

ความหลากหลายของมอส์ในอุทยานแห่งชาติภูกระดึง จังหวัดเลย



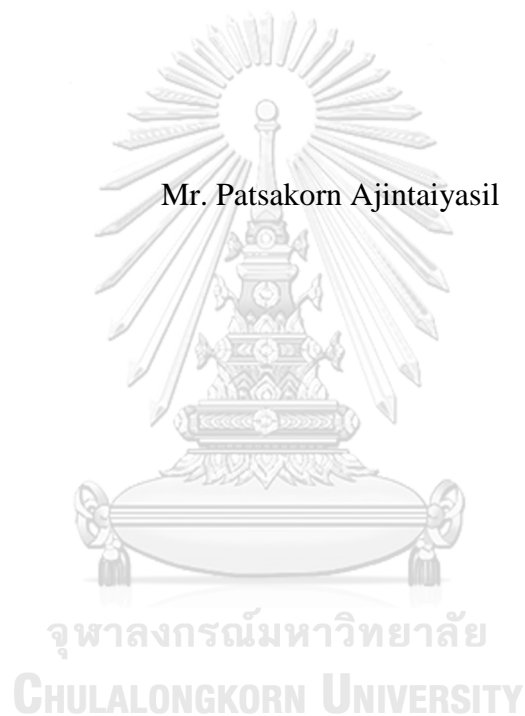
บทคัดย่อและแฟ้มข้อมูลฉบับเต็มของวิทยานิพนธ์ตั้งแต่ปีการศึกษา 2554 ที่ให้บริการในคลังปัญญาจุฬาฯ (CUIR)
เป็นแฟ้มข้อมูลของนิสิตเจ้าของวิทยานิพนธ์ ที่ส่งผ่านทางบัณฑิตวิทยาลัย

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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DIVERSITY OF MOSSES IN PHU KRADUENG NATIONAL PARK,
LOEI PROVINCE

Mr. Patsakorn Ajintaiyasil



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
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ภัสกร อจินไตยศิลป์ : ความหลากหลายของมอสส์ในอุทยานแห่งชาติภูกระดึง จังหวัดเลย (DIVERSITY OF MOSSES IN PHU KRADUENG NATIONAL PARK, LOEI PROVINCE) อ.ที่ปริกษาวิทยานิพนธ์หลัก: ผศ. ดร.รสริน พลวัฒน์, 313 หน้า.

การศึกษาคความหลากหลายของมอสส์ในอุทยานแห่งชาติภูกระดึง จังหวัดเลย ดำเนินการสำรวจและเก็บตัวอย่างตั้งแต่เดือนธันวาคม พ.ศ. 2557 ถึงเดือนธันวาคม พ.ศ. 2559 ผลการสำรวจความหลากหลายของมอสส์ตามเส้นทางศึกษาธรรมชาติ จำนวน 6 เส้นทาง สามารถเก็บตัวอย่างมอสส์ได้ 501 ตัวอย่าง จัดจำแนกได้ 30 วงศ์ 55 สกุล 100 ชนิด 5 ชนิดย่อย 9 พันธุ์ วงศ์ที่พบมากที่สุดคือ Sphagnaceae (11 ชนิด) Fissidentaceae (9 ชนิด) และ Leucobryaceae (7 ชนิด) ตามลำดับ สามารถแบ่งตามถิ่นอาศัย ออกได้เป็น 5 แบบ โดยถิ่นอาศัยที่พบมากที่สุดคือ บนก้อนหิน พบ 45 ชนิด บนพื้นดิน 43 ชนิด และบนลำต้น 37 ชนิด ในจำนวนนี้พบว่าเป็นชนิดที่ไม่เคยมีรายงานมาก่อนในประเทศไทย 4 ชนิด คือ *Leptopterigynandrum decolor* (Mitt.) M. Fleisch., *Octoblepharum pocsii* Magill & B.H. Allen, *Pterobryopsis tumida* (Dicks. ex Hook.) Dixon และ *Trachyphyllum touwianum* W.R. Buck ในการศึกษาครั้งนี้ได้จัดทำคำบรรยายลักษณะของมอสส์แต่ละชนิด รูปวิธานจำแนกวงศ์ สกุล และชนิด พร้อมข้อมูลทางนิเวศวิทยา การกระจายพันธุ์ และภาพประกอบ ตัวอย่างมอสส์ที่เก็บได้จะนำเก็บรักษาที่พิพิธภัณฑ์ ศาสตราจารย์กสิน สุวตะพันธุ์ ภาควิชาพฤกษศาสตร์ คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย และหอพรรณไม้ กรมอุทยานแห่งชาติ สัตว์ป่า และพันธุ์พืช

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The study of mosses diversity in Phu Kradueng National Park, Loei Province was explored from December 2014 to December 2016. The samples were collected along the 6 natural trails. A total of 501 samples were identified into 30 families, 55 genera, 100 species, 5 subspecies, and 9 varieties. Three families of mosses namely Sphagnaceae, Fissidentaceae, and Leucobryaceae were common families which included 11, 9 and 7 taxa, respectively. Additionally, the most common microhabitat was saxicolous with 45 species. The second and third common microhabitats were terrestrial and corticolous with 43 and 37 species, respectively. Additionally, there are 4 species which have not been recorded to Thailand, viz. *Leptopterigynandrum decolor* (Mitt.) M. Fleisch., *Octoblepharum pocsii* Magill & B.H. Allen, *Pterobryopsis tumida* (Dicks. ex Hook.) Dixon and *Trachyphyllum touwianum* W.R. Buck. Description of all species, ecological data, geographical distribution and photographs were prepared. Key to families, genera and species are constructed. The dry specimens are deposited at Professor Kasin Suvathabhandu Herbarium, Department of Botany, Chulalongkorn University (BCU) and Forest Herbarium, Department of Natural Park, Wildlife, and Plant Conservation (BKF).

Department: Botany

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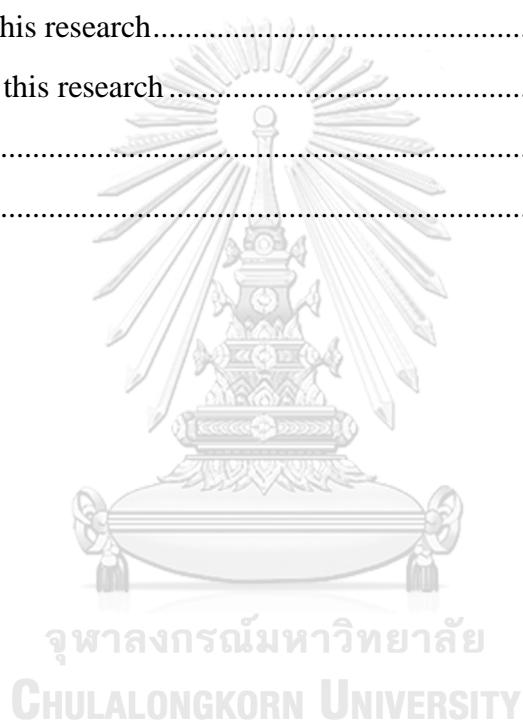
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CHAPTER I

INTRODUCTION

Bryophytes are green embryophytic plants having dominant gametophytes and absence of lignified tissue. The gametophytes are foliose which compose of rhizoid (root-like structure), cauloid (stem-like structure) and phylloids (leaves-like structure). Sometimes, they are thallose – a flat mass of tissue. Bryophytes are widely founded in all terrestrial ecosystems, colonizing a diverse ranges of terrestrial, lithophytic and epiphytic substrates (Frey & Stech, 2009). Bryophytes are currently classified into 3 divisions: Marchantiophyta (liverworts), Bryophyta (mosses), and Anthoceroophyta (hornworts) which strongly supported by molecular data (Shaw & Renzaglia, 2004; Troitsky *et al.*, 2007).

Of the three bryophyte groups, mosses are the most diverse. They are small land plants of about 13,000 species occurring around the world (Goffinet, Buck & Shaw, 2008). About 8,000 species are found in tropical zone (Frahm *et al.*, 2003) and over 700 species can be found in Thailand (He, 1995; Sornsamran & Thaitong, 1995; Sukkharak & Chantanaorrapint, 2014). Mosses are quite specific to their habitats. Thus, moss diversity in each area depends heavily on climate and elevation. They can be found on various kinds of substrates: soils, rocks, water, bark, and dung. Despite their small sizes, mosses play several important ecological roles. They provide food and shelter for small invertebrates and microorganisms (Gradstein, Churchill & Salazar-Allen, 2001). Additionally, mosses can also absorb water and nutrients directly to the cell surface. This ability makes them able to rapidly respond to their environments, such as climate, acidification, air pollution, water pollution and soil pollution with heavy metals. So, mosses are excellent qualitative indicators for detecting the changing environment (Vanderpoorten & Goffinet, 2009).

Mosses can also be used as planting materials, ornamental plants, medicinal use, antimicrobial and biopharmaceutical substances (Ando & Matsuo, 1984; Beike *et al.*, 2010). Extracts of mosses can be used in agriculture to prevent disease caused by fungi in tomatoes, bell pepper, and wheat (Tadese, 2002). Furthermore, they were used in medical treatments as an antibacterial and antifungal agents (Frahm, 2004). Moss extracts from *Abietinella abietina* (Hedw.) M. Fleisch, *Neckera crispa* Hedw, *Platyhypnidium riparoides* (Hedw.) Dixon, *Cratoneuron filicinum* (Hedw.) Spruce var. *filicinum* and *Campylium protensum* (Brid.) Kimbd. have properties in resistance to gram-positive bacteria (*Staphylococcus aureus*, *Micrococcus flavus*, and *Bacillus cereus*), gram-negative bacteria (*Escherichia coli* and *Salmonella typhimurium*) and fungi (*Aspergillus flavus* Link, *A. niger* Tiegh. and *A. fumigatus* Fresen.) (Danka *et al.*, 2012). These documents showed the importance of Thai moss diversity, which can be developed into various future industries.

Phu Kradueng National Park is located in Si Than sub-district, Phu Kradung district, Loei province, Thailand. In general, Phu Kradueng National Park is a sandstone tableland. It locates on the northwest of Khorat Plateau and having an area of about 348.12 km². Ranging in elevations from 260 to 1,316 m above mean sea levels. The climate is mind, mean temperatures are alternating from 20.8 to 32.3 C°,

having annual rainfalls of about 1,278.8 mm and 73.4% of relative air humidity (Thai Meteorological Department, 2016). Additionally, vegetation of the park can be divided into six types depending on climate, edaphic factors, elevation and other biological factors: deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest, lower montane rain forest, lower montane scrub and lower montane coniferous forest (Santisuk, 1994). Moreover, the park is also a source of many streams flow to many waterfalls, such as Phen Phob Mai Waterfalls, Tham Yai Waterfalls, Tham Sor Nuo Waterfalls, Hongtong Waterfalls, Khun Pong Waterfalls, etc. (Tourism Authority of Thailand, 2000). As a result, the park is a suitable sites for dwelling of bryophytes, especially mosses which can be thrived in various microhabitats.

Though, Phu Kradueng National Park is a protected area, however the park has encountered some causes leading to loss of moss diversity, i.e. trampling by tourists which usually increasing in numbers during October to March, burn by forest fire during summer months, habitat fragmentations by addition of building construction, and extensions of forest trails for tourists. These activities may lead to the reduction of moss diversity. Previously, moss diversity is rarely studies in the park and adjacent areas. So it is a time to explore moss diversity in the park, knowledges obtaining from this study can be based for plant conservation in this protected area in the future.

Aim of this work

This research aims to study diversity of mosses in Phu Kradueng National Park, Loei province, Thailand. The result of this study will provide information on the diversity, taxonomy, and ecology for mosses in this park.

CHAPTER II

LITERATURE REVIEW

2.1 History of Moss Studies in Thailand

Over two hundred years ago, plants in Thailand have been studied by plant taxonomist both outside and inside the country. However, plant study in Thailand has been generally focused on the flowering plants or economic crops (Punchay, 2014), while mosses have little information (Sukkharak & Chantanaorrapint, 2014). The following are the example of previous botanical works.

The first study of mosses in Thailand began between 1899 and 1900 when Danish botanist E.J. Schmidt collected bryophyte specimens from Koh Chang Island and adjacent areas. The samples were sent to the Herbarium of the University of Copenhagen (C), Denmark. Moss collections were subsequently identified by V. Brotherus. In total, 44 species of mosses were recognized including 19 species new to science (Brotherus, 1901).

During 1904–1905, C.C. Hosseus collected bryophytes from Doi Inthanon and Doi Suthep in Chiang Mai province. Fifteen species of mosses were identified including three species new to science (Brotherus, 1911). During his stay in Thailand between 1902 and 1932, A.F.G. Kerr collected 25,000 plant specimens including bryophytes throughout the country (Larsen, 1979). The bryophyte specimens were deposited in Bangkok Herbarium (BK), Kew Herbarium (K) and British Museum of Natural History (BM).

Based on Kerr's collections and previous publications, Dixon (1932) published the first checklist of moss in Thailand. In total, 220 species of mosses were reported including 32 new to science. Three years later, an updated checklist was published and 80 species were added, making a total of 300 species of Thai mosses (Dixon, 1935).

During 1950–1970, numerous joint botanical expeditions were undertaken by Danish, Dutch, French and Japanese botanists together with Thai counterparts. Several Thai-Danish expeditions were carried out between 1958 and 1970 by the team consisting of C. Charoenphol, B. Hansen, K. Larsen, T. Santisuk, T. Smitinand, T. Sørensen and E. Warncke. Approximately 7,000 packets of bryophytes were collected and distributed to many herbaria in Europe with duplicates kept at Forest Herbarium (BKF) (Larsen, 1979).

Giesy and Richards (1959) reported 40 moss species based on collections from Pho Temple in Bangkok, Nang Rong Waterfall in Nakon Nayok province, and Doi Chiang Dao and Doi Suthep in Chiang Mai province. Then, Noguchi (1960) reported nine species of mosses based on his collections from Doi Pui and Doi Chiang Dao, Chiang Mai province. One year later, Hansen (1961) studied the genus *Sphagnum* in Thailand and reported seven species including two new records (*Sphagnum erythrocalyx* Hampe and *S. subsecundum* Nees) and one new species to science (*S. personatum* B. Hansen).

Later, Horikawa and Ando (1964) reported 131 species of mosses based on specimens collected by the Osaka City University biological expedition to Southeast Asia in 1957–1958. Of these 67 species were new record for Thailand and four new to science. Two years later, Tixier and Smitinand (1966) reported 168 moss species from Thailand based on collections housed in Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation (BKF). Reed and Robinson (1967a, 1967b) reported 104 species of mosses from Thailand. Touw (1968) reported 195 species of mosses, including 84 new records for Thailand based on the collections from the Thai-Dutch botanical expedition in 1965–1966.

Tixier (1970, 1971, 1971–1972) listed 516 species of mosses and 8 new species based on his collections made in Thailand during 1965–1968 as well the previous publications. Based on the Thai-Japanese botanical expeditions between 1958 and 1963, Noguchi (1972, 1973) reported 188 species of mosses including 15 new recorded species and three new to science: *Garovaglia arcuata* Nog., *Neckeropsis gracilis* Nog., and *Symphyodon gollanioides* Nog.

The first study on mosses by Thai bryologists were focused on particular groups of bryophytes. Manop (1977) studied on moss family Sematophyllaceae based on collections kept in BK and BKF herbaria. Then, Sadakorn (1978) studied on the moss genus *Leucobryum*.

Later, Sornsamran and Thaithong (1995) published a bryophyte checklist for Thailand based on previous literature published during 1900 to 1979. There are 237 genera and 925 species of bryophytes, comprising of 2 hornwort species, 644 moss species, and 279 liverwort species. At the same time, He (1995) published a moss checklist for Thailand based on previous publications and herbarium specimens. His checklist contains a total of 52 families, 190 genera, and 620 species.

Then, there were many studies on diversity and ecology of mosses which were conducted by Thai bryologists, such as Bryophytes of the mangrove forest (Thaithong, 1984), Bryophytes in the Sakarat experiment station area (Sornsamran, 1988), Mosses in Taksin National Park and Doi Museu of Tak province (Pitpan, 1996), Bryophytes diversity at the summit of Khao Luang, Huai Yang Waterfall National Park, Prachuap Khiri Khan province (S. Chantanaorrapint, 2002; S. Chantanaorrapint, Boonkerd & Thaithong, 2004), Moss diversity and ecology at Doi Suthep-Pui National Park, Chiang Mai province (Kornochalert, 2004, 2006; Manachit, 2006; Printarakul, 2015; Wongkuna, 2003, 2005), Bryophyte diversity at Thong Pha Phum National Park, Kanchanaburi province (Boonkerd et al., 2007), Bryophyte at Chae Sorn National Park in Lampang province (Chidburee et al., 2008), Mosses diversity in Kew Mae Pan and Ang Ka areas, Doi Inthanon National Park, Chaing Mai province (Nathi, 2009), Ecological studies of epiphytic bryophytes along altitudinal gradients in Southern Thailand (S. Chantanaorrapint, 2010), Diversity of bryophytes at plant genetic protection area of RSPG, Rajjaprabha Dam EGAT, Surat Thani province (A. Chantanaorrapint & Chantanaorrapint, 2010), Ecology and diversity of epiphyllous bryophytes in the Naka Wildlife Sanctuary, Ranong province (Kraichak & Yaungthong, 2012), Bryophytes in the Khao Soi Dao Wildlife Sanctuary, Chanthaburi province (Sukkharak, Kitlap, et al., 2014), Bryophytes in many area at Chonburi province (Sukkharak & He, 2014; Sukkharak & Khatiyawong, 2014; Sukkharak, Pearaksa, et al., 2014; Sukkharak & Pikroapol, 2014), Bryophytes at Chao Pa

Waterfall, Trang province (Hassama, 2014), Diversity of *Sphagnum* L. in Phu Luang Wildlife Sanctuary, Loei province (Sittichoptham, 2014) and Bryophytes on coastal sandbars in Thai Mueang District, Phang-nga province (Suwanmala, 2015; Suwanmala & Chantanaorrapint, 2016).

Additionally, revisions of Thai moss species were conducted, including Sematophyllaceae (Pollawatn, 2008), Fissidentaceae (Wongkuna, 2010), *Leucophanes* (Calymperaceae) (Promma & Chantanaorrapint, 2013) and Daltoniaceae (Juengprayoon, 2017).

2.2 History of Moss Studies in Phu Kradueng National Park

The first report of moss in Phu Kradueng National Park was conducted by Tixier and Smitinand (1966). They listed mosses in Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation, Thailand, including 38 species of mosses from Phu Kradueng National Park.

Later, Reed and Robinson (1967a) reported 20 species from Phu Kradueng National Park. One year later, Touw (1968) studied moss collections during the Thai-Dutch botanical expedition in 1965–1966, and found 42 moss species from Phu Kradueng .

Then, Tixier (1971) published a checklist of Thai mosses and reported 66 species from Phu Kradueng. During the Thai-Japanese botanical expedition, 29 moss species were collected from Phu Kradueng (Noguchi, 1972, 1973). Sornsamran and Thaithong (1995) published a bryophyte checklist for Thailand based on literature during 1900 to 1979. Of these, 102 species and 3 varieties (105 taxa) were listed in Phu Kradueng National Park.

