) are also important characters. For mosses, the absence or presence of leaf **costa**, and the length of one or two leaf costa (e), and most especially the **alar** cells are additional characters.

At maturity, the gametophyte develops the sex organs, which consists of the female organ(s) called **archegonium**, and the male organ(s) called **antheridium**. Usually, the **archegonia** and **antheridia** of mosses are surrounded and protected by modified leaves, resulting in structures known as **perichaetia** and **perigonia**, respectively. In leafy liverworts these modified leaves are further developed into a structure called the **perianth**. In thalloid liverworts and hornworts, the sex organs are protected within a cylindrical **involucre**. The morphology and position of the perichaetia, perigonia (including their associated leaves), perianths and involucre are all important taxonomic characters.

A single flask-shaped **archegonium** consists of an enlarged basal portion called the **venter**, where the single **egg cell** (female gamete) resides, and an elongated, tube-like



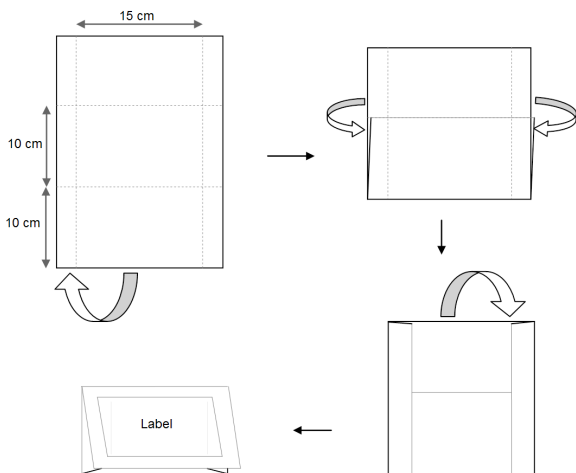
Life-cycle of a moss. Liverworts and hornworts have similar life cycle, i.e. one with dominant haploid gametophyte stage and a diploid sporophyte stage that is (partially) dependent on the gametophyte (after Tan & Ho, 2008).

upper part called the **neck**. On the other hand, each **antheridium** is a club-shaped or globose structure with a short basal stalk. Inside the developing antheridium are hundreds of maturing sperm cells. When released, the mature sperm cells, which are biflagellate, swim through the water medium and pass through the neck of the archegonium to fertilize the egg cell.

Fertilization results in fusion of two haploid gametes forming a diploid cell called the **zygote**, the first stage of the sporophyte generation. The sporophyte in bryophytes typically consists of a foot structure that penetrates into the gametophytic body to absorb nutrients, a capsule which produces the haploid or meiotic spores, and a seta which is the stalk that connects the foot and the capsule.

The spore-bearing capsule of liverworts is elevated on a transparent seta (or without seta) and typically dehisces into four valves. The hornworts produce horn-like sporophyte that lacks a seta and the elongated capsule splits longitudinally into two from the apical end. The basal meristem of the hornwort sporophyte continues develop at the base, while the top part of the capsule progressively ripen and open to release the spores. In mosses, the developing capsule is protected by an extra hood- or bell-like cover called the **calyptra**. The shape and the orientation of the capsule on the seta are additional taxonomic characters needed in identification in many moss genera. In the majority of mosses, the mature capsule opens by an **operculum** or lid. When the operculum is removed or fallen off by itself, the mouth of the capsule shows one or two rows of teeth called the **peristomes**. The release of spores is regulated by the opening and closing movements of the peristome teeth in response to the changing humidity in the air.

When the bryophyte spores land on favorable environment and substrate, they will start to germinate into a tiny protonema before developing into mature leafy or thalloid plants. The moss protonema are often better developed and filamentous. Each moss protonema can give rise to several leafy shoots, thus completing the life cycle. In contrast, liverwort and hornwort protonemata are thalloid and produce only one gametophyte each.



Steps in folding paper packets for collecting and storing bryophytes.

growing (etiolated) specimen will hinder a correct identification later. The best method of drying bryophyte collections *en masse* is to spread out the packets and leave them to air dry for a few days in a well-ventilated place (faster in air-conditioned room). Drying the collected bryophytes specimens under strong heat, e.g. ovens, or under direct sun, is discouraged.

After studying the specimens, the identified packet with the completed label showing the locality, and collector name and date, can be safely stored in an old shoebox without adding any preservatives. The shoeboxes can then be kept in a cool dry place for storage, if not deposited in a museum or herbarium institution.



BRYO FACTS

Do you know that?

- Mosses are the second largest plant group of land plants today after the flowering plants.
- Bryophytes are found in all almost all terrestrial and aquatic habitats except the marine environment. These include extreme ecosystems where most vascular plants are unable to grow such as acidic bogs, deserts, alpine, and polar regions.
- Many bryophytes can withstand long periods of drought and revive almost immediately when re-moistened.
- Bryophytes under 1,500-year-old permafrost in Antarctica has been successfully resurrected.
- Some bryophytes, especially liverworts, can actually grow on animals. The phenomenon is called epizoism.
- Leaves of bryophytes are almost always consisting of a single layer of cells except at the midrib and border region.
- Bryophytes have no roots; they only have rhizoids for attachment.
- Gametophyte of bryophytes has almost no cuticle covering, which allows every part of the plant body to take in water directly from external sources.
- Bryophytes, like ferns, need water medium for fertilization to take place.
- Most bryophytes have the ability to reproduce vegetatively by producing a specialized group of cells called gemmae, and/or modified buds, branches, or leaves called propagules.
- Although the majority of bryophytes stand below 4 cm tall, the tallest moss plant, *Dawsonia*, can be more than half a meter tall; conversely one of the smallest mosses, *Ephemeropsis*, consists merely of a reduced to mass of filamentous protonema.
- Bryophytes are important plants used in many ways, such as in horticulture; medicine in China, India and North America; fuel in Europe; and stuffing for pillows in Malaysia.

- Due to the high absorbent and antibacterial properties, bryophytes such as *Sphagnum* have been used for lining diapers, baby beddings, and even as bandages for wounds at war zones during World War I.
- Some semi-aquatic bryophytes, such as species of *Monosolenium*, *Riccia*, *Taxiphyllum*, and *Vesicularia* are popular aquarium plants grown in many countries around the world, and some even command high prices in the market.
- Although most bryophytes disperse their spores by wind, some species especially the dung mosses (Splachnaceae), depend on flies to disperse their sticky spores.
- Owing to their haploid nature and high totipotency, bryophytes such as *Physcomitrella patens* and *Marchantia polymorpha*, have become popular model experimental organisms in plant genetics, development, and evolution.
- Wild chimpanzees in Uganda have been observed to use mosses as sponge to drink from tree holes.

List of Bryophytes in the Limestone Glass House of Queen Sirikit Botanic Garden

Arrangement of families, genera, and species under the three Divisions of bryophytes is in alphabetical order. Bryophyte classifications follow Goffinet & Shaw (2009).

Division Marchantiophyta

Family Aneuraceae

1. *Aneura pinguis*
2. *Riccardia graeffei*

Family Aytoniaceae

3. *Asterella khasyana*

Family Dumortieraceae

4. *Dumortiera hirsuta*

Family Lophocoleaceae

5. *Chiloscyphus coadunatus*

Family Lunulariaceae

6. *Lunularia cruciata*

Family Marchantiaceae

7. *Marchantia emarginata*

Division Anthocerotophyta

Family Notothyladaceae

8. *Phaeoceros carolinianus*

Division Bryophyta

Family Bartramiaceae

9. *Philonotis hastata*
10. *Philonotis thwaitesii*

Family Brachytheciaceae

11. *Brachythecium buchananii*
12. *Eurhynchium savatieri*
13. *Rhynchostegium celebicum*

Family Bryaceae

14. *Brachymenium nepalense*
15. *Bryum capillare*
16. *Bryum coronatum*

Family Calymperaceae

17. *Octoblepharum albidum*

Family Dicranaceae

18. *Campylopus ericoides*
19. *Campylopus zollingerianus*

- Family Fissidentaceae
20. *Fissidens crispulus*
21. *Fissidens pellucidus*
- Family Funariaceae
22. *Funaria hygrometrica*
23. *Physcomitrium eurystomum*
24. *Physcomitrium sphaericum*
- Family Hypnaceae
25. *Ectropothecium zollingeri*
26. *Vesicularia reticulata*
- Family Leskeaceae
27. *Claopodium prionophyllum*
- Family Leucobryaceae
28. *Leucobryum aduncum* var. *scalare*
- Family Meteoriaceae
29. *Aerobryidium aureonitens*
30. *Cryptopapillaria fuscescens*
31. *Meteoriopsis squarrosa*
32. *Trachycladiella sparsa*
33. *Trachypus bicolor*
- Family Mniaceae
34. *Plagiomnium succulentum*
- Family Pilotrichaceae
35. *Cyclodictyon blumeum*
- Family Pottiaceae
36. *Barbula consanguinea*
37. *Hyophila involuta*
38. *Oxystegus cylindricus*
39. *Splachnobryum obtusum*
40. *Trichostomum siamense*
- Family Pterobryaceae
41. *Pterobryopsis divergens*
- Family Racopilaceae
42. *Racopilum orthocarpum*
- Family Symphyodontaceae
43. *Symphyodon yuennanensis*
- Family Thuidiaceae
44. *Pelekium gratum*
45. *Thuidium cymbifolium*
46. *Thuidium plumulosum*



Descriptions

Aneura Dumort.

Description of the genus Plants thalloid, large, fleshy, unbranched or irregularly to pinnately branched. Thallus without or with an ill-defined midrib, margin entire or toothed, without hairs, internally undifferentiated. Oil bodies granular. Rhizoids colorless. Ventral scales lacking. Mostly dioecious. Antheridia and archegonia borne on short lateral branches or at thallus margins. Seta long. Sporophyte surrounded by a fleshy calyptra. Capsule ellipsoid, opening by 4 valves, wall 2-layered. Spores small. Elaters attached to the tip of the capsule valve.

Aneura is a widespread thalloid liverwort that grows also in greenhouses and shaded gardens in residence areas. It is best identified by the absence of air pores on the thallus, the non-differentiation of a midrib region, and also by its wavy thalloid margin.

Species in the QSBG Limestone Glass House

Aneura pinguis (L.) Dumort.

Ecology and habitat Grows on more or less permanently moist habitat, including moist soil, rotten or dead wood, humus, rock, and in the glass house.

Number of species in the genus 2 species in Thailand and c. 15 species around the world.

Distribution The genus has a nearly cosmopolitan distribution, especially found in disturbed man-made habitats.

Sporophyte observed Mature sporophyte.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Aneura pinguis — Habit of plants showing the ribbon-like thallus.
(Photo by Fulgent Coritico and Syahida-Emiza Suhaimi)

Riccardia Gray

Description of the genus Plants thalloid, small, pale green to glossy fresh green, rarely dark green, less than 3 mm wide. Thalli irregularly to pinnately branched, at times palmately branched in the upper part of the thallus, some taxa with erect, dendroid habit. Thallus surface with no central thickening, nor midline, and without reticulate pattern, margin undulate, internally not differentiated. Oil bodies present in (not all) epidermal cells, with usually 1–3 (–8) large oil bodies per cell. Slime papillae clavate, 1–2 celled. Archegonia and antheridia at the thallus margins. Sporophytes with long and soft seta and ellipsoid capsule. Elaters attached at the tips of the 4 valves of capsule wall after dehiscence.

Species in the QSBG Limestone Glass House

Riccardia graeffei (Steph.) Hewson

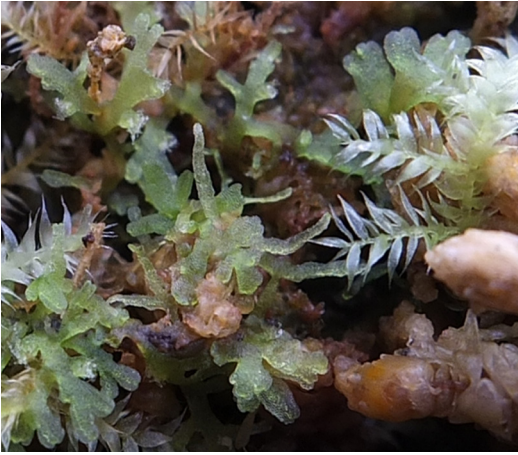
Ecology and habitat On moist sandy soil or on wet rocks. In nature, preferred shady and moist sites.

Number of species in the genus 3 species in Thailand, more than 20 in Asia, and about 175 species in the world.

Distribution A cosmopolitan genus. Widespread.

Sporophyte observed None.

Author: Fulgent Coritico & Syahida-Emiza Suhaimi



Riccardia graeffei —Habit of plants growing among other bryophytes. (Photo by Luong Thien Tam)



Branching thallus of *Riccardia graeffei*.
(Photo by Fulgent Coritico and Syahida-Emiza Suhaimi)

Asterella P.Beauv.

