ความหลากหลายของมอสบริเวณกิ่วแม่ปานและบริเวณอ่าง อุทยานแห่งชาติดอยอินทนนท์ จังหวัดเชียงใหม่

นางสาวโยษิตา นะที

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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MOSSES DIVERSITY IN KEW MAE PAN AND ANG KA AREAS,DOI INTHANON NATIONAL PARK, CHAING MAI PROVINCE

Miss Yosita Nathi

A Thesis Submitted in Partial Fulfillment of the Requirements for
the Degree of Master of Science Program in Botany
Department of Botany
Faculty of Science
Chulalongkorn University
Academic Year 2009

Thesis Title	MOSSES DIVERSITY AT KEW MAE PAN AND ANG KA AREAS,DOI INTHANON NATIONAL PARK, CHAING MAI PROVINCE
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Field of Study	Botany
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โยษิตา นะที : ความหลากหลายของมอสส์ในบริเณกิ่วแม่ปานและบริเวณอ่างกา อุทยานแห่งชาติดอยอินทนนท์ จังหวัดเชียงใหม่. (DIVERSITY OF MOSSES IN KHEW MAE PAN AND ANGKA AREAS, DOI INTHANON NATIONAL PARK, CHIANG MAI PROVINCE) อ.ที่ปรึกษาวิทยานิพนธ์: ผศ.ดร. ต่อศักดิ์ สีลานันท์, 274 หน้า.

การสำรวจความหลากหลายของมอสส์ในอุทยานแห่งชาติดอยอินทนนท์ จังหวัดเชียงใหม่ จากพื้นที่ตัวแทน 2 แห่ง ได้แก่ บริเวณกิ่วแม่ปานและบริเวณอ่างกา ได้ดำเนินการระหว่างเดือนกรกฎาคม พ.ศ. 2550 ถึงเดือนกรกฎาคม พ.ศ. 2551 ซึ่งสามารถรวบรวมตัวอย่างได้ทั้งสิ้น 810 หมายเลข จำแนกเป็นมอสส์ 101 ชนิด ใน 59 สกุล 27 วงศ์ มอสส์วงศ์ที่พบจำนวนชนิดมากที่สุด คือ Sematophyllaceae พบ 16 ชนิด มอสส์วงศ์ที่พบจำนวนชนิดรองลงมาคือ Fissidentacea และ Meteoriaceae พบวงศ์ละ 10 ชนิด มอสที่พบส่วนใหญ่เป็นมอสส์ที่มีการกระจายพันธุ์อยู่ในเขตอินโดจีน ส่วนที่เหลือเป็นมอสส์ที่ขึ้นทั่วไปในทวีปเอเชีย และมี 2 ชนิดที่มีการกระจายทั่วโลก มอสส์ที่อยู่ในบัญชีรายชื่อมอสส์ที่เสี่ยงต่อการสูญพันธุ์ของ ICUN และพบในพื้นที่ศึกษามี 1 ชนิด คือ *Distichophyllum carinatum* Dixon & W. E. Nicholson นอกจากนี้ ยังพบว่ามีมอสส์ 16 ชนิด เป็นมอสส์ที่ไม่เคยมีรายงานว่าพบในประเทศไทยมาก่อน ได้แก่ *Clastobryopsis brevinervis* M. Fleisch., *Clastobryopsis planula* (Mitt.) M. Fleisch. var. *planula*, *Clastobryopsis planula* var. *delicata* (M. Fleisch.) B. C. Tan & Y. Jia, *Clastobryopsis robusta* (Broth.) M. Fleisch., *Didymodon maschalogena* (Renauld & Car-dot) Broth., *Distichophyllum carinatum* Dixon & W. E. Nicholson, *Distichophyllum collenchymatosum* Cardot., *Distichophyllum maibarae* Besch., *Distichophyllum wanianum* B. C. Tan & P. J. Lin, *Fissidens obscurus* Mitt., *Glossadelphus prostratus* (Dozy & Molk.) M. Flesich., *Meteorium subpolytrichum* (Besch.) Broth., *Oligotrichum aligerum/obtusatum* Mitt., *Rhizomnium striatulum* (Mitt.) T. J. Kop., และ *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch. สำหรับมอสส์ชนิด *Warburgiella bistrumosa* นั้น น่าจะมีการกระจายพันธุ์กว้างกว่าที่เคยมีรายงานไว้ และอาจจะไม่ใช่พืชเฉพาะถิ่นของฟิลิปปินส์อีกต่อไป

ภาควิชา พฤกษศาสตร์ ลายมือชื่อนิสิต โยษิตา นะที

สาขาวิชาพฤกษศาสตร์ ลายมือชื่อ อ.ที่ปรึกษา

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YOSITA NATHI: DIVERSITY OF MOSSES IN KHEW MAE PAN AND ANG KA AREAS, DOI INTHANON NATIONAL PARK, CHIANG MAI PROVINCE. THESIS ADVISOR: ASSIST. PROF. TOSAK SEELANAN, Ph. D., 274 pp.

The investigation of diversity of mosses in Doi Inthanon National Park, Chiang Mai province, was carried out in two representative areas, namely Khew Mae Pan and Ang Ka, during July 2007-July 2008. In total, 810 specimens of mosses were collected, comprising of 101 species in 59 genera 27 families. The moss families with the highest species was Sematophyllaceae (16 species), followed by Fissidentaceae and Meteoriaceae (10 species). Most taxa found belong to Indochines flora elements while the rest are of common Asian flora with two are worldwide distributed. One species enlisted in the ICUN red list was also found, namely *Distichophyllum carinatum* Dixon & W. E. Nicholson. It had been found that as many as 16 species of mosses were new records to Thailand, namely *Clastobryopsis brevinervis* M. Fleisch.,*Clastobryopsis planula* (Mitt.) M. Fleisch. var. *planula, Clastobryopsis planula* var. *delicata* (M. Fleisch.) B. C. Tan & Y. Jia, *Clastobryopsis robusta* (Broth.) M. Fleisch., *Didymodon maschalogena* (Renauld & Car-dot) Broth., *Distichophyllum carinatum* Dixon & W. E. Nicholson, *Distichophyllum collenchymatosum* Cardot., *Distichophyllum maibarae* Besch., *Distichophyllum wanianum* B. C. Tan & P. J. Lin, *Fissidens obscurus* Mitt., *Glossadelphus prostratus* (Dozy & Molk.) M. Flesich., *Meteorium subpolytrichum* (Besch.) Broth., *Oligotrichum obtusatum* Mitt., *Oligotrichum semilamellatum* (Hook. F.) Mitt, *Rhizomnium striatulum* (Mitt.) T. J. Kop., and *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch. In addition, it is suggested that *Warburgiella bistrumosa* may have wilder geographic distribution, and may no longer be an endemic to the Philippines.

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Student's Signature Yosita Nathi
Advisor's Signature

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CHAPTER 1

INTRODUCTION

Bryophyte is the second largest group of green land plants, divided in to three Division: Mosses (Division Bryophyta), Liverworts (Division Marchantiophyta) and Hornworts (Division Anthocerotophyta). Bryophytes play an important role in many ecosystems, such as water storage and nutrient uptake from rain and they are also important to ecological interaction. They absorb water and nutrients exclusively through their surface, making them good indicators of air and water pollution, heavy metal and radioactive contamination. As bryophytes are very sensitive to water loss, they are good indicators of microclimates and altitudinal zonation of forests. In addition, due to their prompt reaction to climate factors as well as their short life cycle, bryophytes are also quick and effective indicators of climatic changes.

Among the three groups of bryophytes, moss is the most diversified group. There are approximately 15,000 moss species world-wide, with 8,000 species occur in the tropic (Frahm, 2003). The moss diversity of each region depends on the climate, the geological age and history of the area, and the elevation of habitats, as well as an increase in numbers of species from lower to high altitude forests. He (1998) compiled a moss checklist of Thailand, which includes 652 species. This indicates a high number of Thai mosses; however, there are still few publications available on Thai bryophytes.

Doi Inthanon National Park, located in Chiang Mai province in northern Thailand. This area is under the Indo-Burma floristic influence. The park areas inhibit several high mountains, with the highest peak at 2,576 m above mean sea level. Vegetation types include mixed deciduous forest at 500 m, lower montane forests between 500-1,000 m, and upper montane rain forests or cloud forest at more than 1,500 m (Santisuk, 2006). This national park has a high diversity and large quantity of ferns, bryophytes, orchids and other plants. Fifty years ago, the mountain peaks were exposed to an agricultural method that destroyed the forest ecosystem. Human encroachment has also decreased the number of wild animals in the park, as the animals are hunted and their habitats are destroyed for agriculture (Department of National Parks, Wildlife and Plant Conservation [DNP]: online, 2009).

Doi In thanon has been frequently visited by many botanists and moss specimens also were collected, and new records and new names were

reported as a result, but still little information exists on the bryophyte diversity of Doi Inthanon National Park.

The park receives 200,000 and 300,000 visitors a year (DNP, 2009), largely due to a well-maintained road that provides a comfortable ride to the summit and facilitates visits to the park's many attractions. It will be interesting to re-investigate the moss diversity in this area, and see if the number of species may or may not be affected by environmental change.

Aim of this Thesis

This study investigates the diversity of moss, focusing on two representative areas from the high montane forest of Doi Inthanon National Park, Chiang Mai Province.

CHAPTER 2

LITERATURE REVIEW

History of Thai bryophytes study

The study of Thai bryophytes began between 1899 and 1900, when Johs Schmidt collected numerous bryophyte specimens on Koh Chang Island (Brotherus, 1901; Stephani, 1902). Between 1904 and 1905, German botanist, Carl Hosseus collected a small quantity of bryophytes in northern and northwestern Thailand (Brotherus, 1911). Irish physician A. F. G. Kerr made an extensive collection of bryophytes during his stay in Thailand (Larsen, 1979). Using Kerr's collections and all known records to date, H.N. Dixon (1932) published the first catalogue of 220 species of Thai mosses, and updated the list to 300 species in 1935.

The most intensive study of Thai mosses occurred between the late 1950s and the early 1970s, when numerous joint botanical expeditions were undertaken by western and Japanese botanists with Thai colleagues. Thai-Danish expeditions were carried out (Larsen 1979), along with Dutch (Touw, 1968), French (Tixier & Smitinand, 1966; Tixier 1971, 1971, 1972), and Japanese (Horikawa & Ando, 1964; Noguchi, 1973). The second checklist of Thai moss (including 516 species) was reported by Tixier in 1971.

During 1980-1982, Thai botanists such as O. Thaithong had study bryophytes diversity of mangrove forest in Chantaburi, Trat, Ranong, Phangnga, Krabi, and Satun provinces, reported 5 moss species and 22 liverwort species as the results (Thaithong, 1984).

In 1988, R. Sornsamran reported 9 species of moss and 22 species of liverwort from the Sakaerat Experiment Station, Nakorn Ratchasima Province (Sornsamran, 1988).

In 1993, a checklist of 563 species of Thai moss was compiled by Tan and Iwatsuki. Later, a checklist of bryophytes in Thailand was published by R. Sornsamran and O. Thaitong in 1995 (Sornsamran and Thaitong, 1995).

Based on publications from 1900-1979, He (1998) assembled a catalog of Thai moss with 620 species and 31 subspecific taxa.

In recent publications on Thai bryophytes from a number of bryologist, such as Chantanaorapint (2002), Koronochalert (2006),

Manachit (2006), Akiyama (2007), Pollawats (2008), and Wongkuna *et al*. (2009), new records and new names, and several new species are listed. For more information in the future, it is reasonable to continue studying Thai mosses.

CHAPTER 3

STUDY SITE

3.1 Doi Inthanon National Park

Doi Inthanon is located in northern Thailand. It is part of the Thanon Thongchai mountain range, which was uplifted as a part of the Himalayan range. Doi Inthanon is also referred to as Doi Ang Ka. Doi Inthanon, preserved in 1954 as one of the original 14 national parks of Thailand, occupying the areas of Sanpatong District, Chomthong District, Mae Chaem District, Mae Wang District, and Toi Lor Sub-district of Chiang Mai Province, with an approximate area of 482 km^2 The highest mountain peak is Doi Inthanon, 2,565 meters above mean sea level, followed by Doi Huamodluang at 2,330 meters above the sea level. The 48 kilometer road to the summit was constructed by the Royal Thai Army in 1970s to provide access to a military radar installation close to the peak. Previously, the summit could only be reached by a long and grueling trek on foot or on pony (DNP: online, 2009). As the park starts from the lowlands at 800 m altitude up to the peak at 2,565 m., it includes many diversified climatic and ecological different areas. The climate of the park is affected by southwest summer monsoons and northeast monsoons. As the park ranging from 800 to 2,565 m above mean sea level, various climates exist in different altitudes, *i.e.* tropical climates in the areas below 1,000 m, sub-tropical climates in areas between 1,000-2,000 m, and temperate climates above 2,000 m. In the cold season (December-January), the temperature may drop to lower than 0° C. Generally, mean minimum temperature is 10-14° C, and annual mean temperature is around 15-17° C. The average annual relative humidity is 80% (DNP: online, 2009). The vegetation in the park is quite diverse, including deciduous forest, lowland tropical forests, lower montane oak forests, lower montane pine-oak forest, upper montane rain forests or cloud forest, montane peat bog or sphagnum bog (Santisuk 2006).

The two study areas (altitude between 2,100 meters and 2,565 meters) were selected (Fig. 3.1), namely Ang Ka and Kew Mae Pan. Both areas are classified as cloud forest, according to Bubb *et al*. (2004) and Santisuk (2006). The nature trails for ecotourism are available in both areas.

3.2 Ang Ka

Ang Ka is located at elevation about 2,560 meters above the sea level, and about 300 meters walking-distance from the highest peak. The vegetation

is classified as montane peat bog or sphagnum bog (Santisuk 2006). A stream runs through Ang Ka, emerging downhill as Mae Pan Waterfall.

3.3 Khew Mae Pan

Kew Mae Pan, located at elevation 2,100-2,200 meters above the sea level, classified as upper montane rain forest, with secondary grassland. A stream runs through the area, with a waterfall near the entrance to the nature trail that begins a short distance up the main summit road from Napamaytanidol. The path leads for a kilometer or more through dense, moist evergreen forest, then emerges and follows the top of a steep slope bordering the canyoned headwaters of the Mae Pan River, proceeds southward for another kilometer with fine, open views to the west, and then re-enters the forest, terminating at Napamaytanidol Chedi.

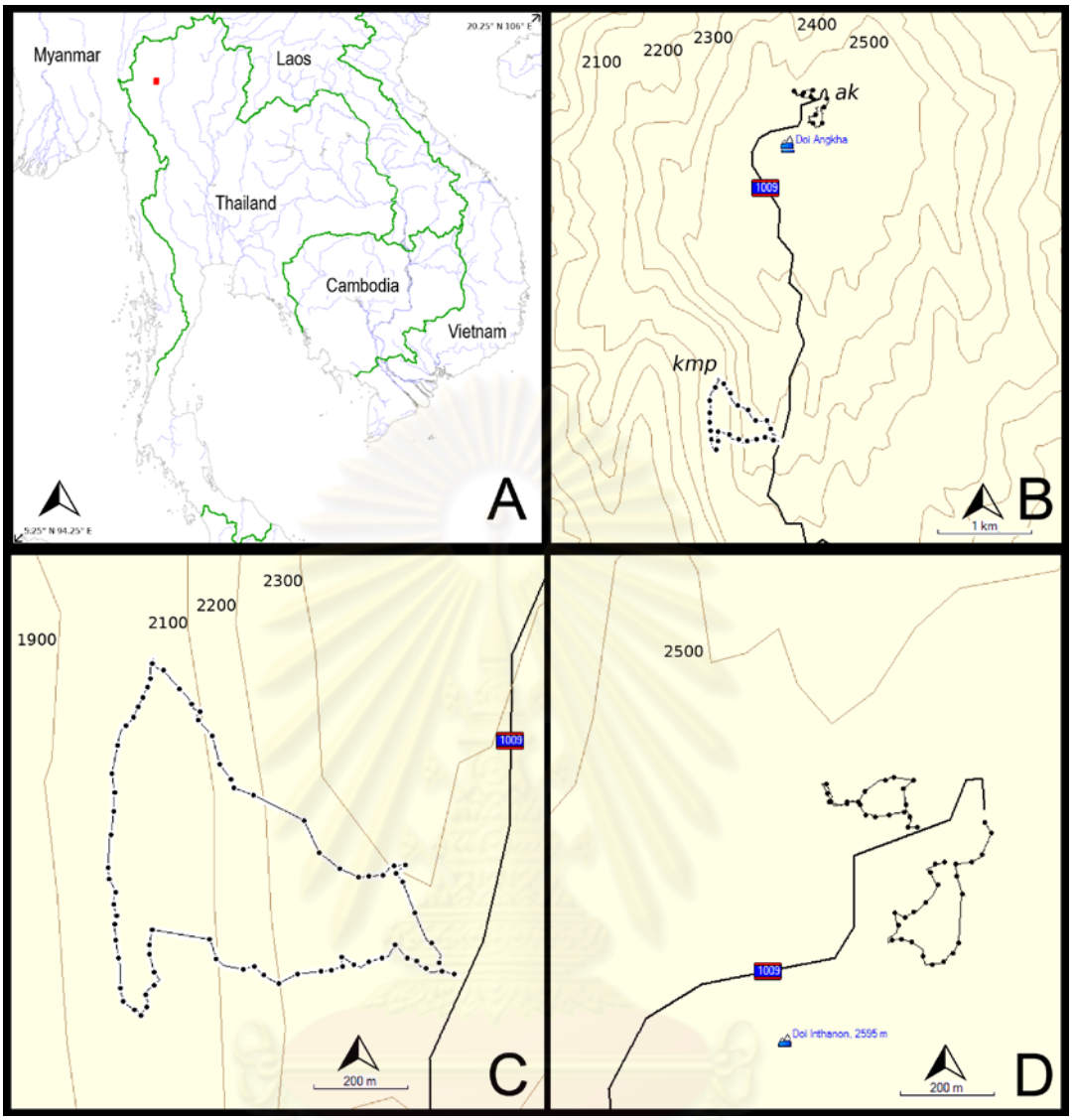


Fig. 3.1 A: Location of Doi Inthanon National Park, Chiangmai (solid square); B: Topographic illustration of 2 representative trials, namely Ang Ka (*ak*) and Kew Mae Pan (*kmp*); C: Enlarge of Kew Mae Pan Trial; D: Enlarge of Ang Ka trials. Elevation are indicated near contour lines and given in meters. Highway 1009 provides transportation to studied sites.

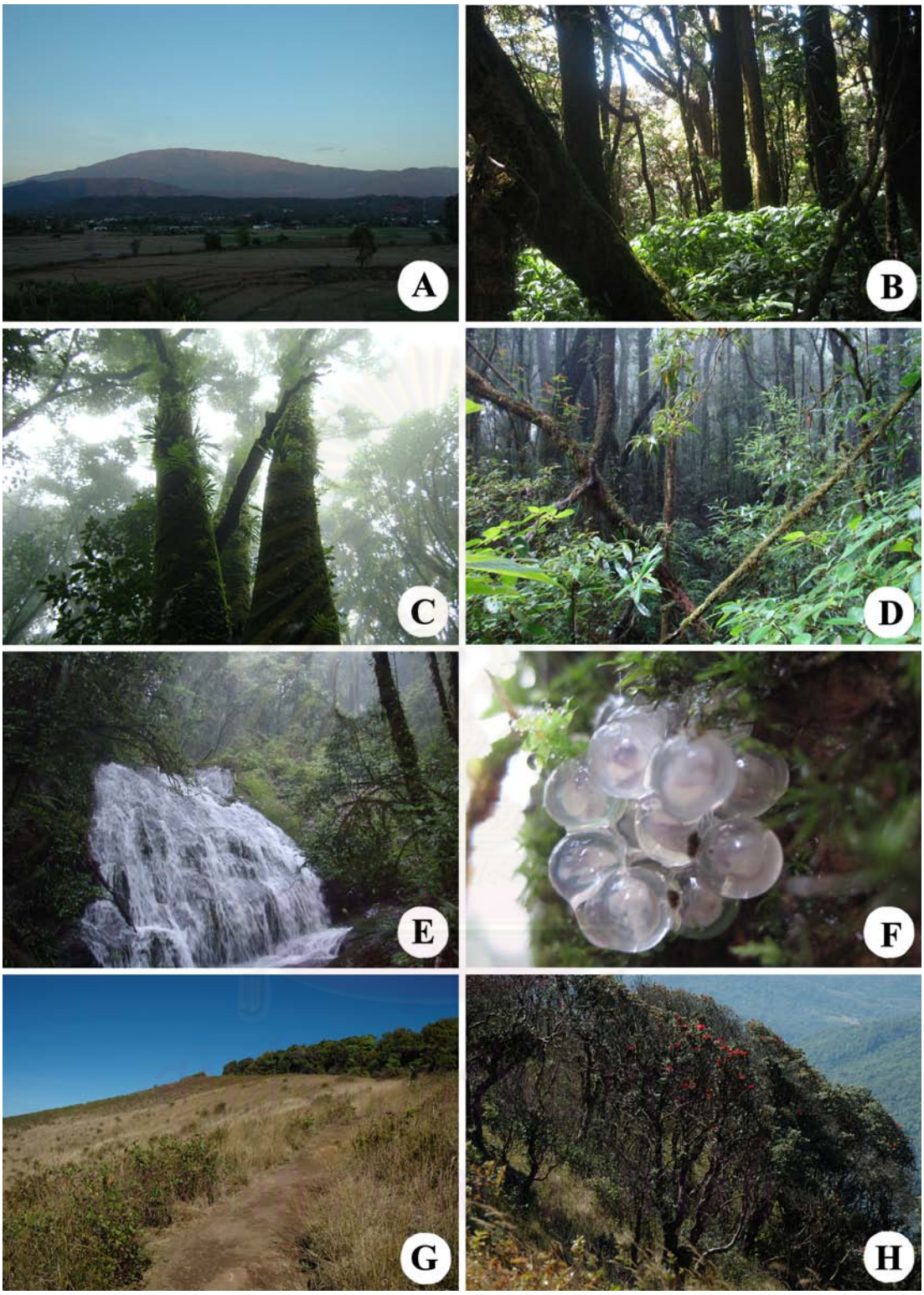


Figure 3.2 A. Doi Inthaon; **B., C,** Ang Ka vegetation ; **D.** Khew Mae Pan vegetation ; **E.,** small watr fall on the way of Khe Mae Pan Trail ; **F.** association between moss and animal in Khew Mae Pan; **G.** Grassland in Khew Mae Pan: **H.** steep slope at 2,200 m.

CHAPTER 4

MATERIALS AND METHODS

4.1 Materials

4.1.1 Specimen collecting equipments

- plastic bags
- pocket knife
- pencil
- field note
- digital camera
- hand lens
- The Global Position System (GPS) receiver: Garmin 60CSx and12XL

4.1.2 Herbarium specimens preparing equipments

- paper envelopes
- label paper

4.1.3 Identification equipments

- stereo microscope with camera lucida
- compound microscope with camera lucida
- microscopic slides and cover glasses
- dissecting needles
- razor blades
- petri dishes
- related taxonomic literatures of mosses

4.1.4 Climatic data collecting equipments

- HOBO® Microstation data logger
- HOBO Weather Station Temp/RH Smart Sensor (part number S-THB-M002)
- HOBO Photosynthetic Light [PAR] Smart Sensor (model number S-LIA-M003)
- HOBO Pro V2 Temp/RH Data Logger (model number U23-001)

4.2 Methods

4.2.1 Literature review

The related literatures were investigated from the libraries at the Professor Kasin Suvathabhandu Herbarium, Department of Botany Chulalongkorn University (BCU), the Forest Herbarium, Department of Biology, Chiang Mai University, Royal Forest Department (BKF), and the SING Herbarium, Singapore Botanic Gardens.

4.2.2 Exploration and collection

Field collections were carried out between July 2007 and August 2008. The nature trails in both representative areas were used as main transect lines. These trails were round trips, *i.e.* one-way entrance-exit, and passed through the area; only a part of the trail in Kew Mae Pan ran along mountain ridges. Secondary transect lines were branched at intervals of 10 meters or where appropriate from the nature trials, and went as far as the terrace allowed. This ensured that specimen collection covered as much area possible. Specimen collection followed the method of Boonkerd *et al*. (1987). Information regarding habit, habitat, altitude and diagnostic characters was noted. Collecting sites were recorded by a GPS receiver (Garmin® GPSmap 60CSx). Moss specimens were collected mainly from ground, tree trunks and shrub or on lower canopy which can be reached.

4.2.3 Climatic data collecting

Climatic factors such as temperature, Relative Humidity or RH, and photosynthetically active radiance or PAR were collected using data loggers (HOBO® Microstation data logger) equipped with HOBO Weather Station Temp/RH Smart Sensor (part number S-THB-M002) and HOBO Photosynthetic Light [PAR] Smart Sensor (model number S-LIA-M003) at Ang Ka Luang while, due to scarcity of equipment, only HOBO Pro V2 Temp/RH Data Logger (model number U23-001) at Kew Mae Pan. These data loggers and probes were placed in shaded areas with intermitted sunlight to simulate habitats from where most bryophyte specimens were collected. Loggers were set to collect data for the duration of 7 months (December 2007 – June 2008).

4.2.4 Laboratory study

Morphological characteristics of the specimens were examined under stereo microscope and compound microscope. Taxonomic determination was carried out by using identification key and species

descriptions from taxonomic literature of bryophytes, such as Flora, Manual, Monograph, Research papers, handbooks, etc. as shown in the reference, as well as comparison to the voucher herbarium specimens deposit at BCU, BKF, Department of Biology Faculty of Science, Chiang Mai University. Full descriptions of all species were given, key to families, genera and species were constructed, together with ecological data and their distributions.

All voucher specimens were deposited at BCU and BKF. Authors of scientific names and their abbreviation used in this thesis are in accordance with "An Annotated Checklist and Atlas of the Mosses of Thailand" is prepared electronically by He Si at Missouri Botanical Garden (He: online, 1995) The terminology used in this thesis was followed Malcolm &Malcolm (2006).

CHAPTER 5

RESULTS

5.1 Climatic data

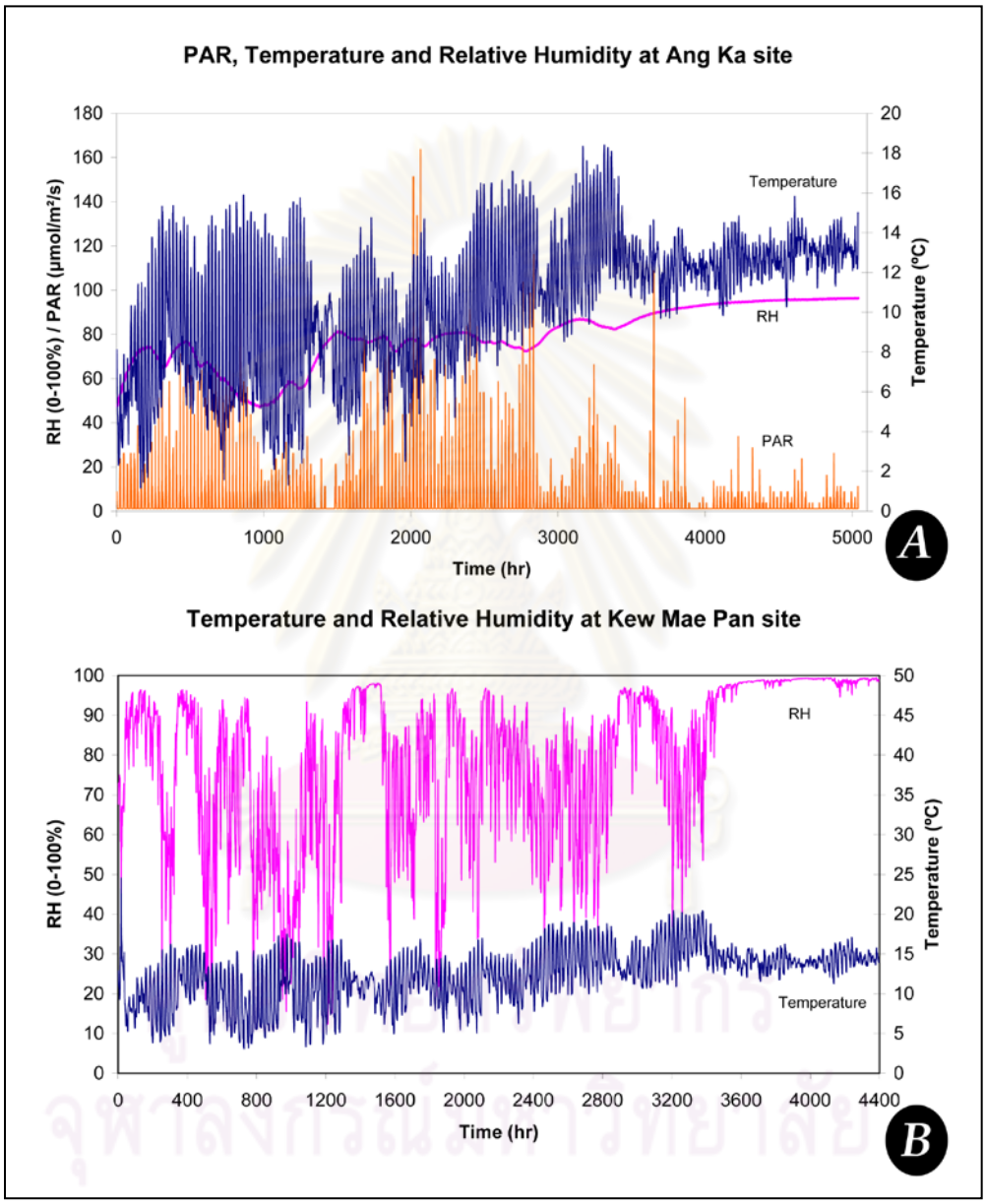


Figure 2 Climate data at Ang Ka (A) and Kew Mae Pan (B). Time is given in hours. At Ang Ka site, a data logger was started at 11.34AM on 2nd December 2007 and ended at 10.34AM on 29th June 2008 while that at Kew Mae Pan site was started at 10.11AM on 1st December 2007 and ended at 03.11AM on 2nd June 2008 (due to battery was exhausted). Data loggers were set to record every hour.

At Ang Ka (Fig. 2A), the temperature fluctuated between 2 C – 16 C between December and January, then started rising to narrower range in between 7 C – 18 C during February to April, and became steadier in between 10 C – 15 C during May to July, after entering rainy season. RH at Ang Ka was relatively stable in a range of 50%-80% most of the time during data logging. The driest period as judged by lowest RH was in January, while afterwards it became more humid as RH started to rise to around 80% during February to nearly-end April, and rose to nearly 100% during May and June. It should be noted that the dry period may also occur during November to December since at the beginning of data logging RH was as low as that in January, ca. 50%. For photosynthetically active radiance or PAR measurement, it should be noted that due to canopy changes caused by strong winds which opened up canopy, PAR measurement could reach as high as 170 $\mu mol \cdot m^{-2} \cdot s^{-1}$, however generally it reads in a range of 10-80 $\mu mol \cdot m^{-2} \cdot s^{-1}$ during 9.00AM to 3.00PM. PAR measurement outside this time period was very low, and might be background noise of a sensor. Nonetheless, it was noteworthy that at beginning of May and afterwards PAR measurement was much lower than that of December – April.

In contrast, at Kew Mae Pan site (Fig. 2B) temperature was between 4 C – 17 C during December to mid-March, then rose a few more degrees to 10 C – 20 C from mid-March to April, and dropped down to 12 C – 17 C during May-June. RH at this site appeared to fluctuate widely in a range of ca. 10% – 95% during December to April, in intervals of approximately 15 days. Since May, RH was constantly high at nearly 100%.

5.2 Species diversity

A total of 810 specimens number of moss were collected during July 2007 to August 2008, and accounting for 101 species in 60 genera, and 29 families, devices to 23 species from Ang Ka, 32 species from Khew Mae Pan, and 46 species from both areas (Table 5.1). The following are descriptions and keys to taxa found from this study.

Table 5.1 Lists of mosses in Khew Mae Pan (K) and Ang Ka (A) areas, Doi Inthanon National Park, Chiang Mai Province.

Taxa	Areas
Bartramiaceae	
1. *Philonotis turneriana* (Schwaegr.) Mitt.	K
2. *Philonotis thwaitesii* Mitt.	K
Bryaceae	
3. *Anomobryum julaceum* (Schrad. ex P. Gaertn., B. Mey. & Scherb.) Schimp.	A,K
4. *Brachymenium nepalense* Hook.	K
5. *Bryum argenteum* Hedw.	A,K
6. *Bryum billarderi* Schwägr.	K
7. *Bryum salakense* Cardot	K
Calymperaceae	
8. *Syrrhopodon spiculosus* Hook. & Grev.	A,K
Dicranaceae	
9. *Brothera leana* (Sull.) C. Müll.	A
10. *Dicranodontium uncinatum* (Harv.) Jaeg.	A
11. *Symblepharis vaginata* (Hook.) Wijk. & Marg.	A,K
Dipphyschiaceae	
12. *Diphyscium longifolium* Griff.	A
Fissidentaceae	
13. *Fissidens anomalus* Mitt.	A,K
14. *Fissidens bryoides* var. *schmidii* (C. Mull.) Chopra & kumar	A,K
15. *Fissidens ceylonensis* Dozy & Molk.	A,K
16. *Fissidens flabellulus* Thwait. et Mitt.	A,K
17. *Fissidens guangdongensis* Iwats. & L.-Z. Li	K
18. *Fissidens gymnogynus* Besch.	A
19. *Fissidens hollianus* Dozy & Molk.	K
20. *Fissidens obscurus* Mitt.*	A,K
21. *Fissidens pellucidus* Hornsch.	A,K
22. *Fissidens polypodioides* Hedw.	K
Funariaceae	
23. *Funaria calvescens* Schwaegr.	A
24. *Funaria hygrometrica* Hedw.	A

Table 5.1 Lists of mosses in Khew Mae Pan (K) and Ang Ka (A) areas, Doi Inthanon National Park, Chiang Mai Province (continued).

Species	Areas
Hookeriaceae	
25. *Calyptocheata remotifolia* (C. Müll.) Iwats., Tan & Touw	A,K
26. *Distichophyllum carinatum* Dixon & W.E. Nicholson *	K
27. *Distichophyllum collenchymatosum* Cardot *	A,K
28. *Distichophyllum maibarae Besch.**	A,K
29. *Distichophyllum wanianum* B.C. Tan & P.J. *	A,K
30. *Hookeriopsis utacaqmundiana* (Mont.) Broth.	A,K
Hylocomiaceae	
31. *Macrothamnium javense* Fleisch.	K
32. *Macrothamnium macrocarpum* (Reinw. & Hornsch.) Fleisch.	A,K
Hypnaceae	
33. *Isopterygium bancanum* (Bosch & Sande Lac.) Jaeg.	A,K
34. *Pseudotaxiphyllum pohliaecarpum* (Suul. & Lesq.) Iwats.	K
35. *Taxiphyllum arcuatum* (Bosch & Sande Lac.) He	A
36. *Glossadelphus prostratus* (Dozy & Molk.) M.Flesich.*	K
Hypopterygiaceae	
37. *Cyathophorella hookeriana* (Griff.) Fleisch.	A,K
38. *Cyathophorella spinosa* (C. Mull.) Fleisch.	K
Leucobryaceae	
39. *Leucobryum juniperoideum* (Brid.) C. Müll.	K
Lembrophyllaceae	
40. *Dixonia thamnioides* (Broth. & Dix.) Horik. & Ando	A,K
Meteoriaceae	
41. *Aerobryidium filamentosum* (Hook.f.) Fleisch	K
42. *Cryptopapillaria chrysoclada* (C. Müll.) Menzel	K
43. *Cryptopapillaria feae* (C. Müll.) Menzel	K
44. *Cryptopapillaria fuscescens* (Hook. f.) Menzel	A,K
45. *Floribundaria sparsa* (Mitt.) Fleisch. var. *sparsa*	A
46. *Floribundaria sparsa* (Mitt.) Fleisch. var. *piliferum*	K
47. *Floribundaria walkeri* (Ren. & Card.) Broth.	K
48. *Meteorium subpolytrichum* (Besch.) Broth.*	A,K

Table 5.1 Lists of mosses in Khew Mae Pan (K) and Ang Ka (A) areas, Doi Inthanon National Park, Chiang Mai Province (continued).

Species	Areas
49. *Papillaria semitorta* (C. Müll.) Jaeg.	A
50. *Pseudobarbella attenuata* (Thwait. & Mitt.) Nog.	A,K
Mniaceae	
51. *Plagiomnium maximovicizii* (Lindb.) Kop.	A
52. *Plagiomnium succulentum* (Mitt.) Kop.	A
53. *Plagiomnium rhynchophorum* (Hook.f.) Kop.	A,K
54. *Rhizomnium striatulum* (Mitt.) T.J. Kop.*	K
Myuriaceae	
55. *Oedicladium rufescens* (Reinw. & Hornsch.) Mitt.**	K
Neckeraceae	
56. *Curvicladium kurzii* (Kindb.) Enroth	A,K
57. *Homalia pennatula* (Dix.) He & Enroth	K
58. *Homaliodendron crassinervum* Thér.	A,K
59. *Homaliodendron montagneanum* (C. Müll.) Fleisch	A,K
60. *Neckera himalaya* Mitt.	A,K
61. *Noguchidendron sphhacrocarpus* (Nog.) Ninh & Pocs.	K
Othotrichaceae	
62. *Macromitrium sulcatum* (Hook. f.) Brid.	A,K
Plagiotheciaceae	
63. *Plagiothecium neckeroideum* Schimp.	A,K
Polytrichaceae	
64. *Pogonatum cirratum* (Schwaegr.) Brid. ssp. *cirratum*	K
65. *Pogonatum contortum* (brid.) Lesq.?	A,K
66. *Pogonatum inflexum* (Lindb.) Sande Lac.	A
67. *Pogonatum microstomum* (Schwaegr.) Brid.	K
68. *Pogonatum neesii* (C. Müll.) Dozy & Molk.	A,K
69. *Pogonatum nudiusculum* Mitt.	A,K
70. *Pogonatum proliferum* (Griff.) Mitt.	A,K
71. *Oligotrichum obtusatum* Broth.*	A
72. *Oligotrichum semilamellatum* (Hook. f.) Mitt.*	A

Table 5.1 Lists of mosses in Khew Mae Pan (K) and Ang Ka (A) areas, Doi Inthanon National Park, Chiang Mai Province (continued).

Species	Areas
Pottiaceae	
73. *Didymodon maschalogena* (Renauld & Car-dot) Broth.	A
74. *Wissia edentula* Mitt.	K
Pterobryaceae	
75. *Pterobryopsis divergens* (Mitt.) Nog.	A,K
Sematophyllaceae	
76. *Brotherella falcata* (Dozy & Molk.) Fleisch.	A,K
77. *Clastobryopsis brevinervis* Fleisch.*	A
78. *Clastobryopsis planula* (Mitt.) Fleisch.*	K
79. *Clastobryopsis planula* var. *delicata* (M. Fleisch.) B.C. Tan & Y. Jia *	A,K
80. *Clastobryopsis robusta* (Broth.) Fleisch.*	A
81. *Gammiella ceylonensis* (Broth. in Herzog) B.C.Tan & W.R.Buck	K
82. *Gammiella pterogonioides* (Griff.) Broth.	A
83. *Gammiella tonkinensis* (Broth. & Paris) B.C. Tan	K
84. *Heterophyllium amblystegum* (Mitt.) Y. Jia, S. He & Crosby	A
85. *Heterophyllum affinae* (Hook.) Fleisch.	A,K
86. *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota	K
87. *Mastopoma subfiliferum* Horik. & Ando	K
88. *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch.*	A,K
89. *Warburgiella leptorhynchoides* (Mitt.) Fleisch.	K
90. *Wijkia deflexifolia* (Ren. & Card.) Crum	A
91. *Wijkia hornschuchii* (M. Fleisch.) H.A. Crum	A
Sphagnaceae	
92. *Sphagnum cuspidatulum* C. Müll.	A
Symphyodotaceae	
93. *Symphyodon asper* (Mitt.) Jaeg.	A,K
94. *Symphyodon echinatus* (Mitt.) Jaeg.	A,K
95. *Symphyodon oblongifolius* (Ren. & Card.) Broth.	A,K
Thuidaceae	
96. *Claopodium assurgens* (Sull. & Lesq.) Card.	A
97. *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk	A,K

Table 5.1 Lists of mosses in Khew Mae Pan (K) and Ang Ka (A) areas, Doi Inthanon National Park, Chiang Mai Province (continued).

Species	Areas
Trachypodaceae	
98. *Diaphanodon blandus* (Harv.) Ren. & Card.	A,K
99. *Duthiella wallichii* (Mitt.) C. Müll.	A,K
100. *Trachypodopsis serrulata* var. *crispatula* (Hook. f.) van Zanten	A,K
101. *Trachypus bicolor* Reinw. & Hornsch. var. *bicolor*	A,K

Note:- * = New record to Thailand.

Key to Family

1. Plants whitish; laminal cell alternating or layered between leucocys and chlorocyst cells 2
1. Plants variously green, yellow, brown to blackish; laminal cells uniformly, not alternating or layered between leucocys and chlorocyst cells..... 3
    2. Plants of bog; forming a compact head of clusterd short branches; stem with short to elongate fasciculate branches; stem and branch leaves dimorphic ..... **Sphagnaceae**
    2. Plants of moist to semi-dry site, epiphytic; not forming a compact head of clusterd short branches, stem with out fasciculate branches; stem and branch leaves monomorphic..... **Leucobryaceae**
3. Leave with vertical lamellae .....**Polytrichaceae**
3. Leave with out vertical lamellae 4
    4. Plants acrocarpous, stem erect or occasionally spreading, solitary or in Short to long tufts or cushions 5
    4. Plants plurocarpous, stem creeping or pendent, frondose..... 16
5. Leaves arranged in 2 rows 6
5. Leaves arranged in 3 or more rows..... 7
    6. Leaves with vaginant lamina .....**Fissidentaceae**
    6. Leaves with out vaginant lamina..... **Mniaceae**
7. Laminal cells papillose or mammalose 8
7. Laminal cells smooth 12
    8. Basal portion of leaf with enlarge clear cells, strongly differentiated from basal margin and distal cells ..... **Calymperaceae**
    8. Basal portion of leaf with out enlarge clear cells 9
9. Plants lithophytes, usually found on sandstone .....**Diphysciaceae**
9. Plants terrestrial or epiphytes 10
    10. Laminal cells narrowly to broadly rectangular with projecting papillae at cells ends; leaf margins often coarsely toothed; capsules subglobose, inclined..... **Bartramiaceae**
    10. Laminal cells mostly isodiametric or short rectangular; papillae mostly over cell lumina; leaf margins entire; capsules ovoid to cylindrical 11
11. Leaves narrowly lanceolate to olong-lanceolate; unipapillae over cell lumens..... **Othotrichaceae**
11. Leaves lanceolate with broader ovate base or ovate-lanceolate; pluripapillose ..... **Pottiaceae**
    12. Leaf margins bordered, inner laminal cells large, often hexagonal-elongate to broadly fusiform or rhomboidal 13
    12. Leaf margins lacking border, marginal cells similar to or slightly differentiated from inner laminal cells..... 14

13. Laminal cells subquadrate and rounded to oblong-oval..... **Mniaceae**
13. Laminal cells rhombic to elongate-hexagonal ..... **Bryaceae**
    14. Leaves linear, linear-lanceolate .....**Dicranaceae**
    14. Leaves ovate to oblong-ovate 15
15. Plants julaceous, erect; leaves erect and appressed on stem ..... **Bryaceae**
15. Plants bud-like; leaves crowded on stem tip ..... **Funariaceae**
    16. Costa absent, short and forked, or elongate and double 17
    16. Costa single 23
17. Leaves ecostate 18
17. Leaves with costa, short and forked or elongate and double..... 19
    18. Alar cells inflated, oval to oblong, mostly thick-walled, porose or not often dark yellow or reddish; lamina cells smooth or papillose .... **Sematophyllaceae**
    18. Alar cells not inflated or oval mostly quadrate; laminal cells pitted .... **Myuriaceae**
19. Leaves strongly cordate; several branched..... **Hylocomiaceae**
19. Leaves not cordate; not many branched 20
    20. Leaves serrulate or dentate at top; capsules spinose..... .....**Symphyodontaceae**
    20. Leaves not serrulate or sometimes slightly dentate; capsules not spinose..... 21
21. Leaves cells scattered minute papillae ..... **Lembrophyllacea**
21. Leaves cells smooth 22
    22. Leaves with fasciculate fusiform gemmae and rhizoids at apex..... .....**Plagiotheciaceae**
    22. Leaves with out fasciculate fusiform gemmae and rhizoids at apex ..... **Hypnaceae**
23. Leaves strongly dimorphic, ventral leaves smaller and different in shape ..... **Hypoterygiaceae**
23. Leaves monomorphic, usually differing only in sized 24
    24. Laminal cells mammailose or papillose 25
    24. Laminal cells smooth 28
25. Laminal cells pluripapillose .....**Meteoriaceae**
25. laminal cells uniformly unipapillose..... 26
    26. Plants flexuose and pendulose.....**Meteoriaceae**
    26. Plants robust and rigid 27
27. Paraphyllia present on stem; leaves of stem and branch differentiated; stems regularly 1-3 pinnately branched.....**Thuidaceae**
27. Paraphyllia absent on stem; leaves of stem and branch not differentiated; stem pendulose or ascending, irregularly branched.....**Trachypodaceae**
    28. Plants mostly erect; numerous filamentous pseudoparaphyllia present..... **Pterobryaceae**
    28. Plants complanate; filamentous pseudoparaphyllia not present..... 29

29. Plants irregularly to regularly pinnately branched; leaves broadly ligulate, truncate to rounded, with out gemmiferous propagules .... **Neckeraceae**
29. Plant not irregularly to regularly pinnately branched; leaves oblong, lanceolate, ovate to spathulate, with numerous gemmiferous propagules in upper leaf axils..... **Hookeriaceae**

BATRAMIACEAE

Plants small to rather large, in loose or dens tuft or compact. **Stem** erect, simple or irregularly branched, densely foliate, often ridiculous or tomentose below; central stand present or absent. **Leaves** appressed, imbricate to widely spreading or squarrose, ovate-lanceolate to lanceolate or linear, usually not decurrent at base, often sheathing at base, rarely plicate; margins not bordered, serrate in the upper margins, often dentate at back; **costa** single, strong; **cells** rectangular or rarely narrowly rectangular, usually thick-walled, papillose or mammilose at or near 1 or both ends, sometimes centrally papilose, rarely smooth; basal cells enlarge, hyaline, usually smooth, alar cells rarely differentiated. **Autoicous** or dioicous. **Sporophytes** terminal, occasionally lateral due to annual innovations of new branches. Perichaetial leaves large, similar to vegetative leaves. **Seta** solitary, rarely 2-5-clustered, elongate; **capsule** erect or inclined, rarely pendulose, usually spherical, furrowed or not furrowed; sometimes neck developed; mouth oblique; stomata superficial, numerous; opercula small, shortly apicalate, rarely rostrate; annuli usually brown, smooth or papillose, usually not bordered, trabeculate on inner surface; **peristome** double; exostome teeth lanceolate, reddish to brownish; endostome segments shorter, keeled, perforate; basal membrane ca. 1/4-1/2 the height of teeth; cilia 1-3, not nodulose, reduced or rudimentary. **Calyptra** small, cucullate, smooth. **Spore** large, spherical, ellipsoidal or kidney-shape, papillose.

PHILONOTIS

Philonotis Brid., Bryol. Univ. 2: 15. 1827; Gangulee, Mosses E. India 4: 1108. 1974; Eddy, A Handb. of Males. Mosses 3: 224. 1996; Mu & He, Moss Fl. China 4: 174. 2007.

Plants small to rater large, dull or glossy, in loose or dense tufts. **Stems** erect, often branched below the fertile buds; radiculose below. **Leaves** mostly erect, appressed when dry, erect-patent or secund when moist, ovate- to narrowly ovate- or triangular-lanceolate, acuminate at apex, rarely obtuse; margins plane or recurved, serrulate or serrate; **costa** strong, usually excurrent, sometimes ending below the apex; apical leaf cells shortly rectangular or rhombic; median cells narrowly rhombic or hexagonal, usually prorate at upper cells ends, sometime prorate at both ends, rarely smooth; basal cells larger, lax, rectangular, papillose at upper or lower ends or smooth; alar cells weakly differentiated. **Dioicous**, rarely autoicous. **Seta** solitary, elongate, straight; **capsule** nearly spherical, asymmetric, inclined; furrowed when dry; neck short; mouth broad; opercula conic at base, shortly rostrate;

peristome double. **Calyptra** shortly cucullate. **Spore** spherical or reniform, papillose .

Key to the Species

1. Plants small, 1.0-1.2 cm high, with dense rhizoids at base; costa excurrent ..... *P. thwaitesii*
1. Plants medium-sized, 1.3-1.7 cm high, slender, rhizoids not dense; costa percurrent ..... *P. turneriana*

1. *Philonotis thwaitesii* Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 1: 60. 1859; Gangulee, Mosses E. India 4. 1118, fig. 546. 1974; Mu & He, Moss Fl. China 4: 187, pl. 235, figs. 7-12. 2007.

Plants small, green, yellowish green, glossy, in loose tufts. **Stems** erect, less than 2 cm high, often branched at top, with dense rhizoids at base. **Leaves** appressed when dry, erect-spreading when moist, triangular-lanceolate to lanceolate, ca 0.5-0.8 mm x 2-3 mm, keeled, somewhat squarrose, slenderly acuminate at apex, broadest above the truncate leaf insertion; margins recurved, serrulate; **costa** excurrent, ending in long awns; upper leaf cells elongate-rectangular to sublinear; median cells rectangular to shortly rectangular, with papillae at upper cell ends ventrally, more or less smooth or papillose at the lower ends dorsally. **Dioicous**. **Seta** 10-20 mm long, reddish; **capsule** spherical, inclined to horizontal, reddish brown, with mouth in the center. (**Figure 5.1)**

Thailand — NORTHERN: Chiang Mai; NORTHEASTERN: Loei SOUTHEASTERN: Nakhon Nayok.

Distribution — Borneo, Mainland China, India, Hong Kong, Korea, Japan, Malaysia, Nepal, New Guinea, Sikkim, Sri Lanka, Sumatra, and Taiwan.

Ecology — On slope along road side.

Specimens examined — *Y. Nathi 1061* (BCU)

GPS location — 18.5880351°N 98.48592284°E

Altitude — 2,543 m

2. *Philonotis turneriana* (Schwaegr.) Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 1: 62. 1859; Gangulee, Mosses E. India 4: 1118. 1974; Eddy, A Handb. Males. Mosses 3, fig. 490: 233. 1996; Mu & He, Moss Fl.

China 4: 189, pl.235, figs. 13-19. 2007. — *Bartramia turneriana* Schwaegr, Sp. Frond., Suppl. 3(1): 238. 1828.

Plants medium-sized, slender, pale green to yellowish green, slightly glossy, in tufts. **Stems** erect, 3-4 cm high, often branched at top of stems, with branches 2-3 mm long, densely tomentose below. **Leaves** appressed when dry, erect-spreading when moist, narrowly triangular-lanceolate, ca 0.25-0.4 mm x 1-2 mm, gradually acuminate at apex, broadest at truncate leaf insertion; margin plane, serrulate above; **costa** percurrent, dentate at back; upper and median leaf cells rhomboidal to elongate-rectangular, 40-45 μm long, thin-walled, with papillae at upper cell ends ventrally, not clearly papillose dorsally; lower cells shorter and broader, rectangular. **Dioicous**. **Seta** 15-25 mm long; **capsule** spherical, horizontal, ca. 2 mm long. (**Figure 5.2**)

Thailand — NORTHERN: Chiang Mai, Tak; SOUTHEASTERN: Nakhon Nayok

Distribution — Bhutan, Mainland China, Hong Kong, India, Indonesia, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, and Taiwan.

Ecology — On humus rich ground in grassland.

Specimens examined — *Y. Nathi 305, 321, 416, 422, 708* (BCU)

GPS location — 18.5604936°N 98.47736626°E, 18.56085126 °N 98.47709494 °E, 18.58937982°N 98.48574833°E

Altitude — 2,141-2,294 m

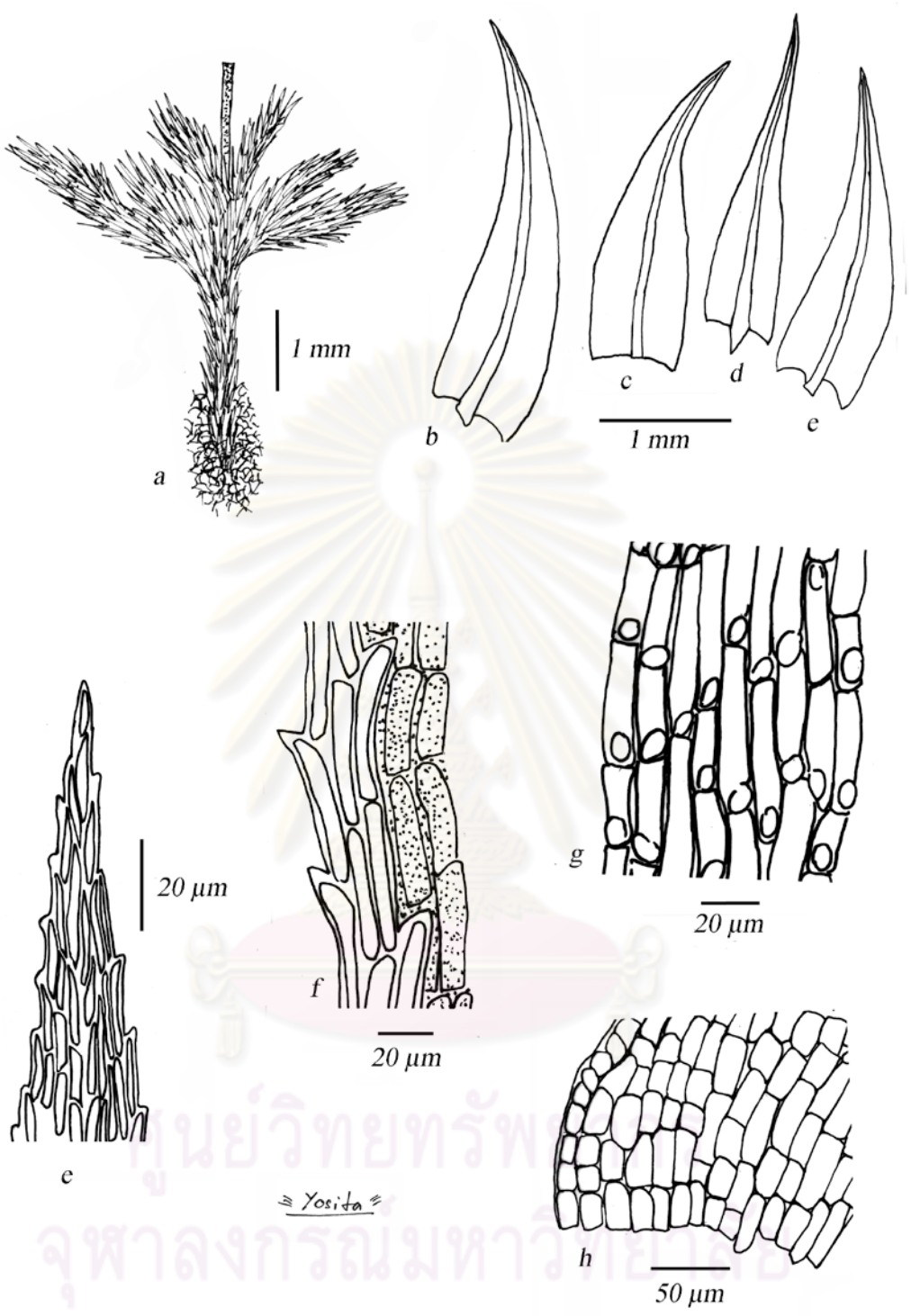


Figure 5.1 *Philonotis thwaitesii* Mitt.
a., b., c., d., e. leaves; f. leaf-tip; g. leaf-margin; h. cells at upper leaf; i. cells at leaf base. Based on *Y. Nathi 1061*.

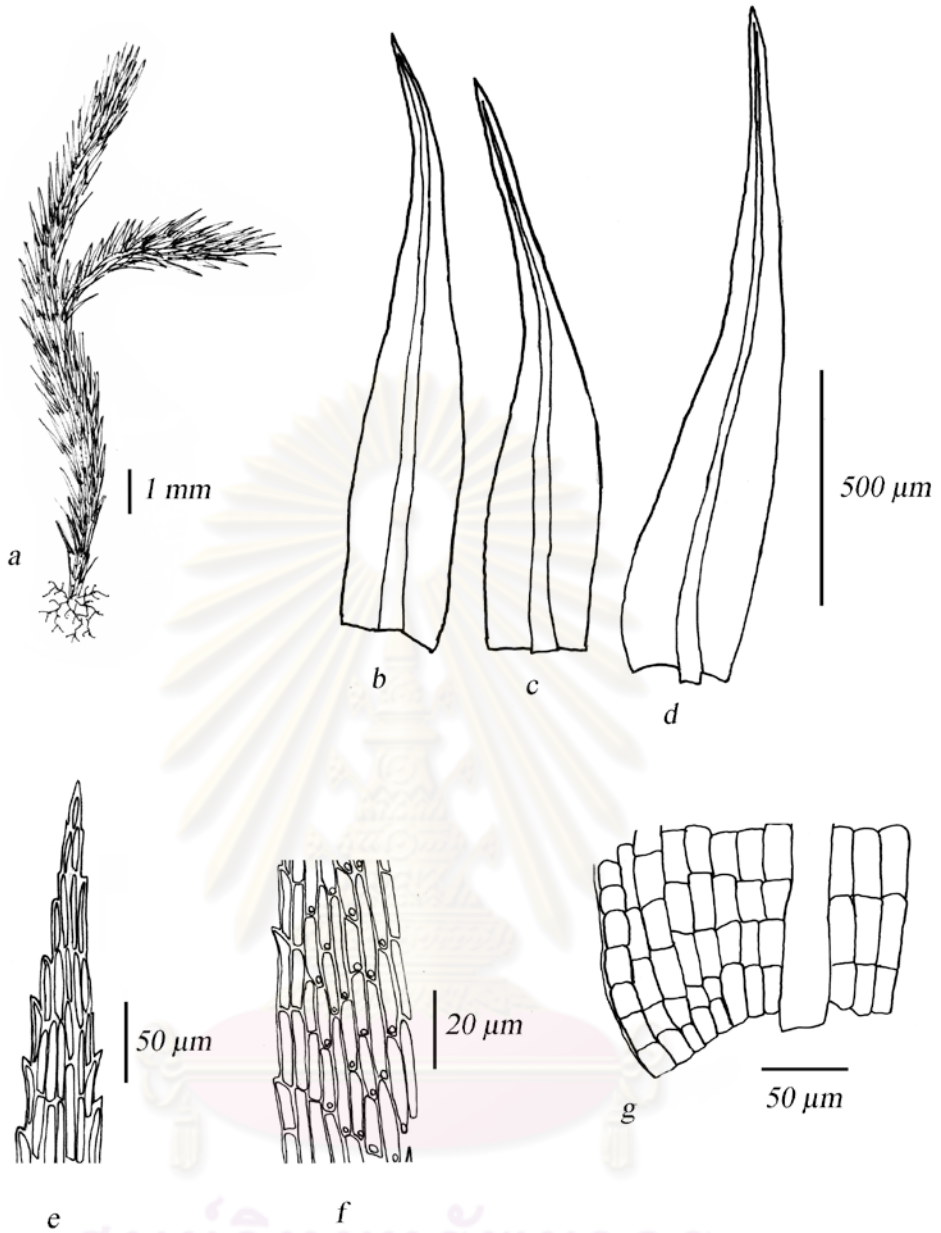


Figure 5.2 *Philonotis turneriana* (Schwaegr.) Mitt.
a.,b.,c leaves; d. cells at middle leaf ; e. leaf-apex; f. cells at leaf base. Based on *Y. Nathi 321.*

BRYACEAE

Plants small to large. **Stems** erect, sometimes primary stem creeping, central strand usually present. **Leaves** ovate, obovate, oblong-ovate to lanceolate, margins entire or serrulate above, usually bordered by elongated cells; **costa** single, often strong, reaching the middle or above; cells unistratose, rarely bistratose or tristratose at margins; basal cells usually rectangular, distinctly larger than those cells above the base; median cells rhomboidal, oblong, oblong-hexagonal to narrowly rhomboidal or linear. Autoicous or dioicous. **Seta** slender; **capsule** erect, suberect to pendulous, usually symmetric or pyriform, rarely spherical; neck clearly differentiated; annuli often persistent; **opercula** conic, often shortly rostrate; **peristome** double. **Calyptra** cucullate, naked.

Key to the genera

1. Stems long, slender, julaceous; leaves strongly appressed, imbricate, ovate or oblong-elliptic ..... *Anomobryum*
1. Stem various, not julaceous; leaves oblong-ligulate, rounded-ovate, oblong-ovate to lanceolate 2
2. Leaves usually crowded at branch apex, oblong-ligulate or oblong-ovate, acuminate ..... *Brachymenium*
2. Leaves not crowded at branch apex, leaves arrange trough out stem, ovate, elliptical or lanceolate ..... *Bryum*

1. *ANOMOBRYUM*

Anomobryum Schimp., Syn. Musc. Eur. 382. 1860; Gangulee, Mosses E. India 4: 954. 1974; Nog., Ill. Moss Fl. Japan 2: 452. 1994; Eddy, A Handb. Males. Mosses 3: 147. 1996; Zhang, Li and He, Moss Fl. China 4: 4. 2007.

Plants small, slender, mostly glossy. **Stems** erect, julaceous; central strand present. **Leaves** apprised when dry and moist, imbricate, oblong-ovate or elliptical, concave, bluntly obtuse; margins plane, entire; **costa** strong, ending in the mid-leaf or up to the leaf apices; median leaf cells linear or rhomboidal, thin-walled, becoming narrower near margins, but borders not differentiated. **Gemma** usually in axils. **Dioicous**. **Seta** elongate; **capsule** suberect, horizontal to pendulous, shortly pyriform to oblong-pyriform; annuli well developed; **peristome** double, perfect or somewhat reduced at times.

Anomobryum julaceum (Schrad. ex P. Gaertn., B. Mey. & Scherb.) Schimp.

Syn. Musc. Eur. 382. 1860; Eddy, Handb. Males. Mosses 3: 147, fig. 431. 1996; Zhang, Li and He, Moss Fl. China 4: 6. 2007. — *Bryum julaceum* Schrad. ex P. Gaertn., B. Mey. & Scherb., Oekon. Fl. Wetterau 3((2)): 97. 1802.

Plants slender, julaceous, 2-4 cm high, yellowish green to grayish green, slightly glossy, in tufts. **Stems** erect, simple. **Leaves** imbricately appressed, ovate to oblong-ovate, concave, acute to bluntly obtuse; margins plane, entire; **costa** strong, ending close to the leaf apex to nearly percurrent; upper lamina cells long and narrow, thick-walled with vemicular lumina; basal cells lax tissue being abrurupt. **Dioicous**. **Sporophyte** not found. (**Figure 5.3)**

Thailand – NORTHERN: Chiang Mai.

Distribution – Thailand and widely distribution in North hemisphere.

Ecology – On ground in open areas,

Specimens examined – *Y. Nathi 19, 32, 72, 195, 307, 354, 388, 408, 423, 459, 500, 580, 749* (BCU)

GPS location – 18.58883332°N 98.48731617 °E, 18.55584081 °N 98.48227453 °E, 18.56049361 °N 98.47736626 °E

Altitude – 2,190-2,568 m

2. *BRACHYMENIUM*

Brachymenium Schwägr., Sp. Musc. Frond., Suppl. 2: 131. 1823; Gangulee, Mosses E. India 4: 928. 1974; Nog., Ill. Moss Fl. Japan 2: 448. 1994; Eddy, Handb. Males. Mosses 3: 165. 1996; Zhang, Li and He, Moss Fl. China 4: 7. 2007.

Plants small to rather large, pale green, in loose or dense tufts. **Stems** erect, with newly innovated branches often in equal length at base. **Leaves** usually crowded at branch apex, sparsely foliate below, ovate, ovate-lanceolate to ligulate, acuminate at apex; **costa** often strong, ending just below the apex or percurrent to excurrent; leaf cells hexagonal, rhomboidal or linear-rhomboidal; basal rectangular. **Dioicous** or autoicous. **Seta** elongate, erect or slightly curved; **capsule** mostly erect or inclined, rarely horizontal to pendulose, symmetric, pyriform, ovoid or club-shaped; neck more or less developed; annuli differentiated; opercula small, conic, often apiculate; **peristome** double.

Brachymenium nepalense Hook. In Schwägr.

Sp. Musc.. Frond., Suppl. 2(1): 131. 1824; Ochi, J. Fac. Educ. Tottori Univ. 49. 1959; Gangulee, Mosses E. India 4: 938, fig. 449. 1974; Eddy, A Handb. Males. Mosses 3: 166, fig.444. 1996; Zhang, Li and He, Moss Fl. China 4: 16, pl.181, fig 11-17. 2007.

Plants medium-sized, rather thick, 1-2 cm high, slightly glossy, in dense tufts. **Stems** erect, with reddish brown rhizoids at base. **Leaves** usually crowded, forming rosettes at top of branches, ca. 2.5-3.5 mm x 0.8-1.2 mm, lower leaves smaller, flexuose or twisted when dry, oblong-ligulate, oblong-spathulate or oblong-ovate, acuminate; margins entire, recurved nearly throughout except at apex, serrulate in the upper part; **costa** strong, excurrent, ending in long awns; upper margins consisting of 1-3 rows of narrowed cells; median cells rhombic or hexagonal, ca. 50-70 μm x 20-25 μm , more or less thin-walled; basal cells, ca. 50-100 μm x 25-35 μm, shortly rectangular to nearly quadrate. **Autoicous**. **Sporophytes** not found. (**Figure 5.4**)

Thailand —NORTHERN: Chiang Mai, Phetchabun NORTHEASTERN: Loei

Distribution — China, Japan, Nepal, Southeast Asia, Papua New Guinea, South Africa, and Madagascar.

Ecology — On branched of tree near the grassland.

Specimens examined — *Y. Nathi 456, 578, 587, 716* (BCU)

GPS location —18.55630886 °N 98.48039045 °E, 18.56131445°N 98.47718731 °E

Altitude — 2,209-2,248 m

3. *BRYUM*

Bryum Hedw., Sp. Musc. Frond. 178. 1801; Gangulee, Mosses E. India 4: 961. 1974; Nog., Ill. Moss Fl. Japan 2: 458. 1994; Eddy, A Handb. Males. Mosses 3: 118. 1996; Zhang, Li and He, Moss Fl. China 4: 19. 2007.

Plants small to robust, in loose tufts. **Stems** simple or branched, often radiculose at base. **Leaves** dens, ovate, elliptical or lanceolate, acute or acuminate or apiculate at apex, upper leaves larger than lower leaves; margins entire or serrulate, often recurved below or throughout, borders often differentiated; **costa** strong, excurrent, percurrent or ending below the

leaf apex; leaf cells usually rhombic, shortly rhomboidal or hexagonal, thin-walled, becoming narrowed close to margin; lower cells larger, oblong-rhomboidal to rectangular. **Dioicous** or autoicous. **Seta** elongate; **capsules** cylindrical or in various shapes, inclined to pendulose; neck mostly developed; opercular conic; annuli well developed, revolute; **peristome** double.

Key to the species

1. Plants whitish to silvery green..... *B. argenteum*
1. Plants green, yellowish green not whitish or silvery..... 2
   2. Plants up to 20 mm long, glossy; leaves often forming rosettes, broadly elliptical, oblong-ovate or obovate ..... *B. billarderi*
   2. Plants up to 30 mm long, leaves oblong-ligulate, obovate or spathulate ..... *B. salakense*

1. *Bryum argenteum* Hedw.

Sp. Musc. Frond. 181. 1801; Gangulee, Mosses E. India 4: 970. 1974; Nog., Ill. Moss Fl. Japan 2: 484, fig. 213. 1994; Eddy, Handb. Males. Mosses 3: 120, fig. 410. 1996; Zhang, Li, and He, Moss Fl. China 4: 24. 2007.

Plants small, 3-7 mm high, grayish to whitish or pale green, more or less glossy, in tufts or compact. **Stems** short, often branched by innovations. **Leaves** imbricate when dry and moist, broadly ovate or rounded-ovate, cucullate, short- to long-filiform or apiculate at apex, ca. 0.5-2.0 mm long, hyaline above, pale green or yellowish green below; margins entire, indistinctly differentiated by 1-2 rows of narrowly rectangular cells; **costa** green, ending below the apex or percurrent; median leaf cells oblong-ovate or rounded-hexagonal, 10-12 μm x 40-55 μm, thin- or thick-walled. **Dioicous**. **Sporophytes** not found. (**Figure 5.5**)

Thailand — NORTHERN: Chiang Mai, Phitsanulok, Phetchabun, Tak; SOUTHEASTERN: Nakhon Nayok.

Distribution — China, India, Japan, Java, Korea, Nepal, Philippines, Siberia, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology — On soil, concrete, on rotten long in open areas.

Specimens examined — *Y. Nathi 73, 125, 335, 385, 983, 1060* (BCU)

GPS location —18.58903575°N 98.48577926°E, 18.58925058°N 98.48741289°E , 18.55595036°N 98.48235148°E

Altitude — 2,186-2,536 m

2. ***Bryum billarderi*** Schwägr.

Sp. Musc. Frond., Suppl. 1: 115. 1816; Gangulee, Mosses E. India 4: 980, fig. 471-473. 1974; Nog., Ill. Moss Fl. Japan 2: 486, fig. 211, B. 1994; Eddy, Handb. Males. Mosses 3: 142, fig. 428. 1996; Zhang, Li and He, Moss F. China 4: 26. 2007.

Plants medium-sized, up to 2 cm high, green to yellowish, glossy, in dense tufts. **Stems** 2-3 branched. **Leaves** sparse on lower stems; upper leaves dense, often forming rosettes, twisted or irregularly flexuous when dry, ca. 1.6-2.0 mm x 0.7-1 mm, upper leaves up to 4.5 mm x 2.0 mm, broadly elliptical, oblong-ovate or obovate, acute or shortly acuminate; margins recurved in the lower 2/3, entire, plane above, distinctly dentate near apex; **costae** percurrent or shortly excurrent, yellowish green or nearly brownish; median leaf cells oblong-hexagonal, 35-80 μm x 12-19 μm; upper margins bordered by 3-4 rows of linear cells, lower margins by 5-6 rows of linear cells, thin- or more or less thick-walled. **Dioicous**. **Sporophytes** not seen. (**Figure 5.6**)

Thailand — NORTHERN: Chiang Mai

Distribution — Mainland China, Hong Kong, India, Japan, Java, Korea, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam

Ecology — On humus rich ground in grassland.

Specimens examined — *Y. Nathi 309, 484, 508, 1070* (BCU)

GPS location —18.56049361°N 98.47736626°E, 18.56177512 °N 98.47630729 °E, 18.58937982 °N 98.48574833 °E, 18.55318073 °N 98.47826891 °E

Altitude — 2,150-2,319 m

3. ***Bryum salakense*** Cardot.

Annuaire Conserv. Jard. Bot. Genève, 15-16: 166. 1912; Gangulee, Mosses E. India 4: 977, fig. 470.1974; Zhang, Li and He, Moss Fl. China 4: 51, figs. 7-11. 2007.

Plants medium-sized, 30-45 mm high, twised when dry, in losse tufts. **Stems** erect, branched at base. **Leaves** dense and larger above, sparse and smaller below, oblong-ligulate, obovate or spathulate, acuminate, ca. 3-5 mm x 2.0-2.8 mm long; margins recurved in lower 2/3 of leaf length, entire, serrulate at apex, bordered by 3-4 rows of narrower, pale yellowish and thick-walled cells; **costae** excurrent, ending in long awns; median leaf cells

elongate-rhombic to hexagonal, 60-80 μm x 20-25 μm, thin-walled; basal cells rectangular. **Dioicous**. **Sporophytes** not seen. (**Figure 5.7**)

Thailand — NORTHERN: Chiang Mai, Phetchabun.

Distribution — China, Bhutan, Nepal, and Indonesia.

Ecology — On soil

Specimens examined — *Y. Nathi 52, 326, 707* (BCU)

GPS location —18.58813679 °N 98.48638745°E, 18.56177512 °N 98.47630729 °E

Altitude —2,319-2,555 m

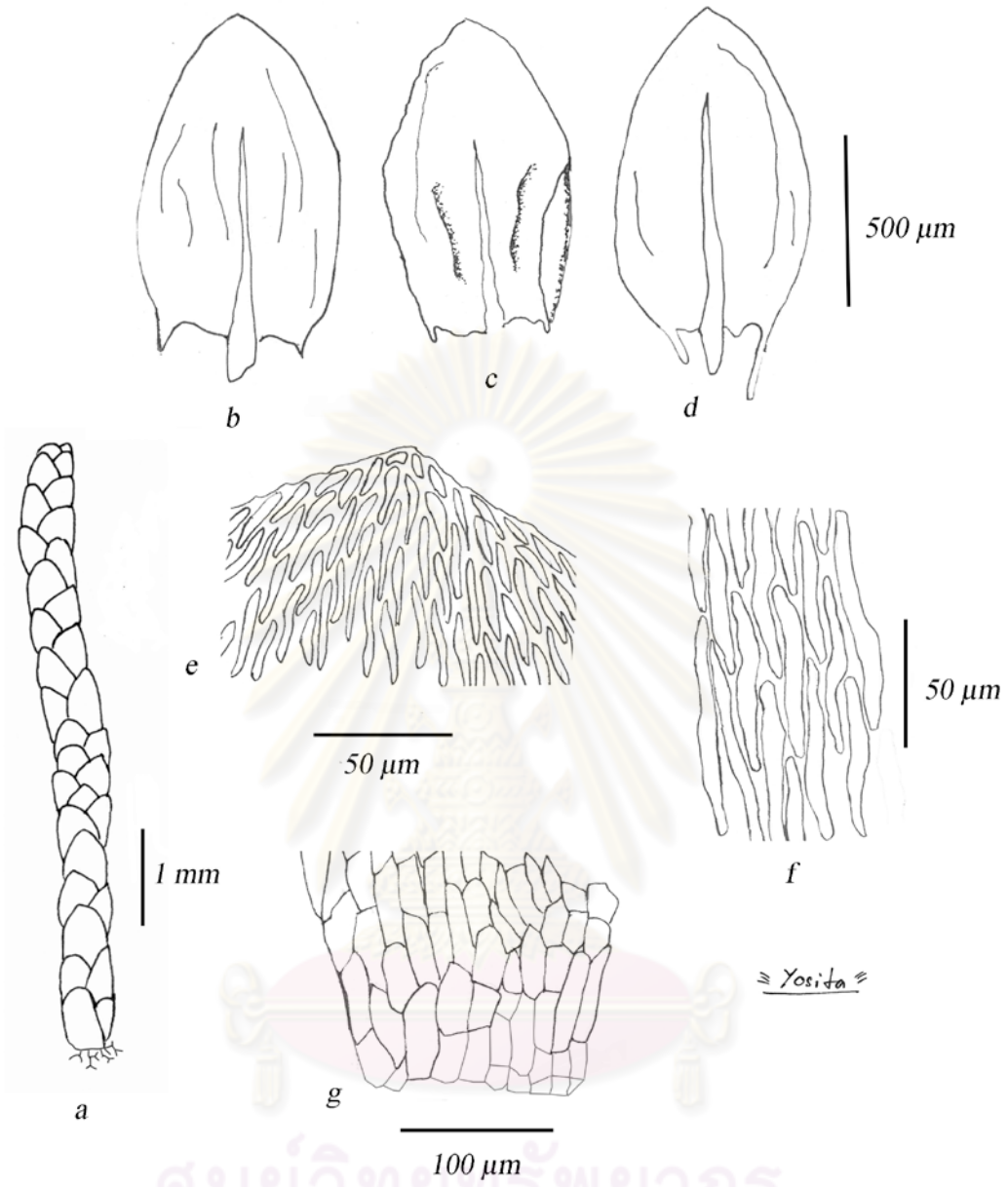


Figure 5.3 *Anomobryum julaceum* (Schrad. ex P. Gaertn., B. Mey. & Scherb.) Schimp.
a. habit; b.,c., d leaves; e. leaf apex; f. cells at mid-leaf; g. cells at leaf base. Based on *Y. Nathi* 19.

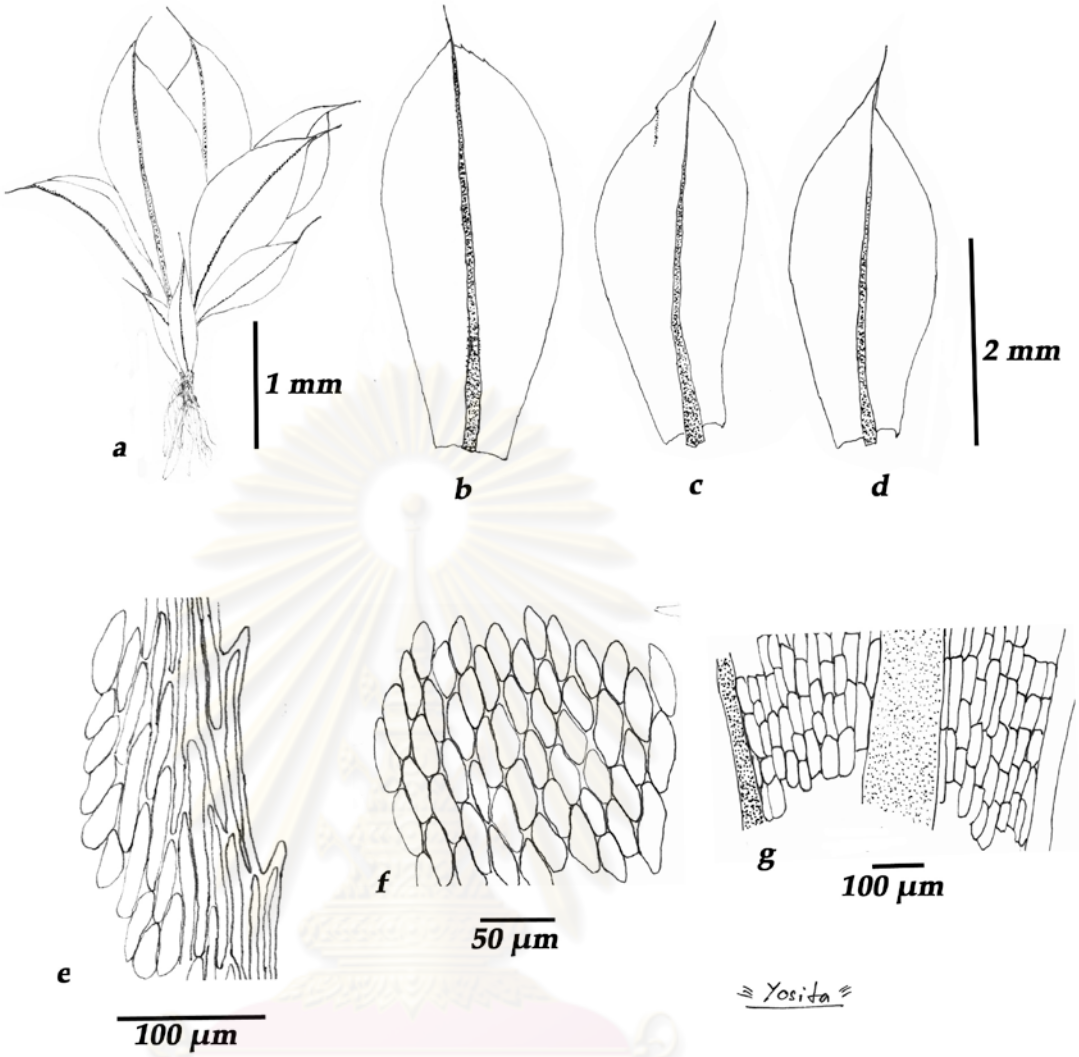


Figure 5.4 *Brachymenium nepalense* Hook.
a. habit; b.c.,d. leaves; e. leaf margin; f. cells at mid-leaf; g. cells of leaf base.
Based on *Y. Nathi 456.*

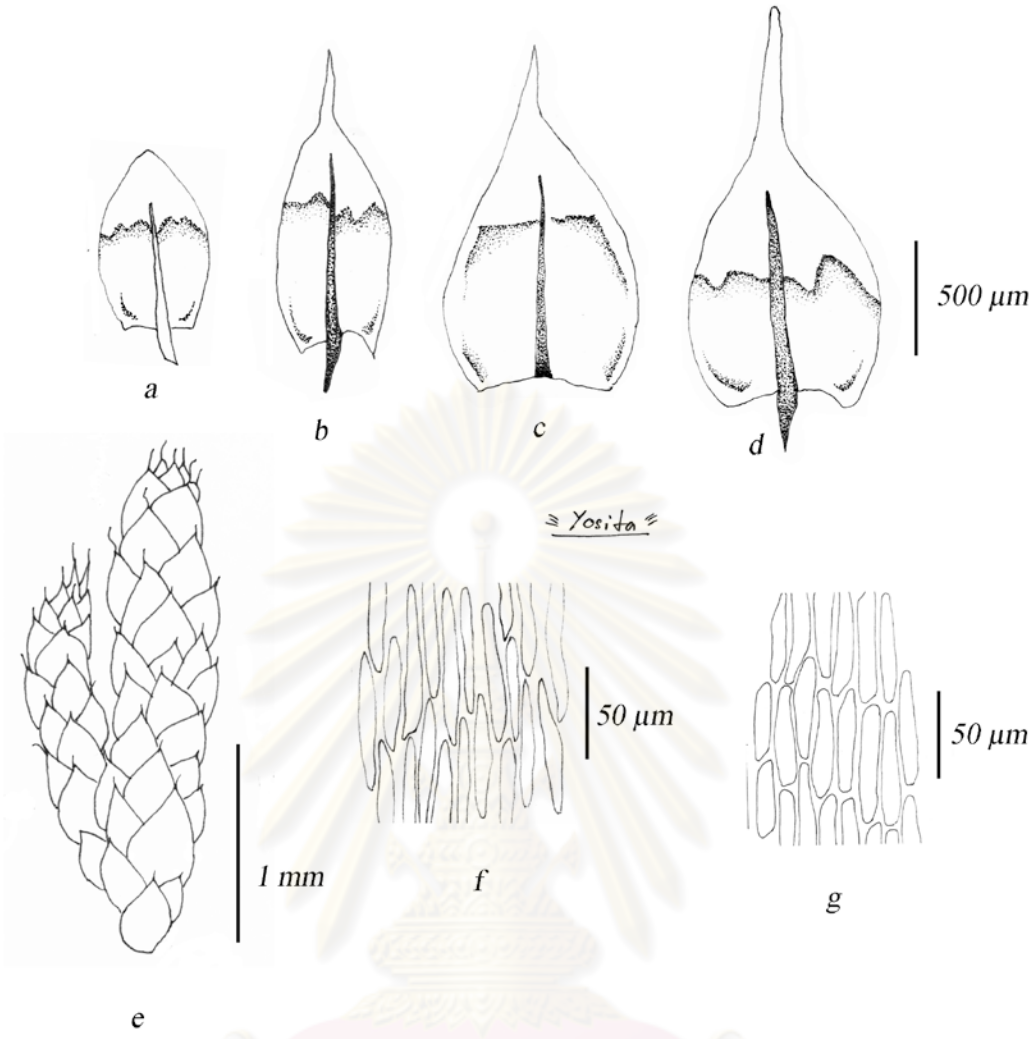


Figure 5.5 *Bryum argenteum* Hedw.
a. b.,c.,d. leaves; e. habit; f. cells of leaf tip; g. cells at leaf base; Based on *Y. Nathi 1060.*

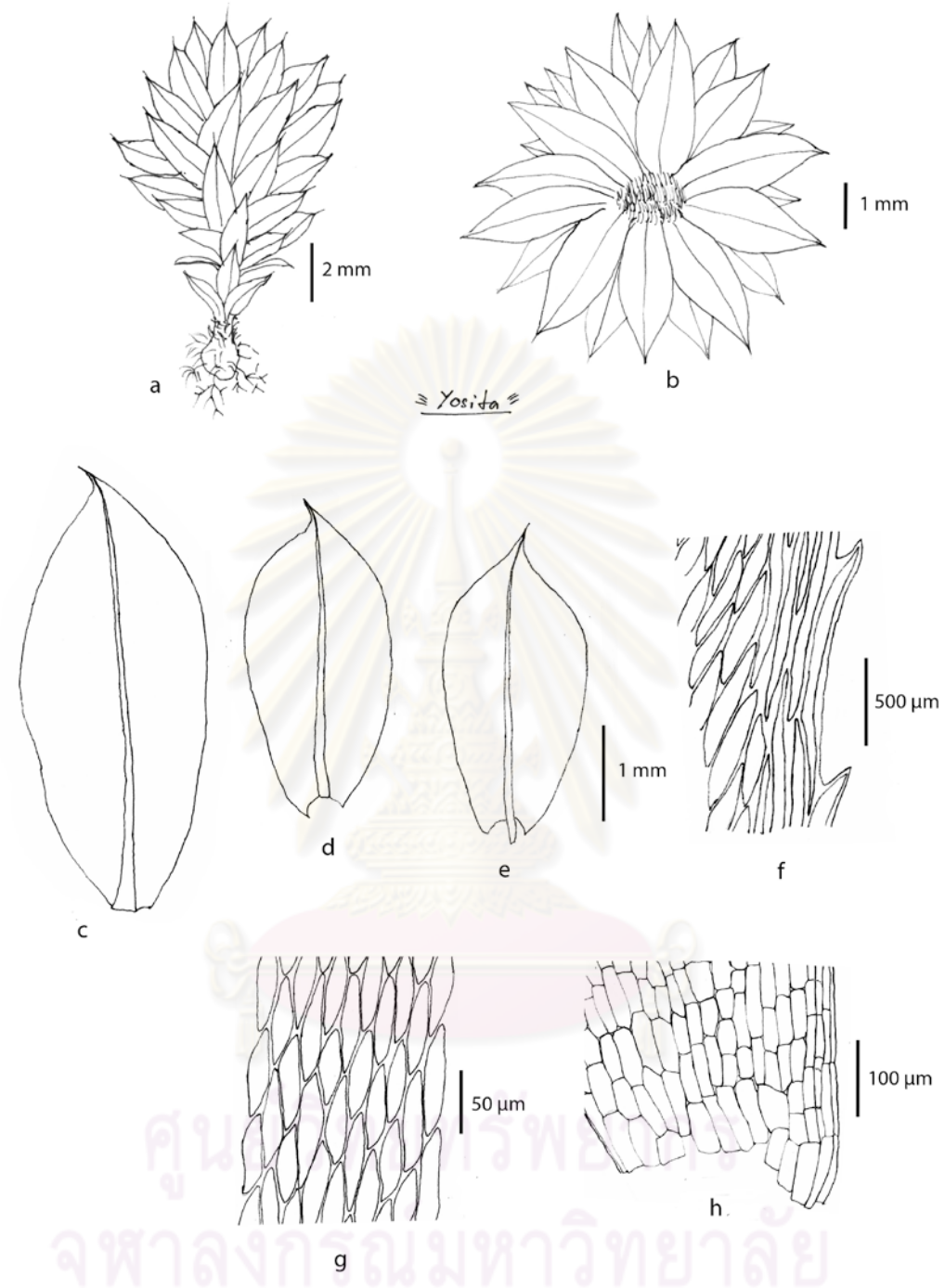


Figure 5.6 *Bryum billarderi* Schwägr.
a. habit; b. habit in upper view; c., d., e. leaves; f. leaf-margins; g. cells at mid-leaf; h. cells at leaf base. Based on *Y. Nathi 484.*

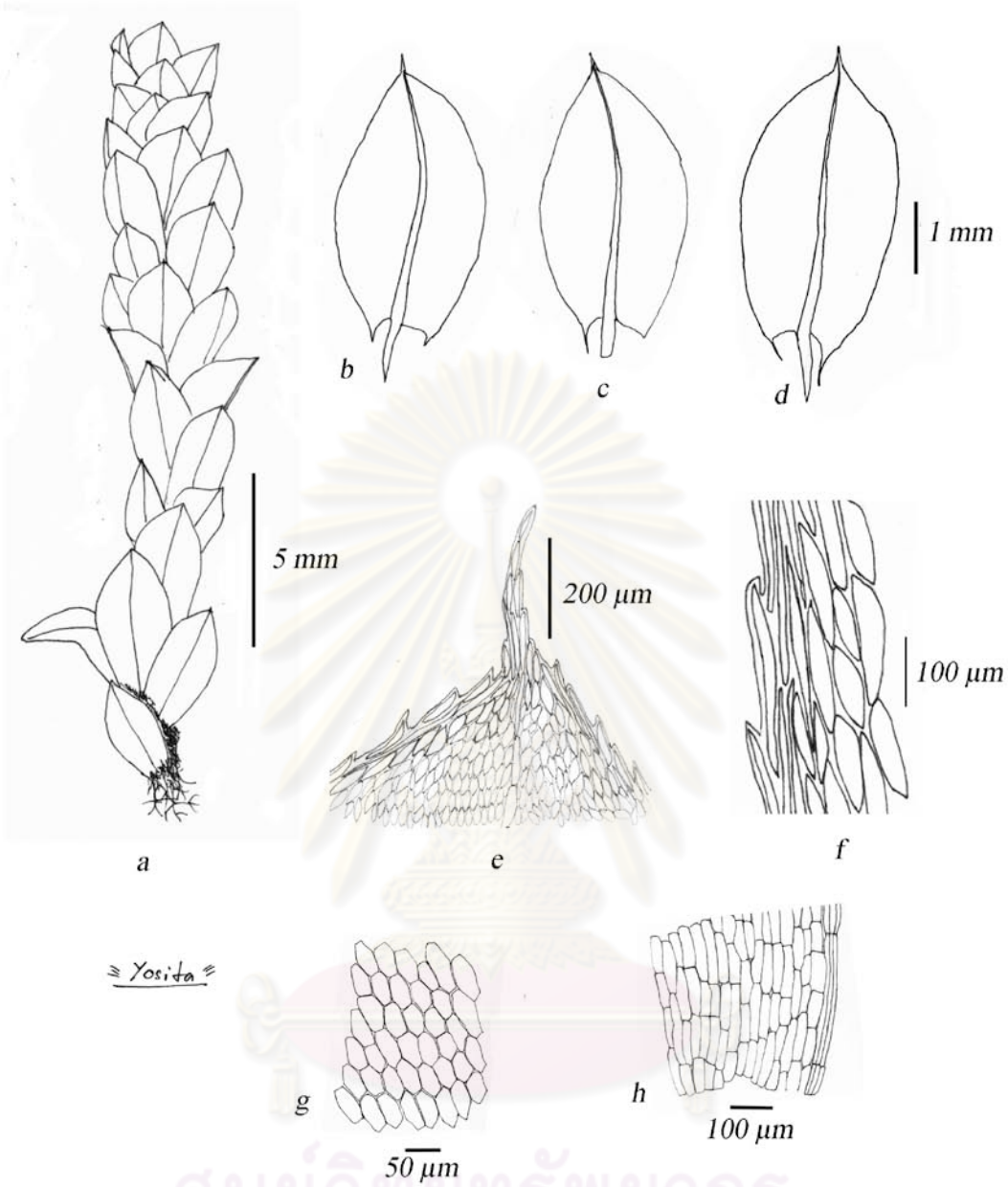


Figure 5.7 *Bryum salakense* Cardot
a. habit; b.,c.,d. leaves; e. leaf margin; f. cells at upper leaf; g. cells at leaf; h. leaf apex. Based on *Y. Nathi 52.*

CALYMPERACEAE

Plants small to robust, **Stems** mostly erect, stemless appearance in some taxa. **Rhizoids** mostly scanty, brown to red. **Leaves** crowded, sheathing at base, axillary hairs mostly inconspicuous; leaf margins mostly thickened, often toothed, bordered with elongate hyaline cells, thickened border often enclosing stereid cells; **costa** strong, convex on back, often papillose or spinose on one or both sides, ending near apex to excurrent, frequently with clusters of gemmae at tip; cells of upper laminae green, mostly isodiametric, smooth to papillose; lower laminae including conspicuous fields of enlarged, internally and externally porose, hyaline cells; intramarginal files of differentiated cells (teniolae) present in leaves of some taxa; gemmae common, uniseriate, fusiform to clavate to filamentous, borne exclusively on leaves. **Dioicous**, rarely monoicous. **Seta** straight, mostly elongate but very short in some Syrrhopodon; **capsule** cylindric; annuli lacking; opercula rostrate; **peristome** lacking, or present, if present single and of 16 jointed smooth or papillose teeth, often reduced and imperfect. **Calyptra** cucullate and deciduous, or enveloping the capsule, persistent, and opening by vertical slits, rarely very small and mitrate.