2.3 Life-forms of Bryophytes

Bryophytes do not live as single individual but in groups of individuals which have characteristic features depending on family, genus or species. According to Bates (1998) life-forms can be classified as follows:

1. Turfs: many loosely or closely packed vertical stems with limited branching, such as Bartramiaceae, Bryaceae, Fissidentaceae, Pottiaceae, Polytrichaceae and etc. (Figure 2.1A)

2. Cushions: dome-shaped colonies formed by regeneration from a central point of origin such that gradually increase in both height and radius and the component shoots vary in orientation from vertical to horizontal, such as *Octoblepharum*, *Leucobryum* and etc. (Figure 2.1B)

3. Dendroids: creeping stem along the substratum than becoming erect sympodial branching shoots, and finally develop an apical cluster of lateral branches bearing the main photosynthetic leaves, such as *Hypopterigium*, *Hyphnodendron* and etc. (Figure 2.1C)

4. Pendants: epiphytes in which the main shoots hang down from the point of attachment and bear many short, horizontal branched, such as Meteoriaceae and etc. (Figure 2.1D)

5. Mats: branched shoots that creep over the substratum and often closely attached by rhizoids, such as Hypnaceae, Erpodiaceae and etc. (Figure 2.1E)

6. Wefts: loosely intertwining, usually richly branched, often with rather few rhizoidal attachments, such as Racopilaceae, Thuidiaceae, Sematophyllaceae and etc. (Figure 2.1F)

7. Fans: shoots arising from vertical bark or rocks, branch repeatedly in the horizontal plane to form flattened photosynthetic surface, such as Neckeraceae, Pterobryaceae and etc. (Figure 2.1G)

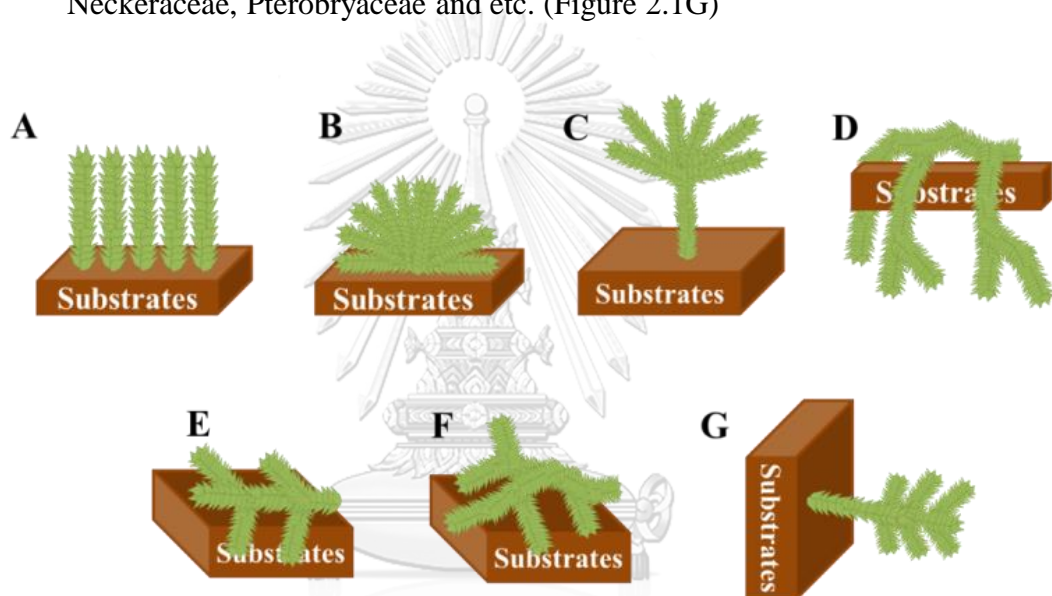


Figure 2.1 Life-forms of mosses, based on Bates (1998).

A. Turfs, B. Cushions, C. Dendroids, D. Pendants, E. Mats, F. Wefts, G. Fans.

CHAPTER III

STUDY SITE

This chapter will introduce the general information for Phu Kradueng National Park: location, topography, geology, climate, and vegetation.

3.1 Location and Topography

Phu Kradueng National Park is located in Si Than sub-district, Phukradung district, Loei province (Fig 3.1A–C). It is about 5 km west of Phu Kradung district, having an area of about 348 km² or 217,576.25 rai (Santisuk, 1994).

The name “Phu Kradueng” comes from a legend relating to a Buddhist Holy Day, a numbers of villagers heard the sound of a large bell. “Phu” comes from the northeastern dialect, "phukao", meaning mountain. The name "kradueng" in the local dialect of Loei Province, "rakhang yai", meaning large bell (Tourism Authority of Thailand, 2000).

The topography of Phu Kradueng National Park is a sandstone tableland. It is located northwest of Khorat Plateau. The elevation is ranging from 400 to 1,316 m above mean sea level. The table mountain is consisting of many peaks, its summit is at Khok Moei at an elevation of 1,316 m. The table mountain is high in descending order from the west and southeast to the northwest. The park is a source of many streams flow to many waterfalls, such as Phen Phob Mai Waterfalls, Tham Yai Waterfalls, Tham Sor Nuo Waterfalls, Hongtong Waterfalls, Khun Pong Waterfalls, etc.(Tourism Authority of Thailand, 2000), then flow together forming water source of Lam Nam Phong or Phong River, which is one of the important rivers in north-eastern Thailand (Santisuk, 1994).

3.2 Geological data

Phu Kradueng National Park is a flat sandstone plateau, surrounded by small hills. Bed rocks are metamorphic rocks and sedimentary rocks of Korat group which consist of four Formations (Fig 3.1C), i.e. Phu Phan Formation (Kpp), Sao Krua Formation (Jsk), Phra Wihan Formation (Jpw) and Phu Kradung Formation (Jpk) (Santisuk, 1994). Korat group was occurred early Jurassic period (200-180 million year ago) to early Cretaceous period (120–100 million years ago) (Wannakomol, 2005).

1. Phu Phan Formation (Kpp) are pale orange. They consist of fine- to coarse-grained and conglomeratic sandstone containing rounded pebbles of quartz and chert.

2. Sao Krua Formation (Jsk) are yellowish-gray to grayish-reddish brown. They consist of an alternation of siltstone and clay, and fine-grained to medium-grained sandstone.

3. Phra Wihan Formation (Jpw) are pinkish white. They consist predominantly of sandstones, less abundant siltstone and rare clay. In addition, the sandstone is medium- to coarse-grained, consisting of clean quartz sand grains with a few scattered grains of gray to black chert.

4. Phu Kradung Formation (Jpk) are reddish-brown and grayish-red. They consist mostly of soft, micaceous, siltstone with rare calcareous conglomerate beds.

3.3 Climate

The climatic data in Phu Kradueng National Park was recorded by Loei Meteorological Stations (Thai Meteorological Department, 2016). Three data were collected, that are temperature, rainfall, and relative humidity. (Fig. 3.3)

3.4 Vegetation

The vegetation of Phu Kradueng National Park includes deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest, lower montane rain forest, lower montane scrub and lower montane coniferous forest (Santisuk, 1994) (Fig 3.1D, Fig 3.2).

1. Deciduous dipterocarp forest can be found on mountain slopes at 200–600 amsl. Trees and shrubs are dominant. Characteristic species include: *Shorea obtusa* Wall., *S. siamensis* Miq., *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., *Pterocarpus macrocarpus* Kurz., *Terminalia mucronata* Craib & Hutch., *Sindora siamensis* Miq., *Schleichera oleosa* (Lour.) Merr., *Morinda pubescens* Sm., and *Vietnamosasa pusilla* (A.Chev. & A.Camus) T.Q.Nguyen (Figure 3.2C).

2. Mixed deciduous forest can be found on mountain slopes at 600–800 amsl. In general, this forest type is similar to deciduous dipterocarp forest but dominant species were different. Characteristic plants include: *Thyrsostachys siamensis* Gamble, *Gigantochloa albociliata* (Munro) Kurz., *Bambusa vulgaris* Schrad., *Dendrocalamus sericeus* Munro, *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen, *Chukrasia tabularis* A.Juss., *Anogeissus acuminata* (Roxb. ex DC.) Wall. ex Guillem. & Perr., and *Millingtonia hortensis* L.f. (Figure 3.2D).

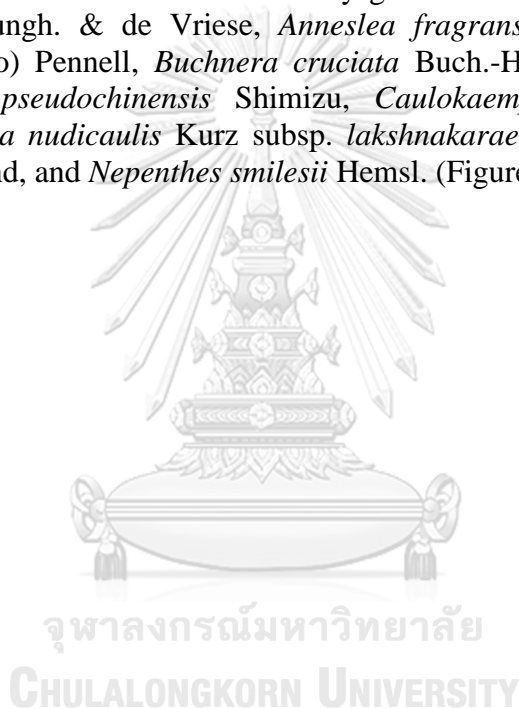
3. Dry evergreen forest can be found in the small area at 800–1,000 amsl. It was completely cleared by scattered small or large rocks. Tree crowns are close together forming shaded area. Characteristic plants include: *Schima wallichii* Choisy, *Irvingia malayana* Oliv. ex A.W.Benn., *Lagerstroemia duperreana* Pierre ex Gagnep., *Syzygium cumini* (L.) Skeels, *Bischofia javanica* Blume, and *Bauhinia scandens* L. (Figure 3.2E).

4. Lower montane rainforest can be found on the summit of the mountain at 1,000–1,300 amsl. The crown cover was dense and continuous. Characteristic plants include: *Castanopsis acuminatissima* (Blume) A.DC., *C. nephelioides* King ex Hook.f., *Gordonia axillaris* (Roxb. ex Ker Gawl.) Endl., *Helicia vestita* W.W. Sm., *H. nilagirica* Bedd., *Eriobotrya bengalensis* (Roxb.) Hook.f., *Photinia stenophylla*

Hand.-Mazz., *Phoebe tavoyana* (Meisn.) Hook. f., *Rhododendron simsii* Planch., *Rubus rufus* Focke, and *R. rugosus* Sm. (Figure 3.2F).

5. Lower montane scrub occurred in rocky open areas on the summit of the mountain at 1,000–1,300 amsl. It consists of small trees and shrubs in rock crevices. Characteristic plants include: *Anneslea fragrans* Wall., *Schima wallichii* Choisy, *Syzygium antisepticum* (Blume) Merr. & L.M.Perry, *Toxicodendron succedanea* (L.) Moldenke, *Craibiodendron stellatum* (Pierre) W.W.Sm., *Rhododendron ciliicalyx* Franch. subsp. *lyi* (H. Lév.) R.C. Fang, *Baekkea frutescens* L., *Lyonia foliosa* (H.R.Fletcher) Sleumer, and *Vaccinium bracteatum* Thunb. (Figure 3.2G).

6. Lower montane coniferous forest can be found together with Lower montane scrub on the summit of the mountain at 1,000–1,300 amsl. The trees are scattered and most of the area is covered by grasses. Characteristic plants include: *Pinus merkusii* Jungh. & de Vriese, *Anneslea fragrans* Wall., *Torenia violacea* (Azaola ex Blanco) Pennell, *Buchnera cruciata* Buch.-Ham. ex D.Don, *Impatiens chinensis* L., *I. pseudochinensis* Shimizu, *Caulokaempferia alba* K.Larsen & R.M.Sm., *Gentiana nudicaulis* Kurz subsp. *lakshnakarae* (Kerr) Halda, *Eriocaulon henryanum* Ruhland, and *Nepenthes smilesii* Hemsl. (Figure 3.2H).



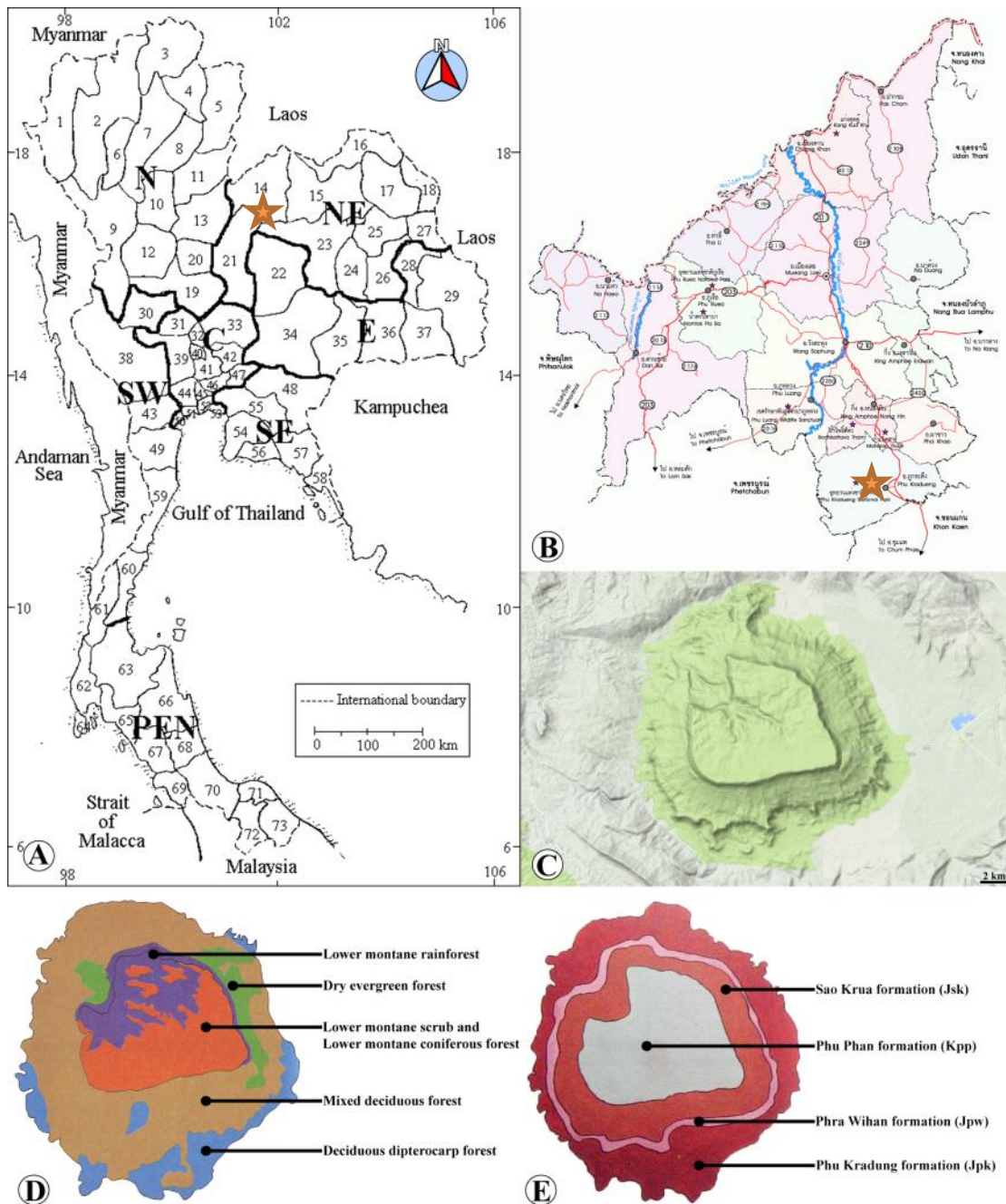


Figure 3.1 Location data of Phu Kradueng National Park.

A. Location in Thailand, B. Loei province, C. Phu Kradueng National Park location, D. A depiction of vegetation, E. A depiction of soil formation (Orange star = Phu Kradueng National Park).

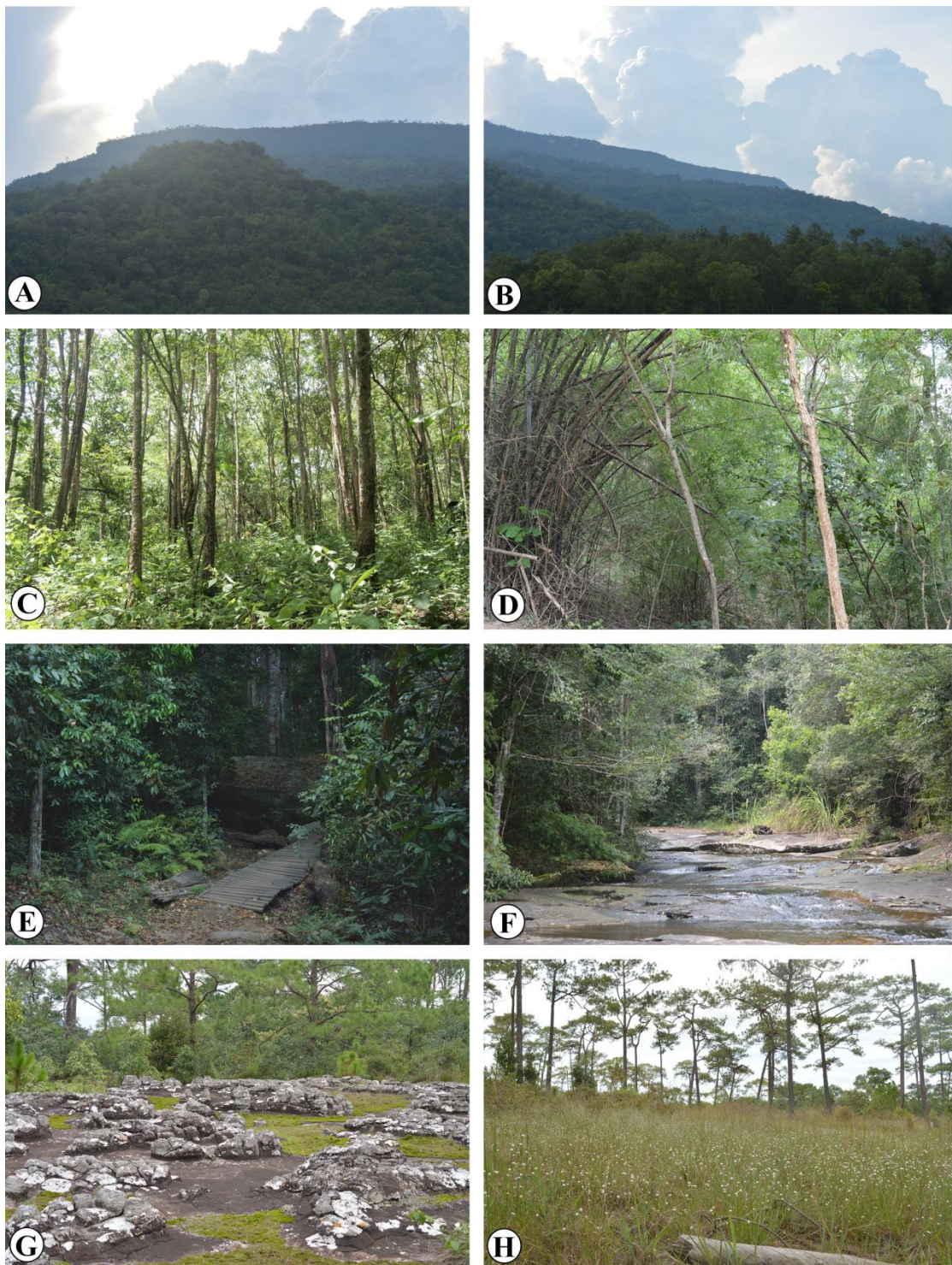


Figure 3. 2 Vegetations in Phu Kradueng National Park.

A–B. Side view of Phu Kradueng National Park, C. Deciduous dipterocarp forest, D. Mixed deciduous forest, E. Dry evergreen forest, F. Lower montane rainforest, G. rocky space in Lower montane scrub, H. Lower montane coniferous forest.

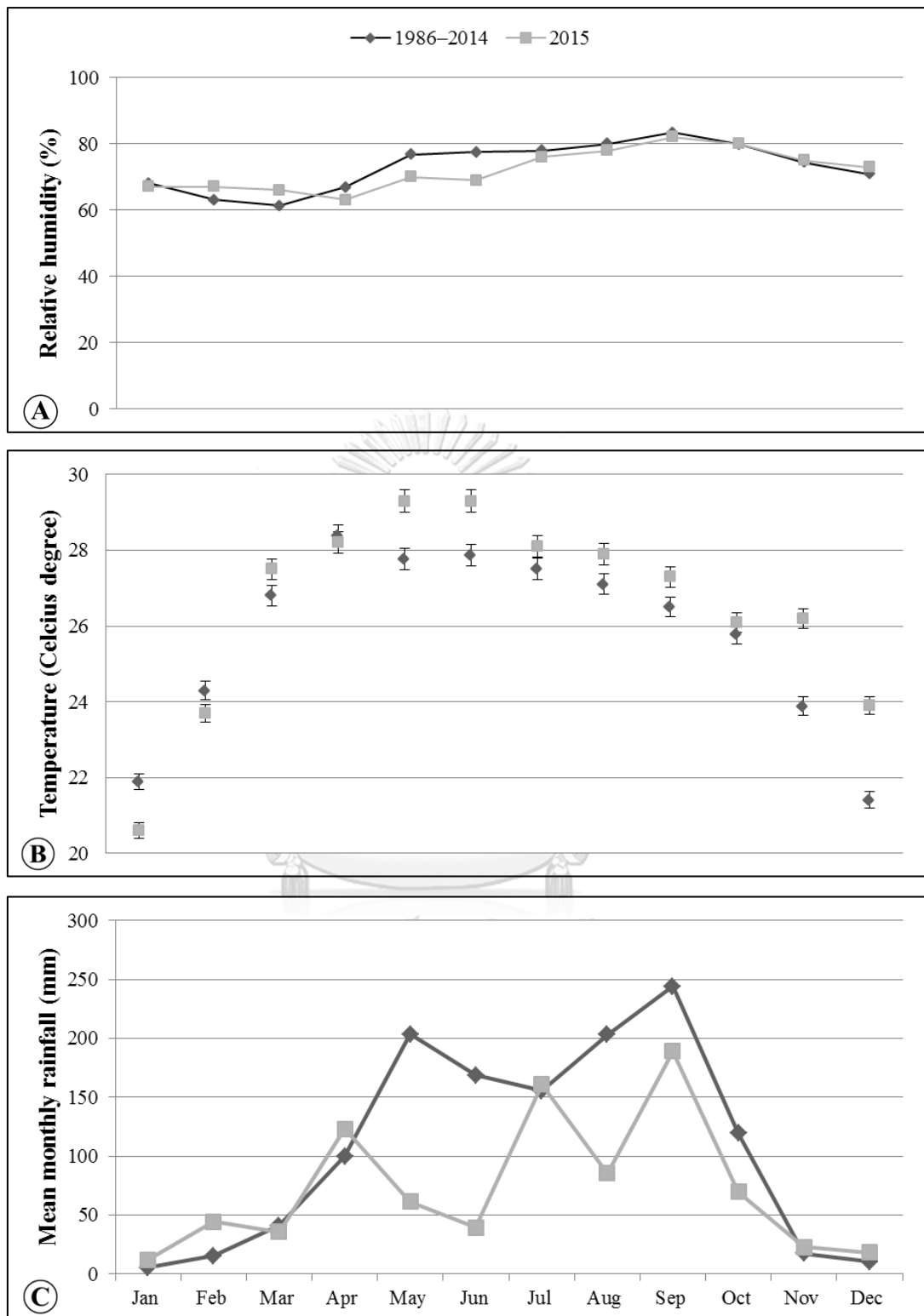


Figure 3.3 Climatic data at Phu Kradueng National Park.