Description of the genus Plants thalloid. Thallus long, narrow ribbon-like, thick, light green to dark green, broader towards the apex. Upper surface of thallus with simple pores. Pores simple, of one layer of cells. Ventral scales not with a large, reniform appendage, in two rows, more or less longer than wide, each with 1 broad, lanceolate appendage. Male receptacle not stalked. Female receptacles stalked, the underside of the receptacle with large conical, purple or whitish pseudoperianths. Sporophytes on female stalked receptacle. Capsule opened by an operculum. Gemma cups absent.

Asterella is distinguished by the presence of a deeply divided “cage-like” pseudoperianth that encloses the sporophyte on underside of the raised receptacles. In addition, many species of *Asterella* smell fishy, which aids recognition in the absence of fertile material.

Species in the QSBG Limestone Glass House

Asterella khasyana (Griff.) Pandé, K.P. Srivast. & Sultan Khan.

Ecology and habitat On moist sandy soil or on rocks in QSBG, forming large patches of populations.

Number of species in the genus 3 species in Thailand, 14 species in Asia, and 45–50 species worldwide.

Distribution The genus is not rare in Thailand and many parts of Asia, nearly cosmopolitan in distribution.

Sporophyte observe Only young sporophytes.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Asterella khasyana — Ribbon-like thallus with young receptacles.
(Photo by Luong Thien Tam)



Raised female receptacles of *Asterella khasyana* with cage-like pseudoperianth enclosing archaegonia and developing sporophytes.
(Photo by Luong Thien Tam)

Dumortiera Nees

Description of the genus Plants thalloid, large, dull greenish. Thallus large, irregularly branched, margin plain, entire, undulate. Upper surface of thallus without pores, with a faint network marking, covered with short hairs and papillate cells. Ventral scales simple, hyaline. Rhizoids papillose. Monoicous. Female gametangia produced on rounded receptacles on stalk arising from the thallus surface, margins and ventral side of receptacles with bristle hairs. Male gametangia terminal on dividing branches, discoid, on non-stalked pad, with bristles. Sporophytes with a soft seta and globose capsule that opens into many valves at maturity. Elaters 2–4 spiraled, some branches.

The genus can be readily recognized by the broad dark-green thallus without air pores and the presence of stiff bristle hairs below the thallus and margins.

Species in the QSBG Limestone Glass House

Dumortiera hirsuta (Sw.) Nees

Ecology and habitat On moist soil or on rocks in glass house. In nature, species of *Dumortiera* form patches of thalloid populations covering road side and trail banks.

Number of species in the genus 1 species in Thailand, Southeast Asia and around the world.

Distribution The genus has an oceanic distribution.

Sporophyte observed Young receptacles seen.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Dumortiera hirsuta — Broad, flat, semi-translucent thalli.
(Photo by Luong Thien Tam)



Raised female receptacles of *Dumortiera hirsuta*.
(Photo by Luong Thien Tam)

Chiloscyphus Corda

Description of the genus Plants leafy, irregularly branched, usually interwoven together in a thin layer of mat, pale green to dark green. Leaves in 2–3 longitudinal rows, succubous, horizontal in some species, lateral leaves more or less alternate, rounded, truncate or weakly indented, and the base runs down onto the stem. Leaves apex clearly bifid or with sharp teeth, asymmetrically emarginated, sometimes unlobed. Leaf cells more or less smooth or slightly striate-papillose. Oil-bodies 2–5 per cells, usually finely granular. Underleaves present, similar in shape, much smaller in size. Rhizoids in bundles from base of underleaves. Archegonia and antheridia on long shoots or on short branches. Young sporophyte surrounded by a perianth that is keeled, inflated, or laterally compressed in some species. Seta thick and long. Capsule thick-walled, 3–8 cell layers. Gemmae rare.

The genus *Chiloscyphus*, along with the closely related *Heteroscyphus* and *Leptoscyphus*, were previously included in the family Geocalycaceae and recently segregated into a separate family Lophocoleaceae based largely on molecular phylogeny.

Species in the QSBG Limestone Glass House

Chiloscyphus coadunatus (Sw.) R.M. Schust. & J.J. Engel

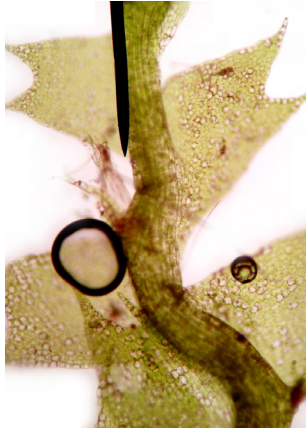
Ecology and habitat Grows mainly on moist rocks in the Limestone Glass House at the QSBG.

Number of species in the genus 2 species in Thailand, 30 species in Asia, and 120 species in the world.

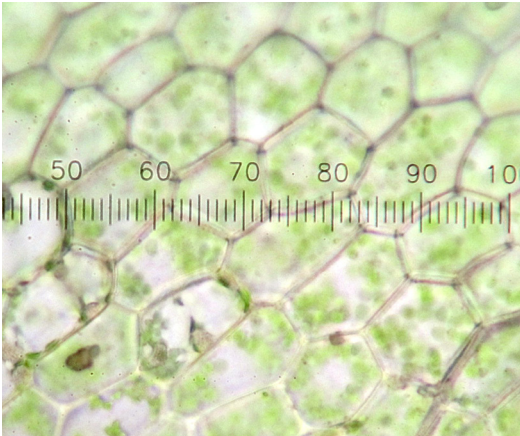
Distribution The genus has a worldwide distribution, predominantly in the tropics and southern hemisphere, and widespread in Thailand and Asia. *Chiloscyphus coadunatus* has a sporadic and scattered distribution in several parts of the world.

Sporophyte observed None.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Chiloscypus coadunatus — Solitary plant; arrangement of the leaves. (Photo by Fulgent Coritico)



Median leaf cells of *Chiloscypus coadunatus*. (Photo by Fulgent Coritico)

Lunularia Adans.

Description of the genus Plants thalloid, dichotomously branched. Thallus large up to 12 mm wide, shiny, pale green, faintly lined, the margins involute when dry, and the surface reticulations almost disappear. Upper surface of thallus with many scattered simple air pores. Female receptacles stalked and have a cross shape. Sporophyte grows from the cross-shaped receptacle and produces small, black spores. Capsule rarely seen. Asexual reproduction by discoid gemmae, developing in crescent-shaped gemma-cups on dorsal side of thallus.

The genus is easily distinguished from the close-looking *Marchantia* found in similar habitats by the crescent-shaped gemma cups.

Species in the QSBG Limestone Glass House

Lunularia cruciata (L.) Dumort. ex Lindb. This is a new record for Thailand and probably also for SE Asia.

Ecology and habitat On moist soil or on rocks in glass house of QSBG.

Number of species in the genus 1 species in Thailand, Asia, and the world. *Lunularia* is a common greenhouse liverwort.

Distribution A native plant of Atlantic-Mediterranean, it has become common within and near glasshouses around the world mainly through human dispersal.

Sporophytes observed None.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Lunularia cruciata — Habit of plants with crescent-shaped gemma cups. (Photo by Luong Thien Tam)



Close-up of a gemma-cup of *Lunularia cruciata*.
(Photo by Luong Thien Tam)

***Marchantia* L.**

Description of the genus Plants thalloid, dichotomously branched. Thallus thick, with plenty of compound air pores on dorsal surface; the air pore opens into a chamber with 2–5-celled filamentous photosynthetic filaments. Sclerotic cells and/or mucilage cavities often present in the compact ventral tissue of the thallus. Scales in 4–10 rows on the ventral surface; median scales with an appendage. Rhizoids of two types, smooth and tuberculate. Oil cells with a single, large oil-body, present in most of the tissues of gametophyte. Male and female receptacles stalked with filiform scales and 2–4 rhizoid furrows, arising from branch systems. Male receptacles lobed or divided into rays, each lobe or ray with several rows of scales on the ventral surface. Female receptacles lobed or dissected into rays, with scales and bivalved involucre on the ventral surface; archegonia several per involucre, each surrounded by a thin calyptra and a campanulate pseudoperianth. Sporophyte composed of foot, short seta and capsule. Capsule wall has cells with annular thickenings; elaters with 2–3 helical bands. Asexual reproduction by discoid gemmae, developing in cup-shaped gemma-cups on dorsal side of thallus.

The genus is easily recognized by the presence of many cup-shaped gemma-containers on the thallus.

Species in the QSBG Limestone Glass House

Marchantia emarginata Reinw., Blume & Nees

Ecology and habitat On moist sandy soil or on rocks at QSBG. This is a liverwort genus common in open disturbed sites, such as rice fields and vegetable farms.

Number of species in the genus 3 species in Thailand, at least 23 in Asia, and about 36 species in the world.

Distribution Cosmopolitan.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Marchantia emarginata — Habit with gemma cups.
(Photo by Luong Thien Tam)



Female receptacles of *Marchantia emarginata* with finger-like extensions. (Photo by Luong Thien Tam)

Phaeoceros Prosk.

Description of the genus Dark green to brownish, thallus forming rosettes, without a midrib, without mucilaginous cavities, but usually with scattered *Nostoc* colonies inside the thallus, visible as black dots. Margins of thallus entire, shallowly lobed, nearly flat or sometime crispate, dorsal surface smooth. Sporophytes cylindrical, 5–30 mm long, erect, with epidermal stomata and a well-developed columella. Spores rounded-tetrahedral, unicellular, usually with papillose, spinulose, or vemiculate surface ornamentation, and with distinct triradiate marks, yellowish. Pseudoelaters short, (1–) 2–4 celled, pale brown, walls thin and with irregular thickenings. The genus is identified mainly by its yellow spores and the structure of pseudoelaters.

Species in the QSBG Limestone Glass House

Phaeoceros carolinianus (Michx.) Prosk.

Ecology and habitat On rocks and soil in QSBG Limestone Glass House. The genus is a ground bryophyte in wet, shaded sites.

Number of species in the genus 2 species in Thailand, about 6 species in Asia, and some 30 species in the world.

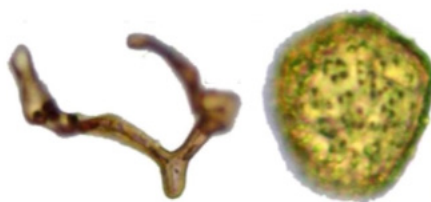
Distribution The genus has a nearly worldwide range.

Sporophyte observed Many sporophytes seen.

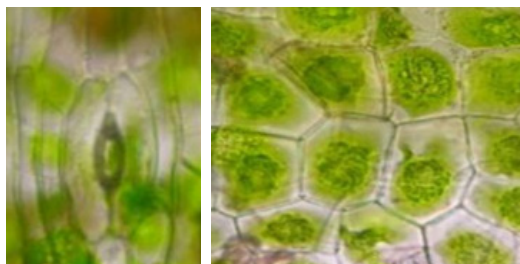
Authors: Mon Samuth & Athisone Silitham



Phaeoceros carolinianus — Habit with sporophytes.
(Photo by Luong Thien Tam)



Elater and spore of *Phaeoceros carolinianus*. (Photo by N. Printarakul)



Capsule wall cells with stoma and thaloid cells showing a single chloroplast in *Phaeoceros carolinianus*. (Photo by Narin Printarakul)

Philonotis Brid.

Description of the genus Plants pale to yellowish-green, radiculose at base. Stems erect, up to 2 cm long. Leaves curled and appressed when dry, ovate to lanceolate, acute, obtuse, or short to long acuminate, marginal teeth bifid. Costa prominent, single, papillose at the back. Leaf cells rhomboidal, short rectangular to elongate, thin to thick walled, mamilllose, or papillose at the anterior end of cell. Capsule globose to ovoid, greenish when fresh, erect to inclined, furrowed when dry, mouth oblique. Peristome teeth single. Calyptra cucullate.

The genus can be identified under the microscope by its prorate or apically papillose leaf cells, coupled with bifid leaf marginal teeth. Its round, greenish capsule when young and the wet habitat preference help to identify the genus.

Species in the QSBG Limestone Glass House

Philonotis hastata (Duby) Wijk & Marg. Some of the collected sterile plants have oblong-lanceolate and acuminate leaves and narrowly rectangular leaf cells may represent another species of *Philonotis* close to *P. thwaitesii* Mitt.

Ecology and habitat On rock in wet places in QSBG. A common moss genus in wet places, especially along wet stream bank and wet cliff near waterfalls.

Number of species in the genus 12 species in Thailand. More than 20 species in Asia, and about 185 species in the world.

Distribution Cosmopolitan.

Sporophyte observed Sporophytes produced frequently.