SYRRHOPODON

Syrrhopodon Schwaegr., Sp. Musc. Frond., Suppl. 2(1):110. 1824; Gangulee, Mosses E. India 3: 568.1972; Eddy, Handb. Males. Mosses 2: 54. 1990; Nog., Ill. Moss Fl. 2: 244. 1994; Reese & Lin, Moss Fl. China 2: 82. 2001.

Plants slender to rather robust, in dense tufts. **Stems** mostly erect; central strand absent. **Leaves** oblong to linear, often bordered with elongate hyaline cells, border usually thickened; teniolae or teniolae-like features lacking or rarely present; **costa** smooth or papillose, reaching leaf apex or nearly so; leaf cells isodiametric, smooth to papillose; gemmae fusiform or filamentous; **gemmiferous leaves** sometimes differentiated from vegetative leaves. Gemma receptacles rarely developed. **Seta** elongate or rarely very short; **capsule** mostly exserted but rarely immersed; peristome present or lacking, often imperfectly developed. **Calyptra** deciduous, mostly cucullate, rarely mitrate.

Syrrhopodon spiculosus Hook. & Grev.

Edinburgh J. Sci. 3:226. 1825; Eddy, Handb. Males. Mosses 2: 67, fig. 208. 1990; Reese & Lin, Moss Fl. China 2: 99. 2001.

Plants small to medium-sized, 0.5–1.5 cm high, pale yellowish green, in loose tufts. **Stems** elongate, **rhizoids** purple-red, often copious and conspicuous. **Leaves** curled-contorted when dry, flexed at shoulders and spreading to somewhat patent when wet, involute distally, linear-acuminate above scarcely broader base, 3–5 mm long, axillary hairs inconspicuous; **costa** spinose-papillose abaxially and adaxially above leaf base; cells of upper laminae obscure, isodiametric, pluripapillose abaxially, bulging-pluripapillose adaxially, dorsal papillae usually tall, peg-like, and pointing distally near leaf tip; margins of upper laminae bordered all around with hyaline cells, entire except toothed toward apex and ciliate at shoulders, border difficult to see sometimes due to involution of margins; cancellinae rounded distally; **gemmae** frequent, inconspicuous, adaxial on tip of costa. **Sporophytes** not found. (**Figure 5.8**)

Thailand — NORTHEASTERN: Loei; SOUTHEASTERN: Trat; PENINSULAR: Satun Surat Thani

Distribution — Bangladesh, Borneo, China, India, Java, Kampuchea, Malaysia, New Guinea, Philippines, Singapore, Sri Lanka, Sumatra, and Vietnam.

Ecology — On rotten log.

Specimens examined — *Y. Nathi 174*, *229* (BCU)

GPS location —18.58876736°N 98.48422073°E, 18.55671328°N 98.48176475°E

Altitude — 2,188-2,511 m

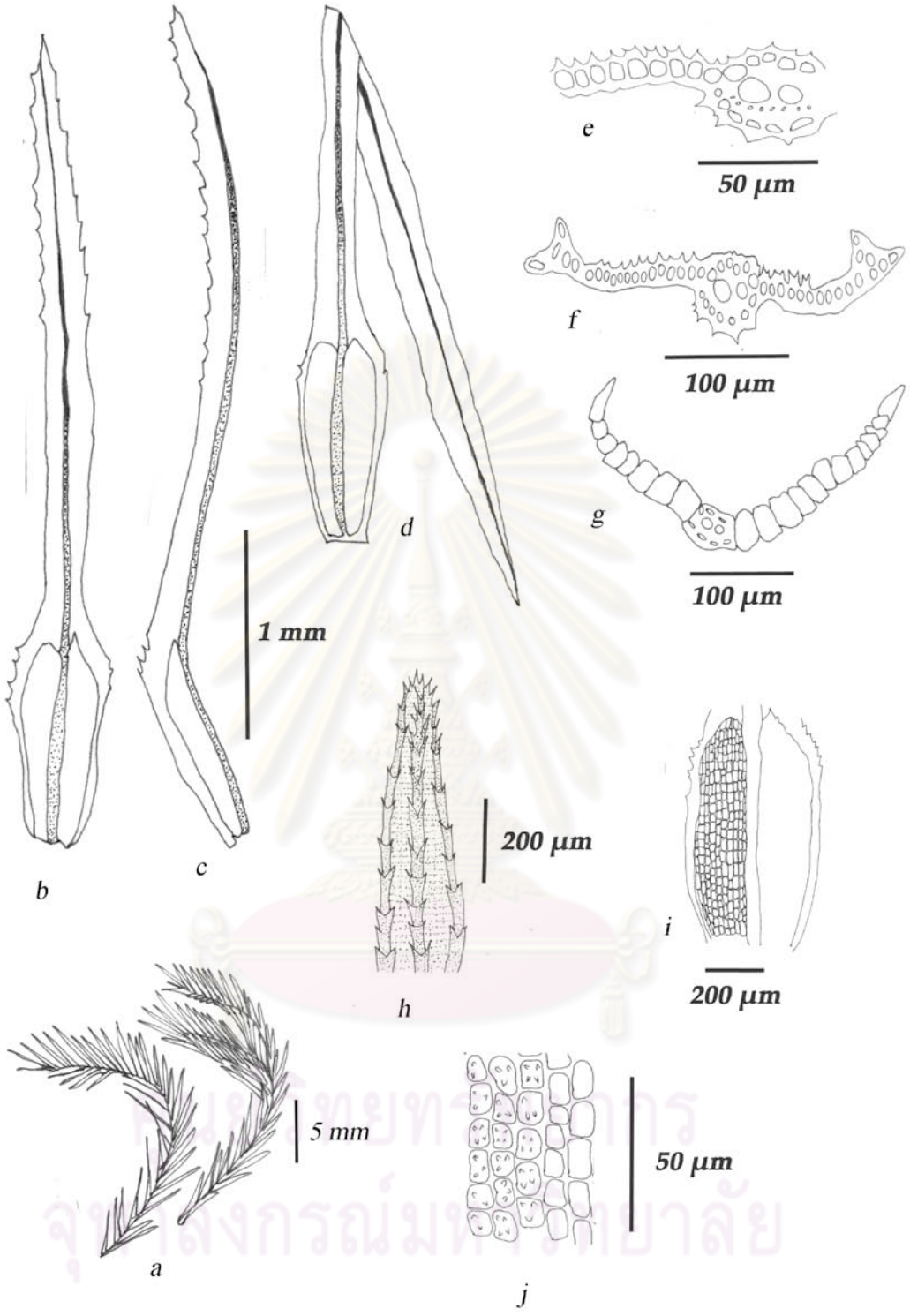


Figure 5.8 *Syrrhopodon gardneri* (Hook.) Schwaegr.
a. habit; b., c., d. leaves e. cross-section of leaf-margin; f. cross-section of costa; g. cross-section of leaf base; h. leaf apex; i. cell at basal leaf; j. cells of median leaf. Based on *Y. Nathi 174.*

DICRANACEAE

Plants small to robust, green to yellowish green or brownish green, in loose or dense, usually radiculose tufts. **Stems** often erect, simple or forked, rounded, rarely triangular, usually with central strand. **Leaves** in many rows, usually falcate-secund, mostly narrowly oblong-lanceolate, often broader at base, subulate in the upper half; margins plane or recurved, entire or serrulate to serrate; **costa** single, usually strong and long, ending near the leaf apex or excurrent, in cross section mostly with a row of median central guide cells; upper leaf cells variable in shape, smooth, rarely mammillose or papillose, lower laminal cells often elongate, **alar cells** often clearly differentiated. **Dioicous** or autoicous. Perichaetial leaves usually differentiated, sheathing at base. **Seta** mostly elongate, rarely very short, straight, flexuose or cygneous; **capsule** often exserted, erect, curved or inclined, ovoid, cylindric or pyriform, sometimes strumose at base; opercula generally differentiated, obliquely rostrate from a conic base; annuli present or absent, simple to complex; stomata present or absent; **peristome** teeth rarely lacking, usually present, well developed, 16, often reddish, dicranate to the middle, mostly lanceolate, deeply split into 2(–3) divisions, sometimes entire, vertically striate or smooth below, smooth or papillose above. **Calyptra** cucullate, entire, smooth or sometimes fringed at base.

Key to the genera

1. Plants slender; usually bearing cluster of brood bodies.....1. *Brothera*
1. Plants medium to large; with out cluster of brood bodies.....2
   2. Leaves curve when dry, capilliform.....2. *Dicranodontium*
   2. Leaves strongly crispate when dry, linear-to oblong-lanceolate ....3. *Symblepharis*

1. *BROTHERA*

Brothera C. Müll., Gen Musc. Frond. 258. 1900; Gangulee, Mosses E. India 2: 342. 1971; Gao, Vitt & He, Moss Fl. China 1: 98. 1994.

Plants small, slender, grayish green to yellowish green, in extensive compact tufts. **Stems** erect, simple or sparsely branched, often bearing compact clusters of brood bodies in axils of the upper leaves; central strand absent. Leaves erect, linear-lanceolate, tubulose below, subtubulose above; **costa** broad, filling 1/3 or more of the leaf base width and nearly all of the subula, in cross section, with a median layer of thin-walled, connected or disconnected green cells, enclosed by a row of large, thin-walled, hyaline cells on both the dorsal and ventral surfaces; **laminal cells** hyaline, rectangular,

marginal cells somewhat elongate, laxer at the base;. **Alar cells** slightly differentiated. **Dioicous. Seta** elongate, smooth, straight and slightly twisted when dry, sinuous-flexuose when moist; **capsule** oblong-ovoid, erect and symmetric; annuli compound, in 2 rows, deciduous; opercula long-rostrate; peristome teeth 16, inserted below the mouth, undivided, papillose nearly throughout or more or less vertically striate at the base. **Calyptra** cucullate or narrowly mitrate, ciliate-fringed at the base. **Spore** small, spherical, pale yellowish, smooth.

Brothera leana (Sull.) C. Müll.

Gen Musc. Frond. 259. 1900 Gangulee, Mosses E. India 2: 343, fig. 162. 1971; Noguchi, Ill. Moss Fl. Japan 1: 175, fig.71. 1994; Gao, Vitt & He, Moss Fl. China, vol.1: 99. 1994.

Plants small, 3-12 mm high, green or yellowish green with grayish sheen, in dense, compact tufts. Stems radiculose at the base, with many small, spindle-shaped brood bodies not found in this study. **Leaves** linear-lanceolate, 2.6-3.2 mm long, gradually narrowed from a short, tubulose base, subtubulose above; margins entire or slightly serrulate at the tips; **costa** broad, filling 1/3 – 1/2 or more of the leaf base width and nearly all of the subula; liminal cells thin-walled, rectangular above, marginal cells somewhat elongate, laxer at the base; **alar cells** not clearly differentiated. **Seta** about 8 mm long, reddish brown; **capsule** reddish brown. (**Figure 5.9**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, India, Japan, Korea, Myanmar, Nepal, Philippines, Siberia, and Sikkim.

Ecology — rotten log and soil.

Specimens examined — *Y. Nathi 98, 569, 1057* (BCU); *Somjai, Kanya & Lens 150* (CMU Herbarium)

GPS location —18.5892257°N 98.48510703°E, 18.58704848°N 98.4871909°E.

Altitude — 2,190-2,566 m.

2. *DICRANODONTIUM*

Dicranodontium Bruch & Schimp., Bryol. Eur. 1: 157. (fasc. 41. Monogr. 1). 1847; Gangulee, Mosses E. India 2: 312. 1971; Gao, Vitt & He, Moss Fl. China 1: 144. 1994.

Plants small to rather robust, tufted. **Leaves** capilliform and not developing distinct fertile caudices or comal tufts, auriculate, usually curved and homomallous; **costa** broad, 1/3 or more width of leaf base, excurrent and occupying almost the whole of the upper part of leaf; in section with distinct deuter cells, more or less distinct sub-deuter cells and well developed abaxial stereid bands; upper surface with a median band of stereids 2-4 cells deep, overlying the median 3-6 deuter cells. **Upper and lower-lateral lamina cells** thick-walled, often pitted, prosenchymatous; lower median juxtacostal cells usually conspicuously larger; **alar cells** present, thin-walled, hyaline or coloured, often fugacious**. Dioicious**. **Seta** 14-20 mm long, arcuate or erect and sinuate above; capsules ovoid-cylindric, erect, sulcate when dry; lid rostrate; peristome of 16 reddish teeth, cleft almost to base, striate on the outer surface.

Dicranodontium uncinatum (Harv.) A. Jaeger

Ber. Thaitgk. St. Gallischen Naturwiss. Ges. 1877-78: 380. 1880; Gangulee, Mosses E. India 2: 327, fig. 155. 1971; Gao, Vitt & He, Moss Fl. China 1: 152. 1994. — *Thysanomitrion uncinatum* Harv., Icon. Pl. 1: 22 f, 5. 1836.

Plants large, robuts, coarser. **Leaves** about 10-12 mm long on average, strongly curved and hamate, from sheathing bases up to 1 mm broad, quickly narrowed to long, fine, setaceous, toothed; **upper and lower-lateral lamina cells** very long and narrow, 4-10 μm long, with thickened walls; inner and juxtacostal cells much larger and more or less hyaline, elongate-rectangular, up to 20 μm wide with thinner, sinuate or distinctly pitted walls ; **alar cells** very fragile, large and thin-walled, forming distict, typically dilated auricles (Fig. 126, B). **Dioicious**. Sporophytes not found. (**Figure 5.10**)

Thailand — NORTHERN: Chiang Mai.

Distribution —Borneo, Mainland China, India, Japan, Java, Kampuchea, Laos, Malay Peninsula, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology — on tree trunk and on soil.

Specimens examined — *Y. Nathi 57, 200, 965, 970* (BCU); *Smitinand 3622* (BKF)

GPS location — 18.5881701°N 98.48680076°E, 18.5558408°N 98.48227453°E, 18.58795976°N 98.48525045°E.

Altitude — 2,507-2,548 m.

3. *SYMBLEPHARIS*

Symblepharis Mont. Ann. Sci. Nat., Bot. sér. 2, 8: 252. 1837; Gangulee, Mosses E. India 2: 370. 1971; Gao, Vitt & He, Moss Fl. China 1: 234. 1994.

Plants fairly coarse to robust, 3-6 cm high, olive green above, dark brown below, in dense tufts. Stems erect, usually branched, radiculose at the base; central strand present. **Leaves** linear-to oblong-lanceolate, gradually to suddenly narrowed from an erect, obovate, usually sheathing or clasping base, crispate when dry, widely spreading to somewhat to strongly squarrose when moist; margins entire, usually recurved; **costae** narrow, percurrent to shortly excurrent, smooth at back, with 2 stereid bands in transverse section; upper cells small, quadrate to short-rectangular, thick-walled, smooth; basal cells elongate-rectangular, hyaline, rather thin-walled; **alar cells** not differentiated. **Autoicous** or dioicous. **Setae** single or clustered, short to elongate, straight, terminal, usually becoming lateral because of innovations; capsules erect, ovoid-cylindric; opercula long-rostrate; annuli none or present; peristome teeth irregularly divided, papillose. **Calyptrae** cucullate, entire at base. **Spores** spherical, smooth.

Symblepharis vaginata (Hook.) Wijk & Marg.

Taxon 8: 75. 1959; Gangulee, Mosses E. India 2: 343, fig. 162. 1971; Gao, Vitt & He, Moss Fl. China, vol.1: 238. 1994. — *Didymodon vaginatus* Hook. ex Harv., Icon. Pl. 1: 18 f, 4. 1836.

Plants glossy, yellowish green, forming dense tufts. **Stems** erect, to 4-8 cm long. **Leaves** to 5.5 mm long, linear-lanceolate from a sheath in base, strongly curled when dry, erect spreading when moist; **costa** single, percurrent; **upper lamina cells** quadrate; cells in sheathing part light brown, rectangular. Seta ca. 15 mm long, erect, yellow to brown. **Capsules** ca. 2.5 mm long, straight, cylindrical. (**Figure 5.11**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Bhutan, Mainland China, India, Nepal, and Sikkim.

Ecology — Common on tree trunks, branches, rotten log, and roof top of tourist information's hut.

Specimens examined — Y. Nathi *17, 37, 45, 337, 348, 394, 561, 688, 941* (BCU); *Touw 9755* (BKF).

GPS location —18.5888333°N 98.48731617°E, 18.5890140°N 98.48710041°E, 18.5881701°N 98.48680076°E 18.58925058°N 98.4874129°E, 18.58923079°N 98.4874572°E, 18.58808876°N 98.4865151°E, 18.58871162°N 98.48361329°E, 18.55502483°N 98.47608257°E

Altitude — 2.191-2,560 m

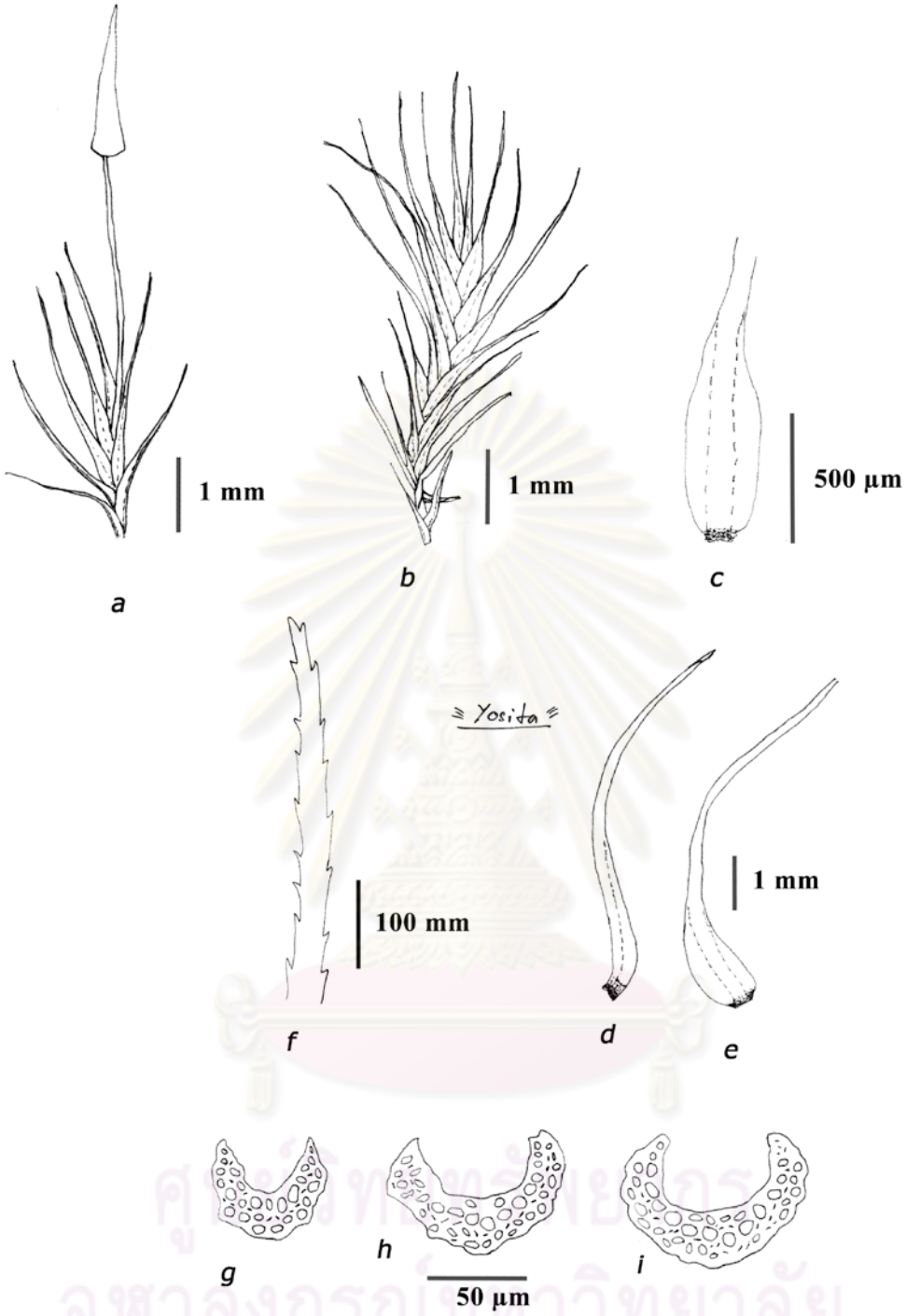


Figure 5.9 *Brothera leana* (Sull.) C. Müll.
a.,b habit; c., d., e. leavese; f. leaf apex; g., h., i. cross section of leaf. Based on *Y. Nathi 93.*

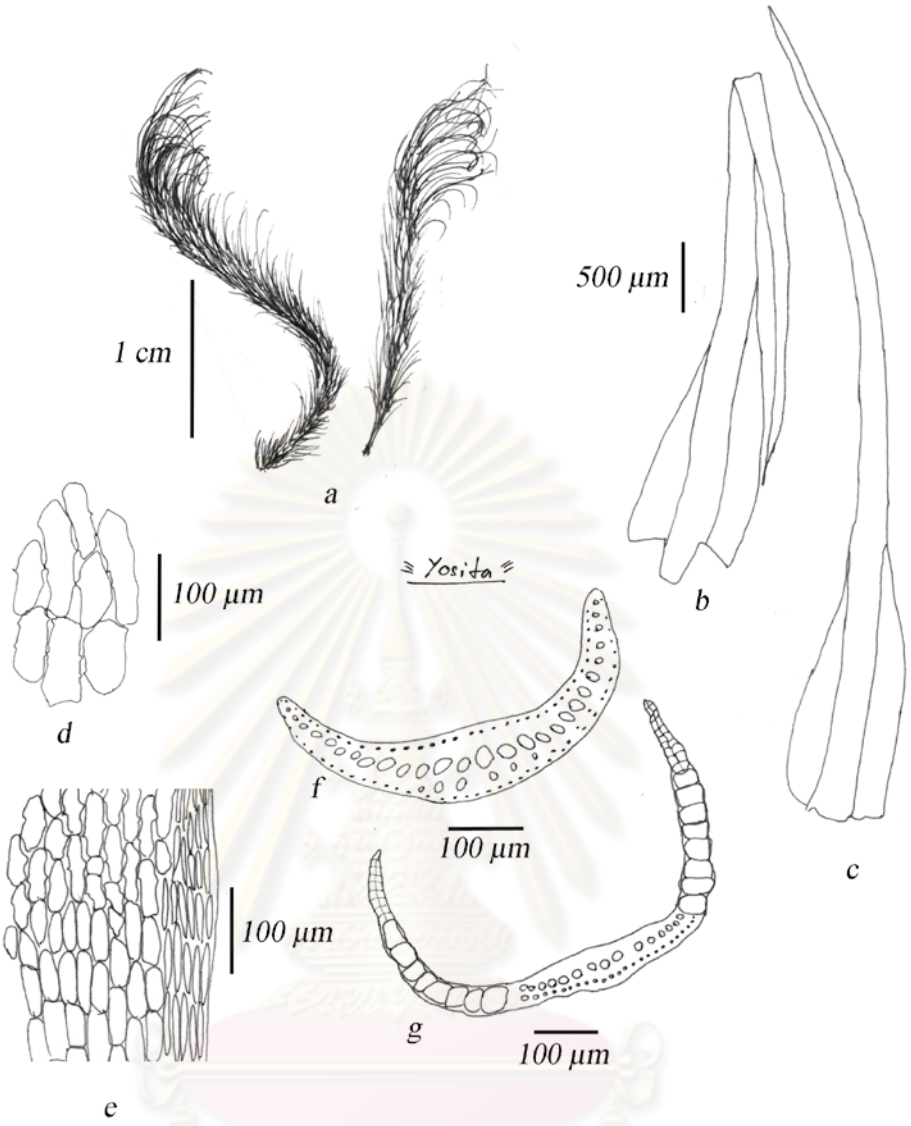


Figure 5.10 ***Dicranodontium uncinatum*** (Harv.) A. Jaeger
a. habit; b., c. leavese; d. cells at median leaf; e. cells at leaf margin; f. cross-section of costa; g. cross section of leaf base. Based on *Y. Nathi 57*.

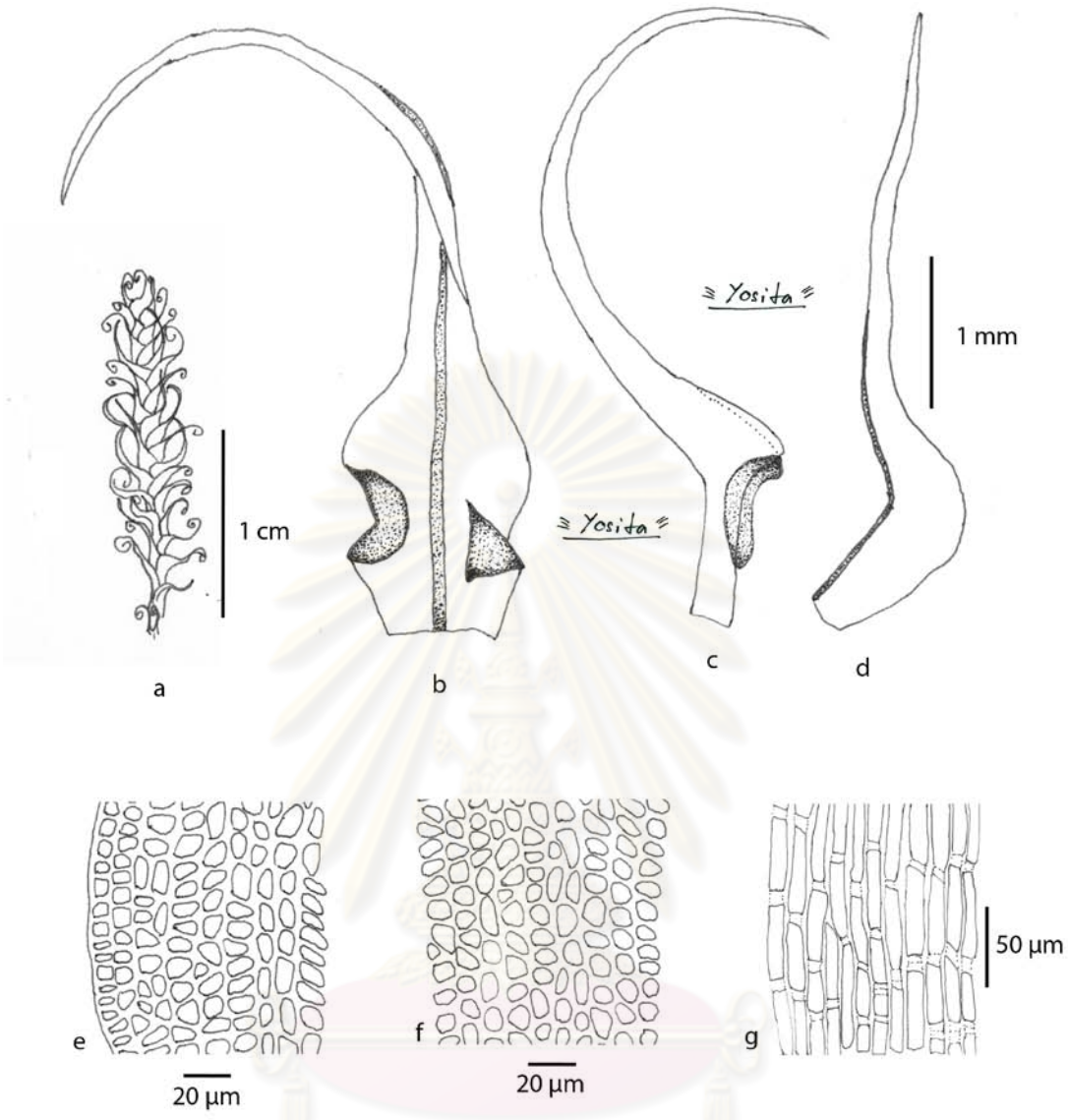


Figure 5.11 ***Symblepharis vaginata*** (Hook.) Wijk & Marg.
a. habit; b., c., d. leavese; e. cells at leaf margin; f. cells at median leaf; g. cells at leaf base. Based on *Y. Nathi 17*.

DIPHYSCIACEAE

Plants small, dark green in loose clumps or in scattered tufts. **Stems** erect, short, with dense papillose rhizoids at base; in cross section central strand mostly absent. **Leaves** often strongly crisped and enrolled, sometimes weakly curled, straight when dry, erect-spreading when moist, larger and longer distally; lower leaves narrowly lingulate to linear or linear-spathulate, rounded obtuse, acute, apiculate or mucronate at apex; margins entire; **costa** stout, strong, often disappearing in the acumen, leaf cells often bistratose to multistratose in upper part of leaves, rounded quadrate or rounded hexagonal to slightly oblate, thick-walled, mammillose or papillose on both sides, rarely smooth, lower leaf cells unistratose, rectangular, smooth, hyaline, thin-walled; upper leaves similar to perichaetial leaves, larger, erect, ovate-lanceolate to oblong-lanceolate, often laciniate at apex, costa excurrent. Axillary hairs filamentose, collared. **Autoicous** or dioicous. Perichaetia terminal. **Perichaetial leaves** longer or shorter than vegetative leaves, lanceolate, awn excurrent, smooth or papillose. **Seta** very short, pale; **capsule** immersed, obliquely ovoid-conic, symmetric, smooth, neck not differentiated; annuli differentiated; **opercula** small, conic; **peristome** double. **Calyptrae** cucullate, conic or campanulate, small, not covering the entire opercula, smooth.

DIPHYSCIUM

Diphyscium Mohr., Observ. Bot. 34. 1803; Mei-zhi, Peng-cheng, He, and Magombo, Moss Flora of China, vol. 8: 292. 2005.

The description of the genus is the same as that of the family.

Diphyscium longifolium Griff.

Calcutta J. Nat. Hist. 2: 477. 1842; Magombo, J. Hattori Bot. Lab. 94: 50. 2003; Wang, Wu, He, and Magombo, Moss Fl. China 8: 296, Pl. 736. 2005.— *Webera longifolia* (Griff.) Broth., Nat. Pflanzenfam. I(3): 664. 1904. — *Diphyxcium rupstre* Dozy & Molk., Pl., Jungh. 3: 340. 1854;

Plants small, 5-6 mm high, growing in clumps, rarely as scattered as scattered individuals. Stems simple, in cross-section central strand present. **Vegetative leaves** curled when dry, spreading when wet, 3-6 mm long, 0.9-2.0 mm wide, linear-lanceolate, oblong-spathulate to oblong-ovate; apices acute to obtuse, mucronate to apiculate; laminae well-developed from base to apex, unistratose at base, bistatose above; median leaf cells rounde to quadrate, 3-6 μm in diameter, smooth; basal cells rectangular,15-35 μm long, 4-9 μm wide,

hyaline, smooth; leaf margin entire below, serrate above, in cross-section 2-4 cells thick; costae percurrent or excurrent, dorsal and ventral stereid bands separated by one to two layers of guidecells. **Dioicous**. **Perichaetia** terminal. **Perichaetial leaves** lanceolate, awn excurrent, smooth or papillose; outer leaves 4-6 mm long, 0.4-0.6 mm wide, margins entire at base, dissected above; inner leaves 3-7 mm long, 0.3-0.6 mm wide, margins entire at base, dissected above, apices sometimes deeply notched. **Sporophyte** not found. (**Figure 5.12**)

Thailand — NORTHERN:Chiang Mai: Phetchabun; PENINSULAR: Nakhon Si Thammarat.

Distribution —China, India, Indonesia, Vietnam, Philippines Borneo, Java, and Malaysia. Central and South America.

Ecology — On sandy rock near by steams.

Specimens examined — *Y. Nathi 247, 849, 1009* (BCU).

GPS location — 18.5579702°N 98.48162410°E, 18.55346848°N 98.47764798°E, 18.55811893°N 98.4810839°E .

Altitude —2,146-2,230 m

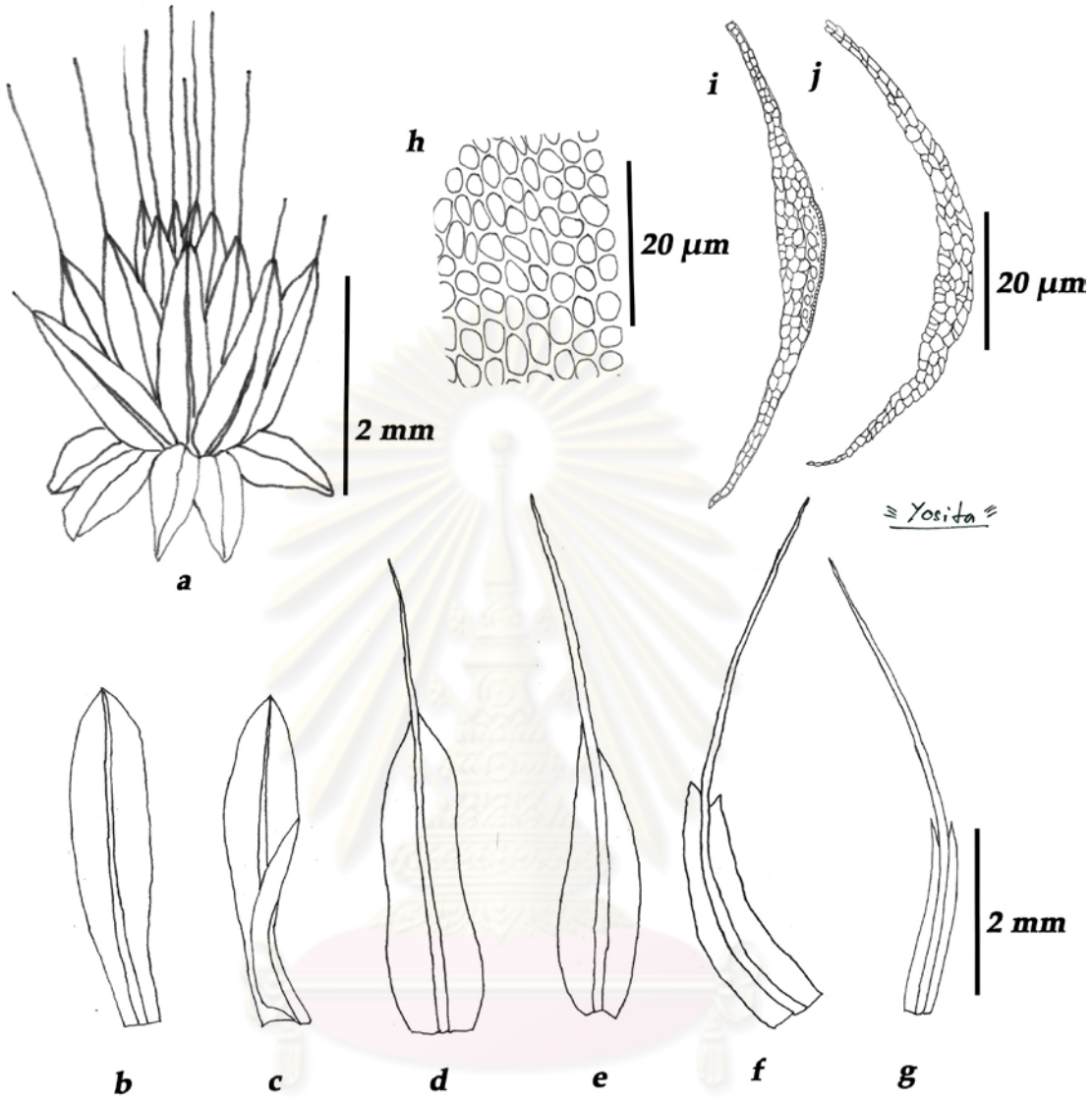


Figure 5.13 *Diphyscium longifolium* Griff.
a. habit; b., c. leaves; d., e., f., g. inner perichetial leaves; i., j, cross-section of costa; h. cells at mid-leaf. Based on *Y. Nathi 849.*

FISSIDENTACEAE

Plants minute to fairly large, green to dark green or reddish brown, gregarious or tufted. **Stems** mostly erect, simple or irregularly branched; rhizoids basal or axillary, smooth or papillose; axillary hyaline nodules developed or lacking; central strand present or absent. **Leaves** distichous, alternate and complanate, consisting of the vaginant laminae; **costa** usually well developed, percurrent, excurrent, or ending below the leaf apex, rarely indistinct or lacking; limbidia usually developed in varying degrees or lacking, if present, composed of narrow, thick-walled and elongated cells, usually one cell thick, rarely multi-stratose; leaf cells variable, smooth, mammillose or pluripapillose, mostly 1 layer, sometimes 2- to multi-stratose, irregularly hexagonal to rounded, isodiametric or elongate. **Dioicous** or **monoicous**. Perichaetial terminal or in axils of leaves; perichaetial and perigonal leaves usually differentiated. **Seta** mostly elongate, sometimes very short to immersed; **capsules** erect, symmetrical, or inclined, curved and asymmetrical; annuli absent; opercula conic, short to long rostrate. **Calyptra** cucullate, usually smooth. Spores small, spherical, smooth to finely papillose.

Fissidens Hedw., Sp. Musc. Frond., 152, 1801; Z. Iwats. & T. Suzuki, J. Hattori. Bot. Lab. 51: 346. 1982. — *Skitophyllum* Pylaie, J. de. Bot. Desv. sér. 2, 4: 133. 1814. nom. Illeg. — *Conomitrium* Mont., Ann. Sc. Nat. Bot. sér. 2, 8: 245. 1837. nom. Illeg. — *Polypodiopsis* (C. Müll.) Jaeg., Ber. S. Gall. Naturw. Ges., 1874-75: 132.1876. — *Schitophyllum* Lindb. Utkast Nat.Crupp. Eur. Badm.: 16. 1878. — Nonobryum Dixon., J. Bot. 60: 100. 1922.

For description of the genus, see that of the family.

Key to the species

1. Leaves limbate or at least partially limbate 2
1. Leaves not limbate 4
   2. Limbidia all around the leaf margins ..... *F. bryoides* var. *schmidii*
   2. Limbidia confined to the vaginant laminae 3
3. Seta smooth ..... *F. hollianus*
3. Seta rough ..... *F. ceylonensis*
   4. Leaf margins pale 1-3 cells wide and smooth, markedly differentiated from inner cells as a paler band ..... *F. anomalus*
   4. Leaf margins not differentiated from other lamina cells 5
5. Plants very small, 1.0-1.4 mm long; margins of vaginant laminae distincly serrate; cells of apical laminae smooth..... *F. flabellulus*
5. Plants small to large more than 1.0-1.4 mm long; margins of vaginant laminae more or less distinctly, cells of apical laminae smooth 6
   6. Plants small; leafy stems 1.0-1.5 mm long 7

6. Plants medium-sized to large; leafy stem 18.0-72.0 mm long 8
7. Costa ending 6-9 cells below leaf apex.....*F. guangdongensis*
7. Costa percurrent to shortly excurrent 8
8. Leaves cells quadrate to irregularly hexagonal, smooth .....*F. pellucidus*
8. Leaves cells hexagonal to rounded-hexagonal, slightly mammalose..... .....*F. gymnogynus*
9. Leaf apex mostly mucronate, rarely obtusely acute; cells of apical laminae, 11-21 μm long, walls clear.....*F. polypodioides*
9. Leaf apex obtusely acute; cells of apical laminae 10-13 μm long, walls obscure.....*F. obscure*

1. *Fissidens anomalus* Mont.,

Ann. Sci. Nat. Bot. ser. 2. 17:252. 1842; L. zhi-hua & Z. Iwats., Moss Fl. of China 2: 7, Pl 69. 2001. — *F. cryptotheca* Dozy & Molk., Plantae Junghuhnianae 314. 1845. — *F. neckeroides* Griff. Calcutta J. Nat. Hist. 2: 504. 1842.

Plants green to light green, in densely gregarious tufts. **Stems** simple or branched, 1.5–4 cm high, axillary hyaline nodules not differentiated; central strand differentiated. **Leaves** in 15–35 pairs, the lowest ones smaller, upper leaves much larger and more densely arranged; middle and upper leaves oblong-lanceolate, 2.2–3.0 mm × 0.5–0.6 mm, distinctly crispate when dry, narrowly acute at apex; base of dorsal laminae rounded, rarely short-decurrent; vaginant laminae 1/2– 3/5 the leaf length, equal or slightly unequal; **costa** stout, excurrent; margins irregularly dentate near leaf apex, finely crenulate to serrulate throughout, bordered by a lighter colored band of 1–3 rows of incrassate, smooth, paler cells, 1 cell thick; cells of apical and dorsal laminae quadrate, rounded to irregularly hexagonal, with thickened corners, 7–10 μm long, distinctly mammillose; apical laminae 1 cell thick; cells of vaginant laminae similar to those of apical and dorsal laminae, **Seta** short, 1.5–2.0 mm long, smooth; **capsule** erect, symmetric; urns 0.7–1.0 mm long. **Calyptra** cucullate. (**Figure 5.13**)

Thailand — NORTH: Chiang mai; NORTHEASTERN: Leoi; SOUTHWESTERN: Prachuap Khiri Khan.

Distribution — China, Nepal, India, Myanmar, Sri Lanka, Vietnam, Indonesia, and Philippines.

Ecology — Common on tree trunk, branch twig.

Specimens examined — *Y. Nathi 18, 38, 176, 288, 295, 365, 367, 450, 454, 463, 473, 481, 540, 738* (BCU); *K. Wongkuna 713* (CMU Herbarium).

GPS location — 18.58883332°N 98.48731617 °E, 18.58901395°N 98.48710041 °E, 18.58876736 °N 98.48422073°E, 18.55971543 °N 98.47769047 °E, 18.55318073°N 98.47826891°E, 18.55437264°N 98.47888942°E.

Altitude — 2,167-2,565 m

2. *Fissidens bryoides* var. ***schmidii*** (C. Müll.) Chopra & Kumar

Ann. Crypt. Phyt. 5: 43. 1981; Iwats. & T. Suzuki, J. Hattori Bot. Lab. 51: 362, Pl. X. 1982. — *Fissidens schmidii* C. Müll., Bot. Zeit. 11: 18. 1853. — *Fissidens bryoides* subs. *schmidii* (C. mull.) Norkett in Gangulee, Mosses E. India 2: 471. 1971.

Plants small, stem often elongate, 4-8 mm long, 1.1–1.7 mm wide with leaves; central strand not differentiated; axillary hyaline nodules lacking. **Leaves** in 5–15 pairs, oblong-lanceolate, 1.3–2.0 mm × 0.2–0.3 mm, acute at apex; base of dorsal laminae wedge-shaped, often slightly decurrent; **costa** percurrent; vaginant laminae 1/2 –2/3 the leaf length, equal; margins entire; limbidia weak, 1 cell thick, usually 1–2 cells wide, usually lacking on the distal part of apical laminae and the proximal part of dorsal laminae, 2–3 cells wide on upper half of vaginant laminae; cells of apical and dorsal laminae quadrate to hexagonal, 4–7 μm long, mammillose, thin-walled. **Dioicous**. **Sporphyte** not found. (**Figure 5.14**)

Thailand — NORTHERN: Chiang Mai

Distribution — Japan, Phillipines, Java, New Guinea, Pakisatan, India and Ceylon.

Ecology — On sandy soil, and wet rock near by streamlet.

Specimens examined — *Y. Nathi 402, 581, 655, 881, 905, 953, 1003, 1019, 1026, 1049, 1055* (BCU); *K. Wongkuna 734* (CMU Herbarium).

GPS location —18.58857801 °N 98.48593784 °E, 18.588676 °N 98.48508256 °E, 18.55691336°N 98.47640025 °E, 18.55578952 °N98.47937666 °E, 18.55544519 °N 98.47598232 °E

Altitude — 2,194-2,541 m

3. ***Fissidens ceylonensis*** Dozy & Molk.

Ann. Sci. Nat. Bot. sér. 3, 2: 304. 1844 ; Gangulee, Mosses E. India 2: 512, fig 240: 1971.— *F. perpusillus* Wils. ex Mitt., Musc. Ind. Or. 141. 1859. — *F. bicolor* Thwai. et Mitt., J. Linn.Soc. 13: 322. 1873. — *F. pennalutus* Thwai. et Mitt., ibd:

325 fid. Foreau. — *F. ceylonensis* Doz. & Molk. var. *jhargramii* Gangulee, Bull. Bot. Soc. Beng. 11: 72. 1957.

Plants small, yellowish green, gregarious. Stems simple or branched, 2–4 mm long and 1.4–1.5 mm wide with leaves; axillary hyaline nodules not or only weakly differentiated; central strand not differentiated. **Leaves** 7–15 pairs, the lowest leaves small; middle to upper leaves oblong-lanceolate, 1.2-2.2 mm × 0.2–0.3 mm, acute to broadly acute at apex; base of dorsal laminae of fertile leaves usually wedge-shaped, rounded to wedge-shaped in sterile ones; vaginant laminae 3/5–2/3 the leaf length, equal to slightly unequal; **costa** light yellow, percurrent to slightly excurrent, with protruding rhombic cells; margins nearly entire; **cells** of apical and dorsal laminae quadrate to rounded-hexagonal, 5–10 μm long, obscure, pluripapillose, thin-walled; limbidia usually found only on lower half of vaginant laminae of upper and perichaetial leaves, composed of 2–4 rows of cells. **Autoicous. Seta** 2.0–2.5 mm long, smooth, geniculate at base; capsules symmetrical, erect; urns cylindrical, 0.4–0.5 mm long. (**Figure 5.15**)

Thailand — NORTH: Chiang Mai, Mae Hong Son, Phitsanulok, Tak; SOUTHEASTERN: Trat; PENINSULA: Songkhla, Narathiwat, Trang, Satun, Surat Thani.

Distribution — Borneo, China, India, Java, Kampuchea, Laos, Malaysia, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Sumatra,Vietnam and New Zealand.

Ecology — On wet soil.

Specimens examined — *Y. Nathi 120, 464, 482, 538, 865* (BCU).

GPS location — 18.58784946°N 98.4861023 °E, 18.55545047 °N 98.47568485°E, 18.55988148°N 98.47579683°E, 18.55437264°N 98.47888942°E, 18.55581265°N 98.48067418°E

Altitude — 2,189-2,527 m

4. *Fissidens flabellulus* Thwait. & Mitt.,

J. Linn. Soc., Bot. 13:324. 1873; Iwats. & T. Suzuki, J. Hattori Bot. Lab. 51: 397, Pl. XXX. 1982.

Plants small to very small. **Stems** with leaves 1.0–1.4 mm long, 0.6.–1.2 mm wide, simple to rarely branched, densely foliated; central strand lacking; axillary hyaline nodules less differentiated. **Leaves** 2-10 pairs; upper leaves lanceolate to narrowly lanceolate, 0.7–1.2 mm × 0.1-0.3 mm, acute to narrowly

acute at apex, wedge-shaped at base of dorsal laminae; vaginant laminae about 1/2 – 1/3 the leaf length; **costa** stout, percurrent to shortly excurrent, often dividing laminae unequally, dorsal side often wider than ventral side at middle of leaves; margins of vaginant laminae more or less distinctly serrate by projecting laminal cells; **cells** of apical laminae quadrate to hexagonal, 10–17 μm long, slightly mammillose to almost smooth, walls clear, moderately thick-walled; cells at upper part of vaginant laminae similar to those of apical laminae. **Sporophyte** not found. (**Figure 5.16**)

Thailand — NORTHERN: Chiang Mai

Distribution — China, Japan, and Sri Lanka.

Ecology — Common on soil or base of trees trunks.

Specimens examined — *Y. Nathi 89, 238, 269, 909, 1058* (BCU)

GPS location — 18.5893751°N 98.48579443°E, 18.5567133°N 98.48176475°E, 18.5577875°N 98.48026271°E, 18.58731226°N 98.48636775°E, 18.58447138°N 98.48910159°E.

Altitude — 2,188-2,560 m

5. *Fissidens guangdongensis* Iwats. & Z.-H. Li

Acta Bot. Fenn. 129: 35. 1985; L. zhi-hua & Z. Iwats., Moss Fl. China 2: 37, Pl 80, fig. 12-18. 2001.

Plants small, reddish brown, loosely tufted. Leafy stems simple, 2.3–4.5 mm long, 1.4–1.8 mm wide; axillary hyaline nodules not differentiated; central strand lacking. **Leaves** 4–10 pairs, lowest leaves small, loosely arranged, upper leaves much larger and densely arranged, oblong-lanceolate to lanceolate, 0.9–1.5 mm × 0.3–0.4 mm, acute at apex; base of dorsal laminae wedge-shaped; vaginant laminae 1/3–1/2 the leaf length, unequal, usually open halfway to costa; **costa** strong, ending far below leaf apex, sometimes forked with short branches in the upper parts; margins serrulate to nearly entire; **cells** of apical and dorsal laminae quadrate, rounded-quadrate to elliptical, 10–18 μm long, evenly thick-walled, smooth to slightly mammillose, each laminal cell often with a nucleus-like hyaline spot inside; cells of upper portions of vaginant laminae similar to those of apical laminae, but larger and longer toward the base near costa. **Sporophyte** terminal, **seta** 2.2-2.5 mm long, **capsule** erect. (**Figure 5.17**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China and Japan

Ecology — Common on soil and base of tree trunk.

Specimens examined — *Y. Nathi 280, 281, 435, 453, 495, 497, 867* (BCU)

GPS location — 18.5583313°N 98.47963390°E, 18.5592401°N 98.47881004°E, 18.55630886°N 98.48039045°E, 18.55630886°N 98.48039045°E, 18.55486549°N 98.47860267°E, 18.55625714°N 98.48112177°E.

Altitude — 2,135-2,275 m

6. *Fissidens gymnogynus* Besch.,

J. Bot. (Morot). 12:292. 1898; Iwats. & T. Suzuki, J. Hattori Bot. Lab. 51: 406, Pl. XXXVI. 1982. —*F. tokubuchii* Broth., Hedwigia 38: 209. 1899. — *F. rubritheca* Sak., Bryologist 39: 4, pl. II. 1936. — *F. iwasakii* Sak., Bot. Mag. Tokyo 53: 59, f. I. 1939.

Plants small to medium-sized, yellowish green. **Stems** usually unbranched, sometimes with a few branches at the base, 7–12 mm long with leaves, 1.8–3.6 mm wide with leaves; axillary hyaline nodules lacking; central strand only slightly differentiated. **Leaves** in 7–18 pairs, rather densely arranged, distinctly crisped when dry; the lowermost leaves smaller, becoming larger toward to the middle; middle and upper leaves lingulate to lanceolate, 1.5–2.4 mm × 0.3–0.5 mm, mucronate to acute at apex; base of dorsal laminae rounded to wedge-shaped; vaginant laminae 1/2 –3/5 the leaf length, unequal; **costa** stout, usually ending a few cells below leaf apex; margins crenulate to slightly serrulate; cells at the apex rounded-rhombic, smooth and thick-walled, forming a lighter region; cells of apical and dorsal laminae cells hexagonal to rounded-hexagonal, 10–14 μm long, mammillose. **Phyllodioicous**. **Sporophyte** not found. (**Figure 5.18**)

Thailand — NORTHERN: Chiang Mai

Distribution — China, Korea, and Japan.

Ecology — on tree trunks or on rocks

Specimens examined — *Y. Nathi 538* (BCU)

GPS location — 18.58923079°N 98.48745715°E.

Altitude— 2,485 m

7. *Fissidens hollianus* Dozy & Molk.

Bryol. Jav. 1:4. 1855; Iwats. & T. Suzuki, J. Hattori Bot. Lab. 51: 401, Pl. XX. 1982. — *Fissidens japonica-punctaus* Shin, Sci. Rep. Kagoshima Univ. 13: 86, f. 21. 1964.

Plants small, green to yellowish green. Stems simple, 2.0–2.4 mm long, 1.5-2 mm wide with leaves; axillary hyaline nodules not developed. **Leaves** in 6–12 pairs, densely arranged, the lowest leaves much smaller, middle and upper leaves almost equal in size, lanceolate to oblong-lanceolate, 1.0–1.5 mm × 0.2–0.3 mm, acute at apex; base of dorsal laminae rounde to wedge-shaped; vaginant laminae 1/2–3/5 the leaf length; **costa** excurrent margins nearly entire; **cells** of apical and dorsal laminae quadrate to irregularly hexagonal, 5–7 μm long, thin-walled, pluripapillose; **limbidia** usually found only on lower one-half of perichaetial leaves, composed of 2–5 rows of cells. **Autoicous. Sporophyte; seta** rough**; capsule** not seen. (**Figure 5.19**)

Thailand — NORTHERN: Chiang Mai, Tak; CENTRAL: Nakhon Nayok; PENINSULAR: Surat Thani, Nakhon Si Thammarat.

Distribution — Japan, Taiwan, Philppines Borneo, Java, Sumatra, New Guinea, Malay Peninsular, Indochina, and Burma.

Ecology — On ground.

Specimens examined — *Y. Nathi 165, 246, 428, 951* (BCU); *K. Wongkuna 440* (CMU Herbarium).

GPS location — 18.55595632°N 98.47984370°E, 18.55698972°N 98.47696074°E, 18.55353110°N 98.47765988°E.

Altitude — 2,121-2,232 m

8. *Fissidens obscurus* Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 1: 138. 1859.— *Fissidens yakumontanus* Nog., J. Jap. Bot. 27: 285, f.52. 1952; Iwats. & T. Suzuki, J. Hattori Bot. Lab. 51: 410, Pl. XL. 1982.

Plant large and dark green, stem simple, 1-4 cm long, 0.5-0.7 mm wide with leaves; axillary hyaline nodules not differentiated; central strand not differentiated. **Leaves** 17-40 pairs, more or less densely arranged, crisped when dry; middle to upper leaves lanceolate, 3.2- 4.0 mm long, 0.5-0.6 mm wide, obtuse to obtusely acute at apex, base of dorsal lamina round to wedge-shaded, not decurrent; vaginant lamina 1/2 to 3/5 of the leaf-length, upper part more or less unequal; **costa** stout, ceasing several cells below apex; **cells** of apical lamina irregularly quadrate to hexagonal, often round, thick-walled,

8-13 μm long, obscure, smooth; cells of vaginant lamina similar to those of apical lamina. **Dioicous**. **Sporophyte** not found. (**Figure 5.20**)

Thailand — NORTH: Chiang Mai.

Distribution — China, japan, Nepal, and India.

Ecology — On rock stream.

Specimens examined — *Y. Nathi 914, 1015, 1024* (BCU)

GPS location — 18.55732005°N 98.48141438°E, 18.58762214°N 98.48505355°E, 18.55598733°N 98.48220857°E.

Altitude — 2,119-2,217 m

Note— New record to Thailand.

9. *Fissidens pellucidus* Hornsch.

Linnaea. 15:146. 1841; L. zhi-hua & Z. Iwats., Moss Fl. China vol. 2: 53. 2001. — *Fissidens crassinervis* Thwait. & Mitt., J. Linn. Soc. Bot. 13: 323. 1873. — *Fissidens crassinervis* Sande-Lac., Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk. 13: 3. Pl. 2: a.1872. — *Fissidens laxus* Sull. & Lesq., Proc. Amer. Acad. Arts Sci. 4: 275. 1859. — *Fissidens mittenii* Par., Ind. Bryol. 477. 1894.

Plants small, growing in loose tufts, usually brownish or reddish brown. Stems simple; axillary hyaline nodules lacking; central strand weakly differentiated. **Leaves** in 6–12 pairs, lower leaves very small, loosely arranged; upper leaves much larger than the lower leaves, densely arranged, lanceolate, 1.0–1.4 mm × 0.2–0.3 mm, acute to narrowly acute at apex; base of dorsal laminae wedge-shaped to rounded; vaginant laminae 1/2 the leaf length, unequal; **costa** stout, percurrent to shortly excurrent; margins crenulate to indistinctly serrulate; **cells** of apical and dorsal laminae quadrate to irregularly hexagonal, 8–18 μm long, thick-walled, transparent, smooth; **Polyoicous. Seta** 2.5–2.9 mm long, smooth; **capsules** erect, symmetrical; urns ovoid. (**Figure 5.21**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, Nepal, India, Sri Lanka, Myanmar, Thailand, Vietnam, Malaysia, Singapore, Indonesia, the Philippines, and South America.

Ecology —Common on ground, in wet and shady light areas.

Specimens examined — *Y. Nathi 89, 94, 235, 238, 269, 279, 419, 464, 494, 720, 721, 784, 801, 816, 855, 863, 909, 1058* (BCU)

GPS location — 18.5567133°N 98.48176475°E, 18.5583313°N 98.47963390°E, 18.58937982°N 98.48574833°E, 18.55988148°N 98.47579683°E,

18.55437264°N 98.47888942°E, 18.58877674°N 98.48578504°E, 18.55581265°N 98.48067418°E, 18.55557142°N 98.48048232°E, 18.55602505°N 98.48041099°E, 18.5893751°N 98.48579443°E, 18.58731226°N 98.48636775°E, 18.58447138°N 98.48910159°E.

Altitude — 2,113-2,260 m

10. *Fissidens polypodioides* Hedw.

Sp. Musc. Frond. 1801; Moss Fl. China vol.2. 55. 2001. — *F. areolatus* Griff., Calcutta J. Nat. Hist. 2: 506. 1842. — *Fissidens polypodioides* var. *areolatus* (Griff.) Wils., Hooker's J. Bot. & Kew Gard. Misc. 9: 294. 1857.

Plants large, green, yellowish green to brownish, in lax tufts. **Stems** simple or branched; central strand well developed. Axillary hyaline nodules not developed. **Leaves** 18–28 pairs, densely arranged except the lowermost ones, which are much smaller and more or less loosely arranged; middle to upper leaves oblong-lanceolate, 3.5–4.0 mm × 1.0 mm, mostly mucronate, occasionally broadly acute; base of dorsal laminae rounded; vaginant laminae 1/2 the length of the leaf, equal or slightly unequal; **costa** stout, usually ending a few cells below leaf apex, rarely percurrent; coarsely serrulate near apex, slightly serrulate throughout the rest of margin; cells of apical and dorsal laminae quadrate to hexagonal, 11–20 μm long, smooth to slightly mammillose, well demarcated, moderately thick-walled. **Dioicous**. **Seta** 5-7 mm long. **Capsule** cylindrical, large. (**Figure 5.22**)

Thailand — NORTHERN:Chiang Mai; SOUTHEASTERN: Nakhon Nayok; NORTHEASTERN: Loei; PENINSULA: Nakhon Si Thammarat, Krabi

Distribution — China, Japan, India, Nepal, Myanmar, Vietnam, Malaysia, Indonesia, the Philippines, New Guinea, the West Indies, and throughout the Americas.

Ecology — Common on soil, on rock, and streams slope

Specimens examined — *Y. Nathi 202, 239, 255, 263, 496, 827, 847, 916* (BCU); *K. Wongkula 764* (CMU Herbarium).

GPS location — 18.5567133°N 98.48176475°E, 18.5561391°N 98.48219197°E, 18.5577792°N 98.48092438°E, 18.58877674°N 98.48578504°E, 18.55632654°N 98.48128865°E.

Altitude — 2,113-2,233 m

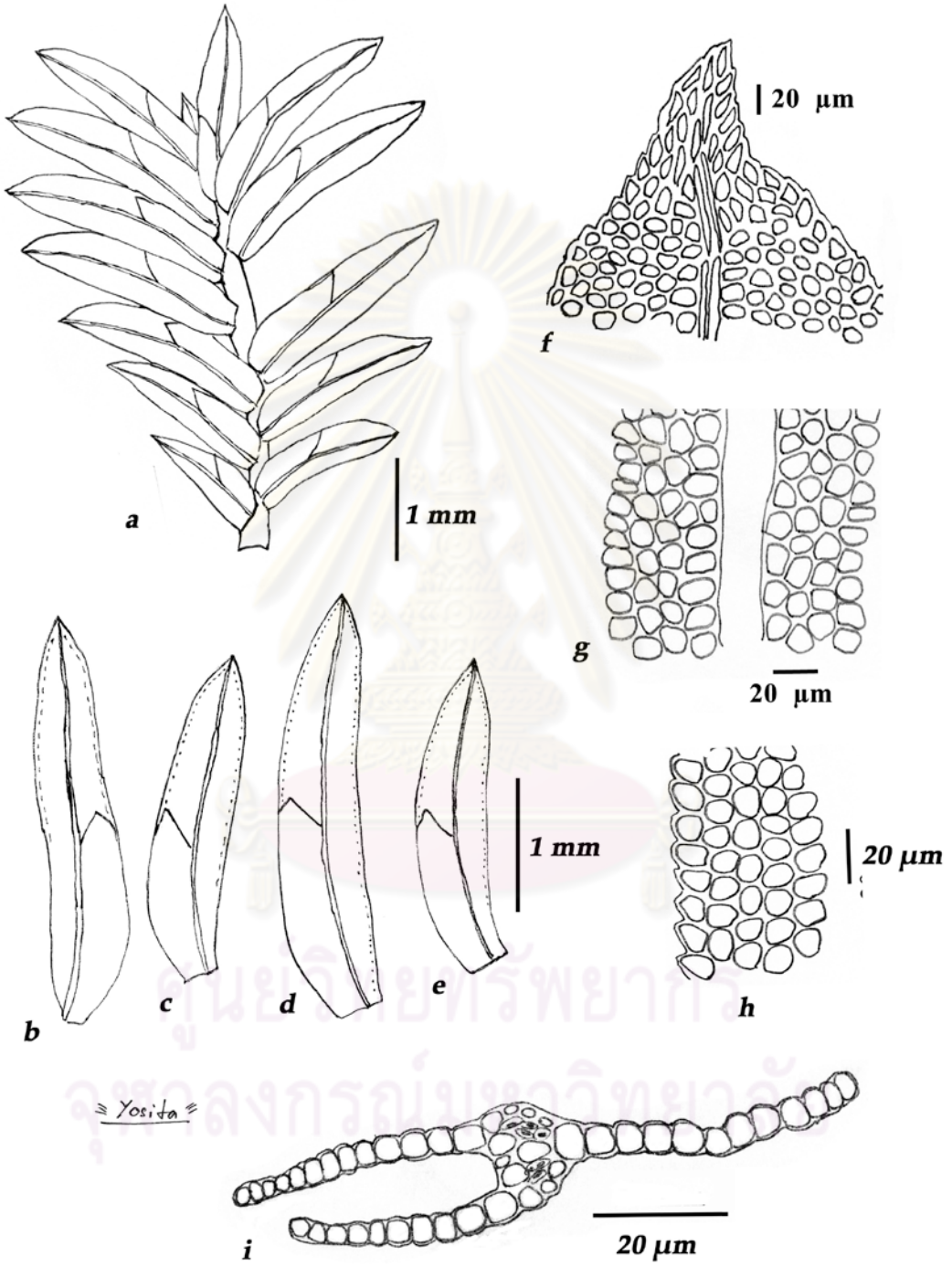


Figure 5.13 *Fissidens anomalus* Mitt.
a. habit; b., c., d., e. leaves; f. leaf apex; g. cells of apical laminae; h. marginal cells of apical laminae; i. cross-section of costa. Based on *Y. Nathi 38.*

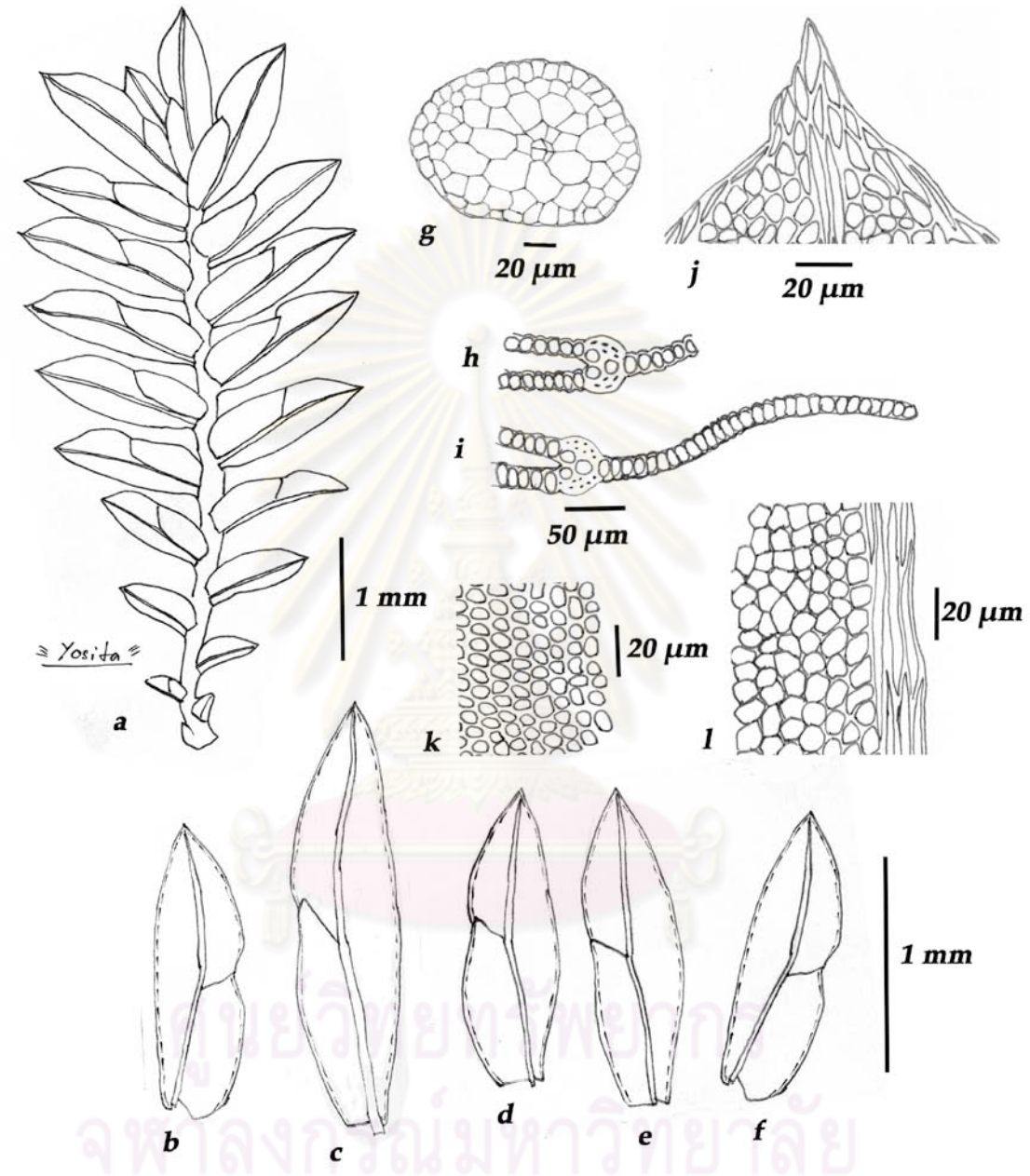


Figure 5.14 *Fissidens bryoides* var. *schmidii* (C. Mull.) Chopra & Kumar
a. habit; b., c., d., e., f. leaves; g. cross-section of stem; h. cross-section of costa; i. cross-section of leaf-margin; j. leaf apex; k. cells at middle lamina; l. cells at base of vaginant lamina. Based on *Y. Nathi 1003*.

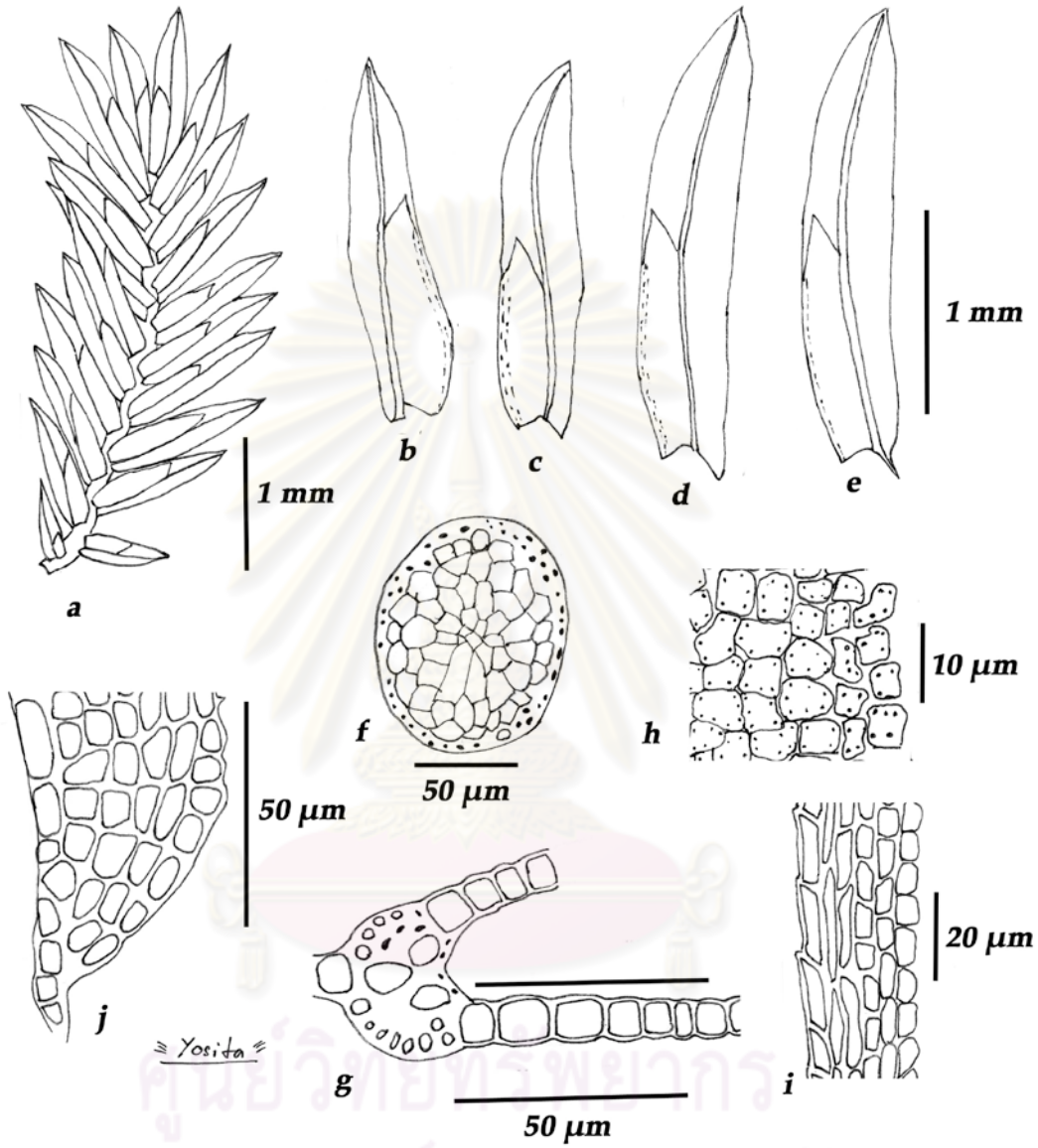


Figure 5.15 ***Fissidens ceylonensis*** Dozy & Molk.
a. habit; b., c., d., e. leaves; f. cross-section of stem; g. cross-section of costa; h. cells of lamina; i. cells at margin of vaginant lamina; j. basal juxtacostal cells of dorsal laminae. Based on *Y. Nathi 120*

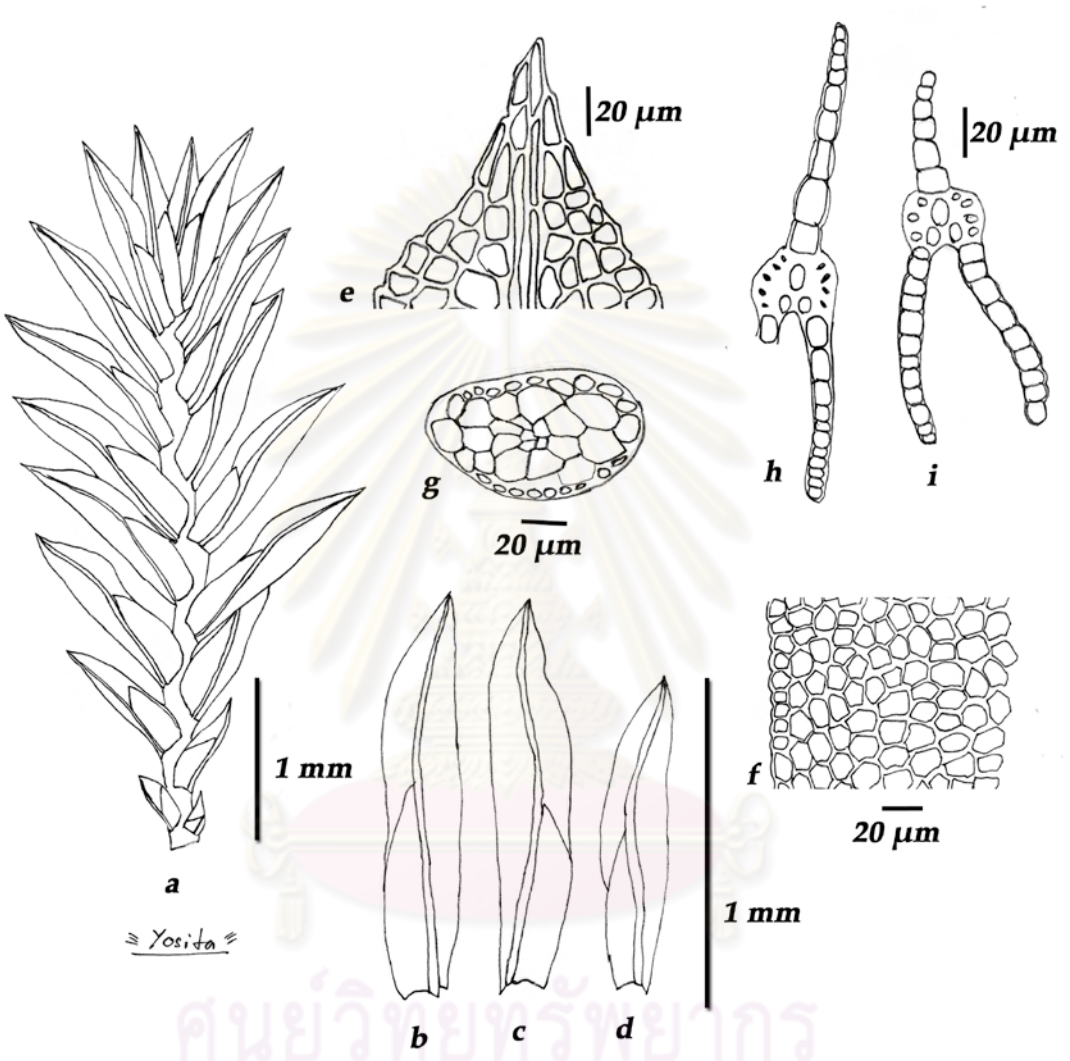


Figure 5.16 *Fissidens flabellulus* Thwait. et Mitt.
a. habit; b., c., d. leaves; e. leaf apex; f. cells at leaf magin; g. cross-section of stem; h., i. cross-section of leaf. Based on *Y. Nathi* 89

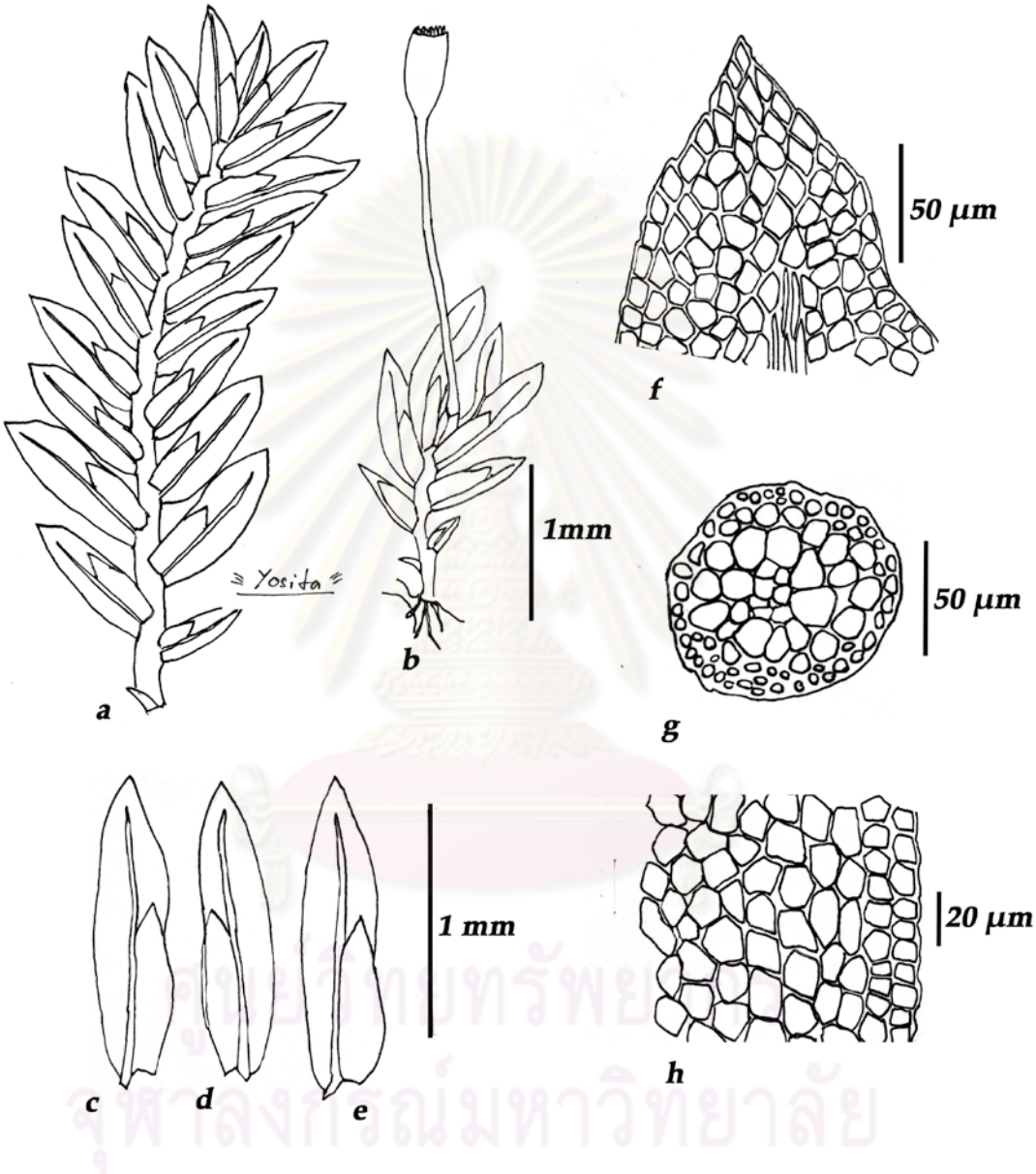


Figure 5.17 *Fissidens guangdongensis* Iwats. & L.-Z. Li
a., b. habit; c., d., e. leaves; f. cells of leaf tip; g. cross-section of stem; h. marginal cells of laminae; leaf apex; cells at leaf base;. Based on *Y. Nathi 43.*

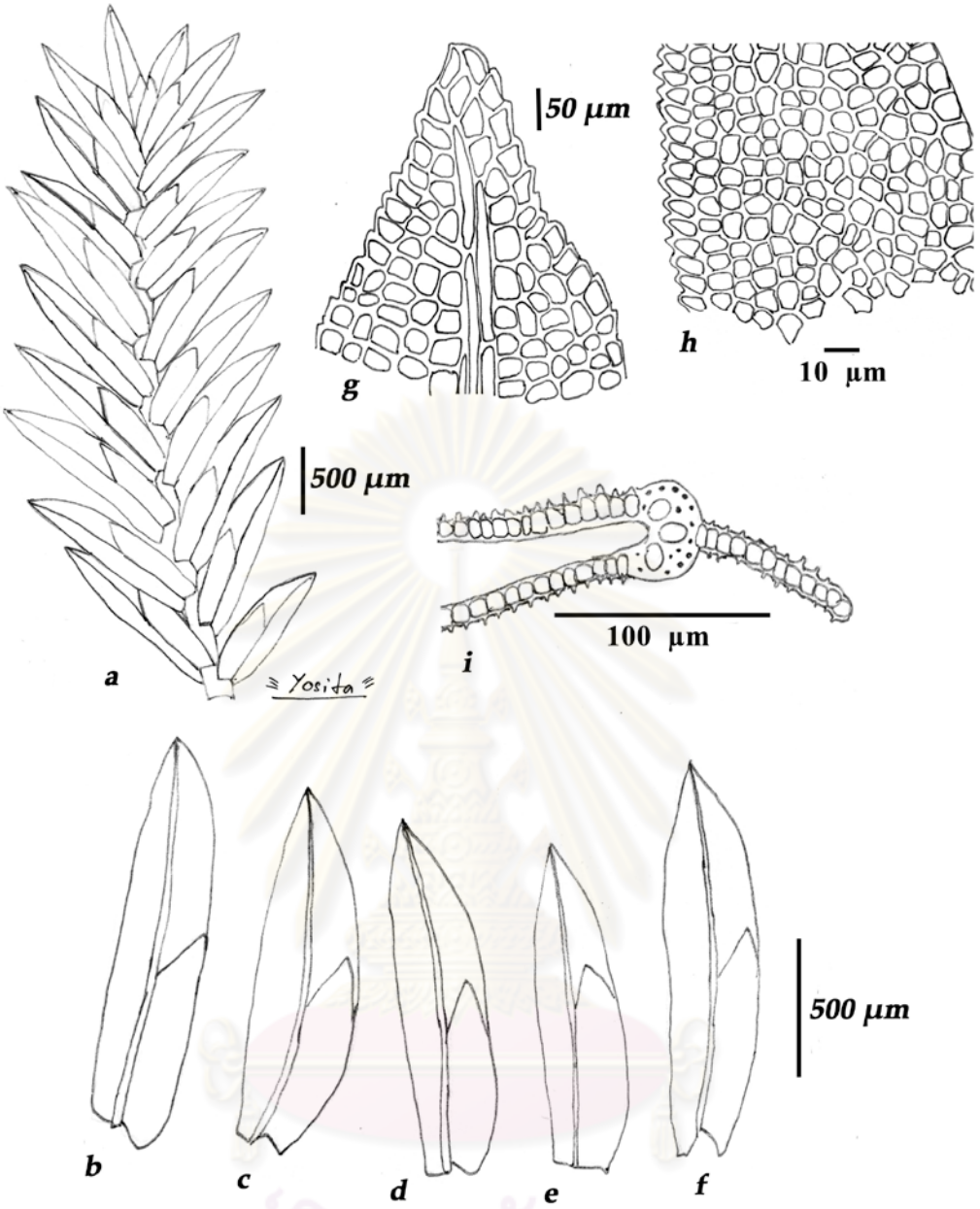


Figure 5.18 *Fissidens gymnogynus* Besch.,
a. habit; b., c., d., e., f. leaves; g. cells of leaf tip; h. cells at margin of upper lamina; i. cross-section of costa. Based on *Y. Nathi 538*.