A. Relative humidity (%), B. Temperature (Celsius degree), C. Mean monthly rainfall (mm).

CHAPTER IV

MATERIALS AND METHODS

This study was divided into two sections, field and laboratory works. For field work, fresh specimens were collected from Phu Kradueng National Park. Laboratory work was performed at Plant of Thailand Research Unit, Department of Botany, Faculty of Science, Chulalongkorn University.

4.1 Materials

1. Specimen Collecting Equipment

- Plastic bags
- Zipper bags
- Penknife
- Permanent marker
- Pencil
- Field note
- Hand lens
- Digital camera: Nikon DSLR D3200 digital camera fitted with Nikon AF-S Micro NIKKOR 40 MM lens
- The Global Position System (GPS) receiver: Garmin ETrex VISTA HCx

2. Herbarium Specimens Preparing Equipment

- Paper envelopes 10.5 x 16 cm
- Herbarium label 10.5 x 13.5 cm
- Deep freezer (-30° C)

3. Identification Equipment

- Microscopic slides and cover glasses
- Stereo microscope: Nikon SMZ800 microscope fitted with Nikon Digital sight DS-Fi1 digital camera
- Compound microscope: Nikon Eclipse E200 microscope fitted with Nikon Digital sight DS-Fi1 digital camera
- Dissecting needles

- Razor blades
- Petri dishes
- Related taxonomic literature of mosses
- Voucher specimens in herbaria: Forest Herbarium (BKF), and Professor Kasin Suvatabhanhu Herbarium (BCU)

4.2 Methods

1. Literature Review

The related taxonomic literature and information of Phu Kradueng National Park such as location, area, boundary, topography, and vegetation were searched from the libraries at Professor Kasin Suvathabhandu Herbarium at Department of Botany, Chulalongkorn University and Office of Phu Kradueng National Park. In addition, climatic data such as temperature, relative humidity, and rainfall were received from Thai Meteorological Department, Bangkok and office of Phu Kradueng National Park.

2. Exploration and Collection

Explorations and specimen collections were done during December 2014 to February 2016, and December 2016. Mosses were collected along trails of Phu Kradueng National Park, six main trails are represented as below (Figure 4.1).

- 1) The trail from Ban Si Than to Lang Pae and Visitor Center (200–1,200 m elevation)
- 2) The trail from Visitor Center to Phen Phob Mai Waterfall and Tham Yai Waterfall (1,000–1,200 m elevation)
- 3) The trail from Visitor Center to Anodard Pond to Tham Sor Nuo Waterfall and Lom Sak Cliff (1,100–1,300 m elevation)
- 4) The trail from Visitor Center to Hongtong Waterfall and Khun Pong Waterfall (1,000–1,200 m elevation)
- 5) The trail from Visitor Center to Song Lok Cliff (1,000–1,200 m elevation)
- 6) The trail from Visitor Center to Mak Dook Cliff and Lom Sak Cliff (1,100–1,200 m elevation)

There were also other additional trails as well, such as Than Sawan Waterfall and Keaw Pond. These trails were extended about five meter on side of the road or where appropriate from the nature trails, this ensured that specimen collection covered as many areas possible. Three duplicates of specimens and photographs were collected and taken. Furthermore, Information about microhabitat, diagnostic characters and ecology were noted. Localities were recorded by a GPS receiver (Garmin ETrex VISTA HCx). Dry specimens were prepared as described in Boonkerd *et al.* (1987) and Glime (2013).

3. Laboratory Study

The external and internal morphological characters of each specimen were examined under stereo and compound microscopes. Moss specimens were identified by using taxonomic keys and description from various taxonomic literatures, such as Guide to the bryophytes of tropical America (Gradstein, Churchill & Salazar-Allen, 2001), Moss flora of China (Chien, Crosby & He, 1999, 2003; Hu *et al.*, 2008; X. Li, Crosby & He, 2001, 2007; Wu, Crosby & He, 2002, 2005, 2011), A handbook of Malesian mosses (Eddy, 1988, 1991, 1996), Mosses of eastern India and adjacent regions (Gangulee, 1969, 1971, 1972, 1974, 1976, 1977, 1978, 1980), Illustrated moss flora of Japan (Noguchi, 1987, 1988, 1989, 1991, 1994), Mosses and other bryophytes an illustrated (Malcolm & Malcolm, 2000) and etc. as shown in the reference. Additionally, life-form of mosses were classified followed Bates (1998).

All specimens were verified by comparison to the specimens at BCU, BKF and CMUB [Herbarium abbreviations according to Thiers (continuously updated)]. The classification system of mosses in this thesis follows Goffinet, Buck and Shaw (2017). Descriptions of all species were prepared from specimens that collected from Phu Kradueng National Park. Key to families, genera, species, and infraspecific taxon were constructed. The ecological data were prepared additionally.

4. Photographs

The photographs were taken in field and laboratory by Nikon DSLR D3200 digital camera fitted with Nikon AF-S Micro NIKKOR 40 MM lens. The illustrations were taken in the laboratory by using compound and stereo microscopes fitted with Nikon Digital sight DS-Fi1 digital camera. In addition, photographs were edited by program “Adobe Photoshop version CS5”.

5. Geographical Distribution มหาวิทยาลัย

Distribution of each species was collected from the website TROPICOS (www.tropicos.org), An Annotated Checklist and Atlas of the Mosses of Thailand (He, 1995), and other taxonomic literature. Distribution in Thailand was arranged to follow by Smitinand (1958), i.e. the Northern (N), North-eastern (NE), Eastern (E), Central (C), South-eastern (SE), South-western (SW), and Peninsular (PEN).

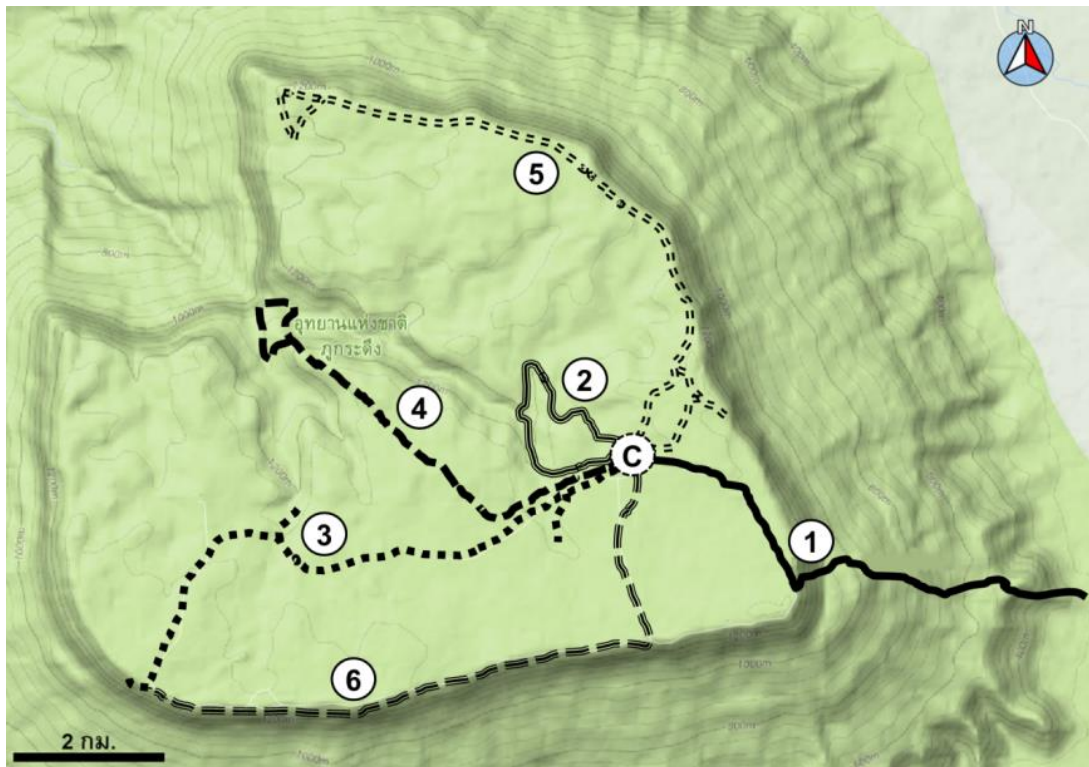


Figure 4. 1 The surveying trails for field exploration in Phu Kradueng National Park.

1= The trail from Ban Si Than to Lang Pae and Visitor Center (200–1,200 m elevation), 2= The trail from Visitor Center to Phen Phob Mai Waterfall and Tham Yai Waterfall (1,000–1,200 m elevation), 3= The trail from Visitor Center to Anodard Pond to Tham Sor Nuo Waterfall and Lom Sak Cliff (1,100–1,300 m elevation), 4= The trail from Visitor Center to Hongtong Waterfall and Khun Pong Waterfall (1,000–1,200 m elevation), 5= The trail from Visitor Center to Song Lok Cliff (1,000–1,200 m elevation), 6= The trail from Visitor Center to Mak Dook Cliff and Lom Sak Cliff (1,100–1,200 m elevation), C=Visitor Center.

CHAPTER V

RESULTS

5.1 Moss diversity in Phu Kradueng National Park

Five hundred and one specimens were collected during December 2014 to December 2016. They were determined in to 100 species, five subspecies, and nine varieties within 30 families, and 55 genera (Table 5.1). Four species are new records. The most common families are Sphagnaceae (11 taxa), Fissidentaceae (nine taxa), and Leucobryaceae (seven taxa), respectively.

Table 5. 1 Checklist of mosses in Phu Kradueng National Park.

Microhabitat: T = terrestrial, S = saxicolous, L = lignicolous, C = corticolous, R=ramicolous

Life-form: c = cushion, f = fan, m = mat, p = pendant, t = turf, w = weft

Symbol: * = New record species, ** = New localities

Vegetation: DDF = Deciduous dipterocarp forest, MDF = Mixed deciduous forest, DEF = Dry evergreen forest, LMR = Lower montane rainforest, LMS = Lower montane scrub, LMC = Lower montane coniferous forest

Abundance: + = rare species: found in one area (100 cm²) and with less than 50 plants/area, ++ = common species: found in many areas and with more than 50 plants/area or found in one area and with more than 100 plants/area, +++ = abundance species: found in many areas with numerous plants.

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
BARTRAMIACEAE Schwägr.						
1. <i>Philonotis hastata</i> (Duby) Wijk & Margad.	1, 3	1,121	S	t	DEF, LMC	++
2. <i>Philonotis mollis</i> (Dozy & Molke.) Mitt.**	1	403	T	t	DDF	+
BRYACEAE Schwägr.						
3. <i>Brachymenium systylium</i> (Müll. Hal.) A. Jaeger	1	294	T	t	DDF	+
4. <i>Bryum argenteum</i> Hedw.	1, 5	1,250–1,262	S	c	LMS, LMC	++
5. <i>Bryum coronatum</i> Schwägr.**	1	470–1,250	T, S	t	DDF, LMC	++
6. <i>Rhodobryum ontariense</i> (Kindb.) Paris**	1	1,275	S	t	LMR	+
7. <i>Rosulabryum billardieri</i> (Schwägr.) J.R. Spence	1, 2	1,054–1,232	S	t	LMR	+
8. <i>Rosulabryum capillare</i> (Hedw.) J.R. Spence	1	967	S	t	DEF	+
CALYMPERACEAE Kindb.						
9. <i>Leucophanes octoblepharioides</i> Brid.	4, 5	1,087–1,233	S, C	c, t	LMR	++
10. <i>Octoblepharum albidum</i> Hedw.	1–6	466–1,257	S, L, C, R	c	LMR, LMC	+++
11. <i>Octoblepharum pocsii</i> Magill & B.H. Allen*	1, 3	552–1,250	S	t	DDF, LMR	++

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
12. <i>Syrrhopodon armatus</i> Mitt.	2, 5	1,197–1,227	S, L	t	LMR, LMC	++
13. <i>Syrrhopodon gardneri</i> (Hook.) Schwägr.	3, 4, 5	1,113–1,233	S, L, C	c, t	LMR, LMC	++
14. <i>Syrrhopodon parasiticus</i> (Sw. ex Brid.) Besch.**	2	1,188–1,248	R	t	LMR	+
DALTONIACEAE Schimp.						
15. <i>Distichophyllum nigricaulae</i> var. <i>elmeri</i> (Broth.) B.C. Tan & H. Rob.	3	1,239	T, S	m	LMR	+
DICRANACEAE Schimp.						
16. <i>Leucoloma mittenii</i> M. Fleisch.**	2	1,241	S	t	LMR	+
17. <i>Leucoloma molle</i> (Müll. Hal.) Mitt.	2	1,187	C	t	LMR	+
DIPHYSCIACEAE M. Fleisch.						
18. <i>Diphyscium mucronifolium</i> Mitt.	3, 5	1,226–1,239	S	t	LMR	++
ENTODONTACEAE Kindb.						
19. <i>Entodon macropodus</i> (Hedw.) Müll. Hal.	1	945	L	m	DEF	+
20. <i>Erythrodontium julaceum</i> (Hook. ex Schwägr.) Paris	1	533–1,031	L, C	m, w	DDF, MDF, DEF	++
ERPODIAACEAE Broth.						
21. <i>Erpodium mangiferae</i> Müll. Hal.	1	405	C	m	DDF	+
22. <i>Solmsiella biseriata</i> (Austin) Steere	1	585	C	m	DDF	+
FISSIDENTACEAE Schimp.						
23. <i>Fissidens ceylonensis</i> Dozy & Molk.**	1	294–1,221	T, C	t	DDF, DEF, LMR	+++
24. <i>Fissidens crispulus</i> Brid. var. <i>robinsonii</i> (Broth.) Z. Iwats. & Z.H. Li**	1, 5	979–1,262	T, S	t	DEF, LMS, LMC	++
25. <i>Fissidens flaccidus</i> Mitt. var. <i>flaccidus</i> **	1	462	T	t	DDF	+
26. <i>Fissidens geppii</i> M. Fleisch.**	1	1,121	S	t	DEF	+
27. <i>Fissidens guangdongensis</i> Z. Iwats. & Z.H. Li**	5	1,260	T	t	LMC	+
28. <i>Fissidens incognitus</i> Gangulee**	1	1,121	T	t	DEF	+
29. <i>Fissidens javanicus</i> Dozy & Molk.**	2	1,244	S	t	LMR	+
30. <i>Fissidens polypodioides</i> Hedw.	1–5	470–1,224	T, S	t	DDF, DEF, LMR, LMC	++
31. <i>Fissidens subangustus</i> M. Fleisch.**	1	1,221	T	t	DEF	+
FUNARIAACEAE Schwägr.						
32. <i>Funaria hygrometrica</i> Hedw.	1	807	T	t	MDF	+

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
HYPNACEAE Schimp.						
33. <i>Ectropothecium dealbatum</i> (Reinw. & Hornsch.) A. Jaeger**	1	966	L	w	DEF	++
34. <i>Ectropothecium monumentorum</i> (Duby) A. Jaeger**	2	1,205–1,240	S	m	LMR, LMC	++
35. <i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.**	1	585–1,000	T, S	m	DDF	++
HYOPTERYGIACEAE Mitt.						
36. <i>Lopidium trichocladon</i> (Bosch & Sande Lac.) M. Fleisch.	2	1,248	C	f	LMR	++
LESKEACEAE Schimp.						
37. <i>Claopodium assurgens</i> (Sull. & Lesq.) Cardot	2, 3	1,183–1,250	C	m	LMR	++
38. <i>Leptopterigynandrum decolor</i> (Mitt.) M. Fleisch.*	1	270–826	C	m	DDF, DEF	+
LEUCOBRYACEAE Schimp.						
39. <i>Brothera leana</i> (Sull.) Müll. Hal.	2	1,256	C	c	LMC	+
40. <i>Campylopus ericoides</i> (Griff.) A. Jaeger**	1, 2, 3, 5, 6	1,191–1,290	T, S, C	c, t	LMR, LMS, LMC	+++
41. <i>Campylopus serratus</i> Sande Lac.	3	1,237	T	t	LMC	+
42. <i>Leucobryum aduncum</i> Dozy & Molck. var. <i>scalare</i> (Müll. Hal. ex M. Fleisch.) A. Eddy	1–6	1,223–1,304	T, S, C, L	c	DDF, LMR, LMC	+++
43. <i>Leucobryum bowringii</i> Mitt.	2, 3	1,222–1,256	T, S	c	LMR, LMC	++
44. <i>Leucobryum javense</i> (Brid.) Mitt.	2, 4, 6	1,113–1,251	T, S, C, L	t, c	LMR, LMC	++
45. <i>Leucobryum juniperoideum</i> (Brid.) Müll. Hal.	2, 3	1,184–1,249	T, S, C	c	LMR, LMC	++
METEORACEAE Kindb.						
46. <i>Aerobryidium filamentosum</i> (Hook.) M. Fleisch.	1	945	S	p	DEF	+
47. <i>Cryptopapillaria chrysoclada</i> (Müll. Hal.) M. Menzel	4	1,087–1,113	R	p	LMR	+
48. <i>Cryptopapillaria feae</i> (Müll. Hal. ex M. Fleisch.) M. Menzel	1	1,262	S	p	LMR	+
49. <i>Cryptopapillaria fuscescens</i> (Hook.) M. Menzel**	5	1,171	S	p	LMC	+
50. <i>Neodiciadiella flagellifera</i> (Cardot) Huttunen & D. Quandt**	4	1,087–1,113	R	p	LMR	+
MIYABACEAE Enroth						
51. <i>Homaliadelphus targionianus</i> (Mitt.) Dixon & P. de la Varde	1	979	C	f	DEF	++
NECKERACEAE Schimp.						
52. <i>Himantocladium cyclophyllum</i> (Müll. Hal.) M. Fleisch.	2	1,178	C	f	LMR	+

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
53. <i>Himantocladium plumula</i> (Nees) M. Fleisch.	2	1,248	C	f	LMR	+
54. <i>Homaliodendron microdendron</i> (Mont.) M. Fleisch.	4	1,087–1,113	S	f	LMR	+
55. <i>Neckeropsis exserta</i> (Hook. ex Schwägr.) Broth. var. <i>exserta</i>	1	447	S, C	f	DDF, DEF, LMR	++
56. <i>Pinatella alopecuroides</i> (Mitt.) M. Fleisch.	1	446	S	f	DDF	++
57. <i>Pinatella ambigua</i> (Bosch & Sande Lac.) M. Fleisch.**	1	281	S	f	LMR	++
ORTHOTRICHACEAE Arn.						
58. <i>Macromitrium densum</i> Mitt.**	1	556	S	m	DDF	++
59. <i>Macromitrium ferriei</i> Cardot & Thér.**	2	1,224	C	m	LMR	++
60. <i>Schlotheimia ferruginea</i> (Bruch ex Hook. & Grev.) Brid.**	1, 5	1,288	C	m	LMC	+
PLAGIOTHECIACEAE M. Fleisch.						
61. <i>Pseudotaxiphyllum arquifolium</i> (Bosch & Sande Lac.) Z. Iwats.	3	1,222	T	m	LMR	++
62. <i>Pseudotaxiphyllum pohliaecarpum</i> (Sull. & Lesq.) Z. Iwats.	5	1,262	T	m	LMS	++
POLYTRICHACEAE Schwägr.						
63. <i>Pogonatum cirratum</i> (Sw.) Brid. subsp. <i>fuscatum</i> (Mitt.) Hyvönen	3, 4	1,222	T	t	LMR	++
64. <i>Pogonatum cirratum</i> (Sw.) Brid. subsp. <i>macrophyllum</i> (Dozy & Molk.) Hyvönen	2, 3	1,200–1,246	T	t	LMR, LMC	++
65. <i>Pogonatum neesii</i> (Müll. Hal.) Dozy	1, 2, 3, 4, 6	1,190–1,242	T	t	LMR, LMC	+++
POTTIACEAE Hampe						
66. <i>Barbula consanguinea</i> (Thwaites & Mitt.) A. Jaeger**	1	403–585	T, S	t	DDF	++
67. <i>Barbula javanica</i> Dozy & Molk.**	1, 3	590–1,234	T, S	t	DDF, LMC	++
68. <i>Hyophila apiculata</i> M. Fleisch.**	1	285	T	t	DDF	+
69. <i>Hyophila involuta</i> (Hook.) A. Jaeger	1	294–1,179	T, S	t	DDF, LMR, LMC	+++
70. <i>Tortella cyrtobasis</i> Dixon	1	966	S	t	DEF	+
71. <i>Weissia edentula</i> Mitt.**	1	470–719	T	t	DDF, MDF	++
PTERIGYNANDRACEAE Schimp.						
72. <i>Trachyphyllum inflexum</i> (Harv.) A. Gepp	1	294–778	S, L, C	w	DDF, MDF	++
73. <i>Trachyphyllum touwianum</i> W.R. Buck*	1	548	S, R	m	DDF	+