Authors: Mon Samuth & Athisone Silitham



Philonotis hastata — Habit with erect sporophytes terminating each with a round, greenish capsule. (Photo by Luong Thien Tam)

Brachythecium Schimp.

Description of the genus Plants pleurocarpous. Stems prostrate to laxly decumbent, irregularly and laterally branching, mat-forming. Leaves ovate to ovate-lanceolate, plicate in some species, acute to acuminate, margins entire to serrulate. Costa single, ending mostly above midrib. Laminal cells usually long, becoming shorter and broader below, alar cells rectangular to subquadrate in some species. Setae elongate, smooth to papillose distally. Capsule quite distinctive in its short-ovoid and arcuate shape, with apiculate opercula, and reddish in coloration at maturity; opercular lid conical. Peristome teeth double. Calyptra cucullate.

The genus is best identified as a creeping and branching moss with single costate leaves and a capsule with short conical opercular lid. The greenish color of the weft and mat forming populations growing on mesic forest floor and rotten logs is another hint for its generic identity.

Species in the QSBG Limestone Glass House

Brachythecium buchananii (Hook.) A.Jaeger

Ecology and habitat On soil in the glass house. In nature, species of *Brachythecium* are found mostly on forest floors, base of trees and roots, also in some swampy sites, bogs, by stream banks and shaded hillsides.

Number of species in the genus 3 species, around 12 species in Asia, and about 149 species in the world. The genus is worldwide in distribution.

Distribution Cosmopolitan.

Sporophyte observed None.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Brachythecium buchananii — Habit. (Photo by Luong Thien Tam)



Branch and leaf of *Brachythecium buchananii*. (Photo by Henrietta P.M. Woo)

BRACHYTHECIACEAE

Eurhynchium Bruch & Schimp.

Description of the genus Plants pleurocarpous, mostly small to medium sized in intricate mats, glossy. Stems creeping, irregular branched, branches sometimes complanate. Leaves ovate-lanceolate, acute to long acuminate, slightly decurrent at base, smooth, plicate in some species; margin mostly serrate, at times serrulate. Costa single, reaching above midleaf, ending in a minute spine on back of the lamina. Leaf cells linear or rhomboidal-elongate, smooth, basal cells shorter, broader, alar cells not well differentiated. Setae elongate, smooth or papillose distally. Capsule horizontally oriented, ovoid or elongate; opercula lid long rostrate. Peristome teeth double. Calyptra cucullate.

Eurhynchium looks like a *Brachythecium* with strongly toothed margins. Leaves of this genus are mostly ovate to broadly ovate-lanceolate, and have a broader ratio of width to length than the leaves of many species of *Brachythecium*.

Species in the QSBG Limestone Glass House

Eurhynchium savatieri Schimp. ex Besch.

Ecology and habitat On rocks and soil in QSBG. Found in less disturbed forest from low to high elevations.

Number of species in the genus 3 species occur in Thailand and about 26 species worldwide.

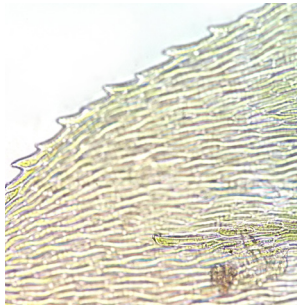
Distribution The genus is nearly worldwide in distribution. *Eurhynchium savatieri* is widespread in Asia.

Sporophyte observed None.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Eurhynchium savatieri — Habit. (Photo by Luong Thien Tam)



Leaf and leaf costa of *Eurhynchium savatieri*.
(Photo by Henrietta P.M. Woo)

Rhynchostegium Schimp.

Description of the genus Plants pleurocarpous, mostly small, some species are of medium-sized, irregularly to slightly bipinnately branched; branches more or less straight when dry. Stem and branch leaves erect to patent, straight, or slightly complanate, narrowly ovate to lanceolate; apex narrowed and long acuminate, twisted. Costa single, smooth or occasionally ending in a small spine on dorsal side of the lamina; margin strongly to finely denticulate above. Median laminal cells linear, abaxially prorate; alar cells undifferentiated in many species, or quadrate to elongate-rectangular and somewhat widened, forming small indistinct group in other species. Setae usually papillose distally. Capsule horizontal or inclined; operculum rostrate. Peristome teeth double. Calyptra cucullate.

The genus is often described as a member of the Family Brachytheciaceae with narrowly lanceolate leaves. The leaf margins are not strongly serrate like the leaves of *Eurhynchium* in the same family. The opercular lid is long-rostrate which is different from that seen in the capsule of a *Brachythecium* that has a conical opercular lid.

Species in the QSBG Limestone Glass House

Rhynchostegium celebicum (Sande Lac.) A.Jaeger

Ecology and habitat On rocks and soil in QSBG. Found also in forested places around the world at elevations below 1,000 m.

Number of species in the genus 4 species occurred in Thailand, about 15 species in Asia, and 127 species worldwide.

Distribution Nearly cosmopolitan

Sporophyte observed None.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Rhynchoszegium celebicum — Habit. (Photo by Luong Thien Tam)



Leaf of *Rhynchoszegium celebicum*. (Photo by Ummul-Nazrah Abdul Rahman)

Brachymenium Schwägr.

Description of the genus Plants pleurocarpous, caespitose, forming cushion. Stems erect. Leaves ovate, oblong-ovate or oblong-lanceolate, acute or obtuse; margins bordered, nearly entire or toothed near apex. Costa single, stout, percurrent or excurrent. Laminal cells elongate to rhomboid-hexagonal, thin to thick walled, alar cells often not well differentiated. Setae very long. Capsule erect, ovoid to clavate, the apophysis distinct to \pm indistinct, tapered to the seta, operculum lid conic to dome-shaped. Peristome teeth double, often somewhat reduced. Calyptra cucullate.

The genus is at times indistinguishable vegetatively from *Bryum* by its similar erect habit and sharing the same leaf areolation typical of the Family Bryaceae. However, it can be separated from *Bryum* by its erect and turbinated shaped capsule.

Species in the QSBG Limestone Glass House

Brachymenium nepalense Hook.

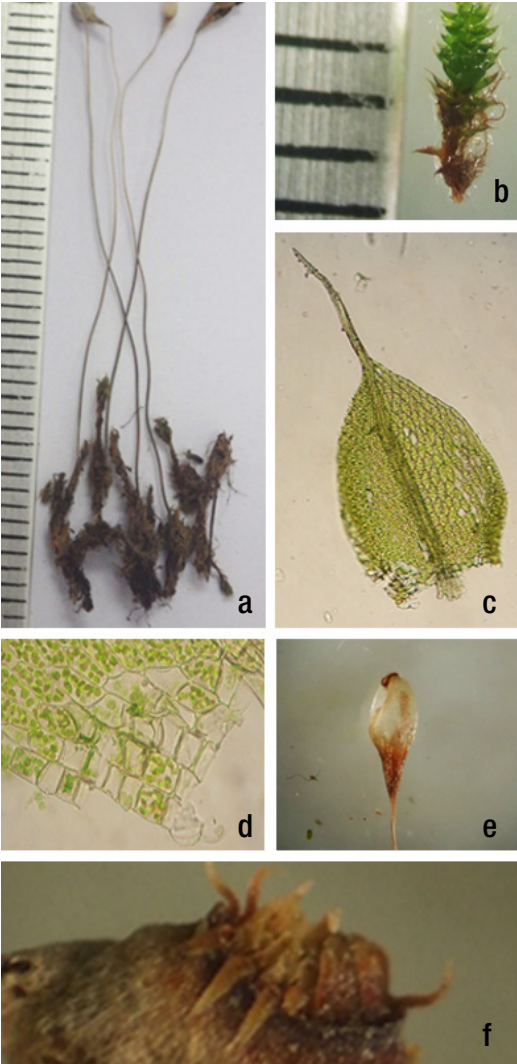
Ecology and habitat On rock at QSBG. In nature, species of *Brachymenium* are often epiphytic on branches and tree trunks.

Number of species in the genus 6 species in Thailand, about 10 species in Asia, and 96 species in the world.

Distribution *Brachymenium nepalense* is common in Thailand and Asia. The genus is mainly distributed in the tropics and extending into sub-temperate regions.

Sporophyte observed Yes.

Authors: Sythat Setthavanxay & Wattana Tanming



Brachymenium nepalense — **a.** Plants with sporophyte; **b.** Shoot; **c.** Leaf; **d.** Alar region; **e.** Capsule; **f.** Peristome teeth.
(Photos by Sythat Setthavanxay & Wattana Tanming)

Bryum Schwägr.

Description of the genus Plants acrocarpous, densely tufted. Stems erect, little branched. Lower leaves small and distant, upper ones larger and often crowded in comal tufts, ovate to lanceolate, sometimes obovate-oblong. Leaf cells smooth, rhomboid to hexagonal in upper part, rectangular in lower part; marginal border mostly differentiated, entire, denticulate, serrulate, rarely serrate. Seta long with curved or hooked tip. Capsule usually pendulous, cylindrical to pyriform to oblong. Peristome teeth double, often complete. Calyptra cucullate, smooth.

Bryum is the largest genus in the Family Bryaceae. Its lax leaf areolation with single costa, oval to rectangular cells, and little or no alar differentiation is typically shared by members of the family. The capsules of many species in this genus are pendulous or inclined. The double peristome teeth in members of Bryaceae is a good diagnostic feature for the family.

Species in the QSBG Limestone Glass House

Two species: *Bryum capillare* Hedw. and *B. coronatum* Schwägr. The short turbinate capsule with a short and thick neck and leaves strongly twisted when dry are diagnostic features for *B. coronatum*. The nearly excurrent and lanceolate leaves with a pendulous and oblong capsule is the diagnostic feature of *B. capillare*.

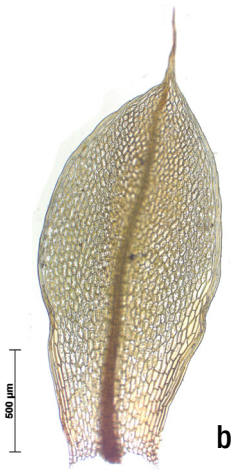
Ecology and habitat On rocks in QSBG. In nature, members of this genus mostly grow in disturbed and open sites and can become weedy.

Number of species in the genus 18 species in Thailand, some 40 species in Asia and about 440 species distributed around the world.

Distribution Cosmopolitan. Common in Thailand.

Sporophyte observed Yes.

Authors: Sythat Setthavanxay & Wattana Tanming



Bryum capillare — **a.** Habit; **b.** Leaf.
 (Photos by Luong Thien Tam, Sythat Setthavanxay & Wattana Tanming)



Bryum coronatum — **a.** Habit; **b.** Capsule.
 (Photos by Luong Thien Tam, Sythat Setthavanxay & Wattana Tanming)

Octoblepharum Hedw.

Description of the genus Plant acrocarpous, tufted, whitish, with a tinge of green. Stems erect, simple, rarely branched. Leaves whitish, ligulate, thick and rigid, erect-spreading from slightly enlarged bases. Costa strong, stout. Leaf cells small, quadrate to rounded-hexagonal, smooth, not conspicuous when viewed under the field lens or light microscope because of the many layers of overlapping larger dead cells. Setae 4–7 mm long, erect, smooth. Capsule ovoid to oblong, erect; lid conical-rostrate. Peristome teeth single. Calyptra cucullate, smooth.

With a whitish colored population, this genus looks like *Leucobryum* plants with rigid thick leaves. *Octoblepharum* has been traditionally placed in the Family Leucobryaceae because of the superficial resemblance of the thick whitish leaves consisting of many layers of empty dead cells. However it has been proven to belong to Calymperaceae based on characters of the peristome with support from molecular phylogenetic studies.

Species in the QSBG Limestone Glass House

Octoblepharum albidum Hedw.

Ecology and habitat On soil and rock in QSBG glass house. On trees and trunk base in forest and national parks, at times found also growing in shaded corner of city parks and gardens.

Number of species in the genus 1 species for Thailand, 3 species in Asia, with about 16 species in the world.

Distribution Found in most tropical to temperate regions of the world.

Sporophyte observed None.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Octoblepharum albidum — Habit. (Photo by Luong Thien Tam)



Cross section of leaf of *Octoblepharum albidum*.
(Photo by Phetlasy Souladeth)

Campylopus Brid.

Description of the genus Plants acrocarpous, small to large. Stems erect, little branched. Leaves erect to appressed wet or dry, oblong-lanceolate to lanceolate-linear, narrow in laminal width, with acuminate tip, often ends in a hairpoint. Costa very broad, c. 2/3 of the leaf width, usually with lamellae formed on dorsal side. Upper laminal cells subquadrate to rhomboid, alar cells well differentiated, large and thin-walled, conspicuous, colored. Setae straight or sinuate when dry. Capsule ovoid to short cylindrical, often striate when dry, operculum rostrate. Peristome teeth single, in 16 teeth, bifid. Calyptra cucullate fringed with cilia in lower part.