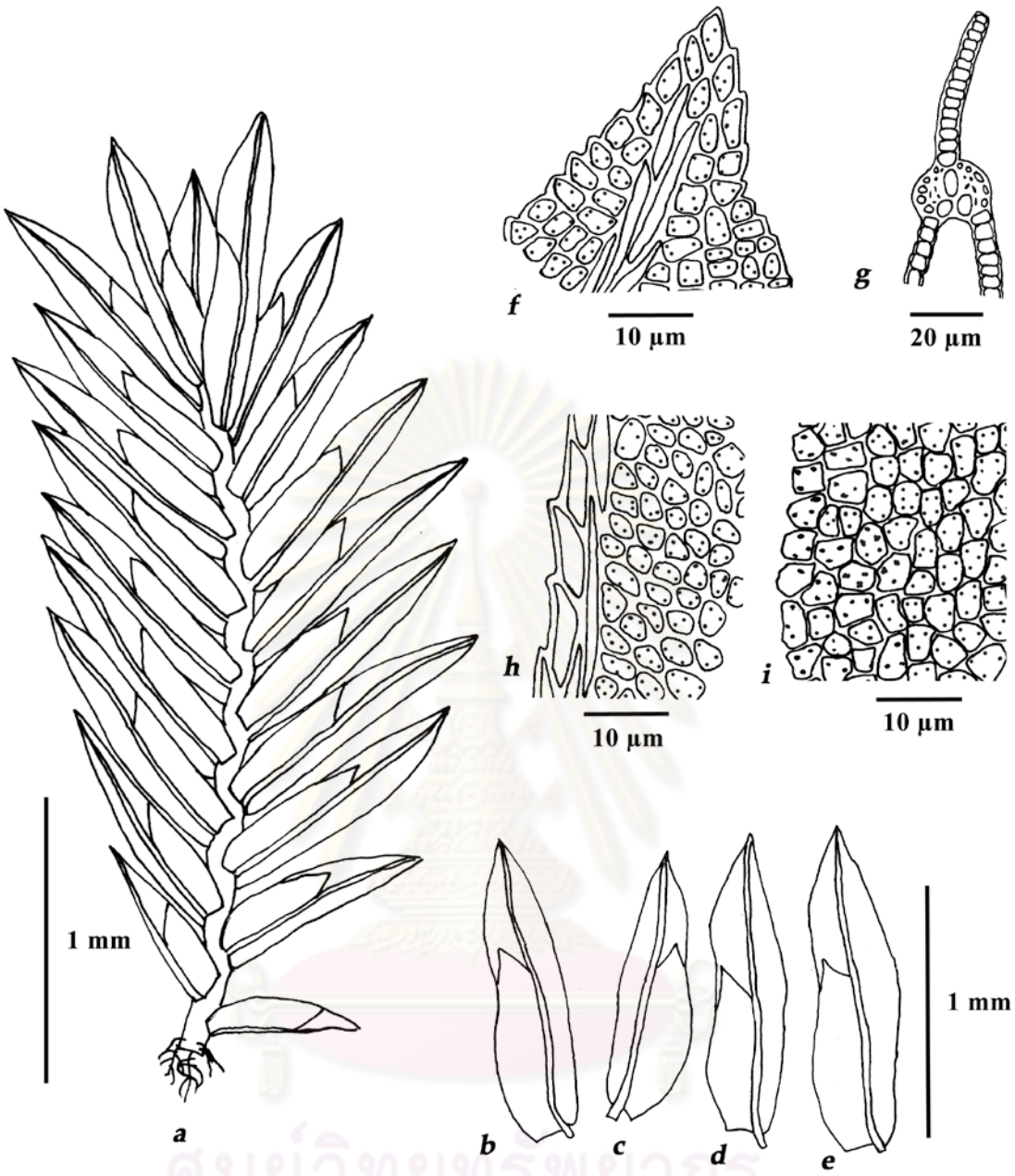


Figure 5.19 *Fissidens hollianus* Dozy & Molk.
a. habit; b., c., d., e. leaves; f. cells of leaf apex; g. cross-section of costa; h. cells at margin of vaginant lamina; cells at upper lamina. Based on *Y. Nathi* 246

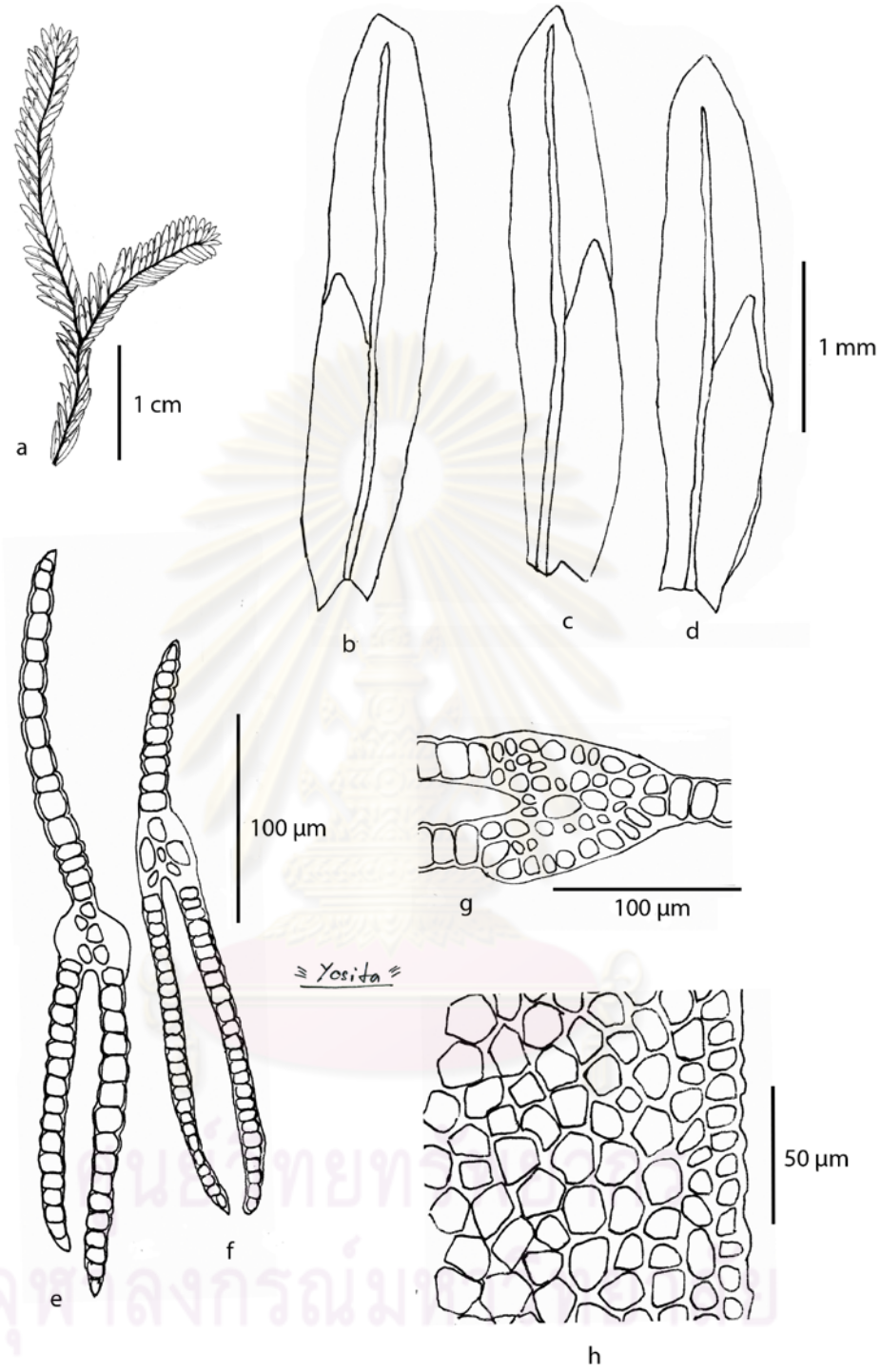


Figure 5.20 *Fissidens obscurus* Mitt.
a. habit; b., c., d. leaves; e., f. cross-section of leaves; g. cross-section of costa; h. cell at margin Based on *Y. Nathi 1015*.

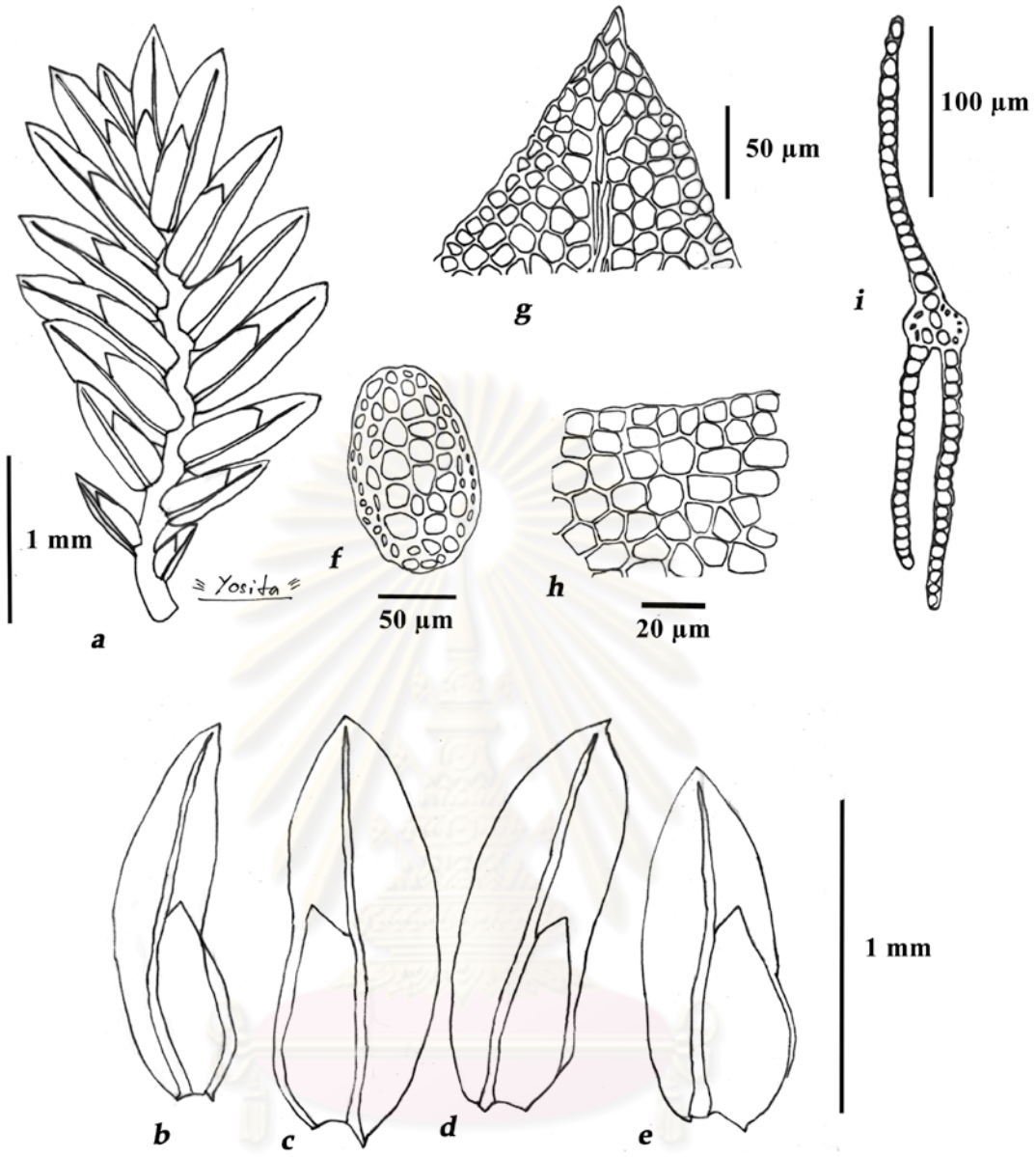


Figure 5.21 *Fissidens pellucidus* Hornsch.
a. habit; b., c., d., e. leaves; f. cross-section of stem; g. cells at leaf apex; h. cells at margin of apical lainae; i. cross-section of leaf-margin. Based on *Y. Nathi* 94

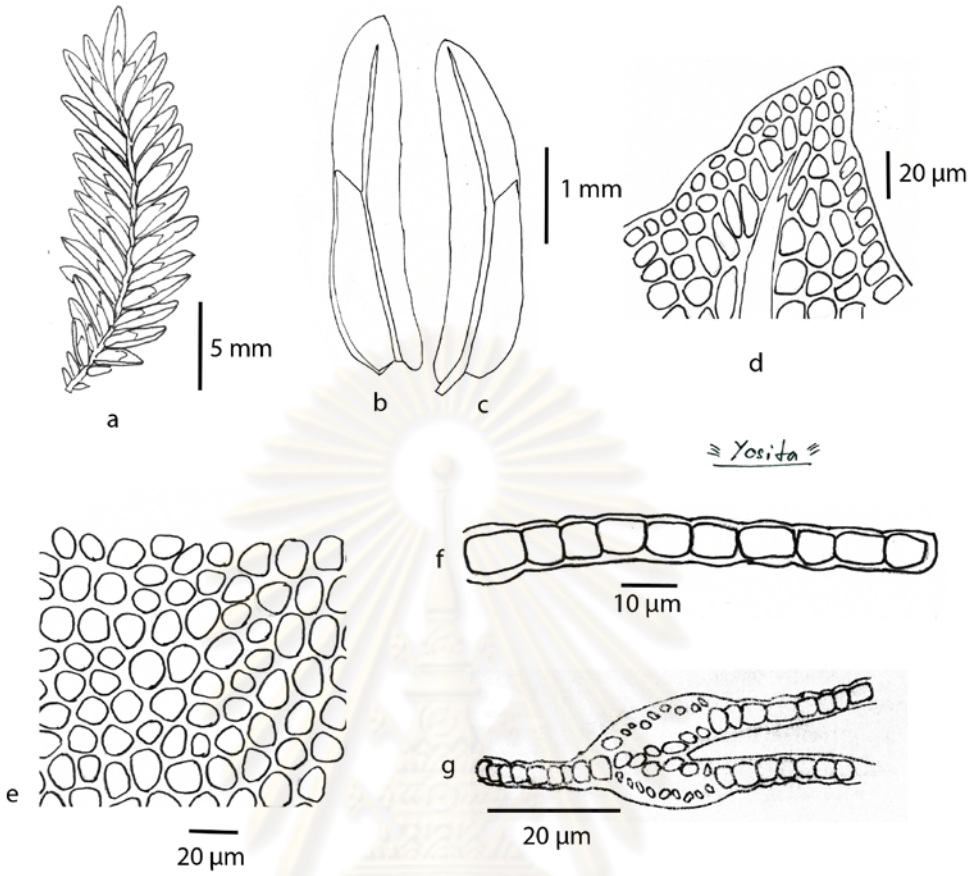


Figure 5.22 ***Fissidens polypodioides*** Hedw.
a. habit; b., c. leaves; d. cells at leaf apex; e. cells at median leaf; f. cross-section of leaf margin; g. cross-section of costa. Based on *Y. Nathi 239*.

FUNARIACEAE

Plants minute to medium-sized, gregarious to forming open tufts, light- to yellow-green, annual to biennial. **Stems** short, erect, simple or with a few branches, central strand present, basal rhizoids few. **Leaves** usually larger and more crowded distally, often comose, reduced proximally, usually contorted when dry, spreading when wet, broadly elliptic to obovate, usually concave, margins plane to somewhat incurved, entire to serrate, sometimes limbate, apex acute to acuminate, rarely somewhat blunt, costa single, percurrent to excurrent; distal and median cells usually irregular-rhombic to hexagonal or rectangular, smooth and rather thin-walled, often lax, weakly chlorophyllose, proximal cells usually longer, oblong to rectangular, sometimes weakly inflated at proximal angles, differentiated alar cells absent. **Autoicous**, sometimes polygamous, rarely synoicous or paroicous. **Perigonia** terminal on short basal branches, bud-like, paraphyses yellowish and club-shaped. **Perichaetia** terminal, paraphyses usually absent and filiform when present, perichaetial leaves often somewhat enlarged. **Sporophytes**; **seta** terminal, solitary, short to elongate, erect to somewhat curved, smooth or rarely papillose. **Capsule** stegocarpous or cleistocarpous, immersed to exserted, globose or pyriform to cupulate, sometimes flaring, symmetric and nearly smooth to asymmetric and striate when dry, usually with a neck; exothecial cells thick- to thin-walled; stomata restricted to neck, consisting of a slit in a rounded guard cell, superficial or immersed, annulus present or absent, revoluble, revoluble in fragments, or not; operculum present or absent, flat, conic-rounded, to rostrate; peristome double, single, rudimentary, or absent, exostome teeth 16, erect to incurved, papillose-striolate or striate, trabeculate on adaxial surface, endostome segments 16 and opposite the exostome teeth, cilia absent, represented only by the exostome when single. **Calyptra** deciduous or persistent, mitrate to cucullate, smooth, usually long-rostrate and inflated towards the base. **Spore** spherical or sub-reniform, strongly ornamented to smooth.

FUNARIA

Funaria Hedw., Sp. Musc Frondosorum 172. 1801; Gangulee, Mosses E. India 4: 855. 1974; Eddy, Handb. Males. Mosses 3: 107. 1996; Li, He & Zhang, Moss Fl. China 3: 84. 2003; Miller & Miller, Fl. N. Amer. 27: 188. 2007.

Plants small to medium-sized, gregarious or tufted, bright green to yellowish green. **Stems** short, erect, simple except for a short basal antheridial branch. **Leaves** larger and erect distally, reduced proximally, oblong-ovate to broadly obovate distally; concave; apex usually acute or acuminate margins erect, entire to serrate beyond middle; costa single, ending before the tip to excurrent; distal and medial laminal cells large, rhombic-hexagonal to rectangular, lax and rather thin-walled, proximal cells oblong-rectangular, differentiated alar cells absent. **Autoicous**. **Seta** elongate, erect to strongly curved or twisted. **Capsule** exserted, usually inclined to pendent, asymmetric and usually curved, yellow to brown, pyriform, often sulcate or plicate when dry and empty, annulus large and revoluble or not differentiated, peristome double, inserted somewhat below the mouth, teeth well developed, obliquely directed, lance-acuminate, papillose-striate, often strongly trabeculate, frequently appendiculate at the tips and fusing with a latticed disk, endostome segments opposite the teeth, papillose or weakly papillose-striate with a basal membrane and cilia absent. **Operculum** usually oblique, convex to weakly conic, cells in obliquely radial rows. **Calyptra** large, cucullate, usually smooth, and often long-rostrate. **Spores** spherical, smooth or papillose to baccate-insulate.

Key to the species

1. Plants small, 4-8 mm high; leaves crowded on top..... *F. hygrometrica*
2. Plants larger, 6-10 mm or higher; leave rosette on top .....*F calvescens*

1. *Funaria calvescens* Schwägr.

Sp. Musc. Frond., Suppl. 2: 77. pl. 65. 1816. — *Funaria hygrometrica* var. *calvescens* (Schwägr.) Mont., Ann. Sci. Nat. Bot., sér. 2, 12: 54. 1839; Gangulee, Mosses E. India 4: 857, fig. 410. 1974; Miller & Miller, Fl. N. Amer. 27: 190. 2008.

Plants green to yellow-green, simple or branched from base, usually about 1 cm high. **Lower leaves** small, showing poor development of costa, sparsely placed. **Upper leaves** large, forming a rosette on top, concave, oblong-obovate to oblong-lanceolate, erect-spreading 2.5-3 mm long, margin entire, apex acute to acuminate. **Costa** strong, percurrent or short excurrent in the upper leaves. Lamina cells thin-walled, suhexagonal, more elongated at base, smaller at apex. **Seta** apical erect, strongly aecuate. **Capsule** horizontal to pendulose to pendulose, arcuate-pyriform, asymmetrical with the narrower mouth oblique, 4 mm long, yellow with a deep red mouth, sulcate when dry **Peristome** teeth typical epicranoid. **Autoicous**. (**Figure 5. 23**)

Thailand — NORTHERN:Chiang Mai, Phetchabun. NORTHEASTERN: Loei

Distribution — Borneo, China, and Java.

Ecology — On wet soil, near by road side..

Specimens examined — *Y. Nathi 390, 967, 980* (BCU); *Smitinand 1997* (BKF).

GPS location —18.5883719°N 98.4868579°E, 18.58797058°N 98.48531817°E

Altitude — 2,549-2,560 m

2. *Funaria hygrometrica* Hedw.

Sp. Musc. Frond. 172. 1801; Gangulee, Mosses E. India 4: 856. 1974. Li, He & Zhang. Moss Fl. China 3: 87. 2003**;** Miller & Miller, Fl. N. Amer. 27: 191. 2008.

Plants 4-8 mm or more, with a basal antheridial branch, medium green to yellowish green; leafless proximally with leaves crowded and bulbiform distally, sometimes laxly foliate throughout. **Leaves** smaller proximally, distal leaves 2-4 mm, deeply concave, oblong-ovate to broadly obovate distally, acute to apiculate or short-acuminate, entire or weakly serrulate distally; **costa** subpercurrent to short-excurrent; distal laminal cells thin-walled and inflated, hexagonal or oblong-hexagonal becoming much more oblong proximally. **Seta** usually 20-40 mm, slender and flexuose, usually hygroscopic. **Capsule** 2-3 mm, pyriform, asymmetric, curved to straight, horizontal to pendent or merely inclined, becoming sulcate when dry below, strongly oblique mouth; annulus revoluble, operculum slightly convex. **Calyptra** cucullate, smooth. (**Figure 5. 24**)

Thailand — NORTHERN:Chiang Mai, Phetchabun NORTHEASTERN: Loei; PENINSULAR: Nakhon Si Thammarat.

Distribution — China, India, Japan, Korea, Myanmar, Pakistan, Siberia, Sri Lanka, Taiwan, and Vietnam, Australia, Hawaii, New Zealand, and USA.

Ecology — On soil.

Specimens examined — *Y. Nathi 412, 560, 964, 1005* (BCU); *Richards 5499* (BKF).

GPS location —18.5886259°N 98.4866078°E, 18.58795976°N 98.48525045°E, 18.5881101°N 98.4856369°E.

Altitude —2,548-2,559 m

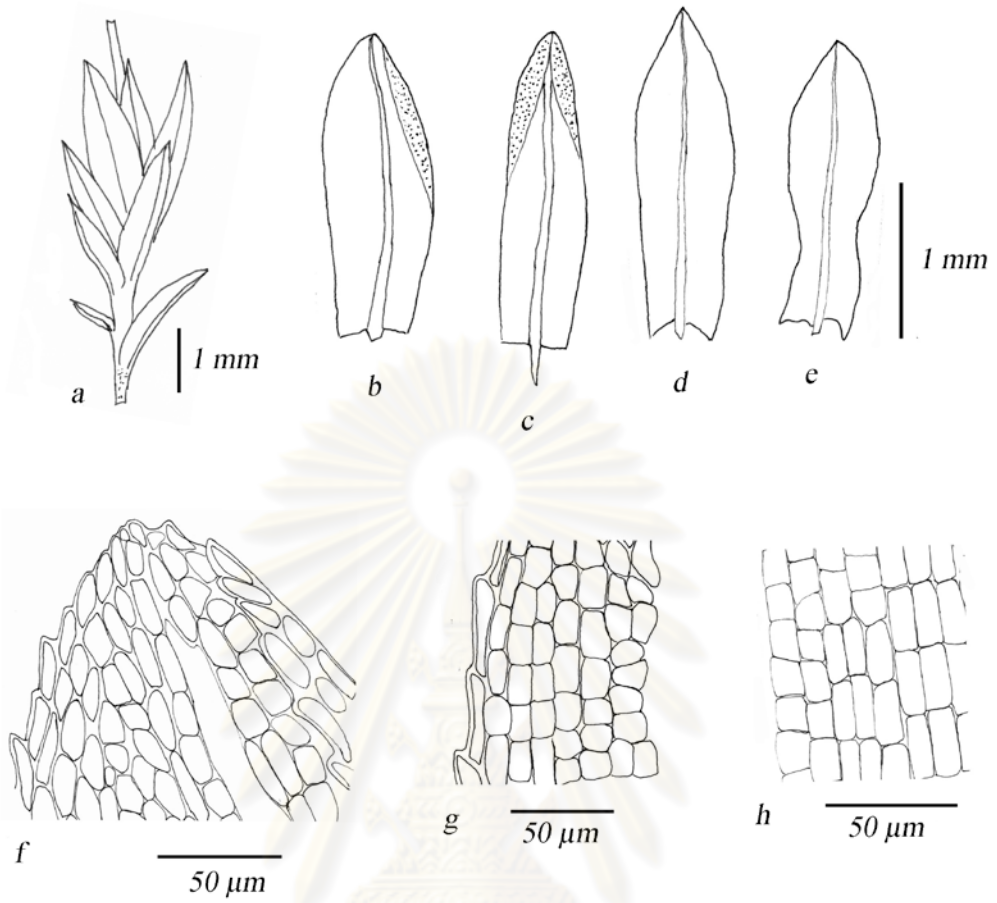


Figure 5.23 *Funaria calvescens* Schwaegr.
a. habit; b., c., d., e.leaves; f. cells of leaf tip; g. cell at margin of apical laminae; h. cells at leaf base. Based on *Y. Nathi 980.*

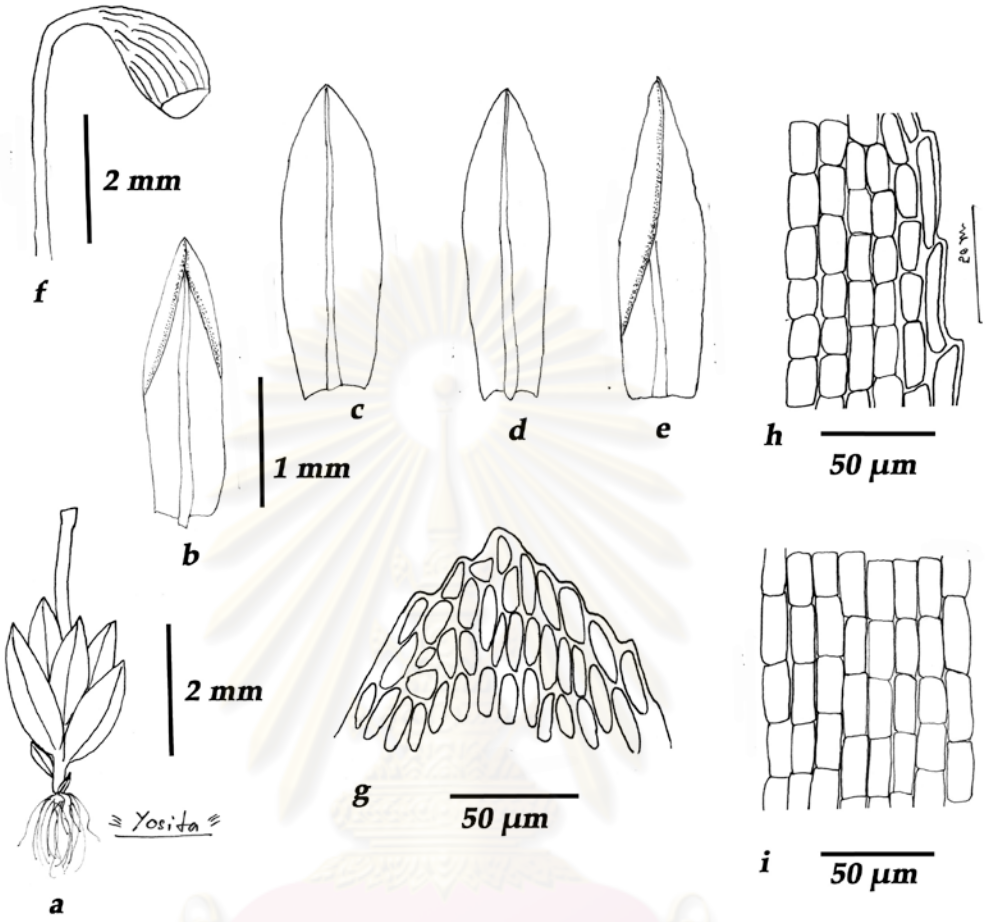


Figure 5.24 *Funaria hygrometrica* Hedw.
a. habit; b., c., d., e. leaves; f. sporophyte; g. cells of leaf tip; h. cells at margins of apical laminae; i. cells at leaf base;. Based on *Y. Nathi 412.*

HOOKERIACEAE

Plants small to robust, frequenly complanate; primary stems usually branched and prostrate; secondary stems prostrate, suberect, or pendent. **Leaves** variable in shape, with or without border, the dorsal leaves erect erect-spreading to spreading; **costa** single, or double; cell smooth or papillose. **Synoicous**, autoicous, or dioicous. **Capsule** inclined or horzonal; **peristome** double, exostome teeth papilose or striate, often with a wide median furrow. **Calyptra** generally mitriform, smooth, scabrous, or pilose, the base usually lobed or fringed-ciliate.

Key to the Genera

1. Costa single.....*Distichophyllum*
1. Costa double.....2
   2. Costa double, reaching only half the leaf length…….*Hookeriopsis*
   2. Costa double, short, forked .....*Calyptrocheata*

1. CALYPTOCHEATA

Calyptrocheata Desv., Mém. Soc. Linn. Paris, 3: 226, 1825; Tan & Robinson, Smithsonian contr. Bot. 75: 7. 1990.

Plants brownish green, in lax tufts. Stems simple or branched, with complanate, flexuous leaves when dry, flat, laxly foliate, usually with conspicuous clusters of brown, filiform propagula in upper leaf axils. **Leaves** dimorphic, lateral leaves spreading, leaves of dorsal and ventral rows smaller and erect, ovate, shortly acuminate, bordered, serrate above; **costa** short, forked; laminal cells lax, smooth, rhomboidal or fusiform in the upper half of the leaf, becoming narrowly rectangular at base. Perichaetial leaves smaller. **Seta** lateral, spinose; **capsule** ovoid or oblong-ovoid, horizontal; exostome teeth striolate below, becoming papillose above; opercula conic, beaked. **Calyptra** campanulate, lobed at base.

Calyptrocheata remotifolia (Müll. Hal.) Z. Iwats., B.C. Tan & Touw

J. Hattori Bot. Lab. 44: 150. 1978; Tan & Robinson, Smithsonian Contr. Bot. 75: 7. 1990. — *Eripopus remotifolius* C. Müll., Gangulee, Moss E. India 6: 1495, fig. 748. 1977.

Plants large, secondary stems to 3-6 cm tall. **Lateral leaves** oblong to oblanceolate, asymmetrical, wrinkled when dry. Leaf margins strongly toothed, with 3-4 rows of linear cells near the apex, c**osta** double, short;

upper leaf cell rhomboidal to fusiform, 90-100 μm long and 21-30 μm wide Dorsal and ventral leaves variable, mostly lanceolate or elliptic, the marginal teeth less strong. Sporophyte not found. (**Figure 5. 25**)

Thailand — PENINSULAR: Nakhon Si Thammarat

Distribution — Borneo, India, Java, Malaysia, New Guinea, Philippines, Sumatra, and Vietnam.

Ecology — on tree trunks.

Specimens examined — *Y. Nathi 145, 746, 1032* (BCU)

GPS location — 18.5883541°N 98.48560500°E, 18.58786463°N 98.48721474°E, 18.5579108°N 98.4809418°E.

Altitude — 2,214-2,545 m

2. DISTICHOPHYLLUM

Distichophyllum Dozy & Molk., Musci Frond. Ined. Archip. Indici 4: 99. 1846; Gangulee, Mosses E. India 6: 1482. 1977; Nog., Ill. Moss Fl. Japan 4: 713. 1991; Lin. & Tan, Harvard Pap. Bot. no. 7: 32. 1995; Lin & Tan, Moss Fl. China 6: 14. 2002.

Plants small to robust. **Stems** sparingly branched. **Leaves** complanate, weakly dimorphous, dorsal and ventral rows usually weakly differentiated, crowded, ovate or spathulate, usually entire, usually with a border of elongate cells; **costa** single, extending from midleaf to upper leaf, not reach to leaf apex; upper cells isodiametric, smooth, more lax and elongate at base. **Seta** smooth or papillose. **Capsule** erect to pendulose; **peristome** double; exostome teeth transverly striolate, with a wide median furrow; endostome with high basal membrane, segments sometimes perforate; **operculum** conic-rostrate. **Calyptra** mitriform, fringed at base.

Key to the species

1. Leaves distinctly carinate……..…….*D. carinatum*
1. Leaves not carinate……..……..……..2
2. Leaf apices round……...……*D. wanianum*
2. Leaf apices acuminate……..…….……..3
3. Upper laminal cells large, more than 20 μm in diameter; leaf apical acumens stout, more than 50 μm long, often twisted …..*D. collenchymatosum*
3. Upper laminal cells small, less than 20 μm in diameter; leaf apical acumens weak, less than 50 μm long, not twisted……...……*D. maibarae*

1. ***Distichophyllum carinatum*** Dixon. ex Nichols.

Rev. Bryol. 36: 24. 1909; P.-J. Lin. & B.C. Tan, Harvard Pap. Bot. no. 7: 35. 1995; B.-J. Lin & B.C. Tan, Moss Fl. China 6: 15. 2002.

Plants small, light yellow green, densely tufted. **Leaves** crowded and helically crisped when dry, ovate-lanceolate when wet, 1.5 mm long, acuminate to short cuspidate, strongly carinate in upper half of lamina and often keeled; leaf margin reflexed below, border with 1-2 rows of thin walled, linear cells; **costa** single, not reaching the leaf apex; **lamina cells** large, roundly rhomboidal to hexagonal, nearly homogeneous, 20-35 μm, thin-walled, becoming smaller near the leaf apex, rectangular near leaf base. **Sporophyte. Seta** about 10 mm long, smooth below, slightly papillose above. **Filiform propagules** present.

Thailand — NORTH: Chiang Mai (Doi Inthanon).

Distribution —China, Japan, and Western Europe.

Ecology — On branched, along forest border.

Specimens examined — *Y. Nathi 460* (BCU)

GPS location — 18.55986153°N 98.47580521°E

Altitude — 2,233 m

Note — New record to Thailand, and rare species.

2. ***Distichophyllum collenchymatosum*** Card., Bull.

Soc. Bot. Genève sér . 2, 3: 287. 1911; Lin & Tan, Harvard Pap. Bot. no. 7: 36. 1995; Lin & Tan, Moss Fl. China 6: 15. 2002. — *Distichophyllum decolyi* Gangulee, Mosses E. India 6: 1488. f. 744. 1977.

Plants small to medium sized. **Stems** slender, to 2 cm long and 3 mm wide with lateral leaves. **Leaves** contorted when dry, broadly oblong, elliptic to lingulate, 2-3 mm long and 1.5 mm wide, with well developed acumina (60-)75-90(-100) μm long. Leaf borders with 2-3 rows of linear cells, entire, slightly undulate. **Costa** strong, reaching beyond 2/3 of the leaf length. **Leaf cells** hexagonal to round, 18-33 μm wide, slightly collenchymatous, decreasing in size toward the margins in the upper half of leaf. **Sporophytes** only young sporophyte were found**; seta** 8-10 mm long, smooth; **calyptra** mitrate.

Thailand — NORTH: Chiang Mai (Doi Inthanon).

Distribution — China, India, Malaysia, and Indochina

Ecology — On wet soil, and rocks by streamlet

Specimens examined — *Y. Nathi 855, 857, 992, 1040* (BCU)

GPS location — 18.55336555°N 98.47752426°E, 18.55349991°N 98.47760288°E, 18.58712769°N 98.48704853°E, 18.55544519 °N 98.47598232°E.

Altitude — 2,143-2,547 m

Note — New record to Thailand

3. ***Distichophyllum maibarae*** Besch.

J Bot . 13: 41. 1899; Lin & Tan, Harvard Pap. Bot. no. 7: 39. 1995; Lin & Tan, Moss Fl. China 6: 22. 2002.

Plants small to medium sized, in loose tufts. **Stems** creeping, to 8 mm long, 3 mm wide with leaves when wet, simple, rarely branched. **Leaves** slightly shrunken and crisped when dry, ovate-oblong to obovate, 1.3-2.2 mm long, 0.6-1.0 mm wide, widest between midleaf and 3/4 from base, slightly asymmetrical, rounded to obtuse with a stout apiculus, the apiculus 14-45 μm long; margin entire and plane; border well differentiated, with 1-2 rows of linear cells near the apex, 2-3 rows towards the base; **costa** flexuose above, extending 3/5 to 4/5 of leaf length; **median cells** small, round to hexagonal, 8-12 μm in width, thin-walled, not collenchymatous, more or less homogeneous in upper half of leaf and in submarginal region towards base; paracostal cells in lower half of leaf larger than submarginal cells, hexagonal to rectangular. **Sporophytes** not seen.

Thailand — NORTH: Chiang Mai (Doi Inthanon).

Distribution — China, Japan and Western Europe.

Ecology — On soils.

Specimens examined — *Y. Nathi 9, 640, 652, 689, 856, 993, 1025* (BCU)

GPS location — 18.55346848°N 98.47764798°E, 18.58713951°N 98.48736788°E.

Altitude — 2,146-2,520 m

Note — New record to Thailand

4. ***Distichophyllum warnianum*** B.C. Tan & P.-J. Lin

Trop. Bryol. 10: 57. 1995; Lin & Tan, Harvard Pap. Bot. no.7: 39. 1995.

Plants small, mat-forming. **Stems** up to 10 mm tall and 2 mm wide including the leaves. **Leaves** strongly crisped or cirrate when dry, broadly

spatulate with a long narrow basal part when wet, 2-2.5 mm x 1-1.2 mm, the leaf apices broadly rounded, at times with a minute mucro. Leaf margin plane, wavy in the upper half even when wet, with strong borders all around; the border about 12-17 μm wired, consisting of 2-3 rows of thick-walled, linear cells, but becoming one row around the leaf apex. **Costa** single, reaching near the apex. **Laminal cells** nearly homogeneously small, quadrate-polygonal, 11-16 um wide, becoming smaller (9-13 um wide) apically and rectangular (33-55 x 11-22 um) basally. **Sporophytes** not seen.

Thailand — NORTH: Chiang Mai (Doi Inthanon).

Distribution — China.

Ecology — On branch, bark and rotten log

Specimens examined — *Y. Nathi 164, 204, 256, 772* (BCU)

GPS location — 18.5892257°N 98.48510703°E, 18.5883898°N 98.48594539°E, 18.5888468°N 98.48451133°E, 18.5561391°N 98.48219197°E, 18.5579239°N °98.48122604E

Altitude — 2,190-2,530 m

Note — New record to Thailand

3. HOOKERIOPSIS

Hookeriopsis (Besch.) A. Jaeger, Ber. S. Gall. Naturw. Ges. 1875-76: 358 .1877; Gangulee, Mosses E. India 6: 1512. 1977; Lin &. Tan, Moss Fl. of China 6: 33. 2002. — *Hookeria* sect. *Hookeriopsis* Besch. Ann. Sci. Nat. Bot., sér. 6, 3: 240. 1876.

Plants medium-sized to large, mat-forming. **Stems** creeping, elongated. **Leaves** complanate, forming dorsal, ventral and lateral rows, slightly heterophyllous, flexuos when dry, concave when wet; lateral leaves mostly ovate-oblong, asymmetrical, margins not border, **costa** long, double, reaching beyond midleaf; dorsal and ventral leaves smaller than lateral leaves, more acuminate; leave cells narrowly rhomboidal, becoming shorter at apex and rectangular at base, thin walled, smooth. Polygamous. **Seta** lateral; **capsule** horizontal; opercula conic-rostrate; peristome double, exstome and typically hookerioid; basal membrane high; cilia absent. **Calyptra** mitriform.

Hookeriopsis utacamundiana (Mont.) Broth.

Nat. Pflanzenfam. 1(3): 942 .1907; Gangulee, Mosses E. India 6: 1513, fig. 757. 1977; Nog., Ill. Moss Fl.Japan 4: 756, fig. 333. 1991; Lin & Tan, Moss Fl. China

6: 33. 2002.— *Hookeria utacamundiana* Mont. Ann. Sci. Nat. Bot., sér. 2, 17: 247. 1842.

Plants mat-forming, silky green, with deep purplish tinge. **Primary stems** prostrate, complanate; the **secondary stems** and branches creeping or erect, to 10-12 mm tall. Leaves flatly arranged, slightly flexuose when dry, concave when wet. **Lateral leaves** ovate-oblong, 2-3 mm long, broadly acute; marginal borders not well differentiated, except for the strongly bifid, unicellular teeth along leaf along leaf margins near the apex. Costae double, strong, asymmetrically placed at leaf base, reaching mid-leaf, spinose abaxially. Dorsal and ventral leaves like the lateral ones but smaller, the apices sometimes acuminate. **Leaf cells** narrowly rhomboidal. 35-60 μm long and 12-15 μm wide, smooth or at times slightly prorulose, becoming oval near apex and rectangular at base, thin to thick-walled. **Autoicous**. **Seta** up to 2 cm long, redish-brown, smooth. **Capsule** ovoid-oblong, horizontal. (**Figure 5.30**)

Thailand — NORTH: Chiang Mai, Phitsanulok: SOUTHWESTERN: Phetchabun: SOUTHEASTERN: Nakhon Nayok: NORTHEASTERN: Loei

Distribution —China, Japan and Western Europe.

Ecology — On ground, tree base and decaying logs.

Specimens examined — *Y. Nathi 160, 183, 695, 786, 900, 912, 945, 984* (BCU)

GPS location — 18.5888328°N 98.48452281°E, 18.5558408°N 98.48227453°E, 18.5567133°N 98.48176475°E, 18.58619344°N 98.48590918°E, 18.55732005°N 98.48141438°E, 18.55346848°N 98.47764798°E, 18.58625933°N 98.48572637°E

Altitude —2,146-2,544 m

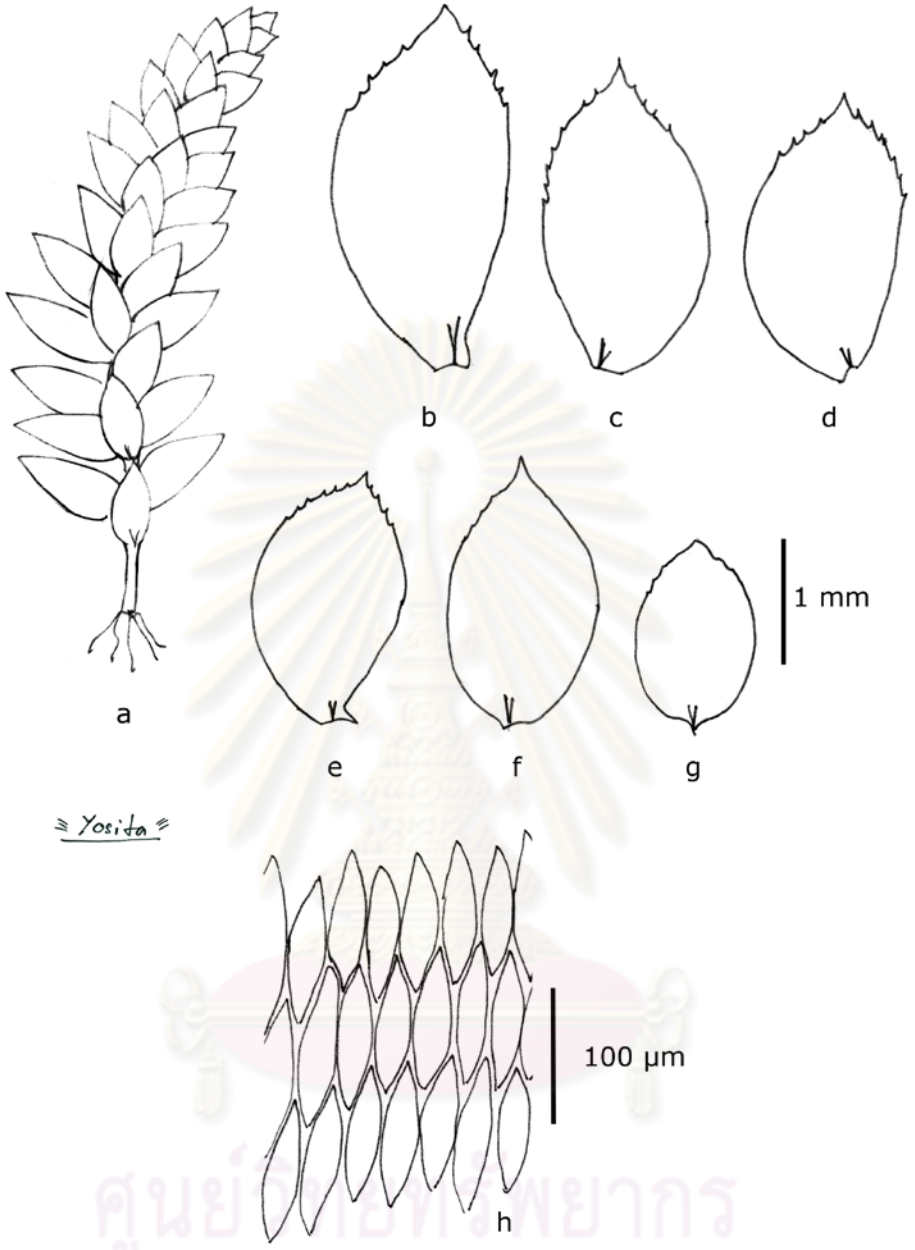


Figure 5.25 *Calyptrocheata remotifolia* (Müll. Hal.) Z. Iwats., B.C. Tan & Touw a. habit; b., c., d., e. leaves; f. leaf apex; g. cells at leaf-margins; h. gemma; cells at median leaf. Based on *Y. Nathi* .

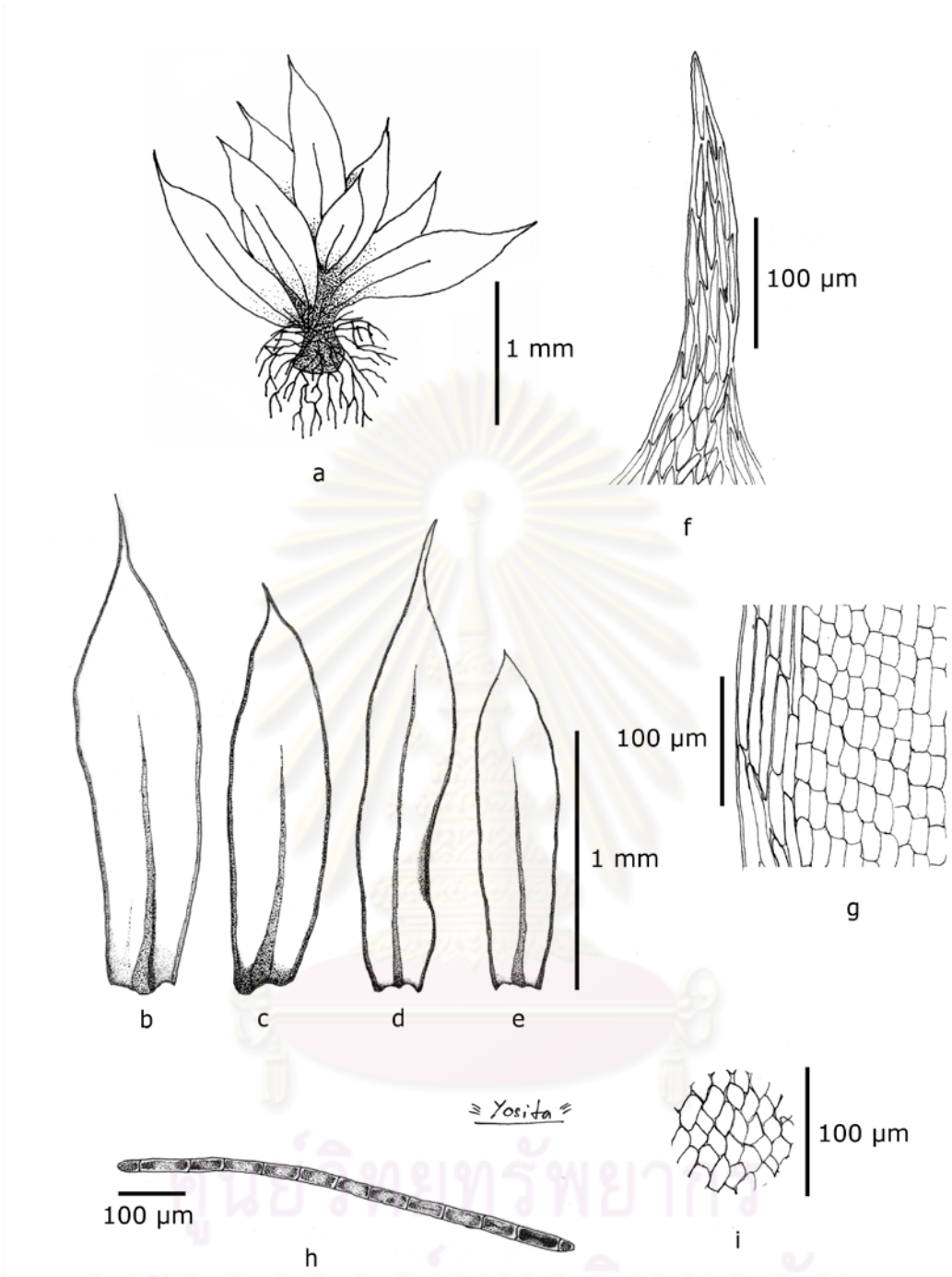


Figure 5.26 *Distichophyllum carinatum* Dixon & W.E. Nicholson
a. habit; b., c., d., e. leaves; f. leaf apex; g. cells at leaf-margins; h. gemma; cells at median leaf. Based on *Y. Nathi460.*

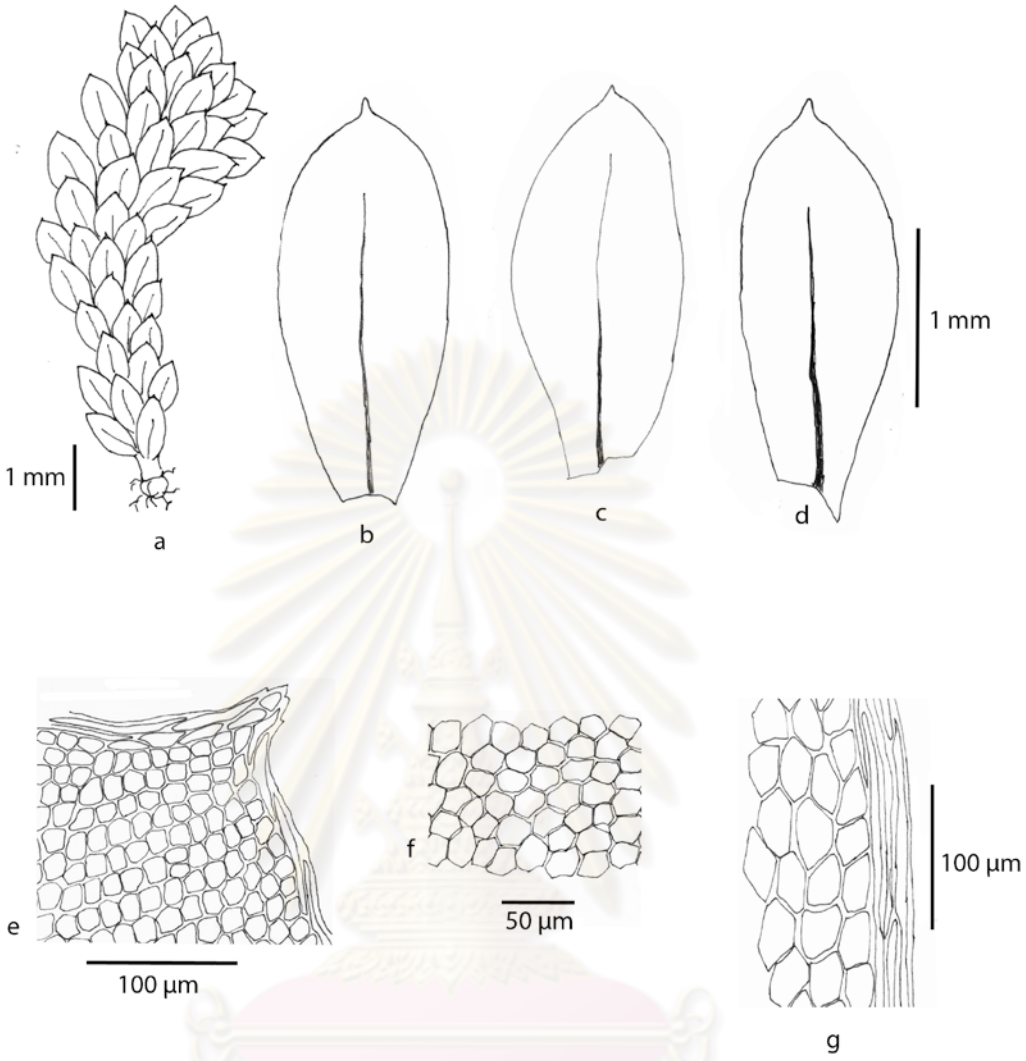


Figure 5.27 *Distichophyllum collenchymatosum* Cardot **
a.habit; b., c., d. leaves; e. leaf apex; f. cells of laminae; g. cells at leaf base.
Based on *Y. Nathi 992.*

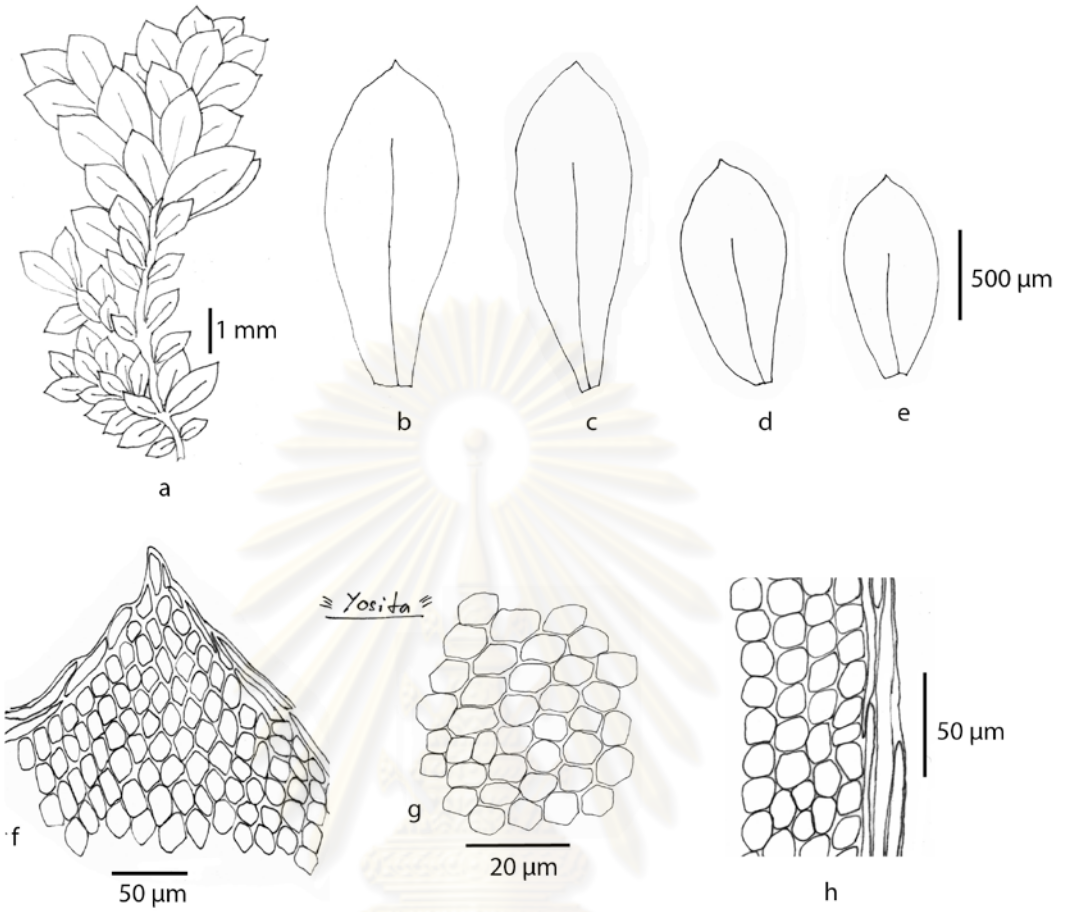


Figure 5.28 *Distichophyllum maibarae Besch.*
a. habit; b., c., d., e leaves; f. leaf apex; g. cells of upper laminae; h. leaf-margins. Based on *Y. Nathi 652*.

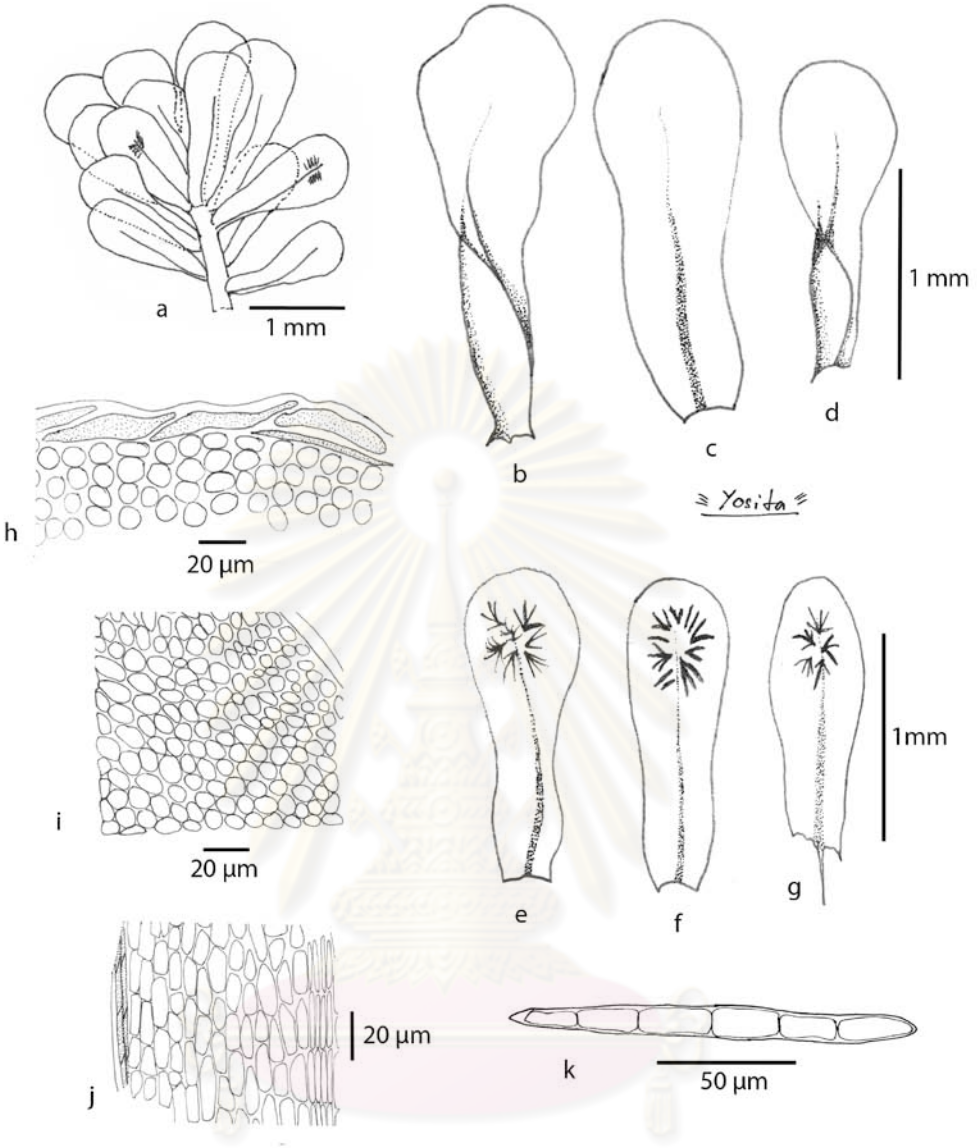


Figure 5.29 *Distichophyllum wanianum* B.C. Tan & P.J. **
a. portion of plant; b., c., dleaves; e., f., g. gemmiferouse leaves; h. leaf apex; i. cells at apical laminae; j. cells at leaf base; k. gemma. Based on *Y. Nathi* 164

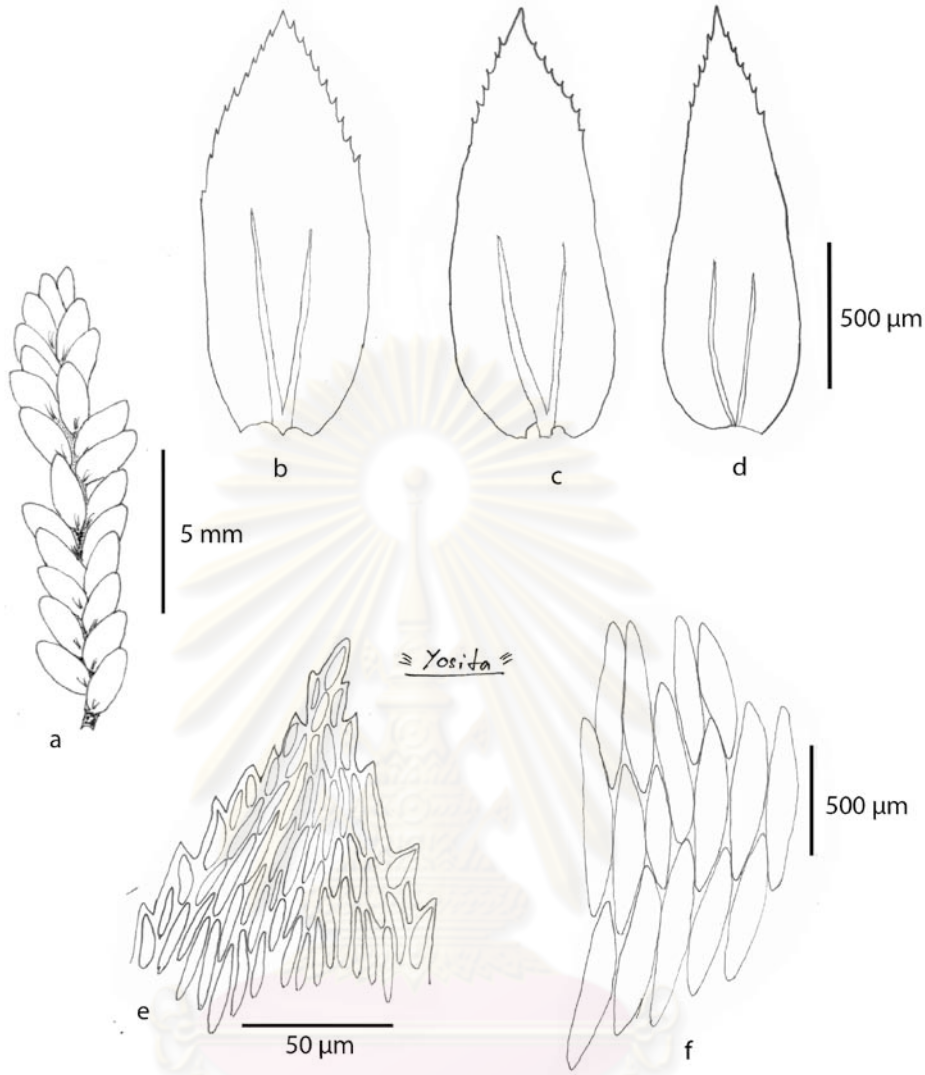


Figure 5.30 *Hookeriopsis utacaqmundiana* (Mont.) Broth.
a. portion of plant; b., c., d. leaves; e. leaf apex; f. leaf cells. Based on *Y. Nathi* 984

HYLOCOMIACEAE

Plants medium-sized to large, stiff, robust, rarely slender, green, yellowish green to yellow, often slightly glossy, in loose or dense wefts. Stems prostrate; secondary stems usually erect-spreading, sometimes arcuate-curved, irregularly branched or regularly 2-3 pinnately branched, usually exhibiting a sympodial or monopodial growth pattern; in cross section a central strand present; branched paraphyllia or foliose pseudoparaphyllia often present on stems and branches, paraphyllia lacking in some genera and species; rhizoids usually brownish. **Leaves** spirally imbricate-arranged; stem leaves usually differentiated from branch leaves, erect-spreading, squarrose-recurved or falcate-secund, clasping at base; ovate-lanceolate, broadly lanceolate or triangularly cordate, sometimes plicate or rugose, rarely concave, acuminate, acute to obtuse; upper leaf margins usually toothed, sometimes slightly reflexed at base; **costa** single, double or irregularly forked, strong or weak, extending to the middle of leaf or vanishing below the middle, rarely absent; **laminal cells** linear or elongate vermiform, smooth, papillose or prorate at back, slightly incrassate or thin-walled; base cells slightly broad, sometimes yellowish , slightly pitted; **alar cells** differentiated, usually short, quadrate or subquadrate. **Dioicous.** Perichaetia restricted on the stems, perichaetial leaves usually not plicate, costae double, short, inner perichaetial not costate. **Seta** elongate, brownish red, smooth; **capsule** ovoid or elongate-ovoid, suberect to horizontal or pendent; apophysis rarely present; stomata superficial, present at base; annuli of 1-3 rows of differentiated cells or absent; opercula shortly conic, rostrate; **peristome** double; exostome teeth narrowly lanceolate, lightly bordered; outer surface cross-striate, usually finely and densely papillose; endostome segments lanceolate, light yellow; basal membrane high, usually smooth, trabeculate, perforated along median line; cilia 1-4, sometimes absent. **Calyptra** cucullate, smooth. **Spor** spherical, yellowish, finely papillose or nearly smooth.

MACROTHAMNIUM

Macrothamnium Flisch, Hedwigia 44: 307. 1905;Nog., Kumamoto J. Sci., Biol., Vol. 11, No 1: 1. 1972; Jia, Wang & Wang, Moss Fl. China 8: 277. 2005;

Plants medium-sized to large, dull or slightly glossy, yellowish green, in loose or dense mats. Main stems elongate and prostrate; secondary stems usually curved, irregularly or regularly 1-3 pinnately branched, central strand

poorly developed; paraphyllia absent; pseudoparaphyllia triangular or lanceolate; rhizoids on tips of branches and main stems, few. **Stem leaves** and branch leaves differentiated; stem leaves erect to spreading, cordate, reniform or broadly ovate, obtuse, acute or acuminate at apex, usually cordate at base, decurrent or not decurrent, somewhat concave, occasionally somewhat plicate; margins reflexed at base, serrate above; **costa** double, 1/4 – 1/2 the leaf length, sometimes indistinct; median leaf cells narrowly oblong to linear, smooth or rarely finely papillose, pitted or slightly pitted at base; alar cells not differentiated, or sometimes conspicuously inflated; **branch leaves** more closely arranged, spreading, rounded ovate or oblong, acute or short-acuminate at apex, not or slightly decurrent; costae weak; laminal cells prorate; alar cells not differentiated. **Dioicous.** Perichaetia on main stems. **Seta** elongate, smooth, reddish; **capsule** erect or slightly inclined, symmetric, usually with a short apophysis, constricted below the mouth or irregularly plicate when dry; stomata superficial at base of capsules; annuli consisting of 2-3 rows of small cells, sometimes absent; opercula conic; **peristome** double; exostome teeth yellow, lanceolate, slightly bordered; outer surface irregularly or regularly cross-striate and papillose, rarely perforated along median line; endostome segments yellow, smooth or papillose, narrowly perforated. **Calyptra** cucullate, smooth, naked. **Spore** spherical, finely papillose, 8-33 μm in diameter.

Key to species

1. Leaf apex reflexed ..... *M. javense*

1. Leaf apex acute ..... *M. macrocarpum*

1. ***Macrothamnium javense*** Fleisch

Hedwigia 44: 311, f. 1905; Nog., Kumamoto J. Sci., Biol., Vol. 11, No.1: 7. 1972; Jia, Wang & Wang, Moss Fl. China 8: 278, Pl. 728. 2005.

Plants rather robust, up to 5-8 cm long. Main stems mostly dendroid; new branches arcuate, creeping, with several small, cuspidate branchlets. **Stem leaves** spreading when dry, cordate at base, semi-orbicular, concave, ca. 1.3-1.5 mm x 1-1.2 mm, broadly acute or obtuse, apex somewhat reflexed, long and broadly decurrent at base, clasping; margins sharply toothed above; costae double; **median leaf** cells linear, 35-45 μm long , thin-walled; basal cells loose; **alar** cells enlarged, numerous, rectangular or irregular, thin-walled; **branch leaves** imbricate when dry, ovate or oblong ovate, broadly acute, ca. 0.5-1.0 mm x 0.4-0.5 mm; costae indistinct. **Sporophyte** not found. (**Figure 5.31**)

Thailand — Northern: Chiangmai.

Distribution — China, Sri Lanka, Malaysia, Philippines, and Papua New Guinea.

Ecology — On root.

Specimens examined — *Y. Nathi 124* (BCU)

GPS location — 18.54257218°N 98.51670245 °E.

Altitude — 2,120 m

2. *Macrothamnium macrocarpum* (Reinw. & Hornsch.) M. Fleisch.

Hedwigia 44: 308. 1905; Nog., Kumamoto J. Sci., Biol., Vol. 11, No.1: 3, fig. 1, *1,2*. 1972; Gangulee, Mosses E. India 8: 2929, fig. 1054, 1055. 1980; Jia, Wang & Wang, Moss Fl. China 8: 280, Pl. 730. 2005. — *Hypnum macrocarpum* Rienw. & Hornch, Nov. Act. Leop. Car., 14 (2) suppl.: 725. 1829.

Plants prostrate, up to 10 cm long. Stems pinnately branched, usually with numerous branches, 10-15 mm long, somewhat curved when dry; central strand slightly differentiated; pseudoparaphyllia shell-like. **Stem leaves** widely spreading or somewhat squarrose-recurved, nearly round, obtuse or broadly acute at apex, widely cordate at base; **costae** double, short, weak, usually not distinct; branch leaves smaller, broadly oblong, obtuse; median leaf cells linear, 40-50 μm long, pitted; basal cells rectangular, partly rectangular, partly incrassate; **alar** cells usually loosely arranged, rectangular. **Dioicous**. **Seta** up to 5 cm long, twisted when dry; **capsule** inclined or horizontal, oblong-cylindrical, asymmetric; opercula shortly rostrate; **peristome** double; exostome teeth orange red, narrowly lanceolate, linear above, finely papillose, cross-striate below; endostome segments linear-lanceolate, keeled, as high as the teeth. (**Figure 5.32**)

Thailand — NORTHERN: Chiang Mai; NORTHEASTERN: Loei.

Distribution —India, Nepal, Sikkim, Sri Lanka, Myanmar, Philippines, Sumatra, Java, China, Japan, Taiwan, and Vietnam.

Ecology — Common on soils and rotten logs.

Specimens examined — *Y. Nathi 59, 106, 132, 152, 171, 184, 232, 249, 351, 370, 407, 531, 551, 558, 728, 758, 762, 797, 802, 809, 1023,* (BCU).

GPS location — 18.5885913°N 98.48579259°E, 18.5881294°98.48610347N °E, 18.5883898°N 98.48594539°E, 18.5888505°N

98.48477117°E, 18.5887674°N 98.48422073°E, 18.5567133°N 98.48176475°E, 18.5579702°N 98.48162410°E, 18.5892308°N 98.4874572°E18.589043, °N 98.4872297°E, °N °E, 18.5886259°N 98.4866078°E.

Altitude — 2,188-2,557 m

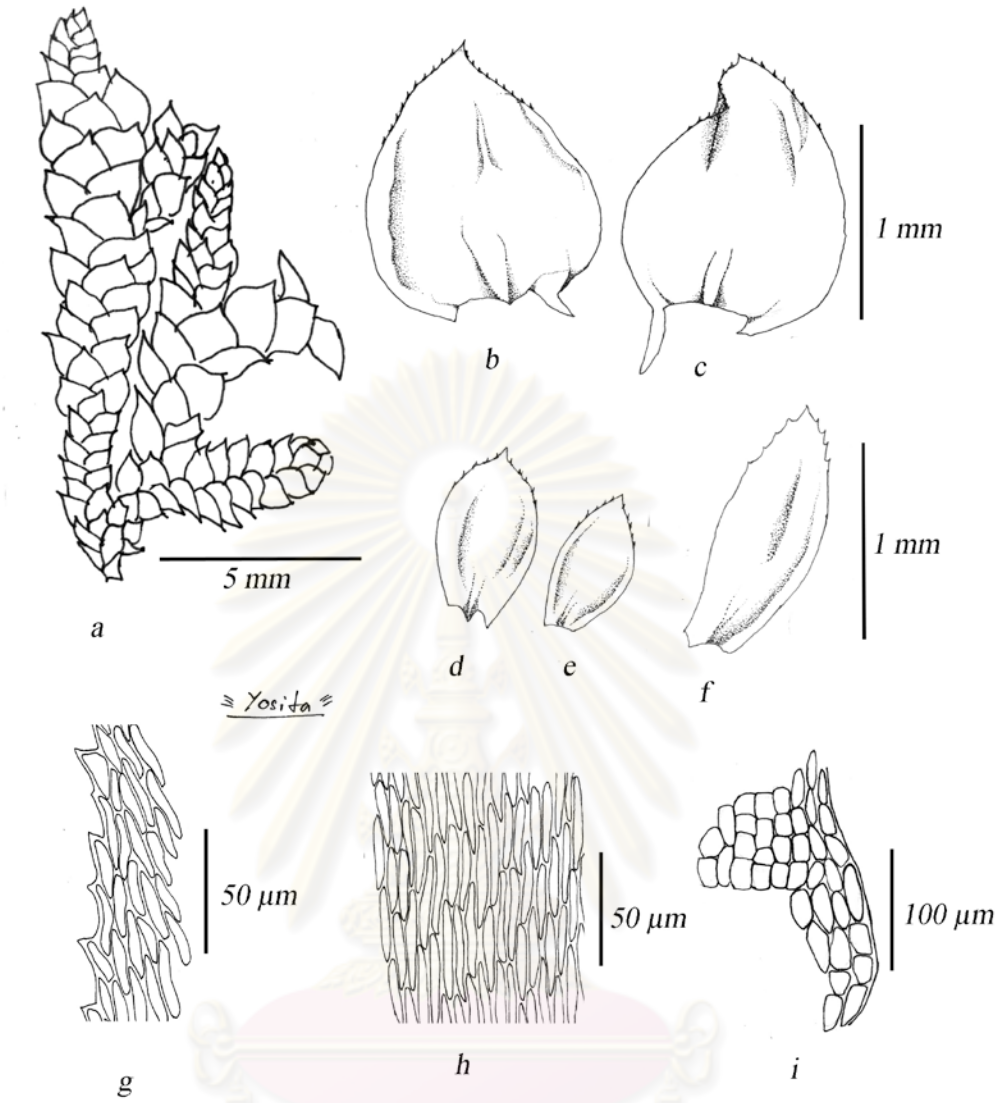


Figure 5.31 *Macrothamnium javense* Fleisch.

a. portion of plant; b., c. stem leaves; d., e., f. branch-leaves; g. cells of leaf margin; h. cells at median leaf; i. cells at leaf base. Based on *Y. Nathi 124.*

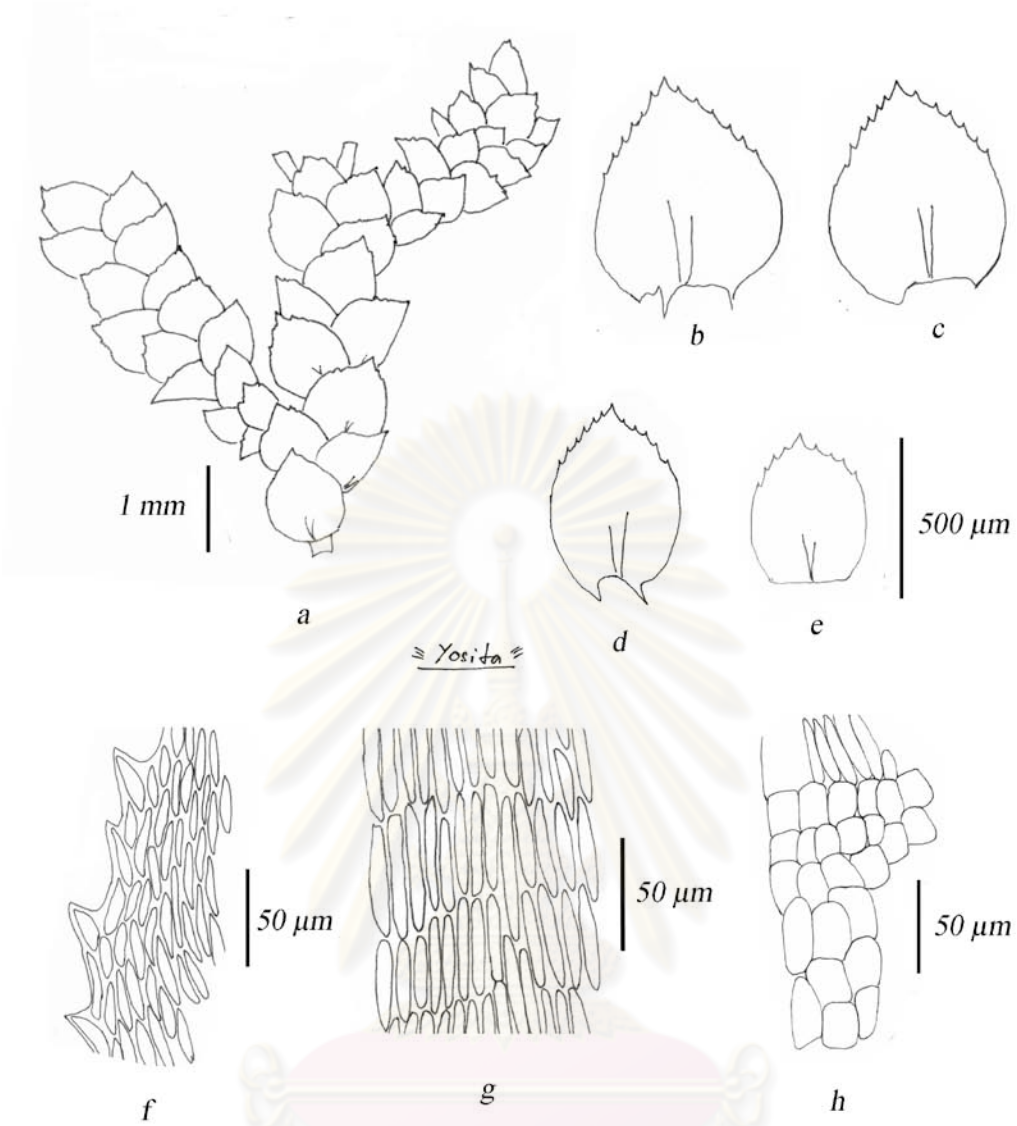


Figure 5.32 *Macrothamnium macrocarpum* (Reinw. & Hornsch.) Fleisch.

a. a portion of plant; b., c. stem leaves; d., e. branch-leaves; f. cells at leaf margin; g. cells at median leaf; h. cells at leaf base. Based on *Y. Nathi* 558

HYPNACEAE

Plants small, slender to robust, green to yellowish green or golden brown, loose or often in densely intermixed patches. Stems usually creeping, or sometimes ascending, irregularly branched to regularly pinnately branched, or sometimes frondose; paraphyllia absent, pseudoparaphyllia usually present; stems in cross section, rounded or elliptic, central strand differentiated or only somewhat differentiated, cortical cells large, with several layers of thick=walled cells. **Stem leaves** and branch leaves usually similar, sometimes dimorphic, symmetric or asymmetric, leaf shape various, usually oblong-ovate, ovate or ovate-lanceolate, slenderly acuminate, sometimes shortly acute, often homomallous, second or falcate-secund, rarely complanate or picate; **costae** double, short, often indistinct; **leaf cells** usually linear, rarely oblong-hexagonal, smooth or sometimes prorate, rarely papillose; **alar cells** usually differentiated in a group of quadrate and rectangular or enlarged cells. **Dioicous** or autoicous. Perichaetia lateral and perchaetial leaves differentiated. **Seta** elongate, mostly smooth; **capsule** erect to horizontal, symmetric to asymmetric, ovoid to cylindrical; annuli often differentiated; opercula conic, usually shortly rostrate; **peristome** double, rarely single (probably with highly reduced endostome); exostome teeth 16, slenderly lanceolate, yellowish to brownish, bordered, the dorsal plates mostly cross-striolate and papillose below, hyaline and papillose above; the ventral plates smooth, strongly trabeculate; endostome segments 16, lanceolate-subulate, nearly as long as or somewhat shorter than the teeth, keeled, perforate, smooth or papillose; basal membrane usually high; cilia often well developed, nodulose, sometimes lacking. **Calyptra** cucullate, usually smooth. **Spore** often small, yellowish or yellowish brown, smooth or papillose.

Key to the genera

1. Plants green and reddish.....3. *Pseudotaxiphyllium*
1. Plants green not reddish.....2
   2. Plants fine, elongate branches; leaves very small, lax.....1. *Glossadelphus*
   2. Plants nearly prostrate or slightly ascending, remotely pinnately or irregular branched 3
3. Plants remotely pinnately branched ..... 2. *Isopterygium*
3. Plants irregularly branches 4.*Taxiphyllum*

1. GLOSSADEPHUS

Glossadelphus M. Fleisch., Musci Buitenzorg 4: 1351. 1923; Zhang & He, Moss Fl. China 8: 33. 2005.

Plants mostly slender, rarely robust, green or yellowish green, slightly glossy. Stems prostrate, elongate with caepitose rhizoids, usually somewhat pinnately branched, branches short, often complanate. **Leaves** oblong-ovate to ligulate, obtuse at apex, rarely acute, asymmetric; lateral leaves broad, concave, ventral leaves narrower; margins entire or serrulate; **costa** short or absent; **leaf cells** narrowly rhomboidal, prorate or unipapillose to pluripapillose. **Dioicous**, rarely autoicous. **Seta** slender, elongate, smooth, rarely papillose above; **capsule** suberect, ovoid, apophyses short; opercula conic, shortly straight rostrate; annuli differentiated; **peristome** double; exostome teeth lanceolate, fused at base, divided above, hyaline, papillose above on outer surface, trabeculate on inner surface; endostome segments papillose, yellowish, proforate along the median line, **Calyptra** cuculate. **Spore** green, smooth or papillose.

Glossadelphus prostrates (Doxy & Kolk.) Fleisch.

Musci Buitenzorg 4: 1353, 219, 1923. — *Hypnum prostratum* Doxy & Molk. Ann. Sci. Nat. Bot., Sër. 3 2: 309. 1844. — *Myurella brevicosa* Lou et Wu, J. Hattori Bot. Lab. 71: 574. 1992.

Plants small, mat forming, intertwined, fine and elongate branches. **Leaves** very small, lax, erect, about 0.25-0.4 mm long, ovate to ovate-lanceolate, concave; leaf margin serrate, denticulate; leaf apex short acuminate; **costa** double, short, or absent; **laminal cells** elongate and often prorulose. **Sporophytes. Seta** 2.0-2.5 cm; **capsule** ovoid. (**Figure 5.33**)

Thailand — NORTH: Chiang Mai.

Distribution — China, Laos, Vietnam, Indonesia (Java, Lombok, Irian Jaya), Papua New Guinea and several Pacific Islands.

Ecology — On rotten log.

Specimens examined — *Y. Nathi 945* (BCU)

GPS location — 18.55791°N 98.48094°E.

Altitude— 2,218 m

Note — New record to Thailand.

2. ISOPTERYGIUM

Isopterygium Mitt., J. Lin. Soc., Bot. 12. 21. 1869; Gangulee, Mosses E. India 8: 1948. 1980; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 1025. 1994; Zhang & He, Moss Fl. China 8: 204. 2005.

Plants small to medium-sized. **Stems** creeping, rediculose at base, irregularly branched; in stem cross section epidermal cells small, thick-walled; central strand somewhat developed; pseudoparaphyllia filamentous. **Stem leaves** and branch leaves similar, oblong-ovate, oblong- or ovate lanceolate, not decurrent, acuminate or suddenly acute, dorsal, ventral leaves symmetric, lateral leaves more or less asymmetric; margins plane, serrulate above or entire; **costae** short and double, sometime absent; median leaf cells linear, thin-walled, lower cells shorter, **alar cells** not differentiated. Brood bodies often present. **Autoicous** or dioicous. Inner perichaetial leaves oblong-lanceolate, straight, **Seta** erect, smooth; **capsule** suberect to horizontal, oblong ovoid, often with long neck; **opercula** conic, shortly rostrate; annuli not seen; **peristom**e double; exostome teeth fused at base, outer surface distinctly cross-striate below, papillose, hyaline above, usually bordered, inner surface trabeculate, endostome segments keeled, papillose, not perforate, basal membrane high, cilia in groups of 1-3, or sometimes lacking. **Calyptra** cucullate, smooth. **Spore** small, smooth or minutely papillose.

Isopterygium bancanum (Sander Lac.) A. Jaeger

Ber. Thätigk. St. Gallischen. Naturewiss. Ges. 1876-77: 442. 1878; Gangulee, Mosses E. India 8: 1959, fig. 1006. 1980; Zhang & He, Moss Fl. China 8: 208, Pl. 691, figs. 1-15. 2005. — *Hypnum bancanum* Sande Lac., Bryol. Jav. 2: 188, 286. 1868.

Plants yellowish green, glossy. **Stems** nearly prostrate or slightly ascending, 4-7 cm long, remotely pinnately branched, radiculose; branches ca. 0.5-1.0 cm long, densely foliate. **Stem leaves** and branch leaves similar, ovate-lanceolate, gradually acuminate, 1.0-1.3 mm x 0.3-0.4 mm, asymmetric, concave; margins entire, serrulate near apex; **costa** double, very short or absent; **leaf cells** linear, ca. 75 μm x 4-5 μm, thin-walled; basal cells shorter and lax. **Autoicous**. **Sporphytes**; **seta** reddish, 1.2-1.4 cm long, straight or bent, slender; **capsule** ovoid to ellipsoid, with short neck, pendulous; opercula shortly rostrate; **peristome** double; exostome teeth reddish and cross-striate below, papillose above; endostome segments yellowish, perforate, with 1 cilium, **Calyptra** cucullate. **Spore** yellowish green, papillose. (**Figure 5.34**)

Thailand — SOUTHEASTERN: Trat.

Distribution —Bhutan, Borneo, Mainland China, Java, Philippines, and Vietnam.

Ecology — On tree trunks.

Specimens examined — *Y. Nathi 596, 1075* (BCU)

GPS location — °18.58837°N 98.48686°E, 18.58809°N 98.48652°E.

Altitude— 2,485 m

3. PSEUDOTAXIPHYLLUM

Pseudotaxiphyllum Iwats., J. Hattori Bot. Lab. 63: 445. 1987; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 1031. 1994; Zhang & He, Moss Fl. China 8: 222. 2005.

Plants small to fairly robust, in thin to dense, light-to yellow-green, glossy. Stems prostrate, irregularly branched; in cross section epidermal cells small, thick-walled; pseudoparaphyllia absent; rhizoids smooth. **Leaves** asymmetric, rhizoids present at base; margins plane, serrulate near the apex; **costa** lacking or short and double; **cells** often flexuose, linear-fusiform, smooth; **alar** regions not differentiated with numerous quadrate to short-rectangular cells. Brood bodies present in leaf axils. **Dioicous**. **Seta** elongate, smooth; **capsule** suberect or horizontal; annli differentiated; **peristome** double. **Spore** spherical, minutely papillose.

Pseudotaxiphyllum pohliaecarpum (Sull. & Lesq.) Z. Iwats.

J. Hattori Bot. Lab. 63: 449. 1987; Zhang & He, Moss Fl. China 8: 223, Pl. 701, figs. 1-12. 2005. — *Hypnum pohliaecarpum* Sull. & Lesq. Proc. Amer. Acad. Arts 4: 280. 1859.

Plants rather robust, pale green, reddish, glossy; pseudoparaphyllia absent. **Leaves** lax, erect-spreading, oblong-ovate, acuminate at apex, 1.0-1.5 mm x 0.4-0.5 mm; margins serrulate above; **costa** double, rarely single, short; **median leaf cells** linear, 80-100um x 4-6 um, thin-walled; apical cells shorter, rhomboidal; basal cells rectangular or rhomboidal, 40-50 um x 4.5-7.0 μm, more or less thick-walled; alar cells not differentiated. **Dioicous**. **Sporophytes** not found. (**Figure 5.35**)

Thailand — NORTHERN: Chiang Mai, Tak; SOUTHEASTERN: Nakhon Nayok; SOUTHWESTERN: Kanchanaburi; PENINSULAR: Nakhon Si Thammarat , Krabi:

Distribution — Borneo, China, India, Japan, Java, Kampuchea, Laos, Malaysia, Myanmar, Philippines, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On wet soil.

Specimens examined — *Y. Nathi 472* (BCU).

GPS location — 18.55988°N 98.4758°E.

Altitude— 2,189 m

4. TAXIPHYLLUM

Taxiphyllum Fleisch., Musci Buitenzorg 4: 1434. 1923 ;Gangulee, Mosses E. India 8: 1918. 1980; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 1031. 1994; Zhang & He, Moss Fl. China 8: 222. 2005.

Plants terete or flattened, in thin to dense, light- to dark- or yellow-green, glossy mats. Sems simple to sparsely and irregularly branched, with clusters of smooth rhizoids below leaf insertions on the lower surface; pseudoparaphyllia large, foliose. **Stem and branch leaves** concave, smooth or sometimes plicate, symmetric or nearly so, ovate or oblong-lanceolate, acuminate or rarely subobtuse, non-decurrent; margins plane or recurved, serrate to serrulate above, serrulate to entire below; **costa** short and double or none; **cells** smooth or papillose at back because of projecting ends the walls not pitted, the median cells linear-flexuose, those near the apex rhomboidal; alar cells quadrate to rectangular in 1-several rows. **Dioicous**. **Perichaetia** numerous on stems and branches, with leaves slenderly acuminate, spreading from an erect base. **Stae** elongate, smooth; **capsules** erect or inclined, oblong-ovoid from short neck; operculum obliquely rostrate; **peristome** double; exostome teeth lanceolate, papillose above, bordered, trabeculate; endostome hyaline papillose with high basal membrane, keeled segments, and cilia in groups of 2-3. **Spores** spherical to ovoid, smooth or minutely papillose.

Taxiphyllum arcuatum (Bosch & Sande Lac.) S. He

J. Hattori Bot. Lab. 81: 37. 1997; He, Zhang & He, Moss Fl. China 8: 245. 2005. — *Homalia arcuata* Bosch & Sande Lac., Bryol. Jav.2: 56, pl. 176. 1862.

Plants small, complanate, to 3 cm long; leafy stems 1-2 mm wide, glossy, yellowish green or pale yellow. Primary stems creeping; secondary stems in soft, flattened mats, irregularly or subpinnately branched, branches short and patent, bifarious and complanate; rhizoids smooth, brownish; **Stem leaves and branch leaves** similar, 0.65-1.15 mm x 0.30-0.50 mm, oblong-ligulate, often arcuate above, obtuse to rounded or obtusely pointed at apex; leaf margins faintly srrulate to crenulate above, entire or subentire below, often inflexed on one side at base; **costa** short, double or obsolete; **leaf cells** thin to moderately thick-walled, median leaf cells linear, 55-100 um x 4.5-5.5 um, basal juxtacostal cells oblong-linear, 25-45 um x 5-7 um, 1-2 rows of quadrate to oblong-quadrate cells at leaf base; **alar cells** not or slightly differentiated. **Autoicious.** Sporophytes not found. (**Figure 5.36**)

Thailand — PENINSULAR: Nakhon Si Thammarat

Distribution — China, Japan, and Sumatra.

Ecology — On sandy soil.

Specimens examined — *Y. Nathi 634, 1062 (BCU)*

GPS location — 18.58887917°N 98.48479573°E, 18.58827°N 98.48607°E.