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
PTEROBRYACEAE Kindb.						
74. <i>Pterobryopsis acuminata</i> (Hook.) M. Fleisch.**	2	1,178	C	f	LMR	+
75. <i>Pterobryopsis orientalis</i> (Müll. Hal.) M. Fleisch.	2	1,177	C	f	LMR	+
76. <i>Pterobryopsis scabriuscula</i> (Mitt.) M. Fleisch.**	3	1,178–1,247	C	f	LMR	+
77. <i>Pterobryopsis tumida</i> (Dicks. ex Hook.) Dixon*	2	1,177	C	f	LMR	++
PYLAISIADELPHACEAE Goffinet & W.R. Buck						
78. <i>Isopterygium albescens</i> (Hook.) A. Jaeger var. <i>smallii</i> (Sull. & Lesq.) Z. Iwats.	1	966	C	m	DEF	++
79. <i>Isopterygium lignicola</i> (Mitt.) A. Jaeger	2, 5	1,233–1,266	S, R	w	LMR	+
80. <i>Taxithelium nepalense</i> (Schwägr.) Broth.**	1	446	S	m	LMR	+
RACOPILACEAE Kindb.						
81. <i>Racopilum cuspidigerum</i> (Schwägr.) Ångström	5	1,218	C	w	LMC	+
82. <i>Racopilum orthocarpum</i> Wilson ex Mitt.	2	1,256	C	w	LMR	+
RHIZOGONIACEAE Broth.						
83. <i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	2, 3, 4	1,248–1,255	T, S, L	t	LMR, LMC	+++
SEMATOPHYLLACEAE Broth.						
84. <i>Acroporium brevipes</i> (Broth.) Broth.	2	1,231	C	w	LMR	++
85. <i>Acroporium laosianum</i> (Broth. & Paris) Broth.	3	1,231	C	w	LMR	++
86. <i>Chionostomum pinicola</i> Tixier**	3	1,248	C	w	LMC	++
87. <i>Sematophyllum humile</i> (Mitt.) Broth.**	2	1,184–1,224	S, C	m	LMR	+
88. <i>Trichosteleum pseudomamosum</i> M. Fleisch.**	4	1,087	S	w	LMR	++
SPHAGNACEAE Dumort.						
89. <i>Sphagnum cuspidatum</i> Müll. Hal.	4	1,250	T	t	LMR	+
90. <i>Sphagnum cuspidatum</i> Ehrh. ex Hofin.	3, 5	1,239–1,292	T	t	LMR, LMC	++
91. <i>Sphagnum cuspidatum</i> Ehrh. ex Hofin. subsp. <i>subrecurvum</i> (Warnst.) Eddy var. <i>subrecurvum</i>	3	1,239	T	t	LMC	++
92. <i>Sphagnum junghuhnianum</i> Dozy & Molk.	2, 3	1,167–1,216	T	t	LMR	+
93. <i>Sphagnum luzonense</i> Warnst.	3	1,167–1,216	T	t	LMC	+

Taxon	Trails	Altitude (m)	Micro-habitat	Life-form	Vegetation	Abundance
94. <i>Sphagnum ovatum</i> Hampe	2, 3	1,216–1,245	T	t	LMR	++
95. <i>Sphagnum palustre</i> L. subsp. <i>palustre</i>	2, 3, 5	1,205–1,239	T	t	LMR, LMS, LMC	++
96. <i>Sphagnum palustre</i> L. subsp. <i>pseudocymbifolium</i> (Müll. Hal.) A. Eddy	2	1,234	T	t	LMR	++
97. <i>Sphagnum perichaetiale</i> Hampe	1–6	1,187–1,292	T	t	LMR, LMS, LMC	+++
98. <i>Sphagnum robinsonii</i> Warnst.	6	1,253	T	t	LMC	+
99. <i>Sphagnum subsecundum</i> Nees	3	1,242	T	t	LMC	+
STEREOPHYLLACEAE W.R. Buck & Ireland						
100. <i>Entodontopsis anceps</i> (Bosch & Sande Lac.) W.R. Buck & R.R. Ireland	1	281–288	C	m	DDF	+
THUIDIACEAE Schimp.						
101. <i>Thuidium plumulosum</i> (Dozy & Molke.) Dozy & Molke.	1, 3	766–1,250	T, C	w	MDF, DEF, LMR	++
102. <i>Thuidium pristocalyx</i> (Müll. Hal.) A. Jaeger var. <i>pristocalyx</i>	1, 2	1,183–1,694	S, C	w	LMR, LMC	++
103. <i>Thuidium pristocalyx</i> (Müll. Hal.) A. Jaeger var. <i>samoanum</i> (Mitt.) Touw	3	1,242	T	w	LMR	++

5.2 Microhabitat of mosses

Mosses in Phu Kradueng National Park thrive in five main microhabitats as was described in Gradstein and Pócs (1989). Among 103 taxa, there are 45 saxicolous mosses, 43 terrestrial mosses, 37 corticolous mosses, 10 lignicolous mosses, and six ramicolous mosses (Table 5.1).

1. Saxicolous mosses are growing on rocks. There are 45 taxa: *Philonotis hastata* (Bartramiaceae), *Bryum argenteum*, *B. coronatum*, *Rhodobryum ontariense*, *Rosulabryum billardierii*, *R. capillare* (Bryaceae), *Leucophanes octoblepharioides*, *Octoblepharum albidum*, *O. pocsii*, *Syrrhopodon armatus*, *S. gardneri* (Calymperaceae), *Distichophyllum nigricaulis* var. *elmeri* (Daltoniaceae), *Leucoloma mittenii* (Dicranaceae), *Diphyscium mucronifolium* (Diphysciaceae), *Fissidens crispulus* var. *robinsonii*, *F. geppii*, *F. javanicus*, *F. polypodioides* (Fissidentaceae), *Ectropothecium cygnicollum*, *Taxiphyllum taxirameum* (Hypnaceae), *Campylopus ericoides*, *Leucobryum aduncum* var. *scalare*, *L. bowringii*, *L. javense*, *L. juniperoideum* (Leucobryaceae), *Aerobryidium filamentosum*, *Cryptopapillaria feae*, *C. fuscescens* (Meteoraceae), *Homaliodendron microdendron*, *Neckeropsis exserta* var. *exserta*, *Pinnatella alopecuroides*, *P. ambigua* (Neckeraceae), *Macromitrium densum* (Orthotrichaceae), *Barbula consanguinea*, *B. javanica*, *Hyophila involuta*, *Tortella cyrtobasis* (Pottiaceae), *Trachyphyllum inflexum*, *T. touwianum* (Pterigynandraceae), *Isopterygium lignicola*, *Taxithelium nepalense* (Pylaisiadelphaceae), *Pyrrhobryum spiniforme* (Rhizogoniaceae), *Sematophyllum*

humile, *Trichosteleum pseudomammosum* (Sematophyllaceae), and *Thuidium pristocalyx* var. *pristocalyx* (Thuidiaceae).

2. Terrestrial mosses are growing on soils or preferring a soil habitat. There are 43 taxa: *Philonotis mollis* (Bartramiaceae), *Brachymenium systylium*, *Bryum coronatum* (Bryaceae), *Distichophyllum nigricaulis* var. *elmeri* (Daltoniaceae), *Fissidens ceylonensis*, *F. crispulus* var. *robinsonii*, *F. flaccidus* var. *flaccidus*, *F. guangdongensis*, *F. incognitus*, *F. polypodioides*, *F. subangustus* (Fissidentaceae), *Funaria hygrometrica* (Funariaceae), *Taxiphyllum taxirameum* (Hypnaceae), *Campylopus ericoides*, *C. serratus*, *Leucobryum aduncum* var. *scalare*, *L. bowringii*, *L. javense*, *L. juniperoideum* (Leucobryaceae), *Pseudotaxiphyllum arquifolium*, *P. pohliaecarpum* (Plagiotheciaceae), *Pogonatum cirratum* subsp. *fuscatum*, *P. cirratum* subsp. *macrophyllum*, *P. neesii* (Polytrichaceae), *Barbula consanguinea*, *B. javanica*, *Hyophila apiculata*, *H. involuta*, *Weissia edentula* (Pottiaceae), *Pyrrhobryum spiniforme* (Rhizogoniaceae), *Sphagnum cuspidatum*, *S. cuspidatum* subsp. *subrecurvum* var. *subrecurvum*, *S. junghuhnianum*, *S. luzonense*, *S. ovatum*, *S. palustre* subsp. *palustre*, *S. palustre* subsp. *pseudocymbifolium*, *S. perichaetiale*, *S. robinsonii*, *S. subsecundum* (Sphagnaceae), *Thuidium plumulosum*, and *T. pristocalyx* var. *samoanum* (Thuidiaceae).

3. Corticolous mosses are epiphytes, living on tree bark. There are 37 taxa: *Leucophanes octoblepharioides*, *Octoblepharum albidum*, *Syrrhopodon gardneri* (Calymperaceae), *Leucoloma molle* (Dicranaceae), *Erythrodontium julaceum* (Entodontaceae), *Erpodium mangiferae*, *Solmsiella biseriata* (Erpodiaceae), *Fissidens ceylonensis* (Fissidentaceae), *Lopidium trichocladon* (Hypopterygiaceae), *Claopodium assurgens*, *Leptopterigynandrum decolor* (Leskeaceae), *Brothera leana*, *Campylopus comosus*, *Leucobryum aduncum* var. *scalare*, *L. javense*, *L. juniperoideum* (Leucobryaceae), *Homaliadelphus targionianus* (Miyabeaceae), *Himantocladium cyclophyllum*, *H. plumula*, *Neckeropsis exserta* var. *exserta* (Neckeraceae), *Macromitrium ferriei*, *Schlotheimia ferruginea* (Orthotrichaceae), *Trachyphyllum inflexum* (Pterigynandraceae), *Pterobryopsis acuminata*, *P. orientalis*, *P. scabriuscula*, *P. tumida* (Pterobryaceae), *Isopterygium albescens* var. *smallii* (Pylaisiadelphaceae), *Racopilum cuspidigerum*, *R. orthocarpum* (Racopilaceae), *Acroporium brevipes*, *A. laosianum*, *Chionostomum pinicola*, *Sematophyllum humile* (Sematophyllaceae), *Entodontopsis anceps* (Stereophyllaceae), *Thuidium plumulosum*, and *T. pristocalyx* var. *pristocalyx* (Thuidiaceae).

4. Lignicolous mosses are growing on wood of fallen logs that has lost its bark. There are 10 taxa: *Octoblepharum albidum*, *Syrrhopodon armatus*, *S. gardneri* (Calymperaceae), *Entodon macropodus*, *Erythrodontium julaceum* (Entodontaceae), *Ectropothecium cyperoides* (Hypnaceae), *Leucobryum aduncum* var. *scalare*, *L. javense* (Leucobryaceae), *Trachyphyllum inflexum* (Pterigynandraceae), and *Pyrrhobryum spiniforme* (Rhizogoniaceae).

5. Ramicolous mosses are epiphytes, living on twigs and branches. There are six taxa: *Octoblepharum albidum*, *Syrrhopodon parasiticus* (Calymperaceae), *Cryptopapillaria chrysoclada*, *Neodictyella flagellifera* (Meteoriaceae), *Isopterygium lignicola* (Pylaisiadelphaceae), and *Trachyphyllum touwianum* (Pterigynandraceae).

Additionally, some mosses are living in more than one microhabitat. There are 28 taxa have experienced this condition.

1. Mosses are living on two microhabitats (20 taxa).

1). Dwelling on soils and rocks. There are 10 taxa: *Bryum coronatum* (Bryaceae), *Distichophyllum nigricaulis* var. *elmeri* (Daltoniaceae), *Fissidens crispulus* var. *robinsonii*, *F. polypodioides* (Fissidentaceae), *Taxiphyllum taxirameum* (Hypnaceae), *Campylopus ericoides*, *Leucobryum bowringii* (Leucobryaceae), *Barbula consanguinea*, *B. javanica*, and *Hyophila involuta* (Pottiaceae).

2). Dwelling on rocks and bark. There are four taxa: *Leucophanes octoblepharioides* (Calymperaceae), *Neckeropsis exserta* var. *exserta* (Neckeraceae), *Sematophyllum humile* (Sematophyllaceae), and *Thuidium pristocalyx* var. *pristocalyx* (Thuidiaceae).

3). Dwelling on soils and bark. There are two taxa: *Fissidens ceylonensis* (Fissidentaceae), and *Thuidium plumulosum* (Thuidiaceae).

4). Dwelling on rocks and twigs. There are two taxa: There are two taxa, including *Trachyphyllum touwianum* (Pterigynandraceae), and *Isopterygium lignicola* (Pylaisiadelphaceae).

5). Dwelling on barks and log. There is one taxa, i.e. *Erythrodonium julaceum* (Entodontaceae).

6). Dwelling on rocks and log. There is one taxa, i.e. *Syrrhopodon armatus* (Calymperaceae).

2. Mosses are living on three microhabitats (5 taxa).

1). Dwelling on soils, rocks and bark. There are two taxa: *Campylopus ericoides*, and *Leucobryum juniperoideum* (Leucobryaceae).

2). Dwelling on rocks, log and bark. There are two taxa: *Syrrhopodon gardneri* (Calymperaceae), and *Trachyphyllum inflexum* (Pterigynandraceae).

3). Dwelling on soils and bark. There is one taxa, i.e. *Pyrrhobryum spiniforme* (Rhizogoniaceae).

3. Mosses are living on four microhabitats (3 taxa).

1). Dwelling on rocks, log, bark and twigs. There is one taxa, i.e. *Octoblepharum albidum* (Calymperaceae).

2). Dwelling on soils, rocks, log, and bark. There are two taxa: *Leucobryum aduncum* var. *scalare*, *L. javense* (Leucobryaceae).

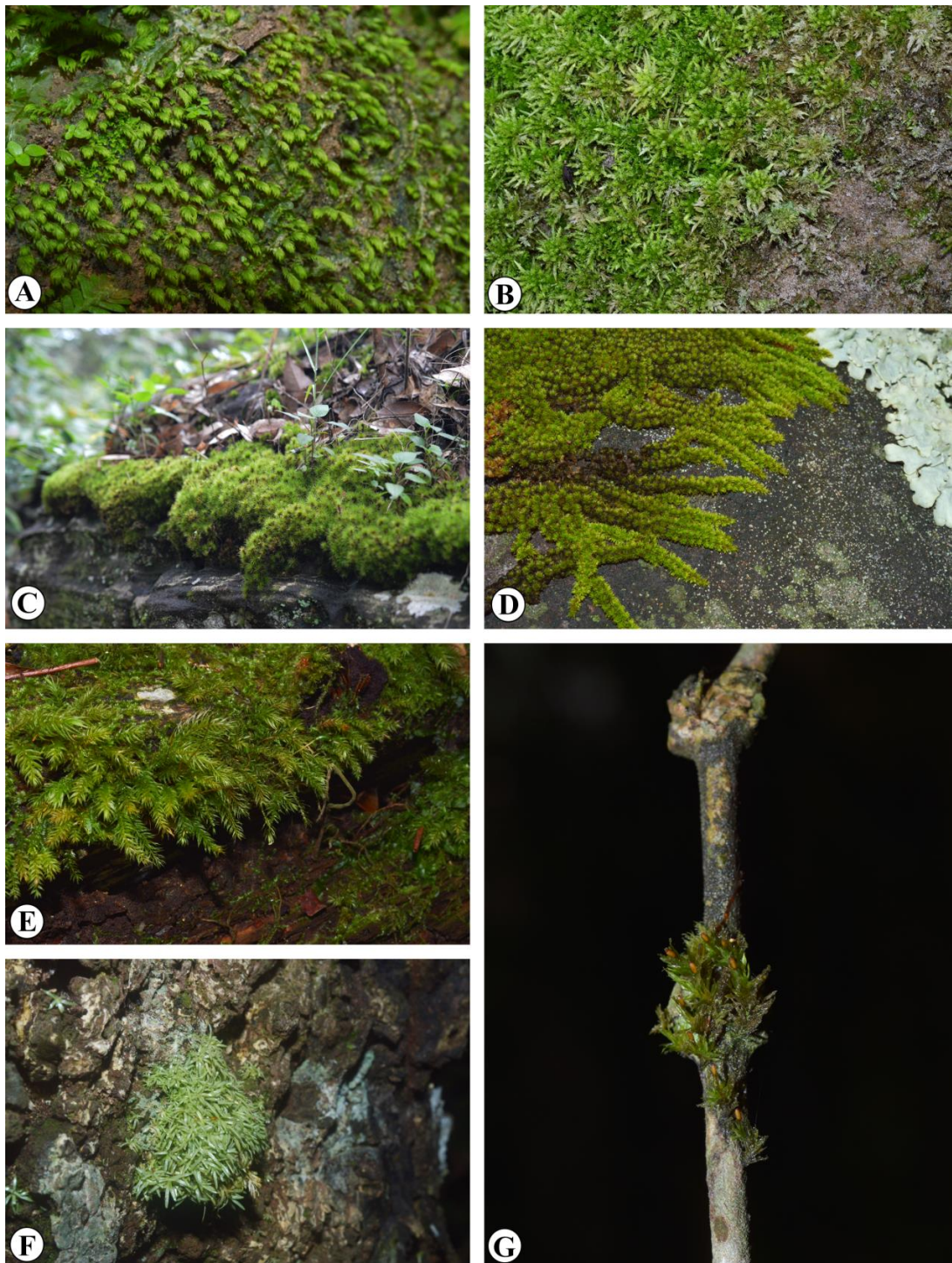


Figure 5. 1 Moss microhabitats in Phu Kradueng National Park.

A–B. Terrestrial mosses: A. *Fissidens subangustus* M. Fleisch., B. *Sphagnum perichaetiale* Hampe; C–D. Saxicolous mosses: C. *Campylopus ericoides* (Griff.) A. Jaeger, D. *Macromitrium densum* Mitt.; E. Lignicolous mosses, *Pyrrhobryum spiniforme* (Hedw.) Mitt.; F. Corticolous mosses: *Octoblepharum albidum* Hedw.; G. Ramicolous mosses: *Syrrophodon parasiticus* (Sw. ex Brid.) Besch.

5.3 Life-form of mosses

Mosses in Phu Kradueng National Park grow in 6 life-forms (after Bates, 1998). Among 103 taxa, there are turfs (49 taxa), mats (19 taxa), wefts (13 taxa), fans (12 taxa), cushions (10 taxa), and pendants (five taxa) (Table 5.1).

1. Turfs: Mosses are thriving on rather open spaces, fully exposed with sunlight, rarely found on leaf litter. There are 49 taxa: *Philonotis hastata*, *P. mollis* (Bartramiaceae), *Brachymenium systylium*, *Bryum coronatum*, *Rhodobryum ontariense*, *Rosulabryum billardierii*, *R. capillare* (Bryaceae), *Leucophanes octoblepharioides*, *Octoblepharum pocsii*, *Syrrhopodon armatus*, *S. gardneri*, *S. parasiticus*. (Calymperaceae), *Leucoloma mittenii*, *L. molle* (Dicranaceae), *Diphyscium mucronifolium* (Diphysciaceae), *Fissidens ceylonensis*, *F. crispulus* var. *robinsonii*, *F. flaccidus* var. *flaccidus*, *F. geppii*, *F. guangdongensis*, *F. incognitus*, *F. javanicus*, *F. polypodioides*, *F. subangustus* (Fissidentaceae), *Funaria hygrometrica* (Funariaceae), *Campylopus ericoides*, *C. serratus*, *Leucobryum javense* (Leucobryaceae), *Pogonatum cirratum* subsp. *fuscatum*, *P. cirratum* subsp. *macrophyllum*, *P. neesii* (Polytrichaceae), *Barbula consanguinea*, *B. javanica*, *Hyophila apiculata*, *H. involuta*, *Tortella cyrtobasis*, *Weissia edentula* (Pottiaceae), *Pyrrhobryum spiniforme* (Rhizogoniaceae), *Sphagnum cuspidatum*, *S. cuspidatum* subsp. *subrecurvum* var. *subrecurvum*, *S. junghuhnianum*, *S. luzonense*, *S. ovatum*, *S. palustre* subsp. *palustre*, *S. palustre* subsp. *pseudocymbifolium*, *S. perichaetiale*, *S. robinsonii*, and *S. subsecundum* (Sphagnaceae).