The genus is easily identified by its broad leaf costa and the conspicuously enlarged and colored alar cells on leaf basal corners. The male plant forms a conspicuous terminal floral bract, while the female plant also forms a comal terminal leafy structure with many young sporophytes attached. Recent molecular phylogeny included members of the subfamily Campylopoideae into the Leucobryaceae, which is not followed here.

Species in the QSBG Limestone Glass House

Campylopus ericoides (Griff.) A. Jaeger and *C. zollingerianus* (Müll. Hal.) Bosch & Sande Lac. The differences between these two species lie in the complex costal anatomy that needs a dissecting microscope to see the details in order to get a correct species identification.

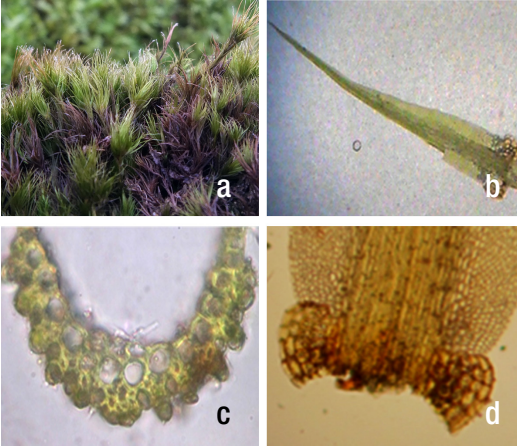
Ecology and habitat On rock in QSBG. The genus is the most common erect mosses which form large patches of cushion on open slopes on high mountains.

Number of species in the genus 9 species in Thailand, c. 20 species in Asia, and some 150 species around the world.

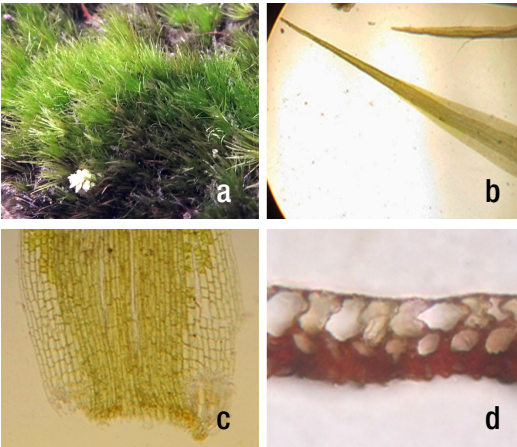
Distribution The genus is common in Thailand and Asia; also cosmopolitan in the world. The two *Campylopus* found in the limestone greenhouse are both common species in Asia.

Sporophyte observed None.

Authors: Sythat Setthavanxay & Wattana Tanming



Campylopus ericoides — **a.** Habit; **b.** Leaf; **c.** Cross-section of the leaf costa; **d.** Leaf base showing differentiated alar cells.
(Photos by Phetlasy Souladeth)



Campylopus zollingerianus — **a.** Habit; **b.** Leaf; **c.** Leaf base; **d.** Cross-section of the costa. (Photos by Phetlasy Souladeth)

Fissidens Hedw.

Synonyms *Conomitrium* Mont., *Octodiceras* Brid.

Description of the genus Plants mostly acrocarpous, terrestrial or epiphytic, minute to large-sized. Stems erect, simple or with a few lateral branches, with or without hyaline nodules on stem and branches. Leaves distichously arranged, complanate, each composed of a dorsal and a ventral lamina and two additional vaginant laminae. Costa single, percurrent to excurrent. Laminal cells usually small, isodiametric, smooth or papillose, often differentiated at the margins called limbidium. Sporophytes terminal or lateral, mostly exserted. Capsule erect or inclined, symmetrical or asymmetrical; operculum conical and apiculate to rostrate. Peristome teeth single, each tooth can be forked apically. Calyptra smooth or rough, mostly cucullate.

Fissidens is easily identified by its distichously arranged leaves on two sides of the stem and branches. The presence of vaginant laminae also identifies the genus.

Species in the QSBG Limestone Glass House

Fissidens pellucidus Hornsch. and *Fissidens crispulus* Brid. The former is characterized by having large smooth leaf cells with distinct globules inside the cell. The latter is characterized by having strongly developed hyaline nodules on the stem and branches and with mammillose leaf cells. Both species are common *Fissidens* on soil in disturbed sites.

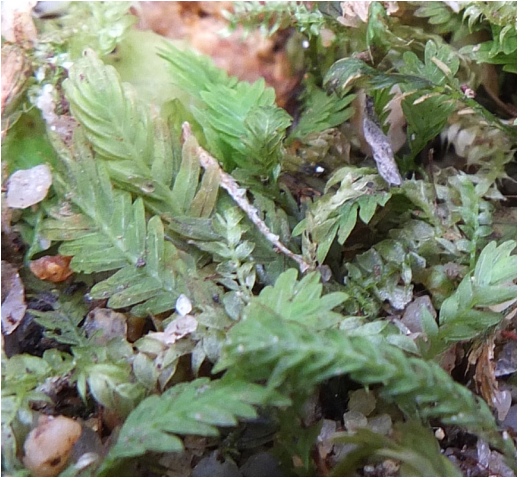
Ecology and habitat Grows on rocks and soil in the glass house at QSBG. In nature, species of *Fissidens* grow on many different substrates, mostly on moist soil and wet rocks in forest and by the stream.

Number of species in the genus 15 species in Thailand, about 40 in Asia, and c. 440 species worldwide.

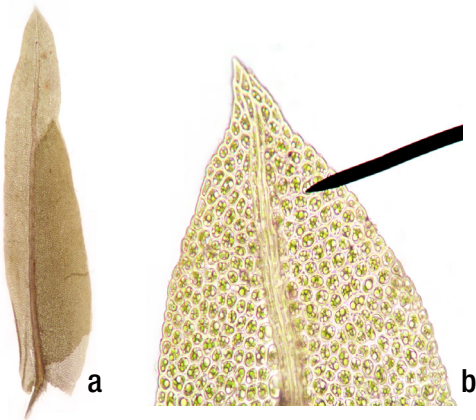
Distribution Cosmopolitan. This genus is the largest and most widely distributed group of mosses in Thailand.

Sporophyte observed Plenty of sporophytes seen.

Authors: Fulgent Coritico & Syahida-Emiza Suhaimi



Fissidens crispulus — Habit. Note the flattened leaves are arranged in two neat rows. (Photo by Luona Thien Tam)



Fissidens pellucidus — **a.** Leaf. Note the extra vaginant lamina; **b.** Close-up of leaf apex. (Photos by Syahida-Emiza Suhaimi & Fulgent P. Coritico)

Funaria Hedw.

Description of the genus Plants acrocarpous, tufted, soft-looking, less than 2 cm tall. Stems erect, little branched. Leaves increasingly in size and also becoming cluster at stem apex. Leaves oblong-lanceolate to obovate. Costa slender, ending below apex. Leaf cells lax in appearance, smooth, rhomboidal above, rectangular toward base. Setae long, erect, smooth. Capsule curved and asymmetrical, smooth and sulcate. Peristome teeth double, strongly developed, the tips of endostomial segments united distally forming a fragile mesh. Calyptra cucullate, smooth.

The genus is easily identified by its asymmetrically shaped capsule that looks like the head of a golf club.

Species in the QSBG Limestone Glass House

Funaria hygrometrica Hedw.

Ecology and habitat On soil in QSBG. Terrestrial or epilithic. *Funaria hygrometrica* is an erect moss commonly found in open, burnt area. Species of this genus grow often on shady and damp soil in open and disturbed locations. Some species may be seen growing in rocks crevices. Distributed from 100–1700 m elevation.

Number of species in the genus 2 species in Thailand, about 5 species in Asia, and 80 species described from all over the world.

Distribution Cosmopolitan.

Sporophyte observed Commonly seen.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Funaria hygrometrica — Leaf. (Photo by Ummul-Nazrah Abdul Rahman)



Capsule of *Funaria hygrometrica*. (Photo by Ummul-Nazrah Abdul Rahman)

Physcomitrium (Brid.) Brid.

Description of the genus Plants acrocarpous, tufted, soft-looking, less than 1 cm tall. Stems erect, little branched. Leaves few, oblong-lanceolate to obovate. Costa slender, ending below apex or slightly excurrent. Leaf cells lax in appearance, smooth, rhomboidal above, rectangular toward base, thin-walled. Setae long, erect, smooth. Capsule erect, small, symmetric, turbinate or top-shaped, smooth. Peristome none. Calyptra cucullate to mitrate, smooth.

The genus is easily identified by its small top-shaped and eperistomate capsule and the laxly areolated leaves. It is an erect moss commonly found along stream banks and moist rice fields.

Species in the QSBG Limestone Glass House

Physcomitrium eurystomum Sendtn. and *P. sphaericum* (C.F.Ludw.) Füllnr. *Physcomitrium eurystomum* is a new record for the Thailand moss flora.

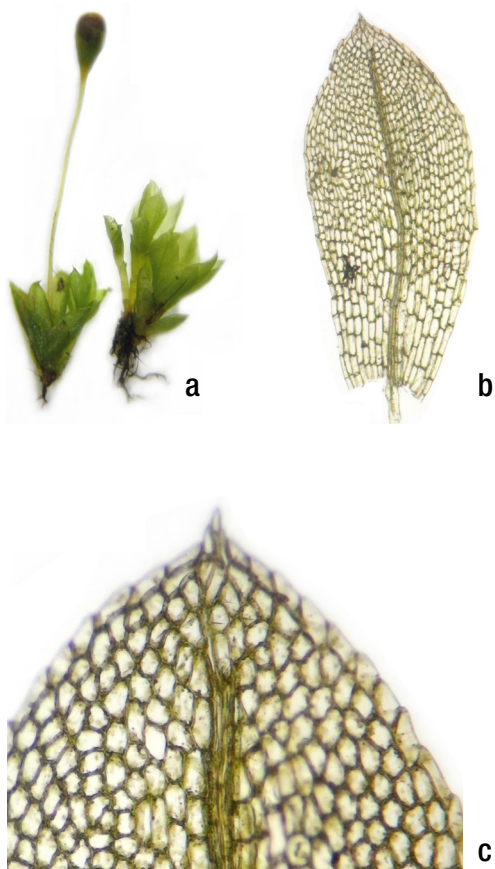
Ecology and habitat Terrestrial. On soil by a stream at the fernery and wet soil bank near the Limestone Glass House QSBG. The species of *Physcomitrium* are mostly seasonal, appearing soon after the wet months on moist, shady and damp soil bank at low elevation.

Number of species in the genus 3 species in Thailand, 10 species in Asia, and 65 species around the world.

Distribution Cosmopolitan.

Sporophyte observed Yes.

Author: Benito C. Tan



Physcomitrium eurystomum — a. Habit; b. Leaf; c. Leaf apex
(Photos by Luong Thien Tam)

Ectropothecium Mitt.

Description of the genus Plants pleurocarpous, slender to rather robust, yellowish green or brownish green, somewhat glossy. Stems prostrate, creeping, sometimes ascending forming extensive mats, irregularly to pinnately branched, branches sometimes ascending. Stem leaves and branch leaves different in size, more or less similar in shape, falcate, ovate- or ovate-lanceolate, at times asymmetric, base slightly decurrent. Costae double, short, weak or distinct. Leaf cells mostly elongate to linear, mostly smooth, sometimes prorate; basal cells shorter and broader; alar cells few, small, quadrate or shortly rectangular, not inflated, but with one or two corner cells clearly inflated. Setae elongate, smooth. Capsule horizontal to inclined, small, ovoid to shortly oblong, often constricted below the mouth when dry; opercular lid apiculate to conical. Peristome teeth double. Calyptra cucullate, smooth, sometimes hairy.

Ectropothecium is a large genus in the Family Hypnaceae. It is a much branching and creeping moss found on rotten logs and forest floor. The leaves are mostly falcate, ecostate or with only two short costae. The laminal cells are mostly smooth, elongate to linear.

Species in the QSBG Limestone Glass House

Ectropothecium zollingeri (Müll. Hal.) A.Jaeger

Ecology and habitat On soil and rocks inside the glass house. Also at base or trunk of trees, rotten wood, or rocks and soil in forests. Although the genus can be present at elevations of up to 1,700 m in the tropics, more species occur at lower elevations.

Number of species in the genus 21 species in Thailand, more than 35 species in Asia, and about 205 species worldwide. The genus seems over inflated in the number of species which need a thorough revision.