Altitude— 2,543 m

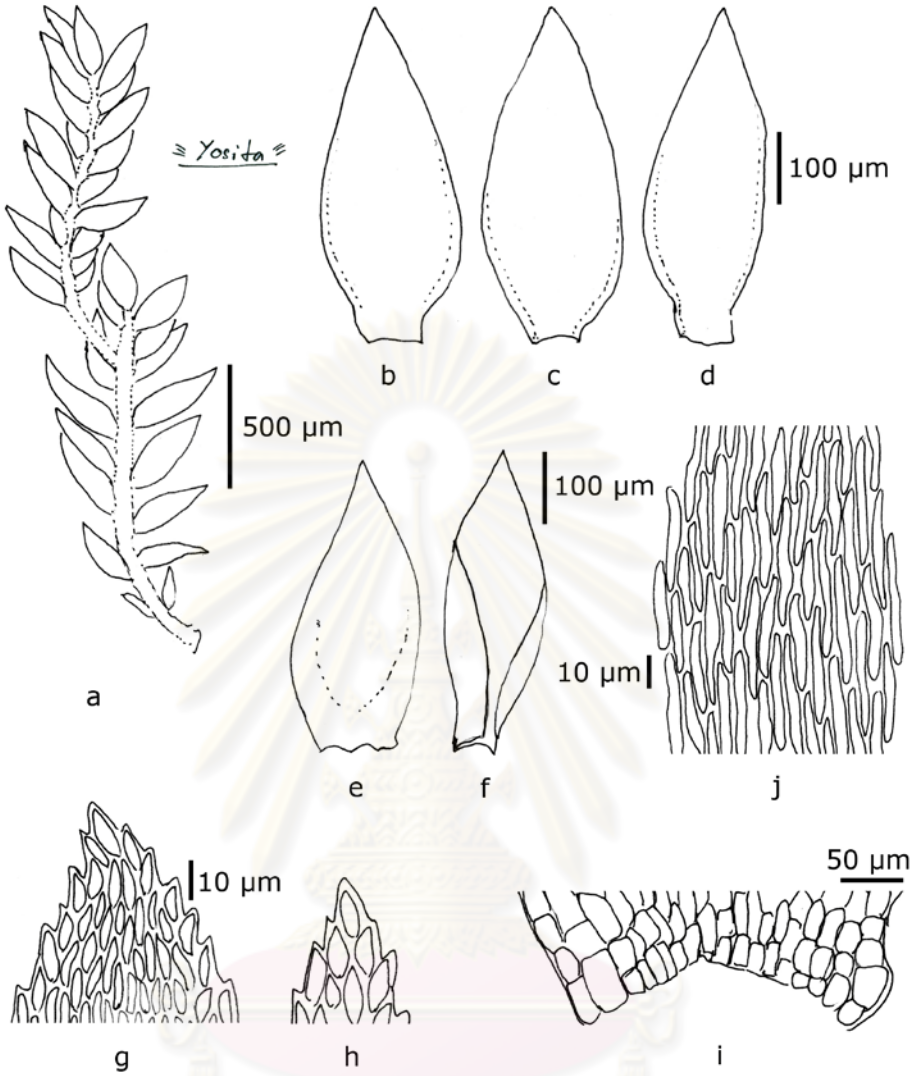


Figure 3.33 *Glossadelphus prostrates* (Doxy & Kolk.) Fleisch.
a. portion of plant; b., c., d., e., f. leaves; g. leaf apex; h. cells at leaf apex; i. cells at leaf base; j. cells at median leaf. Based on *Y. Nathi 945*.

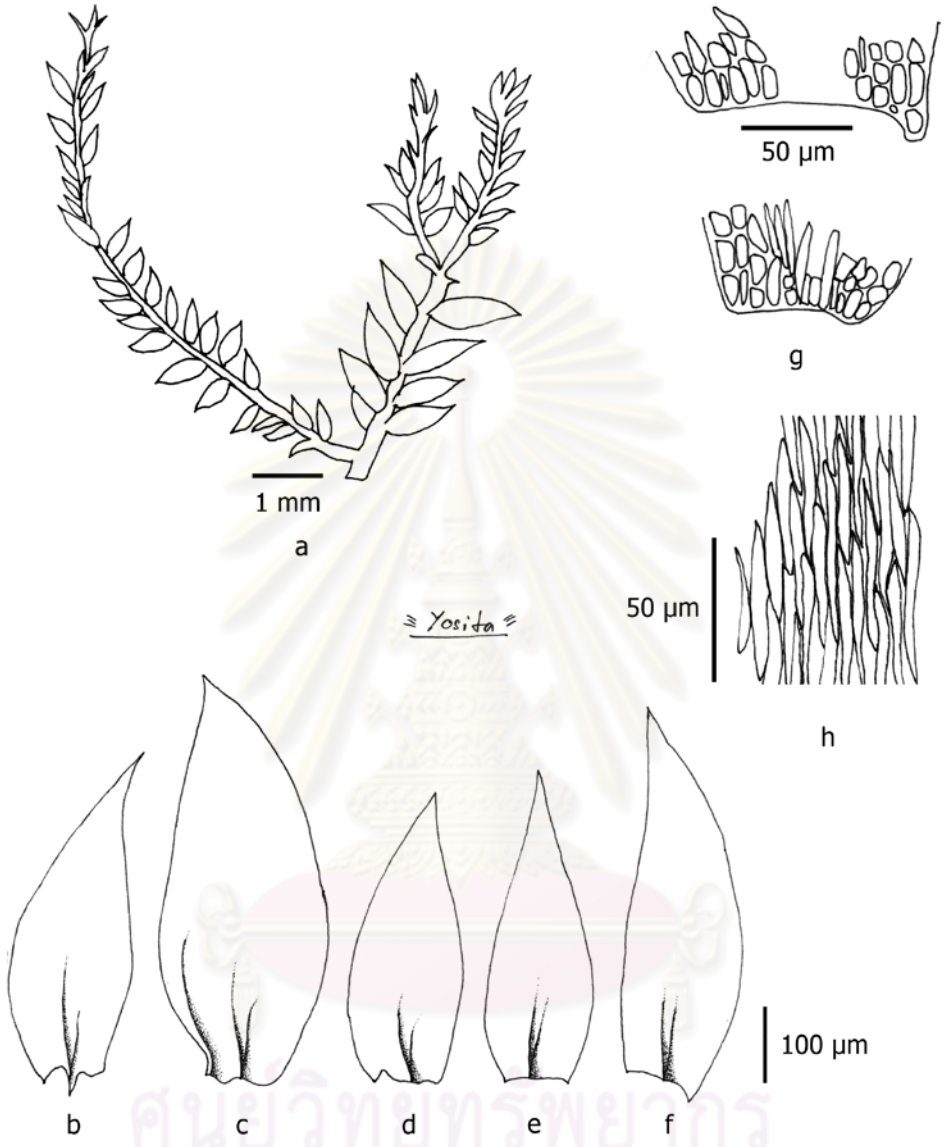


Figure 5. 34 *Isopterygium bancanum* (Bosch & Sande Lac.) Jaeg.
a. portion of plant; b., c., d., e., f. leaves; g. cells at leaf base; h. cells at median leaf. Based on *Y. Nathi* 596.

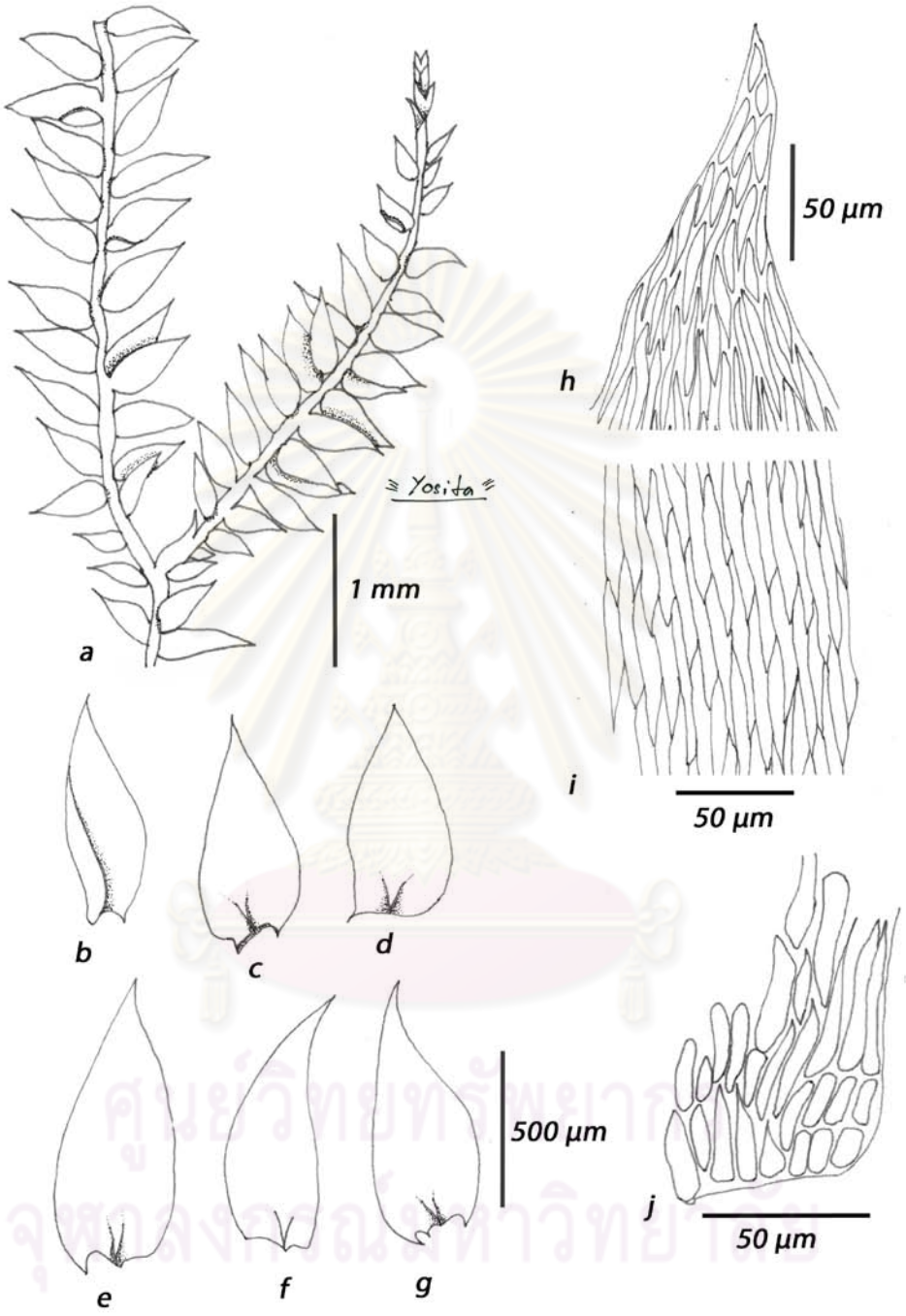
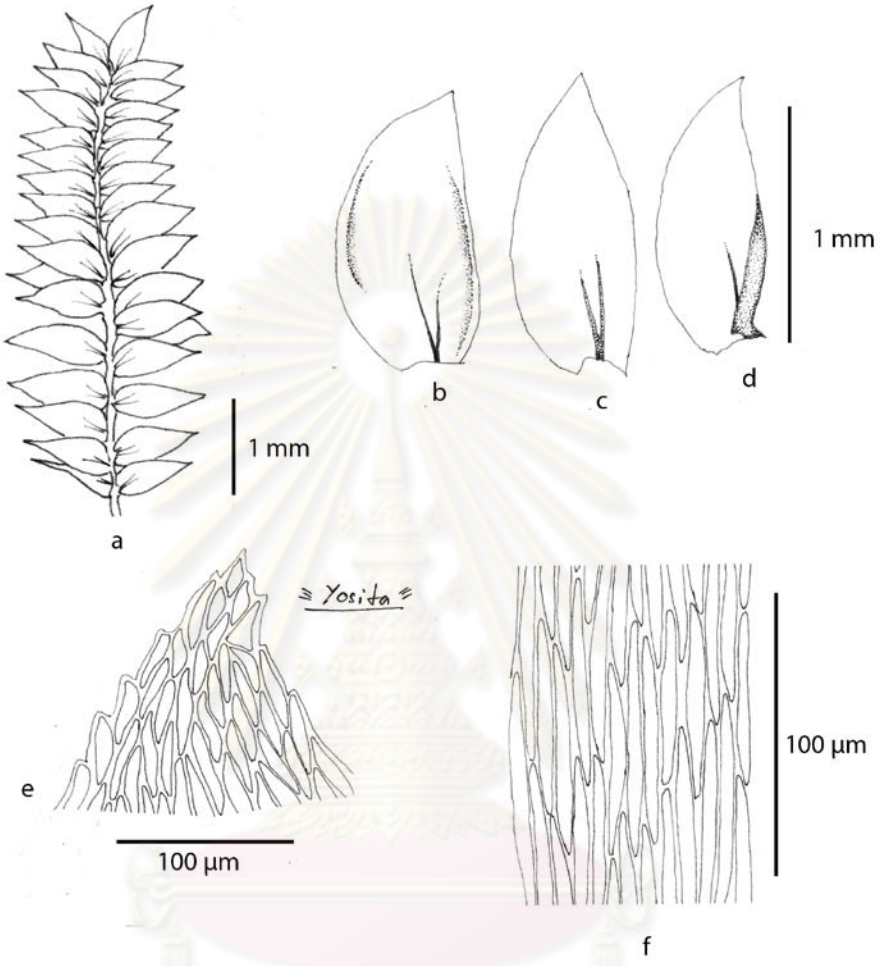


Figure 5.35 *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z. Iwats.
a. portion of plant; b., c., d., e., f., g. leaves; h. leaf apex; i. cells at median leaf; j. cells at leaf base. Based on *Y. Nathi 472*.



Fiure 5.36 *Taxiphyllum arcuatum* (Bosch & Sande Lac.) S. He
a. portion of plant; b., c., d.leaves; e. leaf apex; f. cells at median leaf. Based on *Y. Nathi 634*.

HYPOPTEROGIACEAE

Plants small to medium-sized, solf, complanate, erect-spreading or appressed, lightly yellowish green to dark green, usually not glossy. **Primary stems** slender, complanately explanate, rhizoids brown; secondary stems simple or rarely branched, dendroid, pinnately branched above, tail-like or peacock-like at the apex. **Leaves** in threes rows, including two lateral and one ventral rows (amphigastria), dimorphous; lateral leaves plane, ovate to elongate-ovate, rarely ovate-lanceolate, asymmetric; margins usually bordered; amphigastria smaller and rounded; **costa** uniform cells, single, sometimes forked above; laminal cells isodimetric, smooth; alar cells not differentiated. **Dioicous** or autoicous. **Seta** elongate; **capsule** exerted, mostly suberect or inclined, rarely erect; stomata phenotype, rare at base of capsules; **peristome** double; exostome teeth occasionally reduced, usually densely striate, keeled, furrowed, lamellae well developed inside; endostome segments keeled, basal membrane developed; opercula rostrate. **Calyptra** cucullate or conic, smooth.

CYATHOPHORELLA

Cyathophorella (Broth.) M. Fleisch., Musci Fl. Buitenz. 3: 1088. 1908; Gangulee, Mosses E. India 6: 1531. 1977; Mohamed & H. rob., Smithsonian Contr. Bot. 80: 32. 1991; Nog., Ill. Moss Fl. Japan 4: 770. 1991; Y. Jia, Z.-H. Li & P.-C. Wu, Moss Fl. China 6: 43. 2002. —*Cyathophorum* sect. *Cyathophorum* Broth., Nat. Pflanzenfam. 1(3): 965. 1907.

Plant large, dull green plants in lax tulfs; primary stems creeping, rhizomatous, tomentose; **stems** with central strand; secondary stem simple, rarely folked, distanly foliate, tips caudate and often with abundant brood filaments; **lateral leaves** in two rows, asymmetrical, widely spreading, smaller toward base and tip, ovate, acuminate, unbordered or weakly bordered, more or less toothed; **costae** short, single or forked; cells oval-hexagonal, smooth; **amphigastria** smaller, symmetrical, in one row, with axis parallel with stem. Dioicous. **Setae** short, smooth; **capsule** erect; exostome teeth papillose; cilia lacking; operculum rostrate. **Calyptra** conic, covering only rostrum of operculum, mostly naked, not fringed.

Key to the species

1. Leaf margin entire .....*C. hookeriana*

1. Leaf margin serrate or weakly tooth .....*C. spinosa*

1. ***Cyathophorella hookeriana*** (Griff.) Fleisch.

Musci Buitenzorg 3: 1094, 1908; Gangulee, Mosses E. India 6: 1531. 1977; Y. Jia, Z.-H. Li & P.-C. Wu, Moss Fl. China 6: 43. 2002. — *Neckera hookeriana* Griffith, Notul. Pl. As., 2: 464. 1849.

Plants small, yellowish green, ca 2.5-3 cm high, 0.5-0.8 cm wide with leaves simple, rarely branched. **Leaves** dense, caudate at tips, reddish brown, gemmae forked, often abundant in leaf axils of caudate tips of some branches; rhizoids tomentose at base; lateral leaves bifarious, ovate-lanceolate, asymmetric, ca. 2.5-4.5 mm x 2 mm ; leaf margins entire, bordered throughout by 3 rows of narrowly elongate cells; **costa** single, short and weak; laminal cells rhomboidal, mostly pitted; amphigastria smaller, ovate, symmetric, plicate along margins. **Seta** ca. 1.3 cm long; **capsule** cylindrical. (**Figure 5.37**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, Laos, and Philippines.

Ecology — On tree trunk, rotten logs, rocks and slopes

Specimens examined — *Y. Nathi 36, 144, 182, 286, 296, 364, 415, 451, 565, 702* (BCU).

GPS location — 18.5890140°N 98.48710041°E, 18.5883541°N 98.48560500°E, 18.5558408°N 98.48227453°E, 18.5591652°N 98.47836287°E, 18.5601682°N 98.47757086°E, 18.589043°N 98.4872297°E, 18.5886531°N 98.4865587°E, 18.5563089°N 98.4803905°E, 18.5888333°N 98.48731617°E.

Altitude — 2,187-2,556 m

2. ***Cyathophorella spinosa*** (C. Müll.) Fleisch.

Musci Buitenzorg 3: 1091. 1908; Gangulee, Mosses E. India 6: 1531. 1977; Y. Jia, Z.-H. Li & P.-C. Wu, Moss Fl. China 6: 49, Pl, 1, figs. 1-5. 2002. — *Hookeria spinosa* Müll. Hal., Syn. Musc. Frond. 2: 677. 1851.

Plants robust, dull green; secondary stems up to 5 cm long, tips caudate, to 1 cm wide with leaves, frequently with conspicuous cluster of orange-red blood filaments among leaves widely spreading, asymmetrical,

broadly ovate, short-acuminate with an arista to 180-200 μm long. **Leaves** 4.5-6.0 mm long, 2.4-2.8 mm wide, widest below mid-leaf; margin spinose-serrate in upper third with long multicellular teeth; border not or weakly differentiated; **costa** short, single or forked; cells oval-hexagonal, 65-100 μm long, 25-36 μm wide, thin-walled; amphigastria broad, rounded ovate with an apiculus to 250 μm long, distantly spinose above; costa short, unequally forked; perichaetial leaves smaller than lateral leaves; ovate with a long arista. **Diocous**. **Capsule** cylindrical, seta short. (**Figure 5.38**)

Thailand — NORTHERN: Chiang Mai, Chiang Rai, Phetchabun; SOUTHEASTERN:Chanthaburi, Nakhon Nayok; PENINSULAR: Trang.

Distribution — China, Indonesia, and Philippines.

Ecology — On tree trunk

Specimens examined — *Y. Nathi 216, 287, 332, 807, 1031* (BCU)

GPS location — 18.5564324°N 98.48196248°E, 18.5565715°N 98.48190716°E, 18.5591652°N 98.47836287°E, 18.5597899°N 98.4776597°E.

Altitude — 2,187-2,278 m

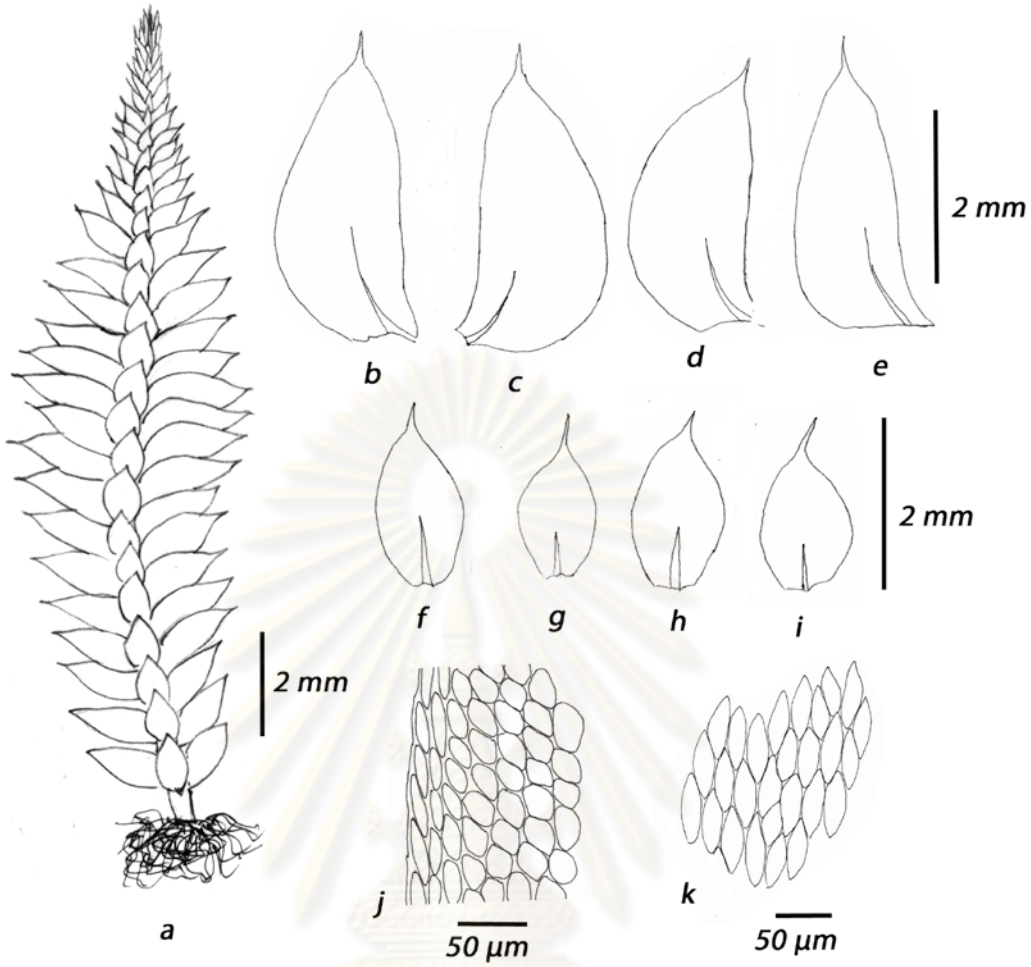


Figure 5.37 *Cyathophorella hookeriana* (Griff.) Fleisch.
a. habit; b., c., d., e. lateral leaves; f., g., h., i. amphigastrial leaves; cells at upper margin of leaf; k. median cells. Based on *Y. Nathi 144.*

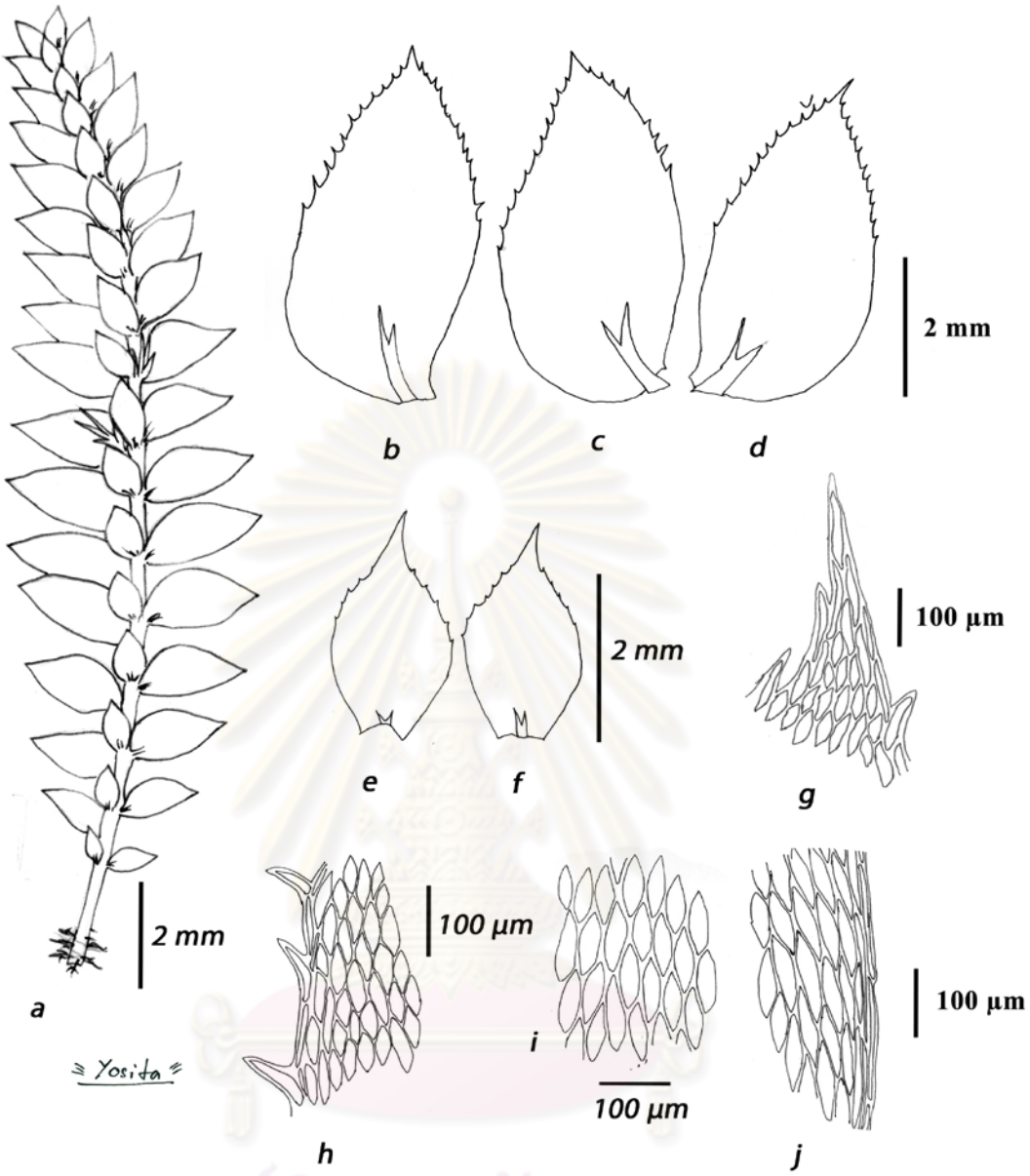


Figure 5.38 *Cyathophorella spinosa* (C. Mull.) Fleisch.
a. habit; b., c. lateral leaf; e., f. amphigastrial leaves; g. cells of leaf tip; h. cells at upper margin of leaf; i. median cells of leaf; j. cells at base of leaf. Based on *Y. Nathi 332.*

LEMBOPHYLLACEAE

Plants usually robust, some time delicate, tufted, glossy, usually corticolous plants. Secondary stem dendroid or elongate and procumbent. **Leaves** ovate, short-poited, deeply concave, dentate above. **Costa** single to nearly midleaf or double and short or missing. Leaf cell prosenchymatous, incrassate, alar often distinct, papillae sometime present. **Seta** slender, elongate, smooth. **Capsule** erect to horizontal. Operculum conic-rostrate. Calyptra cucullate, naked. **Peristome** double, teeth striolate; endostome basal membrane high, processes well developed, cilia present.

DIXONIA

Dixonia Horik. & Ando, Nat. & Life Southe. Asia 3: 23. 1964; Gangulee, Mosses E. India 5: 1460. 1976.

Plants tuft, slender, yellow-green to olive green plants. **Primary stem** wiry, creeping, dark brown with minute, scaly leaves. Secondary shoots erect, rigid, up to 2 cm. high, subdendroid, some flagelliform. **Leaves** complanate, eretopatent, glossy but not much changed when dry, ovate with aute tip, ± 1.15 mm long and 0.5 mm broad; margin dentate at aex, incurved at base either at the proximal or on both side. **Costa** absent or very, faint and bifurcate. **Leaf cells** linear vermicular, ± 76 x 8 μ, only slightly longer and somewhat obscure by cell wall development at base. **Sporophyte** on short shoots lateral on basal parts of shoots. **Seta** long (1.5 to 1.8 cm long), erect-sinuose (twisted when dry). **Capsule** inclined, ovate-cylindrical. **Operculum** large, conic-rostrte. **Peristome** normal, double, hypnoid showing two nodose cilia between endostome segments, basal membrane high.

Note — The genus was defined by Horikawa & Ando (1964) on the basis of the single species thamnioides reported from Ceylon, Eastern Himalaya & Thailand. They notes that the leaf cells were absence of papillae, a few scattered minute papillae are noted in many cells.

Dixonia thamniodes (Broth. & Dixon) Horik. & Ando

Nat. Life S.E. Asia, 3: 23. 1964; Gangulee, Mosses E. India 5: 1460, fig. 726. 1976; Tanaka, Maung Zaw, Gay Ngai & Akiyama, Makinoa 3: 40, fig. 42. 2003. — *Camplochete thamnioides* Broth. & Dix. , J. Bot., 53: 290. 1915.

Plants small, less than 2 cm in height, green to olive green. Primary stem creeping on substrate. Secondary stem erect, with several branch, more or less complanately foliated. **Leaves** glossy, ovate acute, ca 1.0-1.4 mm long; upper margin serrate, entire below; costa very short, bifid or sometime absent**.**

Lamina cells linear vermicular, minutely porate at upper ends, 60-80 μm long. **Dioicous**. Sporophyte unknown. (**Figure 5.39**)

Thailand — NORTH: Chiang Mai

Distribution — Sri Lanka, Philippines, Borneo, Nepal, and India

Ecology — on rocks near by the stream

Specimens examined — *Y. Nathi 163, 188, 230, 595, 698, 826, 991, 1030, 1039* (BCU)

GPS location —18.5887674°N 98.48422073°E, 18.5567133°N 98.48176475°E

Altitude — 2,142-2,530 m

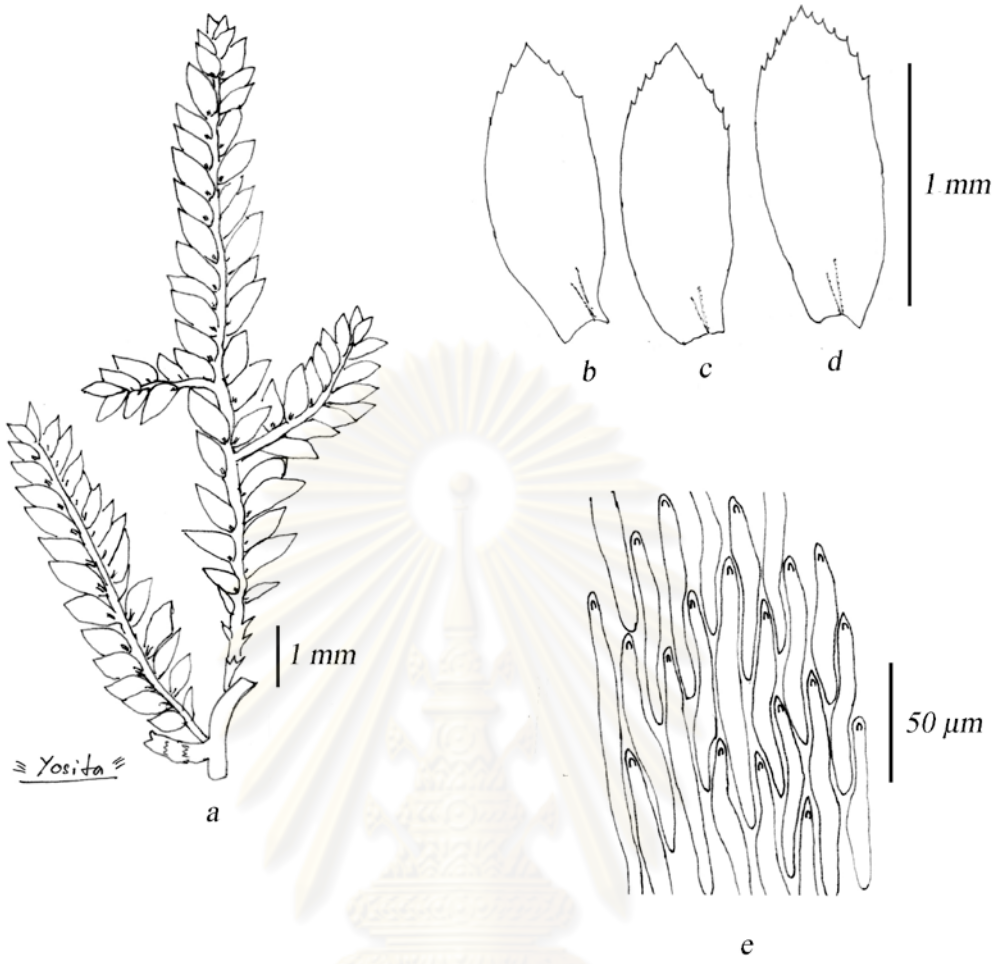


Figure 5.39 *Dixonia thamnioides* (Broth. & Dix.) Horik. & Ando
a. habit; b., c., d. leaves; e. median leaf cells. Based on *Y. Nathi 230.*

LEUCOBRYCEAE

Plants whitish, grayish or bluish green, in dense cushions. Stems erect, simple or branched. **Leaves** arranged in several rows, thick, fleshy, linear, ligulate or lanceolate from a rather narrow to somewhat broad base; **costa** broad, filling most of leaf base and apex, in cross section with 2 to 10 layers of large, empty, hyaline and porose cells (leucocysts), enclosing a single, more or less median layer of smaller green cells (chlorocysts) (except in Exostratum where chlorocysts are arranged in three layers); laminae very narrow, consisting of delicate, hyaline, oblong and linear cells, often restricted to leaf base or extending somewhat above the shoulders as a very narrow, inconspicuous border. **Dioicous** or pseudoautoicous. **Seta** terminal, usually elongate, straight; **capsules** erect, symmetric or inclined, asymmetric, often strumose at base; **peristome** single, consisting of 8 or 16 lanceolate teeth, undivided or bifid, smooth or papillose, or vertically pitted-striolate; opercula conic-rostrate with a long beak. **Calyptra** mostly cucullate.

LEUCOBRYUM

Leucobryum Hampe, Linneae. 13: 42. 1839; Gangulee, Mosses E. India 2: 416. 1971; Eddy, Handb. Males. Mosses 2: 5. 1990; Bang-juan & He, Moss Fl. China 1: 243. 1999.

Plants small to large, sometimes robust, whitish, grayish or bluish green, in compact or loose cushions. **Stems** erect, simple or forked; central strand mostly absent, sometimes present. **Leaves** crowded, appressed, or erect-spreading, sometimes falcate-secund above, linear-lanceolate to lanceolate or subtubulose from oblong-ovate to elliptic sheathing base, acute to mucronate at the apex, often with rhizoids at leaf tips, upper parts of leaves filled mostly by the multi-layered broad costa, laminae confined to the basal parts of leaves with multi-rowed linear cells; margins entire to slightly serrulate at the apex, ± bordered by linear cells up to the leaf apex; costae thick, broad, consisting of 2–8 layers of enlarged leucocysts enclosing a ± median row of small, quadrangular chlorocysts in cross section near leaf base. **Dioicous** or pseudoautoicous. **Perichaetial leaves** sheathing at the base, abruptly linear-filiform from shoulders. **Sporophytes** terminal or lateral. **Seta** erect, elongate, sometimes clustered; **capsule** more or less cylindrical, asymmetric, inclined to horizontal, rarely erect, ± ribbed, often strumose; stomata lacking; annuli often absent, 1–2 rows of small cells when present; **opercula** long-rostrate; **peristome** teeth 16, divided to the middle, lanceolate with a broad base, vertically striolate below and papillose above on inner

surface, papillose or smooth on outer surface. **Calyptra** cucullate. Spore small to large, finely papillose. (**Figure 5.40**)

Leucobryum juniperoideum (Brid.) C. Müll.

Linnaea. 18: 689, f. 196. 1845; Gangulee, Mosses of Eastern India and adjacent Regions, Fasicle 2, fig. 196: 420. 1971; Eddy, A Handbook of Malesian Mosses, vol. 2: 20. 1990; Bang-juan & He, Moss Flora of China, vol. 1: 252, pl. 67, figs. 3-7. 1999. — *Dicranum juniperoideum* Brid., Bryol. Univ. 1: 409. 1826.

Plants small to medium-sized, up to 2.0-2.5 cm high, whitish green, in loose tufts. **Stems** erect, simple or branched; central strand absent. **Leaves** somewhat flexuose when dry, erect-spreading to slightly falcate-secund when moist, 3–5 mm × 0.5–2 mm, lanceolate, gradually narrowed to subtubulous apices from a slightly shorter ovate base, acute to bluntly mucronate at the apex; dorsal side of leaf acumina smooth; margins entire, bordered by 2–3 rows of linear cells, 40–50 μm × 3–5 μm, lamina near leaf base consisting of 5–8 rows of quadrate to rectangular cells; **costae** in cross section, leucocysts 2–4 layers on abaxial side and 1–2 layers on adaxial side, sandwiching a layer of chlorocysts. **Dioicous**. **Sporophytes** not seen. (**Figure 5.40**)

Thailand — NORTHERN:Chiang Mai, Phitsanulok; NORTHEASTERN: Loei; SOUTHEASTERN: Chanthaburi; PENINSULAR: Chumphon.

Distribution — Bhutan, Borneo, China, India, Japan, Java, Kampuchea, Korea, Laos, Malaya Peninsula, Myanmar, Nepal, Philippines, Papua New Guinea, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On tree trunk and forest ground.

Specimens examined — *Y. Nathi 462, 542, 841, 857, 1027* (BCU); *Somjai, Kanya & Lens 103* (CMU Herbarium)

GPS location — 18.5598815°N 98.4757968°E, 18.55600376°N 98.47817411°E, 18.55632654°N 98.48128865°E, 18.55606938°N 98.48004889°E, 18.55600485°N 98.47781737°E

Altitude —2,119-2,212 m

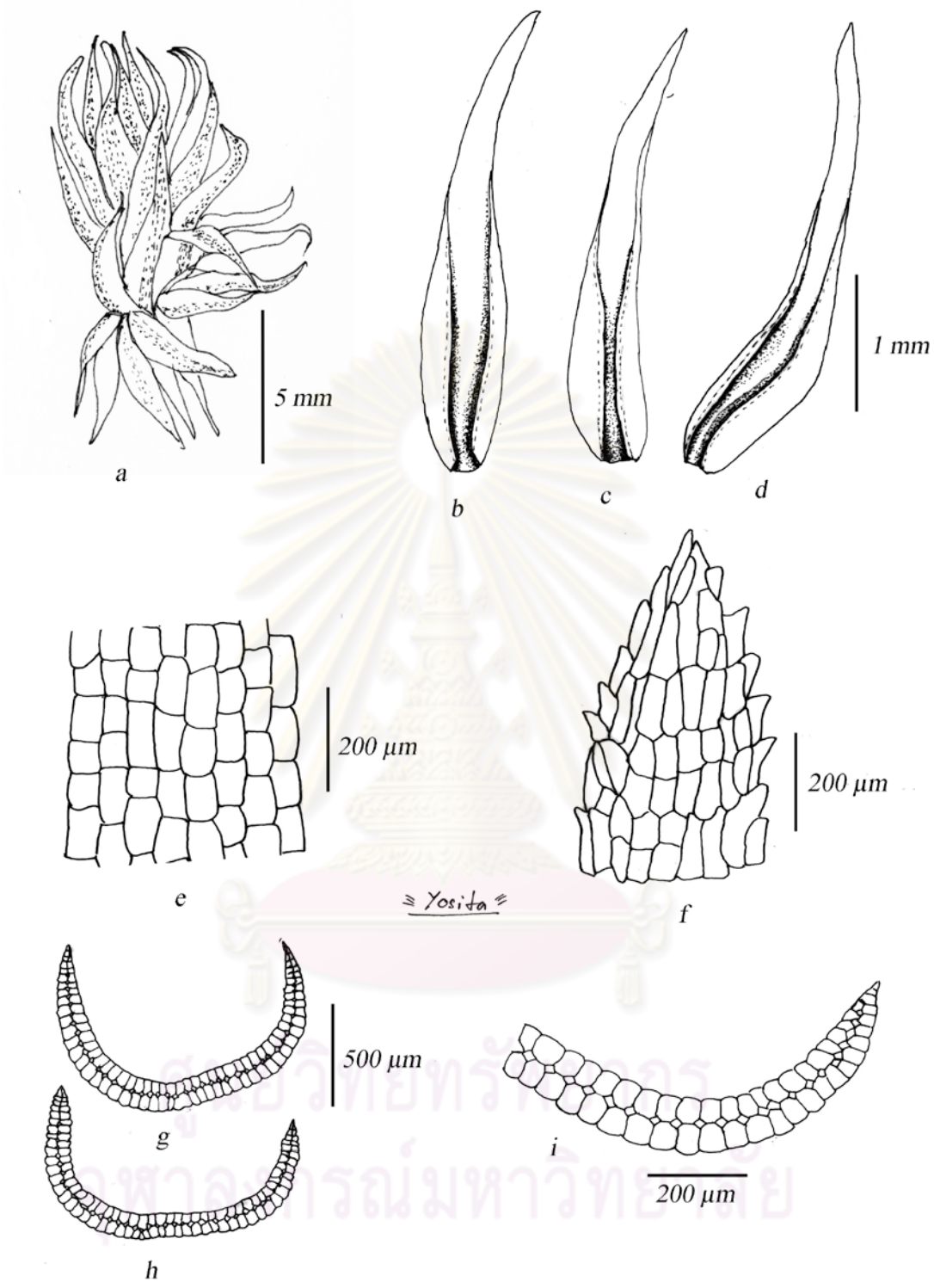


Figure 5.40 *Leucobryum juniperoideum* (Brid.) C. Müll.
a. habit; b., c., d. leaves; e. cells at median leaf; f. leaf apex; g., h., i. croos-section of leaf. Based on *Y. Nathi 542.*

METEORIACEAE

Plant slender to robust, usually hanging or pendulous from tree. **Primary stems** without central strand, creeping filiform; **secondary stems** elongate, terete or flat, flexuose, pendent, branched, densely foliate. **Stem-leaves** ovate-lanceolate, acuminate with a piliferous point; lamina usually undulate or plicate; **costa** single, slender, terminating below tip; **alar cells** differentiated or not; **lamina cells** usually papillose, rarely smooth, incrassate or thin-walled. **Branch leaves** similar to stem leaves or differenced, usually smaller than. **Dioicous. Seta** long or short, smooth or scabrous. erect, oblong to oblong-cylindric with a some what ; **peristome** double; exostome linear-lanceolate, covered with transversely striate below or papilose; endostome well-developed, as long as exostome; **operculum** rostrate. **Calyptra** small, cuculate or mitriform, only slightly covering the beak of operculum, smooth or scabrous.

Key to the genera

1. Branches terete; basal angles of leaf auriculate 2
1. Branch mostly flattened; basal angles of leaf slightly auriculate 4
   2. Leaf cells with several papilla 3
   2. Leaf cells with a single papilla over each lumen ..... *Meteorium*
3. Leaves ovate, oblong-lanceolate; basal leaf auriculate and amplexicaulate .. .. *Papillaria*
3. Leaves lanceolate, basal leaf auriculate..... *Cryptopapillaria*
   4. Leaf cells obscure, with several papillae over each lumen and longitudinal wall ..... *Floribundaria*
   4. Leaf cells pellucid with single papilla over each lumen ..... *Pseudobarbella*

1. AEROBRYIDIUM

Aerobryidium M. Fleisch. ex Broth., in Engler u. Prantl., Nat. Pflanz. 1 (3): 820. 1906 ; Nog., J. Hatt. Bot. Lab. 41: 286. 1976.

Plants robust. Primary stem elongate, with loosely leaves, loosely or densely branched; secondary stems elongate with several branches, densely leaved. Branches short, tumid, obtuse at apex. **Leaves** appressed or somewhat complanately spreading, ovate-oblong or oblong, suddenly or gradually attenuate to long, frequently piliferouse, and crispate or flexuose acumen, cordate at base, often undulate above; margin often undulate at median portion, minutely serrulate; **costa** slender, reaching beyond mid-leaf. Laminal cells elongate-rhomboidal, beaing a papilla in the center of lumen, frequently subporose; lower cells lax, rectangular, with out papillae; alar cells lax, rectangular or subquadrate, forming a somewhat distinct group. Branch-

leaves similar to those of stem but with shorter and less flexuose acumens. **Dioicous**. **Seta** elongate, scabrous. **Capsule** erect, oblong to oblong-cylindrical, with a distinct apophysis, smooth on surface. Opercula conic, with a long, oblique beak. Peristome double. Calyptrae cucullate, long-hairy.

Aerobryidium filamentosum (Hook.) M. Fleisch. ex Broth.

Engler u. Prantl. Nat. Pflanz. 1(3): 821. 1906; Noguchi., J. Hattori Bot. Lab. No. 41. 290, fig. 24. 1976; — *Neckera filamentosa* Hook., Musci Exot. 14, t. 158. 1818. — *Pilotrichum filamentosum* Brid. Ex Muell., Syn. 2. 153. 1851. — *Meteorium filamentosum* (Hook.) Mitt., Journ. Linn. Soc. Bot. suppl. 1: 91. 1859. — *Aerobryum integrifolium* Besch., Ann. Sci. Nat. Bot. sér. 7, 15: 74. 1892. — *Aerobryopsis integrifolia* (Besch.) Broth. in Engler u. Prantl. Nat. Pflanz. 1(3): 820. 1906. — *Aerobryum filamentosum* (Hook.) Fleisch. var. *densum* Thér., Bull. Soc. Bot. Genève 26: 12. 1936. — *Aerobryidium taiwanense* Nog., Journ. Hattori Bot. lab. 3: 71, f. 27. 1948. — *Aerobryidium punctulatum* auct. non (C. Muell.) Dix.: Nog., Candollea 19: 184. 1964.

Plants, secondary stems long, terete, loosely or subpinnately branched. Branches to ca. 3 cm in length, obtuse, densely and somewhat complanately leaved. **Leaves** oblong-ovate with a long, strongly flexuose or undulate apex, strongly concaved, ca. 5 mm long by ca. 1.2 mm wide; margin undulate at median portion, slightly toothed throughout; **costa** very slender, ending near mid-leaf. **Meidan laminal cells** 60-70 x 4-4.5 μm superior cells frequently not papillose; inferior cells subquadrate to rectangular, 20-40 x 5-6.5 μm, walls thick with localized thickenings; alar cells small, similar to other basal cells but smaller, 12-20 μm without localized thickenings. **Sporophytes** not seen. (**Figure 5.41**)

Thailand — NORTH: Chiang Mai, Phitsanulok

Distribution — Ceylon, India, China, Mynmar, Vietnam, Sumatra, Borneo, Java, Philippines, Japan,

Ecology — on tree trunk, branch twigs

Specimens examined — *Y. Nathi 203, 1077* (BCU)

GPS location — 18.55613912 °N 98.48219197 °E18.55614457, °N 98.48136032°E

Altitude — 2,189-2,192 m

2. CRYPTOPAPILLARIA

Cryptopapillaria Menzel, Wildenowia 22: 181. 1992.

Plants rigid, yellow-green, pending. **Leaves** lanceolate, plicate, large auricle at base, acuminate at apex, irregularly bent or twisted; **costa** single , extending beyond mid-leaf. **Leaf cells** linear-rhomboidal, thick-walled, papillose in two rows on longitudinal walls. **Pericheatial leaves** long, linear-lanceolate, plicate; sigle costa. **Seta** short; **capsules** immerse; **calyptra** campanulate, short, and dense-hairy.

Key to the species

1. Plants soft, attenuate at the apex of branches. Branch-leaves acute at apex and some what twisted..... *C. fuscescens*
1. Plants rigid, obtuse at the apex of branches. Branch-leaves long acuminate 2
   2. Plants slender. Leaves gradually narrowed to a long point, concave and deeply plicate .....*C. feae*
   2. Plants thick. Leaves obtuse or round at the upper part and with a long filiferous acumen, cymbiform..... *C. chrysoclada*

1. ***Cryptopapillaria chrysoclada*** (C. Müll) Menzel.

Willdenowia 22: 182. 1992. — *Neckera chrysoclada* Müll. Hal., Syn. Musc. Frond. 2: 139. 1850. — *Papillaria chrysoclada* (Müll. Hal.) A. Jaeger Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1875--76: 270 , Sp. Musc. 2. 1877; Noguchi., J. Hattori Bot. Lab. No. 41. 250, fig. 8. 1976. — *Meteorium chrysocladum* (Müll. Hal.) Broth. Nat. Pflanzenfam.I((3)): 818. 1906.

Plants large, rigid, yellowish-green in the younger, blackish green in older parts, not glossy. Stems elongate, densely leaved, pinnately branched. Branches short, often recurved, densely leaved, obtuse or slightly clavate at apex. **Stem-leaves** erect, strongly appressed when dry, laxly spreading when moist, oblong-ovate, obtuse or rounded at apex, with a long flexuose, slightly twisted, piliferous acumen, strongly auticulate, rounded or angular at basal corner, 2.7-3 mm x 1-1.2 mm, cymbiform, scarcely plicate, the inferior parts undulate; margin incurved in the upper half erect or undulate in the lower part, entire in most parts, erose-dentate at alar regions; **costa** extending beyond mid-leaf, pellucid. **Branch-leaves** similar to those of stem leaves, but more rounded-obtuse at apex, and more concave. **Median laminal** cells linear-rhomboidal, 25-35 μm x 5-6 μm, thick-walled, papillose in almost two rows on longitudinal walls, obscure, inferior cells rectangular, 20-30 μm x 6-8 μm, thick-walled, porose; cells at basal angles rhomboidal, 20-25 μm x 6-7 μm with or without papillae. **Sporphytes** not found. (**Figure 5.42**)

Thailand — NORTHERN: Chiang Mai, Chiang Rai, Tak, Phetchabun; NORTHEASTERN: Chaiyaphum, Loei.

Distribution —China, India, Myanmar, Sri Lanka, and Vietnam.

Ecology —On branches and twigs.

Specimens examined — *Y. Nathi 224, 361* (BCU).

GPS location — 18.5565715°N 98.48190716°E, 18.58812°N 98.48627°E

Altitude — 2,215-2549 m

2. ***Cryptopapillaria feae*** (M. Fleisch.) Menzel.

Willdenowia 22: 182. 1992. — *Papillaria feae* Müll. Hal. ex M. Fleisch. Musci Buitenzorg3: 761. 1908; Noguchi., J. Hattori Bot. Lab. No. 41. 249, fig. 7. 1976.

Plants rigid, dark-green, becoming blackish with age glossy. Stems flexuose, terete, obtuse at apex, laxly branched. Branches reflexed, obtuse at apex. **Stem-leaves** dense and strongly appressed when dry, erect-spreading when moist, ovate-oblong, rapidly long-acuminate, to ca. 2.5 mm x 0.9 mm, rounded or angular at basal corners, strongly auriculate, concave and plicate; margin plane, undulate at basal corners; **costa** reaching mid-leaf, pellucid. Branch-leaves dense and strongly appressed when dry, erect-spreading when moist, oblong, suddenly contracted to a rather long acumen, to 1.5 mm x 0.6 mm, strongly auriculate at base, crenate or serrulate at acumen. **Median laminal** cells elongate-rhomboidal, 20-30 μm x 4-5 μm, multi papillose on longitudinal walls; cells at basal corners linear-rhomboidal, curved, not papillose. **Sporophytes** not found. (**Figure 5.43**)

Thailand — NORTHEASTERN: Chiang Mai, Chiang Rai, Lamphun, Phetchabun; NORTHEASTERN: Loei; SOUTHWESTERN: Rat Buri.

Distribution — China, Myanmar, Sri Lanka, and Vietnam

Ecology —On branches.

Specimens examined — *Y. Nathi 349, 563, 719, 722, 833, 850* (BCU)

GPS location — 18.55630886°N 98.4803905°E, 18.55604432°N 98.48156434°E, 18.55616913°98.48114792N °E

Altitude — 2,184-2,209 m

3. ***Cryptopapillaria fuscenscens*** (Hook.) Menzel.

Willdenowia 22: 183. 1992. — *Neckera fuscescens* Hook., Musci Exot. 2: 157. 1819. — *Daltonia fuscescens* (Hook.) Arn., Mém. Soc. Linn. Paris 5: 296. 1827. — *Papillaria fuscescens* (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen

Naturwiss. Ges. 1875--76: 270 , Sp. Musc. 2. 1877; Noguchi., J. Hattori Bot. Lab. 41. 247, fig. 6. 1976. — *Pilotrichum fuscescens* (Hook.) Brid. Bryol. Univ. 2: 264. 1827. — *Trachypus fuscescens* (Hook.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 128. 1859. — *Meteorium fuscescens* (Hook.) Bosch & Sande Lac. Bryol. Jav.2: 93, 207. 1864.

Plants soft, pale green, becoming blackish in older parts, scarcely glossy. Stems elongate, longer than 15 cm, filiform at apex, rather laxly leaved, remotely branched. Branches mostly simple, ca. 1 cm long, often recurved, tumid, attenuate at apex. **Stem-leaves** lax, erect-spreading when dry, ovate-oblong, gradually tapering to a short, slightly twisted acumen, rounded and angular at base, conspicuously auriculate, 2.5-3.0 mm x 1.0-1.2 mm, somewhat concave and deeply plicate; margin plane, frequently crenulate, the basal corner erose-dentate; **costa** pellucid, yellowish, reaching mid-leaf. **Branch-leaves** lax, erect-spreading, oblong, rather rapidly acuminate to a short, slightly twisted point, strongly auriculate, to 1.6 mm x 0.6 mm, sometimes angular at basal corners, deeply 3-plicate, margin recurved, serrulate above; **costa** reaching 2/3 the leaf length; **median laminal cells** linear-rhomboidal, 25-50 μm x 5-6.5 μm multipapillose on longitudinal walls, the papillae almost in two rows, obscure; inferior cells elongate-rectangular, walls with localized thickenings, cells at basal corners rhomboidal, usually without papillae. **Sporophytes** not found. (**Figure 5.44**)

Thailand — NORTHERN: Chiang Mai, Lamphun, Tak, Phetchabun; NORTHEASTERN: Nakhon Ratchasima; SOUTHEASTERN: Chanthaburi; SOUTHWESTERN: Rat Buri.

Distribution —Bhutan, Borneo, Celebes, China, India, Java, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, and Vietnam.

Ecology — On Branches.

Specimens examined — *Y. Nathi 223, 299, 526, 657* (BCU)

GPS location — 18.5565715°N 98.48190716°E, 18.5601682°N 98.47757086°E, 18.58874020°98.48445743N °E,

Altitude — 2,205-2,524 m

3. FLORIBUNDARIA

Floribundaria Fleisch., Hedwigia 44: 301. 1905; Noguchi., Journ. Hattori Bot. Lab. No. 41. 290, fig. 24. 1976; Gangulee, Mosses E. India 6: 1513, fig. 757. 1977; Nog., Ill. Moss Fl. Japan 4: 756, fig. 333. 1991.

Plants dull. Stems elongate, complanately leaved, laxly or pinnately branched. Branches short, simple, complanate in some taxa, obtuse at apex. **Stem-leaves** gradually tapering to an elongate, linear-lanceolate or flexuose-capillaceous apex from a cordate, ovate, or oblong-ovate base; margin serrulate or crenate excluding the acumen; **costa** reaching mid-leaf. **Branch-leaves** similar stem leaves, but smaller. Laminal cells hyaline or obscure , sublinear to rhomboidal, multi- or unipapillose, walls thin and sinuose; inferior cells lax, not papillose; alar cells slightly differentiated. **Dioicous**. Perichaetia with or without paraphyses. **Capsule** on a short, smooth, **seta** often curved, oblong. Operculum conic, with a short or long, curved beak. Exostome teeth linear-lanceolate, densely striolate in the lower half, densely papillose in the upper half; segments of the inner peristome as long as the exostome teeth, perforated along the keel, papillose; cilia none; basal membrane usually high. Calyptra cucullate or mitriform, lobed at base, with or without hairs.

Key to species

1. Leaves complanate, 1.5 x 0.65 mm long, ovate-lanceolate .....*F. walkeri*
1. Leaves slightly complanate, 1.5-2.0 mm x 0.65 mm , broadly cordate-ovate .....*F. spasa*

1. ***Floribundaria sparsa*** (Mitt.) Broth.

Nat. Pfl., 1(3): 822. 1906; Gangulee, Mosses E. India 5: 1310. 1974; Noguchi, Journ. Hattori Bot. Lab. 41: 285. 1976; Noris & Koponen, Acta. Bot. Fennica 131: 36. 1985.

Plants loosely onece pinnante, yellow to golden-green; stem up to 15 cm long. **Stems leaves** appressed when dry, branch leaves divergent; all leaves ovate to ovate-lanceolate, up to 2 mm long including the subulate to piliferous flexose acumen; leaves hastate to auriculate at base; margins plane or recurved at base of acumen, remotely but distinctly serrate at base; **costa** reaching above midleaf; median laminal cells with seriate papillae on lateral walls, dense and obscure; **alar** cells large, subquadrate to rectangular. Pericheatia on lateral branch, mostly smaller than vegetative leaves, ovate-lanceolate, and long acuminate. **Seta** curve, smooth, 1.3-1.7 mm long. **Capsules** ovate-oblong, brown. **Opercula** rounded-conic, with erect beak. **Peristom**e double. Spores ovate to spherical, verrucose.

F. sparsa is very variable species as may be in inferred from its synonymy. In this species the leaves vary in outline from ovate to ovate-oblong, with the apices either gradually attenuate or provided with a very long piliferous acumen. The latter is classified as a varietal taxon (Noguchi, 1976).

Key to varieties of *F. sparsa*

1. Stems ± complanately leaved; leaves widely cordate-ovate, gradually narrowed to subulate..... 1a. var. *spasa*
1. Stems rather loosely leaves, terete; Leaves ovate-oblong, rapidly contracted to a filiferous apex.....1b. var. *pilifera*

1a. ***Floribundaria sparsa*** var. ***pilifera*** (Nog.) Nog.

Journ. Hattori Bot. Lab. 28: 151, f. 37. 1965; 41: 285. 1976.

Plants yellowish-green, not glossy. Stems to ca. 20 cm in length, laxly branched. Branches 5-15 mm long, obtuse at apex. **Stem-leaves** slightly complanate, broadly cordate-ovate, to 1.5-2.0 mm x 0.65 mm, gradually narrowed, ending in a long piliferous, the basal angles slightly decurrent; margin undulate, crenulate or serrulate throughout, papillose between the teeth; costa slender, reaching mid-leaf, smooth, pellucid. **Branch-leaves** smaller, similar to stem-leaves. **Laminal cells** obscure, thick walls; median cells 30-40 μm x 4-5 μm; marginal cells papillose, rather obscure; inferior cells rectangular, pellucid, smooth, the walls with localized thickening; alar cells large, subquadrate to rectangular, obscure. **Sporphytes** not found. (**Figure 5.45**)

Thailand — NORTHERN: Chiang Mai, Phetchabun.

Distribution — India and Myanmar.

Ecology — On Branches.

Specimens examined — *Y. Nathi 493, 512, 870* (BCU)

GPS location — 18.55630886°N 98.4803905°E, 18.55486549°N 98.4786027°E, 18.58953891°N 98.48577691°E

Altitude — 2,180-2,209 m

1b. ***Floribundaria sparsa*** var. ***spasa*** (Mitt.) Broth.

Nat. Pfl., 1(3): 822. 1906; Gangulee, Mosses E. India 5: 1312, fig. 638. 1974; Noguchi, Journ. Hattori Bot. Lab. 41: 284. 1976.

Plants yellowish-green, not glossy. Stems to ca. 20 cm in length, laxly branched. Branches 5-15 mm long, obtuse at apex. **Stem-leaves** slightly complanate, broadly cordate-ovate, to 1.5 x 0.65 mm, gradually narrowed, ending in a subulate or piliferous, the basal angles slightly decurrent; margin undulate, crenulate or serrulate throughout, papillose between the teeth; costa

slender, reaching mid-leaf, smooth, pellucid. **Branch-leaves** similar to stem-leaves but smaller, to 1.4 x 0.6mm. Laminal cells obscure, walls thick; median cells 30-40 x 4-5; marginal cells papillose, rather obscure; inferior cells rectangular, pellucid, smooth, the walls with localized thickening; alar cells large, subquadrate to rectangular, obscure. **Sporphytes** not found. (**Figure 5.46**)

Thailand — NORTHERN: Chiang Mai, Chiang Rai.

Distribution — Bhutan, China, India, Java, Laos, Myanmar, Nepal, Sikkim, and Taiwan.

Ecology — On branches.

Specimens examined — *Y. Nathi 361, 603* (BCU)

GPS location — 18.58904304°N 98.4872297°E, 18.58812°N 98.48627°E
Altitude —2,549 m

2. ***Floribunadaria walkeri*** (Ren. Et Card.) Broth.

In Engler u. Prantl, Nat. Pflanz. 1(3): 822. 1906; Gangulee, Mosses E. India 6: 1513, fig. 757. 1977; Noguchi., Journ. Hattori Bot. Lab. No. 41. 273, fig. 16. 1976.

Plant delicate, yellowish-green, the older parts brownish not glossy. Stems creeping, laxly and complanately leaved, with few branches. Branches simple, laxly and complanately leaved with leaves ca. 1.5mm wide, the upper part slender, capillaceous. **Leaves;** stem leaves ovate-lanceolate, long-acuminate, cordate at base, to 1.5 mm x 0.5 mm, margin plane, serrulate and papillose; branch-leaves ovate-oblong, narrowly attenuate, widest near base, to 1x0.35 mm; **costa** weak, ending in mid-leaf; upper branch-leaves appressed. Laminal cells obscure, elongate-rhomboidal or sublinear, 30-35 x 3-4 papillae small, in almost 2 rows, walls delicate, flexuose; inferior cells rectangular, hyaline, walls thicker; alar cells slightly differentiated, rectangular or subquadrate. **Sporophytes** not seen. (**Figure 5.47**)

Thailand — NORTHERN: Chiang Mai; PENINSULA: Nakhon Si Thammarat.

Distribution — Himalaya, India, Laos, and Philippines

Ecology — On branch and twigs.

Specimens examined — *Y. Nathi 102, 523, 925* (BCU)

GPS location — 18.56183094°N 98.47633914°E, 18.58923°N 98.48746°E, 18.56183094°N 98.47633914°E

Altitude — 2,315-2,485 m

4. METEORIUM

Meteorium Doz. et Molk., Musci Archip. Ind.: 157. 1854; Noguchi, J. Hattori Bot. Lab. 41: 252. 10. 1976; Sharp, Crum & Eckel, Moss Fl. Mexico 2; 729. 1994.

Plants robust, dull or shiny, pale green, brown, or blackish, loosely subpinnate, pendent. **Leaves** spirally arranged, intricate to spreading, very concave, usually plicate, oblong or oblong-ovae from an auricle base, abruptly apiculate to long-acuminate or hair-pointed; **costa** single, ending above the midleaf; **cells** long-rhomboidal to linear, papillose, those at the base shorter, broader and often pitted, elongate and diagonally seriate at basal angles. **Dioicous**. **Pericheatial** leaves lanceolate, gradually long-acuminate. **Setae** short, rough; **capsules** exserted, oblong-cylindric or oblong-ovoid; annulus none oe narrow; **peristome** double, exostome teeth and endostome segments papillose. **Calyptra** cucullate, hairy.

Meteorium subpolytrichum (Besch.) Broth.

Engler u. Prantl, Nat. Pflanz. 1(3): 818. 1906; Noguchi, J. Hattori Bot. Lab. 41: 256, fig. 10. 1976.

Plants large, rigid, dark-green, not glossy. Stems 30 cm or longer, densely branched, with leave to ca. 1.7 mm in thickness, tumid. Branches straight or arcuate, short or long, tumid, obtuse at apex, with leaves ca. 2.5 mm thick. **Stem-leaves** appressed, imbricate and plicate when dry, to ca. 3 x 1.6mm, ovate, ovate-oblong, or lingulate, with a long (1.3-1/4 the leaf-length, flexuose, widely spreading acumen, auriculate and undulate at basal corners, slightly concave, less plicate; margin crenulate or entire, widely incurved above; costa reaching 2/3 the leaf-length. **Branch-leaves** similar to stem-leaves in outline, but more concave and slightly cymbiform, narrower retuse above due to incurved leaf-margins. **Median laminal** cells elongate-rhomboidal to sublinear, 30-40 x 3-4.5 rather thick-walled; papillae of cells large; superior cells slightly shorter, with thicker walls; marginal cells scarcely shorter; cells at basal corners shorter and broader, rhomboidal to elongate-rhomboidal. costa faint. **Seta** 5-8 mm long. **Capsule** ovate to ovate-oblong, to 2.6 x 1.5 mm, brown. (**Figure 5.48**)

Thailand — NORTHERN: Chiang Mai (Doi Inthanon)

Distribution — Himalaya, China, Japan, Philippines.

Ecology — On branches.

Specimens examined — *Y. Nathi 137, 262* (BCU)

GPS location — 18.5883898°N 98.48594539°E, 18.5577792°N 98.48092438°E

Altitude —2,233-2,543 m

Note —New record to Thailand.

5. PAPILLARIA

Papillaria (C. Muell) C. Muell., Öefv. K. Svensk. Ak. Foerh. 33(4): 4. 1876; Gangulee, Moss E. India 5: 1283. 1976; Noguchi, J. Hatt. Bot. Lab. 41: 237. 1976; Sharp, Crum & Eckel, Moss Fl. Mexico 2; 732. 1994.

Stems densely leaved, terete, densely or laxed branched, olive-green. Branches often long and pendent, densely leaved, terete, attenuate or blunt at apex. **Stem and branch leaves** similar, erect, appressed-imbricate, ovate, oblong-lanceolate, insertion narrow, the basal angles rounded or angular, conspicuously auriculate, amplexicaul, undulate, not decurrent, or widely cordate and slightly auriculate, the apex obtuse or rounded with short or long acumen; margin erect or plane, undulate and often erosely dentate below; **costa** single, weak reaching 1/2-2/3 the leaf length, smooth. **Laminal cells** obscure or pellucid, mostly multipapillose on longitudinal walls or over lumens, thick-walled; median cells elliptic or hexagonal; superior and marginal cells usually similar to median cells; inferior cells not papillose, hyaline, thick-walled; cells at basal corners rhomboidal or linear-rhomboidal, arranged in divergent or arcuate rows. **Dioicous**. Perichaetia mostly on branches, large, pale; inner perichaetial leaves linear-lanceolate, acuminate, plicate. **Seta** sort, rough; **capsule** immersed or exserted, oblong-ovoid; peristome double, exostome and endostom papillose. **Calyptra** cucullate or mitrate, usually hairy.

Papillaria semitorta (Müll. Hal.) A. Jaeger

Ber. S. Gall. Naturw. Ges. 1875-76: 271. 1877; Gangulee, Moss E. India 5: 1287, fig. 625. 1976; Noguchi, J. Hatt. Bot. Lab. 41: 238, fig. 1. 1976.

Plants slender, soft, yellowish-green, becoming blackish with age, not glossy. Stems elongate, creeping, subpinnately branched. Secondary stems ca. 20 cm long, pendent, flexuose, pinnately branched, densely leaved, laxly terete. Branches short, ca. 1 cm long, usually simple, densely leaved, obtuse or attenuate at the apex. **Stem-leaves** appressed when dry, erect-spreading when

moist, ovate-lanceolate, to 2.2 mm x 0.65 mm, gradually tapering to a short, slightly twisted apex, largely angular or rounded-auriculate, undulate at basal corners, very deeply 3-plicate in the lower half, slightly concave or plane above; margin plane, recurving and forming a small notch above the basal corner, mostly serrulate, but distinctly erose-dentate; **costa** ending near the mid-leaf. Branch-leaves similar to stem-leaves but smaller; **median laminal cells** pellucid, linear-rhomboidal, linear, 30-55 μm x 3-4 μm with several papillae in a row; marginal cells shorter; inferior ones elongate-rectangular; cells at basal corners rhomboidal or rectangular, not papillose. Inner perichaetial leaves narrowly oblong-lanceolate, gradually long-acuminate, serrate above, paraphytes not seen. **Sporophytes** not found. (**Figure 5.49**)

Thailand —NORTHERN: Chiang mai.

Distribution — Bhutan, Borneo, Celebes, China, India, Japan, Java, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On branches.

Specimens examined — *Y. Nathi 129, 369, 586, 916* (BCU)

GPS location — 18.5883898°N 98.48594539°E, 18.58904304°N 98.4872297°E, 18.58619344°N 98.48590918°E.

Altitude — 2,533-2,549 m

6. PSEUDOBARBELLA

Pseudobarbella Nog., J. Hattori Bot. Lab. 2: 81. 1947; 41: 341. 1976.

Plants small to medium-sized. Stems elongate, creeping, densely leaved. Branches widely spreading, short, densely and complanately leaved, almost obtuse at apex. **Stem-leaves** mostly complanately and widely spreading, ovate to oblong, gradually tapering to a long apex, cordate at base; margin erect, often involute on one side at base, serrulate to crenulate; **costa** extanding slightly beyond mid-leaf. Branch-leaves similar to stem leaves but usually with broader and shorter apices. **Laminal cells** rhomboidal to linear, with a single central papilla over lumen or with seriate papillae, walls uniformly thin; **alar** cells rectangular, not well defined. **Dioicous**. Inner pericheatial leaves oblong-sheathing; paraphyses numerous. Setae long, scabrous; **capsule** oblong-cylindrial, erect or sub erect, with or with out apophysis, smooth on surface; **opercular** rounded-conic with long oblique beak; **peristome** double, exostome teeth linear-lanceolate, densely papillose in the upper half, striolate in the lower half; basal membrane high. **Spores** spherical, verrucose.

Pseudobarbella attenuate (Thwait. et Mitt.) Nog.

Bull. Nat. Sci. Mus. (Tokyo) 16: 312. 1973; Noguchi, J. Hattori Bot. Lab. 41: 341. 1976.

Plants medium-sized, yellowish-green, becoming brownish with age, glossy. Secondary stems longer than 20cm, densely branched, rather laxly leaved. Branches complanately spreading, simple. 10-15 mm long, densely leaved, with leaves to ca. 4.5 mm in width, obtuse or shortly attenuate. **Stem-leaves** complanately spreading , narrowly oblong or ovate, with a subulate or subpiliferous apex, to ca. 3 x 0.9 mm, involute on one side at base; margin scarcely or slightly undulate along the median part, serrulate or crenulate; **costa** extending to mid-leaf or longer. Branch-leaves similar to those of stem but with somewhat shorter acumens. **Laminal cells** hyaline, with a single papilla per cell, with delicate walls, median cells 75-90 μm x 3-4; inferior cells shorter and wider, without papillae, walls thicker; alar cells scarcely differentiated. Inner perichaetial leaves long-subulate. **Sporophytes** not found. (**Figure 5.50**)

Thailand — PENINSULAR: Nakhon Si Thammarat.

Distribution — China, Japan, Java, Malaysia, Philippines, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On branches.

Specimens examined — *Y. Nathi 71, 341, 359, 514, 583, 605, 648, 667, 690, 750, 761, 872, 922, 1020* (BCU)

GPS location — 18.5616295°N 98.47653192°E, 18.58923079°N 98.4874572°E, 18.58904304°N 98.4872297°E, 18.58953891°N 98.48577691°E, 18.56178207°N 98.47630209°E, 18.58704463°N 98.4871176°E.

Altitude —2,314-2,549 m

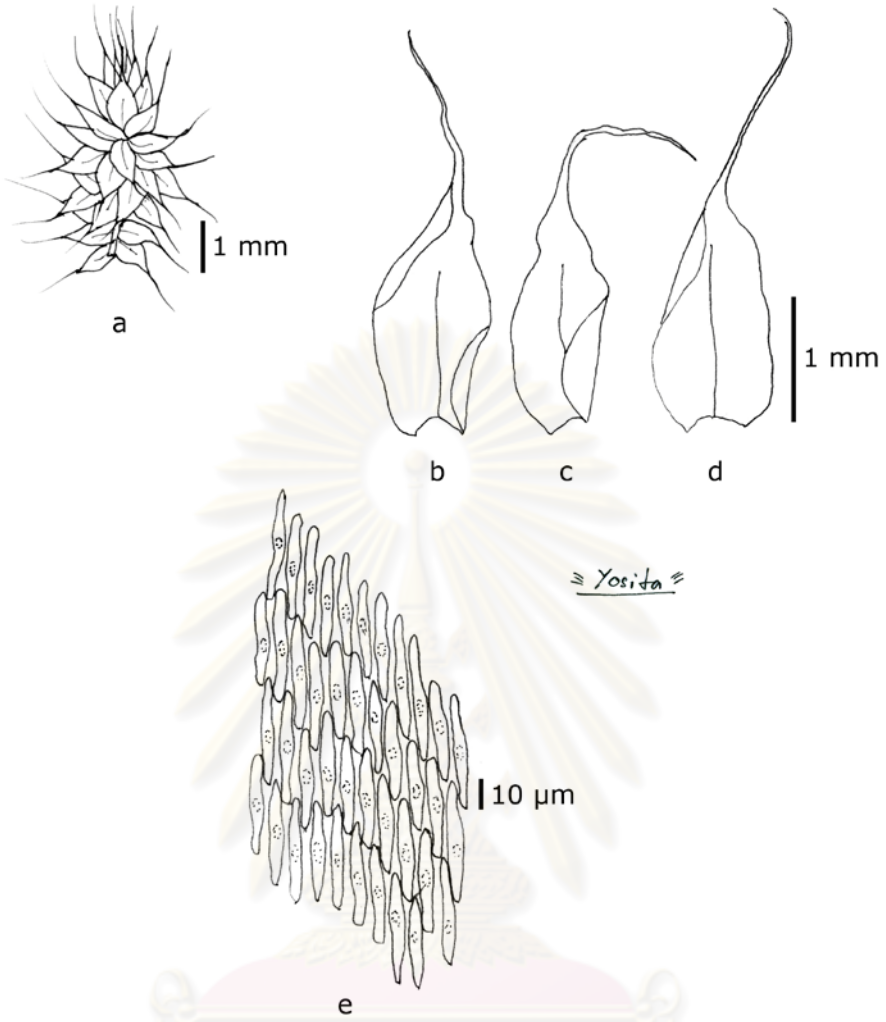


Figure 5.41 *Aerobryidium filamentosum* (Hook.) M. Fleisch. ex Broth.
a. portion of plant; b., c., d. leaves; e. cells at median leaf. Based on *Y. Nathi 1077*.

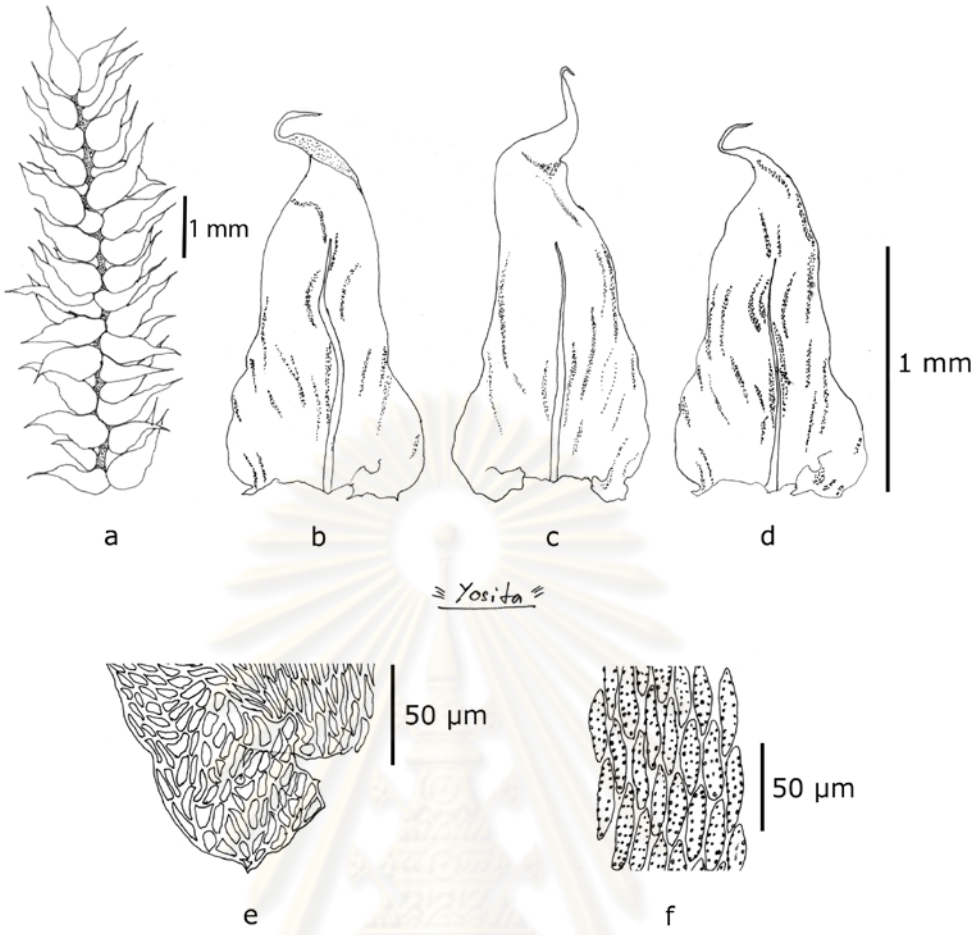


Figure 5.42 ***Cryptopapillaria chrysoclada*** (C. Müll) Menzel.
a. portion of plant; b., c., d. leaves; e. cells at leaf base; f. cells at median leaf.
Based on *Y. Nathi 224*.

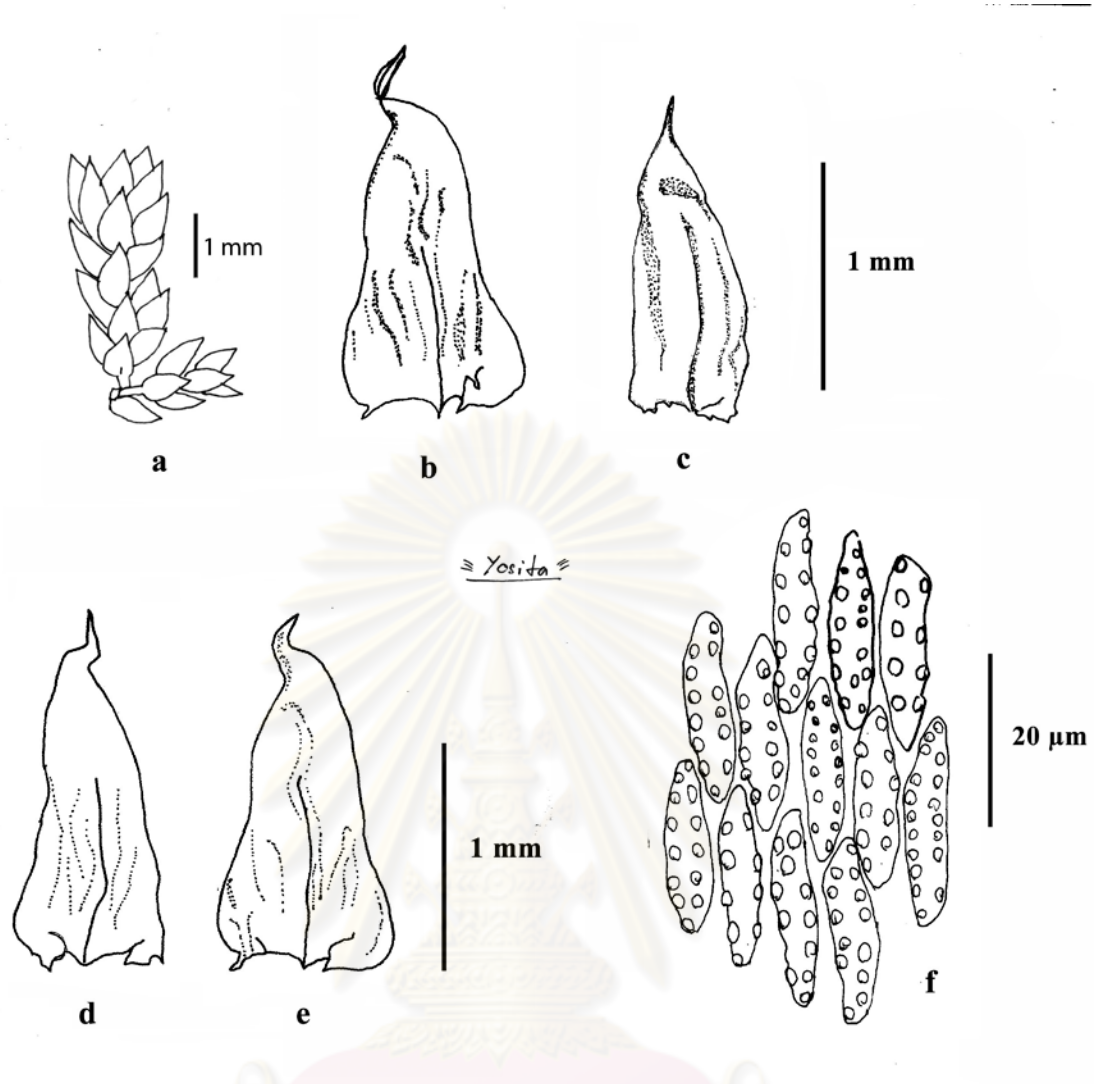


Figure 5.43 ***Cryptopapillaria feae*** (M. Fleisch.) Menzel.
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf. Based on *Y. Nathi 349*.

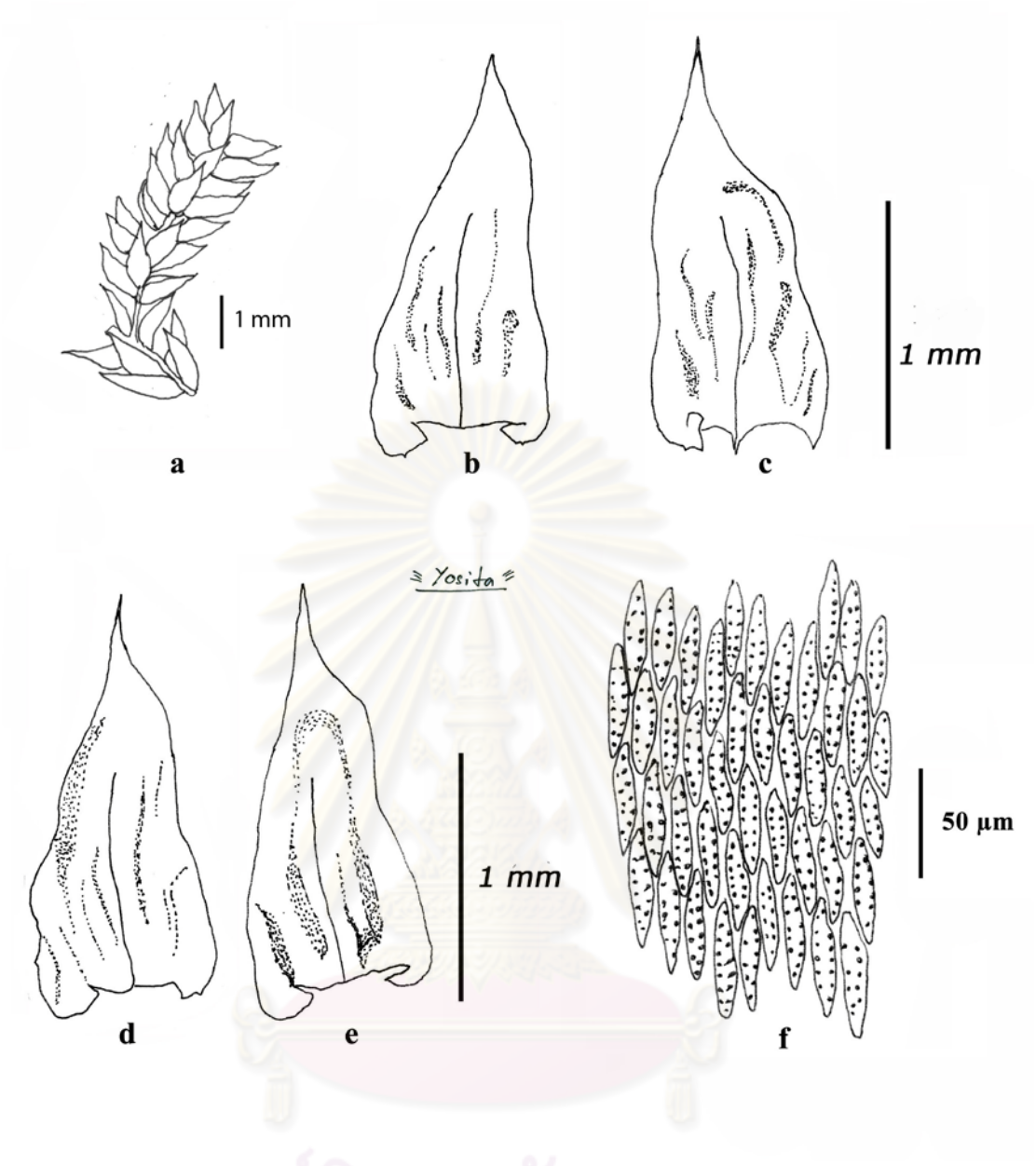


Figure 5.44 ***Cryptopapillaria fuscenscens*** (Hook.) Menzel.
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf. Based on *Y. Nathi 229.*

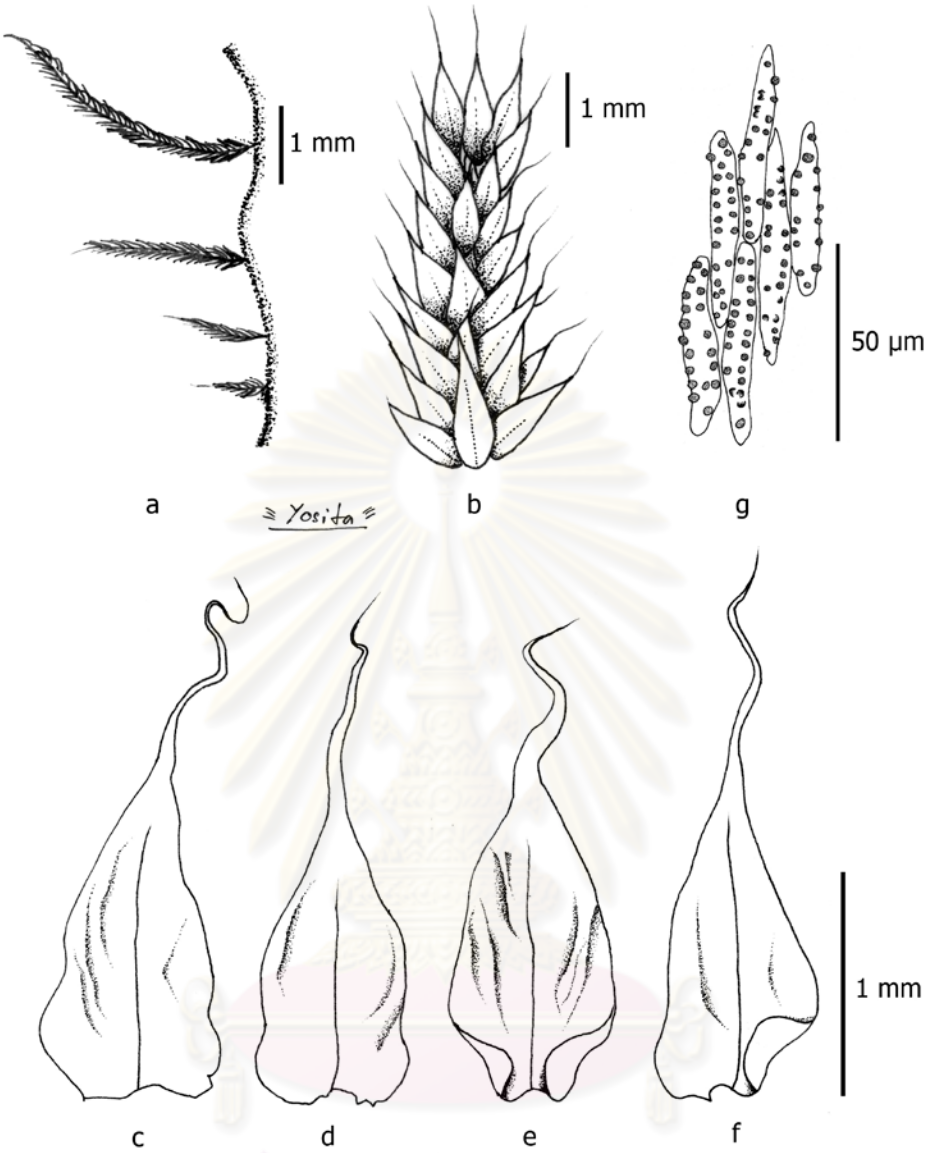


Figure 5.45 *Floribundaria sparsa* var. *pilifera* (Nog.) Nog.
a. habit; b. Portion of plant; c., d., e., f. leaves; g. cells at median leaf. Based on Y. Nathi 493.