2. Mats: Mosses are thriving on hard surfaces in medium or high relative humidity, and medium light intensity. There are 19 taxa: *Distichophyllum nigricaulis* var. *elmeri* (Daltoniaceae), *Entodon macropodus*, *Erythrodontium julaceum* (Entodontaceae), *Erpodium mangiferae*, *Solmsiella biseriata* (Erpodiaceae), *Ectropothecium cygnicollum*, *Taxiphyllum taxirameum* (Hypnaceae), *Claopodium assurgens*, *Leptopterigynandrum decolor* (Leskeaceae), *Macromitrium densum*, *M. ferriei*, *Schlotheimia ferruginea* (Orthotrichaceae), *Pseudotaxiphyllum arquifolium*, *P. pohliaecarpum* (Plagiotheciaceae), *Trachyphyllum touwianum* (Pterigynandraceae), *Isopterygium albescens* var. *smallii*, *Taxithelium nepalense* (Pylaisiadelphaceae), *Sematophyllum humile* (Sematophyllaceae), and *Entodontopsis anceps* (Stereophyllaceae).

3. Wefts: Mosses are thriving on forest ground or tree trunk in rather low air humidity. There are 13 taxa: *Erythrodontium julaceum* (Entodontaceae), *Ectropothecium cyperoides* (Hypnaceae), *Trachyphyllum inflexum* (Pterigynandraceae), *Isopterygium lignicola* (Pylaisiadelphaceae), *Racopilum cuspidigerum*, *R. orthocarpum* (Racopilaceae), *Acroporium brevipes*, *A. laosianum*, *Chionostomum pinicola*, *Trichosteleum pseudomammosum* (Sematophyllaceae), *Thuidium plumulosum*, *Thuidium pristocalyx* var. *pristocalyx*, and *Thuidium pristocalyx* var. *samoanum* (Thuidiaceae).

4. Fans: Mosses are thriving on shady areas, forest grounds are subjected to periodic flooding. There are 12 taxa: *Lopidium trichocladon* (Hypopterygiaceae), *Homaliadelphus targionianus* (Miyabeaceae), *Himantocladium cyclophyllum*, *H. plumula*, *Homaliodendron microdendron*, *Neckeropsis exserta* var. *exserta*,

Pinnatella alopecuroides, *P. ambigua* (Neckeraceae), *Pterobryopsis acuminata*, *P. orientalis*, *P. scabriuscula*, and *P. tumida* (Pterobryaceae).

5. Cushions: Mosses are thriving in wide range of habitats with different light conditions. There are 10 taxa: *Bryum argenteum* (Bryaceae), *Leucophanes octoblepharioides*, *Octoblepharum albidum*, *Syrrhopodon gardneri* (Calymperaceae), *Brothera leana*, *Campylopus ericoides*, *Leucobryum aduncum* var. *scalare*, *Leucobryum bowringii*, *Leucobryum javense*, and *Leucobryum juniperoideum* (Leucobryaceae).

6. Pendants: Mosses are thriving on twigs or rocks in pendulous position, amid high relative humidity. There are five taxa: *Aerobryidium filamentosum*, *Cryptopapillaria chrysoclada*, *C. feae*, *C. fuscescens*, and *Neodiciadiella flagellifera* (Meteoriaceae).

Furthermore, some mosses are thriving in more than one life-forms. There are five taxa that represented as below.

1. Mosses are forming in both turfs and cushions. There are four taxa: *Leucophanes octoblepharioides*, *Syrrhopodon gardneri* (Calymperaceae), *Campylopus ericoides*, and *Leucobryum javense* (Leucobryaceae).

2. Mosses are forming in both mats and wefts. There is one taxa, i.e. *Erythrodontium julaceum* (Entodontaceae).

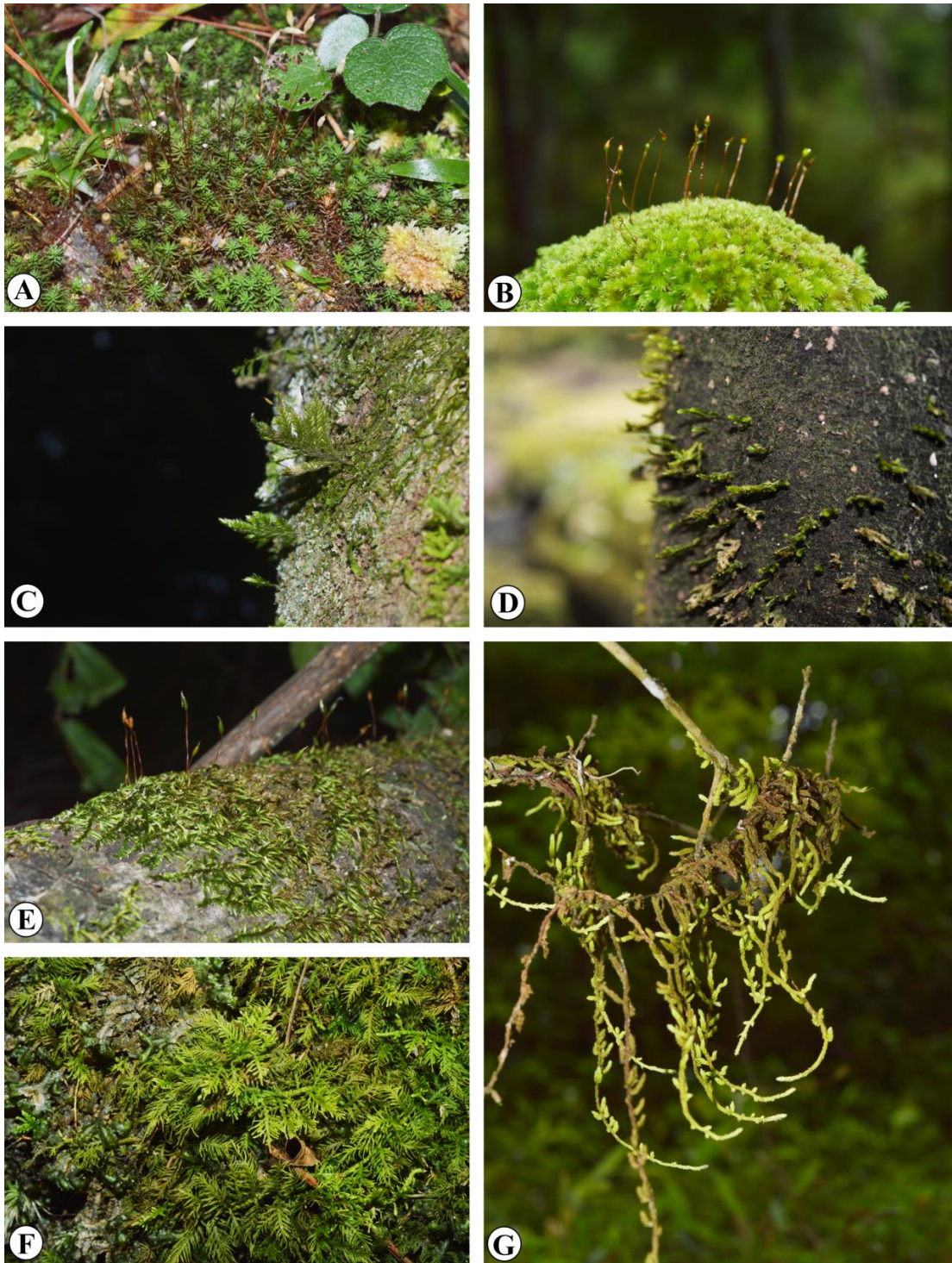


Figure 5. 2 Life-form of mosses in Phu Kradueng National Park.

A. Turfs: *Pogonatum neesii* (Müll. Hal.) Dozy; B. Cushions: *Leucobryum aduncum* var. *scalare* (Müll. Hal. ex M. Fleisch.) A. Eddy; C–D. Fan: *Pterobryopsis scabriuscula* (Mitt.) M. Fleisch.; E. Mats: *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris; F. Wefts: *Thuidium pristocalyx* var. *samoanum* (Mitt.) Touw; G. Pendants: *Cryptopapillaria chrysoclada* (Müll. Hal.) M. Menzel.

5.4 Enumeration of mosses in Phu Kradueng National Park

Five hundred one specimens were collected during December 2014 to December 2016. There are 103 moss taxa, including 30 families, 55 genera, 102 species, five subspecies, and nine varieties (Table 5.1). Descriptions and keys are represented as below.

Key to the Families

- 1a. Plant whitish; cells alternating or layered between hyaline cells (leucocyst) and green cells (chlorocyst).....28. Sphagnaceae
- 1b. Plant variously green, yellow to golden, or brown to blackish; cells uniform, not alternating between hyaline cell and green cell.....2
- 2a. Upper surface of leaves with row of lamellae; peristome nematodontous.....
.....20. Polytrichaceae
- 2b. Upper surface of leaves lacking lamellae; peristome arthrodontous.....3
- 3a. Plants acrocarpous; stems usually erect; sporophyte terminal on stems.....4
- 4a. Leaves arranged in 2 ranks (distichous); composed of vaginant laminae...
.....9. Fissidentaceae
- 4b. Leaves arranged in 3 or more ranks (polystichous); lacking vaginant
laminae.....5
- 5a. Median cells rhombic to hexagonal.....6
- 6a. Leaves border consisting of long linear cells.....2. Bryaceae
- 6b. Leaves border consisting of large, rectangular to fusiform cells...
.....10. Funariaceae
- 5b. Median cells isodiametric to ovate-rounded or subquadrate to
rectangular.....7
- 7a. Median cells isodiametric to ovate-rounded.....8
- 8a. Leaves cells with papillose, uni- to pluripapillose.....
.....21. Pottiaceae
- 8b. Leaves cells smooth.....9
- 9a. Leaves ovate to narrowly or broadly oblong-lanceolate, or
linear-lanceolate central strand present.....26. Rhizogoniaceae
- 9b. Leaves lingulate, weakly concave; central strand absent...
.....6. Diphysiaceae
- 7b. Median cells subquadrate to rectangular.....10
- 10a. Central strand present; leaves cell with papillae over cell
lumen or projecting at angles, rarely smooth.....1. Bartramiaceae
- 10b. Central strand absent; leaves cell smooth or papillose.....11

- 11a. Leaves mostly with an upper lingulate to ligulate or linear-lanceolate, limb from an expanded ovate or obovate to oblong base.....14. Leucobryaceae
- 11b. Leaves narrowly to somewhat broadly lanceolate, often differentiated between a ovate to oblong base and limb lanceolate-linear to subulate.....12
- 12a. Stems erect, simple to more often few to several branched, often densely tomentose; cells mostly smooth, occasionally bulging mammillose or papillose; alar region differentiated or not.....5. Dicranaceae
- 12b. Stems mostly erect, simple to few branches; cells papillose or smooth; often with cancellinae or teniolae or composed of hyalocysts layer above and below triangular or quadrangular chlorocysts.....3. Calymperaceae
- 3b. Plants pleurocarpous; stems creeping; sporophyte lateral on branch.....13
- 13a. Stems with amphigastria.....14
- 14a. Leaves margins bordered; costae single, 2/3 lamina length to excurrent, often flexuose or forked.....12. Hypopterygiaceae
- 14b. Leaves margins lacking a bordered; costae single, strong, often long excurrent, ending in long awns, sometimes nearly as long as the leaf length.....25. Racopilaceae
- 13b. Stems without amphigastria.....15
- 15a. Alar cells not differentiated; leaves not sheathing at the base.....16
- 16a. Leaves ovate-lanceolate or obovate-oblong.....17
- 17a. Median cells oval to isodiametric, uni- or pluripapillose; stems 1-3 pinnately branched, often rather densely tomentose; paraphyllia scattered or dense, simple to more branched, papillose.....30. Thuidiaceae
- 17b. Median cells oval to long-hexagonal, smooth; stems erect to or spreading; radiculose below; pseudoparaphyllia absent or rarely filamentous.....4. Daltoniaceae
- 16b. Leaves ovate or linear-lanceolate or oblong-lingulate.....18
- 18a. Median cell fusiform to linear, rarely shorter, mostly smooth, rarely prorulose or papillose.....17. Neckeraceae
- 18b. Median cells isodiametric, oval to oblong-oval or rhomboidal, smooth or papillose.....19
- 19b. Median cells oval to oblong-oval, smooth, incrassate; base cells distinctly porose.....16. Miyabeaceae

- 19a. Median cells mostly isodiametric, oval to oblong-oval or rhomboidal, smooth, mammillose or papillose; basal cells not porose.....20
- 20a. Central strand absent; paraphyllia absent; leaves linear- to oblong-lanceolate or oblong-lingulate.....18. Orthotrichaceae
- 20b. Central strand present; paraphyllia absent or present, if present not papillose; leaves ovate-lanceolate.....
.....13. Leskeaceae (*Claopodium*)
- 15b. Alar cells differentiated; leaves with a sheathing base.....20
- 19a. Alar cells few, large, often inflated.....21
- 21a. Stem forming primary and secondary stems, secondary stems erect and frondose or dendroid; alar cells differentiated, subquadrate, porose.....23. Pterobryaceae
- 21b. Stem not forming primary and secondary stems; alar cells differentiated, not porose.....22
- 22a. Alar cells conspicuous or large size.....27. Sematophyllaceae
- 22b. Alar cells inconspicuous or small size.....23
- 23a. Pseudoparaphyllia foliose or rarely filamentous; leaves often falcate or homomallous.....11. Hypnaceae
- 23b. Pseudoparaphyllia filamentous or absent; leaves appressed to erect-spreading or complanate.....24
- 24a. Leaves ovate to lanceolate, usually not falcate; apex acute or long-acuminate; alar cells with a few non-inflated quadrate cells, or basal alars well differentiated and inflated.....24. Pylaisiadelphaceae
- 24b. Leaves broadly ovate, elliptical, or ovate-lanceolate, sometimes concave, obtuse; acute or acuminate at apex; alar cells shorter, consisting of 1–8 rows of quadrate to rectangular cells.....19. Plagiotheciaceae
- 19b. Alar cells quadrate to subquadrate, numerous.....25
- 25a. Alar region asymmetric with cells often more numerous on one side.....29. Stereophyllaceae
- 25b. Alar region symmetric with cells equal on both side.....26
- 26a. Median cells linear to fusiform or oval to oblong-oval or rhomboidal and smooth.....27
- 27a. Median cells oval to oblong-oval or rhomboidal and smooth; alar cells subquadrate.....
.....13. Leskeaceae (*Leptopterigynandrum*)
- 27b. Median cells linear to fusiform or rhomboidal; alar cells numerous, subquadrate.....7. Entodontaceae

26b. Median cells quadrate, oval to oblong-oval or rhomboidal to hexagonal.....28

28a. Stem forming primary and secondary stems, secondary stems often pendent or spreading, irregularly to regularly pinnately branched..... 15. Meteoriaceae

28b. Stem not forming primary and secondary stems, stems creeping, pinnately to irregularly pinnately branched.....29

29a. Costae lacking; median cells quadrate or rhombic to hexagonal, smooth to papillose.....8. Erpodiaceae

29b. Costae short and double; median cells short, quadrate, rhomboidal, or elliptical to oblong-rhomboidal, prorate to papillose.....22. Pterigynandraceae



จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

1. BARTRAMIACEAE

Schwägr., Sp. Musc. Frond. 90. 1830; Gangulee, Mosses E. India 4: 1078. 1972; Noguchi, Ill. Moss Fl. Japan 3: 554. 1989; Eddy, Handb. Males. Mosses 3: 515. 1996; Mu & He, Moss Fl. China 4: 161. 2007.

Plants commonly medium sized or large and robust, rarely small. **Stems** erect, rarely pendent, few to several branched by innovations, branches often forming a distal whorl of short subfloral innovations, radiculose; central strand present. **Leaves** commonly spirally arranged; linear- to ovate-lanceolate, occasionally differentiated with a narrow linear to lanceolate limb and an oblong or oblong-obovate sheathing base; apex acute to acuminate, rarely obtuse; margins plane or reflexed to recurved below, dentate to more commonly bluntly or sharply serrate, singly or doubly toothed, elimbate; costae single, strong, subpercurrent to short or long excurrent, often papillose or toothed on back distally; upper and median cells subquadrate to more often short to long rectangular, often narrowly so, mostly papillose, papillae over cell lumen or projecting at angles, rarely smooth, lower and basal cells larger, mostly short to long rectangular, lax or firm; alar cells sometimes differentiated. **Autoicous**, synoicous or dioicous. **Perichaetia** terminal but often appearing lateral by innovations, leaves often differentiated. **Setae** short to elongate, smooth. **Capsules** immersed to more commonly exserted, suberect to inclined, subglobose to globose, asymmetric. **Opercula** plane to conic or shortly beaked. **Peristome** double or reduced to a single series, occasionally absent; exostome teeth 16, smooth or papillose, trabeculate; endostome often reduced, basal membrane high, segments often divided distally, cilia 1-3 or absent. **Calyptrae** cucullate, naked and smooth. **Spores** mostly papillose or coarsely warty.

PHILONOTIS

Brid., Bryol. Univ. 2: 15–28, pl. 6, f. 5. 1827; Gangulee, Mosses E. India 4: 1108. 1972; Noguchi, Ill. Moss Fl. Japan 3: 562. 1989; Eddy, Handb. Males. Mosses 3: 224. 1996; Mu & He, Moss Fl. China 4: 174. 2007.

Plants small to rather large, dull or glossy, in loose or dense turfs. **Stems** reddish brown to brown, erect, often branched below the fertile buds; radiculose below; central strand developed. **Leaves** mostly erect, appressed when dry, erect-patent when moist; ovate- to narrowly ovate- or triangular-lanceolate; acute to acuminate at apex, rarely narrowly obtuse; margins plane or recurved, serrulate or serrate, unistratose; costae 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 cell ends, sometimes 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. **Setae** elongate, straight. **Capsules** nearly spherical, asymmetric, inclined or horizontal; furrowed when dry; neck short; mouth broad. **Opercula** conic at base, shortly rostrate. **Peristome** double; exostome teeth lanceolate, with a median zigzag line, papillose above or throughout, trabeculate; endostome segments split, perforate, papillose; cilia 1–3 or not developed. **Calyptrae** shortly cucullate. **Spores** spherical or reniform, papillose.

Key to the species

- 1a. Leaves small, 0.40–0.70 mm long, with apices acute or narrowly obtuse; costae subpercurrent or ending below the apex.....1. *Philonotis hastata*
- 1b. Leaves medium-sized, 1.0–2.0 mm long, with apices finely acuminate; costae excurrent.....2. *Philonotis mollis*

1. *Philonotis hastata* (Duby) Wijk & Margad., Taxon 8: 74. 1959; Gangulee, Mosses E. India 4: 1127. 1972; Noguchi, Ill. Moss Fl. Japan 3: 572. 1989; Eddy, Handb. Males. Mosses 3: 229. 1996; Mu & He, Moss Fl. China 4: 181. 2007. — *Hypnum hastatum* Duby, Syst. Verz. 132. 1846. — *Bartramia tahitensis* Müll. Hal., Bot. Zeitung (Berlin) 17: 220. 1859. — *Philonotis asperifolia* Mitt, J. Linn. Soc., Bot. 10: 185. 1868. — *Bartramia obtusifolia* Mitt., Fl. Vit. 381. 1873. — *Bartramia amblyoblata* Müll. Hal., Linnaea 38: 631. 1874. — *Bartramia tenuicula* Hampe, Linnaea 38: 210. 1874. — *Bartramia wallisii* Müll. Hal., Linnaea 38: 554. 1874. — *Bartramia comorensis* Müll. Hal., Linnaea 40: 245. 1876. — *Philonotis curvifolia* Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 245. 1880. — *Philonotis tenuicula* (Hampe) Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 245. 1880. — *Bartramia elongatula* Müll. Hal., Linnaea 43: 415. 1882. — *Philonotula jardinii* Besch., Ann. Sci. Nat., Bot., sér. 7, 20: 29. 1894. — *Philonotis obtusata* Müll. Hal. ex Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 34(2): 61. 1896. (**Figure 5.3**)

Plants yellowish green, glossy, in turfs, small, slender, erect, 0.2–1.2 cm high. **Stems** reddish brown to brown, usually simple, sometimes sparsely branched, with brownish rhizoids at base. **Leaves** appressed when dry, erect-spreading when moist; oblong-lanceolate, narrowly oblong-ovate or nearly triangular-ovate at base, small, 0.40–0.70 × 0.13–0.20 mm; acute or narrowly obtuse at apex; broadest near the base, not decurrent; margins plane or slightly recurved above, papillose denticulate throughout; costae subpercurrent or ending below the apex; upper leaf cells subquadrate to quadrate or shortly rectangular to rectangular, smooth or faintly papillose at upper cell ends, 14–23 × 6–11 µm; median cells rectangular or rhomboidal, 20–56 × 9–12 µm, basal cells shortly rectangular, 18–28 × 9–14 µm; alar cells not differentiate. **Sporophytes** not seen. **Asexual reproduction** by brood bodies; brood bodies usually present in clustered at the shoot tips.