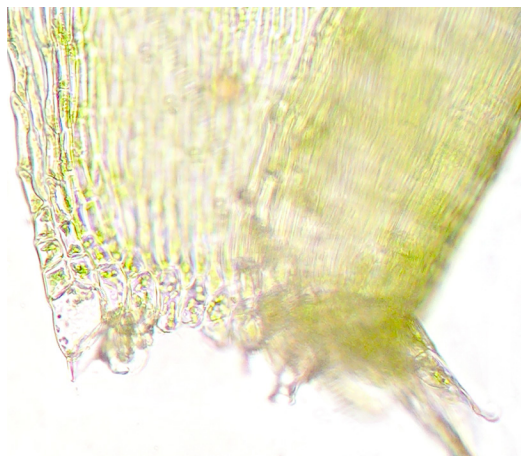
Distribution Common in tropical and warm temperate regions.

Sporophyte observed Frequently produced.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Ectropothecium zollingeri — Habit. (Photo by Luong Thien Tam)



Leaf base of *Ectropothecium zollingeri*
(Photo by Ummul-Nazrah Abdul Rahman)

Vesicularia (Müll. Hal.) Müll. Hal.

Description of the genus Plants pleurocarpous or creeping, slender or somewhat robust, pale green, in flattened mats. Stems prostrate, somewhat radiculose, simple or irregularly branched, rarely pinnately branched, branches usually short, flattened, at times ascending. Leaves flat in appearance, ovate to lanceolate, acute to acuminate, margins entire or serrulate near apex, somewhat bordered by a row of elongate cells. Costae double, short or absent. Leaf cells lax, hexagonal to rhombic, shortly elongate in some species, smooth, thin-walled, alar cells not differentiated. Setae elongate, smooth. Capsule horizontal to inclined, ovoid to oblong-ovoid, constricted below the mouth when dry. Peristome teeth

Vesicularia is a moss genus found frequently on wet ground by the stream bank and wet forest floor. The genus is easily identified in the Family Hypnaceae with straight and flattened leaves that have two short costae and a lax areolation consisting of ovate to broadly oblong, thin-walled cells.

Species in the QSBG Limestone Glass House

Vesicularia reticulata Broth.

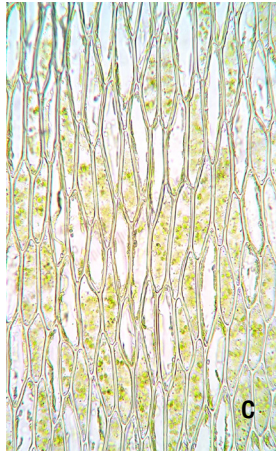
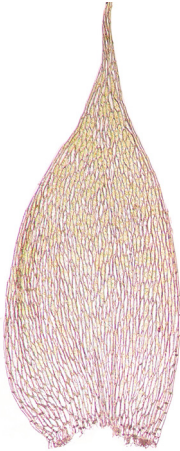
Ecology and habitat Grows on soil and on rocks at QSBG. In natural forested places, species of *Vesicularia* are found in wet stream banks and moist forest floors.

Number of species in the genus 6 species in Thailand, 15 species in Asia, and 116 species worldwide.

Distribution A cosmopolitan genus; less number of species in dry parts of the world, such as the Mediterranean region.

Sporophyte observed Frequently seen.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Vesicularia reticulata — a. Habit; b. Leaf; c. Leaf cells.

(Photos by Syahida-Emiza Suhaimi, Fulgent P. Coritico & Ummul-Nazrah Abdul Rahman)

Claopodium (Lesq. & James) Renaud & Cardot

Description of the genus Plants pleurocarpous, creeping, slender to medium-sized, mat-forming. Stems subpinnately to pinnately branched, densely foliate, with few paraphyllia. Stem and branch leaves incurved and appressed when dry, different in size, ovate lanceolate, contracted to a long, subulate point; margin serrulate, decurrent at base. Costa single, excurrent. Leaf cells oblong to rhomboid-hexagonal, obscure, unipapillose or multipapillose; apical leaf cells elongate and smooth; alar cells not well differentiated. Setae long, papillose. Capsule ovoid to oblong, inclined, opercular lid long rostrate. Peristome teeth double. Calyptra cucullate, not hairy.

This genus is identified by leaves having single, excurrent costa and papillose leaf cells. It has sometimes been considered a member of Thuidiaceae, as suggested from the dense groups of papillae on the stems and branches reminiscence of the paraphyllia seen in members of the Thuidiaceae. However, the irregularly branching and the undifferentiated stem and branch leaves sets it apart from Thuidiaceae and closer to Leskeaceae which has been supported with recent molecular phylogenetic studies.

Species in the QSBG Limestone Glass House

Claopodium prionophyllum (Müll. Hal.) Broth.

Ecology and habitat *Claopodium prionophyllum* grows in small population on rock surfaces in the QSBG. Other species of this genus also grow on bases of tree trunks, boulders, and on forest ground.

Number of species in the genus 2 species in Thailand, 9 species in Asia, and 13 species worldwide.

Distribution A genus, with a center of species diversity in Asia and a few outlier species in North America and Europe.

Sporophyte observed Yes.

Author: Benito C. Tan



Claopodium prionophyllum — **a.** Habit; **b.** Close-up of plant; **c.** Leaf apex; **d.** Leaf marginal cells. (Photos by Narin Printarakul)

Leucobryum Hampe

Description of the genus Plants mostly acrocarpous, small to large-sized, up to 5 cm tall, usually compactly tufted, forming pale, greenish-white to yellowish cushions or mats. Stems erect, simple, rarely branched. Leaves mostly falcate-secund, lanceolate and acuminate, smooth, or scabrid to rough on dorsal side at apex. Costa single, thick and broad, in section with leucocysts or empty dead cells in a single abaxial and adaxial layers sandwiching a layer of small, green living cells called chlorocysts; below mid leaf, the costal thickness becomes consisting of 2-3(4) layered of dead cells. Setae long, straight or flexuose. Capsule inclined and gibbose, strumose at neck position. Peristome teeth single. Calyptra cucullate, smooth.

Leucobryum is easily identified by its thick, falcate and whitish leaves made up of several layers of dead cells or leucocysts sandwiching a layer of living green cells or chlorocysts. Known as 'white moss' in many local languages in Asia.

Species in the QSBG Limestone Glass House

Leucobryum aduncum Dozy & Molk. var. *scalare* (Müll. Hal. ex M.Fleisch.) A.Eddy

Ecology and habitat On soil in shaded corner inside QSBG. In nature, large populations of many species of this genus grow on logs, stumps, tree trunks and forest floors.

Number of species in the genus 9 species in Thailand, 14 species in Asia, and 83 species worldwide.

Distribution Cosmopolitan.

Sporophyte observed None.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Leucobryum aduncum var. *scalare* — **a.** Habit; **b.** Leaf; **c.** Cross section of leaf. (Photos by Luong Thien Tam and Yoghi Budhiyanto)

Aerobryidium M.Fleisch. ex Broth.

Description of the genus Plants pleurocarpous, robust. Stems and branches pendulous, short to long, tumid, densely leaved. Leaves ovate to lanceolate, usually with a long, flexuose or crispate acumen and a rounded to cordate base. Costa single. Laminal cells oblong to elongate, unipapillose, cell-walls thin to thick, scarcely porose. Seta elongate, scabrous. Capsule oblong, erect. Peristome teeth double. Calyptra cucullate, smooth.

Aerobryidium is distinctive in having a long stem with pendulous or hanging branches. The unicostate leaves ending in a long and crispate apex is distinctive.

Species in the QSBG Limestone Glass House

Aerobryidium aureonitens (Hook. ex Schwägr.) Broth.

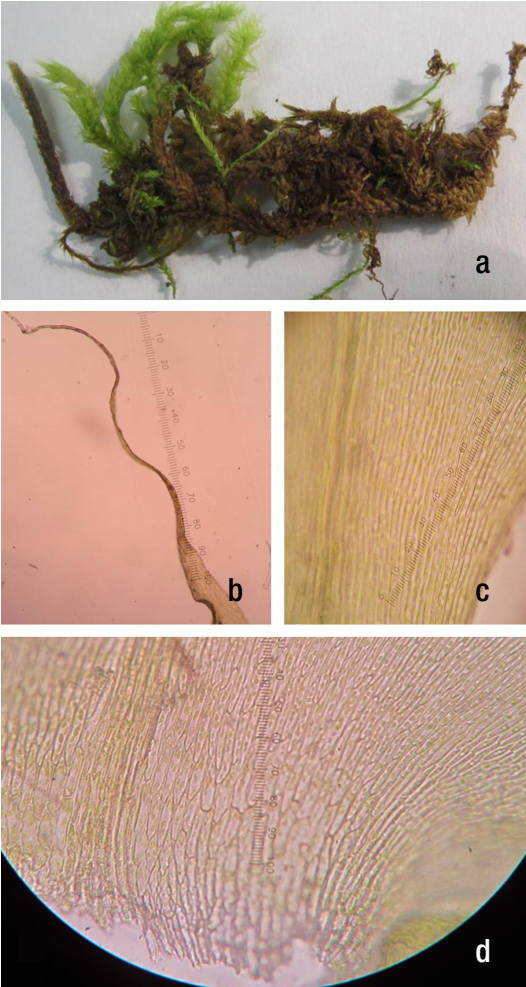
Ecology and habitat *Aerobryidium aureonitens* grows on tree trunk and branches of plants in the QSBG. In nature, species of this genus also grow epiphytically on branches and tree trunks in forests.

Number of species in the genus 3 species in Thailand, 4 species in Asia and the world.

Distribution The genus is widespread in tropical and subtropical Asia, not reported from the African and American continents.

Sporophyte observed None.

Authors: Nootjaree Tathana & Dek Vimeanreaksmey



Aerobryidium aureonitens — **a.** Habit; **b.** Leaf apex; **c.** Median leaf cells; **d.** Basal leaf cells. (Photos by Nootjaree Tathana & Dek Vimeanreaksmey)

Cryptopapillaria M.Menzel

Synonyms *Papillaria* (Müll. Hal.) Lorentz sect. *Penicillatae* Broth.; *Papillaria* sect. *Cryptopapillaria* M.Fleisch. *nom. illeg.*

Description of the genus Plants pleurocarpous, mostly slender. Stems and branches pendulous, short to long, tumid, densely leaved. Leaves appressed, wet or dry, ovate lanceolate, acute to acuminate, with a large, cordate base; margins entire, but toothed at the basal alar lobes. Costa single. Laminal cells oblong to elongate, multipapillose on thick cell-walls. Setae short. Capsule nearly sessile or emergent, oblong. Peristome teeth double. Calyptra mitrate, hairy.

As a member of the Family Meteoraceae, *Cryptopapillaria* is also distinctive in having a long stem with pendulous or hanging branching habit. It is best identified by the uncostate leaves, the multipapillose lateral cell walls, and the hairy and mitrate calyptra covering the upper part of emergent capsule.

Species in the QSBG Limestone Glass House

Cryptopapillaria fuscescens (Hook.) M.Menzel

Ecology and habitat *Cryptopapillaria fuscescens* occurs on tree trunks and branches of plants in the QSBG. In nature, species of *Cryptopapillaria* also is epiphytic on branches and tree trunks.

Number of species in the genus 3 species in Thailand, 5 species in Asia and the world.

Distribution The genus is widespread in Asia, not known from the American and African continents.

Sporophyte observed None.

Author: Benito C. Tan



Cryptopapillaria fuscescens — Habit. (Photo by Luong Thien Tam)

Meteoriopsis M.Fleisch. ex Broth.

Description of the genus Plants pleurocarpous, medium size in the family, forming extensive hanging populations. Stems long creeping, pendent, subpinnately branched and densely leaved. Branches more or less erect. Leaves on stem and branches broadly ovate to ovate-oblong, with abruptly narrow, long and recurved apex, squarrose, or widely spreading, margins serrulate. Laminal cells pellucid, linear-rhomboidal, thin-walled, usually with 1, rarely 2–3 papillae. Setae short. Capsule oblong, erect, emergent. Peristome teeth double. Calyptra mitrate.

In the family Meteoriaceae, the genus is most easily identified by its squarrose or widely spreading and recurved branch leaves.

Species in the QSBG Limestone Glass House

Meteoriopsis squarrosa (Hook.) M.Fleisch. ex Broth.