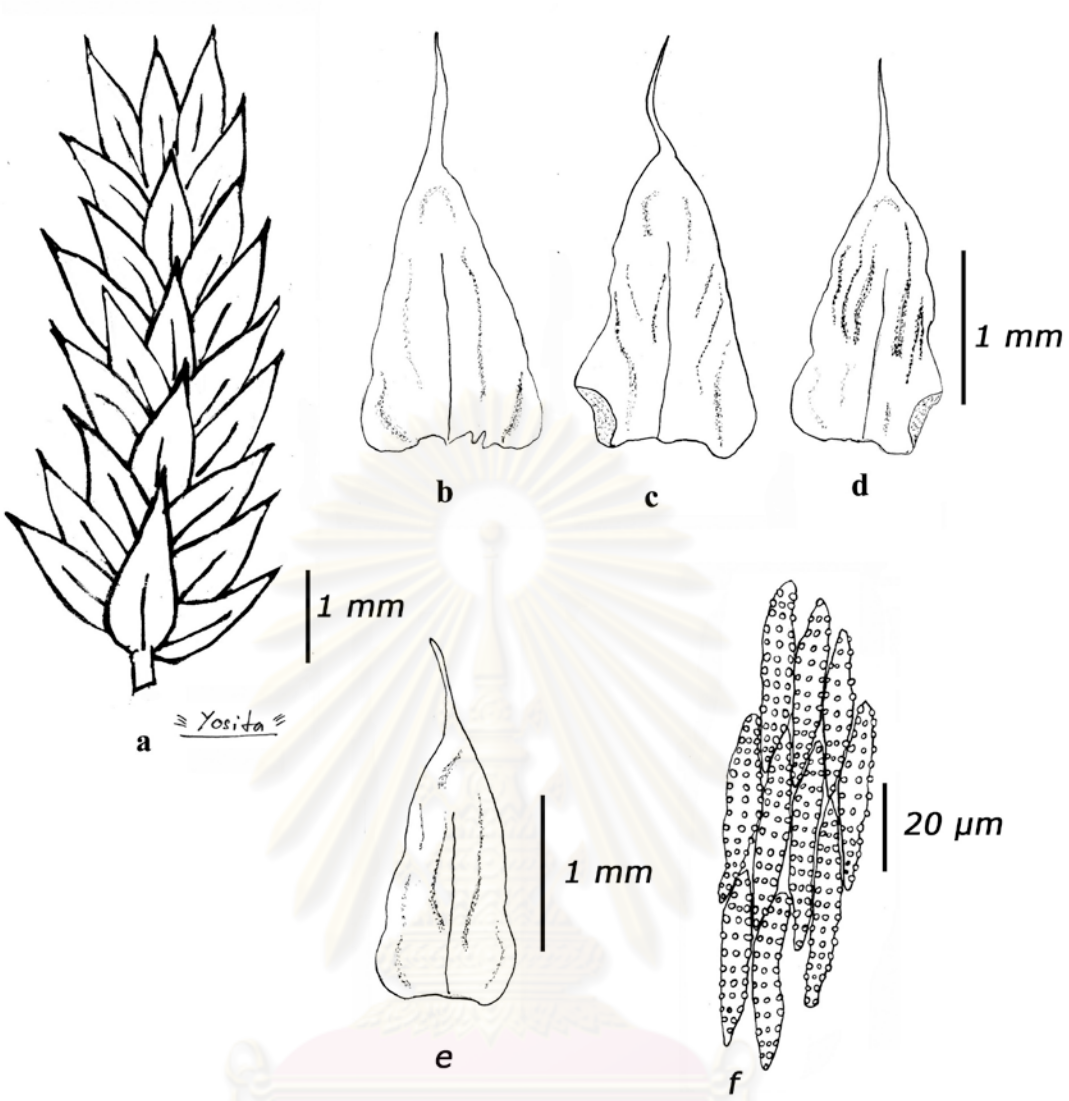


Figure 4.46 ***Floribundaria sparsa*** var. ***spasa*** (Mitt.) Broth.
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf. Based on *Y. nathi 361*.

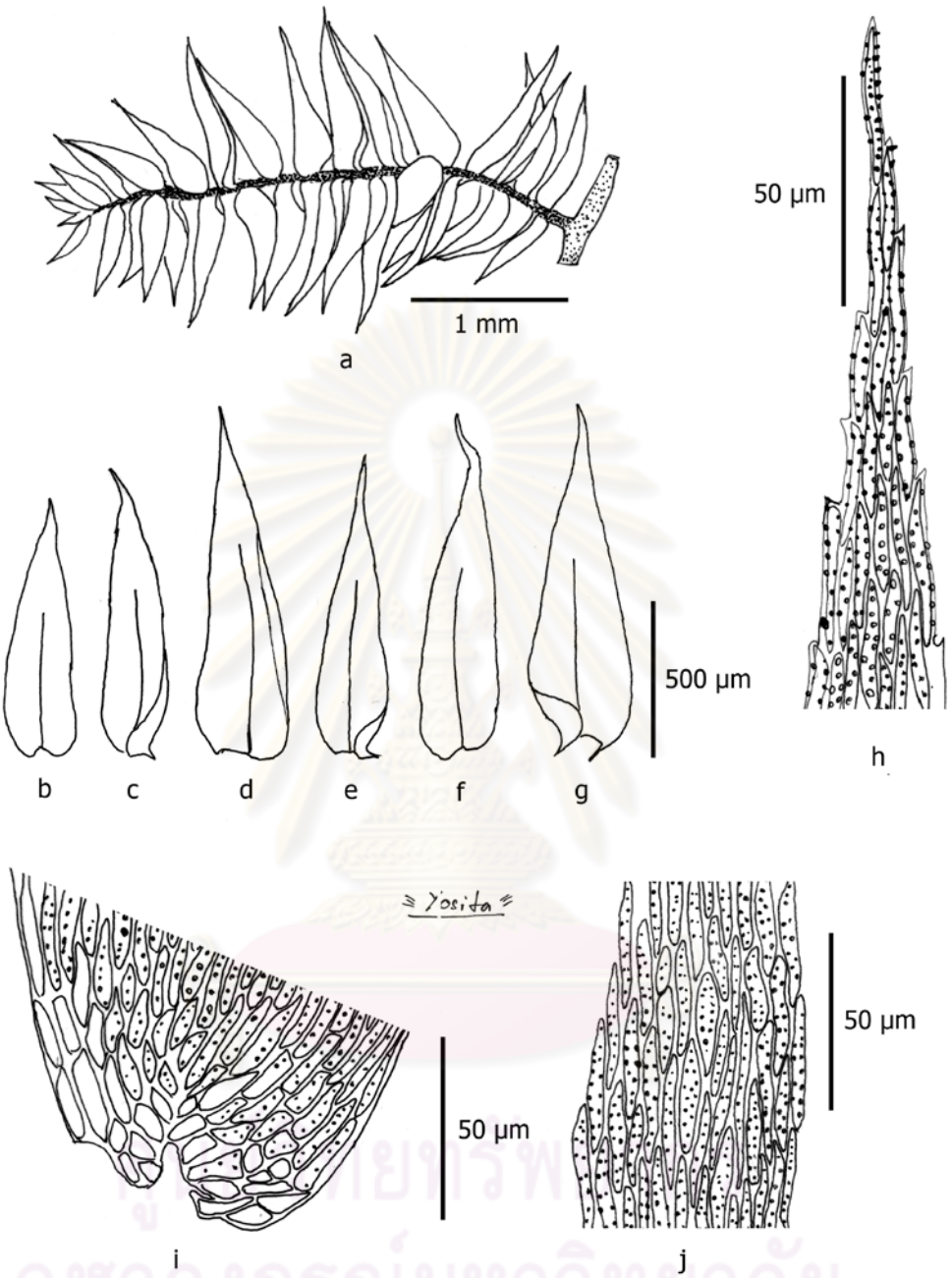


Figure 5.47 *Floribundaria walkeri* (Ren. & Card.) Broth.
a. portion of plat; b., c., d., e., f., g. leaves; h. leaf apex; i. cells at leafbase; j. cells at median leaf. Based on *Y. Nathi 952.*

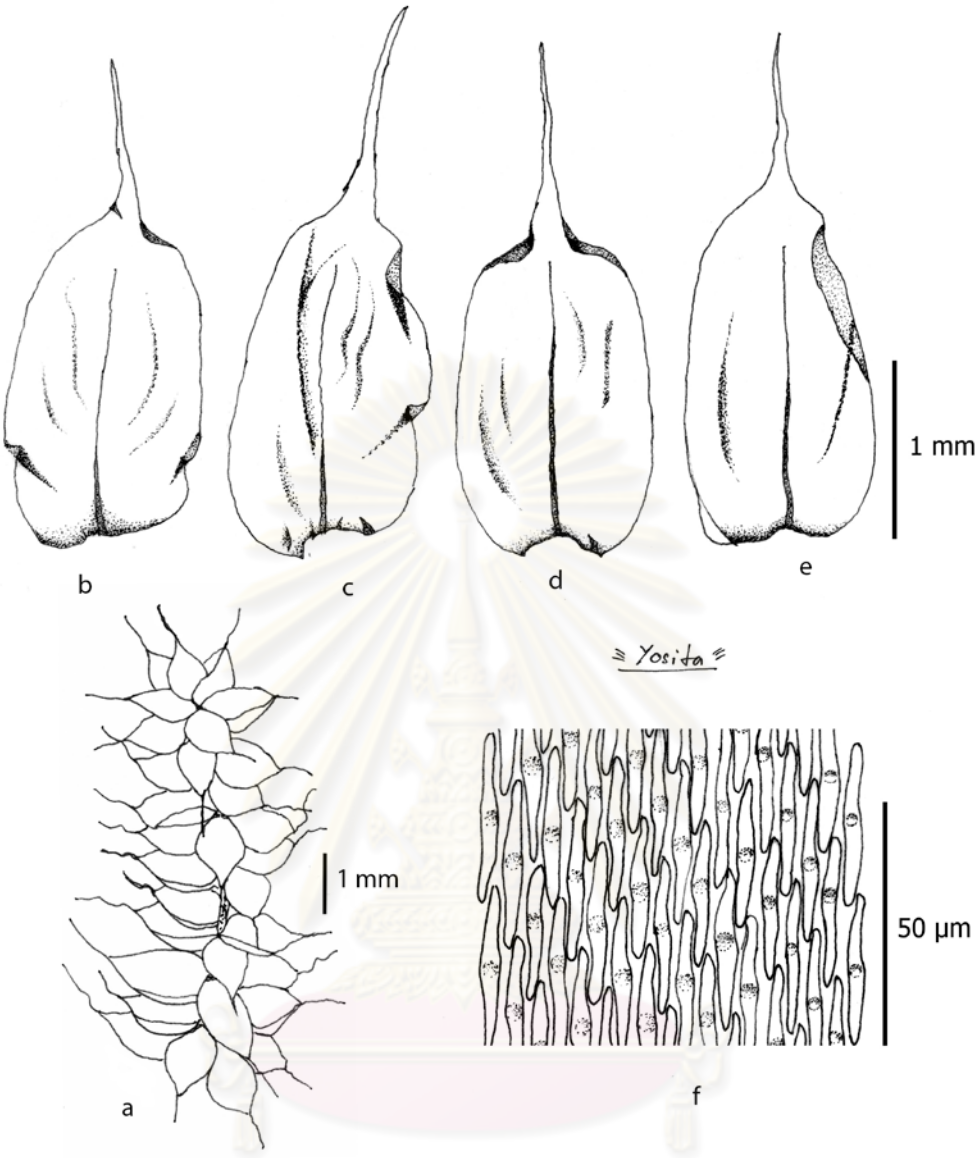


Figure 48 *Meteorium subpolytrichum* (Besch.) Broth.
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf. Based on *Y. Nathi 137.*

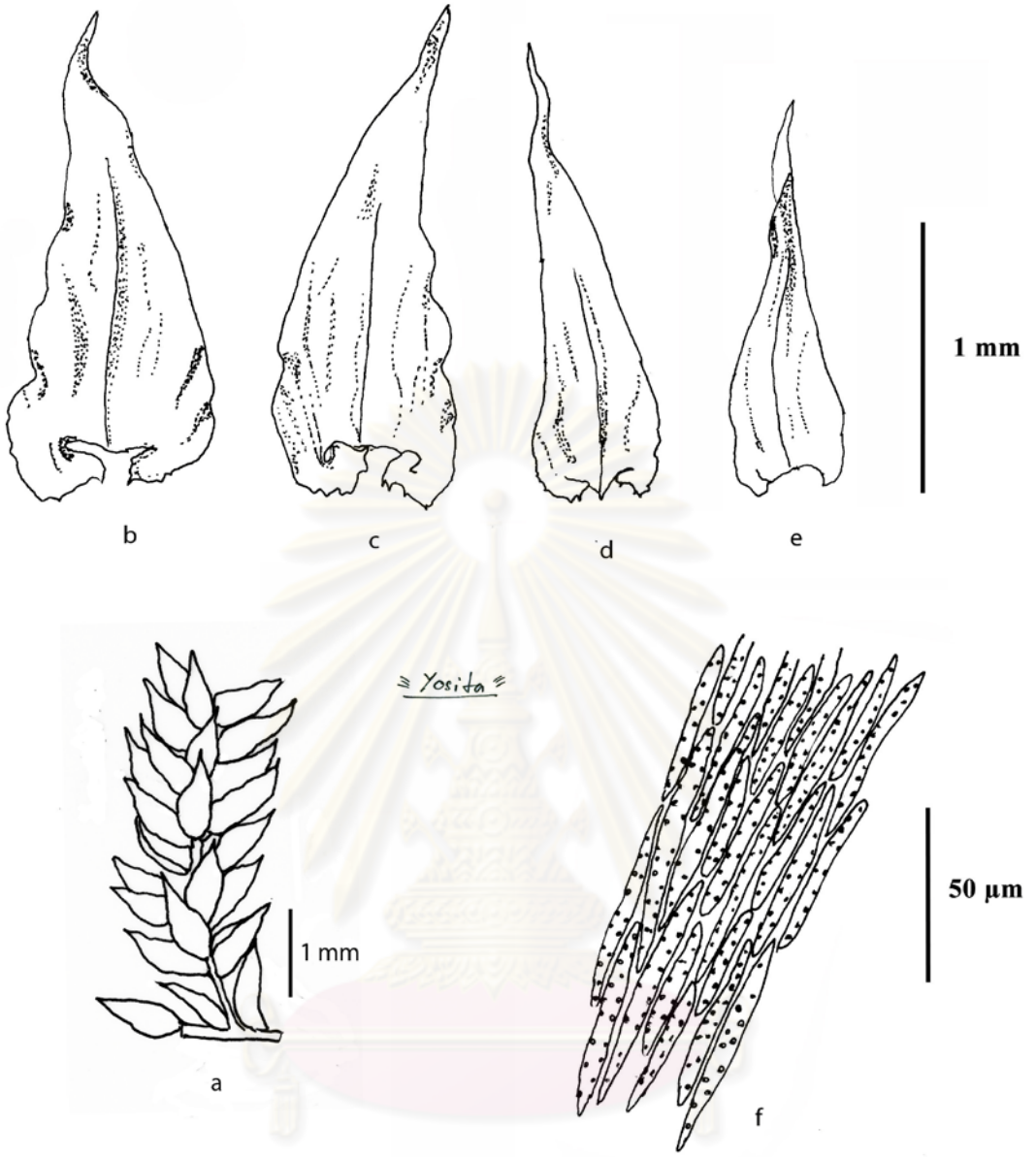


Figure 5.49 ***Papillaria semitorta*** (Müll. Hal.) A. Jaeger
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf. Based on *Y. Nathi 129*.

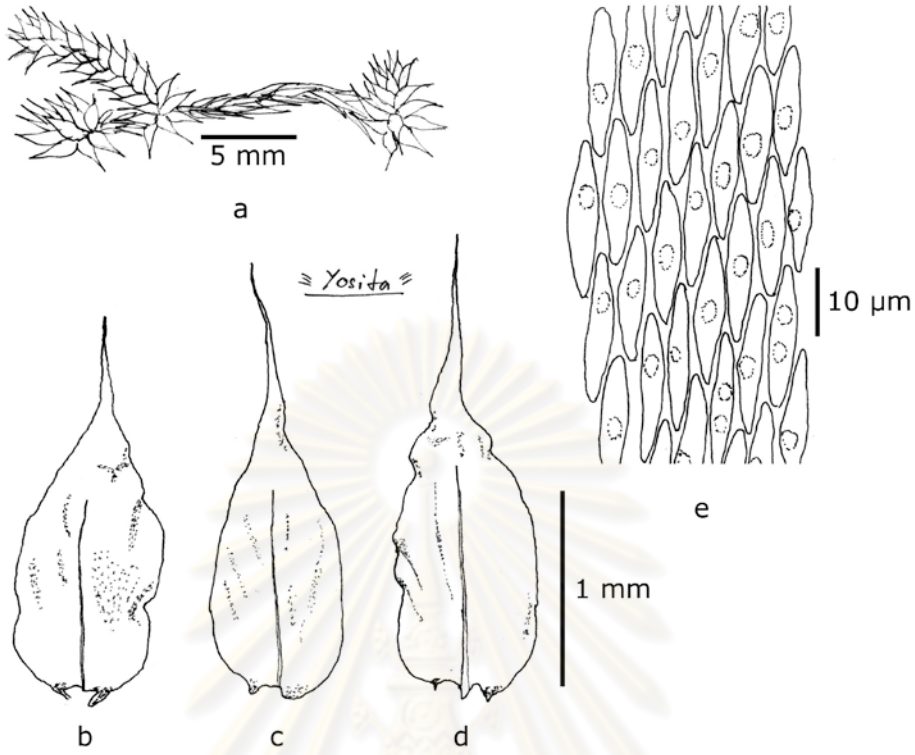


Figure 5.50 ***Pseudobarbella attenuate*** (Thwait. et Mitt.) Nog.
a. portion of plant ; b. c., d. leaves; e. cells at median leaf. *Y. nathi 1020*.

MNIACEAE

Plants medium-sized to rather robust, bright green to dark green, in loose turts or compact. **Stems** 2-8 cm long, erect or prostrate, with rhizoids at base; infertile branches mostly creeping; fertile branches erect; sometimes with flagelliform branches. **Leaves** usually distant, sometimes forming rosettes on the top of stems, flexuose or twisted when dry, when moist, mostly ovate, elliptical or obovate, rarely ligulate or ovate-lanceolate, acute, bluntly acute, apiculate or shortly acuminate at apex; margins bordered or not bordered, single-toothed or double-toothed, rarely entire; narrowed and often decurrent at base; **costa** single, strong, sometimes branched, ending below the apex, percurrent, or shortly excurrent, dentate or smooth at the back; **leaf cells** pentagonal to hexagonal, rounded-quadrate to nearly round, rarely rhombic, mostly smooth, mostly smooth, sometimes mammilose. **Dioicous** or autoicous. **Perichaetia** terminal. **Seta** solitary or clustered, mostly slender, straight; **capsule** mostly pendulous or obliquely rostrate; annuli usually present; peristome double; exostome teeth thick, lanceolate; endostome slenderly lanceolate, split, often as long as the teeth; basal membrane high; cilia 2-3, nodulose, sometimes endostome segments and cilia reduced. **Calyptra** usually cucullate, smooth, rarely hairy. **Spore** spherical, mammilose or coarsely papillose.

1. PLAGIOMNIUM

Plagiomnium T. Kop., Ann. Bot. Fenn. 5: 145. 1968; Nog., Ill. Moss Fl. Japan 3: 508. 1989; Li, He & Zhang, Moss Fl. China 4: 111. 2007.

Plants rather large, mostly pale green, in large mats or loose turfs. **Stems** prostrate, with many creeping branches or flagelliform branches; creeping branch curved, with dense rhizoids; fertile branches erect; **lower leaves** small, scale-like; upper leaves large, often forming rosettes at top of stems; flagelliform branches usually with larger leaves in the middle, smaller ones at base or tips, ovate, obovate, obong-elliptical or lingulate, crisped or twisted when dry, spreading when moist; leaf base narrowed, decurrent, acute or obtuse at apex; margins often bordered by 1-4 rows of elongate cells, entire or serrate; **costa** single, percurrent or ending ending below the apex; **leaf cells** pentagonal to hexagonal, rarely rectangular or rhombic, sometimes rounded, often thick-walled at corners. **Dioicous** or autoicous. **Seta** solitary, sometimes clustered, elongate, thick, orange; **capsules** inclined to pendulouse, rarely erect, usually elongate-ovoid, sometimes curved; **opercula** conic, rostrate; **peristome** double; exostome teeth reddish brown, lanceolate;

endostome segments as long as the teeth, orange-red, lanceolate, often split. **Spore** large green or yellow, roughened or coarsely papillose.

1. ***Plagiomnium maximovizii*** (Lindb.) T.Kop.

Ann. Bot. Fenn. 5: 147. 1986; Nog., Ill. Moss Fl. Japan 3: 520, fig. 229. 1989; Li, He & Zhang, Moss Fl. China 4: 120, pl. 212, figs. 1-6. 2007.— *Mnium maximoviczii* Lindb., Contr. Fl. Crypt. As. 224. 1872. — *M. maximoviczii* var. *angustilimbatum* Dix., Rev. Bryol., n.s. 1: 182. 1928. — *M. maximoviczii* var. *Emarginatum,* P.-C. Chen ex X.-J. Li & M. Zang. Acta Bot. Yunnan. 1: 68. 1979. M. *micro-ovale* C. Müll. var. *minutifolium* C. Müll. in Levier, Nuovo Gion. Bot. Ital., n.s., 13: 269. 1906, *nom. nud.*

Plants relatively small, in loose tufts. Primary stems prostrate, secondary stems erect, ca. 1.0-1.8 cm high, radiculose below, with leaves forming rosettes at the tips of stems; branches slender, from base of the stems, curved, 0.8-1.2 cm long. **Leaves** crisped when dry, spreading when moist, narrowed and slightly decurrent at base, abruptly acute, obtuse or apiculate at apex; margins distinctly bordered by 2-4 rows of obliquely elongate-rectangular cells below mid-leaf, upper margins not clearly bordered, serrate; costae percurrent; **leaf cells** rather small, irregularly rounded-hexagonal, walls slightly thickened at corners; basal cells rectangular, ca. 60 long, with a row of juxtacostael cells 2-4 times larger than adjacent cells, quadrate or pentagonal. **Dioicous**. **Seta** clustered, 1.5-3.5 cm long; **capsule** ovoid-cylindrical, ca. 2.8-4.0 mm x 1.2-1.8 mm, horizontal to pendulous, opercula conic, rostrate. (**Figure 5.51**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, India, Japan, Java, Korea, Pakistan, Philippines, and Sri Lanka.

Ecology — On soil, on rock, on tree trunk.

Specimens examined — *Y. Nathi54, 115, 172, 383, 548, 663, 961* (BCU); *Somjai, Kanya & Lens 155* (CMU Herbarium)

GPS location — 18.5883353°N 98.48588646°E, 18.5879204°N 98.48591790°E, 18.5887674°N 98.48422073°E, 18.58898906°N 98.48739739°E, 18.58795976°N 98.48525045°E

Altitude — 2,510-2,550 m

2. ***Plagiomnium rhynchophorum*** (Hook.) T.J.Kop.

Li, He & Zhang, Moss Fl. China 4: 122, pl. 212, figs. 7-11. 2007. — *Mnium rhynchophorum* (Hook.), Icon. Pl. l, pl. 20. f. 3. 1836. — *M. minutidentatum* C. Müll. in Sak., Bot. Mag. (Tokyo) 49: 689. 1935, *nom illeg*. — *M. minutidentatum* C. Müll., Gen. Musc. Fond. 134. 1900, *nom. nud*. — *M. rhynchophorum* var. *minutum* Ren. & Card., Bull. Soc. Roy. Bot. Belgique 34(2): 63. 1896. — *M. succulentum* var. *densum* Fleisch. in Dix. & Reim., Hedwigia 71: 52. 1931, *hom. illeg*. *M. succulentum* var. *densum* Fleisch., Musci Frond. Archipel. Ind. Exs. 467. 1908, *nom. nud*.

Plants deep green, forming dense mats. Fertile stems erect, ca. 1-1.5 cm tall. Sterile, procumbent stems much elongate on substrate. **Leaves** ca. 3.0-7.2 mm long, 1.8-2.2 mm wide, spathulate, some what undulate; **costa** single, usually reaching the apex; margin bordered, small toothed. **Lamina cells**, 38-50 μm long, quadrate to rectangular, or elongated hexagonal. **Seta** straitght, ca. 1.6 mm long. **Capsule** 2-3 mm long, horizontal, oblong. (**Figure 5.52**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, India, Indonesia, Myanmar, Nepal, Philippines, Sri Lanka, and Vietnam.

Ecology — On rocks near by the stream

Specimens examined — *Y. Nathi 15, 107, 541, 1022, 1054* (BCU)

GPS location — 18.5888333 °N 98.48731617°E, 18.4217216 °N 98.67853973°E, 18.58786463 °N 98.48721474°E, 18.55573369 °N 98.47615197°E.

Altitude — 2,209-2,568 m

3. ***Plagiomnium succulentum*** (Mitt.) T. Kop.

Ann. Bot. Fenn. 5: 147. 1968; Nog., Ill. Moss Fl. Japan 3: 508, fig. 231. 1989; Li, He & Zhang, Moss Fl. China 4: 125, pl. 213, figs. 1-4. 2007. — *Mnium succulentum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 143. 1895. — *M. denticulum* P.-C. Chen ex X.-J. Li & M. Zang, Acta Bot. Yunnan. 1: 63. 1979. — *M. Esquirolii* Card. & Thé., Bull. Acard. Int. Géogr. Bot. 19: 19. 1909. — *M. mackinnonii* Broth. in Kab., Hedwigia 76: 52. 1963, *nom. illeg.*

Plants meium-sized to rather robust, bright green, in loose turft. Primary stems and infertile branches prostrate, 4.0 cm long, sparsely foliate, with dense rhizoids; fertile branches erect, ca. 1.0-1.7 cm high, radiculose below, densely foliated above. **Leaves** crisped when dry, spreading when moist, broadly ovate or elliptical, 3.0-6.0 mm long, 2.8-4.0 mm wide, obtuse, apiculate at apex; **costa** single, reaching leaf apex; margins indistinctly nearly entire, thin-walled, regularly arranged, usually oblate, enlarged and

irregularly pentagonal near margins. **Dioicous**. **Seta** clustered, 3 cm long; **capsule** horizontal, elongate-ovoid. (**Figure 5.53**)

Thailand — PENINSULAR: Nakhon Si Thammarat

Distribution — Borneo, China, India, Japan, Java, Kampuchea, Malay Peninsula, Myanmar, Nepal, Philippines, Sumatra, Taiwan, and Vietnam.

Ecology — On tree trunk, on stair concrete, on soils.

Specimens examined — *Y. Nathi 400, 596, 633, 962, 1007, 1018* (BCU); Korn. 97 (CMU Herbarium)

GPS location — 18.58812346 °N 98.48627094°E, 18.58619344 °N 98.48590918°E, 18.58723657 °N 98.48690721°E.

Altitude — 2,485-2,550 m

2. RHIZOMNIUM

Rhizomnium (Broth.) Kop.,Ann. Bot. Fenn. 5: 142. 1968; Nog., Ill. Moss Fl. Japan 3: 526. 1989; Li, He & Zhang, Moss Fl. China 4: 131. 2007.

Plants small to medium-sized or rather large, reddish brown or reddish, in loose or dense tufts Stems erect, usually not branched, densely radiculose nearly throughout, especially at base. **Leaves** usually broadly ovate, obovate or nearly rounded, narrowed at base, obtuse at apex; margins entire, bordered by one to several rows of elongate-rectangular cells; **costae** percurrent or ending below the apex; **leaf cells** mostly regularly pentagonal or hexagonal, rarely shortly rectangular or rounded, uniformly thick-walled or somewhat thickened at corners. **Dioicous** or synoicous. **Seta** usually solitary, stout. **Capsule** horizontal to pendent, oblong to ovate. **Opercula** long-rostrate. **Peristome** double. **Calyptra** cucullate, reddish.

Rhizomnium striatulum (Mitt.) Kop.

Ann. Bot. Fenn. 5: 143. 1968; Nog., Ill. Moss Fl. Japan 3: 530, fig. 233, B. 1989; Li, He & Zhang, Moss Fl. China 4: 139, pl. 220, figs. 1-6. 2007. — *Mnium sraitulum* Mitt., Trans. Linn. Soc. London, Bot. 3: 167. 1869.

Plants small, in loose tufts. Stems erect, 3.5-7.0 mm high, sparsely foliate, with dense rhizoids at base. **Leaves** slightly crisped when dry, spreading when moist, obovate or elliptical, 0.8-2.5 mm long, 0.5-1.5 mm wide, narrowed and not decurrent at base, broader above, rounded and apiculate at apex; **margins** entire, bordered by 2-4 rows of elongate-rhomboidal cells, usually reddish yellow at margins; **costa** percurrent; **leaf**

cell small, rounded or rounded hexagonal, 10-20 μm wide, cells walls thickened at corners. **Dioicous**. **Sporophyte** not found. (**Figure 5.54**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, Korea, India, and Russia.

Ecology — On rocks near by stream.

Specimens examined — *Y. Nathi 1016, 1051, 1077* (BCU)
GPS location — 18.54257218 °N 98.51670245°E
Altitude — 2,120 m
Note — New to Thailand.

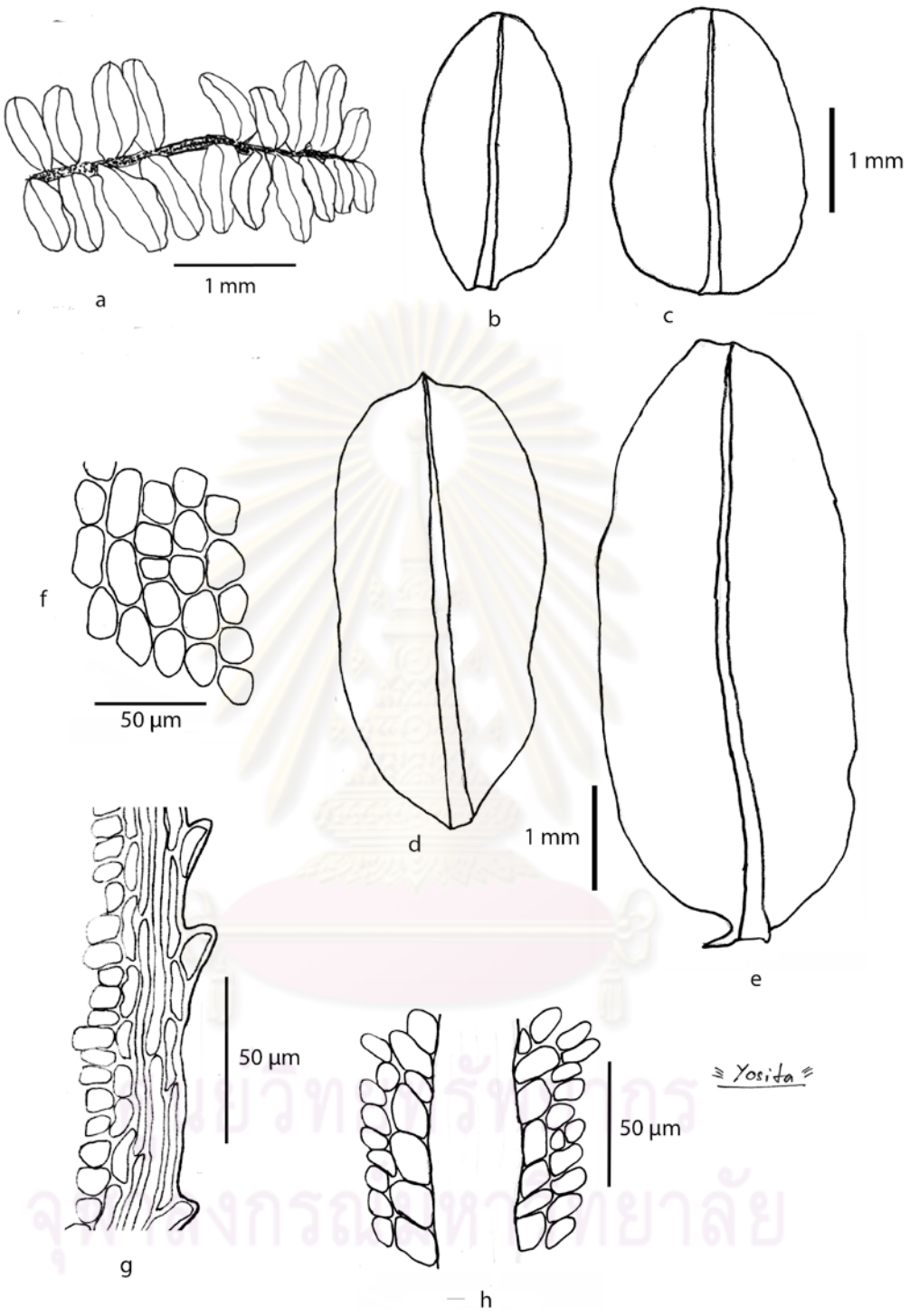


Figure 5.51 *Plagiomnium maximovizii* (Lindb.) T.Kop.
a. portion of plant; b., c., d., e. leaves; f. cells at median leaf; g. leaf margin; h. juxtacostal cells. Based on *Y. nathi 663*.

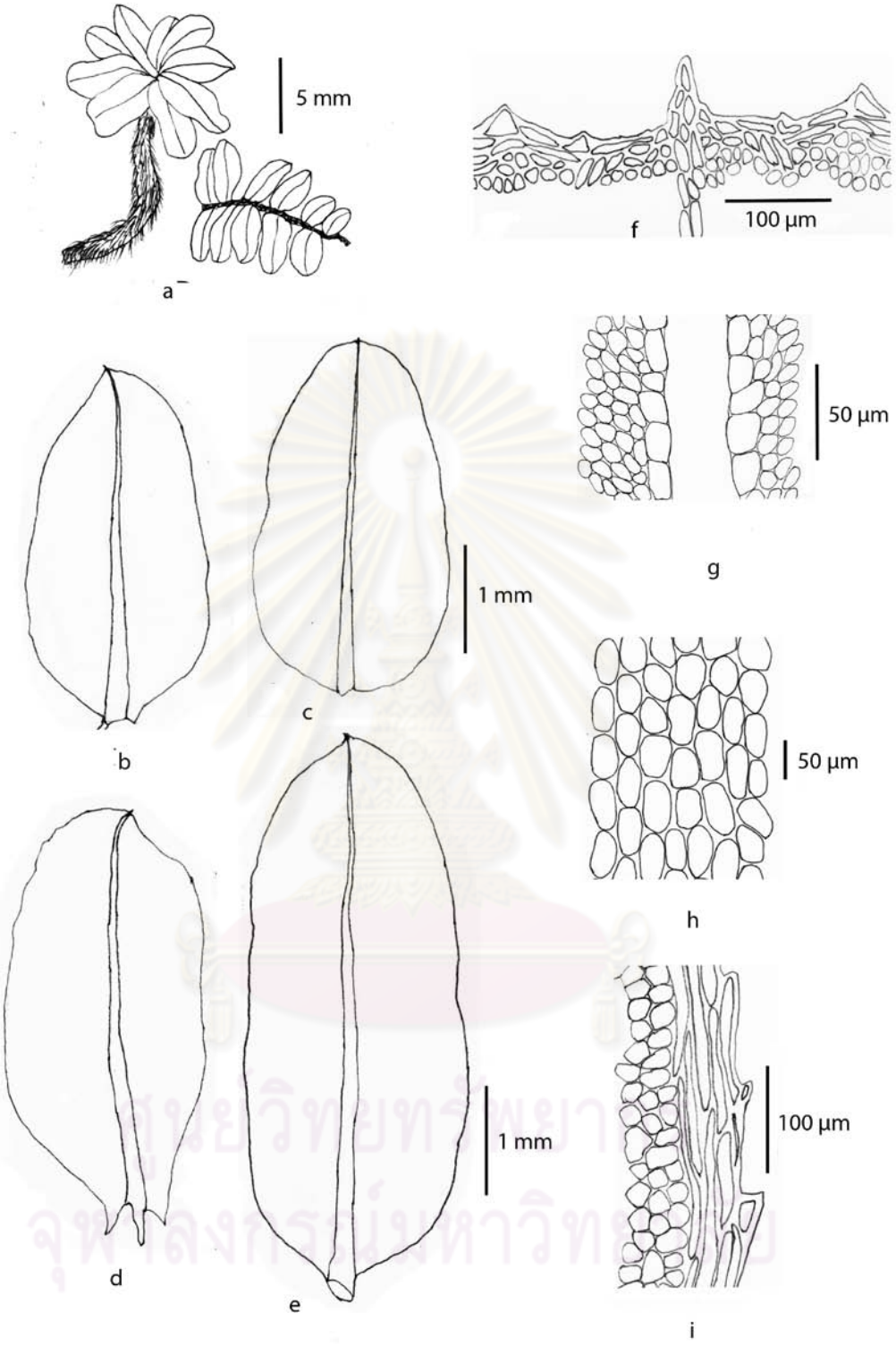


Figure 5.52 *Plagiomnium rhynchophorum* (Hook.) T.J.Kop.
a.habits; b., c., d., e. leaves; f. cells at leaf apex; g. juxtacostal cells; h. cells at median leaf; i. cells at leaf margin. Based on *Y. Nathi 541.*

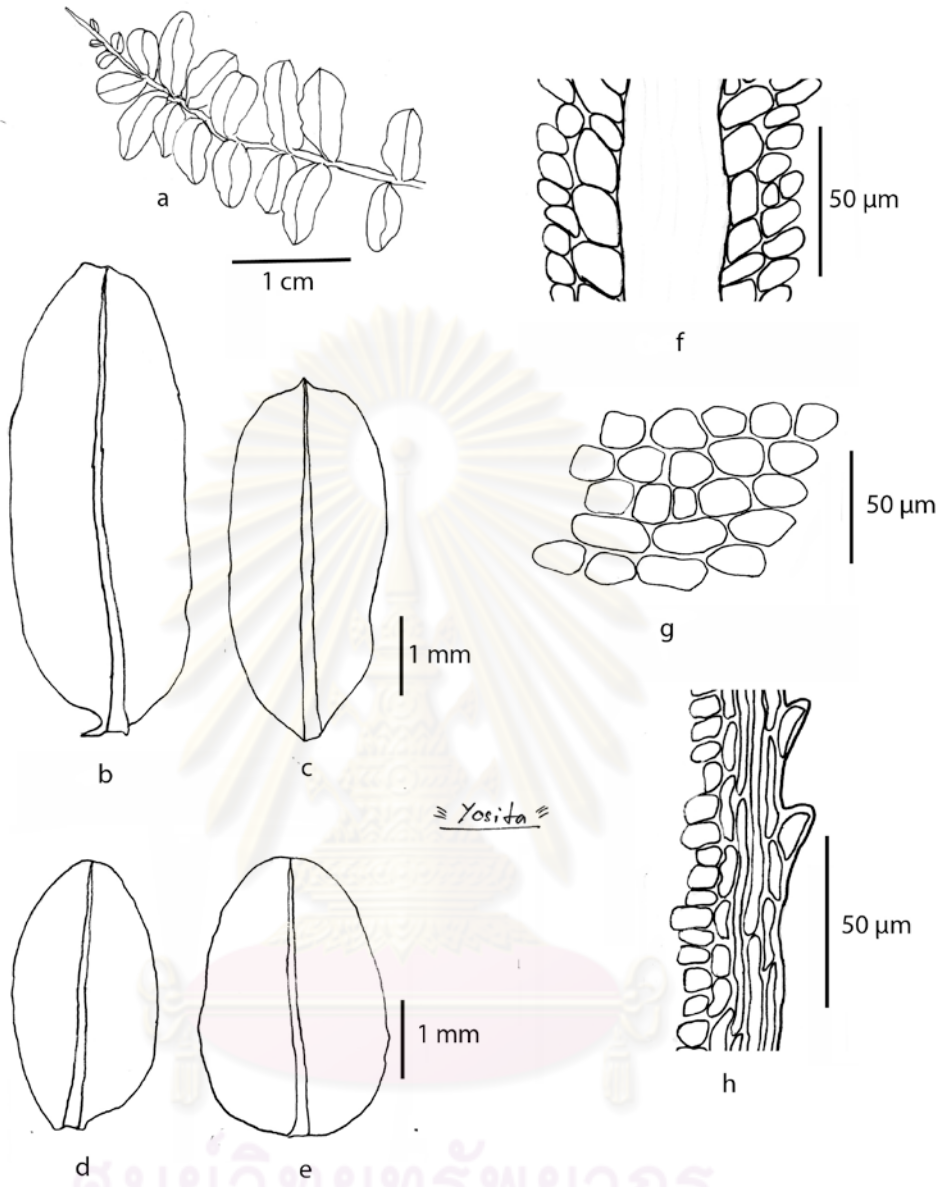


Figure 5.53 *Plagiomnium succulentum* (Mitt.) T. Kop.
a. portion of plant; b., c., d., e. leaves; f. juxtacostal cells; g. cells at median leaf; h. cells at leaf margin. Based on *Y. Nathi 596*.

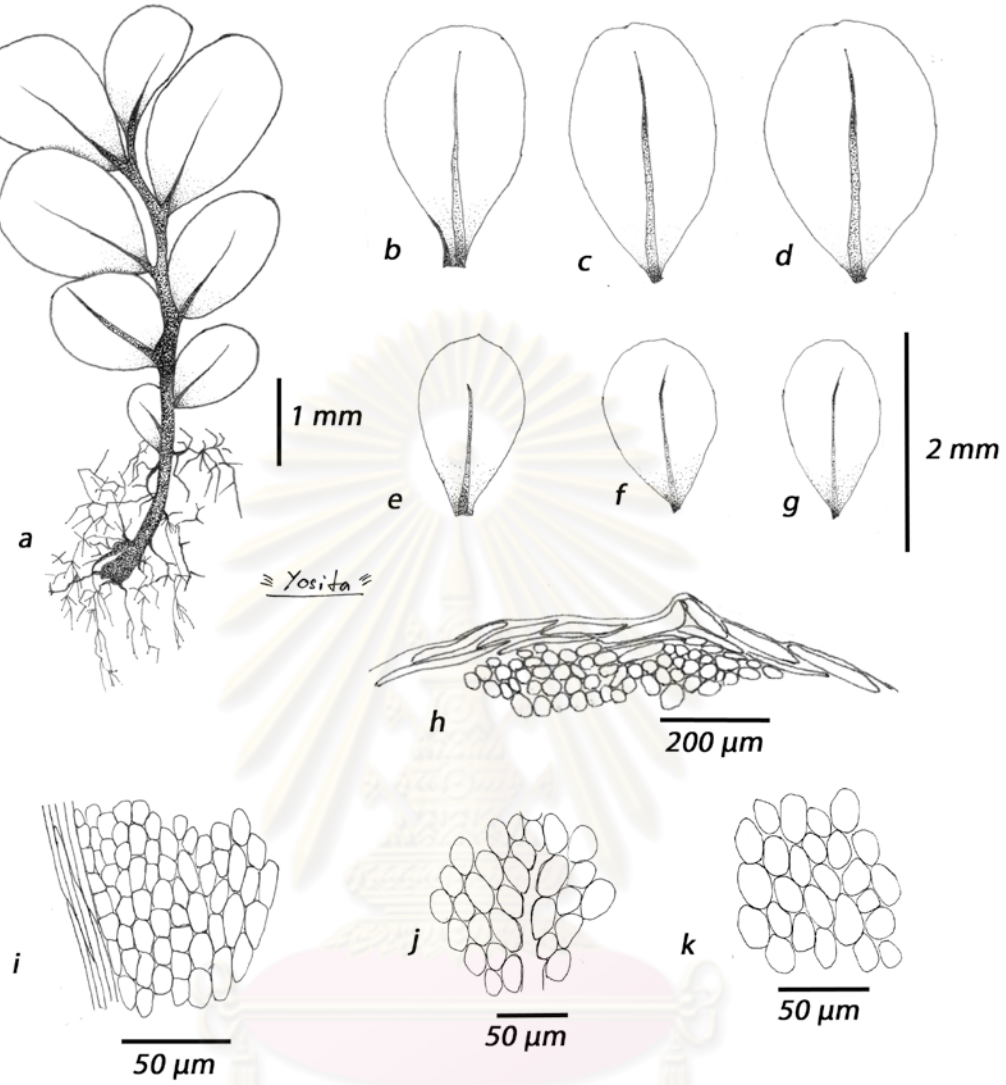


Figure 5.54 *Rhizomnium striatulum* (Mitt.) T.J. Kop.
a. habit; b., c., d., e., f., g., leaves; h. apical leaf cells; i. basal leaf cells; j. median juxtacostael leaf cells; k. median leaf cells. Based on *Y. Nathi 1016.*

MYURIACEAE

Plants fairly robust, glossy, in dense tufts. Stem with out central stand. Secondary branch erect or ascending. **Leaves** dense, ovate-lanceolate, acuminate. **Costa** absent. **Leaf** cells linear, smooth. **Sporophyte** on short lateral branches. **Seta** long. **Capsules** erect. **Peristome** double. **Calyptra** cucullate, not hairy.

OEDICLADIUM

Oedicladium Mitt., J. Lin. Soc. Bot., 10: 194. 1868. Iwatsuki, Z., J. Hattori Bot. Lab. 46: 265.1979; Noguchi, Iwatsuki & Yamaguchi, Ill. Moss Fl. Japan 5: 1069. 1994.

Plants medium-sized to large, yellowish green to brownish or reddish brown, often glossy. Stems creeping or clustered, central strand lacking; rhizoids papillose. **Stem leaves** small. Branch leaves appressed and imbricate when dry, erect-spreading when moist, gradually or abruptly tapering to a long or short subulate acumen, semicanaliculate at apex, not plicate, brownish at base; margins involute; **costa** indistinct or lacking. **Median laminal cells** linear, with incrassate porose wall; alar cells small, subquadrate or rectangular, forming a small, brown alar group. **Dioicous**. Inner perichaetial leaves similar to the branch leaves, weakly serrulate above. **Seta** elongate, smooth. **Capsules** erect or suberect, usually oblong to ovate. **Opercula** rostrate. Exostome teeth often irregular in outline, often perforate, membranous, pellucid, hyaline, smooth; endostome rudimentary.

Oedicladium rufescens (Reinw. & Hornsch.) Mitt.

J. Linn. Soc., Bot.: 1950. 1868; Iwatsuki, Z., J. Hattori Bot. Lab. 46: 267, fig. V.1979; Noguchi, Iwatsuki & Yamaguchi, Ill. Moss Fl. Japan 5: 1070, fig. 471, A. 1994. — *Leucodon rufescens* Reinw. & Hornsch., Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 14((2)): 712. 1829.

Plants rigid, yellowish- or reddish brown, very glossy. Stems filiform, creeping, to 70 mm long, flexouse, densely branched, densely leaved, the leaves triangular-ovate, to 1 mm long, concave, ecostate; margin serrulate. **Branch leaves** densely appressed, imbricate when dry, erect spreading when moist, oblong, with a linear-lanceolate acumen, to 4 mm long, strongly concave, semicanaliculate at apex; margin involute, minutely serrulate; **costa** very short and forked, or absent; **median cells** linear, 40-70 μm x 5.5-8.0 μm, the walls incrassate, porose, the mdille lamellae distinct; upper laminal cells 30-45 μm x 9 μm, the walls more incrassate, porose; **alar cell** group small, the

cells lax, rectangular or subquadrate, brown. **Seta** smooth, erect, 2 cm long; **capsules** erect ovoid. (**Figure 5.55**)

Thailand — NORTHERN: Chiang Mai; NORTHEASTERN: Nakhon Ratchasima Loei; SOUTHEASTERN: Nakhon Nayok Kanchanaburi PENINSULAR: Nakhon Si Thammarat Ranong.

Distribution — Borneo, Celebes, India, Japan, Java, Malaysia, Myanmar, New Guinea, Philippines, Sri Lanka, Sumatra, and Vietnam.

Ecology — On tree trunks and branches.

Specimens examined — *Y. Nathi 314, 413, 443, 489, 789, 919, 1033* (BCU)

GPS location — 18.5608153°N 98.47721203°E, 18.55937479°N 98.47546172°E, 18.55630886°N 98.48039045°E, 18.55427868°N 98.47803765°E, 18.56084548°N 98.47726677°E.

Altitude — 2,185-2,301 m

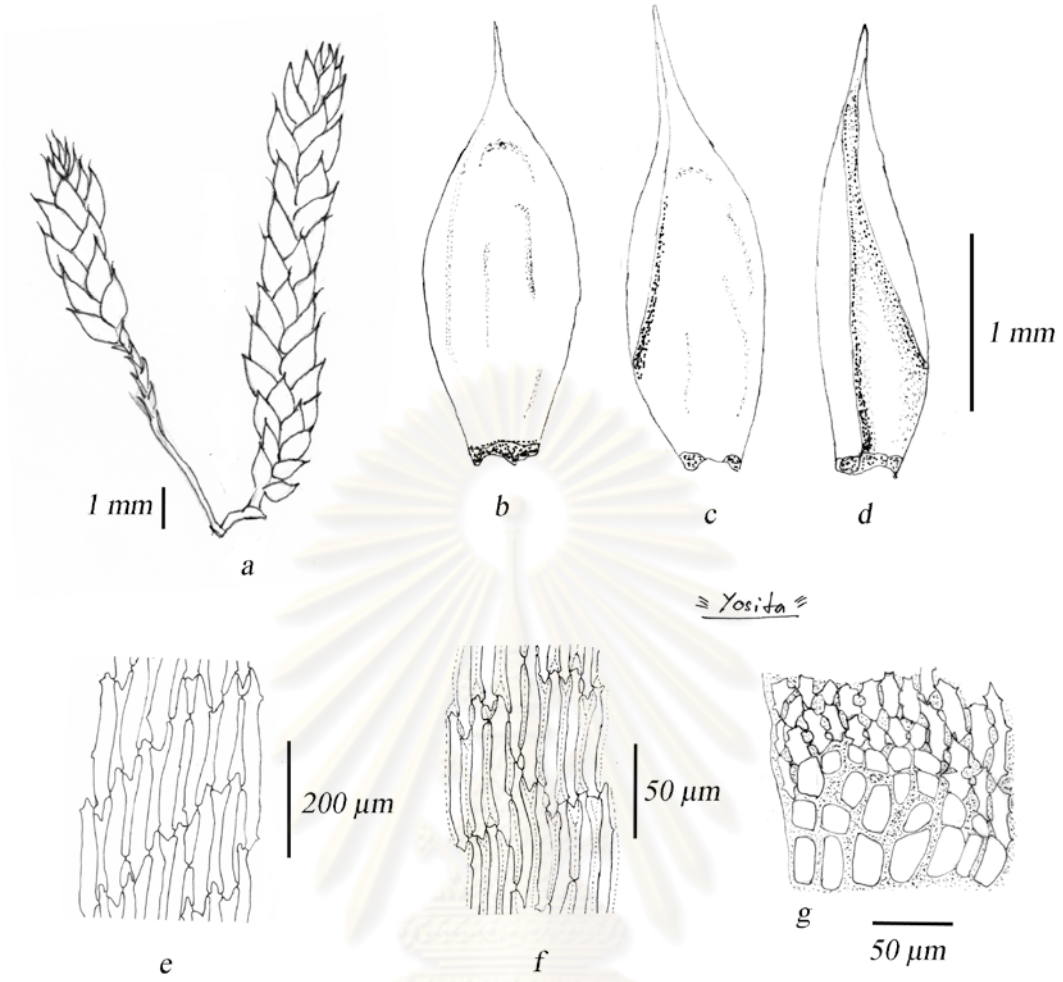


Figure 5.55 ***Oedicladium rufescens*** (Reinw. & Hornsch.) Mitt.

a. portion of plant; b., c., d., leaves; e. cells at median leaf; f. cells at lower leaf; g. cells at basal leaf. Based on *Y. Nathi 413*.

NECKERACEAE

Plants generally rather robust, usually shiny, green, yellowish-green, or golden. Primary stems creeping and usually stoloniform, naked or remotely foliate, radiculose. Secondary stems prostrate, erect-arching, or pendent, freely branched, densely foliate except at base. **Leaves** in 8-ranked, mostly complanate, smooth or undulate, often asymmetric, ovate or lingulate, truncate to rounded, acute, or acuminate; margin unbordered, generally toothed toward the apex; **costa** single and ending above the midleaf or less commonly short and double or lacking; **upper cells** rounded-quadrate, rhombic, or oblong-hexagonal, mostly smooth; basal cells more elongate and often porose, those of the alar regions not or slightly differentiated. **Perichaetial** leaves sheathing, slenderly acuminate. **Setae** very short to elongate; **capsule** immersed to long-exserte, usually erect and symmetric, oblong or ovoid-cylindric; annulus usually none; operculum obliquely rostrate from a conic base; **peristome** double. **Calyptra** mitrate or cucullate, naked or hairy.

Key to genera

1. Branch leaves complanate 2
1. Branch leaves not complanate ..... *Currvicladium*
   2. Leaf apex acute, acuminate or rounded with deeply serrate 3
   2. Leaf apex rounded not deeply serrate..... *Homalia*
3. Leaves in about 8 rows ..... *Neckera*
3. Leaves in 4 rows..... 4
   4. Leaf base inflexed in one side ..... *Homaliodendron*
   4. Leaf base decurrent, not inflexed in one side ..... *Noguchidendron*

1. CURRVICLADIUM

Currvicladium Enroth gen. nov., Ann. Bot. Fennnici 30: 109-117. 1993.

Plants robust, pinnately branched, dull, dark green. Secondary stems frondose above a stipitate base, stem and branches usually arcuate, pseudoparaphyllia absent. Stipe leaves small, wide-spreading. **Branch leaves** spreading, margin narrowly recurve; **costa** strong, ending below leaf apex; leaf apexcosrsely dentat; **leaf cells** small, incrassate, smooth; apical laminal cells strongly colenchymatous, oval or subrhomboid, median lamina cells larger and strongly collenchymatous, basal lamina cells oblong to long-rectangular. **Dioicous**. **Seta** erect, smooth below but distinctly mamalouse above. **Capsles** erect, broadly cylindric to subellipsoid.

Note: This genus is closely related to *Pinnatella* Fleisch., but differs in the usually arcuate stems and branches, the consistent absence of

psuedoparaphyllia, the large composite teeth in the leaf apices, the post-fertilization growth of the inner perichaetial leaves, the 8-11 mm long , reddish brown, slightly twisted seta and the frequent presence of reduced cilia between the endostome segment (Enroth, 1993). There is only one species.

Curvicladium kurzii (Kindb.) Enroth

Ann. Bot. Fennici 30: 109-117. 1993. — *Thamnium kurzii* Kindb., Hedwigia 41:246. 1902. — *Pinnatella kurzii* (Kindb.) Wijk & Marg., Taxon 11:222. 1962. — *Thamnium siamense* Horik. & Ando in Kira & Umesao (eds.), Nature and Life in Southeast Asia 3:23. f. 4. 1964. — *Thamnobryum siamense* (Horik. & Ando) Nog. In Ohashi (ed.), Fl. Eastern Himalaya, Musci:272. 1975. — *Pinnatella siamensis* (Horik. & Ando) Nog., J. Hattori Bot. Lab. 61:262. 1968.

Plants growing in loose groups, robust, pinnately to bipinnately branched, elongate frondose, dull, dark green, stems and branches usually arcuate. Stems up to 12 cm long. **Upper stem leaves** up to 2.0-2.5 mm long and 0.9-1.2 mm wide, loosely imbricate, erecto-patent when dry, patent when wet, especially the basal parts distinctly plicate, somewhat concave, from an ovate base narrowed at about 2/3 the leaf length into a ligulate acumen, leaf apices obtuse. Branch leaves similar but smaller; leaf margins narrowly recurved near base, plane; leaf apices mostly coarsely dentate, the larger teeth composit. **Costa** single, strong ending below leaf tip. **Leaf cells** incrassate, smmth; apical laminal cells rather strongly collenchymatous, oval or rhomboid; median laminal cells less strogly collenchymatous, approximately as large as the apical laminal cells, basal laminal cells oblong to long-rectangular, walls solid or withscattered pores **Dioicous. Sporophytes** not found. (**Figure 5.56**)

Thailand — NORTHERN: Chiang Mai, Phitsanulok.

Distribution — Bangladesh, Bhutan, Mainland China, India, Java, Myanmar, Nepal, Sikkim, and Vietnam.

Ecology — On tree trunks and branches.

Specimens examined — *Y. Nathi 11, 397, 741, 755, 769, 839, 1010* (BCU)

GPS location — 18.5888333°N 98.48731617°E, 18.58808876°N 98.4865151°E, 18.55614457°N 98.48136032°E, 18.55754586°N 98.4800629°E.

Altitude —2,192-2550 m

2. HOMALIA

Homalia Brid., Bryol. Univ. 2: 812. 1827; Gradstein, Churchill & Salazar-Allen, Mem. New York Bot. Gard., vol. 86: 751. 2001.

Plants medium-ized to large, forming tufts, iridescent yellow-green. Primary stems creeping; leaves oblong-ligulate; costae single or double. Secondary stems frondose, perpendicular to substrate, 11 cm tall, complante-foliate, simple to irregularly pinnately branched. **Leaves** erect-spreading, oblong-lingulate or lingulate, 1.2-3.5 mm long, 1.5 mm wide, asymmetric, apex obtuse-rounded to broadly acute; margins plane, occasionally folded, serrulate to serrate distally; **costa** single or forked , 1/4-2/3 lamina length; apical cells rhomboidal to irregularly rhombic; **median cells** long fusiform or long hexagonal, porose or not; basal cells hexagonal to linear, weakly porose. **Pericheatia** lateral. **Seta** elongate, 10-20 mm long, smooth. **Capsule** erect, urn cylindrical, to 2.2 mm. Operculum conic. Peristome with exostome teeth finely cross-striate below, distally papillose; endostome basal membrane high, segments keeled and perforate, papillose. **Calyptra** cucullate. **Spore** spherical, faintly papillose.

Homalia pennatula (Dix.) He & Enroth

NOVON. 5: 334-335. 1995. — *Stereodon pennatulus* Mitt. ex Dix., Rec. Bot. Surv. India 6 : 66. 1914. — *Symphyodon pennatulus* (Mitt. ex Dix.) Dix. in Broth., Nat. Pfl. ed. 2, 11 : 267. 1925. — *Homalia erosa* Hamp. In Mason, nom. nud., Burma, Its People and Productions. Vol. II (Botany): 52. 1883; He, J. Hattori Bot. Lab. No. 81: 36-37. 1997.

Plants small to medium sized, 3-5 cm long, leafy stems 1.5-2.5 mm wide, strongly flattened, bright green to yellowish green, shiny mats. Primary stems creeping; secondary stems sparsely and irregularly branched; central strand absent; rhizoids smooth. **Primary stem leaves** scale-like; secondary stem and branch leaves similar, 0.8-1.2 mm x 0.50-0.65 mm, wide-spreading, strongly complanate, inserted in 8 rows, oblong-ovate to spatulate, forming a contracted base, rounded to truncate at the apex; leaf margins irregularly serrulate to erosely denticulate above the middle, entire below, slightly inflexed on the side at base, straight to slightly convex at the insertion; **costae** double, often forked at base, occasionally single, faint, extending to the mid-leaf; epical cells irregulary oblong-rhomboidal; upper and median leaf cells narrowly linear, 35-65 long, often thickened at the upper corners; basal angular cells oblong to rectangular. **Dioicous**. **Sporophytes** not found. (**Figure 5.57**)

Thailand — NORTHERN: Chiang Mai, Tak,; SOUTHEASTERN: Chanthaburi, Nakhon Nayok, Prachinaburi, Trat; PENINSULAR: Krabi.

Distribution — India and Myanmar.

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 831* (BCU)

GPS location — 18.55604432°N 98.48156434°E.

Altitude — 2,184 m

3. HOMALIODENDRON

Homaliodendron Fleisch, Hedwigia, 45. 74. 1906; Gangulee, Mosses E. India 6: 1412. 1976; Ninh., J. Hattori Bot. Lab. 57: 9**.** 1984; Gradstein, Churchill & Salazar-Allen, Mem. New York Bot. Gard., vol. 86. 755. 2001.

Plants usually robust, dendroid, somewhat glossy, light-green or yellowish. **Secondary stems** erect or ascending, stipitate and sparsely foliate below, freely and sometime regularly 1-3 pinnate or frondose above; branches sometime flagellate-attenuate paraphyllia none. **Stipe leaves** small, scalelike, appressed and increasing in sized from the base of the stipe upward**. Leave** complanate, mostly plicate when dry, wide-spreading and asymmetric, broadly oblong-ovate to obovate, broadly rounded or rounded-obtuse; margins inflexed on one side at base, coarsely and irregularly incised-dentate above; **costa** single, slender, ending at or above the midleaf; **cells** smooth, subquadrate to rhombic above, longer and porose at base. **Dioicous**. **Seta** elongate, longer than capsules, pale yellow, smooth, straigth; **capsule** shortly exserted, yellow to brown, erect or nearly so, ovoid to cylindrical, smooth, not or slightly contracted near the mouth; annulus absent or nearly differentiated; **peristome** double, *Neckera* type. **Calyptra** cucullate, smooth, naked or hairy.

Key to the genera

1. Secondary stems pinnately frondose, on a stipe bearing short, appressed scale leaves; leaf cells 50-80 μm long.....*H. crassinervum*
1. Secondary stems sometime sparsely branch, sometimes coarsely bipinnately frondose, on a stipe not bearing short, appressed scale leaves; leaf cells 25-50 μm long.....*H. montagneanum*

1. *Homaliodendron crassinervum* THér.

Recueil Publ. Soc. Harvraise, Etud. Div. 1919: 39. 1919; Gangulee, Mosses E. India 6: 1425, fig. 705. 1976. Ninh., J. Hattori Bot. Lab. 57: 27, fig. 14**.** 1984.

Plants medium sized, 6.0-7.2 cm long, yellow-green plants with long creeping main stem. Secondary stem pinnately frondose on a stipe bearing short, appressed scale leaves. **Upper leaves** complanate, horizontally spread, longitudinally plicate when dry, asymmetrically ovate-spathulate, 1.4 mm x 0.65 mm; leaf apex deeply serrate; margin serrate at top, inflexed on one side at base; **costa** single, ending below leaf tip; **leaf cells** 50-80 μm long, incrassate, smooth, rhomboid; leaf base cells elongate, . Lower lamina shows one row of short and compressed cells, rectangular cells at three inner rows. Branch leaves erecto-patent to spreading, ovate-oblong with 3-5 teeth. **Pericheatial** leaves long and narrow tops. **Sporophytes** not found. (**Figure 5.58**)

Thailand — NORTHEASTERN: Nakhon Ratchasima.

Distribution — Kampuchea, Nepal, and Vietnam.

Ecology — On tree trunks.

Specimens examined — *Y. Nathi 555, 643, 659, 682, 691, 781* (BCU)

GPS location — 18.58904°N 98.48723°E, 18.58809°N 98.48652°E, 18.58904°N 98.48723°E, 18.58892519°N 98.48474468°E.

Altitude —2,550-2,556 m

2. *Homaliodenron montagneanum* (C. Muell.) Fleisch.

Hedwigia, 45. 74. 1906; Horikawa& Ando. Nat. & Life in Southeast Asia (ed. Kira & Umesao) 3: 1-44. 1964; Gangulee, Mosses E. India 6: 1419, fig. 701. 1976; Ninh., J. Hattori Bot. Lab. 57: 17, fig. 7-9**.** 1984.

Plants robust, yellow-green. Secondary branches erect or inclined from a strong stipe bearing minute scaly leaves, 6-12 cm long, complanate, sparsely branched or frondose. **Leaves** horizontally spread, longitudinally plicate when dry, asymmetrically ovate-lingulate, 2.8-3.9 mm long and 1.8-2.0 mm wide; leaf apex rounded, strongly serrate; margin smooth below, inflexed on one side at base; **costa** single, covering 2/3 of leaf length; **leaf cells** 25-50 μm long, incrassate, smooth, rhomboid to quadrate at top with a marginal row of smaller cells, gradually more elongate below and porose walled. **Pericheatial leaves** erect, narrow, small. **Sporophytes** not found. (**Figure 5.59**)

Thailand — NORTHERN: Chiang Mai; PENINSULAR: Yala.

Distribution — Borneo, Mainland China, India, Java, Myanmar, Nepal, and Vietnam.

Ecology — Common on tree trunks.

Specimens examined — *Y. Nathi 126, 243, 704, 740, 767, 875, 923* (BCU)

GPS location — 18.5887674°N 98.48422073°E, 18.5578328°N 98.48141070°E, 18.58957873°N 98.48559025°E, 18.58809186°N 98.48389006°E, 18.58925°N 98.48741°E, 18.58837°N 98.48686°E, 18.58904°N 98.48723°E

Altitude —2,301-2,525 m

4. NECKERA

Neckera Hedw., Sp. Musc. 200. 1801; Gangulee, Mosses E. India 6. 1387. 1976; Nog., Ill. Moss Fl. Japan 3: 694. 1994; Gradstein, Churchill & Salazar-Allen, Mem. New York Bot. Gard., vol. 86. 743. 2001.

Plants robust, shiny, pale-green to golden, usually strongly flattened. Secondary stems erect, horizontally spreading, or pendent, sparsely to irregularly or regularly pinnate or bipinnate; paraphyllia none, few, or numerous, simple to branched polymorphous. Branches blunt or tapered, sometimes flagelliform. **Leaves** mostly undulate, asymmetric, oblong-lingulate to oblong-ovate, acute to acuminate; margins inflexed on one side near the slightly decurrent base, sometimes serrulate or denticulate; **costa** short and double or single, occationally lacking; **leaf cells** smooth, pitted, rhomboidal at the apex, becoming long-rhomboidal below, often subrectangular at the basal angles. **Inner pericheatial leaves** oblong-ovate, variously acuminate, with costa short, single, indistinct, vanishing well belowmidleaf. **Seta** short or elongate; **capsule** immersed to exserted, erect and symmetric, subglobose to oblong-cylindric; **peristome** usually double. **Calyptra** generally cucullate, mostly naked.

Neckera himalayana Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 2: 121. 1859; Gangulee, Mosses E. India 6: 1387. 1976; Gradstein, Churchill & Salazar-Allen, Mem. New York Bot. Gard., vol. 86. 743. 2001.

Plants medium size, green. Primary stem creeping. Secondary stem pendulous, irregularly pinnately branched, 6-15 cm long, complanate foliated. **Leaves** ovate to lingulate, obtuse, to 2.8 mm long, slightly concave, distinctly transversely undulate, widely spreading even in dry condition; margin almost entire or minutely crenulate; **costa** single, reaching half of leave length. Lamina cells rhomboid, porose. **Seta** to 2 cm long, smooth, **Capsule** exserted, ovoid, 2 mm long, with long beak calyptra. (**Figure 5.60**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Bhutan, India, Myanmar, Nepal, Sikkim, and Sri Lanka.

Ecology — On tree trunks and branches.

Specimens examined — *Y. Nathi 134, 170, 268, 590, 781, 808, 893* (BCU)

GPS location —18.5884407°N 98.48576023°E, 18.5887674°N 98.48422073°E, 18.5577005°N 98.48041576°E, 18.55602010°N 98.47636890°E, 18.58883869°N 98.48426524°E.

Altitude — 2,213-2,545 m

5. NOGUCHIDENDRON

Noguchiodendron Pócs & Ninh., Acta Bot. Acad. Sci. Hung. 27: 161. 1981.

Plants medium, 3-10 cm long. Stem erect from the tree trunk, upper portion forming pinnately branched frond, strongly curled and not so complanat in dry condition. **Stem leaves** and branch leaves oblong-ovate to ovate, obtuse and serrulate at apex; costa single. **Lamiana** cells slightly incrassate, smooth, rhomboid.

Noguchiodendron sphaerocarpum (Nog.) Ninh & Poes

Acta Bot. Acad. Sci. Hung. 27: 161. 1981; Tanaka, Maung Zaw,Gay Ngai & Akiyama, Makinoa New Ser. 3: 38, fig. 40. 2003.— *Homaliodendron sphaerocarpum* Nog., Fl E. Himalaya: 576. 1966; Gangulee, Mosses of Eastern India and adjacent Regions, Fasicle 6. 1421, fig. 702. 1976; Ninh., J. Hattori Bot. Lab. 57: 23, fig. 11**.** 1984.

Plants yellow green, fairly robust; secondary branches pinnately frondose on a stipe bearing amall leaves, 7-12 cm long. **Upper stem leaves** glossy, horizontal to erect spreading, longitudinal plicate when dry, complanate, asymmetrical, ovate-spathulate, 1.5-1.8 mm long and 1.0 mm wide; apex obtuse, sharp teeth, narrowed down to acute point; base decurrent; margin serrate-dentate at tip, dentate-crenulate at base of tip, inflexed at one side of leaf base; **costa** single, vanishing below leaf tip; **leaf cells** incrassate, smooth, rhomboid, subquadrate at tip, gradually longer below. Branch leaves similar to upper stem leaves, but smaller. **Sporophytes** not found. (**Figure 5.61**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Bhutan, Nepal, and Sikkim**.**

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 751* (BCU)
GPS location — 18.58938°N 98.48575°E
Altitude — 2,141 m

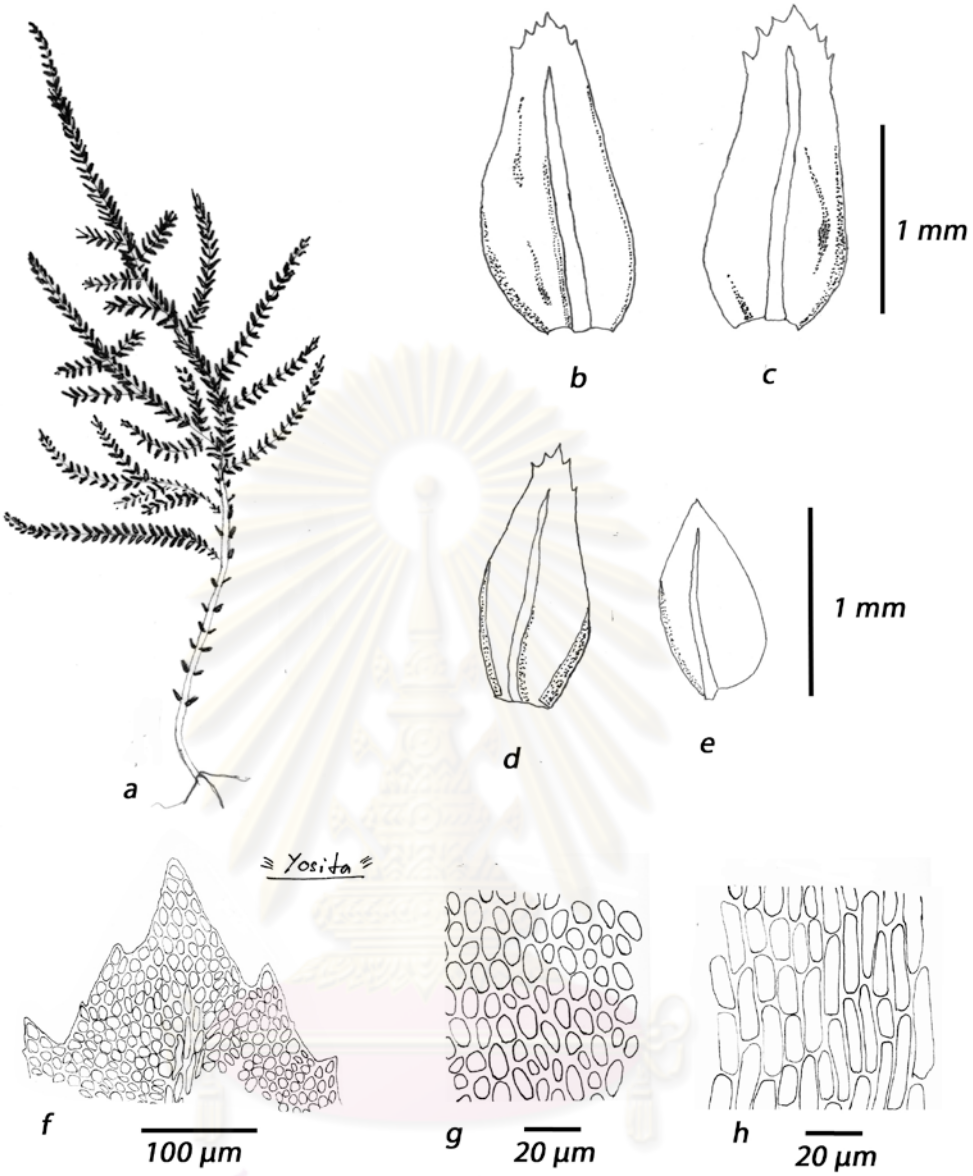
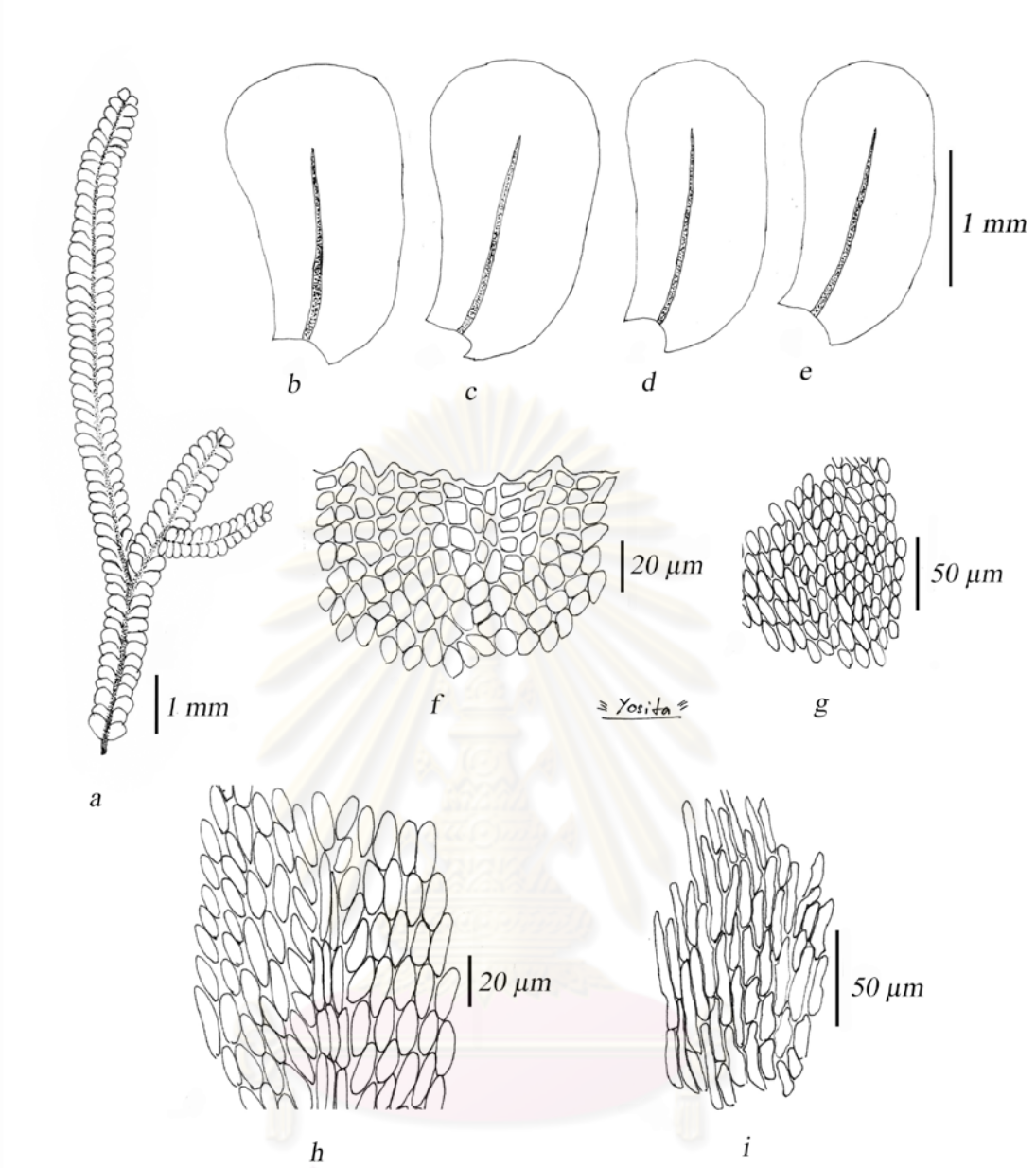


Figure 5.56 ***Curvicladium kurzii*** (Kindb.) Enroth

a. habit; b., c., d. leaves; f. cells at leaf apex ; g. cells at median leaf; h. cells at leaf base. Based on *Y. Nathi 741*.



Fogure 5.57 ***Homalia pennatula*** (Dix.) He & Enroth

a. portion of plant; b., c., d., e. leaves; cells at leaf apex; g. cells at upper part of leaf; h. cells at median leaf; i. cells at basal leaf. Based on *Y. Nathi 831*.

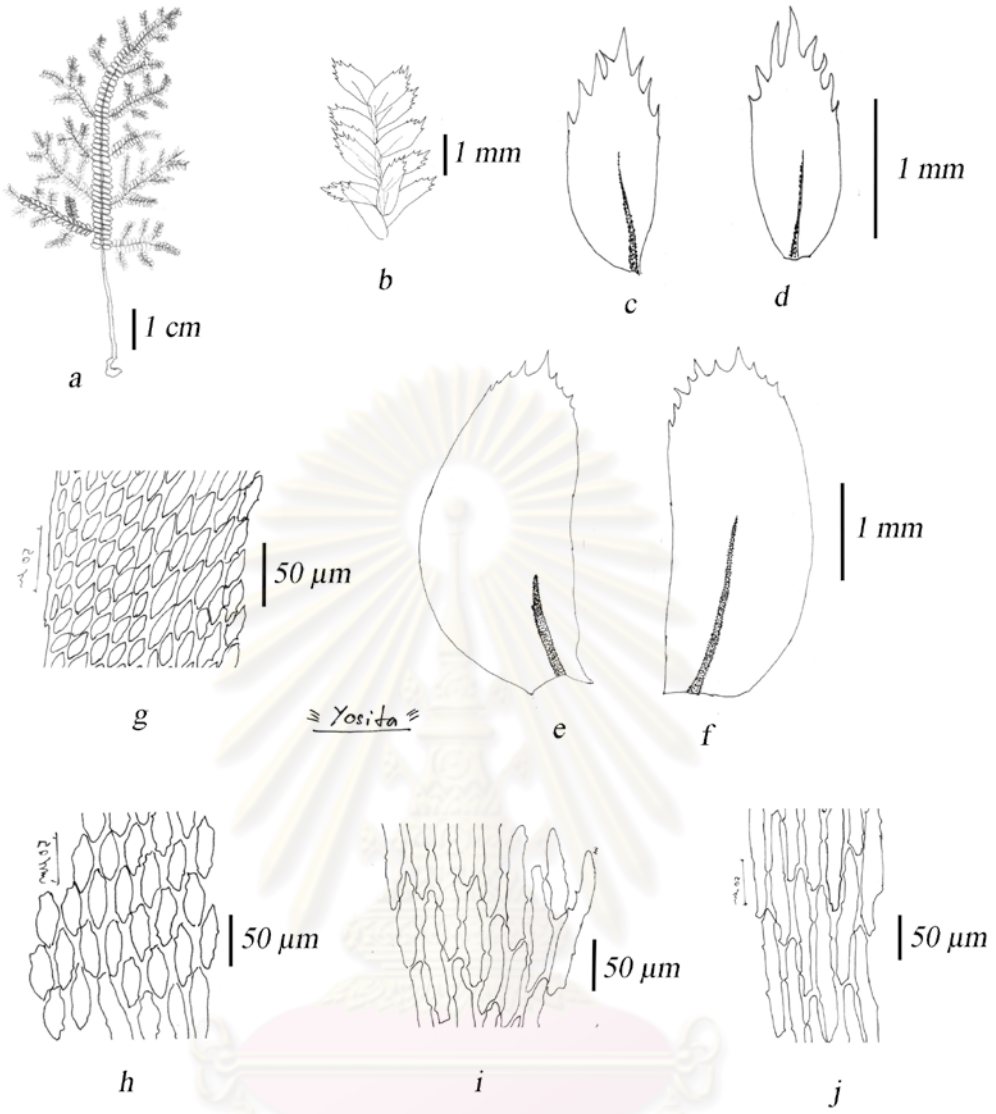


Figure 5.58 ***Homaliodendron crassinervum*** THér.

a. habit ; b. portion of plant ; c., d., branch leaves; c., f. leaves; g. cells at leaf margin; h. cells at median leaf; i. cell at lower leaf; j. cells at basal leaf. Based on *Y. Nathi* 659.

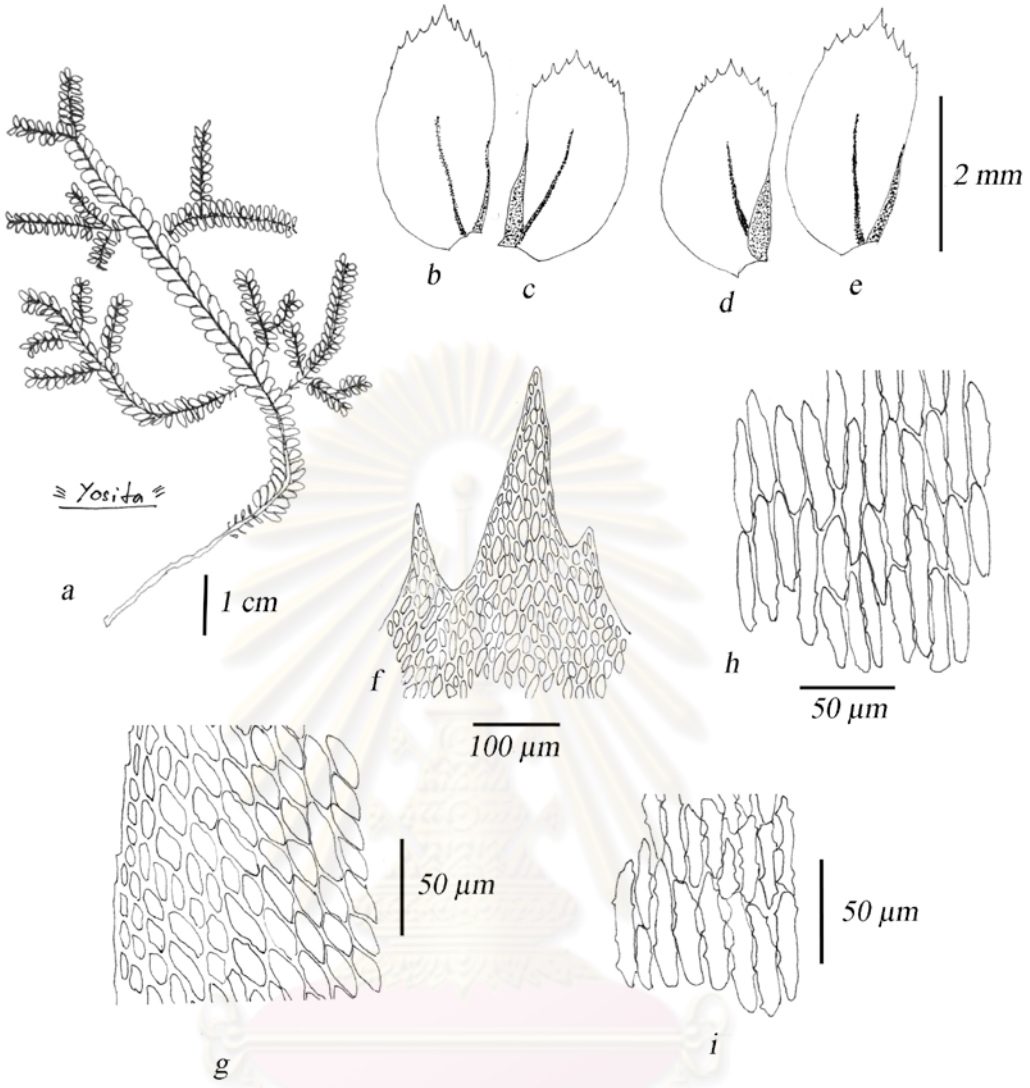


Figure 5.59 ***Homaliodenron montagneanum*** (C. Muell.) Fleisch.

a. habit ; b., c., d., e. leaves; f. cells at leaf apex; g. cells at leaf margin; h. cell at lower leaf; i. cells at basal leaf. Based on *Y. Nathi* 243.

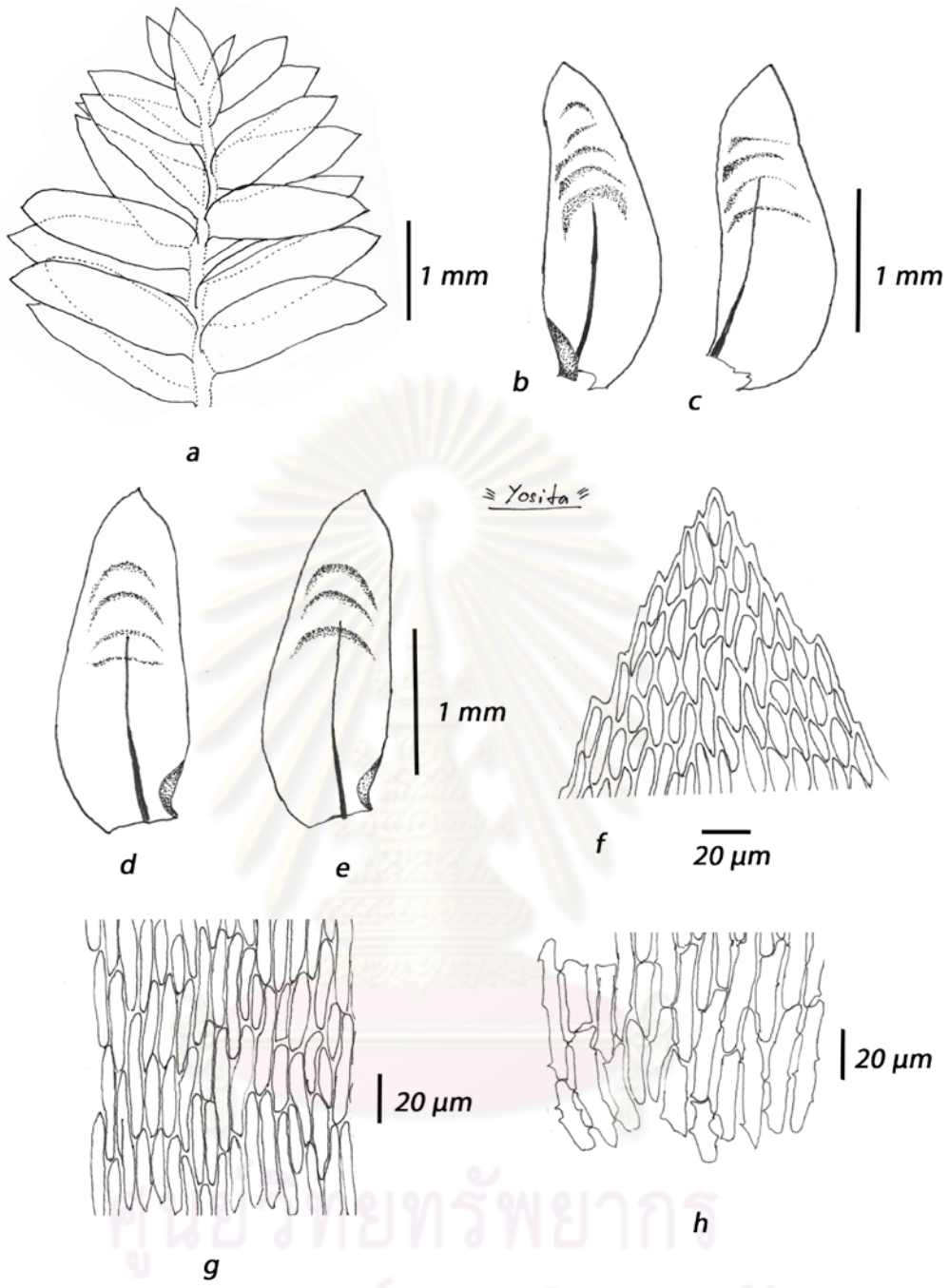


Figure 5.60 ***Neckera himalayana*** Mitt.

a. portion of plant ; b., c., d., e. leaves; f. cells at leaf apex; g. cells at median leaf; h. cells at basal leaf. Based on *Y. Nathi 590*.