Additional illustration. – Eddy (1996: 231–232, Fig 487–488); Gangulee (1972: 1127, Fig. 549); Noguchi (1989: 572, Fig. 254B); Li, Crosby, & He (2007: 182, Pl. 232, Fig. 1–6).

Thailand. – NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Loei. SOUTH-WESTERN: Ratchaburi. PENINSULAR: Chumphon, Trang, Pattani (He, 1995).

Distribution. – Angola, Botswana, Brazil, Brunei, Burkina Faso, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, China, Comoros, Democratic Republic of the Congo, Ethiopia, Gabon, Guinea, Hong Kong, India, Indonesia, Ivory Coast, Japan, Kenya, Lesotho, Malawi, Malaysia, Mauritania, Mozambique, Myanmar, Nigeria, Philippines, Reunion, Rwanda, Seychelles, Sierra

Leone, South Africa, Sri Lanka, Sudan, Swaziland, Tanzania, Taiwan, Togo, Uganda, Vietnam, and Zimbabwe (Forzza, 2010; He, 1995; O'shea, 2006).

Ecology. – On rocks under shade of Pine tree, at 1,121 m elevation.

Specimens examined. – *P. Ajintaiyasil 340A* (BCU).

2. *Philonotis mollis* (Dozy & Molk.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 60. 1859; Gangulee, Mosses E. India 4: 1120. 1972; Noguchi, Ill. Moss Fl. Japan 3: 564. 1989; Eddy, Handb. Males. Mosses 3: 239. 1996; Mu & He, Moss Fl. China 4: 183. 2007. — *Bartramia mollis* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 300. 1844. **(Figure 5.4)**

Plants yellowish green or green, glossy, in loose turfs, 0.5–0.6 cm high. **Stems** erect, densely foliate on terminal, with brownish rhizoids at base. **Leaves** strongly appressed when dry; narrowly lanceolate or triangular-lanceolate, medium-sized, 1.0–2.0 × 0.2–0.3 mm; apex finely acuminate; margins plane or slightly recurved, serrulate above; costae excurrent; upper leaf cells long-rectangular to elongate-rhomboidal, with papillae at upper cell ends ventrally, at lower ends dorsally, 28–63 × 6–10 μm, basal cells larger, rectangular, 23–44 × 11–18 μm. **Sporophyte** not seen.

Additional illustration. – Eddy (1996: 240, Fig. 493A–F); Gangulee (1972: 1121, Fig. 545); Noguchi (1989: 567, Fig. 251B); Li, Crosby, & He (2007: 184, Pl. 233, Fig. 1–8).

Thailand. – NORTHERN: Chiang Mai (He, 1995).

Distribution. – Bhutan, Brunei, China, India, Indonesia, Japan, Malaysia, Myanmar, New Guinea, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. – On soils with *Barbula consanguinea* under shade of tree, at 403 m elevation.

Specimens examined. – *P. Ajintaiyasil 451B* (BCU).

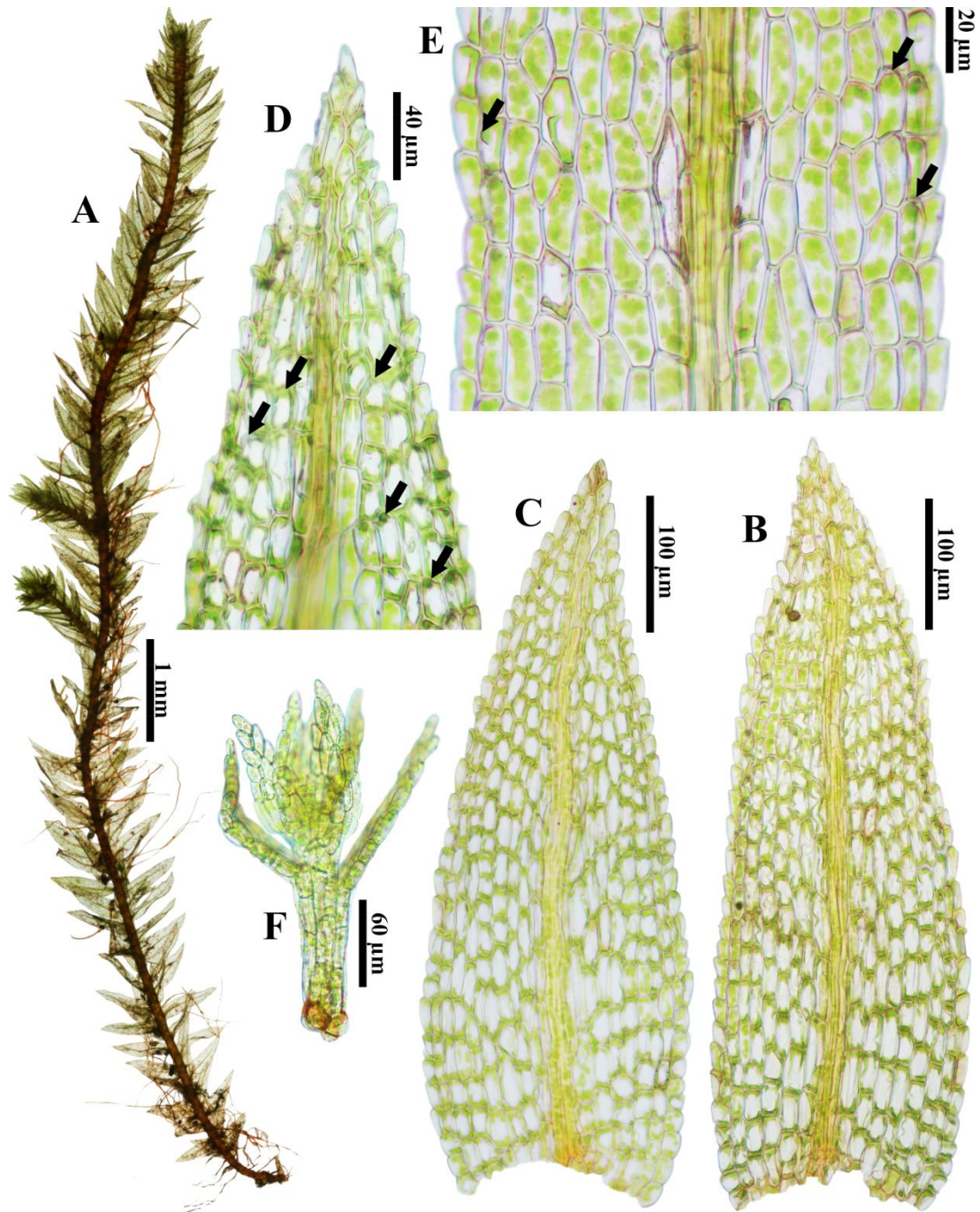


Figure 5.3 *Philonotis hastata* (Duby) Wijk & Margad.

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. median part of leaf, F. brood body (The black arrow indicated papillöse). Based on *P. Ajintaiyasil* 340A.

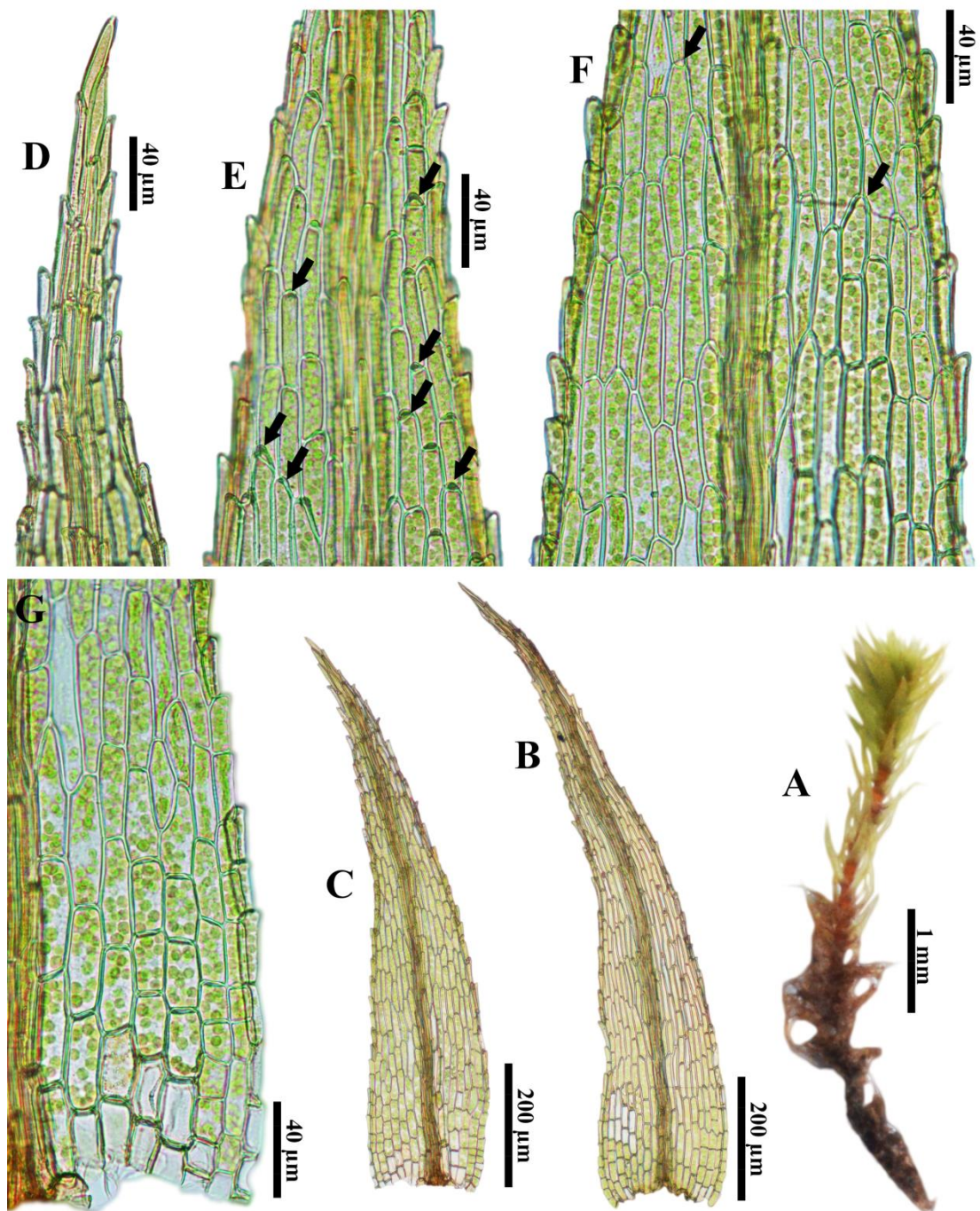


Figure 5.4 *Philonotis mollis* (Dozy & Molke.) Mitt.

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. Cells at leaf apex, F. Cells at median part of leaf, G. Cells at leaf base (The black arrow indicated papillae). Based on *P. Ajintaiyasil* 340A.

2. BRYACEAE

Schwägr., Sp. Musc. Frond. 47. 1830; Gangulee, Mosses E. India 4: 888. 1974; Noguchi, Ill. Moss Fl. Japan 2: 421. 1988; Eddy, Handb. Males. Mosses 3: 117. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 3. 2007.

Plants small to large and robust, mostly forming dense turfs. **Stems** erect, solitary or mostly unbranched, radiculose, occasionally densely tomentose; in cross section central strand present. **Leaves** spirally arranged, usually small and distant below, equally spaced or distally crowded and occasionally forming a rosette; variously shaped, linear- to broadly lanceolate, ovate, oblong, or obovate; apex broadly acute to acuminate, occasionally decurrent; margins plane to recurved or reflexed, entire to serrate distally, often sharply so, limbate or elimbate; costae single, subpercurrent to excurrent; laminal cells mostly rhomboidal, smooth, thin-walled, marginal cells similar or of long linear cells if forming a border. **Autoicous** or dioicous, occasionally synoicous. **Perichaetia** terminal or appearing lateral, leaves usually little differentiated, or smaller or larger than stem leaves. **Setae** elongate, single or several, smooth. **Capsules** exserted, inclined to pendulous, occasionally erect or suberect, urn ovoid to obloid, or more often pyriform, with differentiated neck. **Opercula** conic or conic-apiculate. **Peristomes** mostly double or variously reduced or single, typically exostome teeth 16, papillose and trabeculate; endostome basal membrane present, segments 16, keeled, hyaline or yellowish, cilia 1–3. **Calyptrae** cucullate, naked and smooth. **Spores** spherical, often lightly papillose.

Key to the genera

- 1a. Plant turfed or gregarious; small plants with evenly foliate stems; if leaves forming rosette, less than 4 mm long.....2
 2a. leaves forming rosette; upper margins denticulate.....4. *Rosulabryum*
 2b. leaves with evenly foliate stems; upper margins rather entire.....3
 3a. Border cells usually distinctly; cells rather broad.....1. *Brachymenium*
 3b. Border cells indistinctly; cells narrow.....2. *Bryum*
- 1b. Plant stoloniferous; large plants with rosette capitula composed of spatulate leaves over 5 mm long.....3. *Rhodobryum*

1. BRACHYMENIUM

Schwägr., Sp. Musc. Frond., Suppl. 2(1): 131–134, pl. 135. 1824; Gangulee, Mosses E. India 4: 928. 1974; Noguchi, Ill. Moss Fl. Japan 2: 448. 1988; Eddy, Handb. Males. Mosses 3: 165. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 7. 2007.

Plants pale green, yellowish green to brownish, in loose or dense turfs, small to rather large. **Stems** erect, with newly innovated branches often in equal lengths at base. **Leaves** usually crowded at branch apex, sparsely foliate below; ovate, ovate-lanceolate to ligulate; acuminate at apex; costae often strong, ending just below the apex or percurrent to excurrent; leaf cells hexagonal, rhomboidal or linear-

rhomboidal, basal cells rectangular. **Dioicous** or autoicous. **Setae** elongate, erect or slightly curved. **Capsules** mostly erect or inclined, rarely horizontal to pendulous, symmetric, pyriform, ovoid or club-shaped; neck more or less developed. **Opercula** small, conic, often apiculate. **Peristome** double; exostome teeth lanceolate, brownish at base, hyaline above, papillose; endostome segments usually not well developed, keeled; basal membrane $1/3$ – $1/2$ the height of teeth, more or less papillose. **Spores** spherical, papillose.

Brachymenium systylium (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1873–74: 117. 1875; Eddy, Handb. Males. Mosses 3: 166. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 18. 2007. — *Bryum systylium* Müll. Hal., Syn. Musc. Frond. 1(2): 320. 1848. — *Bryum capillifolium* Müll. Hal., Syn. Musc. Frond. 2: 578. 1851. — *Bryum crinitum* Mitt., Hooker's J. Bot. Kew Gard. Misc. 3: 56. 1851. — *Bryum imbricatifolium* Müll. Hal., Syn. Musc. Frond. 2: 578. 1851. — *Bryum velutinum* Müll. Hal., Bot. Zeitung (Berlin) 11: 33. 1853. — *Bryum subcapillifolium* Müll. Hal., Linnaea 38: 624. 1874. — *Bryum carionis* Müll. Hal., Bull. Herb. Boissier 5: 180. 1897. — *Brachymenium chlorocarpum* Cardot, Rev. Bryol. 36: 111. 1909. — *Brachymenium lozanoi* Cardot, Rev. Bryol. 38: 5. 1911. — *Brachymenium muenchii* Broth. ex Cardot, Rev. Bryol. 38: 5. 1911. (**Figure 5.5**)

Plants green to yellowish green above, brownish below, in dense turfs, small to medium-sized, 0.7–1.2 mm high. **Stems** erect, usually simple, sometimes sparsely branched. **Leaves** imbricate when dry, slightly erect-spreading when moist; oblong-ovate to rounded-ovate, 1.8 – 2.0×0.7 – 0.8 mm; obtuse or shortly apiculate at apex; margins entire or bluntly serrulate near the apex; border cells elongate, thick-walled, hyaline, forming a distinct but narrow border; costae thick, excurrent into long awns, sometimes shorter at awn tips; median leaf cells oblong-hexagonal to rhomboidal, thick-walled, 39 – 68×10 – 13 μm , basal cells quadrate to shortly rectangular, 25 – 57×12 – 21 μm . **Sporophyte** not seen.

Additional illustration. – Eddy (1996: 168, Fig. 445).

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – Angola, China, Costa Rica, Democratic Republic of the Congo, Ethiopia, Guatemala, India, Indonesia, Kenya, Malawi, Malesia, Mexico, Namibia, Nicaragua, Panama, Rwanda, South Africa, Sri Lanka, Tanzania, Uganda, United States, Zambia, and Zimbabwe (Bartram, 1949; Haring, 1961; He, 1995; O'shea, 2006).

Ecology. – On soils in the sun, at 294 m elevation.

Specimens examined. – *P. Ajintaiyasil 179* (BCU).

2. BRYUM

Hedw., Sp. Musc. Frond. 178–187, pl. 42, fig. 8–12; pl. 43–44. 1801; Gangulee, Mosses E. India 4: 961. 1974; Noguchi, Ill. Moss Fl. Japan 2: 458. 1988; Eddy, Handb. Males. Mosses 3: 118. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 19. 2007.

Plants small, extremely variable in colour. **Stems** weakly to strongly rounded julaceous or short-gemmiform, not or weakly branched. **Leaves** ovate-lanceolate to ovate, concave; base not decurrent; apex broadly rounded to acute or rarely acuminate; margins recurved, plane distally, entire; costae not reaching apex or excurrent, often hyaline, guide cells usually absent; medial and distal cells short-rhomboidal to elongate-hexagonal, walls thin to incrassate; alar cells not or somewhat differentiated from juxtacostae cells, usually shorter. **Dioicous**. **Perichaetia** terminal, leaves same size as vegetative leaves or usually larger, not forming rosette, inner leaves not much differentiated. **Setae** somewhat twisted when dry. **Capsules** inclined to pendent, ovate or clavate to pyriform; hypophysis differentiated or not. **Opercula** weakly convex, short-conic. **Peristome** double; exostome pale yellow or tan, teeth slender lanceolate; endostome separate from exostome or sometimes adherent or absent, basal membrane low to high, segments present, perforate, cilia appendiculate or sometimes absent. **Spores** shed singly, not as tetrads, finely papillose, pale tan or yellow-tan.

Key to the species

1a. Plants green; leaves ovate or ovate-lanceolate; costae brownish, excurrent into long awns.....2. *Bryum coronatum*

1b. Plants silvery white; leaves broadly ovate or rounded-ovate; costae hyaline, excurrent.....1. *Bryum argenteum*

1. *Bryum argenteum* Hedw., Sp. Musc. Frond. 181–182. 1801; Gangulee, Mosses E. India 4: 970. 1974; Noguchi, Ill. Moss Fl. Japan 2: 484. 1988; Eddy, Handb. Males. Mosses 3: 120. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 24. 2007. — *Bryum liebmannianum* Müll. Hal., Syn. Musc. Frond. 2: 573. 1851. — *Bryum brevicaulis* Schimp. ex Mitt., J. Linn. Soc., Bot. 12: 303. 1869. — *Bryum pendulinum* Hampe, Linnaea 38: 214. 1874. — *Bryum arenae* Müll. Hal., Flora 68: 402. 1885. — *Plagiobryum argenteoides* R.S. Williams, Bull. New York Bot. Gard. 2(6): 129. pl. 21. 1901. (**Figure 5.6**)

Plants grayish or pale green, glossy, in cushions, small, 3–5 mm high. **Stems** short, julaceous. **Leaves** imbricate when dry and moist; broadly ovate or rounded-ovate, very concave, 0.9–1.0 × 0.6–0.7 mm; short- to long-filiform or apiculate at apex; margins entire, indistinctly differentiated by 2 rows of narrowly rectangular cells; costae hyaline, excurrent, 0.5–0.6 mm long; lamina cells in above leaf region hyaline, chlorophyllose below, median leaf cells oblong-ovate or oblong-hexagonal, thin- or thick-walled at both ends, 44–56 × 10–15 µm, basal cells rectangular, thin- or thick-walled, 22–38 × 19–27 µm. **Dioicous**. **Setae** slender, 1–1.5 cm long. **Capsules** pendulous, elongate-ovoid, reddish brown, 2.5–3.0 cm long; neck indistinct. **Opercula** not seen. **Peristome** double; exostome teeth hyaline above, orange-brown below; endostome basal membrane ca. 1/2 the height of teeth; nodose, papillose. **Calyptrae** not seen.

Additional illustration. – Eddy (1996: 121, Fig. 410A–F); Noguchi (1988: 485, Fig. 213).