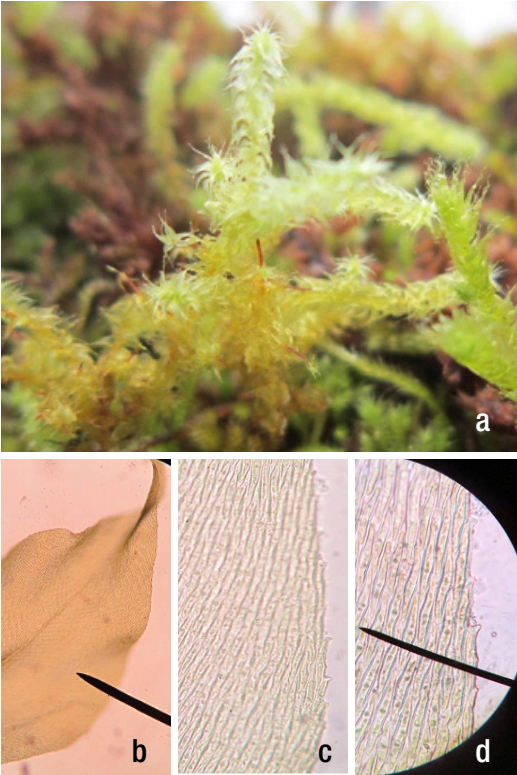
Ecology and habitat On rock at the limestone glass house of QSBG. In humid forests, species of *Meteoriopsis* form also large patches of drape-like populations on branches.

Number of species in the genus 3 species in Thailand, 4 species in Asia, and 10 in the world. Many species of *Meteoriopsis* are variable and are recognized for their many varietal forms seen in nature.

Distribution Widespread in Asia, Australasia and southern South America in forests from mid-elevation to high mountains.

Sporophyte observed None.

Authors: Nootjaree Tathana & Dek Vimeanreaksmey



Meteoriopsis squarrosa — **a.** Habit; **b.** Leaf; **c.** Median marginal leaf; **d.** Apical marginal leaf.

(Photos by Nootjaree Tathana & Dek Vimeanreaksmey)

Trachycladiella (M.Fleisch.) M.Menzel

Synonyms *Floribundaria* M.Fleisch. sect. *Trachycladiella* M.Fleisch.

Description of the genus Plants pleurocarpous, slender, dull light green in color. Stems elongate, irregularly branched to laxly pinnately branched, densely leaved. Leaves ovate-lanceolate to oblong-lanceolate, long acuminate to subulate; margins slightly undulate, entire to serrulate. Laminal cells clear or obscure, sublinear to rhomboidal, multi-papillose on lateral cell walls, alar cells weakly developed at leaf base. Costa single. Setae short. Capsule oblong, erect. Peristome teeth double. Calyptra mitrate.

The genus has long slender stem and branches. The plant has many papillae on lateral cell walls and a short emergent capsule. The sterile specimen can be confused with species of *Trachypus* with similar leaf areolation, the latter is also found in the Limestone Glass House of the QSBG.

Species in the QSBG Limestone Glass House

Trachycladiella sparsa (Mitt.) M.Menzel.

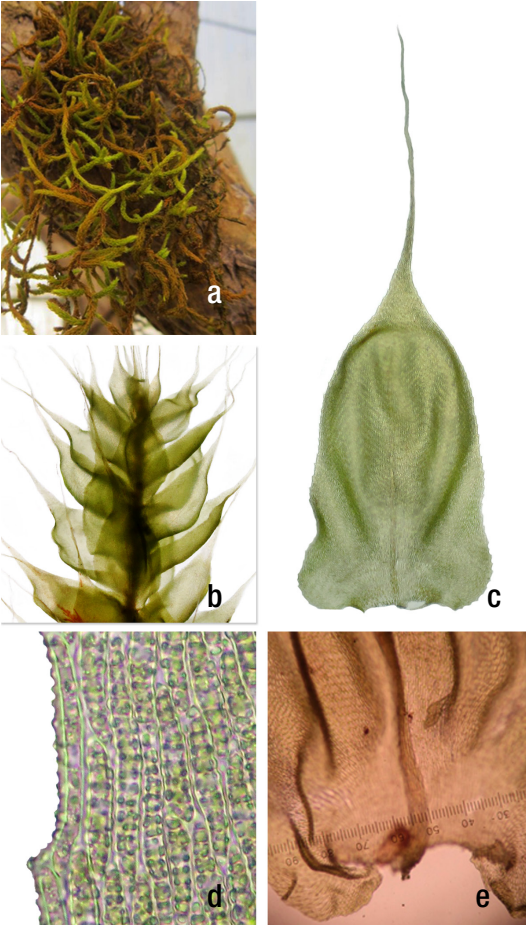
Ecology and habitat On tree-trunks in the QSBG. Species of *Trachycladiella* also grow attached to tree trunks in natural forests.

Number of species in the genus 2 species in Thailand and 2 species in Asia and the world.

Distribution A widespread pendulous genus restricted to warm Asian tropics.

Sporophyte observed None.

Authors: Neetjoree Tathana & Dek Vimeanreaksmey



Trachycladiella sparsa — a. Habit; b. Close-up of plant; c. Leaf apex; d. Leaf marginal cells; e. Leaf base.

(Photos by Narin Printarakul, Nootjaree Tathana & Dek Vimeanreaksmey)

Trachypus Reinw. & Hornsch

Description of the genus Plants pleurocarpous, slender to fairly robust, densely tufted plants. Secondary stems creeping, subpinnately branched, densely foliate. Leaves incurved and appressed when dry, spreading when wet, ovate lanceolate to narrowly lanceolate, contracted to a long, subulate point. Costa single, short. Leaf cells elongate, obscure due to the dense papillae on lateral cell walls, margins denticulate above, with well differentiated basal part of smooth leaf cells; alar cells differentiated in auricular leaf base. Setae long, papillose to spinose. Capsule ovoid, erect. Peristome teeth double. Calyptra cucullate, hairy.

This genus is identified by leaves having single costa and pleuripapillose leaf cells with the papillae lining the lateral cell walls. The long seta with ovoid capsule is also diagnostic for the genus. The genus previously belongs in the Family Trachypodaceae.

Species in the QSBG Limestone Glass House

Trachypus bicolor Reinw. & Hornsch.

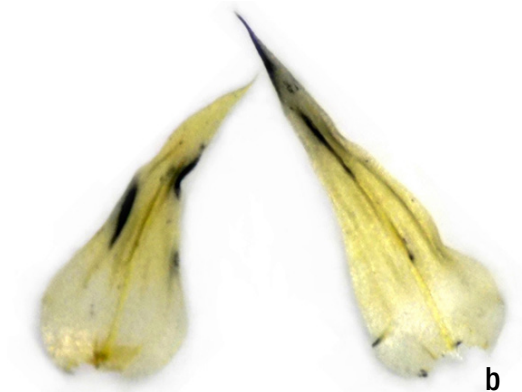
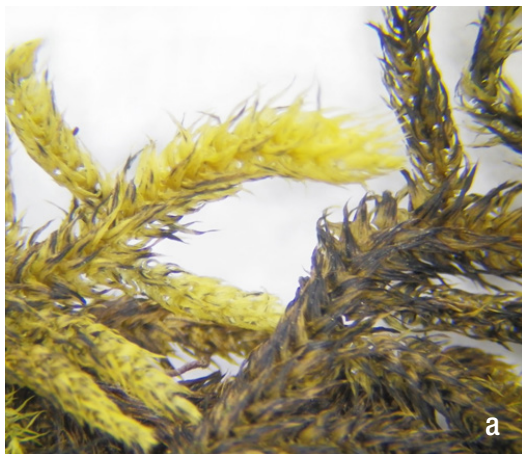
Ecology and habitat On rock and soil in the greenhouse at QSBG. In nature, species of *Trachypus* are found growing mostly on forest ground and tree trunks, rarely on branches like members of the Family Meteoraceae.

Number of species in the genus 2 species in Thailand, 4 species in Asia, and 5 species in the world.

Distribution *Trachypus* is widespread in tropical and warm temperate forests, with a center of diversity in SE Asia. *Trachypus bicolor* is very common in SE Asia, including Thailand.

Sporophyte observed Yes.

Authors: Nootjaree Tathana & Dek Vimeanreaksmey



Trachypus bicolor — a. Close up of plant; b. Leaves.
(Photo by Luong Thien Tam)

Plagiomnium T.J.Kop.

Description of the genus Plants acrocarpous, large, forming tufts or mats. Stems erect and procumbent, with plagiotropic shoots. Leaves on fertile shoot and sterile creeping branches are of two different kinds; often broadly oblong to ovate-oblong, rarely oblong-lanceolate, acute, acuminate to emarginate, with or without decurrent leaf bases, crispate when dry; leaf margins bordered, nearly entire or serrate. Costa single. Leaf cells rectangular to hexagonal-rounded, basal cells large and lax. Setae long, smooth to mammillose distally. Capsule inclined to pendulous, operculum conical to dome-shaped or rostrate. Peristome teeth double. Calyptra cucullate.

The genus is identified by having two kinds of branches, both erect and creeping types. The crispate leaves when dry and the preference of wet habitats help in the field identification of members of this genus.

Species in the QSBG Limestone Glass House

Plagiomnium succulentum (Mitt.) T.J.Kop.

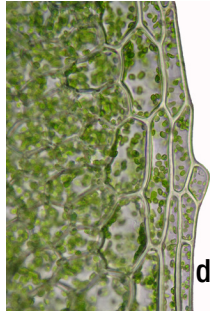
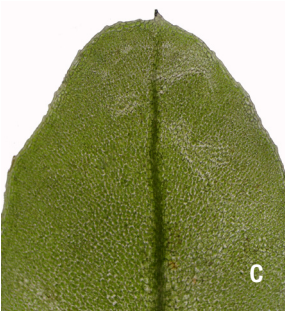
Ecology and habitat On rocks in the QSBG. Species of *Plagiomnium* prefer wet and shaded habitats along streams and rivers in forest.

Number of species in the genus 5 species in Thailand, 17 species in SE Asia, and 25 species in the world.

Distribution *Plagiomnium succulentum* is common in Thailand and in Asia.

Sporophyte observed None.

Author: Sythat Setthavanxay & Wattana Tanming



Plagiomnium succulentum — a. Habit; b. Leaves; c. Leaf apex; d. Leaf margin. (Photos by Narin Printarakul)

Cyclodictyon Mitt.

Description of the genus Plants pleurocarpous, creeping, mat-forming, soft looking. Stems creeping, irregularly branched. Leaves complanately arranged, oblong-ovate, short acuminate, narrowly bordered with elongated narrow cells, more or less toothed above, with lax cell areolation, smooth, light green in color. Costae double, long, extending beyond midrib. Setae long, smooth. Capsule horizontally inclined, opercular lid long-beaked. Peristome teeth double. Calyptra campanulate, naked above, laciniate at base.

This genus is distinctive in having strong and long, double costae, a clearly differentiated leaf border, and lax leaf cells that are large, round to hexagonal and smooth. It was formerly included in a broadly defined Hookeriaceae.

Species in the QSBG Limestone Glass House

Cyclodictyon blumeinum (Müll. Hal.) Kuntze. This is a new species record for Thailand and also for Indochina.

Ecology and habitat On rocks at the QSBG. Species of *Cyclodictyon* prefer humid to wet and shaded places such as creek banks and dark, moist cliff faces.

Number of species in the genus 1 species in Thailand, 1 or 2 species in Asia, and about 90 species in tropical regions of the world.

Distribution The genus has most of its species described from America and Africa, with only 1–2 species in Asia. Previous records of *Cyclodictyon blumeinum* in Asia are from insular Malesia and China, as well as, from tropical India.

Sporophyte observed None.

Authors: Manuel L. Castillo & Mai Ngoc Bich Nga



Cyclodictyon blumeorum — Habit. (Photo by Luong Thien Tam)



Leaf of *Cyclodictyon blumeorum*. (Photo by Manuel L. Castillo)

Barbula Hedw.

Synonyms *Hydrogonium* (Müll. Hal.) A.Jaeger, *Semibarbula* Herzog ex Hilp., *Streblotrichum* P.Beauv.

Description of the genus Plants acrocarpous, small, often under 5 mm, green to yellowish green, in dense tufts. Stems erect, simple or with few branches. Leaves ovate to linear-lanceolate, contorted when dry, erect when moist, acute or rounded apex; margins entire or crenulate. Costa single, stout. Upper leaf cells small, quadrate to rounded-hexagonal, papillose, mammilose or smooth. Setae elongate, smooth. Capsule erect, oblong-ovoid or oblong-cylindrical. Peristome teeth single, filiform, twisted when dry. Calyptra cucullate, smooth.

This genus is identified by its erect plant habit with leaves having multipapillose cells and a long capsule with filamentous peristome teeth.

Species in the QSBG Limestone Glass House

Barbula consanguinea (Thwaites & Mitt.) A.Jaeger.