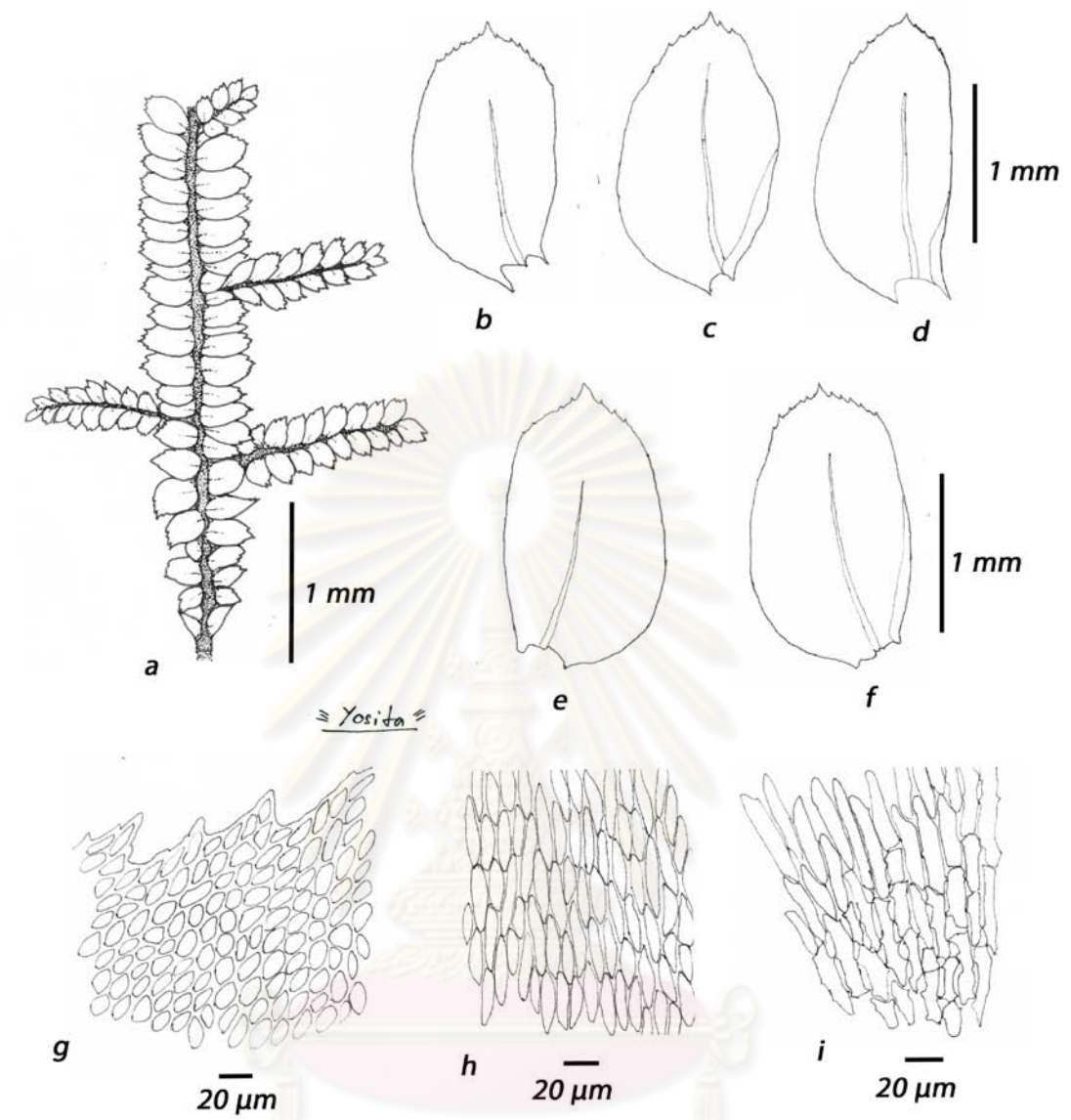


Figure 5.61 ***Noguchiodendron sphaerocarpum*** (Nog.) Ninh & Poes

a. portion of plant ; b., c., d., e., f. leaves; g. cells at leaf apex; g. cells at median leaf; h. cells at basal leaf. Based on *Y. Nathi 751*.

ORTHOTRICHACEAE

Plants small to robust, in dull or occasionally somewhat shiny, dark-green, red-brown, or greenish –brown tufts, cushion or mats. **Stems** erect-ascending and often forked or creeping with nurous erect-ascending, simple or forkedbranches. **Leaves** crowded, erect, spiral-twisted, crisped, conrted, or flexuose when dry, erect spreading to squarrose-recurved when moist, keeled, lingulate, ovate-lanceolate, or linear lanceolate, rounded-obtuse, acute, apiculate or hair-pointed, usually not decurrent; margins plane to revolute or rarely erect to incurved, sometimes denticulate to irregularly serrulate near the apex; **costa** single, strong, ending near the apex to excurrent; upper cells rounded-hexagonal or rarely rectangular to linear, often thick-walled and commonly papillose, rarely smooth and flat to convex; basal cells subquadrate, rectangular or linear, sometimes bulging, smooth, papillose, or tuculate; alar cells rarely differentiated. **Pericheatial** terminal. **Seta** very short to elongate, erect or flexuose-twisted; **capsules** immersed, emergent, or exserted, erect and symmetric, ovoid, cylindric, sometimes 8-16 ribbed; **opercula** convex to conic, rostrate; stomata superificial or immersed, usually below the middle of capsules; **peristome** none, single or double, often rudimentary; exostome teeth 16, lanceolatedensely papillose or striate; endostome thin, hyaline.

MACROMITRIUM

Macromitrium Brid., Mantissa music: 132 .1804; Gangulee, Mosses E. India 5: 1169. 1974; Eddy, Handb. Males. Mosses 3: 30. 1988; Sharp, Crum, and Eckel, Moss Fl. Maxico, Part 2: 621. 1994;

Plants extremely variable in seize and colour, olive to bright orange-brown, slender or robust, primary stems creeping, usually closely adherent to substrate with dense rhizoidal mats; **leaves** variously reduced; branches short or elongate, densely foliate. Branch leaves variable in attitude, often distinctly arranged in linear or shallowly spiral ranks, often strongly curled and contorted when dry; costae; **costa** varying from sub-percurrent to long-excurrent, in section with few (usually 2) guide cells and a thin abaxial stereid band. **Lamina cells** extremely variable, often in the same leaf, the upper usually short and papillose or mamillose, the basal usually strongly elongate, thick-walled, and with or without tall tubercles or mammillae. Mainly phyllodioecious and markedly anisosporous; male plants dwarf, consisting of a few small bracts and a cluster of antheridia and paraphyses; **perichaetia** weakly to strongly differentiated; **seta** short or long, smooth or papillose. **Capsule** erect, ovoid, usually narrowed at mouth and sulcate when dry; lid

erect, acicular. **Peristome** double often weak and sometimes reduced to ribbon-like vestiges.

Macromitrium sulcatum (Hook.) Brid.,

Bryologia universa 1:319. 1826; Gangulee, Mosses E. India 5: 1181. 1974; Eddy, Handb. Males. Mosses 3: 63. 1988. — *Schlotheimia sulcata* Hook., Musci Exot. 2: 156. 1819.

Plants variable, usually robust, slightly glossy, rufous-brown; branches turgid, 3.5-5.3 cm long, with abundant rhizoids below. **Leaves** dense, widely spreading when moist, flexuose and usually rugose or more or less undulate and contorted distally, not obviously ranked, 2.0-5.5 mm long, lanceolate or ovate bases gradually tapered to narrowly or broadly acute apices, sometimes subobtuse and mucronate; margins plane, entire below, finely crenulate or denticulate in upper acumen; **costa** reddish, percurrent or shortly excurrent; **upper lamina cells** rather irregular, quadrate-rotund, with slightly to strongly thickened walls, superficially protuberant but not conspicuously mamillate or papillose; lower lamina cells becoming pellucid, elongate, strongly incrassate with sinuate-pitted walls, towards leaf insertion becoming strongly tuberculate, those at the leaf angles especially so; a small but usually sharply delimited area of large, thin-walled hyaline and yellowish cells situated on one or both sides of the costa. **Dioecious**: perichaetial leaves ovate, rerect and sheathing the base of the seta; **seta** smooth, very variable in length, mainly beween 1-2 cm; **capsule** ovoid, faintly but distinctly grooved when moist, strongly sulcate when dry; **peristome** double, exostome a tall, muricate and finely papillose membrane with short crenellations; endostome concealed by the exostome; **calyptra** campanulate, elegantly multiplicate and laciniate, naked. (**Figure 5.62**)

Thailand — NORTHERN: Chiang Mai; EASTERN: Nakhon Ratchasima; SOUTHEASTERN: Nakhon Nayok

Distribution — Borneo, India, Kampuchea, Malay Peninsula, Myanmar, Nepal, Philippines, Sri Lanka, and Vietnam.

Ecology — on tree trunks and branched.

Specimens examined — *Y. Nathi 133, 211, 275, 401, 501, 576, 753* (BCU).

GPS location — 18.5884407°N 98.48576023°E, 18.5563194°N 98.48220748°E, 18.5583313°N 98.47963390°E, 18.58923079°N 98.4874572°E, 18.55318073°N 98.4782689°E.

Altitude — 2,188-2, 559 m.

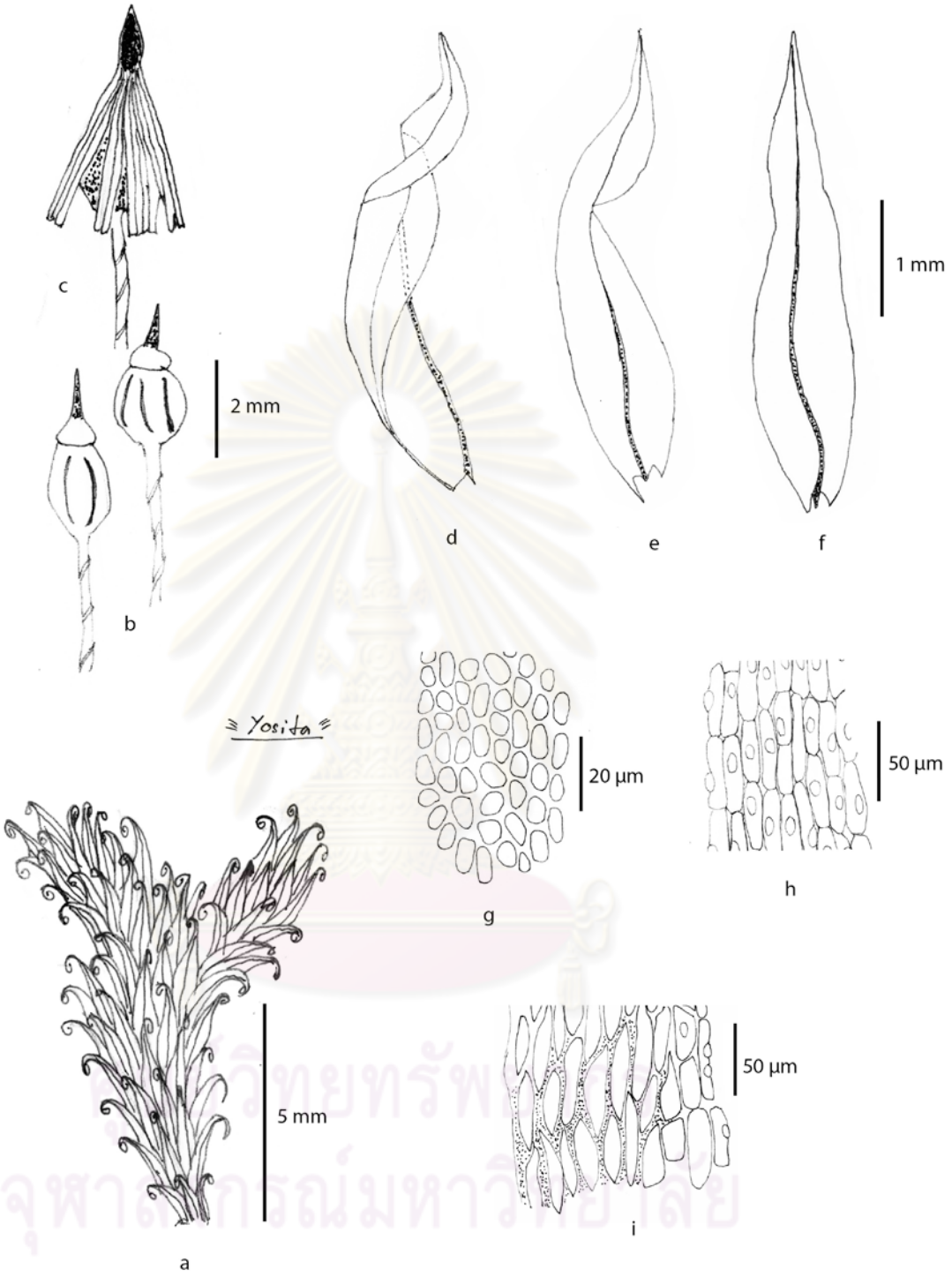


Figure 5.62 ***Macromitrium sulcatum*** (Hook.) Brid.,
a. habit; b. capsules; c. calyptra ; d., e., f. leaves ; g. cells at median leaf ; h. cells at lower leaf; i. cells at basal leaf. Based on *Y. Nathi 275*.

PLAGIOTHECIACEAE

Plants of moderate size, in flat, shiny, green or yellow- green mats. Stems simple or sparsely and irregularly branched; outermost cortical cells, as seen in section, large and thin- walled; rhizoids smooth, arising below leaf insertions, sometimes at leaf tips; paraphyllia none; pseudoparaphyllia none(or rarely foliose). **Stem and branch leaves** similar, erect-spreading to aquarrose and generally strongly complanate, occasionally falcate, sometimes second at the tips, little altered on drying, symmetric to asymmetric, ovate to ovate-lanceolate, broadly acuminate, decurrent, often strongly so; margins plane or sometimes recurved, especially at the base, often serrulate at the apex; **costa** short and double(1 branch often 1/3 - ½ the leaf length) , sometimes indistinct; upper cells smooth, linear to linear – flexuose; **alar cells** inflated and often spherical, those of the decurrencie quadrate to oblong, thin walled. **Antoicous** or dioicous. **Seta** elongate, straight,orange-brown, smooth, twisted when dry; **capsule** erect or inclined, straight or curved, ellipdoidal, smooth or striate, tapered to a wrinkled neck, and somewhat contracted below the mouth when dry; annulus of 2-3 rows of deciduous cells; **operculum** conic to short – rostrate; exostome teeth cross-striolate below, paillose above, bordered, trabeculate; endostome consisting of a high basal membrane and keeled segments alternating with 1-3 cilia. **Spore** spherical to ellipsoidal, smooth or papillose. **Calyptra** cucullate, smooth, naked.

PLAGIOTHECIUM

Plagiothecium Schimp. in B.S.G., Bryl. Eur., 5: 179. 1851; Gangulee, Mosses E. India 8; 1802. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1994.

Plants large to medium-sized. Stems crowed, protrate or ascending, mostly complanate-foliate; the outermost cortical cells with thin surface walls. Pseudoparaphyllia lacking. **Stem leaves** and branch leaves similar, ovate to ovate-oblong, asymmetric or rarely obtuse at apex; basal and upper leaves smaller; margin erect, entire; **costa** forked at base, short or sometimes long, median laminal cells elongate-hexagonal to linear, with acute ends,uniformly thin-walled; lower laminal cells lax; **alar** regions usually not well differentiated. **Dioicous** or autoicous. Perichaetia on the basal part of stem. Perichaetial leaves few, ecostate. **Setae** elongate, smooth. **Capsules** inclined to horizontal, narrowly oblong to cylindrical, attenuate and with few stomata at apophysis; annulus persistent. **Peristome** hypnoid, lamellae large. Spores medium-sized. Axillary fusiform **Gemmae** often present.

Plagiothecium neckeroideum Schimp.

B. S. G. Bry. Eur. 5: 195, t. 505.1851; Gangulee, Mosses E. India 8: 1807. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1994.

Plants large, pale-green, ± glossy. Stems with few branches, attenuate at apex. Branches complanate-foliate, ca. 3 mm with **leaves**. **Leaves** lax, ± contorted, scarcely overlapping, broadly spaced when dry, spreading in 2 rows when moist, ovate, acute, asymmetric, the lateral **leaves** wide-spreading, the anterior side broadly curved, the posterior side narrower, less curved, asymmetric, to 2.0 x 0.9 mm, shortly decurrent, with fasciculate fusiform **Gemmae** and rhizoids at apex; margin plane, entire; **costa** short, forked above. Median laminal cells linear, ± vermicular, 80-90 x 4.0-4.5 μm; lower larminal cells shorter leaf insertion lax, oblong to elongate-rectangular, 40-60 x 12-15 μm, thin-walled; **alar** regions not differentiated; the cells of decurrent wings elongate-rectangular, not inflated. (**Figure 5.63**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Borneo, Mainland China, Japan, Java, India, Nepal, Philippines, Sikkim, Sumatra, and Taiwan

Ecology — on tree trunks and rotten logs.

Specimens examined — *Y. Nathi* 363, 376, 614, 624, 687, 700, 852, 1034 (BCU)

GPS location — 18.58904304°N 98.4872297°E, 18.58953891°N 98.48577691°E, 18.55600376°N 98.47817411°E, 18.55836242°N 98.4796693°E.

Altitude —2, 550 m.

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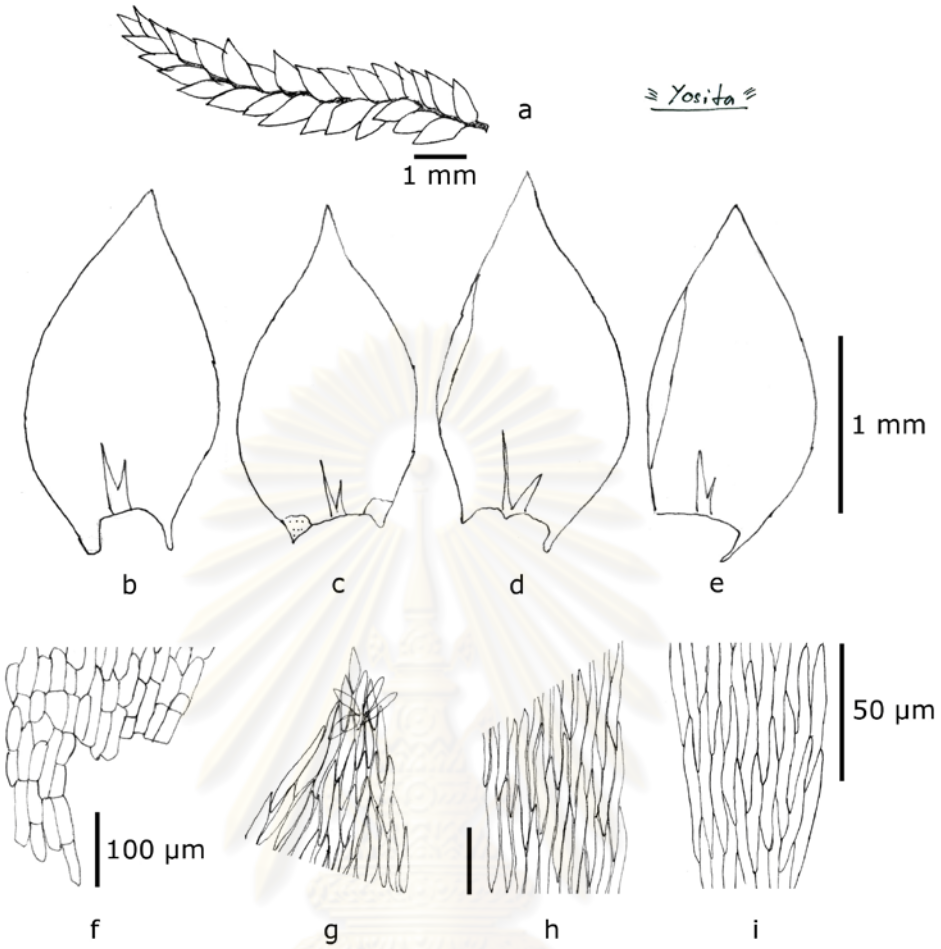


Figure 5.63 ***Plagiothecium neckeroideum*** Schimp.
a. portion of plant; b., c., d., e. leaves; f. cells at leaf base; g. leaf apex; h. cells at median leaf; i. cells at lower leaf. Based on *Y. Nathi 376*.

POLYTRICHACEAE

Plants small, medium to large, densely to loosely caespitose or scattered among other bryophytes, rarely with individual plants scattered on a persistent protonema. **Stems** erect, acrocarpous, from a developed underground rhizome, simple or rarely branched, bracteate proximally, grading gradually or abruptly to mature leaves. **Leaves** with a chartaceous, sheathing base and a divergent, firm-textured blade, or the whole leaf membranous and sheath not or weakly differentiated, the blade rarely transversely undulate, crisped and contorted when dry; adaxial surface of blade with numerous closely packed longitudinal photosynthetic lamellae across most of the blade, the marginal lamina narrow, or the lamellae restricted to the costa, flanked by a broad, 1 (rarely 2)-stratose lamina, rarely with abaxial lamellae; margins 1(-3)-stratose, entire, denticulate, serrate, or toothed; **costa** narrow in basal portion, in the blade abruptly broadened and diffuse, smooth or toothed adaxially, rarely with abaxial lamellae, in cross section with a prominent arc of large diameter guide cells and an abaxial stereid band; lamellae entire, finely serrulate, crenulate, or coarsely serrate, the marginal cells in cross-section undifferentiated or sharply distinct in size and/or shape from those beneath; cells of back of costa typically in longitudinal rows, isodiametric to transversely elongate-hexagonal. **Dioicous** or rarely monoicous. **Seta** solitary or rarely several from the same perichaetium. **Capsule** obtuse, with indistinct longitudinal angles or ridges, or terete; **peristome** pale or strongly pigmented, nematodontous, with a single series of [16-]32-64 rigid, unjointed teeth composed of elongate, fiber-like, sinuate cells, the teeth simple or compound, attached by their tips to the epiphragm covering the capsule mouth. **Calyptra** cucullate, with a matted felt of hairs arising from its tip and covering all or part of the capsule, or the calyptra sparsely ciliate to smooth.

Key to the genera

1. Ventral lamella of leaves only narrow costa, less than 10 rows.....
   .....1.*Oligotrichum*
2. Ventral lamella of leaves on rather broad costa, more than 10 rows.....
   .....2. *Polytrichaceae*

1. OLIGOTRICHUM

Oligotrichum Cand. In Lam. & Cand. Fl. Franc. (ed. 3) 2: 491. 1805; Gangulee, Mosses E. India 1: 83. 1969; Nog., Ill. Moss Fl. Japan 1: 26. 1994; Wu & Wang, Moss Fl. China 8: 319. 2005.

Plant small, brownish green, erect, usually in tufts. **Lower leaves** small, scale-like, upper leaves larger, crowded, incurved, contorted or crisped when dry, with an oblong, lingulate or lanceolate limb arising from a well-defined sheathing base, concave, not bordered; **costa** with several lamellae on both sides; ventral lamellae straight or wavy, variable in height, notched and crested or crenate in profile, the marginal cells scarcely different from the rest; **dorsal lamellae** long but low, ridged or toothed. Dorsal surface of lamina often bearing many, short and serrate lamellae. Leaf margin involute, not border; costs stout. Limb with unistratose lamina, leaves cells hexagonal to quadrate, thin-walled, somewhat longer towards leaf base. **Dioicous**. **Seta** long smooth; **capsule** inclined, cylindric, without appophysis and ridges; operculum convex, with short oblique beak. **Peristome** teeth 32 or more. **Calyptra** cucullate.

Key to the species

1. Leaves oblong, obtuse; ventral lamellae slightly wavy, 3-10 rows..... ..... *O. obtusatum*
1. Leaves narrowly ovate laceolate; ventral lamellae longitudinally undulate or crisped, usually 5-6 rows .....*O. semillatum*

1. *Oligotricum obtusatum* Broth.

Symb. Sin. 4: 133. 1929; Wu & Wang, Moss Fl. China 8: 324, Pl. 754, figs. 1-11. 2005;

Plants rather small, 0.5-1.2 cm high, brownish green to redish brown, often in turfts. **Leaves** nearly oblong-oval, 1.5-2.0 mm x 0.5-1.2 mm, usually concave; margins serrate; **costa** somewhat broad, ending near the apex; **ventral lamellae** slightly wavy or crisped, usually in 3-10 rows, 3-5 cells high; on leaf back with only a few spines; median leaf cells rounded quadrate to irregularly oval, 9-15 μm wide; basal cells elongate or irregularly rectangular, slightly thick-walled. **Dioicous**. **Sporophytes** not seen. (**Figure 5.64**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China and Nepal.

Ecology — on soil along the road side.

Specimens examined — *Y.Nathi 196, 955 (BCU*)

GPS location — 18.58863°N 98.48661°E.

Altitude —2,190-2,493 m

Note — New record to Thailand.

2. *Oligotrichum semilamellatum* (Hook. F.) Mitt.

J.Proc. Linn. Soc., Bot., Suppl. 2: 150.1859; Gangulee, Mosses of Eastern India and Adjacent Regions, Fascicle 1: 77. 1969; Wu & Wang, Moss Flora of China, vol. 8: 324, Pl. 754, figs. 1-11. 2005.

Plants small to medium-sized, 1-2 cm high. **Stems** with weakly developed central strand; rhizoids numerous at base, loosely arranged, **upper leaves** usually revolute when dry, erect spreading when moist; middle leaves 2.5-4.5 mmx0.5-0.8 mm, sheathing or often clasping at base; margins serrate; **costa** somewhat broad, vanishing below the apex; **ventral lamellae** longitudinally undulate or crisped, usually 5-6 rows, 3-6 cells high; on the leaf back, sometimes with low lamella, 1-3 cells high; **leaf cells** unistratose; median cells rounded quadrate; basal cells mostly elongate, rather thin-walled. **Dioicous. Sporophytes** not found. (**Figure 5.65**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China and the Himalayas.

Ecology — moist substrates along roadsides.

Specimens examined — *Y. Nathi 29 (BCU)*

GPS location — 18.5890140°N 98.48710041°E

Altitude — 2,500 m**.**

Note — New record to Thailand.

2. *POGONATUM*

Pogonatum P. Beauvois, Mag. Encycl. 5: 329. 1804; Nog., Illustrated Moss Flora of Japan, part 1: 26. 1994; Wu & Wang, Moss Flora of China, vol. 8: 328. 2005;

Plants medium to large, in loose pure tufts or growing among other bryophytes, or individual stems small and scattered over a persistent protonemal mat. **Stems** simple or branched by subfloral innovations. **Leaves** with a sheathing base merging gradually or ± abruptly contracted to the blade, the sheath entire (toothed in *P. contortum*), with or without incrassate hinge-cells at the shoulders, not hyaline-margined; margins serrate, toothed, or entire, without a differentiated border of elongated cells**;** adaxial lamellae numerous and compact, occupying the full width of the blade, or somewhat fewer with an evident marginal lamina, marginal cells not differentiated, or strongly differentiated, thick-walled and coarsely papillose. Dioicous. **Seta** smooth. **Capsule** ovoid to short-cylindric, ± regular to somewhat asymmetric,

terete; hypophysis not differentiated, tapering; stomata none; exothecium mammillose to scabrous, the exothecial cells mamillate or with a single papillate projection of the outer wall; operculum rostrate from a convex base; epiphragm persistent, attached to the peristome teeth; peristome deeply reddish pigmented (at least in the median line), the teeth 32, compound, with median sinus narrow or almost obliterated. **Calyptra** with a densely matted felt of hairs, covering most or all over the capsule.

Key to species

1. Lamellae present only on ventral suface or lateral sides of the costa 2
1. Lamellae densely covering upper part of leaves except margins.....3
   2. Plants robust, up to 20 cm high; leaf apices broad; margins glossy tooth .....7. *P. proliferum*
   2. Plants slender, only 2 cm high, leaf apices narrow; margins serrulate ....6. *P. nuidiusculum*
3. Apical cells of lamellae double, flask-like..... 4. *P. microstomum*
3. Apical cells of lamellae single, not flask like .....4.
   4. Lamellae 1-3 cells high.....5
   4. Lamellae 3-6 cells high.....6
5. Apical cells of lamellae obtuse, 1-2 cells high.....1. *P. cirratum* ssp. *cirratum*
5. Apical cells of lamellae rounded to rectangular, 2-3 cells high ....2. *P. contortum*
   6. Apical cells of lamellae strongly papillose, 3-4 cells high .....5. *P. neesii*
   6. Apical cells of lamellae oblong or rounded quadrate, 4-6 cells high..... .....3. *P. inflexum*

1. *Pogonatum cirratum* (Sw.) Brid. ssp. ***cirratum***

Bryol. Univ. 2: 110. 1827; Hyvönen, Acta Bot. Fennica 133: 127. 1986; Wu & Wang, Moss Fl. China 8: 331.

Plants robust, rigid, brownish green, brown when old, usually loosely tufted. **Stems** 5-10 cm high, reddish. **Basal leaves** small, scale-like, upper leaves more or less crowded, erect patent when moist, crisped when dry, gradually narrowed form a widely oval and sheathing base, constricted to a narrow lanceolate limb, acuminate with a hairy spine at apex; **leaf margin** plane, bistratose, grossly dentate on the back; **lamella** often more than 50 ranks, only 1-2 cells high, apical cells obtuse, indistinct, partially in pairs; leaf marginal cells rounded or rounded oval. **Seta** single, 2-3 cm long, brownish red; **capsules** ovoid; exothecial cells smooth; **peristome** teeth 32, obtuse; membrane low. (**Figure 5.66**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Bhutan, Borneo, Celebes, Mainland China, Japan, Java, Laos, Malay Peninsula, Papua New Guinea, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On wet soil, on the mountain slope..

Specimens examined — *Y.Nathi 483, 620, 789* (BCU)

GPS location — 18.55437264°N 98.4788894°E.

Altitude — 2,190 m

2. *Pogonatum contortum* (brid.) Lesq.

Mem. Calif. Acad. Sci. I: 27. 1868; Noguchi, Ill. Moss Fl. Japan 1: 40; 1994. Wu & Wang, Moss Fl. China 8: 333, Pl. 757, figs. 1-12. 2005.

Plants large, dark green, brownish green when old, tufted in large patches**. Stems** 7 – 11 cm long, usually simple. **Basal leaves** small, deciduous; upper leaves erect patent when moist, strongly crisped when dry, slightly constricted from rounded oval base to a broad lanceolate limb, sheathing indistinct, 3-4 mm x 1 mm; **leaf margin** cell 1-2 layers, up to 3 cells wide, rarely remotely grossly toothed, teeth consisting of several cells, light brown; **costa** broad, with spines on the back; **lamella** about 40 ranks, disappearing along leaf margin, 2-3 cells high; apical cells of lamellae slightly differentiated, larger, round. **Dioicous. Seta** single, dark brown, 20-30 mm long; **capsule** erect, narrowly ovoid, ca 2.5 mm x 1.0 mm; exothecial walls mammillose; **peristome** teeth 32, lanceolate, obtuse at apex; membrane low. (**Figure 5.67**)

Thailand — Northern: Chiang Mai.

Distribution — China, Japan, Russia, and western North Amerca.

Ecology — on soils and rotten log.

Specimens examined — *Y. Nathi 56, 154, 205, 607, 638, 956, 1009 (BCU)*

GPS location — 18.5885913°N 98.48579259°E, 18.5888505°N 98.48477117°E, 18.5561391°N 98.48219197°E, 18.58959088°N 98.48569980°E, 18.58731226°N 98.48636775°E.

Altitude — 2,215-2,560 m

3. *Pogonatum inflexum* (Lindb.) Sande Lac.

Ann. Mus. Bot. Lugd. Bat. 4: 308. 1869; Noguchi, Ill. Moss Fl. Japan 1: 38, fig. 13, A. 1994;. Wu & Wang, Moss Fl. China 8: 336, Pl. 759, figs. 1-11. 2005.

Plants medium-sized, grayish green, brownish green when old. **Stems** single, mostly 1-3 cm long. **Basal leaves** loose, triangular or ovate-lanceolate; upper leaves tutted, incurved, crisped when dry, erect patent when moist, lanceolate from an oval sheath base, 4-6 mm x 0.5-0.7 mm, strongly constricted above sheath base, sharply acute and incurved at apex; leaf margins slightly incurved, unistratose, grossly toothed above; **costa** reddish, densely and sharply dentate above; **upper cells** large, often brown; **lamella** numerous, densely arranged on ventral surface, 4-6 cells high, in cross section., apical cells of lamellae plane, oblong or rounded quadrate, mostly wider than long, slightly thick-walled; lower cells quadrate, 20-35 um x 12-16 um, thin-walled. **Dioicous. Sporophyte** not found. (**Figure 5.68**)

Thailand — NORTHERN: Chiang Mai, Lamphun.

Distribution — China, India, Japan, Korea, Laos, Myanmar, Taiwan, and Vietnam.

Ecology — on soil.

Specimens examined — *Y. Nathi 676* (BCU)

GPS location — 18.58447138°N 98.4891016°E.

Altitude —2,446 m

4. *Pogonatum microstomum* (Schwagr.) Brid.

Bryol. Univ., 2: 745. 1827; Wu, Wang, & He, Moss Fl. China 8: 331. 2005.

Plants robust, forming a thick carpet on soil. **Stems** simple, 5-10 cm. **Leaves** to 5-9 mm long, lanceolate to ovate, wider, sheathing at base, appressed and some what incurved when dry, erect spreading when moist; **lamellae** green, occupying, almost the entire width of ventral surface of lamina; **margin** sharply toothed. **Seta** up to 2 cm long, reddish-brown. **Capsule** yellowish-brown, cylindric, straight or inclined. **Calyptra** densely covered with long hairs. (**Figure 5.69**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Bhutan, Mainland China, India, Indonesia, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology — On soil, on mountain slope and sandy rock.

Specimens examined — *Y. Nathi 199, 318, 329, 503, 567, 747, 517, 1170* (BCU)

GPS location ─ 18.5558408°N 98.48227453°E, 18.5608153°N 98.47721203°E, 18.5605574°N 98.47572969°E.

Altitude ─ 2,168-2,301 m.

5. *Pogonatum neesii* (Müll.Hal.) Dozy & Molk.

Bryol. Jav. 1: 40. Pl. 36. 1856; Hyvönen, Acta Bot. Fennica 133: 127. 1986; Wu, Wang, & He, Moss Fl. China 8: 342. 2005.

Plants pale green, forming dense tufts on soil. **Stems** erect up to 1 cm tall. **Leaves** up to 7 mm long, appressed and curled when dry, erect spreading when moist, lanceolate from a sheathing base; margins coarsely dentate; **lamellae** 3-4 cells high, strongly crenate in side-view, apical cells differentiated with strongly papilose and in many case incrassate outer wall. Lamina cells round or rectangular; **costa** strong but not distinct. **Seta** up to 1.7 cm long, straight, reddish-brown. **Capsule** cylindric, erect to straightly inclined, yellowish-brown. (**Figure 5.70**)

Thailand ─ NORTHERN: Chiang Mai, Phitsanulok; EASTERN: Nakhon Ratchasima; SOUTHEASTERN: Nakhon Nayok, Chanthaburi Ranong.

Distribution ─ Bhutan, Borneo, Celebes, Mainland China, India, Japan, Java, Kampuchea, Korea, Laos, Malay Peninsula, Myanmar, Nepal, Papua New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology ─ On wet soil.

Specimens examined ─ *Y. Nathi 417, 1047, 1095* (BCU)

GPS location ─ 18.58937982°N 98.4857483°E, 18.58447138°N 98.4891016°E, 18.55346848°N 98.47764798°E.

Altitude ─2,145-2,446 m

6. *Pogonatum nudiusculum* Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 2: 153. 1859; Wu, Wang, & He, Moss Fl. China 8: 343, Pl. 763. 2005.

Plants medium-sized, somewhat rigid, gregarious. **Stems** single, ca. 2.2-3.5 cm long. **Basal leaves** small, scale-like sheathing base indistinct; upper leaves ovate-lanceolate, strongly crisped when dry, 3.5-4 mm long; leaf margins sharply toothed; **costa** brown, excurrent, dentate on the back in the upper part; lamellae numerous on the ventral surface, covering ca. 2/3 the leaf width, 4-6 cells high, in cross section the paical cells of lamellae rounded,

thick-walled, smooth; upper leaf cells broad and short; basal leaf cells rectangular, thick-walled. **Seta** brown, ca. 3 cm long; **capsule** shortly cylindrical, erect or inclined; expthecial cells smooth; **peristome** teeth 32, with brown stripes. **Calyptra** covering the whole capsule. Spores globose, hyaline, 7-10 um in diameter. (**Figure 5.71**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Nepal, Bhutan, India, Sri Langka, and Philippines.

Ecology — on soil and rotten log.

Specimens examined — *Y. Nathi 110, 240, 682, 982* (BCU)

GPS location — 18.5881294°N 98.48610347°E, 18.5567133°N 98.48176475°E, 18.55698972°N 98.47696074°E.

Altitude — 2,188-2,536 m.

7. *Pogonatum proliferum* (Griff.) Mitt.

J. Proc. Linn. Soc., Bot., Suppl. 2: 152. 1859; Wang, Wu & He, Moss Fl. China 8: 347. 2005.

Plants robust, brownish green, often in large patches. **Stems** single, rarely branched above, up to 27 cm high, 0.8-1.2 cm wide with leaves. **Basal leaves** small, scale-like; upper leaves constricted from a sheathing base to a lanceolate limb, twisted or slightly crisped when dry, erect patent when moist, 0.6-1.8 cm x 1.2 1.8 mm, apices acute; leaf margins with multi-celled sharp teeth; **costa** brown, dentate at the back near apex; **lamella** sparse, only on the ventral surface of costa, 1-2 cells high, rounded oval, thin-walled, smooth, in cross section apical cells of lamellae slightly elongate; **upper leaf cells** irregular or rounded hexagonal, thick-walled; basal leaf cells quadrate to rectangular. **Dioicous**. **Seta** dark brown, 2-5 cm long, single; **capsule** inclined, oblong ovoid to cylindrical, brown, smooth; opercula beaked; peristome teeth 32, with dark brown stripes. **Calyptra** covering with dense yellowish hairs. (**Figure 5.72**)

Thailand — SOUTHEASTERN: Chon Buri, Trat, Ranong .

Distribution — Borneo, Java, Malay Peninsula, Papua New Guinea, Philippines, Sumatra, and Vietnam.

Ecology — on tree trunks, rotten log and soil.

Specimens examined — *Y. Nathi 140, 148, 632, 635, 814, 836, 1001* (BCU)

GPS location — 18.5883541°N 98.48560500°E, 18.55602010°N 98.47636890°E, 18.58877674°N 98.48578504°E, 18.55614457°N 98.48136032°E, 18.58783538°N 98.4851108°E.

Altitude — 2,219-2,560 m.

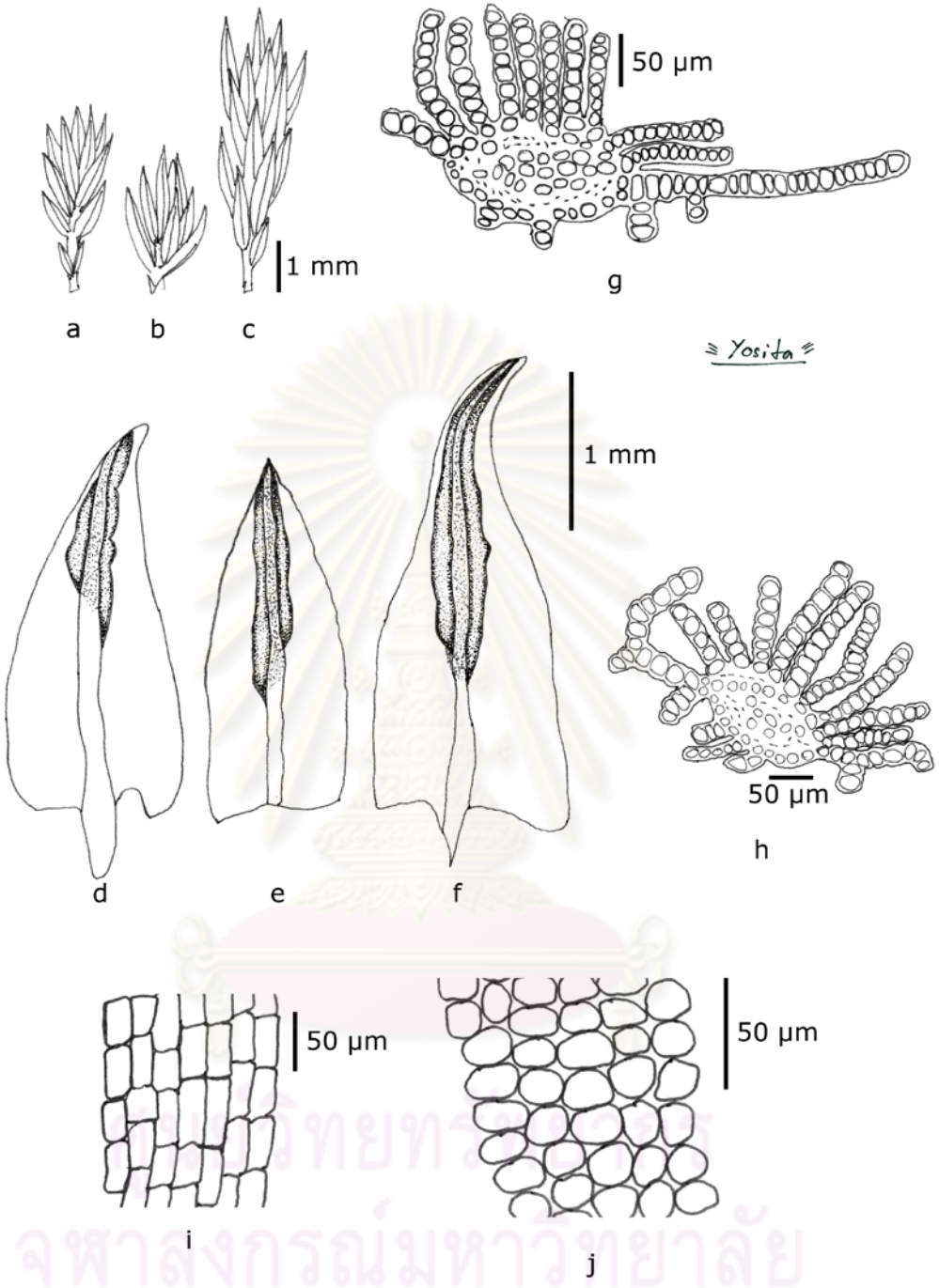


Figure 5.64 ***Oligotricum obtusatum*** Broth.
a., b., c. habits; d., e., f., leaves ; g., h. cross-section of leaf; i. cells at leaf base; j. cells at median leaf. Based on *Y. Nathi 196*.

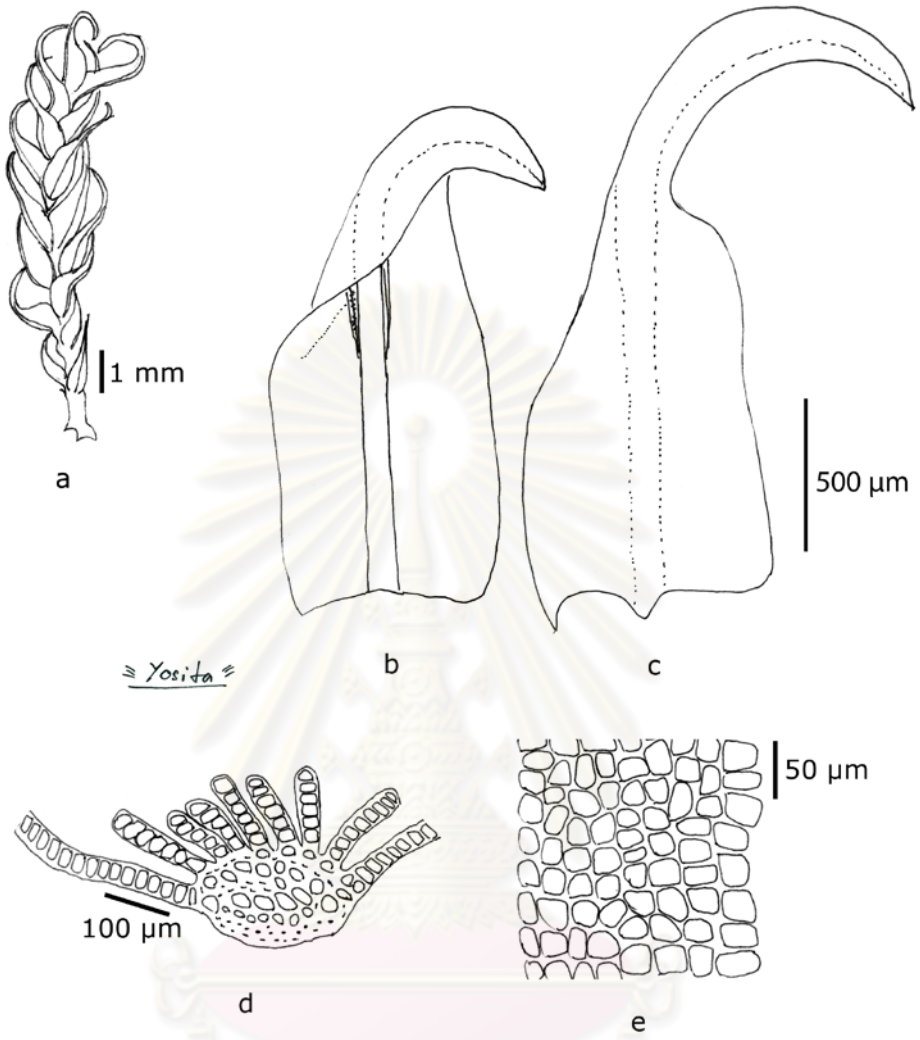


Figure 5.65 *Oligotrichum semilamellatum* (Hook. F.) Mitt.
a. habit; b., c. leaves; d. cross-section of leaf ; g. cells at median leaf. Based on *Y. Nathi 29*.

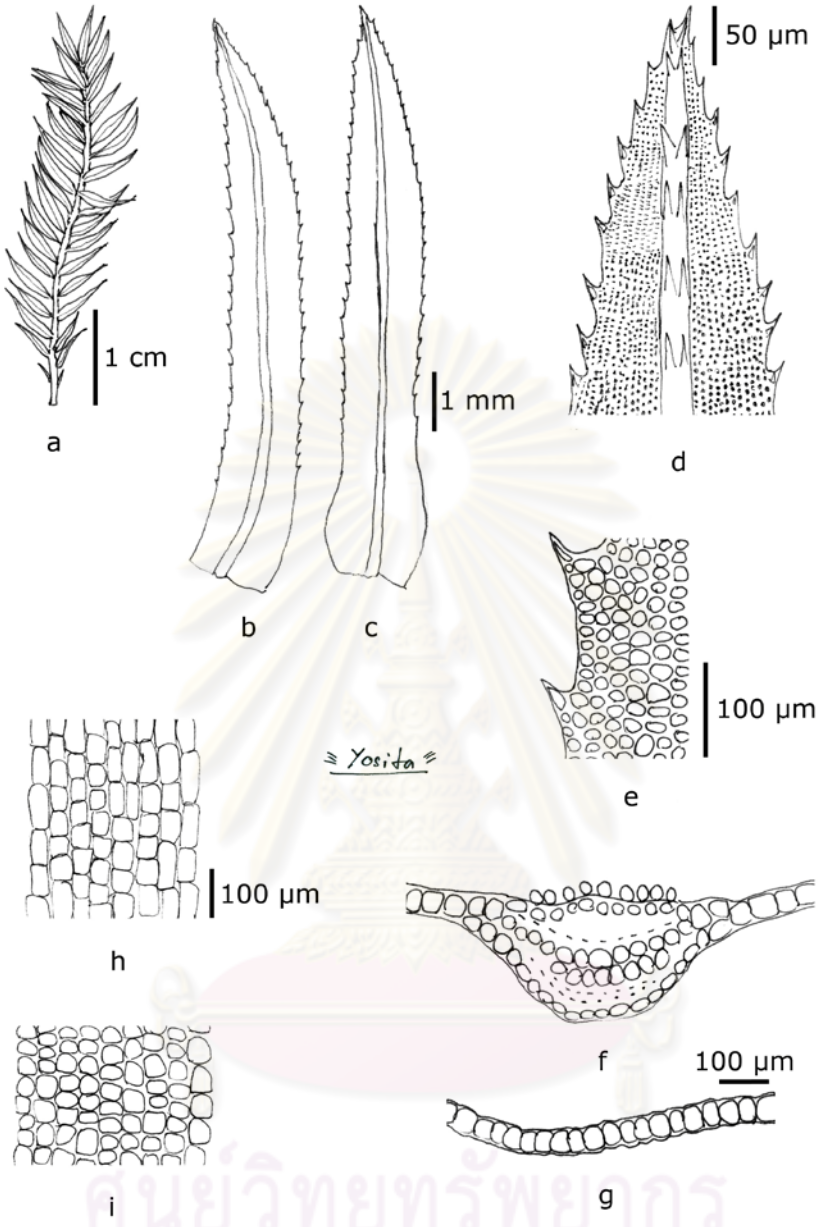


Figure 5.66 *Pogonatum cirratum* (Sw.) Brid. ssp. *cirratum*
a. habit; b., c. leaves; d. leaf apex ; e. leaf margin ; f. cross-section of costa ; g. cross-section of leaf blade. Based on *Y. Nathi 483*.

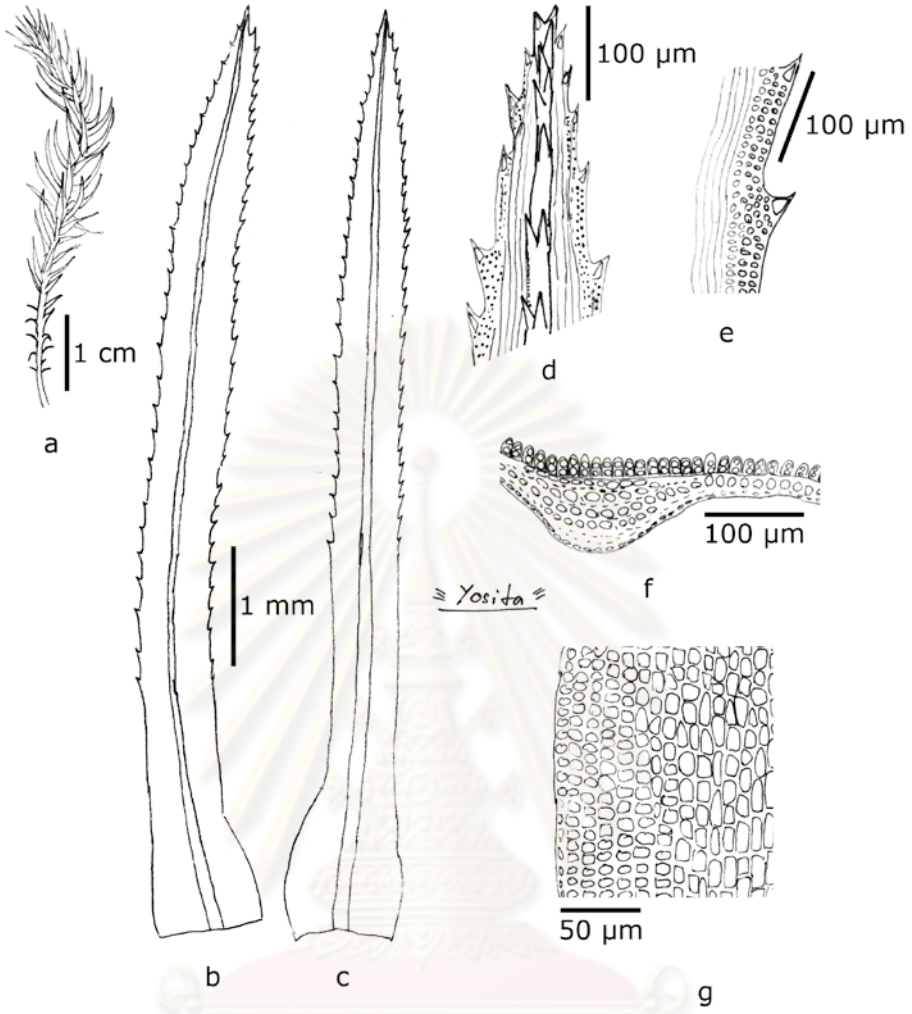


Figure 5.67 *Pogonatum contortum* (brid.) Lesq.
a. habit; b., c. leaves; d. leaf apex ; e. leaf margin ; f. cross-section of costa; g. cells at leaf based. Based on *Y. Nathi 56*.

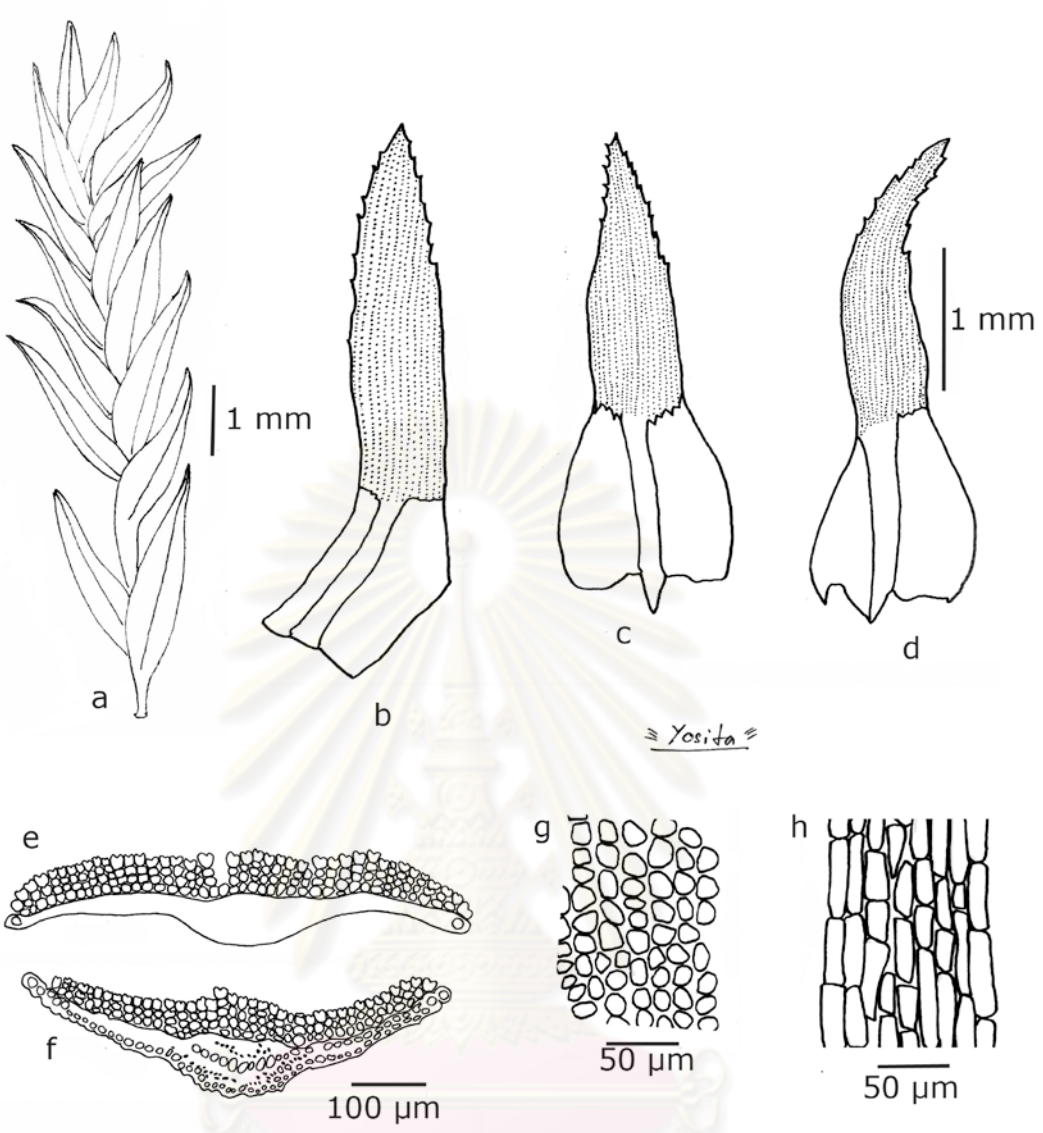


Figure 5.68 *Pogonatum inflexum* (Lindb.) Sande Lac.
a. habit; b., c., d. leaves; e., f. cross-section of leaf ; g. cells at upper leaf; h. cells at leaf base. Based on *Y. Nathi 676*.

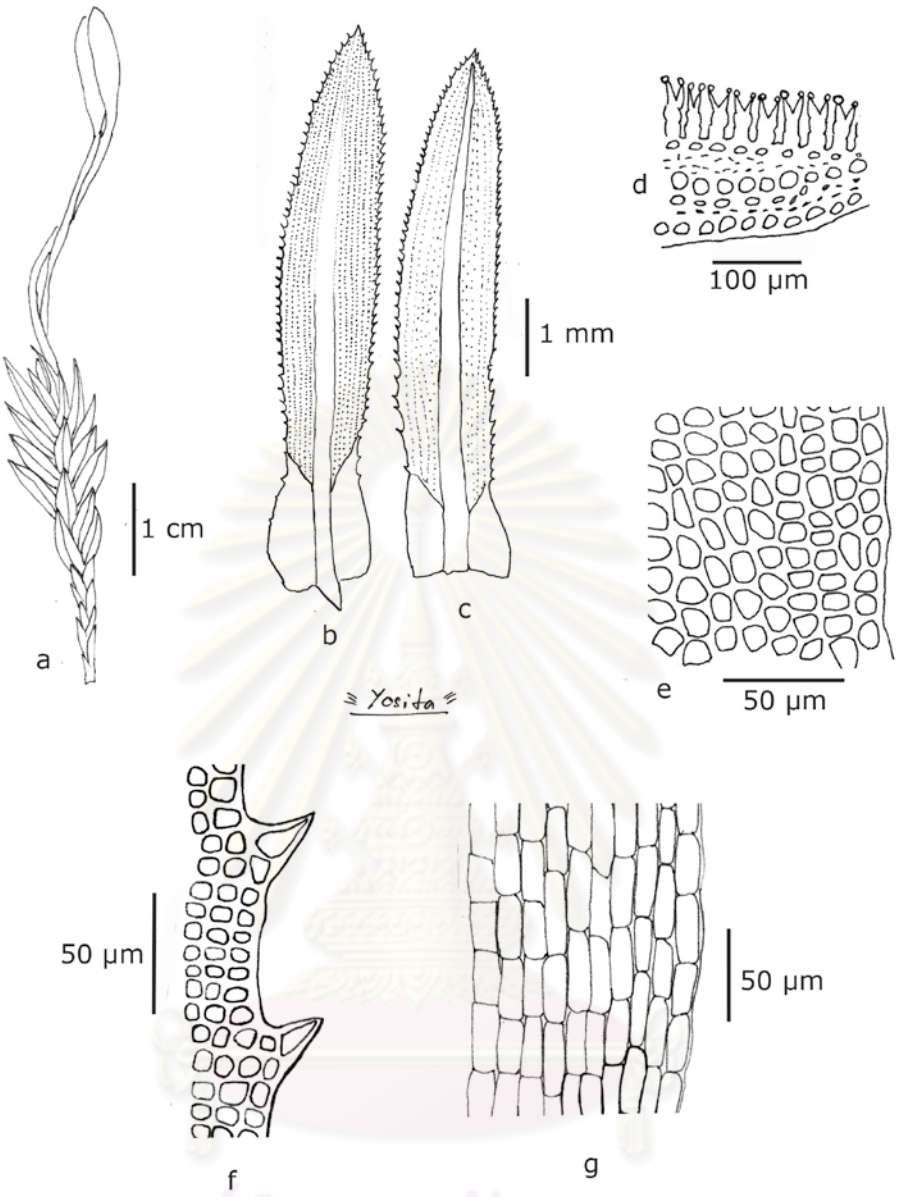


Figure 5.69 *Pogonatum microstomum* (Schwagr.) Brid.
a. habit; b., c. leaves; d. lamellae ; e. cells at upper leaf ; f. leaf margin; g. cells at leaf base. Based on *Y. Nathi 199*.

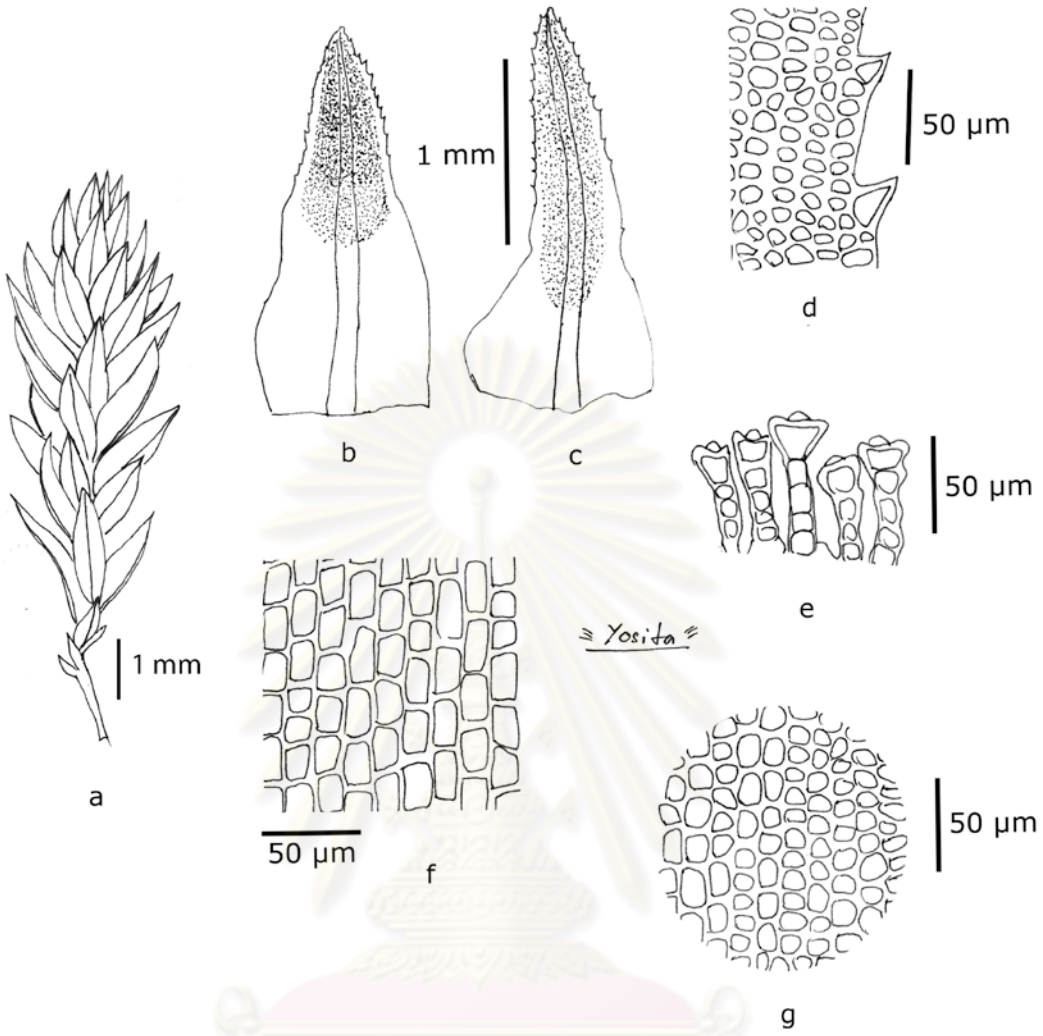


Figure 5.70 *Pogonatum neesii* (Müll.Hal.) Dozy & Molk.
a. habit; b., c., leaves; d. leaf margin ; e. lamellae ; f. cells at leaf base ; g. cells at upper leaf. Based on *Y. Nathi 417*.

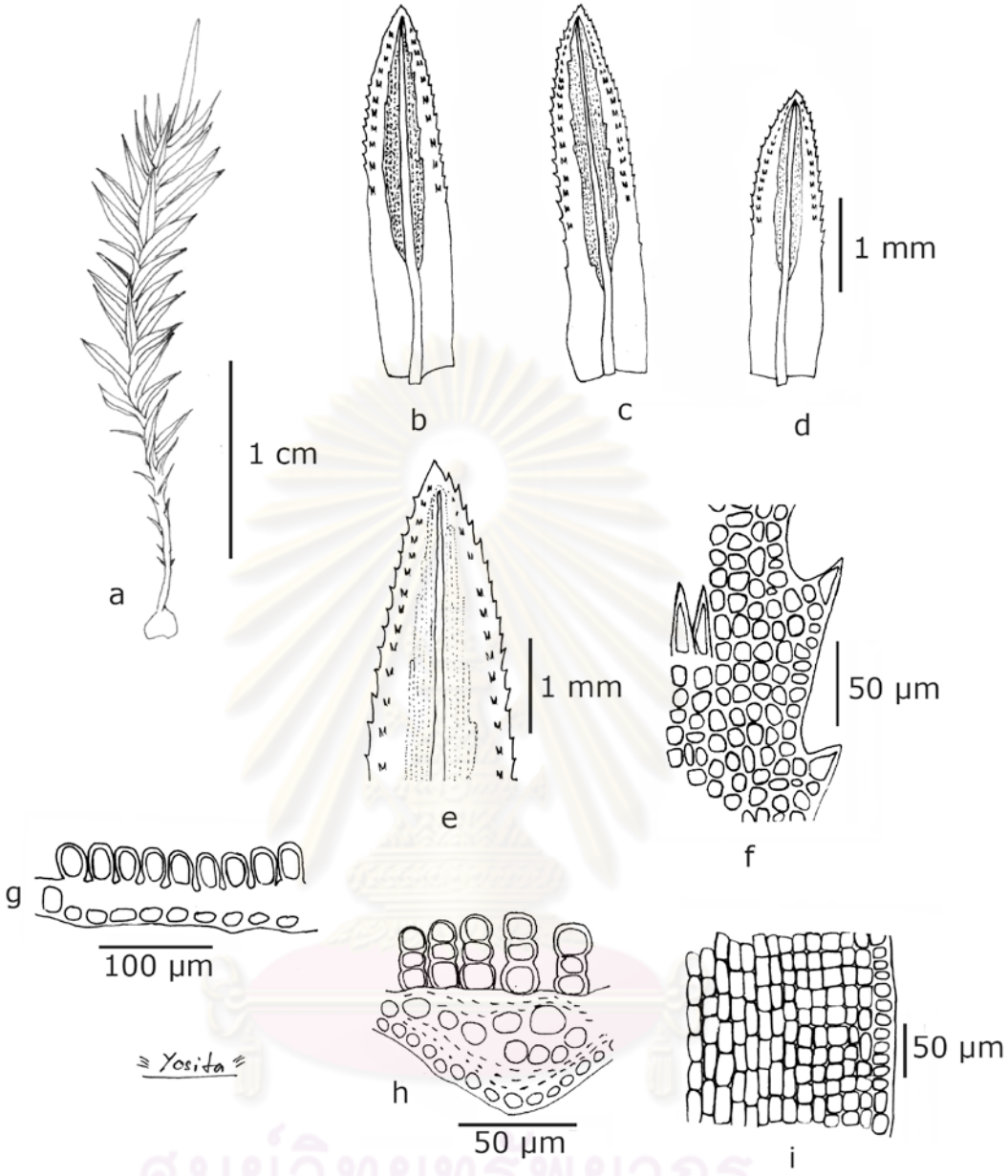


Figure 5.71 *Pogonatum nudiusculum* Mitt.
a. habit; b., c., d. Leaves; e. leaf apex ; f. leaf margin ; g. cross-section of leaf blade ; h. cross-section of costa; i. cells at leaf base. Based on *Y. Nathi 240*.

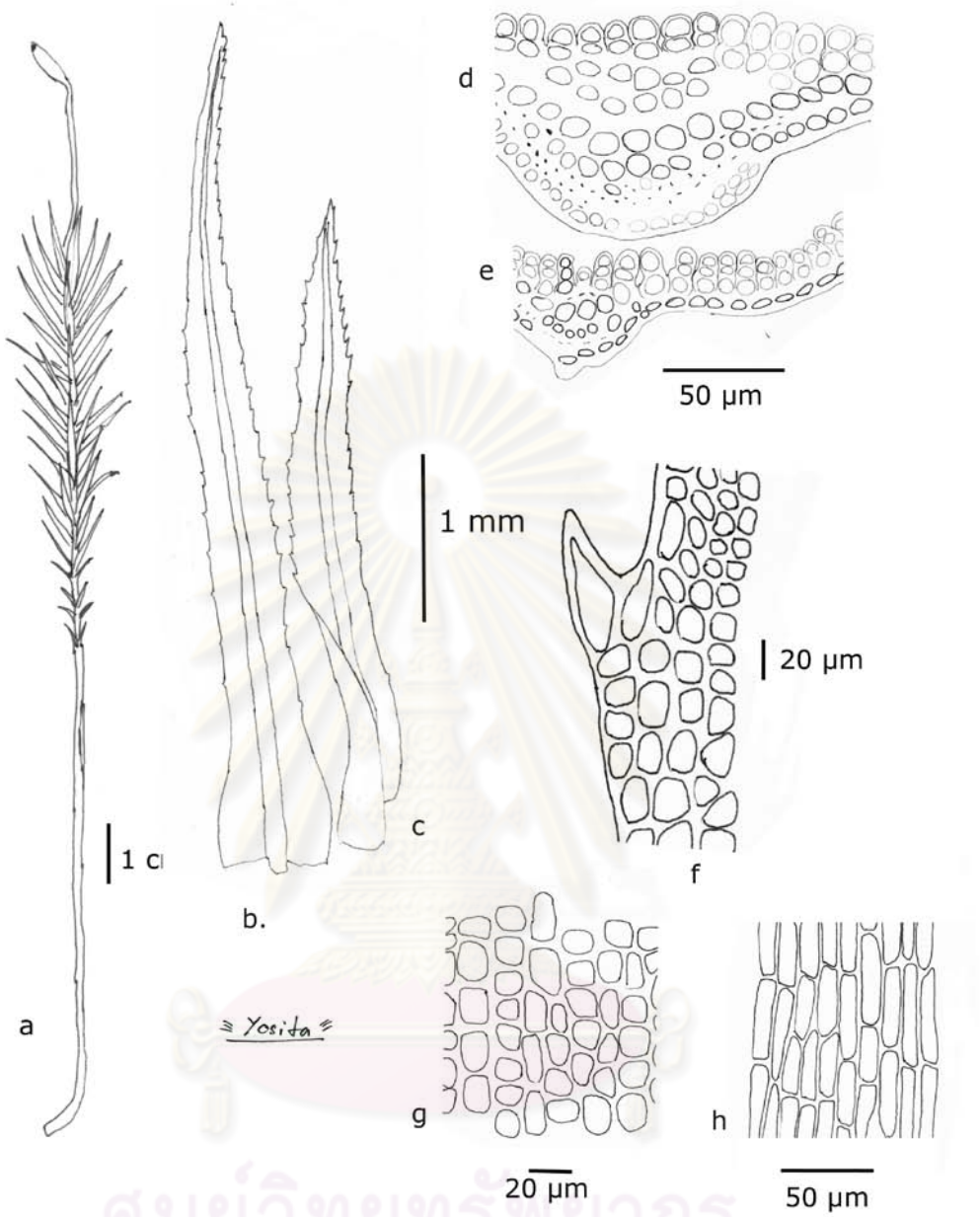


Figure 5.72 *Pogonatum proliferum* (Griff.) Mitt.
a. habit; b., c. Leaves; d. cross-section of costa; e. cross-section of leaf blade; f. leaf margin; g. cells at upper leaf; h. cells at basal leaf. Based on *Y. Nathi 836*.

POTTIACEAE

Plants small to medium-sized, or rather large, often turf-forming or in loosely caespitose patches, dull greenish above, brownish below. Stems erect, short to elongate, simple or irregularly to compositely branching; central strand mostly developed, sometimes absent. **Leaves** in several rows, usually contorted, or appressed when dry, erect-spreading or squarrose-recurved when wet, often narrowly lanceolate to linear-lanceolate, or ovoid, triangular to elliptic or ligulate; apices usually gradually acuminate or abruptly acute, occasionally obtuse or rounded; bases usually narrowly ovate to oblong, sometimes sheathing; margins entire, sometimes dentate above, seldom bordered by thick-walled or elongate cells, often unistratose, sometimes multistratose, commonly recurved or incurved below, sometimes plane; **costa** single, well developed, percurrent to shortly excurrent or awned, occasionally ending a few cells below the apex; upper leaf cells generally small, subquadrate, quadrate or hexagonal, rarely short-rectangular, usually firm-walled or incrassate, mostly papillose or at least bulging, rarely smooth; lower cells mostly smooth, rectangular, generally thin-walled, pellucid, not differentiated at the alar regions. **Dioicous** or autoicous. Perichaetial leaves often sheathing at base. **Seta** generally terminal, elongate, erect, but often twisted; **capsule** usually erect, symmetric, ovoid to cylindric; **peristome** single, consisting of 16, erect, oblique or often spirally (clockwise) twisted teeth, occasionally absent or rudimentary, teeth entire, linear-lanceolate or deeply split into 2 filiform, striate or papillose divisions; basal membrane usually low or absent, sometimes high, trabeculate. **Calyptra** smooth, usually cucullate, seldom mitrate. Spores spherical, small, usually densely papillose.

Key to genera

1. Plants terrestrial, growing on rock and soil; leave appressed on stem when dry .....1. *Didymodon*
1. Plants epiphytic, growing on tree trunks; contorted-curved or crisped when dry.....2. *Hyophila*

1. DIDYMODON

Didymodon Hdew. Sp. Musc. Fond. 104. 1801; Li, He & Iwatsuki, Moss Fl. China 2. 154. 2001.

Plants small to rather robust, usually growing on calcareous soil or rocks, brownish green to reddish brown, in loose or dense tufts. Stems erect, simple or sometimes branched; central strand present, rarely absent. **Leaves** appressed or contorted when dry, erect-spreading to squarrose-recurved when moist, ovate-lanceolate or broadly lanceolate; margins entire or

occasionally crenulate, narrowly revolute; **costa** strong, percurrent or excurrent, or occasionally ending below the apex, ventral cells of costa narrowly elliptic or rounded quadrate, in cross section with 2 stereid bands; upper leaf cells rounded to rounded quadrate or rhombic, somewhat thick-walled, smooth or bluntly papillose, cell outlines clear; basal cells firm, shortly rectangular to oblong-ovate or rounded quadrate, light green to brownish. **Gemma** sometimes present in specialized rhizoids or in leaf axils. **Diocious**. Perichaetial leaves similar to stem leaves or slightly differentiated. **Setae** elongate, erect, reddish brown at the base, yellowish brown at the upper part; **capsules** erect, oblong-ovoid or cylindrical; annuli not differentiated or in 1-3 rows of cells; opercula shortly rostrate; **peristome** teeth with a low basal membrane, 16 undivided or split into 32 linear, straight or twisted counterclockwise, densely papillose, occasionally peristome teeth absent. **Calyptrae** cuculatte, smooth, naked. Spores spherical, yellowish green.

Didymodon maschalogena (Renauld & Cardot) Broth.

Nat. Pflanzenfam. — *Barbula maschalogena* Renauld & Cardot Bull. Soc. Roy. Bot. Belgique I(3): 1192. 1909. 41((1)): 53. 1905. — *Barbula michiganensis* Steere., Gangulee, Mosses E. India 3: 695. 1972; Mosses E. N. Amer. 1: 340. 1981.

Plants mall, yellow-green or yellow-brown plants in dense tufts about 5-12 mm high; **spherical gemma** smooth, red-brown, very small, about 20-30um in diameter and consisting of 2-6 cells, abundant in leaf axils. **Leaves** incurved and slightly twisted when dry, erect-spreading when moist, 1-1.5 mm long, ovate, abruptly acuminate, acute, shortly decurrent; margins narrowly recurved in the lower 2/3, irregulary sinuate or wavy; **costa** ending at or near the apex, the upper surface consisting of elongate cells; **upper cells** 6-8 μm, rounded-quadrate to shortly oblong or oblong-oblate, thick-walled, indistinctly papillose; lower cells similar but somewhat larger, arranged in obvious longitudinal rows. **Sporophyte** not found.

Thailand — NORTHERN: Chiang Mai

Distribution — Africa, Mexico, Japan, India, Sri Lanka, Himalayas, China and Philippines

Ecology — on soil near by the road side.

Specimens examined — *Y. Nathi 49, 411, 577, 562, 986* (BCU)

GPS location — 18.5881368°N 98.48638745°E, 18.58862587°N 98.4866078°E, 18.58809848°N 98.4856483°E.

Altitude — 2,549-2,550 m

Note — New record to Thailand.

2. HYOPHILA

Hyophila Brid., Bryol. Univ. 1:760. 1827; Eddy, A Handb. Males. Mosses: 2 196.1990; Li, He and Iwasuki, Moss Fl. China 2. 191. 2001.

Plants small, to 10 mm high, green above, red to reddish brown or dark green below, in dense tufts. **Stems** erect, simple, rarely branched; central strand present or absent. **Leaves** usually rosulate, incurved or contorted when dry, oblong-elliptic to oblong-spatulate or oblong-lanceolate to lanceo-ligulate, blunt to rounded-obtuse or weakly apiculate at the apex; margins entire or serrulate; **costa** stout, percurrent to shortly excurrent; **upper leaf cells** small, quadrate to rounded-hexagonal, smooth or papillose; basal cells rectangular, smooth, hyaline. **Dioicous** or autoicous. Perichaetial leaves smaller than or similar to stem leaves. **Seta** elongate, straight; **capsule** erect, oblong-cylindrical; annuli differentiated, deciduous; **peristome** absent; opercula conic-rostrate, usually with long oblique beak. **Calyptra** cucullate, smooth. **Spore** spherical, small, smooth.

Hyophila involuta (Hook.) Jaeg.

Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1871–72:354. 1873; Eddy, A Handb. Males. Mosses: 2 199.1990; Li, He and Iwasuki, Moss Fl. China 2. 191. 2001; — *Gymnostomum involutum* Hook., Musci Exot. 2: 154. 1819.

Plants small, to 6-8 mm high, yellowish green, in dense tufts. **Stems** erect, simple or branched. **Leaves** involute to subtubulose when dry, erect- to wide-spreading when moist, oblong-ovate to oblong-spatulate, 2.0–3.5 mm × 1.2–1.8 mm, broadly acute to obtusely apiculate, slightly reflexed at the base; margins serrate in the upper half; **costa** stout, percurrent to shortly excurrent; **upper leaf cells** small, subquadrate to rounded hexagonal, 5–8 μm × 5–7 μm, somewhat thick-walled, not papillose, slightly mammillose on the ventral surface; **basal cells** short-rectangular, 28–62 μm × 10–18 μm, pale or hyaline. **Gemmae** present. **Dioicous. Setae** ca. 8-10 mm long; **capsule** not found.

Thailand — NORTHERN: Chiang Mai Chiang Rai, Mae Hong Son Phitsanulok; NORTHEASTERN: Khon Kaen; SOUTHEASTERN: Chanthaburi, Nakhon Nayok Trat; Central: Bangkok; SOUTHWESTERN: Kanchanaburi Rat Buri; PENINSULAR: Chumphon: Trang.

Distribution — Borneo, Celebes, Mainland China, India, Japan, Java, Kampuchea, Korea,Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology — On three trunk.

Specimens examined — *Y. Nathi 34, 194, 338* (BCU).

GPS location — 18.5890140°N 98.48710041°E, 18.5558408°N 98.48227453°E, 18.58925058°N 98.4874129°E.

Altitude — 2,190-2,546 m.

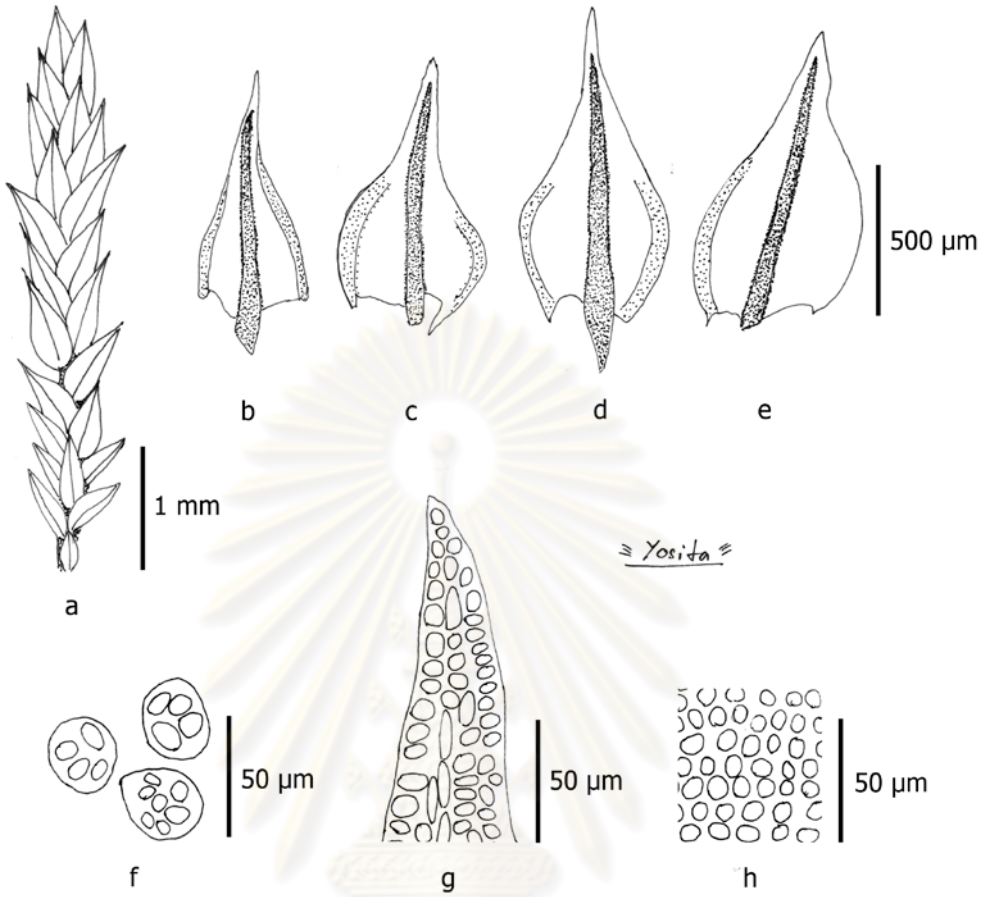


Figure 5.73 *Didymodon maschalogena* (Renauld & Cardot) Broth.

a. habit; b., c., d., e. leaves ; f. gemmae ; f. leaf apex ; h. cells at median leaf. Based on *Y. nathi 49.*

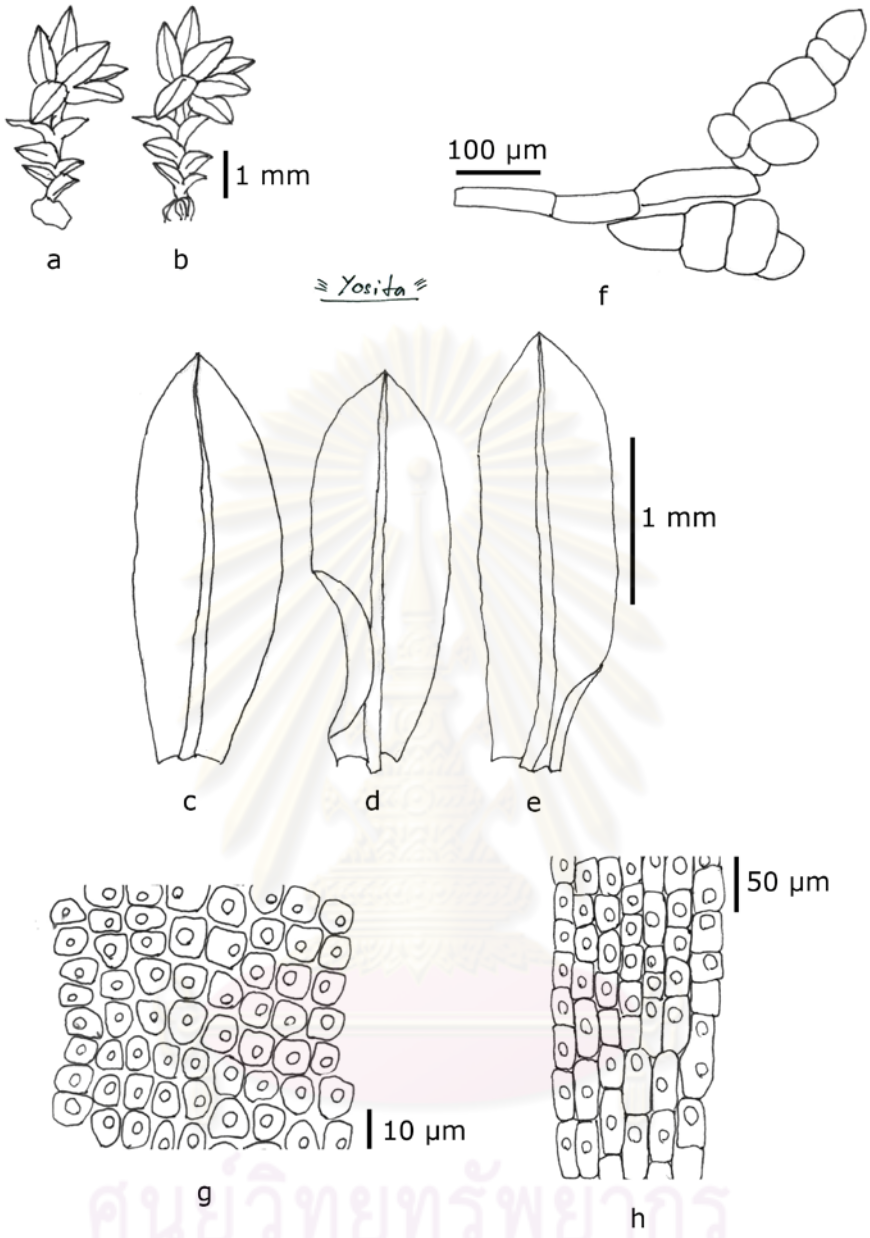


Figure 5.74 *Hyophila involuta* (Hook.) Jaeg.

a., b. Habits; c., d., e. leaves ; f. gemma ; g. cells at median leaf ; h. cells at basal leaves. Based on *Y. nathi 194*.

PTEROBRYACEAE

Plants medium to robust size, often regularly pinnate, generally frondose above a stipitate base. Pimary stems creeping, filiform, with small clasping, scalelike, fragile leaves; insection showing cell walls thick throughout, red-brown and especially thick-walled in epidermal and cortical regions, laer and pale within, without a central stand. Secondary stems erect or, less commonly, pendent, simple or irregularly branched to regularly 1- or 2-pinnate. Filamentous pseudoparaphyllia present in most. **Gemma** common in leaf axils, cylindric, sepate. **Leaves** erect-spreading and spirally seriate to spreading or squarrose, smooth or plicate, concave, oblong to ovate or ovate-lanceolate, rounded to the insertion, occasionally auriculate or decurrent, cuculate; margins entire to serrulate; **costa** single, short and double, or none; **upper cells** rhomboidal to linear, thick-walled, often porose, smooth or papillose; basal cells colored, strongly thick-walled and porose; **alar cells** often distinctly often distinctly differentiated. **Diocous**. Perichaetia on secondary stems or branches. **Seta** short; **capsule** immersed to exserted, erect, oblong to ovoid; operculum conic-rostrate; **peristome** single or double, the exostome teeth 16, generally smooth, narrow, pale, often irregularly developed or fragile, sometimes with a preperistome; endostome rudimentary. Spores large, papillose. **Calyptra** small, cuculate or mitrate, often sparsely.

PTEROBRYOPSIS

Pterobryopsis Fleisch., Hedwigia, 45: 56. 1905; Gangulee, Mosses E. India 6: 1230. 1967; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 710. 1994.

Plants medium sized to robust, in loose, glossy, dark- to yellow-green tufts. Secodary stems erect, pinnately branched above a stipitate base. Gemmae sometimes present. **Leaves** crowded, concave, broadly ovate, short-acuminate, decurrent; **costa** single, occasionally spurred; **leaf cells** smooth, pitted; upper cells elongate; basal cells quadrate to short-regtangular, alar cells quadrate, dark-red to reddish-yellow. Perichaetial leaves slenderly acuminate from a sheathing base. **Seta** short; **capsule** usually shortly exserted, oblong-cylindric; peristome double, the exostome teeth striolate. **Calyptra** cuculate.

Pterobryopsis divergens (Mitt.) Nog.

J. Hattori Bot. Lab., 28: 147. 1965. — *Meteorium divergens* Mitt., J. Proc. Linn. Soc. Suppl. 87. 1859. — *Garovaglia breviflagellosa* C. Müll., Ren. et Card. Bull. Soc. roy. boy. Belgique, 319. 1902. — *Meteoriopsis divergens* (Mitt.) Broth., Nat.

PFL. 1(3): 826. 1906. — *Pterobryopsis caudate* Bartram, Farlowia, 1: 180. 1943. — *P. levieri* Broth. mss. 1902; Gangulee, Mosses E. India 6: 1262, fig. 609. 1976.

Plants ascending to hanging, up to 12 cm long, pinnatelly branched, with many flagelliform at side branches. **Leaves** dense, squarrose, ovate to subcordate, 2-3 mm long, 1.2-1.8 mm wide, acuminate; costa single, covering half of leaf. **Leaf cells** narrow elongate, thick-walled, porose walls, cells at leaf attachment red-brown; **alar cells** distinct, rectangular to quadrate. **Sporophytes** not found.(**Figure 5.75**)

Thailand — NORTHERN: Chiang Mai, Chiang Rai.