Thailand. – NOETHERN: Chiang Mai, Tak, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei. CENTRAL: Nakhon Nayok.

Distribution. – Australia, Brazil, Cameroon, Caribbean, Central African Republic, China, Colombia, Costa Rica, Egypt, El Salvador, Gabon, Guatemala, Guinea, Honduras, India, Iraq, Japan, Java, Korea, Mexico, Mongolia, Nepal, New Zealand, Nicaragua, Panama, Philippines, Siberia, Sikkim, Sri Lanka, Taiwan, Vietnam, and United States.

Ecology. – On rocks in the sun, at 1,250–1,262 m elevation.

Specimens examined. – *P. Ajintaiyasil* 220, 345 (BCU).

2. *Bryum coronatum* Schwägr., Sp. Musc. Frond., Suppl. 1(2): 103–104, pl. 71. 1816; Gangulee, Mosses E. India 4: 1002. 1974; Noguchi, Ill. Moss Fl. Japan 2: 484. 1988; Eddy, Handb. Males. Mosses 3: 124. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 33. 2007. — *Bryum rufinerve* Müll. Hal., Linnaea 38: 549. 1874. — *Bryum barbulateum* Müll. Hal., Linnaea 39: 389. 1875. — *Bryum zygodontoides* Müll. Hal., Bot. Jahrb. Syst. 5: 83. 1883. — *Bryum balanocarpum* Besch., Bull. Soc. Bot. France 41: 82. 1894. (**Figure 5.7**)

Plants yellowish green above, dark brown below, in loose turfs, small, 2.0–4.0 mm high. **Stems** short, not branched. **Leaves** imbricate when dry, erect-spreading when moist; ovate or ovate-lanceolate, 1.1–1.4 × 0.4–0.5 mm; apices acuminate; margins recurved throughout, entire, not clearly bordered, but marginal cells narrower; costae brownish, excurrent into long awns; median leaf cells rhombic to elongate-hexagonal, thin-walled, 34–56 × 11–15 µm; basal cells rectangular, 26–47 × 13–16 µm. **Dioicous**. **Setae** reddish brown, 1.5–1.7 cm long. **Capsules** pendulous, cylindrical, 1.2–2.0 mm long, reddish brown; neck expanded, thicker than urn, rugose. **Opercula** conic, shortly rostrate. **Peristome** double; exostome teeth papillose, orange below, hyaline above; endostome segments shorter than the teeth, perforate; basal membrane 1/2 the height of teeth; cilia 1–2, slightly shorter than the segments, nodose. **Calyptrae** not seen.

Additional illustration. – Eddy (1996: 123, Fig. 412A–G); Noguchi (1988: 483, Fig. 212).

Thailand. – NORTHERN: Chiang Mai, Lampang, Tak, Phitsanulok. NORTH-EASTERN: Khon Kaen. SOUTH-WESTERN: Kanchanaburi. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Prachin Buri, Chon Buri, Chanthaburi, Trat. PENINSULAR: Chumphon, Nakhon Si Thammarat (He, 1995).

Distribution. – Angola, Burundi, Brazil, Cameroon, Chad, China, Colombia, Congo, Gabon, Guatemala, Guinea, Honduras, India, Ivory Coast, Japan, Kampuchea, Kenya, Liberia, Madagascar, Malawi, Malaysia, Mauritius, Mozambique, Myanmar, New Zealand, Nicaragua, Niger, Nigeria, Panama, Philippines, Rwanda, Sao Tome, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda, Vietnam, United States, Zambia, and Zimbabwe (Breen & Reese, 1971; He, 1995; O'shea, 2006; Waard & Florschütz, 1979).

Ecology. – On rocks or soils in the sun, at 470–1,250 m elevation.

Specimens examined. – *P. Ajintaiyasil 218A, 246B* (BCU).

3. RHODOBRYUM

(Schimp.) Limpr., Laubm. Deutschl. 2(20): 444. 1892; Gangulee, Mosses E. India 4: 1015. 1974; Noguchi, Ill. Moss Fl. Japan 2: 489. 1988; Eddy, Handb. Males. Mosses 3: 152. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 90. 2007. — *Bryum* subg. *Rhodobryum* Schimp., Laubm. Deutschl. 2(20): 444. 1892.

Plants rather large to robust, green to deeply green, in loose turfs. **Stems** erect, with primary stems prostrate and underground. **Leaves** large, forming rosettes on the top of stems; oblong-obovate to spatulate; broadly acute or bluntly acute, apiculate; margins mostly plane, strongly serrate above, entire, recurved below; costae broader at base, slender toward apex, nearly percurrent to shortly excurrent; in cross section dorsal stereids absent or present. **Dioicous**. **Setae** elongate. **Capsules** horizontal or pendulous, cylindrical; neck very short or indistinct. **Opercula** conic at base, shortly rostrate. **Peristome** double; exostome teeth 16, linear-lanceolate, papillose; endostome segments 16, linear-lanceolate, minutely papillose, nearly as long as the teeth, centrally perforate; basal membrane ca. 2/3 the height of segments; cilia 2–3, nodose or appendiculate. **Spores** small, spherical, smooth to scabrose.

Rhodobryum ontariense (Kindb.) Paris, Eur. N. Amer. Bryin. 2: 346. 1898; Eddy, Handb. Males. Mosses 3: 154. 1996; Da-cheng, Xing-jiang & He, Moss Fl. China 4: 91. 2007. — *Bryum ontariense* Kindb., Ottawa Naturalist 2(12): 155. 1889. (**Figure 5.8**)

Plants dark green, in turfs, stoloniferous, medium-sized. **Primary stems** prostrate, 1.5–2.5 cm long. **Secondary stems** erect, 0.8–2 cm high, often branched innovation from the capitulum, tomentose. **Leaves** forming rosettes, twisted and contorted with non-undulate margins when dry, spreading when wet; ligulate or obovate-oblong, upper part broader than the lower part, 4.3–6.0 × 2.5–2.7 mm; apices cuspidate; upper margins plane, serrate, recurved below; not distinctly bordered by 1–2 rows; costae shortly excurrent, in cross section with distinctly ventral 1 row of large guide cells and dorsal stereids; upper cells rhomboidal to rhomboidal-hexagonal, thin-walled, 62–77 × 19–30 μm, basal cells long rectangular, 71–160 × 25–29 μm. **Dioicous**. **Setae** brownish red, 2.0–2.5 cm high. **Capsules** horizontal, ovoid-cylindrical, 3.0–3.5 mm long. **Opercula** conic at base, shortly rostrate. **Peristome** double; exostome teeth 16, linear-lanceolate, papillose; endostome segments 16, linear-lanceolate, minutely papillose, nearly as long as the teeth, centrally perforate.

Additional illustration. – Eddy (1996: 154, Fig. 436, A–G).

Thailand. – SOUTH-WESTERN: Prachuap Khiri Khan (Chantanaorrapint, 2002).

Distribution. – China, Kenya, Lesotho, Malawi, Malesia, South Africa, Tanzania, Uganda, and United States (Churchill, 1985; Li, Crosby & He, 2007; O'shea, 2006).

Ecology. – On rocks under shade of trees, at 1,275 m elevation.

Specimens examined. – *P. Ajintaiyasil* 237, 341 (BCU).

4. ROSULABRYUM

J.R. Spence, *Bryologist* 99(2): 222–224. 1996.

Plants small to large, in open to dense low turfs or gregarious, green. **Stems** usually strongly rosulate, sometimes in 2 or more interrupted rosettes, subfloral innovations common; rhizoids often many. **Leaves** variously contorted to spirally twisted around stem when dry or rarely nearly imbricate, erect to erect-spreading when moist; ovate, obovate, or spatulate, flat or weakly concave; apex broadly rounded to acute; margins recurved upper or sometimes plane, plane distally, nearly entire to distinctly serrate near apex; costae sometimes short- to long-excurrent, awn pigmented or hyaline; in cross section guide cells present, in 1 (or 2) layers; upper laminal cells rectangular, medial and distal cells rhomboidal, walls thin to thick, sometimes porose. **Dioicous**, rarely synoicous, polyoicous, or autoicous. **Perichaetia leaves** same size as vegetative leaves; inner leaves differentiated, more acuminate. **Setae** straight. **Capsules** nutant to inclined, clavate to cylindrical or rarely pyriform. **Opercula** short-conic to umbonate. **Peristome** double; exostome yellow, teeth lanceolate to narrowly lanceolate; endostome, not adherent to exostome, basal membrane high, 1/2–2/3 exostome length, segments same height as exostome, widely perforated, cilia 2 or 3, appendiculate. **Spores** shed singly, smooth to finely papillose, dark yellow. **Asexual reproduction** by rhizoidal tubers or filiform leaf axil gemmae.

Key to the species

- 1a. Leaves broadly elliptical or oblong-ovate; apices acute or shortly acuminate; bordered by 3–4 rows of linear cells.....1. *Rosulabryum billardierii*
- 1b. Leaves obovate, oblong-ovate to ligulate; apices acuminate; bordered by 1–2 rows of narrowed to linear cells.....2. *Rosulabryum capillare*

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1. *Rosulabryum billardierii* (Schwägr.) J.R. Spence, *Bryologist* 99: 223. 1996. — *Bryum billardierii* Schwägr., *Sp. Musc. Frond.*, Suppl. 1(2): 115. pl. 76. 1816; Gangulee, *Mosses E. India* 4: 977. 1974; Noguchi, *Ill. Moss Fl. Japan* 2: 486. 1988; Eddy, *Handb. Males. Mosses* 3: 142. 1996; Da-cheng, Xing-jiang & He, *Moss Fl. China* 4: 26. 2007. (**Figure 5.9**)

Plants green, glossy, in dense turfs, medium-sized, 0.5–1.5 mm high. **Stems** erect, tomentose below, 2–3 branched by innovations. **Leaves** lightly on lower stems; upper leaves often forming rosettes, dense, twisted when dry; broadly elliptical or oblong-ovate, 2.4–3.4 × 1.2–1.5 mm; apices acute or shortly acuminate; margin entire, plane above, recurved in the lower 1/2, clearly dentate near apex; margins bordered by 3–5 rows of linear cells, thick-walled; costae percurrent or shortly excurrent, ending in short awns, nearly brownish; median leaf cells oblong-hexagonal, 42–64 × 15–22 μm, basal cells larger than the cells above, long-rectangular, 53–120 × 19–33 μm. **Sporophyte** not seen.

Additional illustration. – Gangulee (1971: 978, Fig. 471–473, as *B. billardierii*); Eddy (1996: 143, Fig. 428A–H, as *B. billardierii*); Noguchi (1988: 482, Fig. 211B, as *B. billardierii*).

Thailand. – NORTHERN: Chiang Mai (He, 1995).

Distribution. – Brazil, China, Hong Kong, India, Indonesia, Japan, Mexico, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, and Vietnam (Forzza, 2010; He, 1995).

Ecology. – On rocks under shade of tree, at 1,054–1,232 m elevation.

Specimens examined. – *P. Ajintaiyasil* 348, 373 (BCU).

2. Rosulabryum capillare (Hedw.) J.R. Spence, *Bryologist* 99(2): 223. 1996. — *Bryum capillare* Hedw., *Sp. Musc. Frond.* 182. 1801; Gangulee, *Mosses E. India* 4: 987. 1974; Noguchi, *Ill. Moss Fl. Japan* 2: 470. 1988; Eddy, *Handb. Males. Mosses* 3: 128. 1996; Da-cheng, Xing-jiang & He, *Moss Fl. China* 4: 30. 2007. — *Bryum immarginatum* Broth., *Öfvers. Finska Vetensk.-Soc. Förh.* 35: 50. 1893. — *Bryum luehmannianum* Müll. Hal., *Hedwigia* 37: 100. 1898. — *Bryum plebejum* Müll. Hal., *Hedwigia* 37: 94. 1898. — *Bryum laxulum* Cardot, *Rev. Bryol.* 36: 113. 1909. — *Bryum siamense* Dixon, *J. Siam Soc., Nat. Hist. Suppl.* 10: 10. 1935. (**Figure 5.10**)

Plants deep green to blackish green, not particularly glossy, in turfs, small. **Stems** often branched by innovations. **Leaves** twisted or flexuous when dry, spreading when moist; obovate, oblong-ovate to ligulate, widest in the middle, 1.6–1.9 × 0.6–0.8 mm; apices acuminate; margins plane above and slightly recurved below; distantly bordered by 1–2 rows of narrowed to linear, yellowish cells, slightly serrulate above; costae shortly to long-excurrent; upper and median leaf cells rhombic, oblong- to rounded-hexagonal, thin-walled, 35–56 × 13–22 µm, basal cells larger than the cells above, oblong-hexagonal to short-rectangular, 52–70 × 13–18 µm. **Diocious**. **Setae** twisted, reddish brown, 15–17 mm long. **Capsules** inclined to horizontal, narrowly elongate-ovoid or club-shaped, reddish brown, ca. 3 mm long. **Opercula** shortly apiculate. **Peristome** double; exostome teeth yellowish brown below; endostome segments widely perforate; basal membrane 2/3 the height of teeth; cilia 2–4, nearly as long as the segments. **Spores** 10–16 µm in diameter.

Additional illustration. – Gangulee (1974: 988, Fig. 477); Eddy (1996: 129, Fig. 415A–F); Noguchi (1988: 473, Fig. 206).

Thailand. – NORTHERN: Chiang Mai, Phitsanulok. NORTH-EASTERN: Loei. PENINSULAR: Narathiwat (He, 1995).

Distribution. – Worldwide (Eddy, 1996; Gangulee, 1974; Noguchi, 1994).

Ecology. – On rocks under shade of tree, at 967 m elevation.

Specimens examined. – *P. Ajintaiyasil* 459 (BCU).

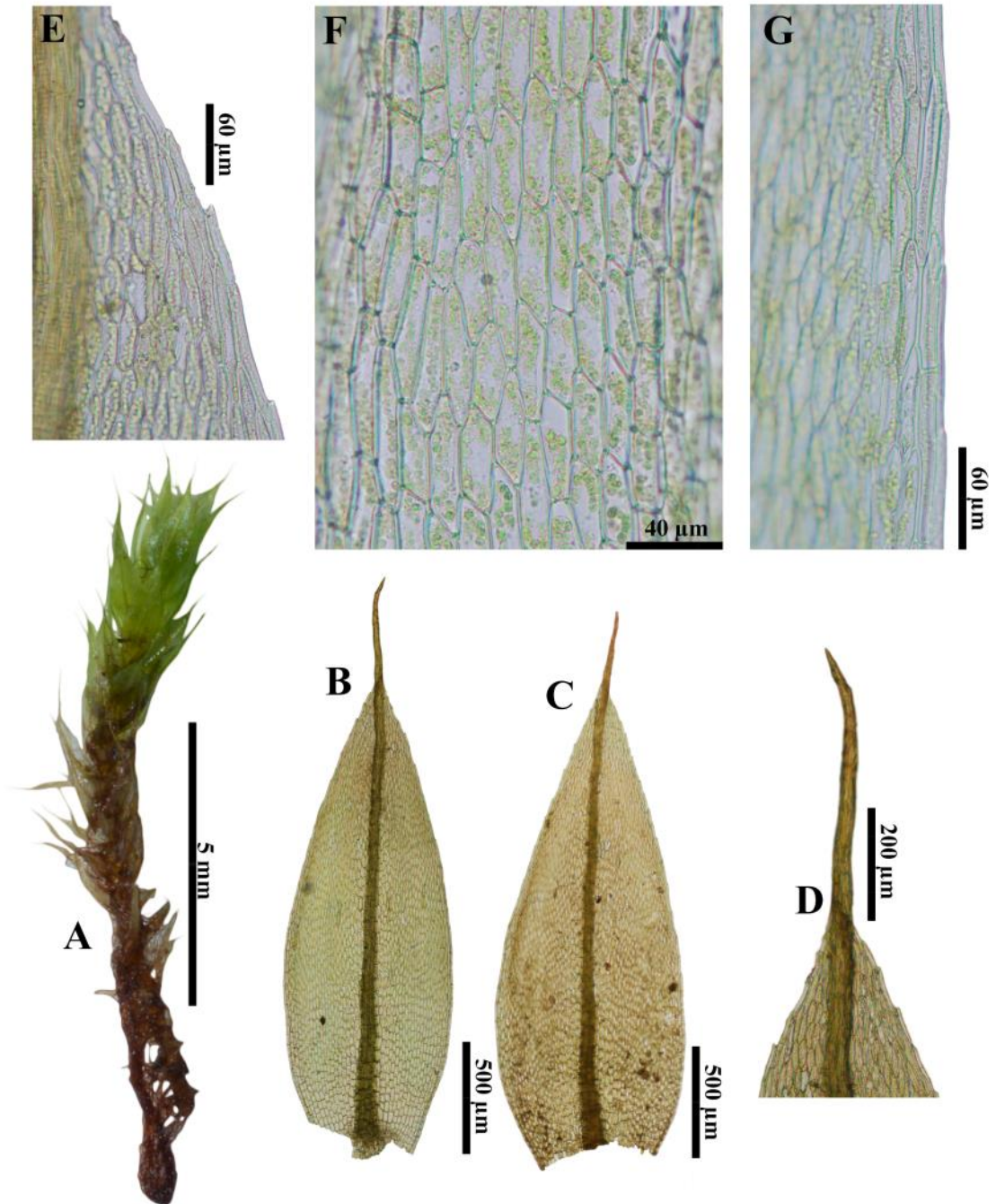


Figure 5.5 *Brachymerium systylium* (Müll. Hal.) A. Jaeger

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. Upper margin of leaf, E. Cells at median part of leaf, F. Margin at median part of leaf. Based on *P. Ajintaiyasil* 345.

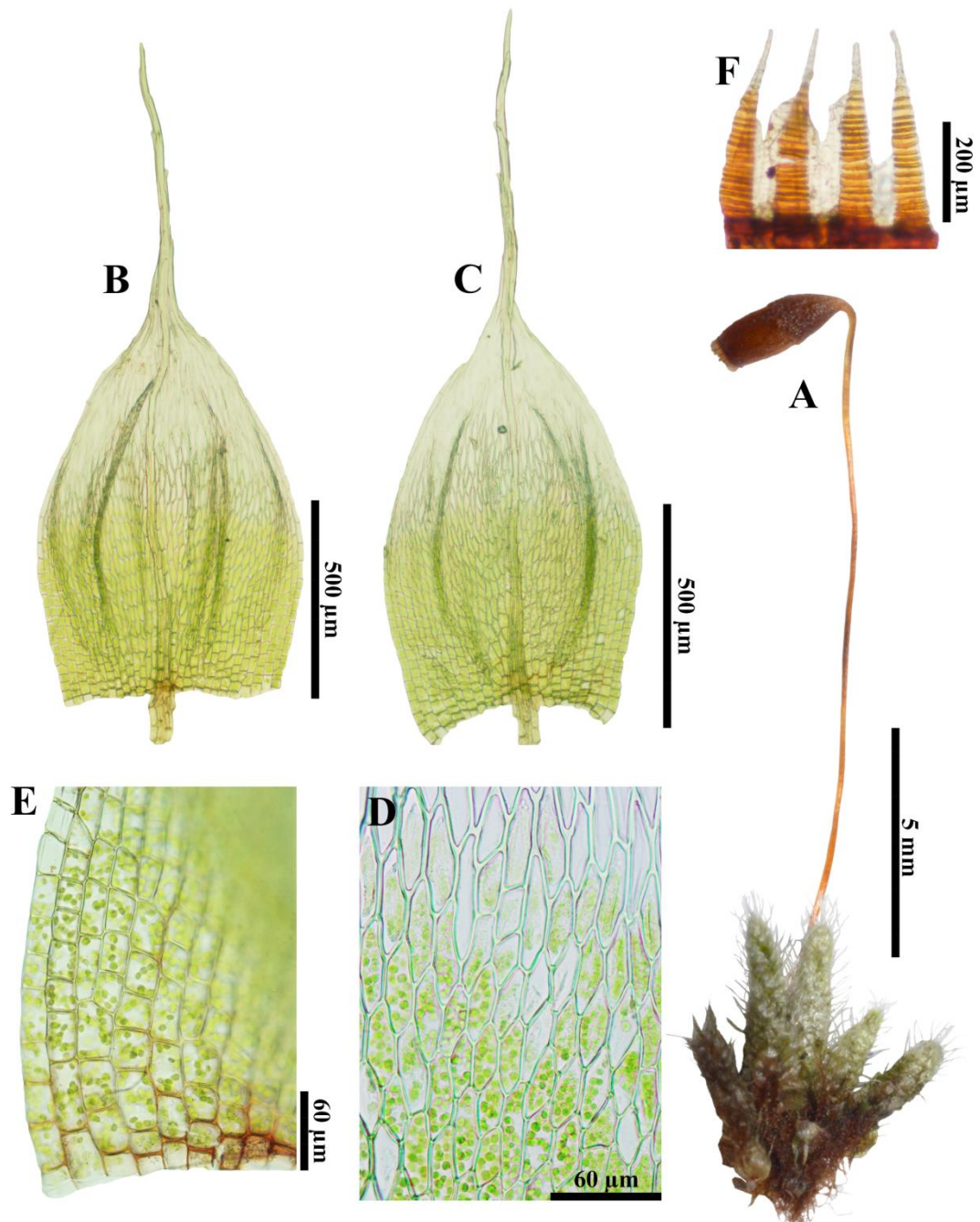


Figure 5. 6 *Bryum argenteum* Hedw.