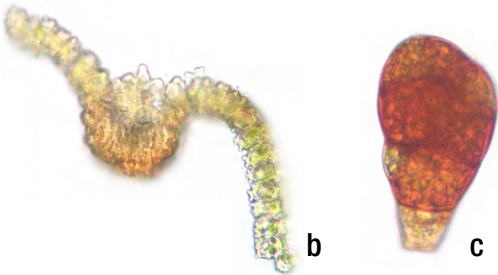
Ecology and habitat On damp soils and rocks. Outside the glass house, species of *Barbula* are common rock inhabitants in dry places.

Number of species in the genus 6 species in Thailand, 15 species in Asia, and 196 species in the world.

Distribution Cosmopolitan.

Sporophyte observed Yes.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Barbula consanguinea — **a.** Habit; **b.** Cross section of leaf;
c. Gemma for asexual reproduction.

(Photos by Luong Thien Tam and Phetlasy Souladeth)

Hyophila Brid.

Description of the genus Plants acrocarpous, small to medium-sized, up to 1.5 cm tall, red to reddish brown or dark green below, in dense tufts. Stems erect, simple, rarely branched. Leaves incurved and twisted when dry, erect spreading when wet, broadly ovate-oblong, oblong-spathulate or oblong-lanceolate to lingulate, blunt to rounded-obtuse or with weakly apiculate apex; margins entire or serrulate. Costa single, stout, percurrent to short-excurrent. Upper leaf cells small, quadrate to rounded-hexagonal, smooth or papillose; basal leaf cells rectangular, smooth, hyaline. Setae elongate, straight. Capsule erect, oblong-cylindrical. Peristome teeth absent. Calyptra cucullate, smooth.

Hyophila is identified by its broad, ovate to lanceolate leaves with smooth ventrally bulging cells. The lack of peristome in the erect capsule and its preferred habitat on limestone and cement substrates help to identify the genus.

Species in the QSBG Limestone Glass House

Hyophila involuta (Hook.) A.Jaeger

Ecology and habitat On soil or damp calcareous and cement rocks. Outside the glass house, species of *Hyophila* are common limey rock dwellers.

Number of species in the genus 4 species in Thailand, 8–10 species in Asia, and 86 species in the world.

Distribution Found in most tropical to temperate regions of the world.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Hyophila involuta — Habit. (Photo by Luong Thien Tam)



Fertile population of *Hyophila involuta*. (Photo by Luong Thien Tam)

Oxystegus (Limpr.) Hilp.

Synonyms *Trichostomum* Bruch subg. *Oxystegus* Limpr.

Description of the genus Plant small to medium sized, up to 1.5 cm, green to yellowish green, in dense tufts. Stems erect, simple, seldom branched. Leaves ovate to linear-lanceolate, contorted when dry, erect when moist, apex acute; margins nearly entire. Costa stout. Upper leaf cells small, quadrate to rounded-hexagonal, multipapillose; basal leaf cells rectangular, less papillose. Seta elongated, smooth. Capsule erect, oblong or oblong-cylindrical. Peristome teeth single, filiform.

This genus is treated in some floras as a synonym of *Trichostomum* Bruch and is differentiated from *Trichostomum* mainly by its long filiform peristome teeth. *Oxystegus cylindricus* has also been treated recently in the North American Flora, as a synonym of *Trichostomum tenuirostre* (Hook. & Taylor) Lindb. var. *tenuirostre*, however, we are accepting the more traditional view here.

Species in the QSBG Limestone Glass House

Oxystegus cylindricus (Bruch ex Brid.) Hilp.

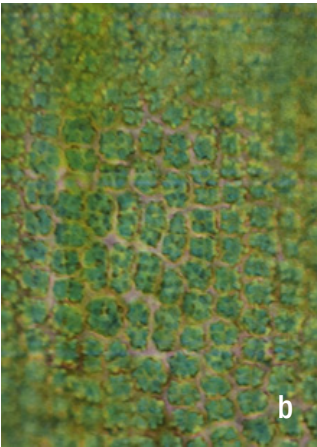
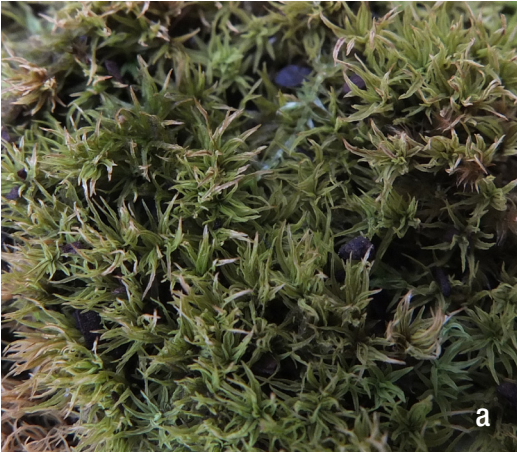
Ecology and habitat On damp soils and rocks. Outside the glass house, species of *Oxystegus* are common ground mosses in dry places.

Number of species in the genus Probably 2 species in Thailand, 5 species in Asia, and about 12 species worldwide.

Distribution Widespread around the world. Common species on calcareous rocks and boulders in Thailand.

Sporophytes observed None.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Oxystegus cylindricus — **a.** habit; **b.** multipapillose leaf cells;
c. transition area of larger basal cells near leaf base.
 (Photos by Luong Thien Tam & Phettasy Souladeth)

Splachnobryum Müll. Hal.

Description of the genus Plants small, erect, up to 10 mm tall, green to orange below, in soft and lax tufts. Stems erect, seldom branched. Leaves ovate-oblong, lingulate, spathulate; apex rounded to acute; margin plane to slightly reflexed, entire below, crenulate to papillose above. Costa single, weakly developed, ending in upper half of leaf to shortly below apex. Laminal cells mostly hexagonal, thin-walled, smooth, flat to slightly bulging; basal leaf cells short to rectangular, also smooth. Setae slender, erect. Capsule ovoid to subcylindric, erect; opercular lid short, conical. Peristome teeth single, short, papillose. Calyptra cucullate.

Splachnobryum looks like a small *Barbula* with smooth leaf cells. Its apical leaf areolation consisting of a row of quadrate cells is distinctive for the genus. The systematic placement of this genus has been a subject of much debate. About 35 years ago, *Splachnobryum* has been formally separated out from Pottiaceae and put in a family of its own Splachnobryaceae based on its unique morphology. More recent molecular phylogenetic studies however, favor the return of this genus back to Pottiaceae.

Species in the QSBG Limestone Glass House

Splachnobryum obtusum (Brid.) Müll. Hal.

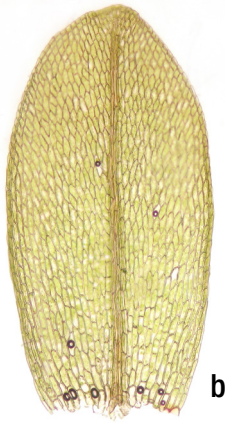
Ecology and habitat On damp soils and rocks. The genus is a ground moss frequently overlooked because of the small plant size.

Number of species in the genus 3 species in Thailand and about 10 species in the world. *Splachnobryum obtusum* is a very recent find in Thailand first collected and reported from Chiang Mai in 2014 by Mr Narin Printarakul at the University of Chiang Mai.

Distribution Widespread and scattered around the world, easily overlooked due to its small plant size.

Sporophyte observed None.

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Splachnobryum obtusum — a. Habit; b. Leaf.
(Photos by Luong Thien Tam) & Phetlasy Souladeth)

Trichostomum Bruch

Description of the genus Plants rather large in the family, densely tufted. Leaves linear-lanceolate, oblong-lanceolate, or ovate-oblong, from a broad, but non-sheathing base; margins plane to involute, entire, or somewhat incurved near the apex when dry; mostly acuminate. Costa single, shortly excurrent. Upper leaf cells small, quadrate to round, thick-walled, papillose, rarely smooth, basal leaf cells rectangular, thin-walled. Setae long, straight. Capsule oblong to cylindrical. Peristome teeth single, short, erect, often bifid at tip. Calyptra cucullate, smooth.

This genus can be described as a large *Barbula* with erect capsule having short peristome teeth. Only one species of this genus, *T. siamense* Broth., is found in the Limestone Glass House of the QSBG. The species is also a Thai endemic moss when accepted as a distinct species. Based on its leaf morphology, the fragile leaf apices and the basal part of lamina of leaf that has a well differentiated, V-shaped area consisting of thin-walled, rectangular and smooth cells, *T. siamense* is most likely a misplaced member of the genus *Tortella* (Lindb.) Limpr. The species however has been considered a synonym of a very broadly defined *Pseudosymbblepharis bombayensis* (Müll. Hal.) P.Sollman, which is not followed here.

Species in the QSBG Limestone Glass House

Trichostomum siamense Broth.

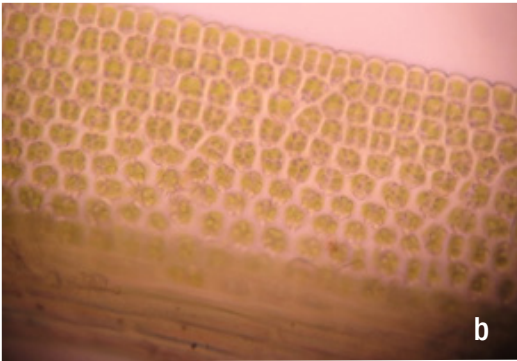
Ecology and habitat On damp soils and rocks. Species of *Trichostomum* are widespread and common mosses found on rocks and boulders, as well as, shaded ground.

Number of species in the genus 5 species in Thailand, 10–12 species in Asia, and more than 100 species in the world.

Distribution A large genus found on all continents, except Antarctica. The genus is widespread in Thailand on calcareous substrates.

Sporophytes observed None

Authors: Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto



Trichostomum siamense — **a.** Habit; **b.** Leaf cells.
(Photos by Khin Myo Htwe, Phetlasy Souladeth & Yoghi Budhiyanto)

Pterobryopsis M.Fleisch.

Description of the genus Plants pleurocarpous, fairly robust, laxly tufted, glossy plants. Secondary stems creeping, woody, branched, densely foliate, and tumid. Leaves erect-spreading, concave, abruptly contracted to a long, subulate point. Costa single or none. Leaf cells oblong-ovate to elongate, smooth; margins entire to denticulate above, with well differentiated basal angle forming a conspicuous alar region. Setae short. Capsule mostly immersed. Peristome teeth double, short, smooth.

This genus is identified by its creeping primary stem, dendroid habit of its secondary stem or main branch, often with pinnate secondary branches, single costate and concave leaves with colored alar and basal region.

Species in the QSBG Limestone Glass House

Pterobryopsis divergens (Mitt.) Nog.

Ecology and habitat On rocks in the QSBG. Species of *Pterobryopsis* is primarily found in tropical and subtropical regions; many species live on both limestone rocks and trees.

Number of species in the genus 8 species in Thailand, 12 species in Asia, and 29 in the world.

Distribution A pantropical genus. More species in tropical Asia and Africa. *Pterobryopsis divergens* is a member of the family known at present from the Indian Himalayas, Myanmar, Thailand and Vietnam, and not in Malesia.

Sporophytes observed None.

Authors: Manuel L. Castillo & Mai Ngoc Bich Nga



Pterobryopsis divergens — Habit. (Photo by Luong Thien Tam)

Racopilum P. Beauv.

Description of the genus Plants pleurocarpous, medium size, forming green mats. Stems elongate, creeping, subpinnate with short branches, with dense rhizoids on the ventral side. Leaves strongly dimorphic, arranged in two lateral rows and a dorsal row. Lateral leaves contorted upwards when dry, widely spreading when moist, ovate to oblong, somewhat asymmetric, rounded or wide obtuse at apex. Dorsal leaves suberect, ovate to triangular, symmetric, acute. Costa single, stout, short to long excurrent in median and lateral leaves. Laminal cells mostly rounded-hexagonal or subquadrate, thin to thick walled; upper leaf cells smaller. Setae long. Capsule long cylindric inclined or suberect, striate or sulcate when dry. Peristome teeth double. Calyptra cucullate.

The genus is easily identified, when wet, by its three ranked or three rows of leaves, two on lateral side of the stem and branches, and a dorsal row facing the sky. The single, excurrent costa of the leaves is also diagnostic for the genus.

Species in the QSBG Limestone Glass House

Racopilum orthocarpum Wilson ex Mitt.

Ecology and habitat On rocks and ground inside the Limestone Glass House at the QSBG. In nature, species of *Racopilum* prefer shaded and wet habitats.

Number of species in the genus 4 species in Thailand, about 6 species in Asia, and 44 species in the world.

Distribution The genus is widespread in the tropics, with extension to north and south temperate regions. *Racopilum orthocarpum* is known from Indochina, India and China.

Author: Nootjaree Tathana & Dek Vimeanreaksmey



Racopilum orthocarpum — **a.** Habit; **b.** Lateral leaf.
(Photos by Luong Thien Tam, Nootjaree Tathana & Dek Vimeanreaksmey)

Symphiodon Mont.