Distribution — India, Myanmar, Nepal, Sikkim, and Vietnam.

Ecology — Common on tree trunk and branches.

Specimens examined — *Y. Nathi 212, 222, 438, 502, 790, 843, 1008, 1077* (BCU)

GPS location — 18.5563194°N 98.48220748°E, 18.5565715°N 98.48190716°E, 18.55630886°N 98.4803905°E, 18.55318073°N 98.4782689°E, 18.55632654°N 98.48128865°E, 18.55599755°N 98.4795948°E, 18.56183094°N 98.47633914°E

Altitude — 2,167-2,315 m

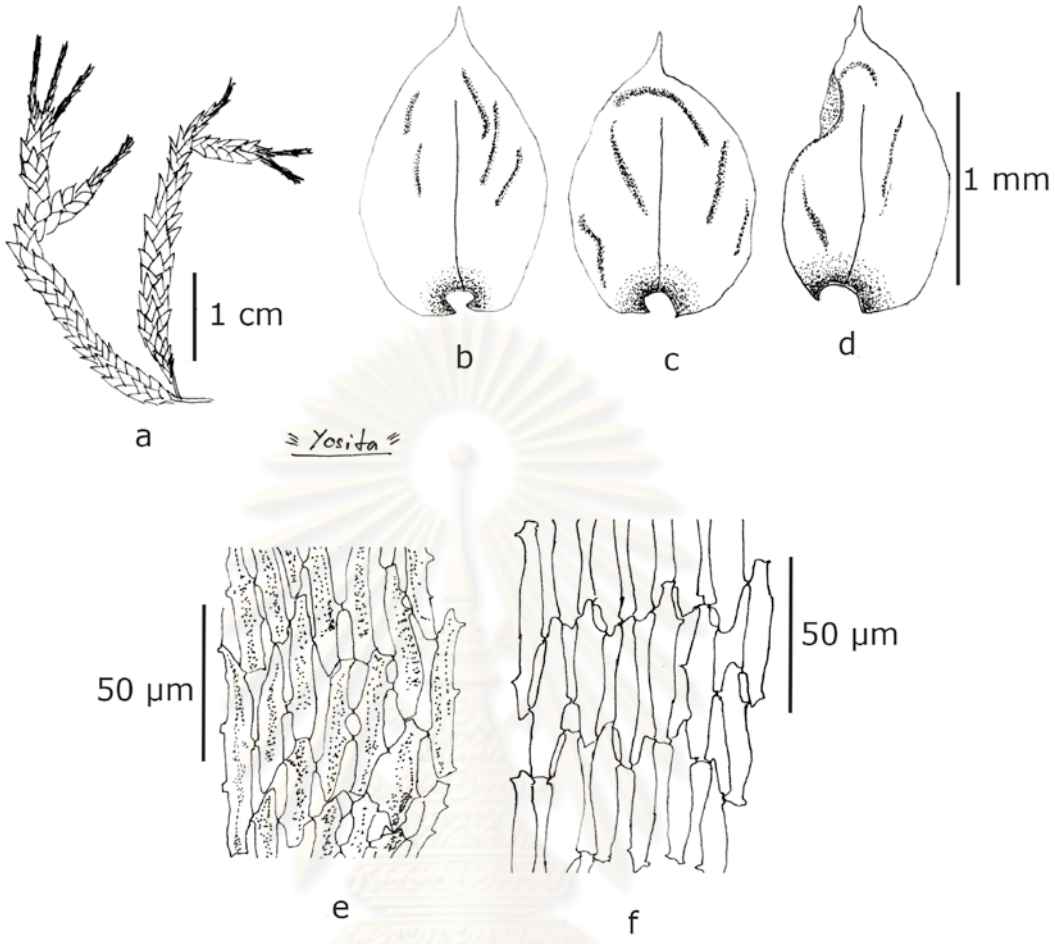


Figure 5.75 *Pterobryopsis divergens* (Mitt.) Nog.
a. habit ; b., c., d. leaves ; e. cells at leaf base ; f. cells at median leaf. Based on *Y. Nathi 212*.

SEMATOPHYLLACEAE

Plants slender or robust, delicate or stiff, yellow, yellowish green, green or yellowish brown, somewhat glossy, often in dense mats of tufts. **Main stems** creeping to ascending or erect, with rhizoids, usually irregularly branched, branches round or complanate. **Leaves** in several ranks, stem and branch leaves usually similar in shape, rarely differentiated, symmetric, not plicate, variable among genera in shape of leaf; **costa** double, very short or absent; leaf cells linear, smooth or papillose; alar cells well developed, large, often inflated, usually colored, thick-walled. Seta elongate, smooth. **Capsule** inclined or pendulous, rounded ovoid or oblong-ovoid, often asymmetric; **operculum** conic, rostrate; **peristome** double; exostome narrowly lanceolate. **Calyptra** often cucullate, smooth.

Key to the genera

1. Alar cells numerous, forming a cluster or grouping in tiers, mostly colored, quadrate or rectangular, not much inflated, usually thick-walled 2
1. Alar cells oval or kidney-shaped, usually translucent, inflated, thin-walled, forming at least one distinctly defined basal row 5
   2. Leaf bases decurrent; leaf axillary propagula abundant ..... 2. *Clastobryopsis*
   2. Leaf bases not decurrent; propagula not many 3
3. Plants small, mat forming, with irregular long branches; leaves less than 1.5 mm long, margins entire ..... 3. *Gammiella*
3. Plants large, weft forming; leaves longer than 1.5 mm long, margin toothed 4
   4. Leaves ovate-lanceolate, falcate, concave, apex narrow subulate, margin denticulate at tip sometimes recurved to border .....4. *Heterophyllium*
   4. Leaves lingulate, margin bordered, irregularly and strongly toothed in the tongue-like portion .....6. *Psuedotrismegistia*
6. Plants irregularly bi- to tripinnately branched; stem and branch leaves different in size and shape .....8. *Wijkia*
6. Plants regularly branched, at most irregularly pinnate; stem and branch leaves similar, or differentbonly in size 7
   7. Leaves strongly falcate, abruptly contracted to a narrow apex, margin serrulate in upper margin.....7. *Warbugiella*
   7. Leaves acute or gradually long acuminate 8
8. Leaves ovate-ligulate; almost alar cells numerous, rectangular, inflated, thin-walled, forming several rows .....5. *Mastopoma*
8. Leaves ovate, oblong to lanceolate; alar cells 3-4 cells, with few small cells above .....1. *Brotherella*

1. *BROTHERELLA*

Brotherella Loeske ex M. Fleisch., Nova Guinea 12(2): 119. 1914; Gangulee, Mosses E. India 8: 1892. 1980; Tan & Jia, J. Hattori Bot. Lab., no. 86: 30-31. 1999. Jia, Wu & Tan, Moss Fl. China 8: 13. 2005.

Plants slender or robust to moderate-sized, yellowisf green or deeoly green, rarelybrownish green, glossy in tufts. **Stems** creeping, prostrate, densely irregular pinnate branched. **Leaves** spreading, erectopatent, ovate-lanceolate or narrow oblong-lanceolate,often falcate, concave, usually long acumunate apex, margins slightly recurved, serrulate above; **costa** often absent; **leaf cells** rhomboid or narrowly rhomboidal to elongated linear;alar inflated, tinted along line of insertion, with a few, smaller and hyaline cells above. **Autoicous**, rarely dioicous. **Sporophyte** on main stem. **Capsule** erect, oblong-ovoid, or cylindrical, slightly curved; opercula conic, shortly or long-rostrate; annuli differentiated, persistent; **peristome** double.

Brotherella falcata (Dozy & Molk.) M. Fleisch.

Nova Guinea 12(2): 120. 1914; Gangulee, Mosses E. India 8: 1901, fig. 971. 1980; Tan & Jia, J. Hattori Bot. Lab., no. 86: 30-31. 1999.

Plants large, in loose mats. **Main stems** elongate, creeping, subpinnately branched; branches short or long, complanate. **Stem leaves** large, erect to appressed, oblong-lanceolate, strongly concave, plicate when dry, constricted into a long acuminate apex; margins entire or denticulate at apex; **branch leaves** narrower than stem leaves, with a longer acuminate acumen, entire or denticulate from middle to apex; **leaf cells** elongated fusiform to linear, 60-80 μm long; **alar** differentiated, about 4 large, inflated, colored, oblong cells in one row with a few irregular cells on top, **Sporophyte** not found. (**Figure 5.76**)

Thailand — NORTHERN: Chiang Mai.

Distribution —Borneo, Celebes, Mainland China, India, Japan, Java, Laos, Sikkim, Taiwan.

Ecology —on tree trunks and branches.

Specimens examined — *Y. Nathi 40, 619, 647, 764, 871 (BCU).*

GPS location — 18.58901395° N 98.48710041° E.

Altitude — 2,514-2,566 m

2. *CLASTOBRYOPSIS*

Clastobryopsis Fleisch., Musci Fl. Buitenz., 4: 1179. 1923; Gangulee, Mosses E. India 8: 1831. 1980; Jia, Wu, & Tan, Moss Fl. China 8: 24. 2005.

Plants yellowish green or reddish. **Main stems** prostrate, branches complanate, delicate, branches bearing filamentous gemmae at the apex of branches. **Leaves** ovate-lanceolate, entire, decuurent; **leaf cells linear**; **alar cells** well developed, colored or hyaline, quadrate or rectangular, usually thick-walled. **Seta** erect or slightly twisted, smooth; **capsule** ovoid; exostome cells thickening along the vertical walls, a row of perforations along the median line; basal membrane low, endostome segments linear.

Key to the species

1. Plants coarse, propaguliferous leaves more than 2.5 mm long and about 2 mm wide; margins strongly recurved, especially at apex.....2
1. Plant slender, propaguliferous leaves less than 2.0 mm long and about 1.5 mm wide; margins plane or narrowly reflexed throughout .....2. *C. planula*
   2. Leaves smooth, narrowly decurrent; costae single; alar cells not enlarged, thick-walled ..... 1. *C. brevinervis*
   2. Leaves slightly plicate, broadly decurrent; costae double, equal in lengh; alar cells sometimes enlarged, thin- or thick-walled ....3. *C. robusta*

1. *Clastobryosis brevinervis* Fleisch

Musci Buitenzorg 4: 1185. 1923; — *Aptychella brevinervis*, Nog., Ill. Moss Fl. Japan 5: 1084, fig. 477, A. 1994; Jia, Wu, & Tan, Moss Fl. China 8: 25, fig,1-13. 2005.

Stems short, prostrate or spirally ascending near the apex, simple, 4-5 mm long. **Gemmae** not found. **Leaves** lanceolate, acuminate, 2.5 mm x 0.6 mm, deeply plicate, semicanaliculate above; leaf margins frequently involute throughout; **costa** single, up to the midleaf; **leaf cells** linear, 50-65 μm long; upper cells short, thick-walled; lower cells shorter; strongly decurrent, sometimes up to 1/4 the leaf length; **alar cells** 15-25 μm x 9-15 μm. **Sporophyte** not found. (**Figure 5.77**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, and India.

Ecology— On twigs.

Specimens examined — *Y. Nathi 150, 627, 1071* (BCU).

GPS location — 18.5888505°N 98.48477117°E
Altitude — 2,542 m
Note — New record to Thailand.

2a. ***Clastobryopsis planula*** Fleisch.

Musci Buitenzor 4: 1180. 1923; Gangulee, Mosses E. India 8: 1833, fig. 930. 1980; — *Aptychella planula*, Nog., Ill. Moss Fl. Japan 5: 1084, fig. 477, B. 1994; Tan & Jia, J. Hattori Bot. Lab. 86: 13. 1999; Jia, Wu & Tan, Moss Fl. China 8: 25. 2005.

Plants in mats, prostrate. **Stems** densely branched, erect, complanate. **Leaves** broadly ovate or ovate-lanceolate, 2.0-2.6 mm long, decurrent, short acuminate at apex; **costa** double, short and faint, sometimes not evident; stem leaves reflexed at margins, 1.3-1.6 mm long; branch leaves complanate, weakly toothed; **leaf cells** narrowly elongated or rhomboidal, 30-45 μm long; **alar cells** inflated, quadrate or rectangular, thin- or thick-walled, gradually becoming narrowly elongated upwards. **Gemma** numerous, smooth, 0.36-0.56 mm long, composed of 8-12 cells in leaf axils at tips of branches. **Sporophyte** not found. (**Figure 5.78**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, India, Sikkim, Nepal, Indonesia and Philippines.

Ecology — On twigs.

Specimens examined — *Y.Nathi 258, 328, 486, 838, 924, 959 (BCU).*

GPS location —18.5579239°N 98.48122604°E, 18.5617751°N 98.47630729°E, 18.55614457°N 98.48136032°E, 18.55944981°N 98.4769294°E, 18.55596101°N 98.4763336°E .

Altitude — 2,190-2,311 m

Note — New record to Thailand.

2b. ***Clastobryopsis planula*** Fleisch. var. ***delicate*** (Broth. ex Fleisch.) B. C. Tan & Y. Jia

J. Hattori Bot. Lab. No. 86: 14. 1999; — *Aptychella delicate* (Fleisch.) Fleisch., Gangulee, Mosses E. India 8: 1839, fig. 934. 1980.

Plants delicate, yellow-greens in lax turfts. Main stem creeping, giving rise to erect, moderately branched shoots as in the previous species. **Leaves** not dense, spreading, ovate-lanceolate, apical margin distantly dentate, apex

narrowly acute. **Leaf cells** linear; **alar cells** distinguished but hyaline, lowermost cells larger. **Sporophyte** not found. (**Figure 5.79**)

Thailand — New record to Thailand.

Distribution — China, Japan, India, Sikkim, Nepal, Indonesia and Philippines.

Ecology — On twigs.

Specimens examined — *Y.Nathi 55, 349, 525, 653, 664, 701, 850 (BCU).*

GPS location —18.5579239°N 98.48122604°E, 18.5617751°N 98.47630729°E, 18.55614457°N 98.48136032°E, 18.55944981°N 98.4769294°E, 18.55596101°N 98.4763336°E

Altitude — 2,487-2,564 m

3. *Clastobryopsis robusta* (broth) Fleisch

Musci Buitenzorg 4: 1181. 1923; Tan & Jia, J. Hattori Bot. Lab. No. 86: 15. 1999; Jia, Wu & Tan, Moss Fl. China 8: 27. 2005.

Plants coarse, brownish green, loose or in the dense mats. **Main stems** prostrate, irregularly branched, branches 0.8-2.7 cm long with leaves loosely arranged, erect, sometimes with broad, complanate caudate apices. **Leaves** erect patent, stem leaves ovate-lanceolate, branch leaves broadly ovate, frequently plicate, with slender acumina, broadly decurrent at base, often concave, more than 2 mm long; leaf margins invoute throughout, strongly involute near acumen, entire or weakly toothed; **costa** double, short and faint, sometimes absent; upper branch leaves broadly ovate, strongly concave, margins not involute; **leaf cells** narrowly oblong to linear, 45-60 um x ca. 5 um, strongly thickened, often pitted, smooth; **alar cells** brownish to purple, numerous, quadrate or rectangular, unevenly thickened, not all cells inflated. **Propagula** brown, smooth, borne in leaf axils. **Sporophyte** not seen. (**Figure 5.80**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Japan, Indonesia, Philippinnes, and Papua New Guinea.

Ecology — On twigs.

Specimens examined — *Y. Nathi 627, 1072 (BCU).*

GPS location — 18.58867600°N 98.48508256°E.

Altitude — 2,516-2,523 m

Note — New record to Thailand.

3. *GAMMIELLA*

Gammiella Broth., Nat. Pflanzenfam. I(3): 1067. 1908; Jia, Wu & Tan, Moss Fl. China 8: 29. 2005.

Plants robust, soft, glossy, in loose mats. **Stems** extensively creeping, with few, remote and irregular branches; branches long and somewhat regularly pinnately further branched with short branchlets; branchlets round, blunt at tips, frequently bent down. **Leaves** imbricate-appressed when dry, nearly erect-spreading when moist, oblong-ovate, concave, slightly decurrent at base, abruptly narrowed to a filiform acumen; margins plane or only involute at apex, entire or weakly toothed at tip; **costa** double, very short or absent; leaf cells narrowly linear, smooth; basal cells broader and shorter, brownish yellow; **alar cells** in several rows, yellowish quadrate, thick-walled, somewhat hyaline, forming a large, slightly concave, well-differentiated alar region. **Autoicous**. **Seta** slender, reddish, smooth, often twisted when dry; capsules erect, cylindrical; opercula conic bluntly tipped; annuli narrow, persistent; **peristome** double.

Key to the species

1. Plants large; leaves more than 1.25 mm long, lightly to moderately plicate, margins recurved, serrulate .....2. *G. pterogonioides*
1. Plants small; leaves less than 1.25 mm long, plane to lightly concave.....2
   2. Leaves lanceolate, more than 0.75 mm long; apex acuminate to long acuminate .....3. *G. tonkinensis*
   2. Leaves narrowly ovate to ovate-oblong, less than 0.75 mm long; margin serrate from base to apex; apex acute to acuminate ..... 1. *G. ceylonensis*

1. *Gammiella Ceylonnensis* (Broth. in Herz.) B. C. Tan & W. R. Buck

J. Hattori Bot. Lab. 66: 318. 1989; Tan & Jia, J. Hattori Bot. Lab. No. 86: 16. 1999; Jia, Wu & Tan, Moss Fl. China 8: 30. 2005.

Plants small, yellowish to brownish, in dense mats. **Stems** prostrate, ca. 10 mm long. **Leaves** erect, ovate to oblong, less than 1 mm long, concave, obtusely acuminate at apex or abruptly acuminate to shortly acuminate; leaf margins serrulate; **leaf cells** narrowly uniform to elongated, 20-45 μm long; alar cells quadrate, thick-walled, isodiametric. **Monoicous**. **Sporophytes** not seen. (**Figure 5.81**)

Thailand — NORTHERN: Chiang Mai, Phitsanulok; EASTERN. Nakhon Ratchasima.

Distribution— Mainland China, India, Japan, Java, Kampuchea, Laos, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 293, 795, 861 (BCU).*

GPS location — 18.5597154°N 98.47769047°E, 18.55557142°N 98.48048232°E.

Altitude — 2,297 m

2. *Gammiella pterogonioides* (Griff.) Broth.

Nat. Pflanzenfam. I(3): 1067. 1908; Gangulee, Mosses E. India 8: 1849, fig. 940. 1980; Tan & Jia, J. Hattori Bot. Lab. No. 86: 18. 1999; Jia, Wu, & Tan, Moss Fl. China, vol. 8: 31, figs. 1-11. 2005.

Plants large, in loose mats. **Main stems** creeping, irregularly branched; branches ca. 10 mm long, 1.2 – 2.0 mm wide with leaves. **Leaves** imbricately arranged, erect, sometimes curved, ovate to oblong-lanceolate, 1.25-1.75 mm long, concave, weakly plicate, apex abruptly narrowed or short; margins entire, narrowly involute, dentate near tips; leaf cells narrowly rhomboidal to elongated, 50-70 um long, gradually becoming shorter toward apex; **alar cells** colored or hyaline, quadrate or rectangular, thick-walled. **Autoicous**. **Sporophyte** not found. (**Figure 5.82**)

Thailand — NOTHERN: Chiang Mai; EASTERN: Nakhon Ratchasima

Distribution —Himalaya, Mainland China, India, Kampuchea, Laos, Sikkim, and Vietnam.

Ecology — On branch.

Specimens examined — Y. *Nathi 469, 710 (BCU).*

GPS location — 18.5881294°N 98.48610347°E, 18.5883719°N 98.4868579°E.

Altitude — 2,190 m

3. *Gammiella tonkinensis* (Broth. & Par.) B.C. Tan

Bryologist 93: 433. 1990; Tan & Jia, J. Hattori Bot. Lab. No. 86: 19. 1999; Jia, Wu, & Tan, Moss Fl. China 8: 33. 2005. — *Clastobryum tonkinense* Broth. & Paris Rev. Bryol. 35: 47. 1908.

Plants in mats. **Stems** and brances long and slender, sometimes up to 3 cm long. **Branch leaves** complanate, lanceolate, 1.0 – 1.5 mm long, acuminate; margins plane, weakly toothed or nearly entire; **leaf cells** elongated to linear; **alar cells** numerous, rectangular, thick-walled, colored, isodiametric. **Sporophytes** not seen. (**Figure 5.83**)

Thailand — NORTHEASTERN: Phetchabun; EASTERN. Nakhon Ratchasima.

Distribution — China, Japan, Philippines, Indonesia, Kampuchea, Laos and Vietnam.

Ecology — On branch.

Specimens examined — *Y. Nathi 105, 387 (BCU).*

GPS location — 18.55486549°N 98.4786027°E, 18.5881294°N 98.48610347°E.

Altitude — 2,536-2,560 m

4. *HETEROPHYLLUM*

***Heterophyllium* (Schimp.) Kindb.**, Canad. Rec. Sci., 6:72. 1894; Jia, Wu, & Tan, Moss Fl. China 8: 37. 2005.

Plants robust, green, yellowish green or brownish green, glossy. **Stems** often extensively prostrate, usually not evidently branched; paraphyllia numerous. **Leaves** patent-spreading or falcate, ovate-lanceolate, slightly concave, long acuminate at apex; **costae** short, weak or absent; leaf cells narrowly linear; basal cells yellowish; **alar cells** loose, often quadrate or rectangular, yellow or yellowish brown, forming an excavate alar area. **Autoicous** or dioicous. **Capsule** erect or patent-spreading, symmetric or slightly curved; opercula conic, shortly rostrate; annuli slightly differentiated; **peristome** double.

1. *Heterophyllium affine* (Hook.) Fleisch.

Musci Buitenzorg 4: 1177. 1923; Jia, Wu, & Tan, Moss Fl. China 8: 37, figs, 1-12. 2005.

Plants large, in dense mats. **Stems** subpinnately branched to irregularly branched; branches short to long, ca. 1-3 cm long, somewhat complanate; **pseudoparaphyllia** well developed, foliose, deeply split. **Leaves** erect to patent-spreading, sometimes falcate, broadly lanceolate to ovate-oblong, long acuminate or gradually narrowed into a filiform acumen;

margins entire or serrate at tips; **leaf cells** elongated to linear; **alar cells** numerous, quadrate or rectangular, thick-walled, colored. **Sporophyte** not found. (**Figure 5.84**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Wildely distribution in the mountain of tropical and sub tropical regions.

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 233, 309 (BCU).*

GPS location — 18.5567133°N 98.48176475°E, 18.5604936°N 98.47736626°E

Altitude — 2,249-2,562 m

2. *Heterophyllium amblystegum* (Mitt.) Y. Jia, S. He & Crosby

Novon 17: 332-334, f. 1. 2007.

Plants medium-sized to rather robust, brownish yellow or golden yellow. Main stems creeping, regularly pinnately branched. **Leaves** dimorphic, imbricately appressed when dry, patent to squarrose when moist; stem leaves broadly lanceolate with long, slender, flexuose acumina, strongly serrate above, 1.5-2.2 mm long; **median leaf cells** linear-rhomboidal, 40-75 μm long; **alar cells** in an excavate group with 12-18 reddish brown, inflated, rectangular or subquadrate, thick-walled cells; branch leaves narrowly lanceolate with slender acumina, 1.2-1.4 mm x 0.2-0.3 mm; alar cells fewer, 6 to 12 in number. **Dioicou***s.* **Sporophytes** on main stems. **Seta** reddish, smooth, twisted when dry, 3.5-4.0 cm long. **Capsule** not found. (**Figure 5.85**)

Thailand — NORTHERN: Chiang Mai.

Distribution — India, Himalaya.

Ecology —on tree trunks and branches.

Specimens examined — *Y. Nathi 92,618,812,883,316,645,929 (BCU).*

Altitude — 2,303-2,562 m.

GPS location — 18.5893751°N 98.48579443°E, 18.58870014°N 98.48552395°E, 18.58840803°N 98.48405426°E.

5. *MASTOPOMA*

***Mastopoma* Cardot**, Rev. Bryol. 28: 116. 1901.

Plants large, usually robust, glossy, in lax or dense mats. *Stems* creeping, pinnately branched. **Leaves** crowed, erect-spreading or second, ovate-lanceolate, concave, spinoseserrate in upper half; costa short and double or none; cells linear, smooth; **alar** group inflated and colored. **Pseudoautoicous**. **Sporophyte** on main stem. **Seta** very long, curved at tip. **Capsule** horizontal, ovoid; operculum short, conical, apiculate, not beaked.

***Mastopoma subfiliferum* Horik. & Ando**

Nat. & Life Southe. Asia 3: 36. f. 8.1964

Plants large, yellowish green to greenish brown, robust in dense mats, glossy. *Main stems* creeping, to 5 cm long, irregularly pinnate to bipinnate branched; branches spreading, short to long, up to 3 cm in length and 2 mm in width, slightly complanate, slender, cuspidate at tips; **Leaves** slightly falcate, rigid, gradually narrowed to linear acumen from an ovate-lanceolate, 2.0-2.5 mm x 0.5-0.8 mm, concave base; margins densely serrate in upper half; **ecostate**; **laminal cells** fusiform to elongate, 45-70 μm, becoming smaller and broader near margins and leaf apex; **alar cells** numerous, quadrate to subrectangular, 20-25 μm x 15-20 μm, inflated, thin-walled, hyaline or colored, forming several rows; leaves of ultimate branches smaller. **Sporophyte** not found. (**Figure 5.86**)

Thailand — NORTHERN: Chiang Mai.
Distribution— Endemic to Thailand.
Ecology —on tree trunks.
Specimens examined — *Y. Nathi 213, 538 (BCU).*
Altitude — 2,198 m
GPS location — 18.5564324°N 98.48196248°E

6. *PSEUDOTRISMEGISTIA*

Pseudotrismegistia Akiyama & Tsubota, Acta Phytotax. Geobot. 52: 85. 2001; Jia, Wu, & Tan, Moss Fl. China 8: 43. 2005.

Plants robust, stiff, often yellowish green, glossy, in interwoven patches. **Main stems** elongate and spreading, usually arcuate, erect or erect-spreading, with dense rhizoids; secondary stems erect, simple below, pinnately or densely branched above branches thick and short. **Leaves** appressed or loosely appressed when dry, erect or erectspreading when moist; stem leaves gradually becoming narrowly lanceolate to ligulate or forming a narrowly filiform acumen from an ovate base, often twisted at

apex; margins slightly reflexed below, involute, serrate above; **costa** double, very short or none; leaf cells elongate, thick-walled, becoming shorter and wider upward, clearly prorate; leaf marginal cells in several rows, not prorate, forming a broad border, lower cells longer, smooth; basal cells yellowish brown; **alar cells** differentiated, large, golden yellowish or yellowish brown, with many small and short cells above alar cells; branch leaves small, acuminate, serrate. **Dioicous. Seta** thick, elongate, purple; **capsule** horizontal, often arculate; opercula conic, long rostrat; annuli differentiated.

Pseudotrismegistia undulate (Broth. & Yas.) Akiyama & Tsubota

Acta Phytotax. Geobot. 52: 86. 2002; Jia, Wu, & Tan, Moss Fl. China 8: 43, Pl. 605, figs. 1-13. 2005.

Plants large, green when fresh, shininy. Main stems prostrate, up to 5 cm long, irregularly branched, procumbent on substrata; leafy branches short or elongate, up to 3 cm long, ca. 2 mm wide. **Leaves** erect-spreading, slightly curved, oblong-lanceolate to lingulate, distinctly narrowed in the middle, strongly undulate, widely acute at apex; margins serrulate below, sharply serrate above; **leaf cells** uniform to oblong-elongate, 45-65 μm long, gradually becoming shorter and wider upward and toward margins; **alar cells** numerous, inflated, hyaline or colored, thin-walled, arranged in several rows. **Seta** thick, elongate, up to 5 cm long, reddish, smooth. **Capsule** large, ovate to oblong, inclined; annulus red permanent; **peristome** double; opercula conic, 1-2 mm long. (**Figure 5.87**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Kampuchea, Laos, and Vietnam.

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 41, 117, 156, 209, 244, 410, 601, 622, 671, 777, 818 (BCU).*

GPS location — 18.5881701°N 98.48680076°E, 18.5878495°N 98.48610230°E, 18.5888505°N 98.48477117°E, 18.5561391°N 98.48219197°E, 18.5578328°N 98.48141070°E, 18.58862587°N 98.4866078°E, 18.58877674°N 98.48578504°E.

Altitude — 2,189-2,565 m

7. *WABURGIELLA*

Warburgiella C. Muell. In Broth, Monsunia 1: 176. 1900; Jia, Wu, & Tan, Moss Fl. China 8: 71. 2005.

Plants small, glossy, in dense mats. **Stem** elongate and twisted, prostrate, irregularly or pinnately branched; pseudoparaphyllia foliose. **Stem leaves** and branch leaves similar in shape, falcate-secund or circinate, often concave, narrowly oblong-ovate to rounded ovate-lanceolate, serrulate near apex, subentire below; **costa** short, double, or absent; leaf cells narrowly rhomboidal to linear, smooth or prorate; basal cells yellowish, inflated, rounded oval, hyaline. **Autoicous**. **Seta** slender, reddish, smooth or papilose above; **capsule** horizontal or pendent, papillose at neck when mature; opercula slenderly rostrate; annuli not differentiated; **peristome** double. **Calyptra** cucullate to campanulate, covering large part of capsules, smooth, lobular at base. **Spore** small, finely papillose.

Key to the species

1. Leaves narrowly ovate-lanceolate, slihtly concave; cells linear, with a single large tuberculate papilla..... *W. bistrumosa*
2. Leaves falcate to falcate-secund, narrow to lanceolate; laminal cells rhomboidal, unipapillose over lumen..... *W. leptorhynchoides*

1. *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch.

Musci Fl. Buitenzorg, 4: 1258. 1923.— *Hypnum bistrumosum* Müll. Hal., Linnaea 38: 566. 1874. — *Trichosteleum bistrumosum* (C. M.) Jaeg., Bartram, Philipp. J. Sci. 68: 341, pl., 25, fig. 437. 1939.

Plants slender, yellowish plants in dense mats, slightly glossy. Stems creeping, closely pinnate, branches short. **Leaves** narrowly ovate-lanceolate, slihtly concave, gradually narrowed to a long, fine, flat, denticulate point, to 1.3 mm long; cells linear, firm, smooth or with a single large tuberculate papilla over lumens, **alar cells** usually 2, large inflated, thick-walled. **Seta** long; **capsule** not seen. (**Figure 5.88**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Philippines.

Ecology — On tree trunk.

Specimens examined — *Y. Nathi 109, 207, 215, 683, 990, 1037 (BCU)*

GPS location — 18.5888468°N 98.48451133°E, 18.5561391°N 98.48219197°E, 18.5577792°N 98.48092438°E, 18.55647717°N 98.47627770°E, 18.55569044°N 98.4762096°E

Altitude — 2,189-2,580 m

Note — New record to Thailand.

2. *Warbugiella leptorhynchoides* (Mitt.) M. Fleisch**.**

Musci Fl. Buitenzorg 4: 1253. 1923; Ramsay, Schofield & Tan, J. Hattori Bot. Lab. No. 95: 62, fig. 61. 2004; Pollawatn, Systematic treatment of Sematophyllaceae (Musci) in Thailand, p. 135. 2008.

Plants creeping, irregularly pinnate to bipinnate, greenish to yellow-green, forming mats. **Main stems** creeping; branches upright to spreading, 4-5 mm long. **Leaves** falcate to falcate-secund, narrow to lanceolate, abrubtly narrowed to a long serrulate acumen; laminal cells rhomboidal 55-75 x 5-6 μm, often unipapillose over lumen, apical cells long; **alar region** with basal row of 2-3 large alar cells, orange, elliptical, thick-walled, 85-110 x 15-20 μm; supra-alar cells few, thickwalled. **Polyoicous. Seta** orange, 1.4-1.9 cm, smooth, often curled upward; **capsule** horizontal, cylindrical; **peristome** double. (**Figure 5.89**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China

Ecology — On tree trunks.

Specimens examined — *Y. Nathi179, 277, 649 (BCU).*

GPS location — 18.5558408°N 98.48227453°E, 18.5583313°N °98.47963390E.

Altitude — 2,171-2,256 m

8. *WIJKIA*

***Wijkia* H.A. Crum**, Bryologist 74: 170. 1971; Gangulee, Mosses E. India 8: 1857. 1980; Jia, Wu, & Tan, Moss Fl. China 8: 72. 2005.

Plants creeping, irregularly subpinnately to irregularly bipinnately branched with stem and branch leaves differing. **Stem leaves** appressed to erect widespreading whendry, abruptly tapered from an ovate to ovate-lanceolate, strongly concave base, sometimes with a piliferous, serrulate apex. Branch leaves smaller and gradually acuminate. Laminal cells long, hexagonal to linear, smooth to seriately papillose over lumina and cell walls; **alar region** clearly differentiated with basal row of large, inflated and coloured or hyaline cells, and several rows of small quadrate supra-alar cells. **Gemma** as groups of flegelliform brood branches with microphyllous leaves sometimes occur at ends of branches. **Seta** long; **capsule** horizontal; **peristome** double, diplolepidous. **Spores** small.

Key to the species

1. Leaves erect, oblong-ovate; leaf margins plane or involute, slightly toothed above; lamina cells linear to fusiform; alar cells with a large and thin-walled decurrent cell .....2. *W. hornschuchii*
1. Leaves, ovate-lanceolate, deflexed tips, narrow acuminate apex, margin smooth; leaf cells linear; alar cells with some irregular cells on top..... .....1. *W. deflexifolia*

1. *Wijkia deflexifolia* (Ren. & Card.) H.A. Crum,

Bryologist 74: 171. 1971; Gangulee, Mosses E. India & 8: 1860, fig. 945. 1980; Jia, Wu, & Tan, Moss Fl. China 8: 73, Pl. 619, figs. 1-14. 2005.

Plants robust, brownish green, glossy in dense tufts. **Main stem** creeping, irregularly and bi- to tripinnately branched, ultimate branchlets attenuate, subulate at the apex, brownish green. **Stem leaves** erect spreading, broadly ovate to oblong-ovate, gradually subulate-acuminate, concave, deflexed tips narrow acuminate; margins plane, entire to weakly dentate below, serrulate at apex; branch leaves smaller, ovate-lanceolate, concave, abruptly acuminate to shortly acuminate; **ecostate**; **leaf cells** linear, firm to thick-walled, slightly prorulose, more lax across the insertion; **alar** differentiated by 3 - 4 large cells, 45-50 x 20-25 μm, in one row with some irregular cells on top and becoming narrower along the line of insertion. **Sporophyte** on main branches. **Capsule** horizontal, oblong-ovoid, cylindrical; **operculum** conic at base, long rostrate; peristome double . (**Figure 5.90**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, Himalayas, Bhutan, Sikkim, India, Laos, Vietnam, Kamphuchea, Taiwan, and Philippines.

Ecology — On rotten logs, tree trunks, or branches.

Specimens examined — *Y. Nathi 1037 (BCU).*

GPS location — 18.58058553°N 98.4926264°E.

Altitude — 2,207 m

2. *Wijkia hornschuchii* (M. Fleisch.) H.A. Crum.

Bryologist 74: 172. 1971. Gangulee, Tan & Jia, J. Hattoti Bot. Lab. No. 86: 60, fig. IX. 13-15. 1999; Jia, Wu, & Tan, Moss Fl. China 8: 73, Pl. 619, figs. 1-14. 2005.

Plants green to yellowish brown, glossy, in mats. **Main stems** 2-3 pinnately branched, branches long and slender, slightly plane, distally attenuate. **Stem leaves** erect, oblong-ovate, concave, often abruptly constricted into a short filiform acumen, weekly toothed, constricted at base; leaf margins plane or involute, slightly toothed above; branch leaves small narrower than stem leaves at base, concave, acumen shorter; **ecostate**; **leaf cells** linear to fusiform, uniformly, thin-walled, gradually becoming shorter towards apex, oblong and thick-walled near base; **alar cells** few, inflated, hyaline or slightly yellowish, with a large and thin-walled decurrent. **Dioicous. Sporophytes** on main stem**. Seta** smooth. **Capsule** inclined, oblong-ovoid or subcylindrical. (**Figure 5.91**)

Thailand — NORTHERN: Chiang Mai.
Distribution — China and Japan.
Ecology — On stones or rotten logs; alt. 2000-2150 m.
Specimens examined — *Y. Nathi 198, 727, 891, 888, 1074 (BCU).*
GPS location — 18.5893751°N 98.48579443°E, 18.5888328°N 98.48452281°E, 18.58883869°N 98.48426524°E.
Altitude — 2,530-2,570 m

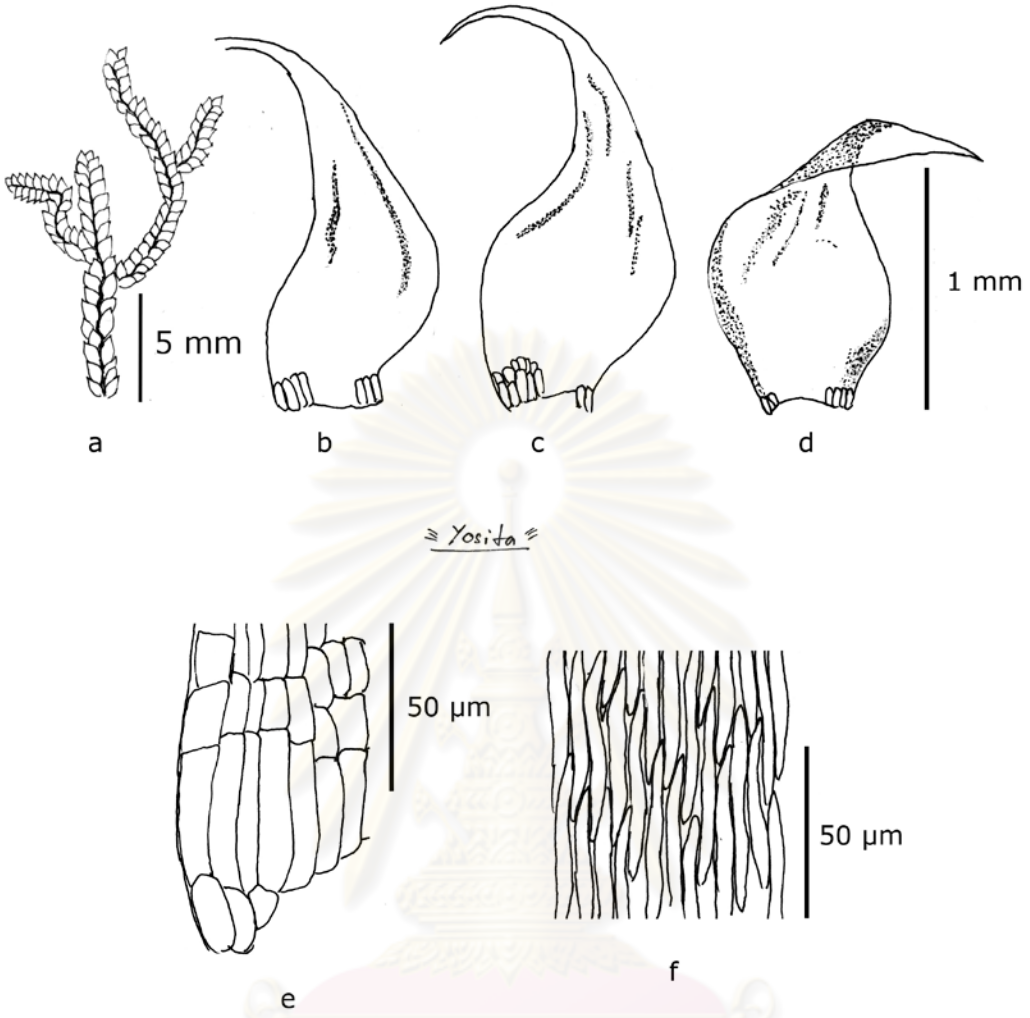


Figure 5.76 *Brotherella falcata* (Dozy & Molk.) Fleisch.
a. portion of plant; b., c., d. Leaves; e. Alar cells; f. cells at median leaf. Based on Y. Nathi 619.

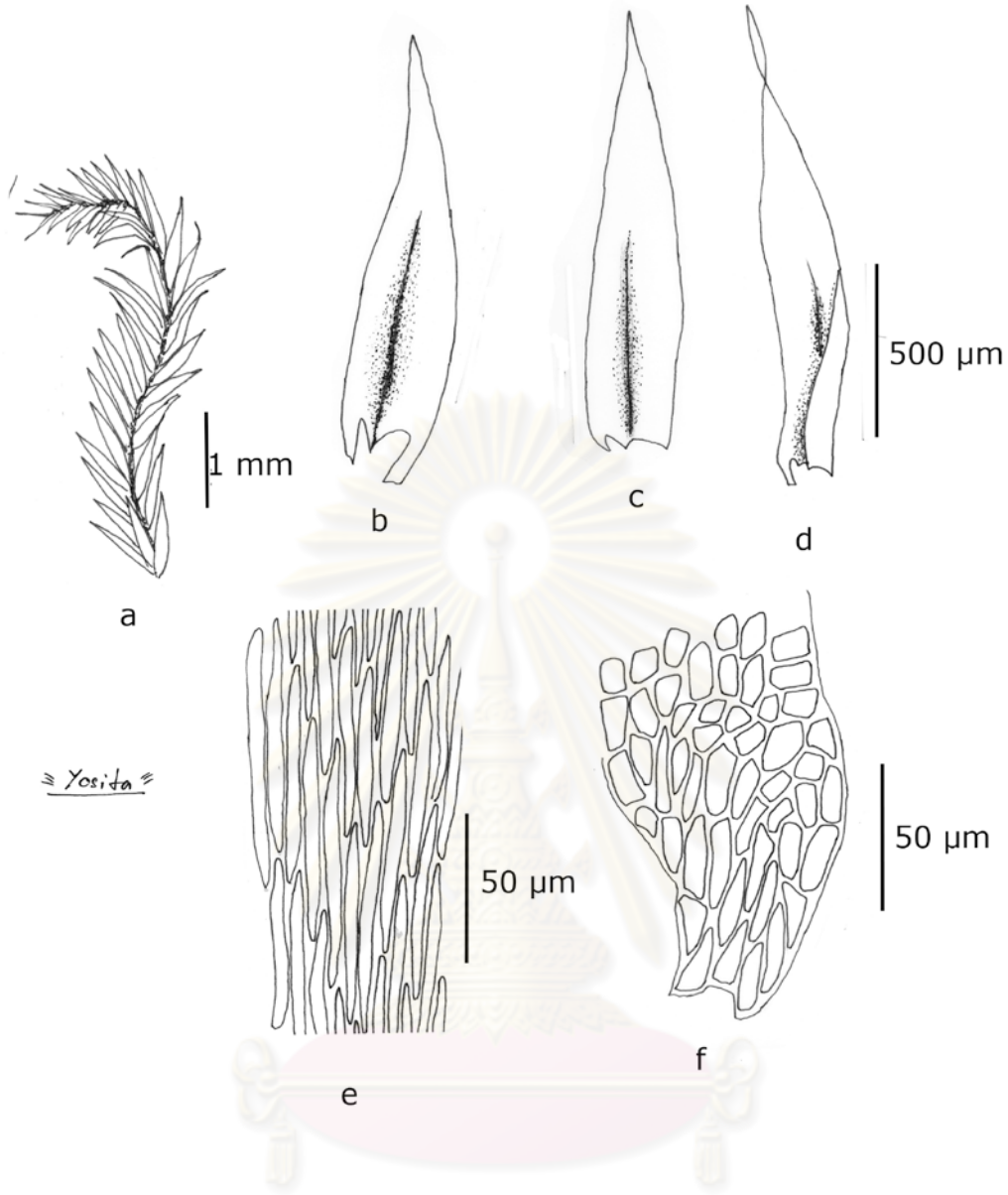


Figure 5.77 *Clastobryopsis brevinervis* Fleisch.
a. portion of plant; b., c., d. Leaves; e. cells at median leaf; f. cells at basal leaf. Based on Y. Nathu. 150.

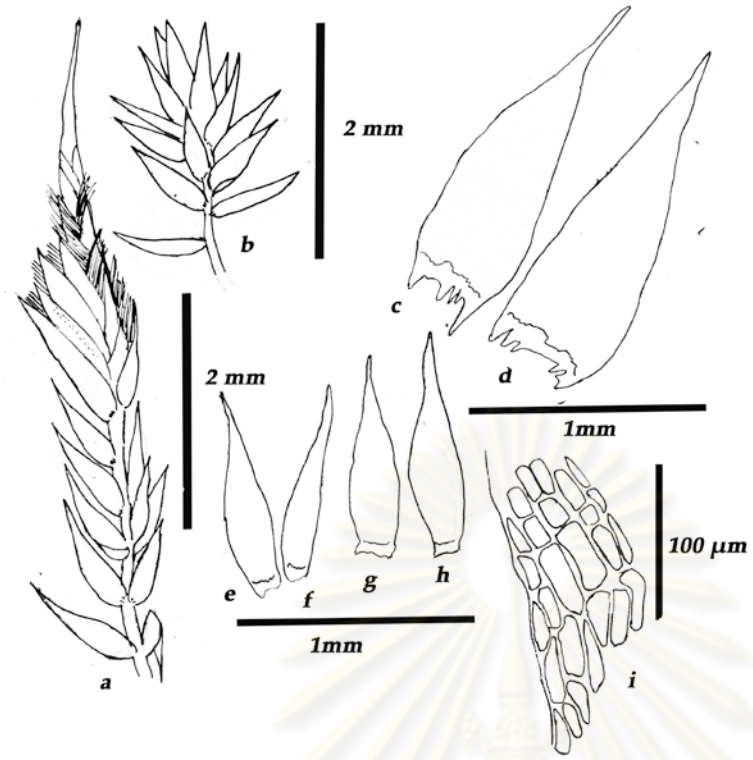


Figure 5.78 *Clastobryopsis planula* (Mitt.) Fleisch.
.a. propaguliferouse leaves; b. portion of plant; c., d., e., f., g., h. leaves. i. alar cells. Based on *Y. Nathi 528.*

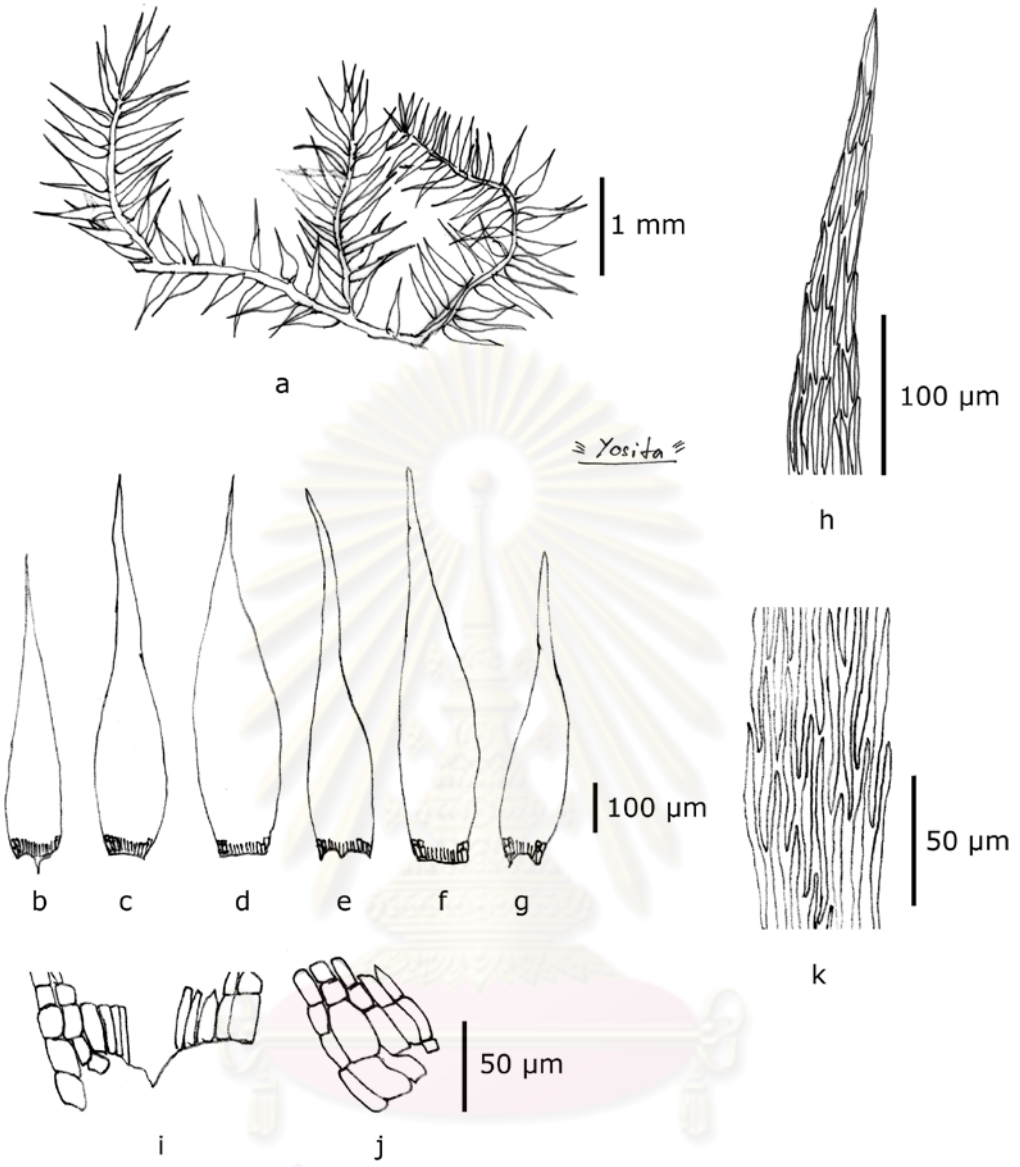


Figure 5.79 *Clastobryopsis planula* var. *delicata* (M. Fleisch.) B.C. Tan & Y. Jia a. habit; b., c., d., e., f., g. leaves ; h. leaf apex; i. cell at leaf base; j. alar cells; k. cells at median leaf. Based on *Y. Nathi 238.*

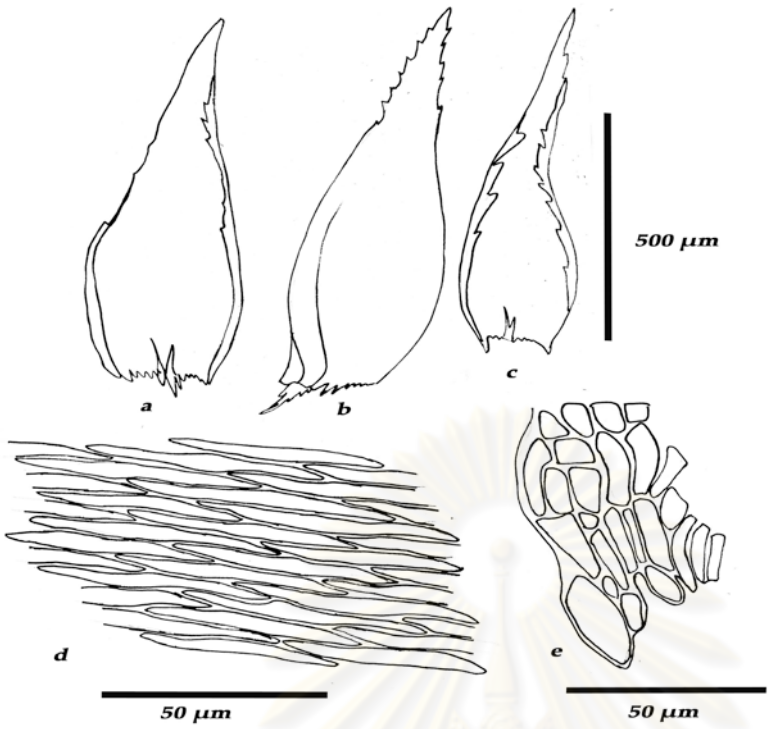


Figure 5.80 *Clastobryopsis robusta* (Broth.) Fleisch.
a., b., c. leaves; d. Cells at median leaf; e. alar cells. Based on *Y. Nathi 627*.

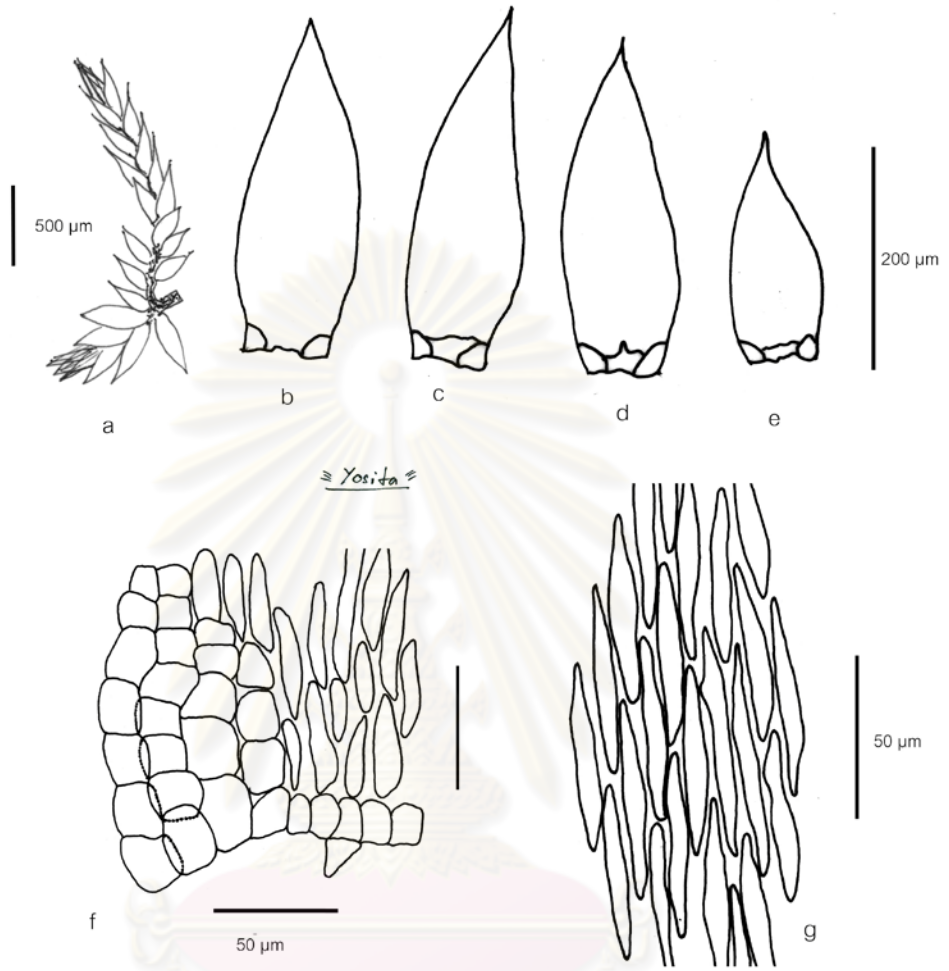


Figure 5.81 *Gammiella ceylonensis* (Broth. in Herzog) B.C.Tan & W.R.Buck
a. portion of plant; b., c., d., e. leaves; f. alar cells; g. cells at median leaf. Based on Y. Nathi 293.

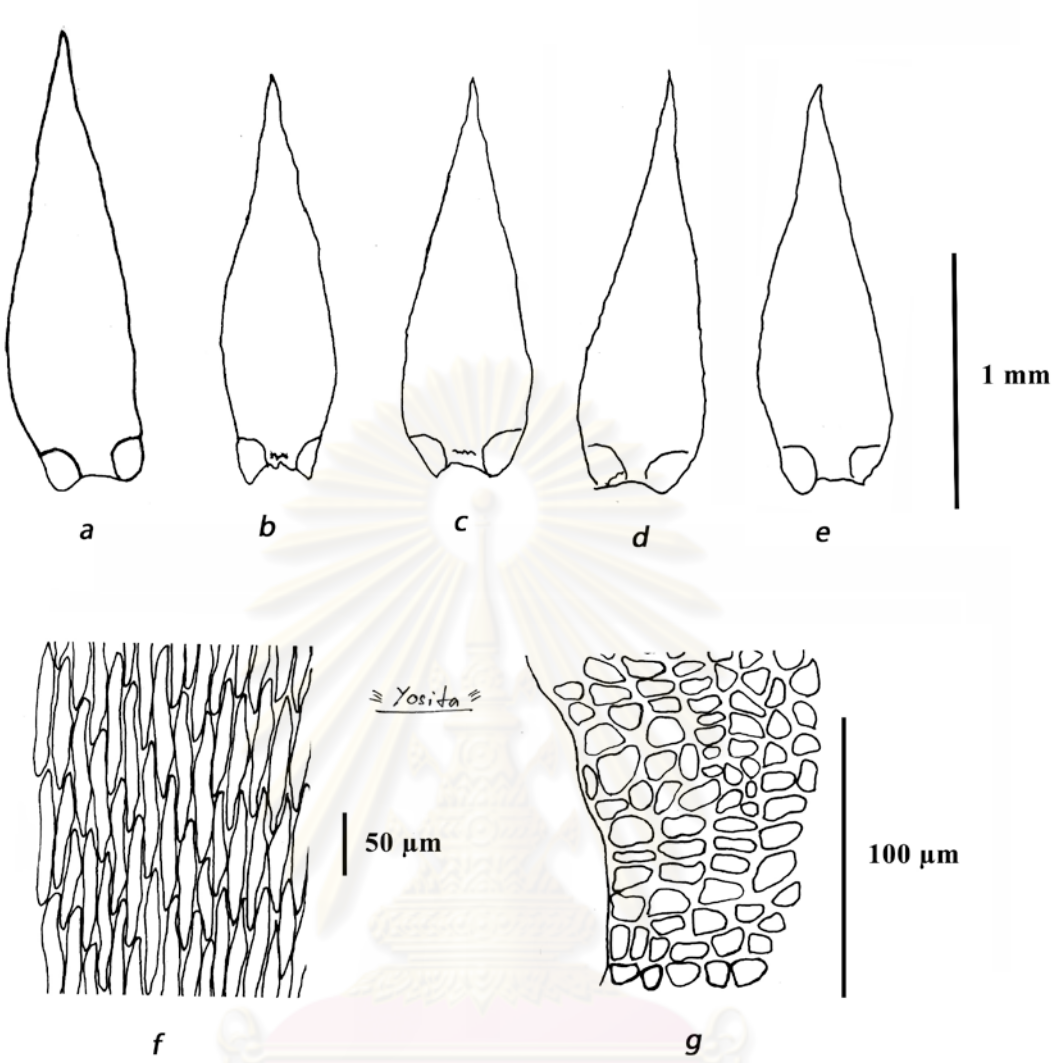


Figure 5.82 *Gammiella pterogonioides* (Griff.) Broth.
a., b., c., d., e. leaves; f. cells at median leaf.; g. alar cells. Based on *Y. Nathi 469.*

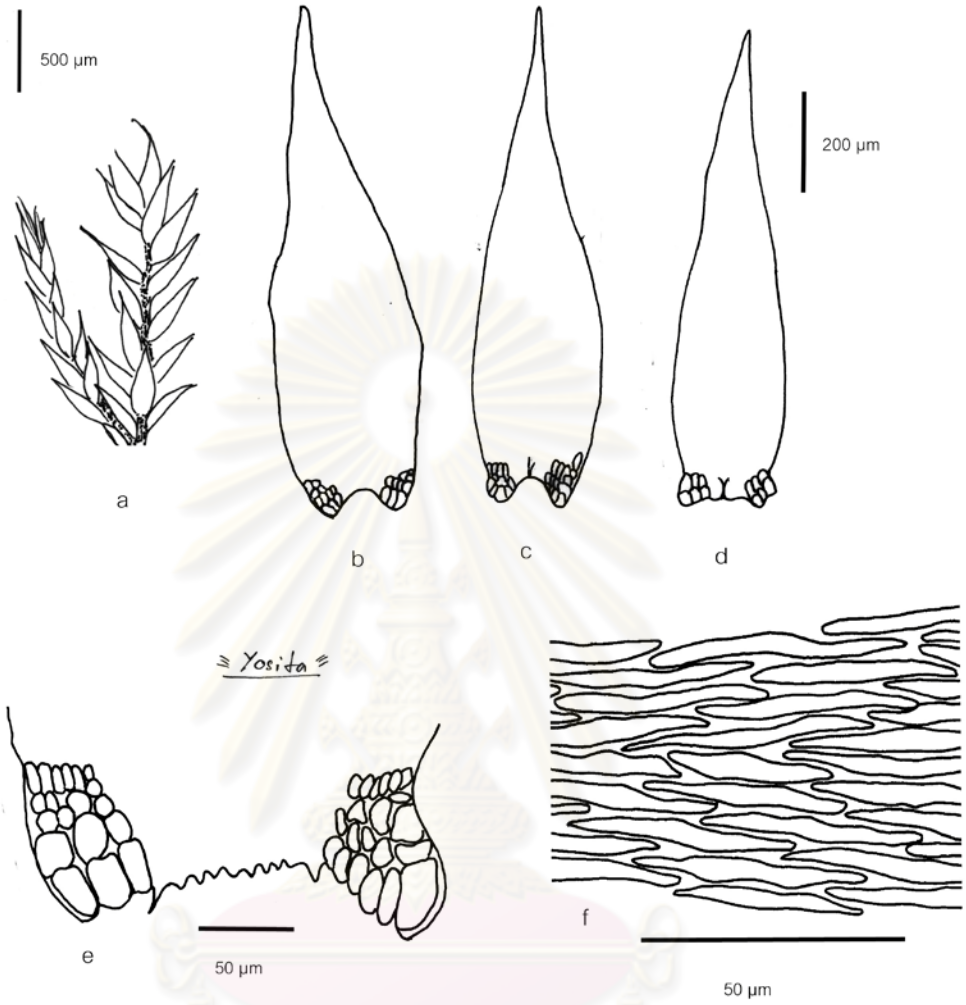


Figure 5.83 *Gammiella tonkinensis* (Broth. & Paris) B.C. Tan
a. portion of plant; b., c., d. leaves; e. alar cells; f. cells at median leaf. Based on *Y. Nathi 387*.

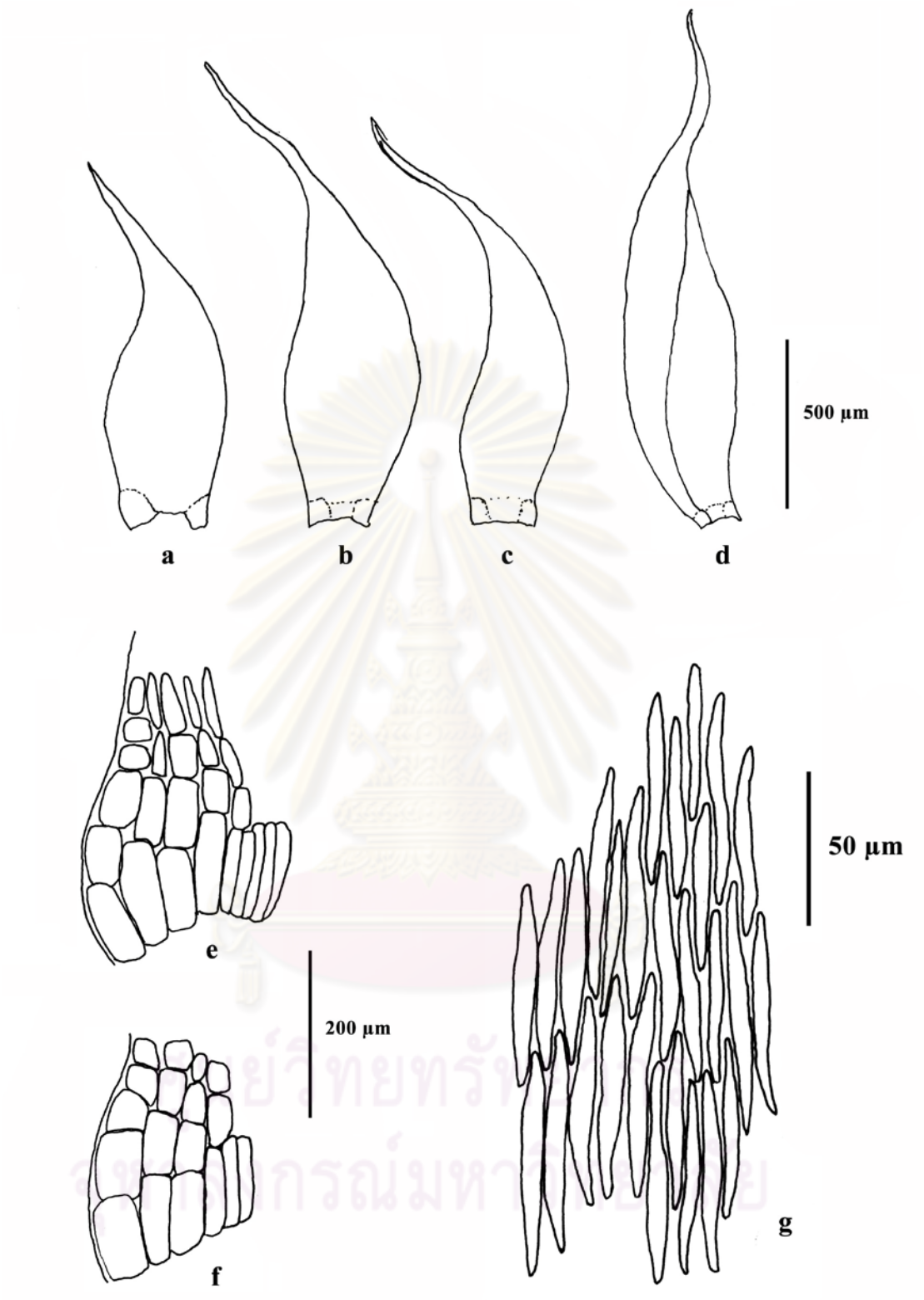


Figure 5.84 *Heterophyllium affinae* (Hook.) Fleisch.
a., b., c., d. leaves; e., f. alar cells; g. cells at median leaf. Based on *Y. Nathi 233.*

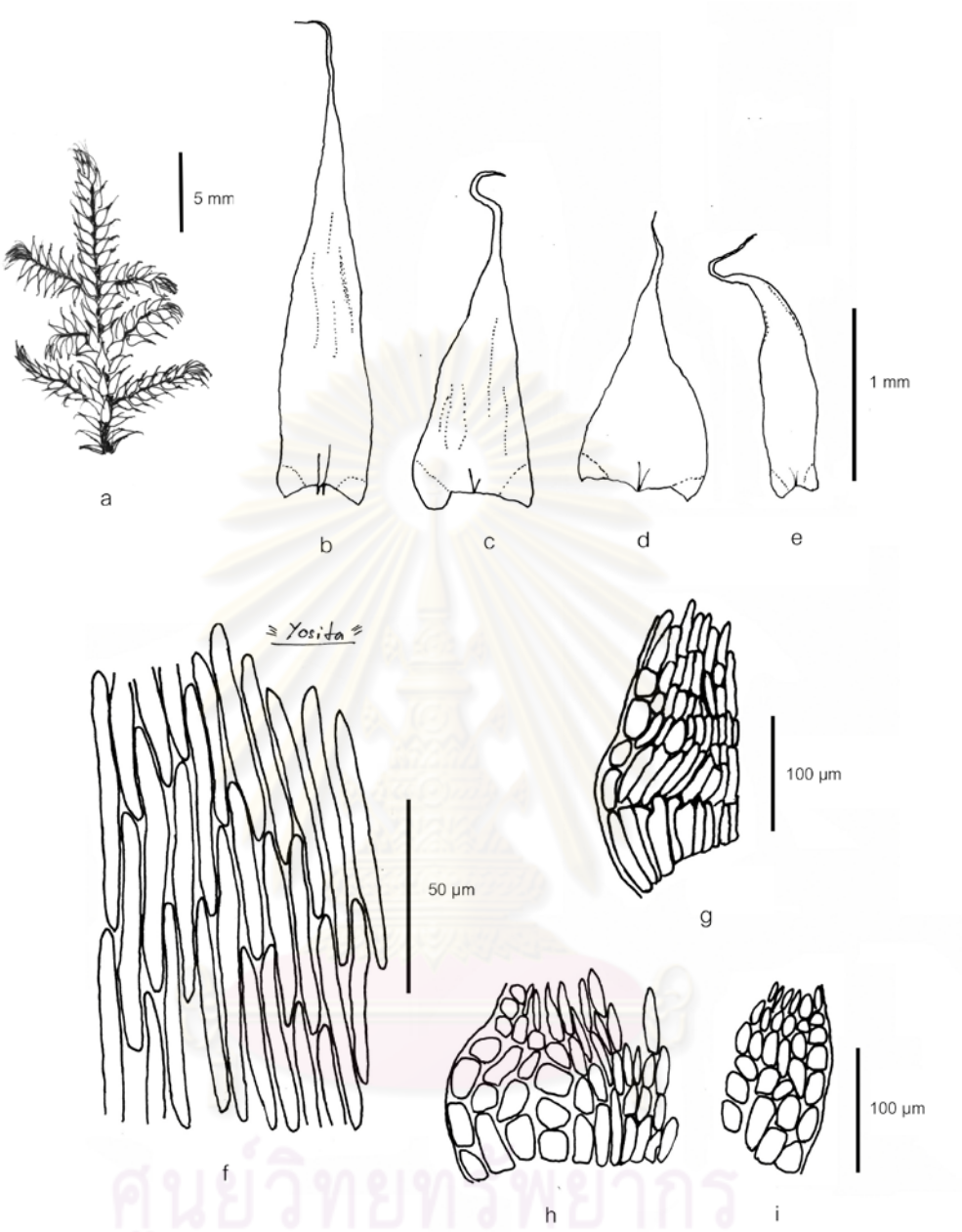


Figure 5.85 *Heterophyllium amblystegum* (Mitt.) Y. Jia, S. He & Crosby
a. portion of plant; b., c., d., e., f., g. leaves; h. cells at median leaf; i., j., k. alar cells. Based on *Y. Nathi 812*.

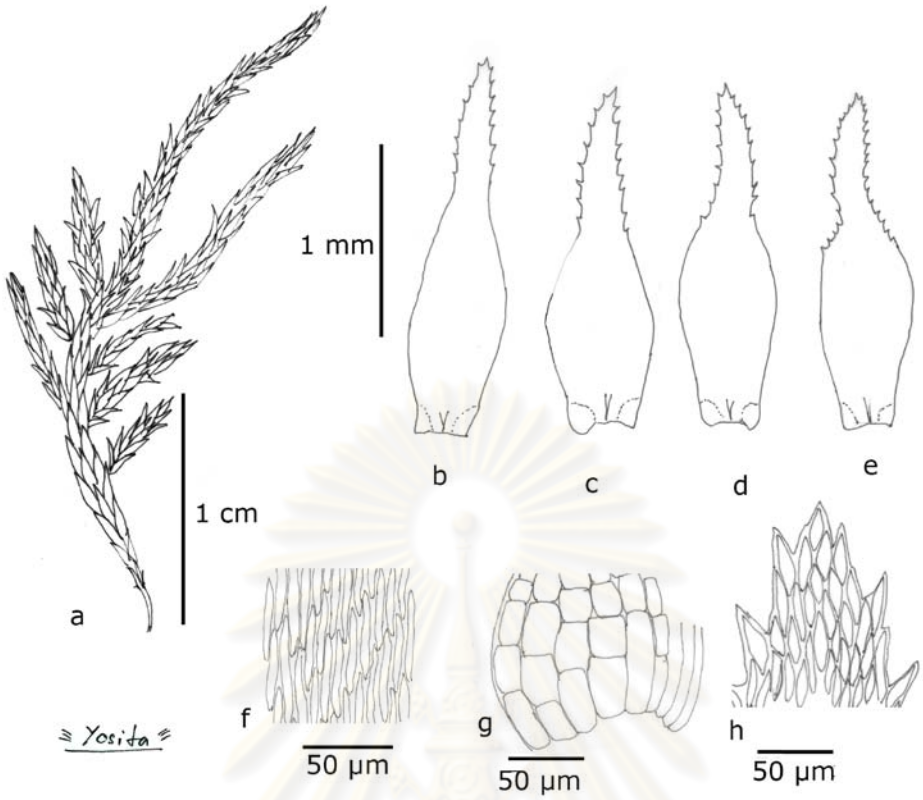


Figure 5.86 *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota a. habit; b., c., d. E. leaves; f. cells at median leaf; g. alar cells; h. Cells at leaf apex. Based on *Y. Nathi. 117*.

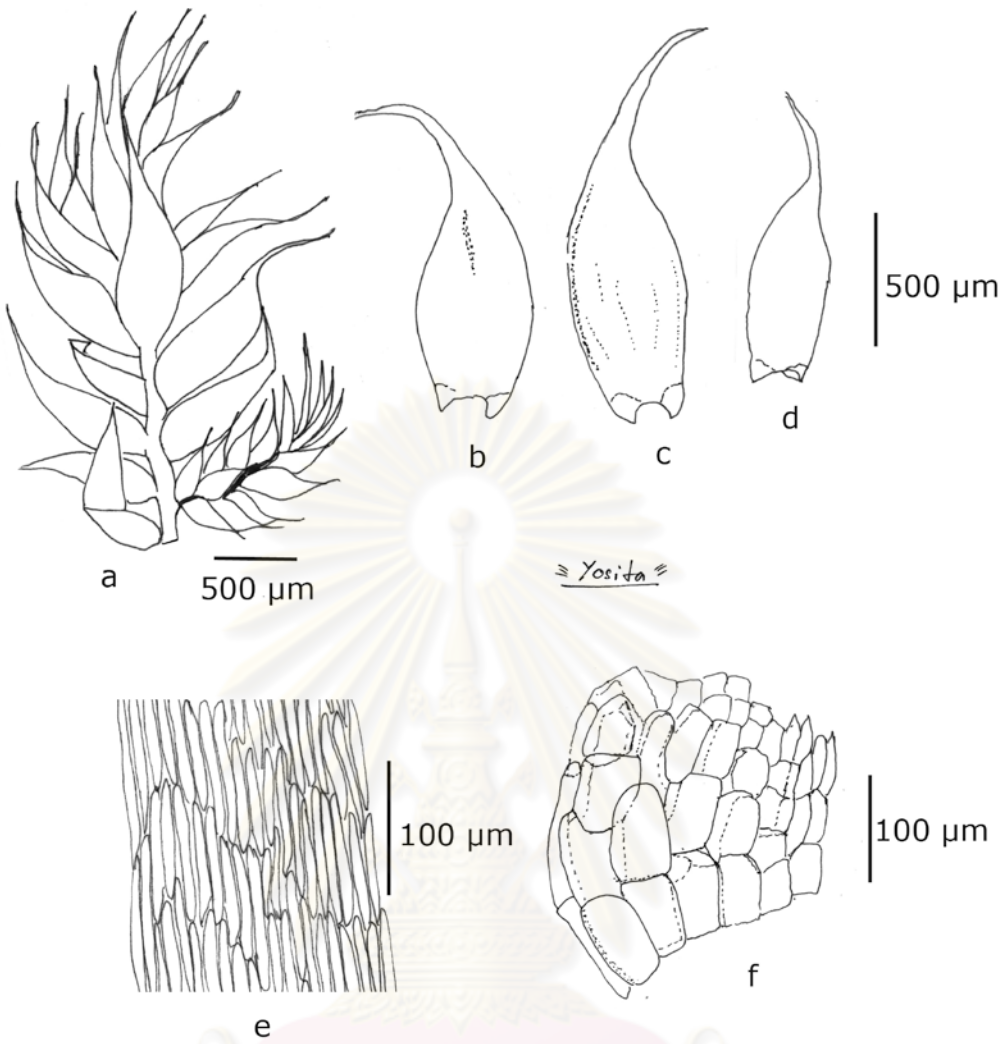


Figure 5.87 *Mastopoma subfiliferum* Horik. & Ando
a., portion of plant; b. c. d. leaves; e. cells at median leaf; f. alar cells. Based on *Y. Nathi 213*.

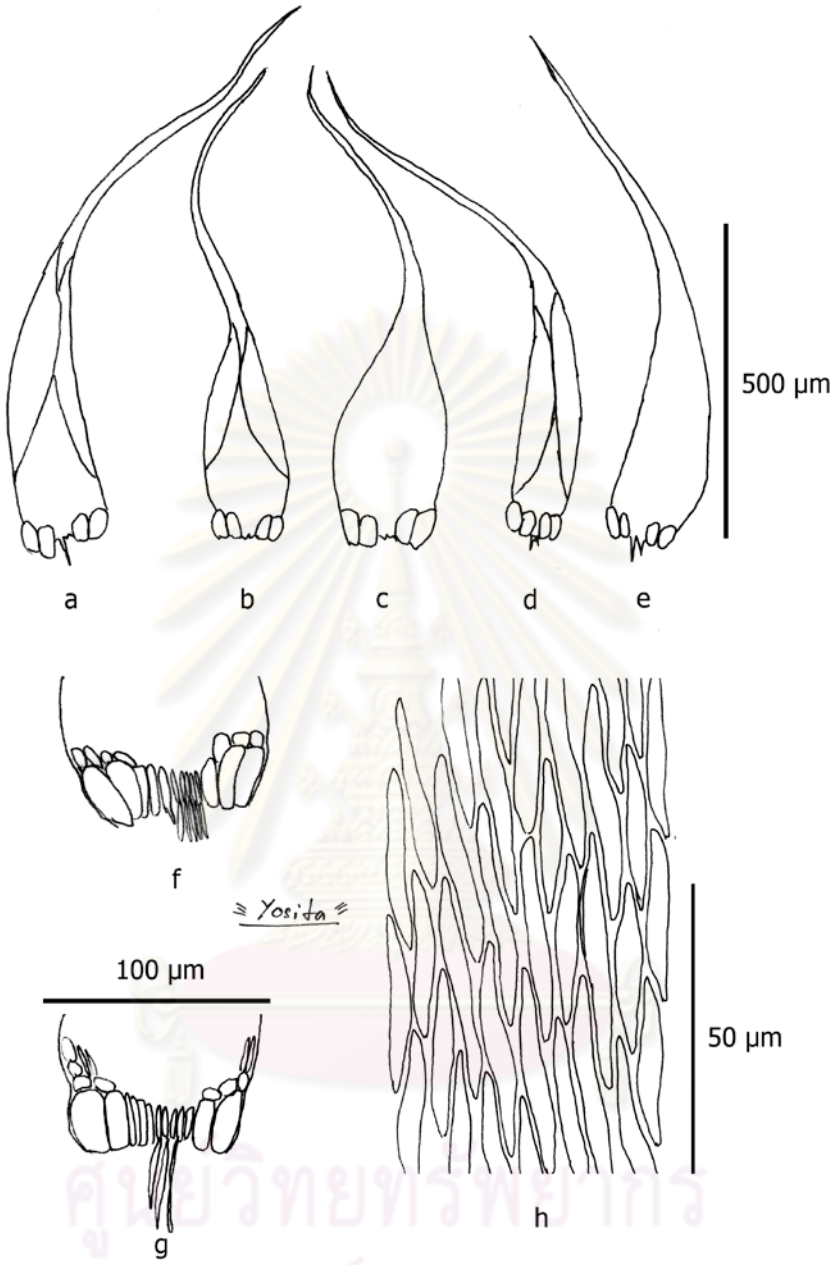


Figure 5.88 *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch.
a., b., c., d., e. leaves; f., g. leaf base; h. cells at median leaf. Based on *Y. Nathi 207.*

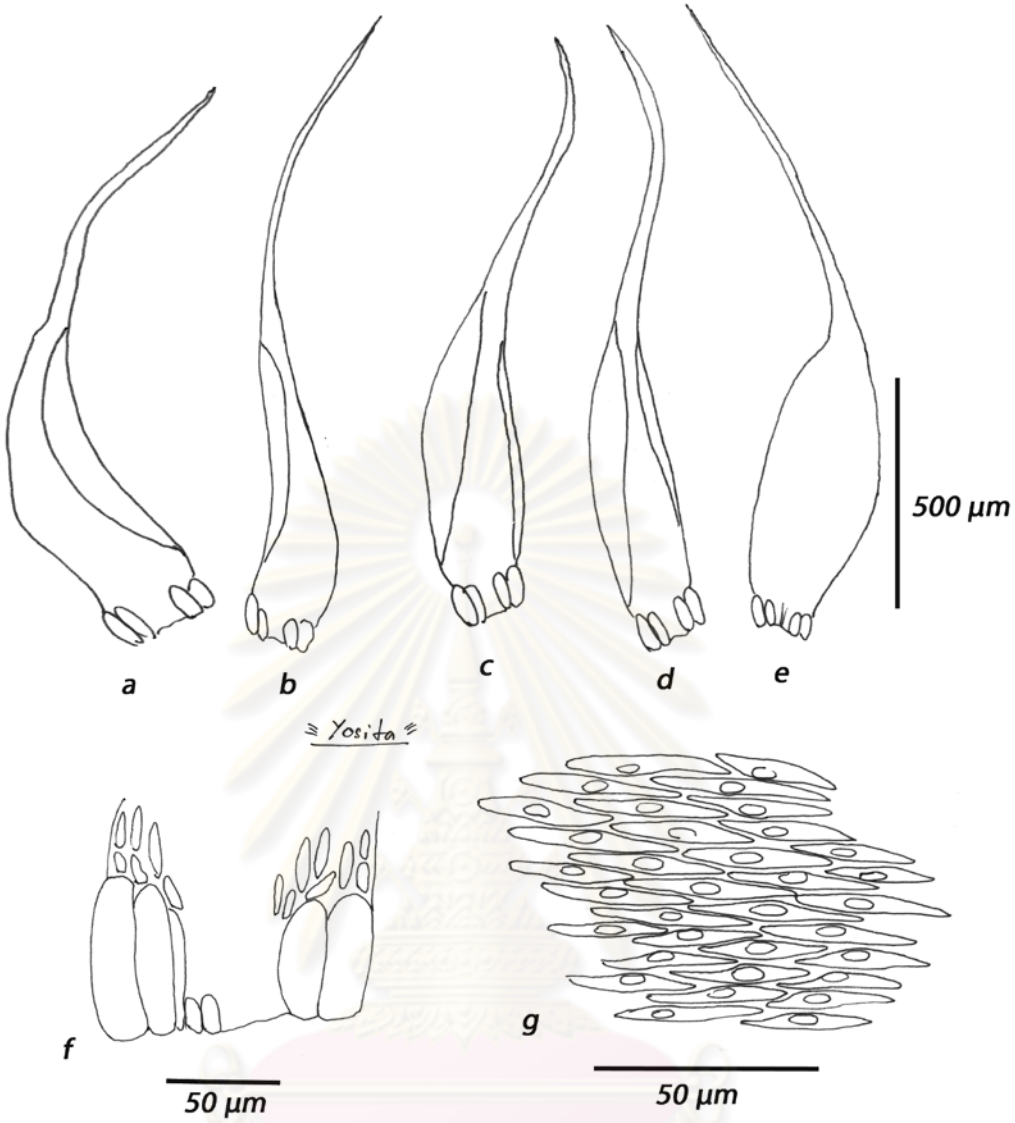


Figure 5.89 *Warburgiella leptorhynchoides* (Mitt.) Fleisch.
a., b., c., d., e. leaves; f. alar cells; g. cells at median leaf. Based on *Y. Nathi 197.*

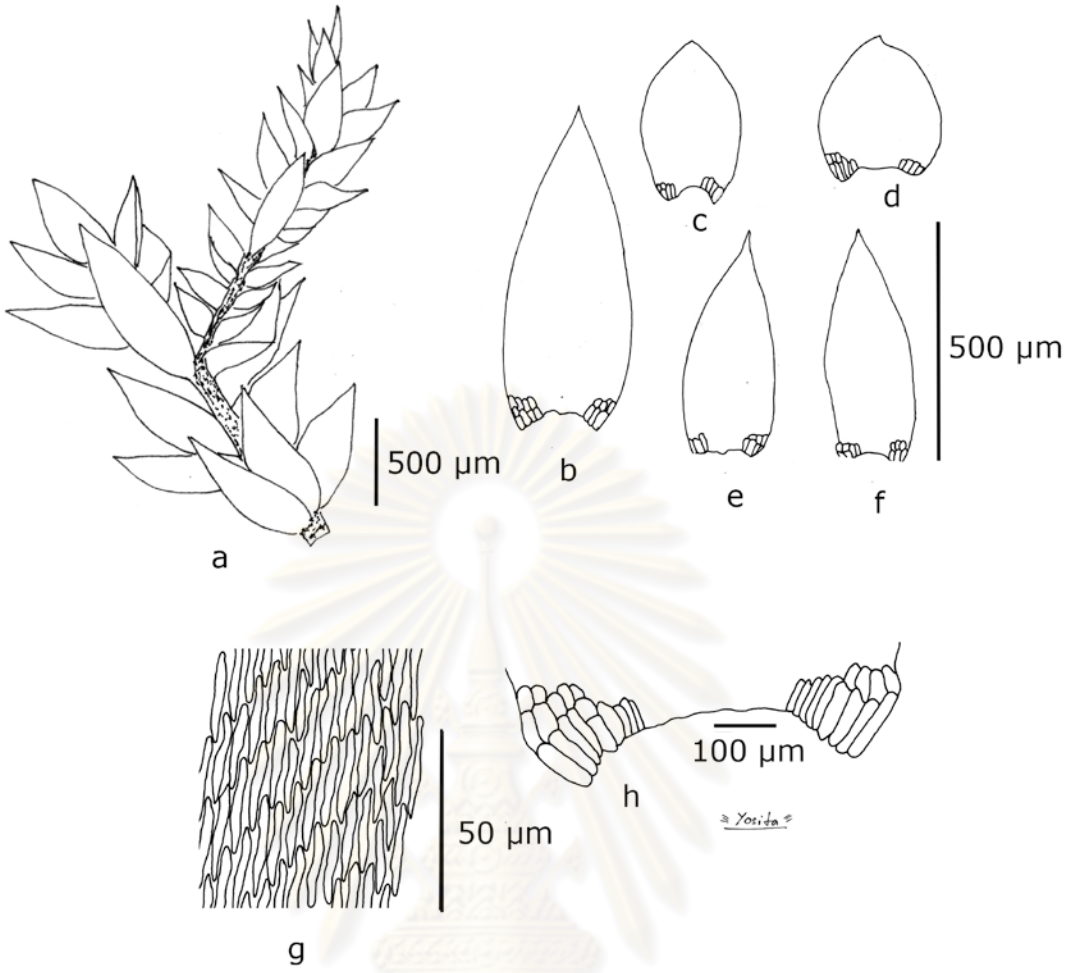


Figure 5.90 *Wijkia deflexifolia* (Ren. & Card.) Crum
a. portion of plant; b., c., d., e., f. Leaves; g. Cells at median leaf; h. alar cells . Based on *Y. Nati 1073*.

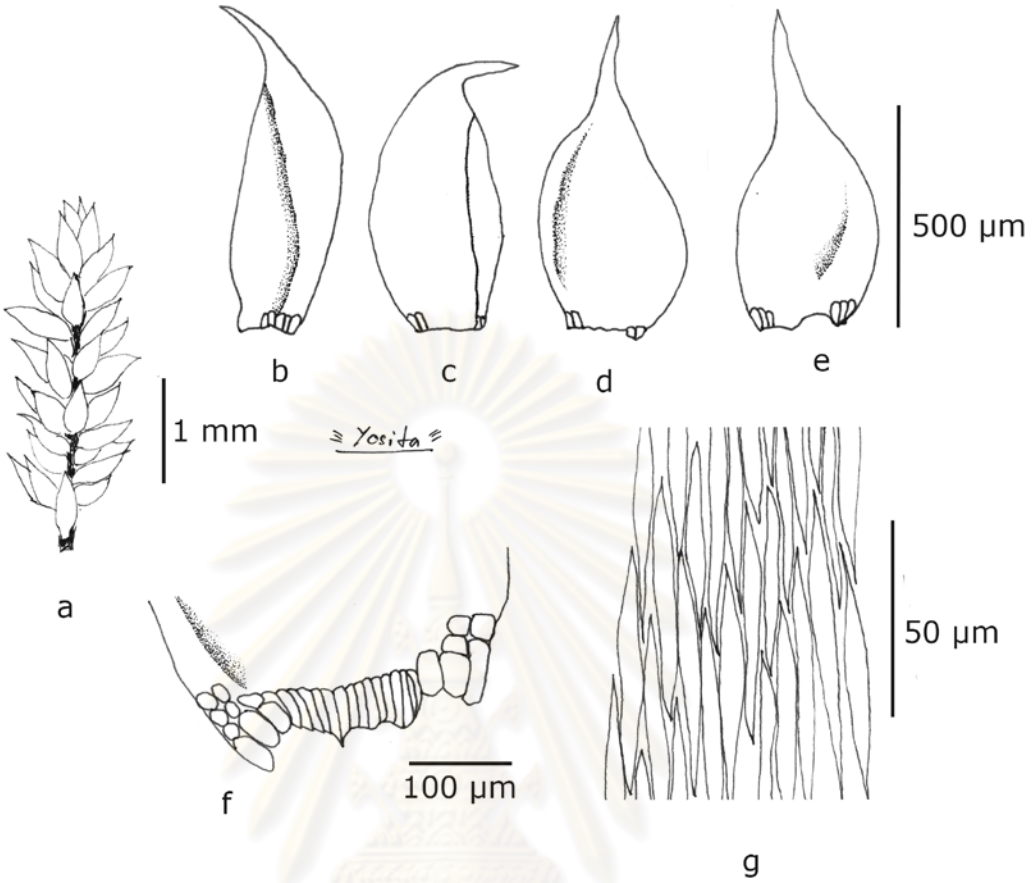


Figure 5.91 *Wijkia hornschuchii* (M. Fleisch.) H.A. Crum
a. portion of plant; b., c., d., e. leaves; f. basal leaf; g. Cells at median leaf.
Based on *Y. Nathi 198.*

SPHAGNACEAE

Plants small to robust, whitish green to yellowish brown, sometimes tinged with purple or reddish color, in mats, cushions or hummocks, growing in wet habitats, infrequently submerged in water. **Stems** erect, simple or sparsely branched; stem tissues consisting of three distinct layers with thin-walled parenchyma centrally surrounded by a colored wood cylinder of thick-walled prosenchyma and enclosed by 1 or more layers of large, thin-walled, empty (hyaline) cortical cells, sometimes with spiral fibrils. **Branches** often arranged in fascicles, spirally disposed around the stems, each fascicle often consisting of two or more divergent branches and two or more slender pendent branches; branches usually crowded at the stem tips forming a head-like tuft or capitulum; branch cortical cells often with numerous enlarged, apical pores, at times with fibrils. **Stem leaves** spirally and widely spaced, usually differentiated in size, shape, and structure from branch leaves; mature stem leaves with little or no chlorophyll, the divided hyaline cells often with a weak development of pores and lack of transverse fibrils. Branch leaves spirally arranged in more or less 4–5 rows, often bordered by several rows of linear cells, enclosing a network of elongated green cells surrounding large, empty hyaline cells; the hyaline cells nearly always reinforced by ring-like fibrils and porous at the surfaces. **Dioicous** or monoicous.