Description of the genus Plants pleurocarpous or creeping, medium to large sized plants reaching 20 cm long, dull to glossy. Stems and branches are prostrate, at times subpendulous, irregularly or laxly and pinnately branched, some species are bipinnately or even tripinnately branched, forming a frondose pattern. Leaves ovate-lanceolate to oblong-lanceolate, somewhat concave, acute to acuminate, apices truncate, rounded, obtuse, or apiculate in some species, margins serrulate to coarsely serrate above. Costae double, unequal, extending to 1/2 of leaf length. Median leaf cells linear, smooth, prorulose to strongly prorate in some species; basal alar cells differentiated, with a few quadrate to subquadrate cells. Setae long, smooth proximally and papillose distally. Capsule mostly erect, strongly spinulose. Peristome teeth double. Calyptra cucullate.

This genus is easily identified by its strongly spinose capsule, a distinctive character seen only in few moss genera. Without the capsule, the somewhat flattened leaves look like members of the Family Neckeraceae.

Species in the QSBG Limestone Glass House

Symphiodon yuennanensis Broth., a species known from China and northern Vietnam. The large and pinnately branched plants are distinctive among mosses found in the glass house. This is a new species record for Thailand.

Ecology and habitat On soil and rock in shaded part of the garden at QSBG forming large patch of ground cover.

Number of species in the genus 9 species in Thailand and 17 species in the world.

Distribution *Symphiodon* is mainly distributed in the tropical and subtropical regions of the world, with most of the species occurring in southern and southeastern Asia near the Himalayan floristic region.

Sporophytes observed None.

Authors: Parusuraman Athen, Ummul-Nazrah Abdul Rahman & Henrietta P.M. Woo



Symphiodon yuennanensis — **a.** Habit; **b.** Leaf, **c.** Leaf apex.
 (Photos by Luong Thien Tam and Henrietta P.M. Woo)

Pelekium Mitt. emend. Touw

Synonyms *Cyrto-hypnum* (Hampe) Hampe & Lorentz

Description of the genus Plants pleurocarpous, slender, without luster, forming feathery mats or low wefts. Stems creeping, less than 5 cm long, mostly bipinnately branched, with green, short, papillose and unbranched paraphyllia on stems and lacking or limited to basal part of branches. Leaves dimorphous; stem leaves larger, triangular to ovate in shape from a broad, cordate base, often long-acuminate to subulate; branch leaves small, ovate, concave, short-pointed. Costa single. Leaf cells rounded, uni- to multipapillose. Setae short or long, mammillose to papillose. Capsule usually inclined or horizontal, lid beaked. Peristome teeth double. Calyptrae cucullate and mostly naked, at times campanulate, lobed, plicate and hairy.

This genus looks like a small *Thuidium* plant.

Species in the QSBG Limestone Glass House

Pelekium gratum (P.Beauv.) Touw

Ecology and habitat On limey rock face in QSBG. Species of *Pelekium* are smaller in plant size than the species *Thuidium*. It has short and unbranched paraphyllia on the stem and branches, while species of *Thuidium* often have long and branched paraphyllia. Like *Thuidium*, species of *Pelekium* can be found also growing on tree bases, decaying logs, and humus-covered rocks from low to high elevations. *Pelekium gratum* is a common species in Thailand and the neighboring countries in SE Asia and in India.

Number of species in the genus 10 species in Thailand, about 15 species in Asia, and 29 species in the world.

Distribution The genus is found all over the world favoring the moist temperate and warm tropical regions.

Sporophytes observed Only young sporophytes seen.

Author: Benito C. Tan



Pelekium gratum — Habit of plants among other larger bryophytes.
(Photo by Luong Thien Tam)

Thuidium Bruch & Schimp.

Description of the genus Plants pleurocarpous, slender, medium to large-sized in the family, forming flat and feathery mats. Stems creeping, bipinnately to partly tripinnately branched, with abundant green paraphyllia on stem and branches. Leaves dimorphous; stem leaves larger, from a broad, cordate base, long-acuminate, with long hairpoint; branch leaves small, ovate, concave, short-pointed. Costa single. Leaf cells rounded, papillose. Setae short or long, mostly smooth. Capsule usually inclined or horizontal, lid beaked. Peristome teeth double. Calyptra mostly cucullate and naked, rarely campanulate and scabrous.

This genus is best identified by its bi- to tri-pinnate branches with numerous green paraphyllia on the stem and branches.

Species in the QSBG Limestone Glass House

Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk. and *Thuidium plumulosum* (Dozy & Molk.) Dozy & Molk. The main difference between these two species lies in the morphology of the stem leaves. In the former, the stem leaf ends with a very long hair point, while the stem leaf of *T. plumulosum* has only acuminate leaf apex. The branch leaves of *T. plumulosum* also typically have strongly protruding costal cells on the back forming a distinct crest.

Ecology and habitat On limey rock face in the QSBG. In nature, species of *Thuidium* can be found growing on tree bases, decaying logs, and humus-covered rocks from low to high elevations. *Thuidium cymbifolium* and *T. plumulosum* are commonly seen growing on limestone rocks in SE Asia.

Number of species in the genus 5 species in Thailand, about 9 species in Asia, and 64 species in the world.

Distribution The genus is found all over the world favoring the moist temperate regions.

Sporophytes observed None.

Authors: Manuel L. Castillo & Mai Ngoc Bich Nga



Thuidium cymbifolium — **a.** Habit; **b.** stem leaves with long hair point. (Photos by a, Luong Thien Tam; b, Manuel L. Castillo)

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GLOSSARY

acrocarpous — with gametophyte producing sporophytes at the terminal end of stems or main branches. Acrocarpous mosses mainly grow erect with no or few lateral branches.

acumen — of leaf tip.

acute — sharp pointed leaf apex with an angle of 45–90°.

air pore — small aperture, opening in wall of some cells; space or opening; in upper surface of thallose liverworts.

alar cells — cells at basal angles of leaf, often differentiated in size, shape or color from other leaf cells.

antheridium (pl. antheridia) — male sex organ, club-shaped to cylindrical stalked structure containing male gametes or sperms.

archegonium (pl. archegonia) — female sex organ, flask-shaped structure consisting of a stalk, an enlarged basal venter, which contains the egg cell, and an elongated, tubular upper part called the neck.

bicostate — having two leaf costae.

caducous — of propagules, readily detaching or falling off.

calyptra (pl. calyptrae) — a membranous structure developed largely from the venter of the archegonium, which covers the mature capsule of mosses.

cancellina (pl. cancellinae) — large, dead, empty, and usually hyaline leaf cells (leucocysts) forming a well-marked lattice-like region, such as in the basal part of leaves of Calymperaceae.

capsule — the spore bearing structure or sporangium of the bryophyte sporophyte.

chlorocysts — green (chlorophyllose) photosynthetic small cells found in the leaf of mosses; generally used to distinguished them from the larger leucocysts in Leucobryaceae and Calymperaceae.

columella (pl. columellae) — central sterile portion in sporogenous region of capsule in mosses, hornworts, and some fungi.

companulate — of calyptrae, bell-shaped.

complanate — flattened or compressed, such as leaves flattened in one plane.

costa (pl. costae) — midrib or nerve of a leaf, always more than one cell thick; adj., costate.

crisped — strongly curled and twisted; also, crispate.

cucullate — of calyptrae, hood-shaped calyptra that splits down on one side only.

dorsal — side directed away from axis; in liverworts, upper side.

ecostate — without a costa.

elater — dead, elongate cells with coiled thickenings in liverworts; sensitive to humidity; unequal wall thickenings cause twisting during drying; help disperse spores.

elimbate — of leaves, without limbidium or differentiated border.

entire — smooth leaf margin without any teeth.

excurrent — of costae, projecting beyond the leaf tip.

falcate — of leaves, curved like the sickle blade.

falcate-secund — regularly curved and pointing to one direction.

gametangium (pl. gametangia) — general term for the bryophyte sex organs, i.e. antheridium and archaegonium.

gametophore — the mature gametophytic leafy body of moss that developed from protonema.

gametophyte — the dominant haploid sexual phase of the moss life cycle, consisting normally of green leafy moss plants bearing gametangia and producing gametes.

gemma (pl. gemmae) — specialized group of uniform, relatively undifferentiated cells used in vegetative reproduction; usually small, globular, ellipsoidal, or cylindrical to filamentous in outline; adj., gemmiferous.

gemma cup — a cup-shaped, gemmae containing structure.

incubous — lying upon; oblique leaf insertion in which distal leaf margins are oriented toward dorsal stem surface.

involucre — a tube-like tissue surrounding and protecting the gametangia or the developing sporophyte, especially in thalloid bryophytes.

lamina (pl. laminae) — leaf blade; photosynthetic portion of a leaf, excluding the costa.

lanceolate — lance-shaped, narrow and tapered from below the middle, length-wide ratio = 3:1.

leucocysts — large, dead, empty, colorless, and water-storage cells, as seen in leaf of Leucobryaceae and Sphagnum.

lobule — the smaller lobe in bilobed leaves, often sac-like in some leafy liverworts in the Lejeuneaceae, Jubulaceae etc.

limbidium (pl. limbidia) — of leaves, having distinct, elongated and thick-walled marginal cells forming a well differentiated border; adj., limbate.

monoicous — producing male and female sex organs (antheridia and archegonia) on the same plant (the opposite of dioicous); not the same as monoecious, which applies to the diploid sporophytes of vascular plants.

mammilla (pl. mammillae) — bulging part of a cell resulting from the strongly protruded cell lumen; adj., mammillose.

mitrate — of calyptrae, conical shape and without splits (like a bishop's mitre), or equally lobed at base.

mucronate — leaf apex ending with an abrupt relatively broad short point.

multifid — divided many times.

multipapillose — having many papillae, or one compound or branched papilla on each leaf cell surface.

oblong — longer than broad with sides parallel.

obtuse — broadly pointed leaf apex, more than 90°.

oil body — membrane-bound, terpene-containing organelle unique to liverworts

operculum (pl. opercula) — lid covering the mouth of a moss capsule.

ovate — egg-shaped, broadest below middle, length-width ratio: 3:2.

papilla (pl. papillae) — type of cell ornamentation resulting from surface projection from cell wall; adj., papilllose.

paraphyllia — small green leafy or filamentous appendages found scattered across the stem and branches, commonly seen in members of Thuidiaceae.

percurrent — of costae, extending to the apex.

perichaetium (pl. perichaetia) — a structure often composed of modified leaves surrounding or enclosing a group of archaegonia.

perigonium (pl. perigonia) — a structure usually composed of modified leaves surrounding or enclosing a group of antheridia.

peristome — the single or double circular row(s) of teeth around the mouth of the capsule seen after the lid or cover of the capsule has fallen off.

perianth — structure of foliar origin enclosing archegonia and developing sporophyte in most leafy liverworts.

pinnate — branches produced regularly on opposite sides of the stem axis, resembling a feather; adj., pinnately.

pleurocarpous — with gametophyte producing sporophytes laterally on short modified shoots or laterally positioned perichaetia. Pleurocarpous mosses are usually creeping in habit with many lateral branches.

propagules — reduced buds, branches or plant fragments for vegetative reproduction.

prorate — having a roughened surface caused by protruding cell tips overlapping at their ends.

protonema (pl. protonemata) — the often filamentous structure produced after spore germination and from which the leafy gametophores develop.

pseudoelater — false elater; one, two, or four-celled sterile filament developed after several mitotic divisions and subsequent differentiation of diploid pseudoelater mother cell among spores in capsules of hornworts; outnumber spores.

receptacle — a disc- or umbrella-like structure bearing antheridia or archegonia in thalloid liverworts, with or without a stalk.

rostrum (pl. rostra) — of opercula, forming a narrowed slender tip or beak; adj. rostrate.

seriate — arranged in rows; e.g. uniseriate (single row), seriatly papillose (many papillae arranged in a row) etc.

seta (pl. setae) — the elongated stalk of a sporophyte between the foot and capsule.

sporophyte — the asexual diploid phase of the moss life cycle, consisting of the foot, seta and capsule, which bears the meiotic spores.

succubous — lying under; oblique leaf insertion in which antical (distal) margins are oriented toward ventral stem surface.

thallus (pl. thalli) — a flattened plant body, not differentiated into stems and leaves; adj., thalloid.

teniola (pl. teniolae) — a differentiated intra-marginal (border) band of elongate cells seen near the leaf margins in Family Calymperaceae; adj., teniolate.

underleaf — modified leaf on underside of plant, especially in leafy liverworts.

unicostate — having a single leaf costa.

unipapillose — with one simple unbranched papilla on the surface of a leaf cell.

vaginant lamina — the additional leaf blade found on the lower upper half of the leaf of Fissidens.

ventral — lower or under surface.

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