SPHAGNUM

Sphagnum Linnaeus, Sp. Pl. 1106. 1753; Gangulee, Mosses E. India 1: 1. 1969; Eddy, Handb. Males. Mosses 1: 14, fig. 7. 1996; Li & He, Moss Fl. China 1: 3. 1999.

The description of the genus is the same as that of the family.

Sphagnum cuspidatulum C. Müll.

Linnaea. 38: 549. 1874; Gangulee, Mosses E. India 1: 40, fig. 17. 1969; Eddy, Handb. Males. Mosses 1: 14. 1996; Eddy, Bull. Brit. Mus. (Nat. Hist.) Bot. 5: 359-445. 1977; Li & He, Moss Fl. China 1: 13, plate 2. 1999.

Plants stout, robust, whitish green tinged with brownish, in dense tufts, shiny when dry. **Stem** cortex in 2–3 layers, hyaline cells narrow, thin-walled, without fibrils; central cylinder not clearly differentiated. Stem leaves 0.7–1.6 mm × 0.5–0.9 mm, oblong-ligulate or triangular-ligulate, sometimes the basal width wider than length, narrowly obtuse to acute, at times

lacerated at the apex, borders narrow, evenly differentiated; hyaline cells divided, rather short and broad, without fibrils and pores, occasionally with one or two large, central pores on the ventral surface. Branches in fascicles of 4–6, with 2–3 spreading, often slender and curved at the apex. **Branch leaves** usually in 5 rows, 0.8–1.3 mm × 0.3–0.6 mm, ovate-lanceolate, gradually narrowed to a chanelled apex, margins involute, often undulate when dry; hyaline cells densely fibrillose, with numerous large pores at the corners on the ventral surface, with small, ringed pores at the cell angles on the dorsal surface, the inner walls adjacent to green cells smooth; the green cells in cross section triangular, exposed on the dorsal surface. **Dioicous**. **Sporophytes** not seen. (**Figure 5.92**)

Thailand — NORTHERN:Chiang Mai, Phetchabun; SOUTHEASTERN: Nakhon Nayok: EASTERN: Nakhon Ratchasima.

Distribution — Borneo, Celebes, China, India, Laos, Malay Peninsula, Myanmar, New Guinea, Philippines, Sabah, and Sumatra.

Ecology — Small bog.

Specimens examined — *Y. Nathi66, 609, 1002* (BCU)

GPS location — 18.5890358°N 98.48577926°E

Altitude — 2,554 m

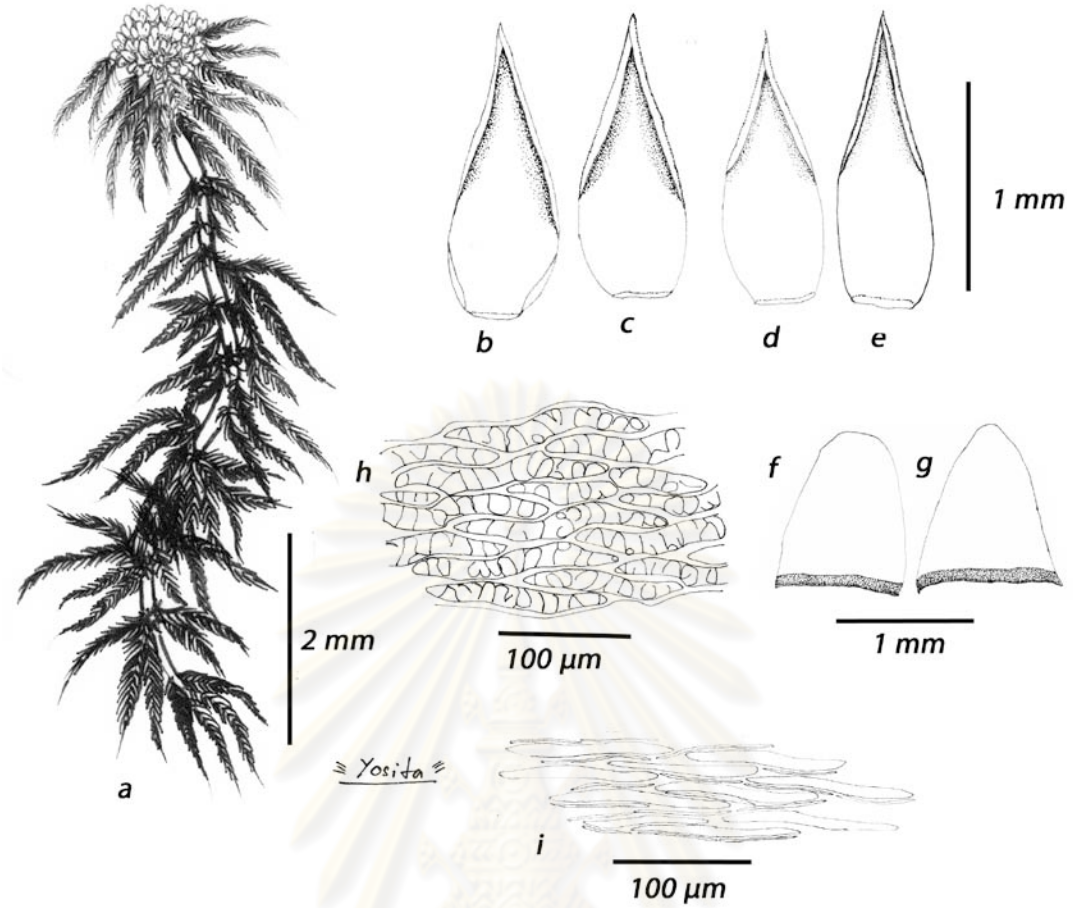


Figure 5.92 *Sphagnum cuspidatulum* C. Müll.
a. habit; b., c., d., e. bran leaves; f., g. stem leaves; h. lower cells of stem leaf; i. cells at leaf margin. Based on *Y. Nathi 66.*

SYMPHYODONTACEAE

Plants medium to robust, glossy, tufted plants of soft texture**. Primary stems** creeping, without definite central stand. Secondary branches usually pinnately branched, weak but usually ascending, rarely pendant, slightly pinnate. **Leaves** ovate, concave, short pointed, serrulate or dentate at top usually rough papillose on upper or lower or both surfaces. **Costa** double, short. Leaf cells linear, generally papillose. **Seta** long, scabrous above. **Capsule** erect or nodding, mostly densely spinulose. **Peristome** double, endostome with low basal membrane. **Operculum** conic-rostrate. **Calyptra** cucullate, smooth.

SYMPHYODON

Symphyodon Mont., Ann. Sci. Nat. Bot., sér. 2, 16: 279. 1841; He & Snider, Bryologist 103(1): 55. 2000.

Plants small to large, dull to glossy, yellowish green, golden yellow. **Stem** prostrate, irregularly pinnately branched or tripinnately branched; leafy stems appressed or subcomplanate to complete. **Leaves** similar or dimorphic, plane to deeply concave, sometimes undulate when dry, oval, ovate, oblong, oblong-ovate, oblong-lanceolate or lingulate; leaf apices truncate, rounded, obtuse, apiculate, or acute to acuminate; margins plan to slightly inflexed, finely serrulate to coarsely serrate above, serration nearly always formed by now of slightly enlarged cells, subentire to entire below, not or narrowly decurrent at base; **costae** double, unequal, extending to 1/2 total leaf length; apical leaf cells undifferentiated or conspicuously shorter than adjacent cells; median cells linear, prorulose to strongly prorate; **alar cells** more or less differentiated, quadrate, subquadrate, or irregularly rectangular, thin- to thick-walled, of 3-5 rows of cells extending 3-6 cells up margins. **Dioicous**. **Setae** 1.0-4.5 cm long, roughened to strongly papillose distally, smooth proximally; **capsule** suberect to erect, oblong-oviod to cylindric, symmetric to faintly asymmetric, sparsely to densely echinate, spines to 150 μm long, formed as extensions of exothecial cell walls; **annulus** differentiated; **opercula** conic, apiculate to obliquely long rostrate, smooth to occasionally prickly papillose; **peristome double**. **Calyptra** cuculate, smooth.

Key to species

1. Leaf of ultimate branches not complanate ..... *S. echinatus*
1. Leaf of ultimate branches not complanate..... 2
   2. Leaves elliptical oblong ..... *S. oblongifolius*
   2. Leaves ovate oblong..... *S. asper*

1. *Symphyodon asper* (Mitt.) Jaeg.

Ber Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 296. 1878; Gangulee, Mosses E. India 6: 1526, fig. 766. 1977; He & Snider, Bryologist 103(1): 70. 2000. — *Stereodon saper* Mitt., J. Proc. Linn. Soc. Bot. Suppl. 1: 110. 1859.

Plants slender, medium-sized, yellowish green to yellow, somewhat glossy. **Stems** bipinnately branched. **Leaves** appressed, clearly dimorphic; stem leaves oblongovate or somewhat oblong-cordate, asymmetric, slightly decurrent; branch-leaves oblong to ovate-lanceolate or sometime cultriform; all leaf apices broadly acuminate to narrowly acute; margins irregularly serrate in upper half, serration formed by row of larger cells, entire below; costae unequal; apical leaf cells not particularly than adjacent cell; median cell linear, strongly prorate; **alar cells** clearly differentiated, numerous, thick-walled, quadrate, of 3-5 rows extending 4-6 cells up margings. Setae 1.5-2.5 cm long, faintly to strongly papillose distally, smooth proximally; **capsule** erect, ovate-cylindric , asymmetric; densely echinate, spines to 90 μm long; exothecial cells rectangular; **annulus** differentiated, of 3-4 rows of small cells; opercula, rostrate, ca 9.5 mm long; peristome double.(**Figure 5.93**)

Thailand — NORTHERN: Chiang Mai.

Distribution — India, Myanmar, Nepal, and Sikkim.

Ecology — On branches.

Specimens examined — *Y. Nathi 130, 811, 865, 1053* (BCU).

GPS location — 18.5883898°N 98.48594539°E, 18.58622639°N 98.48684158°E, 18.5592602°N 98.4781121°E,

Altitude — 2,277-2,561 m

2. *Symphyodon echinatus* (Mitt) Jaeg.

Ber. Thaätigk. St. Gallischen Naturwiss. Ges. 1876-77: 296. 1878; Gangulee, Mosses E. India 6: 1519, fig. 761. 1977; He & Snider, Bryologist 103(1): 70. 2000. — *Stereodon echinatus* Mitt. J. Proc. Linn. Soc., Bot., Suppl. 2: 110. 1859.

Plants medium-sized to rather large, yellow green to brownish green, not glossy. **Stems** with bipinnate to tripinnate branchlets. **Leaves** appressed, clearly dimorphic: stem leaves ovatelanceolate, 1.3-1.6 mm x 0.5-0.7 mm symmetric, gradually tapered, narrowly acuminate at apex; margins irregularly serrate above, serrulate or subentire below, often clearly decurrent at base; branch leaves 0.7-1.1 X 0.35-0.55 mm wide, slightly incurved on one

or both side, oval, broadly ovate to oblong-ovate, cordate or oblong-lanceolate; all leaf apices broadly to moderately broad acute; margins irregularly serrate in upper 2/3, serration formed by row of enlarged cell, subentire below; **costae** double**,** short, unequal; margins irregularly serrate in upper 2/3, serration formed by row of enlarged cells, supentire below; apical leaf cell not particularly shorter than adjacent cell; median cells linear, strongly prorate at upper ends, especially in branch leaves; **alar cells** differentiated, quadrate to rectangular, thick-walled, of 2-4 rows extending 2-4 cells up margins. **Dioicous**. **Seta** 2.0 cm long, papillose distally, smooth proximally; **capsules** erect, cylindric, slightly asymmetric, echinate, spines to 45-50 μm long; **opercula** conic, long rostrate; **Spores** finely papillose. (**Figure 5.94**)

Thailand — NORTHERN: Chiang Mai; SOUTHEASTERN: Nakhon Nayok.

Distribution — China, India, Nepal, Sikkim, and Sri Lanka.

Ecology — On branches.

Specimens examined — *Y. Nathi 5, 100, 266, 270, 630, 933, 1043* (BCU)

GPS location — 18.5888333°N 98.48731617°E, 18.5892257°N 98.48510703°E, 18.5577005°N 98.48041576°E, 18.5577875°N 98.48026271°E, 18.58840803°N 98.48405426°E, 18.5555824°N 98.476048°E, °N °E, °N °E

Altitude — 2,195-2,565 m

3. *Symphyodon oblongifolius* (Ren. & Card.) Broth.

Nat. Pfl., 1(3): 877. 1907; Gangulee, Mosses of E. India 6: 1523, fig. 764. 1977; He & Snider, Bryologist 103(1): 80. 2000.

Plants yellow-green shoots irregularly pinnately branched. **Leaves** dense, not complanate, patent to erect, elliptical-oblong, concave, apex rounded but gradually pointed, margin very faintly crenulate at tip. Leaf cells elongated linear, thin-walled, with papillae at the upper angles , of the same size but with broad and rectangular tip. **Costa** double and very short. (**Figure 5. 95**)

Note: The taxonomic of this species is uncertain because of the type specimen has not been located (He & Snider 2000).

Thailand — NORTHERN: Chiang Mai.

Distribution — Unknown.

Ecology — On branches.

Specimens examined — *Y. Nathi 206, 725, 859* (BCU)

GPS location — 18.5561391°N 98.48219197°E, 18.58870014°N 98.48552395°E.

Altitude — 2,195-2,565 m

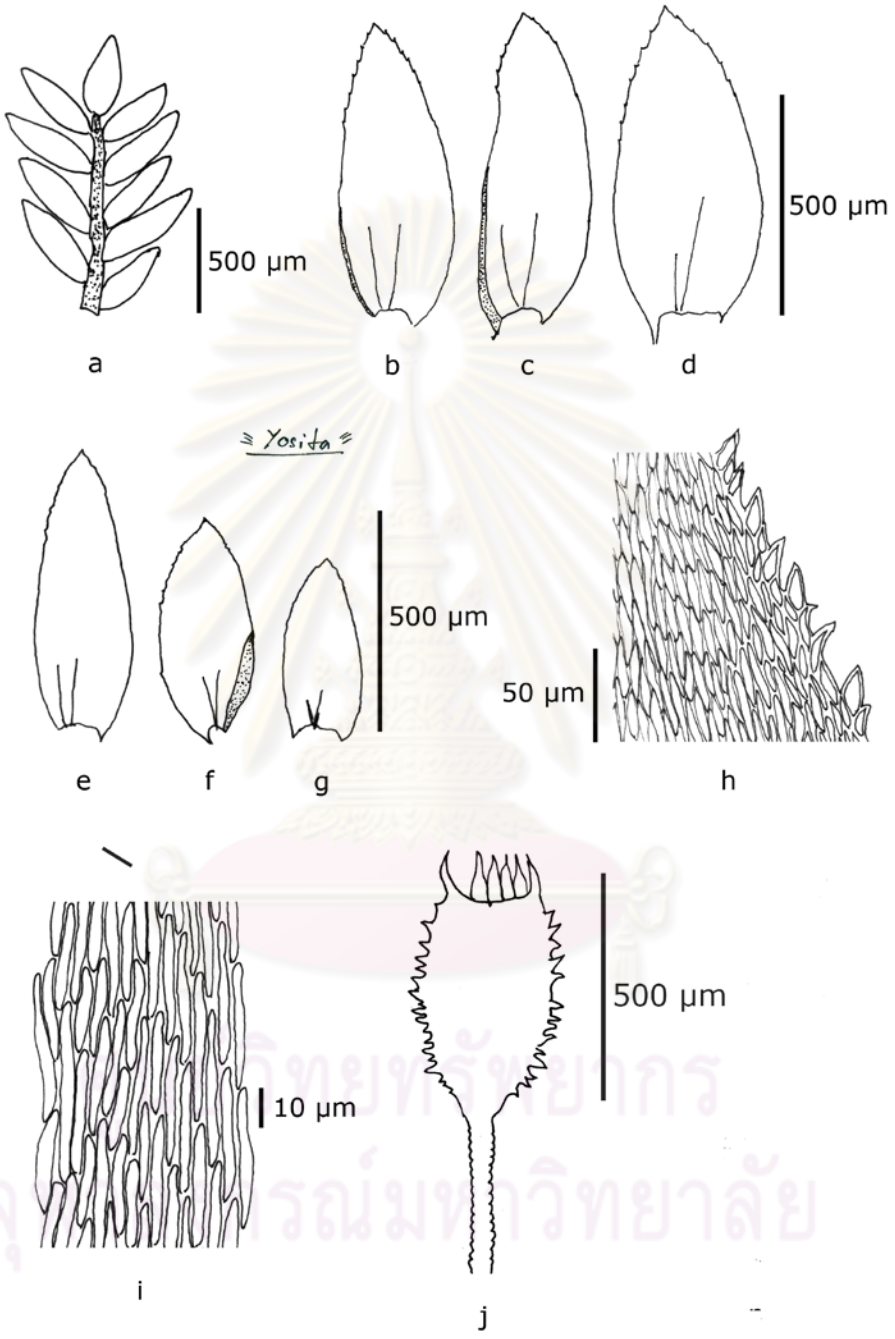
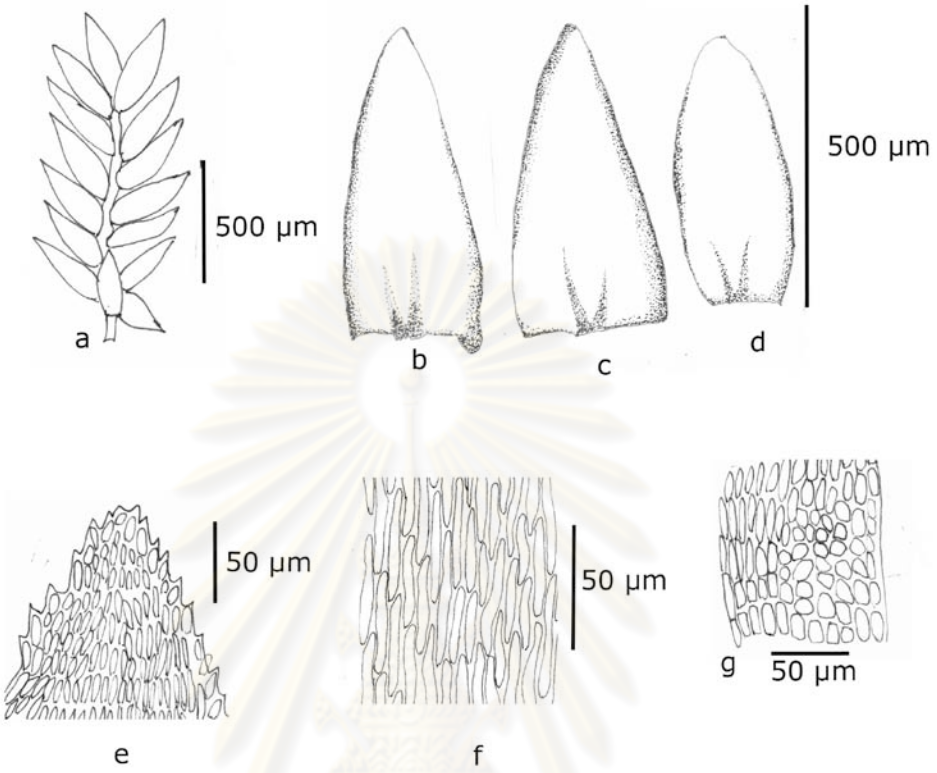


Figure 5.93 *Symphyodon asper* (Mitt.) Jaeg.

a. portion of plant; b., c., d., e., f., g. leaves; h. leaf margin; i. cells at median leaf; j. capsule. Based on Y. Nathi 130.



Figurur 5.94 *Symphyodon echinatus* (Mitt) Jaeg.

a. portion of plant; b., c., d. leaves; e. leaf apex; f. cells at median leaf; g. cells at leaf base. Based on *Y. Nathi 5.*

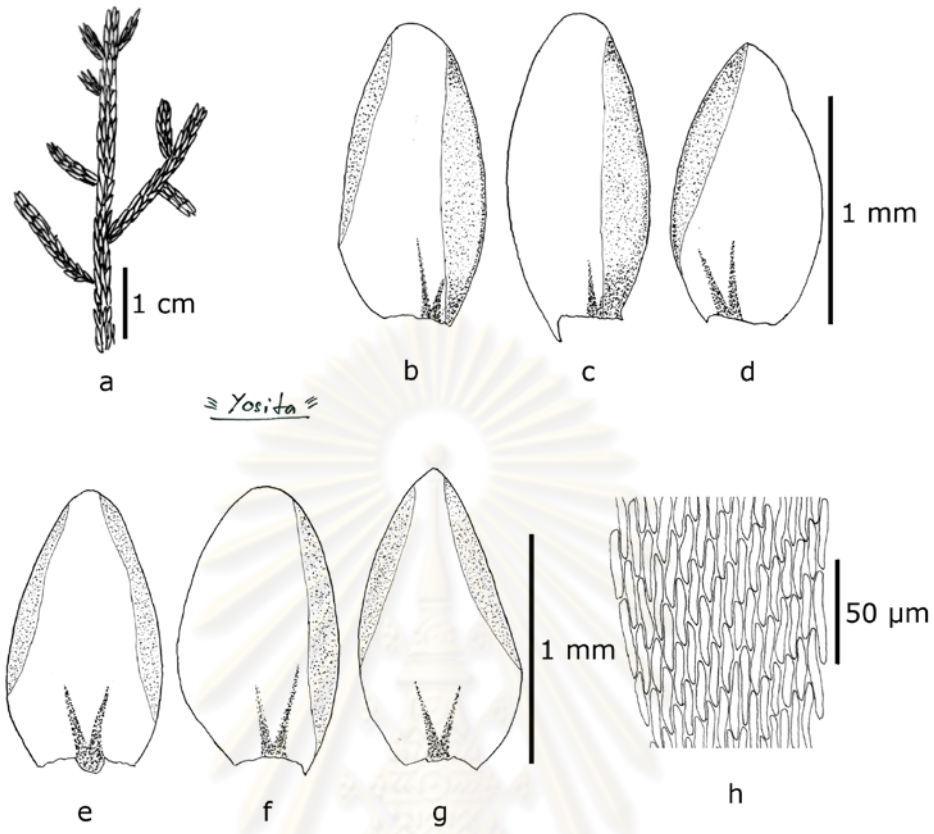


Figure 5.95 *Symphyodon oblongifolius* (Ren. & Card.) Broth.

a. portion of plant; b., c., d., e., f. g. leaves; h. cells at median leaf. Based on *Y. Nathi 206.*

THUIDIACEAE

Plants small to robust, yellowish green or brownish green , dull, rigid when dry, often in small mats or thick mats after years. Stems creeping or ascending above, irregularly branched or regularly pinnately, bipinnately or tripinnately branced; central stand present or absent; paraphyllia often present, single or branched, usually numerous. **Stem leaves** and branched leaves often differentiated; leaves arranged in several rows, appressed or usually imbricate when dry, erect-spreading when moist, ovate, widely ovate or ovate-triangular, acuminate or filiform above; leaf margin entire, finely serrulate or papillose; **costa** mostly single, usually reaching 2/3 the leaf length or excurrent, rarely short, weak, forked or inconspicuous; leaf cells mostly hexagonal or rounded hexagonal, thick-walled, mostly papillose; basal cells longer and pitted; marginal leaf cells nearly quadrate. **Autoiocous** or dioicous. Perichaetia laterally growing on stem; pericheatial leaves usually ovate-lanceolate. **Seta** slender, light reddish when old, smooth; **capsule** declinate, asymmetrical, smooth; stomata rare, at the base of capsule or lacking; annuli usually present; opercula conical, mostly rostrate; transversly striolate in the low parts, papilose in the upper parts, borders differentiated; endostome segments narrowly lanceolate, pale, papillose; basal membrane high; cilia often present. **Calyptra** cucullate, smooth.

Key to the genera

1. Paraphyllia usually absent..... *Claopodium*
1. Paraphyllia present.....*Thuidium*

1. CLAOPODIUM

Claopodium (Lesq. & Jam.) Ren. & Card.,Noguchi, Ill Moss Flora of Japan. p. 4: 843.1991; Sharp, crum & Eckel, Moss Flora of Mexico, Part 2. 875. 1994.

Plants small to medium-sized, sometime delicate light green or yellowish green not shining, forming lax interwoven mats. **Stem** creeping or ascending, pinnately or irregularly branched, smooth rarely papilose; central stand absent; **paraphyllia** mostly lacking. **Stem leaves** and branch leaves slightly to clearly differented; stem leaves loosely arranged, usually circinate when dry; ascending when moist, prolongated into a lancelate or filiform acumen from an ovate or triangularly ovate base, rarely flexuose; leaf margins erect or slightly involute, serrate or seeulate; **costa** rigid, excurrent or vanishing below leaf apex, smooth or papilose onback; leaf cell rhomboidal, hexagonal or oblong ovate, unipapillose; marginal cells rather long and smooth; basal cells long and hyaline; branch leaves similar to the stem leaves but rather smaller. **Dioicous** or phyllodiocous. **Seta** elongate, smooth or

scabrous. **Capsule** inclined to horizontal, ovate or oblong. Operculum long-rostrate. **Peristome** hypnoid. **Calyptra** cuculate.

Claopodium assurgens (Sull. & Lesq.) Cards.

Bull. Soc. Bot. Genève sér. 2,3: 283. 1911; Noguchi, Ill Moss Flora of Japan. p. 4: 846, f. 371. 1991.

Stems long-creeping, irregularly or pinnately branched, sparsely leaved, smooth on the surface; branches simple, attenuate. **Stem leaves** narrowed to linear acumen from a broadly cordate base, keeled above, plicate below; margins serrate, revolute in the upper half, plane below; **costa** long excurrent, smooth, pellucid. Median laminal cells subquadrate or rectangular, unipapillose; marginal cells smooth. Branch leaves ovate lanceolate, gradually attenuate, not plicate; margins revolute almost throughout the entire length; laminal cells rounded, smaller than those of stem leaves. **Phyllodioicous**. **Sporophytes** not seen. (**Figure 5.96**)

Thailand — NORTHERN: Chiang Rai, Tak, Phitsanulok; SOUTHEASTERN: Nakhon Nayok; PENINSULAR: Nakhon Si Thammarat.

Distribution —China, India, Japan, Java, Kampuchea, Korea, Laos, Sumatra, Taiwan, and Vietnam.

Ecology — on branched.

Specimens examined — *Y. Nathi 544* (BCU)

GPS location — 18.58904°N 98.48723°E.

Altitude — 2,486 m

2. THUIDIUM

Thuidium Bruch &Schimp. in B.S.G.,Bryol. Eur. 5: 157. 1852; Sharp, Crum & Eckel, Moss Fl. Mexico 2. 875. 1994.

Plants medium-sized to robust, green, yellowish green, often in loosely interwoven mats. **Stems** procumbent to climbing, bi- to tripinately branched; paraphyllia abundant on stems and branches filamentous or foliose, often papillose; central stand present. **Stem leaves** and branch leaves differentiated; stem leaves ovate or ovate-cordate, usually with slender apex, decurrent, multiplicate; leaf margins revolute, serrulate above; **costa** not extending to leaf apex, rarely excurrent; leaf cells isomorphic, mostly hexagonal or rounded to rounded-hexagonal, equally thick-walled, uni- or multipapillose. Primary branch leaves similar to the stem leaves, but smaller; secondary or

yong branch leaves minute, mostly ovate or oblong-ovate, concave; leaf margins erect; costa weak and short. **Autoicous** or dioicous. Perichetial leaves lanceolate or ovate-lanceolate, with slender apices, sometimes leaf margins with long cilia; costa ending at leaf apex or slightly excurrent; leaf cells rectangular, smooth or papillose. **Seta** slender, smooth or densely papillos above; **capsule** horizontal or declining, ovoid or cylindrical, slightly curved, brownish, smooth; annuli 2-3 rows, revolute, deciduous; opercula acute to conical, obliquely beaked; stomata present; **persistome** double. **Calyptra** cucullate or campanulate, smooth, rarely scabrous.

Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.

Bryol. Jav. 2: 115, t. 221. 1865; Noguchi, Ill Moss Flora of Japan. p. 4. 847, f. 384. 1991.

Plants large, dark-green. **Stems** tripinately branched; branches to 10 cm long, straight when dry. **Paraphyllia** abundant on stems and primary branches, sparse on secondary branches, filiform, flexuose, long-branched, the cells short, centrally papillose on stems and primary branches. **Stem leaves** sparse, broadly deltoid-ovate, abruptly contracted to a subulate, often piliferous, pellucid, flexuose point, deeply biplicate; margins serrate, recurved below; **costa** stout, percurrent as a long, flexuose acumen, mammillose by projections at upper cell ends, with dense paraphyllia below on the dorsal surface. **Median laminal cells** rectangular, centrally unipapillose on dorsal surface, the ventral surface smooth but often with papillae near the leaf margins, the papillae conic to high conic. Primary branch leaves ovate, shortly acuminate, not plicate; margins serrate recurved below; costa extending to near leaf apex, rough on dorsal suface. **Dioicous**. **Seta** to 40 mm long, smooth. **Capsule** inclined, oblong-cylindric, curved. **Operculum** long-conic; **peristome** double. (**Figure 5.97**)

Thailand — NORTHERN Lamphun; NORTHEASTERN: Chaiyaphum, Loei, Phetchabun; SOUTHEASTERN: Nakhon Nayok; PENINSULAR: Chumphon, Nakhon Si Thammarat.

Distribution — Borneo, Mainland China, India, Japan, Java, Korea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — Common on tree trunks, branches, rock, and forest ground.

Specimens examined — *Y. Nathi* 31, 42, 83, 86, 131, 155, 231, 234, 252, 346 (BCU)

GPS location — 18.5890140°N 98.48710041°E, 18.5881701°N 98.48680076°E, 18.5892802°N 98.48572008°E, 18.5893751°N 98.48579443°E, 18.5883898°N 98.48594539°E, 18.5888505°N 98.48477117°E, 18.5567133°N 98.48176475°E, 18.5581161°N 98.48143660°E 18.5892308°N 98.4874572°E, 18.58877674°N 98.48578504°E, 18.55616913°N 98.48114792°E, 18.5876221°N 98.4850536°E.

Altitude —2,188-2,542 m

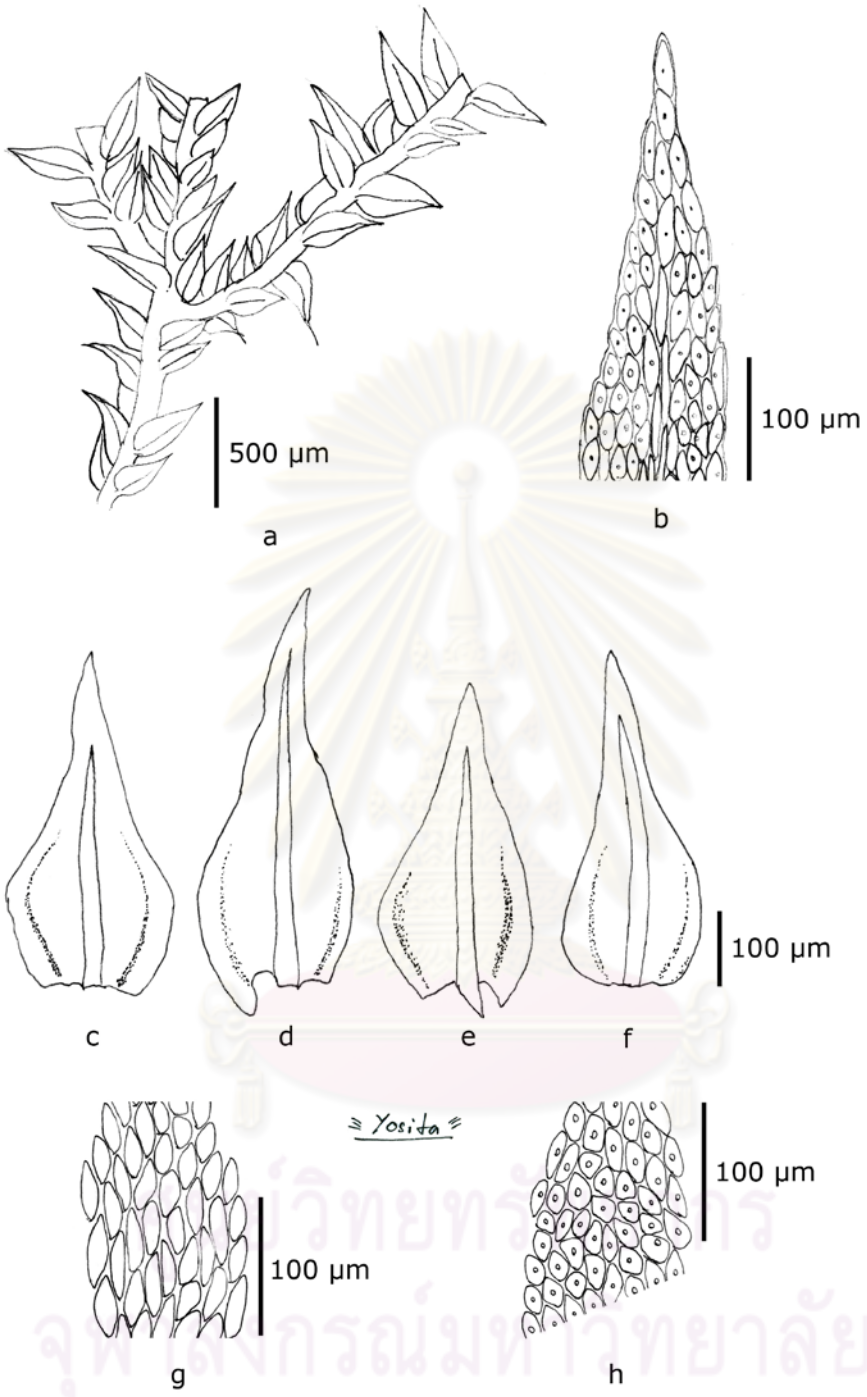


Figure 5.96 *Claopodium assurgens* (Sull. & Lesq.) Cards.

a. portion of plant; b. leaf apex; c., d., e., f. leaves; g. cells at leaf base; h. cells at median leaf. Based on *Y. Nathi 544*.

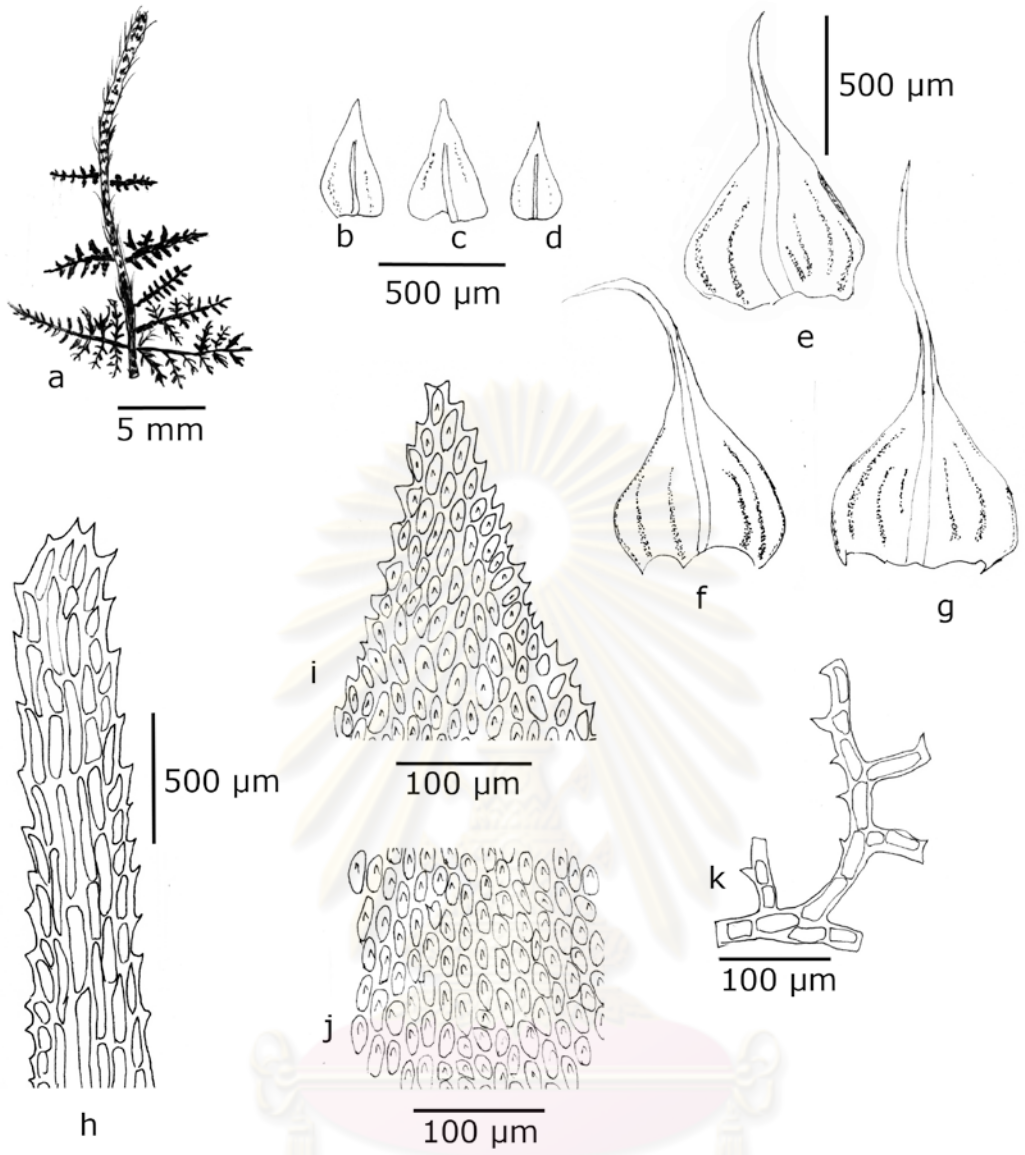


Figure 5.97 ***Thuidium cymbifolium*** (Dozy & Molk.) Dozy & Molk.
a. habit; b., c., d. branch leaves; e., f., g. stem leaves; h. leaf apex of stem leaf; i. leaf apex of branch leaf; k. paraphyllia. Based on *Y. Nathi 86*.

TRACHYPODACEAE

Plants slender to robust, not or slightly shiny. Primary stem creeping, sometime filifrom; secondary stem spreading or pendent, irregularly to subpinnately branched. **Leaves** crowded, plicate, gradually to abruptly narrowed to short to long acumen from a broad, oblong or ovate base, usually auriculate; margins serrulate to serrete; **costa** single; **cells** elliptic, oblong-hexagonal, or rhomboidal, variously papillose. **Dioicou**s. **Seta** short to very long, smooth or strongly roughened; **capsule** mostly exerted, generally erect, ovoid to subglobose; annulus none; operculum rostrate from a conic base; exostome teeth well developed, smooth or papillose, trabeculate at back; endostome with a high basal membrane, broad, keeled segments, and well-developed cilia or with a low membrane, narrow but usually elongate segments. **Calyptra** cucullate or narrowly mitrate, naked or hairy.

Key to the genera

1. Plants medium to large-sized, branches more than 10 cm long, robust 2
1. Plants slender to medium-sized, branches 2-3 cm long ..... *Diaphanodon*
   2. Plants robust with reddish tinge, branches up to 20 cm long .... *Trachypodopsis*
   2. Plants semi-robust to fairly robust green, branches not more than 10 cm long.....3
3. Plants green, darker or black below ..... *Trachypus*
3. Plants yellow-green, not darker or black below ..... *Duthiella*

1. DIAPHANODON

Diaphanodon Ren. & CARD., Rev. Bryol., 22: 33. 1895., Gangulee, Mosses E. India 5: 1222.1974.

Plants very slender to mediumsized plants, light or yellow green, dark in lower part, intufted. Primary stem creeping, with tuft rhizoids, and small scaly leaves. Secondary stem usually procumbent, may be erect or hanging, short or long, usually pinnately branched once or twice. **Leaves** dimorphous or not, dense on branches, usually ovate-deltoid, sharply narrowing and acuminate in upper half, margin dentate at tip and recurved at base. **Costa** strong, single, ending below tip. **Leaf cells** thick-walled, elongate to isodiametric, usually with one papilla on the lumen on both sides; border row smooth and differentiated, often dentate. **Sporophtyte** lateral on secondary stems. **Perichaetial** leaves erect, narrower. **Seta** short, rough. **Capsule**

exserting, subglobose. **Operculum** conic-rostrate. **Peristome** double, neckeroid. **Calytra** small, cucullate, naked.

Diaphanodon blandus (Harv.) Ren. & Card.

Bull. Soc. R. Bot. Belg., 38 (1): 23. 1900; Gangulee, Mosses E. India 5: 1224, fig. 522. 1974.

Plants in dense tufts with secondary procumbent branches bipinnately branched several, 2-3 cm long. **Leaves** dimorphic. **Stem leaves** 1.6-2.00 mm long and 0.7 mm wide at base, sharply narrowed in the upper half from a wide, ovate-deltoid base. Branch leaves erectopatent to spreading 1.0 mm long and 0.3-0.4 mm wide at base, less sharply narrowed at top from the ovate base, acuminate; margin incurved at base, lightly dentate in the upper to thirds of the leaf. **Costa** ends below tip or dissolves there. **Leaf cells** thick-walled, irregularly elongated rhomboid at tip ca. 19 μm x 7.7 μm, dentate in the border row, teeth erect. Lower down, in the lamina the border row is similar but the inner rows are smaller, rhomboid and each with a central papilla on the lumen on both sides. At base the border row is smooth, rectangular such rows increasing at alar region, the next 4 to 5 rows, rhomboid papillose as on top. The inner rows are smooth, narrow rhomboid, in oblique row at first then erect as the costa is approached. **Sporophyte** on short lateral shoots, 1.5 mm long. **Opereulum** conic-rostrate. **Peristome** double. **Calyptra** cucllate, small, naked. (**Figure 5.98**)

Thailand — NORTHERN: Chiang Mai.

Distribution — Borneo, Bhutan, Mainland China, India, Java, Myanmar, Nepal, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On branch twigs.

Specimens examined — *Y. Nathi 104, 128,301, 320, 342, 344, 356, 375, 519, 529, 591, 715, 825* (BCU)

GPS location — 18.5881294°N 98.48610347°E, 18.5883898°N 98.48594539°E, 18.5616295°N 98.47653192°E, 18.5892308°N 98.4874572°E, 18.589043°N 98.4872297°E, 18.5601682°N 98.47757086°E.

Altitude — 2,278-2,550 m

2. DUTHIELLA

Duthiella C. Muell. in Broth.. Nat. Pfl., 1(3): 1009. 1908., Gangulee, Mosses E. India 5: 1237.1974.

Plants irregularly branched, procumbent or partly ascending, sometimes complanate. **Leaves** lanceolate from a wider ovate base, margins dentate, apiculate point often undulate and crispate when dry, narrowly bordered. **Costa** single, ending below ape. **Leaf cells** rhomboid hexagonal, rarely isidimetric, unipapillate or seriate papillate on lumen. **Sporophyte** on side shoots on branches. **Seta** long, smooth. **Capsule** inclined, oblong-cylindric. Peristome double, endostome with segments on a high basal membrane with three nodose cilia. **Operculum** conical. **Calyptra** cucullate. **Spore** small.

Dutheilla walichii (Mitt.) C. Muell.

in Broth., Nat. Pfl., 1 (3): 1010. 1908; Gangulee, Mosses E. India 5: 1238, fig. 598.1974. **—** *Leskea wallichii* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 132. 1859.

Plants medium-sized to fairly robust, yellow-green, forming mats. Stem 6-10 cm or more long with ascending or procumbent secondary branches, irregularly pinnately branched. **Leaves** dense, erectopatent to spreading, lanceolate from a broader, ovate base, 2.5 mm long and 1.0 mm wide at base, apex gradually acuminate; margin to base, flat. **Costa** single ending below tip. **Leaf cell** at tip rhomboid-quadrate, thick-walled, some isodiametric but mostly slightly longer than broad with single papilla at centre of lumen except in one or two border rows, outermost row forms the dentate margin. Middle cells unipapilla as above but longer with spine cells. Basal cells smooth, sub-rectangular, comparatively thin-walled, with border row dentate; alar distinct of rounded-quadrate cells. **Sporophyte** not seen. (**Figure 5.99**)

Thailand — NORTHERN: Chiang Mai.

Distribution — China, India, Japan, Java, Nepal, Taiwan, and Vietnam.

Ecology — On tree trunks, branch twigs and soil slope.

Specimens examined — *Y. Nathi 228, 310, 347, 357, 452, 552* (BCU)

GPS location — 18.5565715°N 98.48190716°E, 18.5604936°N 98.47736626°E, 18.5892308°N 98.4874572°E, 18.589043°N 98.4872297°E, 18.5563089°N 98.4803905°E

Altitude — 2,187-2,550 m.

3. TRACHYPODOPSIS

Trachypodopsis Fleisch.; Gangulee, Mosses E. India 5: 1232.1974.; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 703. 1994.

Plants rather slender to coarse and robust, dull or somewhat shiny, dirty-green, yellow, or golden-brown, never blackish. Secondary stems mostly elongate, spreading, curved-erect or pendent, usually remotely and irregularly pinnate. **Leaves** loosely appressed or spreading, strongly plicate, and often crisped-undulate at the tips when dry, erect-spreading, to spreading when moist, gradually long-acuminate from an ovate base, moderately auriculate; margins bordered by longer, smooth cells, serrulate to serrate; **costa** ending in the acumen; **cells** oblong-rhombic to narrowly elliptic or linear, thick-walled, porose, unipapillose , and smooth at the base, rounded in the auricles. **Seta** elongate, warty-papillose; **capsule** erect, subglobose, brown; operculum small, obliquely short-rostrate; **peristome** double. **Calyptra** small, conic-cucullate, naked or sparsely hairy. (**Figure 5.100**)

Trachypodopsis serrulata (P. Beauv.) M. Fleisch.

Hedwigia 45: 67. 1906; Gangulee, Mosses E. India 5: 1235, fig 597. 1974. — *Pilotrichum serrulatum* P. Beauv., Prodr. Aethéogam. 1805.

Plants robust, brownish-green forming dense mat on tree trunks, rotten logs, etc., in montane forests. **Primary stems** laxly and pinnately branched often reaching to 20 cm long, ascending or pending on substratata. **Leaves** erect-spreading, distinctly plicate, ca. 3.0 mm long, 0.5-0.6 mm wide, ovate-lanceolate with wide-triangula base, gradually narrowed into long, some what flexuose acumense; margins sharply serrate thoughout; **costa** ending below apex; leaf base forming distinct auricules. **Lamina cells** rhomboid, unipapillose; smooth in several rows at margins. **Capsule** not seen.

Thailand — NORTHERN:Chiang Mai, Chiang Rai; SOUTHEASTERN: Chanthaburi.

Distribution — Widely distribution in Asia, South and Central Africa, and Central America.

Ecology — Road side, open areas, on branches

Specimens examined — *Y. Nathi 3, 33, 306, 327, 355, 530, 543, 549, 546, 658, 771, 793, 873, 938, 960, 985* (BCU)

GPS location — 18.5888333°N 98.48731617°E, 18.5890140°N 98.48710041°E, 18.5604936°N 98.47736626°E, 18.5617751°N 98.47630729°E, 18.58904304°N 98.4872297°E, 18.58741041°N 98.48668828°E, 18.55926096°N 98.47550020°E, 18.58795976°N 98.48525045°E, 18.5880409°98.4868826N °E

Altitude — 2,294-2,550 m

4. TRACHYPUS

Trachypus Reinw. & Hornsch., Gangulee, Mosses E. India and 5: 1237.1974.; Sharp, Crum & Eckel, Moss Fl. Mexico 2: 703. 1994.

Plants slender to fairly robust, in dense, dull green, usually black-tinged. Stems spreading or pendent, freely and irregularly branched. **Leaves** loosely erect or spreading, rather rigid and plicate when dry, rather broadly long-acuminate from a broadly oval base, often auriculate at the basal angles; margins not bordered, generally serrulate to serrate; **costa** extending well beyond the middle; **cells** elongate, thick-walled, densely and finely papillose over the lumen and also over adjoining walls, the mid-basal cells linear and smooth, a few in the small auricles, rounded. **Seta** up to 2 cm long, hispidulose; **capsule** erect, subglobose, blackish; operculum obliquely lon-rostrate; exostome teeth pale, narrowly acuminate, papillose; endostome much shorter, with a low basal membrane, rudimentary. **Calyptra** cucullate or narrowly mitrate, densely hairy.

Trachypus bicolor Reinw. & Hornsch.

Gangulee, Mosses E. India 5: 1237. 1974.; Nog., Ill. Moss Fl. Japan 3: 560, fig. 287, B. 1994.

Plants robust to semirobust, green to yellowish brown, often blackish in old portion. **Primary stems**, with reduced, small leaves. Secondary stems irregularly branch, to 10 cm long. **Leaves** lusterless green, older leaves often becoming blackish at tips, ovate with oblong base , more or less plicate, appressed to stems when dry; **costa** single, indistinct; margins weakly serrulate; not auriculate at base. Lamina cells linear, with seriate papillae on lateral walls. **Seta** 1.5 cm long densely papillose. **Capsules** straight , ovoid. (**Figure 5.101**)

Thailand — NORTHERN: Chiang Mai, Chiang Rai, Tak, Phetchabun; NORTHEASTERN: Nakhon Ratchasima, Loei; SOUTHEASTERN: Nakhon Nayok; PENINSULAR: Nakhon Si Thammarat, Trang.

Distribution — China, India, Japan, Java, Korea, Laos, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam.

Ecology — On tree trunks and twigs.

Specimens examined — *Y. Nathi 35, 175, 225, 339, 345, 360, 405, 426, 449, 487, 527, 547, 566, 576,656* (BCU).

GPS location — 18.5890140°N 98.48710041°E, 18.5883541°N 98.48560500°E, 18.5565715°N 98.48190716°E, 18.58925058°98.4874129N °E, 18.58923079°N 98.4874572°E, 18.58904304°N 98.4872297°E, 18.58862587°N 98.4866078°E, 18.56061699°N 98.4758569°E, 18.55630886°N 98.4803905°E, 18.55427868°N 98.4780377°E**.**

Altitude — 2,185-2,559 m

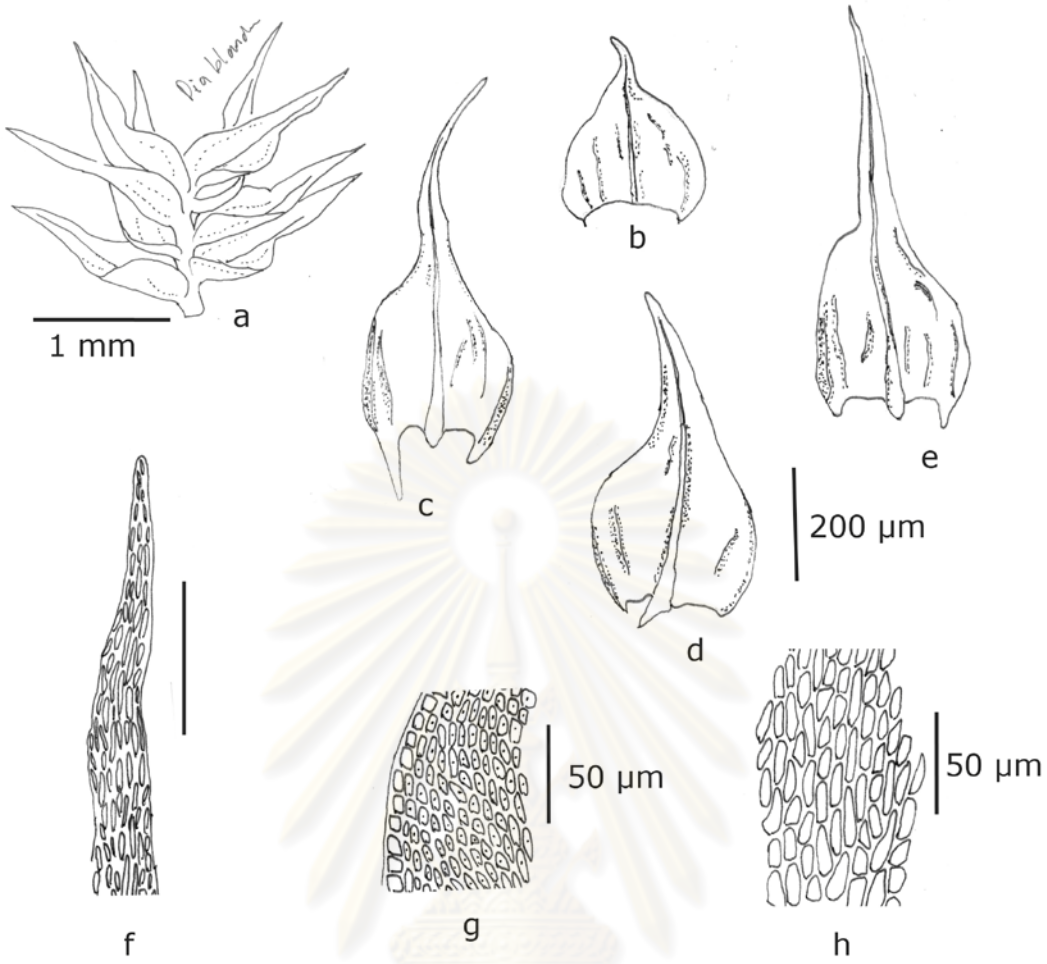


Figure 5.98 *Diaphanodon blandus* (Harv.) Ren. & Card.
a. portion of plant; b., c., d., e. leaves; f. leaf apex; g. cells at upper leaf; h. cells at leaf base. Based on *Y. Nathi 104*.

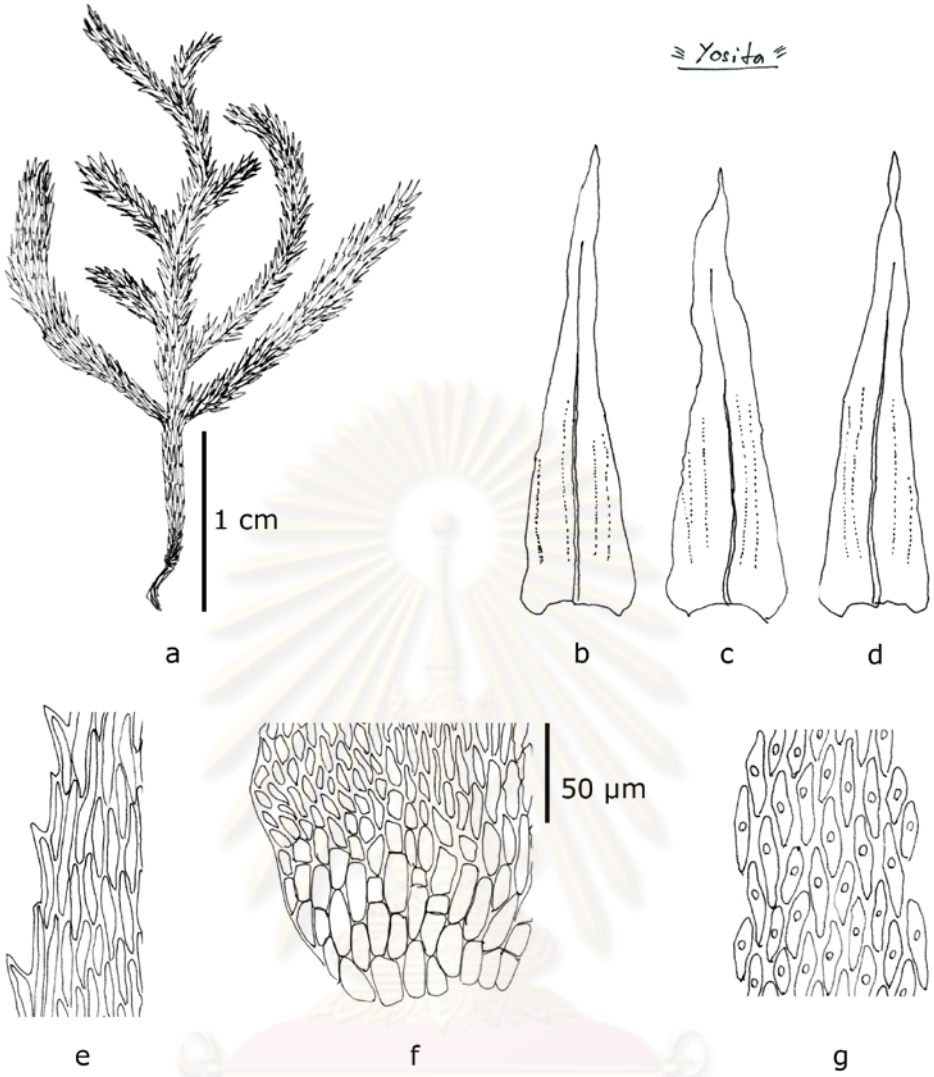


Figure 5.99 *Dutheilla walichii* (Mitt.) C. Muell.
a. habit; b., c., d. Leaves; e. cells at leaf margin ; f. cells at leaf base; g. cells at median leaf. Based on *Y. Nathi 228*.

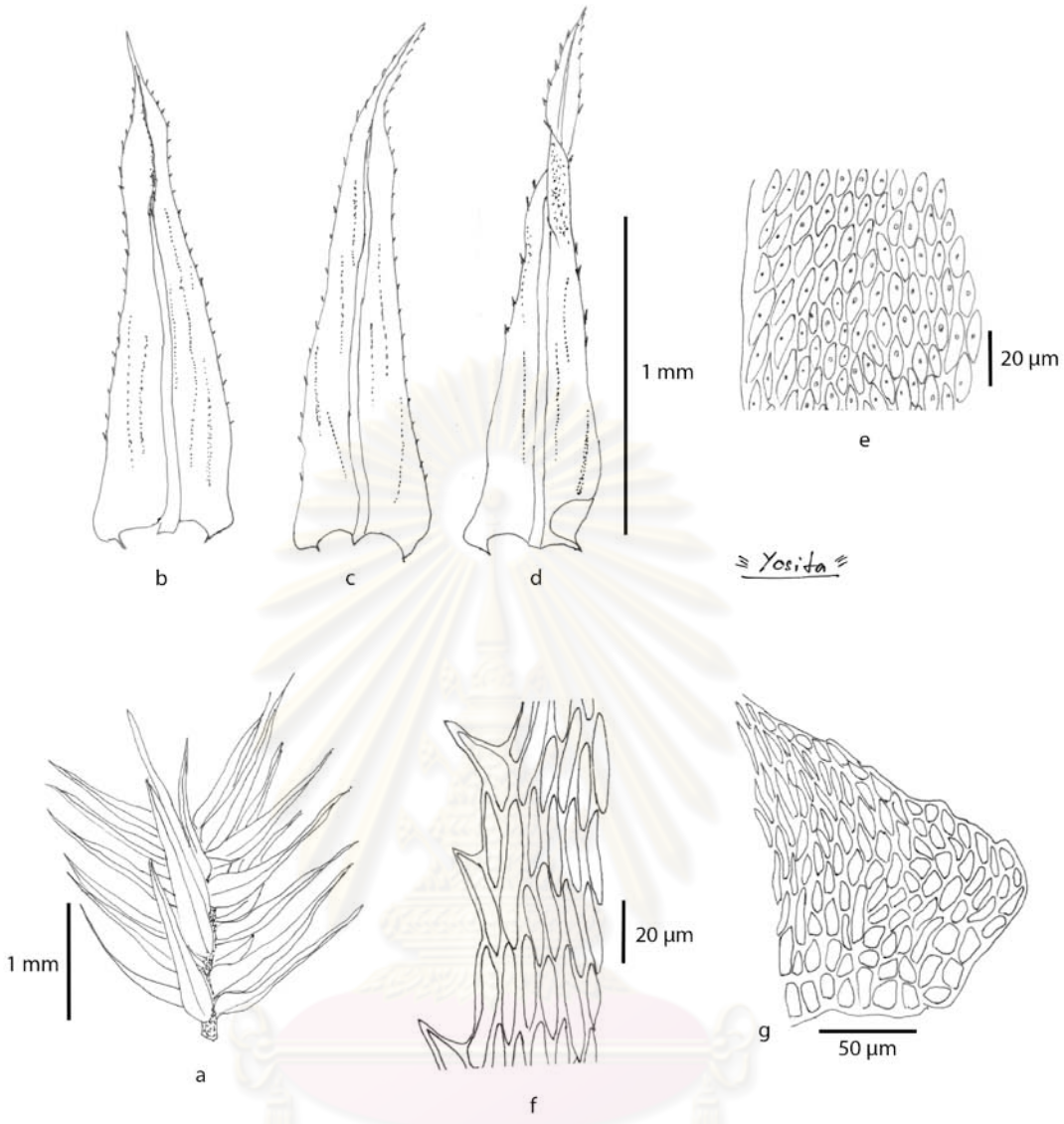


Figure 5.100 *Trachypodopsis serrulata* var. *crispatula* (Hook. f.) van Zanten a. portion of plant; b., c., d. leaves; e. cells at median leaf; f. leaf margin; g. cells at leaf base. Based on *Y. nathi 306*.

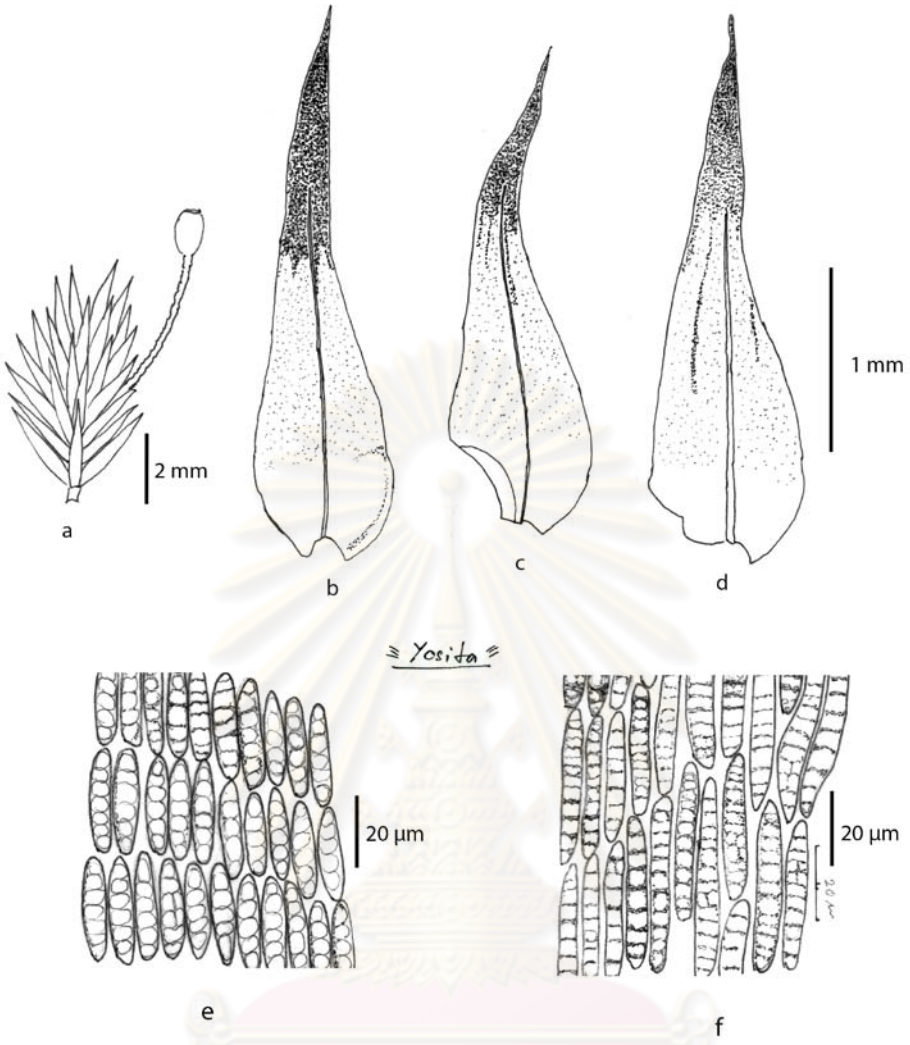


Figure 5.101 *Trachypus bicolor* Reinw. & Hornsch.
a. portion of plant; b., c., d. Leaves; e. cells at median leaf; f. cells at lower leaf. Based on *Y. Nathi 175*.

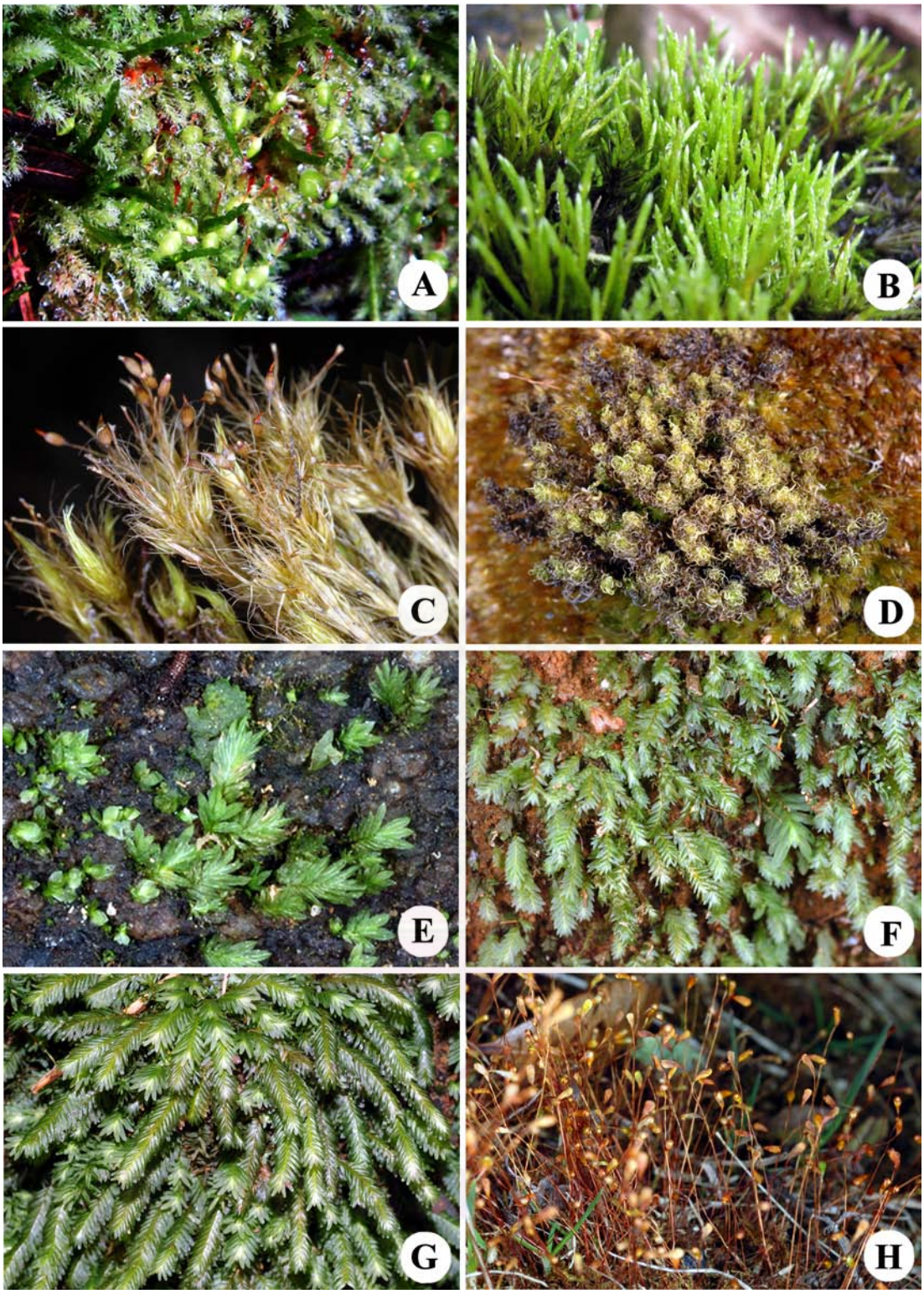


Figure 5.1: A. *Philonotis turneriana* (Schwaegr.) Mitt.; **B.** *Anomobryum julaceum* (Gaertn.et.al.) Schimp.; **C.** *Dicranodontium uncinatum* (Harv.) Jaeg.; **D.** *Symblepharis vaginata* (Hook.) Wijk. & Marg.; **E.** *Fissidens bryoides* var. *schmidii* (C. Mull.) Chopra & kumar; **F.** *Fissidens flabellulus* Thwait. et Mitt.; **G.** *Fissidens polypodioides* Hedw.; **H.** *Funaria hygrometrica* Hedw.

Figure 5.2: A. *Hookeriopsis utacaqmundiana* (Mont.) Broth.; **B.** *Taxiphyllum arcuatum* (Bosch & Sande Lac.) He; **C.** *Pseudotaxiphyllum pohliaecarpum* (Suul. & Lesq.) Iwats.; **D.** *Cyathophorella hookeriana* (Griff.) Fleisch.; **E.** *Plagiomnium maximovicizii* (Lindb.) Kop.; **F.** *Plagiomnium rhynchophorum* (Hook.f.) Kop.; **G.** *Floribundaria sparsa* (Mitt.) Fleisch. var. *sparsa*; **H.** *Cryptopapillaria fuscescens* (Hook. f.) Menzel

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Climatic factors

When temperature and relative humidity or RH was considered, little differences in climate during rain season (end of April to June) existed between these two sites. However, a difference in both climatic parameters from December to mid April may be due to canopy coverage, i.e. Ang Ka has less canopy coverage while Khew Mae Pan has much more canopy coverage and more trees, except in area such as grassland, deforested mountaing ridge, and along banks of creeks. Steadier RH at Ang Ka may be partly due to easier cloud passage through the area than through Khew Mae Pan. Therefore the latter "caught" less humidity from the cloud belt than the former, resulting in high fluctuation of RH. In addition, temperature at Ang Ka was lower than that at Khew Mae Pan possibly due to the former situates at higher altitude than the latter. Thus, the temperature at the Ang Ka site was somewhat lower at night and early morning.

Light available for plants as measured by photosynthetically active radiance, or PAR, was done at Ang Ka in shaded area area to mimic microhabitatr where mosses were found, and found that it is quite low. Although comparison of PAR at Ang Ka and Khew Mae Pan could not be made, however based on observation during field collection, it appeared that mosses grow Khew Mae Pan, except in open sunny area, may not obtain PAR different from that in Ang Ka, and possibly less in some places. As a result the PAR measurement at the Khew Mae Pan site might not differ from that at Ang Ka site. Interestingly, PAR measured from shaded areas of the Ang Ka site was lower than PAR reported from similar studies elsewhere (e.g. León-Vargas, Engwald, and Proctor 2006). Thus, it seems that bryophytes on these sites are more tolerant to lower light than others.

6.2 Habitat and Diversity of Mosses

Habit-wise, mosses found in Ang Ka and Khew Mae Pan can be classified as terrestrial, epiphytic, and lithophytic mosses (Table 6.1). Terrestrial mosses were found on soil along forest trails, roadsides and humus rich soil. Epiphytic mosses were occurred on tree trunks, branches, twigs, leaf surfaces, and on rotten logs. Lithophytic mosses grow on rocks, concrete walls, and stair steps made of concrete.

Of 101 species of mosses found, there are 55 epiphytes, 19 terrestrials and 4 lithophytes. The rest were species that can be grow in more than one habit types: 9 species were epiphytes or terrestrials, 5 species were

lithophytes or terrestrials, 2 species were epiphytes or lithophytes, and 7 species were epiphytes, terrestrials and lithophytes (Fig 6.1).

Most of epiphytic mosses are found on tree trunks and branches (corticlous). The base of the tree trunk is the richest in moss diversity, since it is always shaded and humid. The majority of epiphyte mosses represent all the members of the following families: Sematophyllaceae (16 species), Meteoriaceae (10 species) and Neckeracea (6 species). Further more, one species was found growing on leaf surfaces (epiphyllous), namely *Pseudobarbella attenuata* (Thwait. & Mitt.) Nog.

The terrestrial moss was mostly found in open places such as grassland, roadsides, mountain slopes and stream banks as well as in shady places. The common terrestrial mosses were members of the Polytrichaceae, Fissidentaceae, Bryaceae, Funariaceae, and Bartramiaceae.

The lithophytic mosses usually grow on muddy rocks or humus-rich rocks along streams or streamlets near waterfalls, which are flooded for 2-3 months during the rain season.

In 1958, Horikawa and Ando collected moss specimens at Doi Inthanon from altitudal range of 1,300-2,567 m, and they reported 131 species of mosses. They also noted that most of mosses reported were found at altitude above 2,300 m (Horikawa and Ando, 1964) and were epiphytic. The result from this study is in line with the Horikawa and Ando's study since most of the findings in this study has been epiphytes. However the study site of this study was much smaller than that of Horikawa and Ando's but it has also produced more findings of epiphytic mosses than the study of 1958.

Table 6.1 Moss habitat.

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
Bartramiaceae						
1. *Philonotis turneriana* (Schwägr.) Mitt.						✓
2. *Philonotis thwaitesii* Mitt.						✓
Bryaceae						
3. *Anomobryum julaceum* (Gaertn.et.al.) Schimp.			✓		✓	✓
4. *Brachymenium nepalense* Hook.	✓	✓				
5. *Bryum argenteum* Hedw.	✓				✓	✓
6. *Bryum billarderi* Schwägr.						✓
7. *Bryum salakense* Cardot						✓
Calymperaceae						
8. *Syrrhopodon gardneri* (Hook.) Schwägr.	✓					
Dicranaceae						
9. *Brothera leana* (Sull.) Müll. Hal.	✓		✓			
10. *Dicranodontium uncinatum* (Harv.) A. Jaeger	✓					✓
11. *Symblepharis vaginata* (Hook. ex Harv.) Wijk & Margad.	✓	✓				
Dippyschiaceae						
12. *Diphyscium longifolium* Griff.					✓	
Fissidentaceae						
13. *Fissidens anomalus* Mont.	✓					✓
14. *Fissidens bryoides* var. *schmidii* (Müll. Hal.) R.S. Chopra & S.S. Kumar					✓	✓

Table 6.1 Moss habitat. (continued)

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
15. *Fissidens ceylonensis* Dozy & Molk.						✓
17. *Fissidens guangdongensis* Z. Iwats. & Z.H. Li	✓					✓
18. *Fissidens gymnogynus* Besch.	✓					
19. *Fissidens hollianus* Dozy & Molk.						✓
20. *Fissidens obscurus* Mitt.					✓	
21. *Fissidens pellucidus* Hornsch.	✓					✓
22. *Fissidens polypodioides* Hedw.					✓	✓
Funariaceae						
23. *Funaria calvescens* Schwägr.						✓
24. *Funaria hygrometrica* Hedw.						✓
Hookeriaceae						
25. *Calyptrochaeta remotifolia* (Müll. Hal.) Z. Iwats., B.C. Tan & Touw	✓					
26. *Distichophyllum carinatum* Dixon & W.E. Nicholson		✓				
27. *Distichophyllum collenchymatosum* Cardot					✓	✓
28. *Distichophyllum maibarae* Besch.					✓	✓
29. *Distichophyllum wanianum* B.C. Tan & P.J. Lin	✓	✓				
30. *Hookeriopsis utacaqmundiana* (Mont.) Broth.	✓	✓			✓	✓
Hylocomiaceae						
31. *Macrothamnium javense* M. Fleisch.						✓
32. *Macrothamnium macrocarpum* (Reinw. & Hornsch.)M. Fleisch.	✓	✓	✓		✓	

Table 6.1 Moss habitat. (continued)

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
Hypnaceae						
33. *Isopterygium bancanum* (Sande Lac.) A. Jaeger	✓					
34. *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z. Iwats.						✓
35. *Taxiphyllum arcuatum* (Bosch & Sande Lac.) S. He						✓
36. *Glossadelphus prostratus* (Dozy & Molk.) M. Flesich.			✓			
39. *Leucobryum juniperoideum* (Brid.) Müll. Hal	✓					✓
Lembrophyllaceae						
40. *Dixonia thamnioides* (Broth. & Dixon) Horik. & Ando.					✓	
Meteoriaceae						
41. *Aerobryidium filamentosum* (Hook.) M. Fleisch		✓				
42. *Cryptopapillaria chrysoclada* (Müll. Hal.) M. Menzel		✓				
43. *Cryptopapillaria feae* (Müll. Hal. ex M. Fleisch.) M. Menzel	✓	✓				
44. *Cryptopapillaria fuscescens* (Hook.)M. Menzel	✓	✓				
45. *Floribundaria sparsa* var. *sparsa* (Nog.) Nog.	✓	✓				
46. *Floribundaria sparsa* var. *piliferum* (Nog.) Nog.	✓	✓				
47. *Floribundaria walkeri* (Renauld. & Cardot.) Broth.	✓	✓				
48. *Meteorium subpolytrichum* (Besch.) Broth.		✓				
49. *Papillaria semitorta* (Müll. Hal.) A.	✓					
50. *Pseudobarbella attenuata* (Thwaites. & Mitt.) Nog.	✓	✓	✓	✓		

Table 6.1 Moss habitat. (continued)

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
Mniaceae						
51. *Plagiomnium maximovicizii* (Lindb.) T.J. Kop.	✓				✓	✓
52. *Plagiomnium succulentum* (Mitt.) T.J. Kop.	✓				✓	✓
53. *Plagiomnium rhynchophorum* (Harv.) T.J. Kop.	✓				✓	✓
54. *Rhizomnium striatulum* (Mitt.) T.J. Kop.					✓	
Myuriaceae						
55. *Oedicladium rufescens* (Reinw. & Hornsch.) Mitt.	✓				✓	
Neckeraceae						
56. *Curvicladium kurzii* (Kindb.) Enroth	✓					
57. *Homalia pennatula* (Mitt. ex Dixon) S. He & Enroth	✓					
58. *Homaliodendron crassinervum* Thér.	✓	✓				
59. *Homaliodendron montagneanum* (Müll. Hal.) M. Fleisch.	✓					
60. *Neckera himalaya* Mitt.	✓					
61. *Noguchiodendron sphaerocarpum* (Nog.) Ninh & Poes	✓					
Othotrichaceae						
62. *Macromitrium sulcatum* (Hook.) Brid.	✓	✓				
Plagiotheciaceae						
63. *Plagiothecium neckeroideum* Schimp.	✓		✓			

Table 6.1 Moss habitat (continued)

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
Polytrichaceae						
64. *Pogonatum cirratum* (Sw.) Brid. ssp. *cirratum*			✓			✓
67. *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid.					✓	✓
68. *Pogonatum neesii* (Müll. Hal.) Dozy						✓
69. *Pogonatum nudiusculum* Mitt.			✓			✓
70. *Pogonatum proliferum* (Griff.) Mitt.	✓		✓			✓
75. *Pterobryopsis divergens* (Mitt.) Nog.		✓				
Sematophyllaceae						
76. *Brotherella falcata* (Dozy & Molk.) M. Fleisch.	✓	✓	✓			
77. *Clastobryopsis brevinervis* M. Fleisch.		✓				
78. *Clastobryopsis planula* (Mitt.) M. Fleisch.		✓				
79. *Clastobryopsis planula* var. *delicata* (M. Fleisch.) B.C. Tan & Y. Jia	✓	✓				
80. *Clastobryopsis robusta* (Broth.) M. Fleisch.		✓				
81. *Gammiella ceylonensis* (Broth.) B.C.Tan & W.R.Buck		✓				
82. *Gammiella pterogonioides* (Griff.) Broth.		✓				
83. *Gammiella tonkinensis* (Broth. & Paris) B.C. Tan		✓	✓			
84. *Heterophyllium affine* (Hook.) Fleisch.	✓					
85. *Heterophyllium amblystegum* (Mitt.) M. Fleisch.	✓	✓				
86. *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy.& Tsubota	✓		✓			
87. *Mastopoma subfiliferum* Horik. & Ando	✓					

Table 6.1 Moss habitat. (concluded)

Taxon	Epiphytes				Lithophytes	Terrestrial
	Bark	Bran	Rott	Leaf		
88. *Warburgiella bistrumosa* (Müll. Hal.) M. Fleisch.	✓	✓				
90. *Wijkia deflexifolia* (Mitt. ex Renauld & Cardot) H.A. Crum			✓			
92. *Sphagnum cuspidatulum* Müll. Hal.						✓
Symphyodotaceae						
93. *Symphyodon asper* (Mitt.) A. Jaeger	✓		✓			
94. *Symphyodon echinatus* (Mitt.) A. Jaeger	✓	✓				
95. *Symphyodon oblongifolius* (Renanld & Cardot) Broth.	✓	✓				
Thuidaceae						
96. *Claopodium assurgens* (Sull. & Lesq.) Cardot		✓				
97. *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.	✓	✓	✓		✓	✓
Trachypodaceae						
98. *Diaphanodon blandus* (Harv.) Renauld & Cardot	✓	✓				
99. *Duthiella wallichii* (Mitt.) Müll. Hal.	✓	✓				
100. *Trachypodopsis serrulata* var. *crispatula* (Hook.) Zanten	✓	✓				✓
101. *Trachypus bicolor* var. *bicolor* Reinw. & Hornsch.	✓	✓				

6.3 The common mosses

The common mosses in this study were observed in four families, i.e. Sematophyllaceae (16 species), Fissidentaceae (10 species), Meteoriaceae (10 species), and Polytrichaceae (9 species). Among these families, Sematophyllaceae was the richest in terms of species composition and abundance. Sematophyllaceae is represented by 16 species in 8 genera including *Brotherella* (1), *Clastobryopsis* (4 species), *Gammiella* (3 species), *Heterophyllium* (2 species), *Pseudotrismegistia* (1 species), *Mastopoma* (1 species), *Warburgiella* (2 species), *Wijkia* (2 species). There were 9 families that are represented by only one species, including Calymperaceae, Diphysciaceae, Leucobryaeae, Lembrophyllaceae, Myuriaceae, Orthotrichaceae, Plagiotheciaceae, Pterobryaceae and Sphagnaceae.

For all 59 genera of mosses found, *Fissidens* (10 species) showed the highest number of species.

6.4 The rare species

All of the moss species reported in this study were found commonly or abundantly in the respective study areas, whereby the species *Distichophyllum carinatum* Dixon & W. E. Nicholson made an exception, since it was found only in small clumps, mixed with other species. Conversation of Nature and Natural Resources or IUCN lists *D. carinatum* in its Red List of Mosses since *D. carinatum* is found only in a few localities world wide, within the Alps in Europe, Central Japan as well as Southwest China. The presence of this endangered moss species on Doi Inthanon justifies a protection of the remaining vegetation of Doi Inthanon National park (IUCN: online, 2009).

An investigation also found that *Leucobryum juniperoideum* (Brid.) C. Müll. and *Sphagnum cuspidatulum* C. Müll. are rare in the study areas of Doi Inthanon, even though these two species are widely distributed in tropical Asia, pantropic and temperate zone including West and Central Europe (Gangulee 1971; Eddy 1977; Noguchi 1987; Li & He 1999; Chien and Crosby 2000). *S. cuspidatulum* grows in small swamps in Ang Ka. The swamps have shrunk in size in recent years, due to environmental succession and invasion of other plant species. *L. juniperoideum* has been reported as distinct species (Ando and Horikawa, 1964). Observations in recent years found that in study sites are more sunlight and many trees in the study sites were uprooted due to storms during the rainy season. This has led to significant shortage of hosts for epiphytic mosses including *L. juniperoideum* and as a result a gradual disappearance of this species in these areas can be observed.

6.5 Endemic species

Thailand's endemic species is also found in this study, namely *Mastopoma subfiliferum* Horik. & Ando. It is an epiphytic species growing on tree-trunks. *M. subfiliferum* and has been reported from Doi Inthanon by Ando and Horikawa (Ando and Horikawa 1964; He 1995).

6.6 New records

The most recent checklist of Thai moss contains 652 species (He, 1998) as well as other newly reported Thai mosses (Akiyama 2007; Pollawats 2008; Wongkuna *et al*., 2009). This study found that 16 species are new records to Thailand as shown in table 6.2.

Table 6.2 New records of mosses to Thailand and their previously known geographic distribution.

Species	Distribution
1. *Clastobryopsis brevinervis*	China, Japan, Indonesia (Java, lesser Sunda), Malaysia (Sabah), the Philippines and Papua New Guinea
2. *Clastobryopsis planula*	China
3. *Clastobryopsis planula* var. *delicata*	China
4. *Clastobryopsis robusta*	China (Taiwan), Japan, Philippines, Borneo, Java and Papua New Guinea.
5. *Didymodon maschalogena*	Africa, Mexico, Japan, India, Sri Lanka, Himalayas, China and Philippines
6. *Distichophyllum carinatum*	Alps in Europe, Central Japan, and southwest China
7. *Distichophyllum collenchymatosum*	India
8. *Distichophyllum maibarae*	China,
9. *Distichophyllum wanianum*	China, Himalaya
10. *Fissidens obscurus*	China, Japan, Nepal, India
11. *Glossadelphus prostratus*	China, Laos, Vietnam, Indonesia (Java, Lombok, Irian Jaya), Papua New Guinea and Pacific Islands
12. *Meteorium subpolytrichum*	Himalayas, China, Japan, Philippines
13. *Rhizomnium striatulum*	Eastern Russia, Korea, Japan, China, Taiwan, Himalayas
14. *Oligotrichum obtusatum*	China, Himalaya.
15. *Oligotrichum semilamellatum*	China, Taiwan, Nepal, India
16. *Warburgiella bistrumosa*	Philippine

6.7 Phytogeography and Distribution

Of 101 species of mosses found, 64 species in these areas are Indochinese mosses (Tan and Iwatsuki, 1993). They are primarily distributed in east India, south China, Cambodia, Laos, Mynmar, Thailand and Vietnam. The rest, 34 species, are common Asian species and widely distributed, with 2 more species are worldwide distributed or cosmopolitan species and 1 endemic species of Philippine was found.

Bryum argenteum Hedw. and *Funaria hygrometrica* Hedw. are distributed world wide except for the Antarctic. Both species were found on tarred roads, on concrete structures (e.g. between paving stones, at the bases of walls and on roofs), on soil as well as on rotten logs.

One of Philippine's endemic species, namely *Warburgiella bistrumosa* (Müll. Hal) M. Fleisch, was also found at Doi Inthanon National Park. This species was distributed on Bartan Island and on Mt. Iraya (Tan and Iwatsuki, 1991). This surprising outcome implies that *W. bistrumosa* can be assumed not to be an endemic species of the Philippines because it was also found outside of the Philippines. Given that the different vegetations between Mt. Iraya and Doi Inthanon, there is possibility that the distribution of this species is not limited to the Philippines but widely distributed throughout Asia, which still has to be proven.

6.8 Dubious Species

The specimens of this study, contained one dubious species, namely *Symphyodon oblongifolius* (Ren. & Card.) Broth. because the type specimen has not been located. The taxonomic status of this species was discussed by He and Snider in 1992 that the taxonomic position of this species is uncertain because of none of the Herbarium specimens on loan under this name.(He and Snider 2000).

6.9 Obstacles

During the study, 2 obstacles were encountered. These are:

1. Increasing number of new buildings, due to the provision of places and facilities to enhance the comfort for visitors. As a consequence an anew collection of species in sporophyte stages was not possible anymore.

2. The taxonomic literature on mosses especially keys and species descriptions are insufficient and difficult to obtain.

6.10 Benefit of this research

An account for moss diversity in high mountains of Thailand was added to serve as the basic information and to be beneficial for further researches in the ecological aspects including forest composition, forest and pollution indicator, climatic change, and arts.

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