A. Gametophyte with sporophyte, B–C. Leaves, C. Cells at median part of leaf, D. Cells at leaf base, E. Part of peristome. Based on *P. Ajintaiyasil* 345.

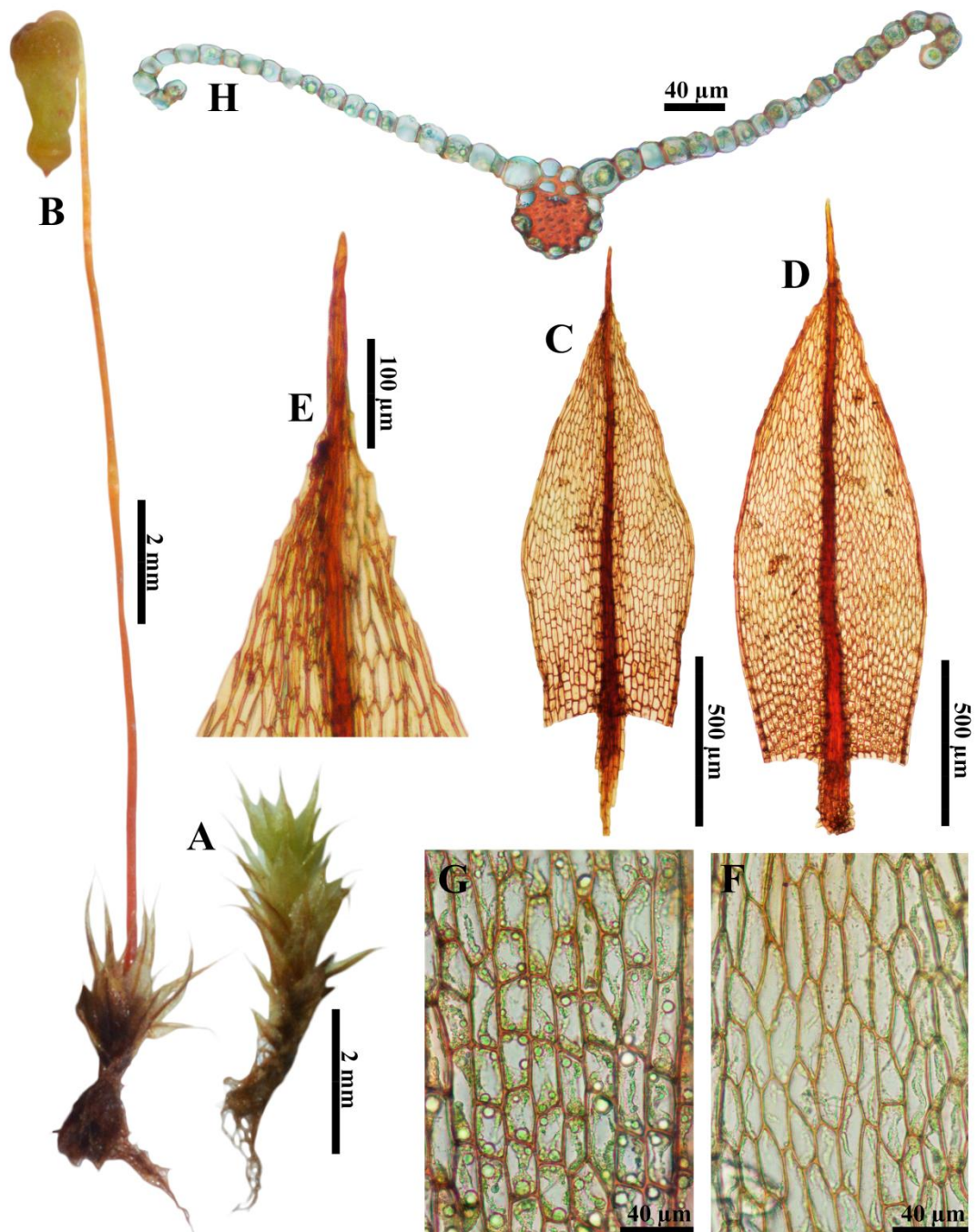


Figure 5.7 *Bryum coronatum* Schwägr.

A. Sterile gametophyte, B. Gametophyte with Sporophyte, C–D. Leaves, E. Leaf apex, F. Cells at median part of leaf, G. Cells at leaf base, H. Cross section of leaf. Based on *P. Ajintaiyasil* 218A.

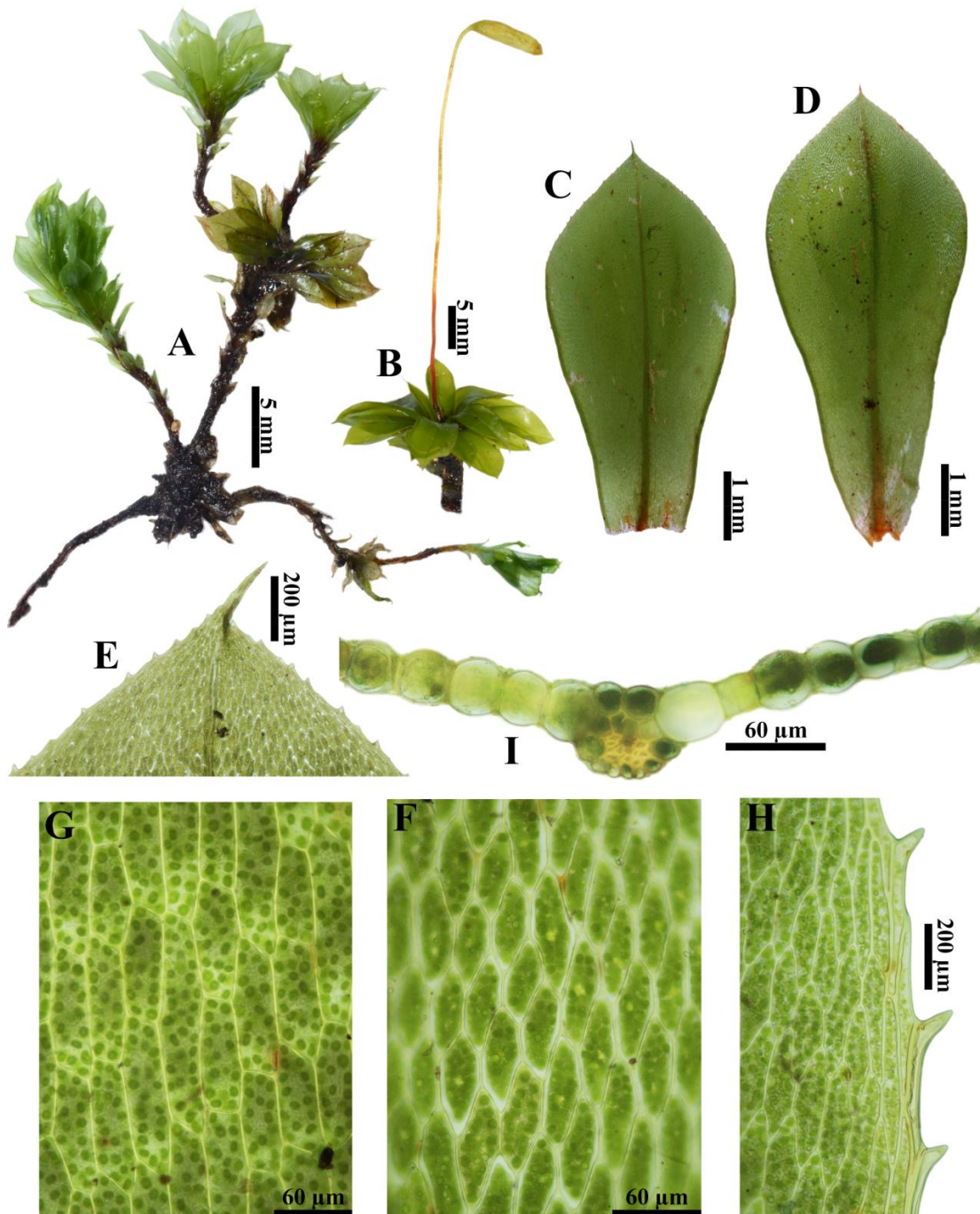


Figure 5. 8 *Rhodobryum ontariense* (Kindb.) Paris

A. Sterile gametophyte, B. Gametophyte with Sporophyte, C–D. Leaves, E. Leaf apex, F. Cells at median part of leaf, G. Cells at leaf base, H. Leaf margin, I. Cross section of leaf. Based on *P. Ajintaiyasil 341*.

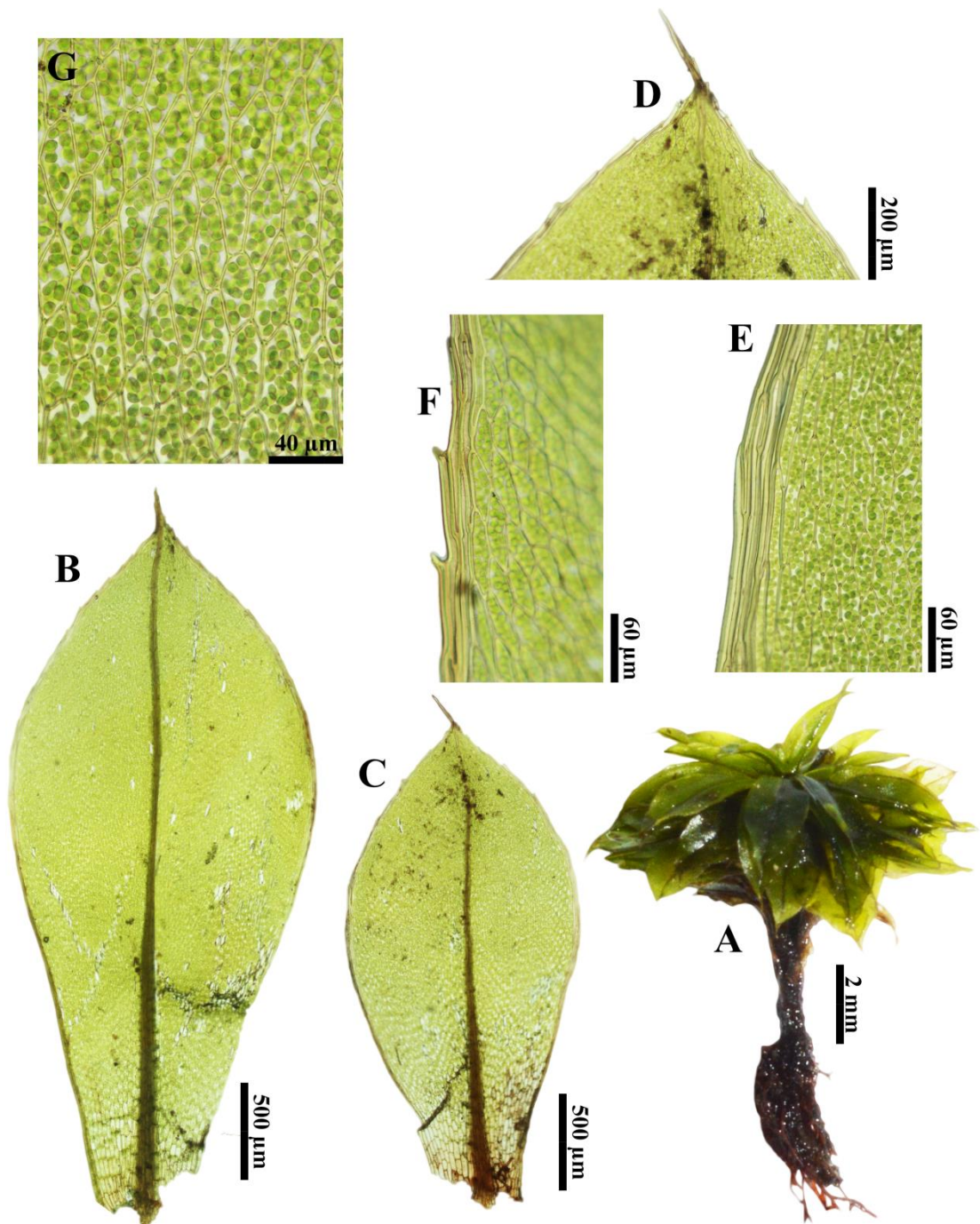


Figure 5. 9 *Rosulabryum billardierii* (Schwägr.) J.R. Spence

A. Sterile gametophyte, B–C. Leaves, C. Leaf apex, D. Upper leaf margin, E. Lower leaf margin, F. Cells at median part of leaf. Based on *P. Ajintaiyasil* 348.

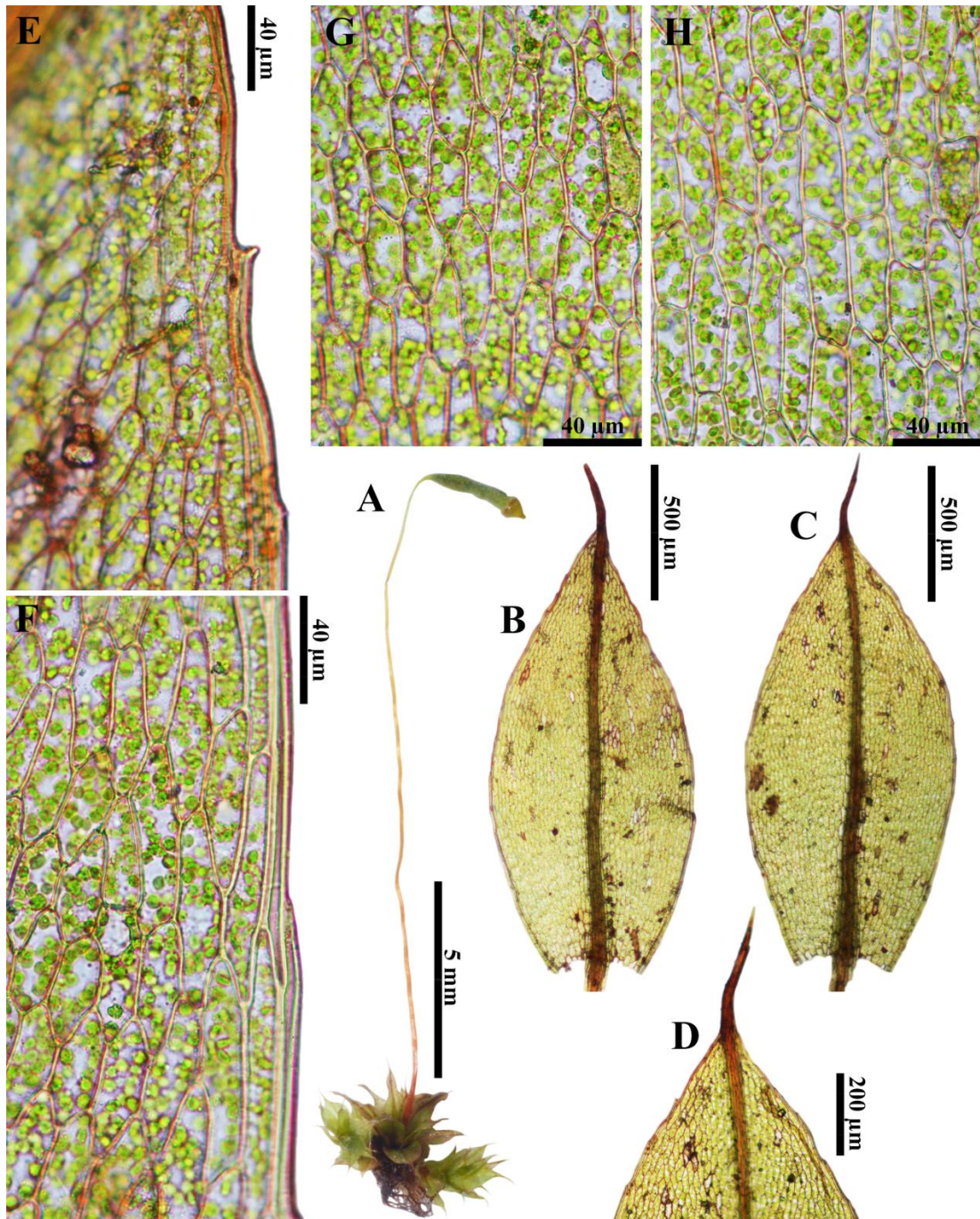


Figure 5.10 *Rosulabryum capillare* (Hedw.) J.R. Spence

A. Plant, B. Leaf, C. Leaf apex, D. Cells on median lamina, E. Cells on base lamina, F. Upper margin of lamina, G. Below margin of lamina. Based on *P. Ajintaiyasil* 459.

3. CALYMPERACEAE

Kindb., Gen. Eur. N.- Amer. Bryin. 11. 1897; Gangulee, Mosses E. India 3: 567. 1971; Noguchi, Ill. Moss Fl. Japan 2: 243. 1988; Eddy, Handb. Males. Mosses 2: 33. 1991; Bang-juan & Reese, Moss Fl. China 2: 70. 2001.

Plants very small to large, forming turfs or cushions, pale to dark green, glossy or dull. **Stems** mostly erect, simple to few branches; lacking central strand. **Leaves** often crispate, usually sheathing at base, base often expanded; narrowly to broadly lanceolate; apex acute to acuminate; margins entire or more commonly serrate or ciliate, teeth single, double or more; costae single, mostly percurrent; laminal cells papillose or smooth; often with hyaline on either side of costae at leaf base (cancellinae); outer cells beyond the cancellinae often with a differentiated intramarginal band of linear cells (teniolae) usually separated by isodiametric cells or margins bordered by linear cells; composed of hyalocysts layer above and below triangular or quadrangular chlorocysts. **Dioicous**, rarely autoicous. **Perichaetia** terminal. **Setae** short to elongate, smooth. **Capsules** immersed to exserted, erect, urn cylindrical. **Opercula** calyptrae persistent or not. **Peristome** of 16 (rarely fused into 8) segments, smooth, papillose or vertically striate. **Calyptra** cucullate and deciduous, or campanulate and persistent (clasping at base) with few to several longitudinal slit. **Spores** spherical, smooth to finely papillose or granulate.

Key to the genera

- 1a. Basal portion of leaves lacking a cancellinae, cells either similar to distal cells.....2
 2a. Costae with a central stereid band; the chlorocysts quadrangular in the upper part of leaves.....1. *Leucophanes*
 2b. Costae without a central stereid band; the chlorocysts triangular in the upper part of leaves.....2. *Octoblepharum*
 1b. Basal portion of leaves exhibiting a cancellinae, strongly differentiated from basal margin and distal cells.....3. *Syrhodon*

1. LEUCOPHANES

Brid., Bryol. Univ. 1: 763. 1827; Gangulee, Mosses E. India 2: 431. 1969; Noguchi, Ill. Moss Fl. Japan 2: 243. 1988; Eddy, Handb. Males. Mosses 3: 40. 1991; Bang-juan & He, Moss Fl. China 1: 255. 1999.

Plants soft, slender, grayish green to yellow or glaucous green, in loose to dense turfs. **Stems** erect, orange-brown to dark red, sparsely branched. **Leaves** erect to more or less contorted when dry, loosely overlapping when moist; narrowly to broadly lanceolate, concave to keeled at base or through most of their length, plane above; acuminate, acute, obtuse, retuse or bent backwards at the apex; margins serrate particularly in the upper third with single or paired teeth; marginal stereome forming a distinct, sharply differentiated border; costae percurrent to shortly excurrent, smooth to strongly papillose on back and tips, convex on the dorsalside, flat on the ventral side; basal hyaline lamina extending to 1/5–1/3 leaf length on both sides of costae,

cells linear; chlorocysts in cross section quadrangular, central stereid band present. **Dioicous** or monoicous. **Setae** sinistrorse, smooth. **Capsules** dark orange, erect to horizontal. **Opercula** long, subulate-rostrate. **Peristome** teeth 16, more or less papillose, lanceolate, with a colorless properistome. **Calyptrae** cucullate.

Leucophanes octoblepharioides Brid., Bryol. Univ. 1: 763. 1827; Gangulee, Mosses E. India 2: 436. 1969; Noguchi, Ill. Moss Fl. Japan 2: 243. 1988; Eddy, Handb. Males. Mosses 2: 46. 1991; Bang-juan & He, Moss Fl. China 1: 256. 1999; Promma & Chantanaorrapint, Thai Forest Bull., Bot. 41: 31. 2013. — *Octoblepharum smaragdinum* Mitt., Bonplandia 9: 366. 1861. — *Leucophanes pungens* M. Fleisch. ex Dixon, Proc. Linn. Soc. New South Wales 55: 268. 1930. (**Figure 5.11**)

Plants whitish green, in turfs or cushions, medium-sized, 2.0–5.0 mm high. **Stems** erect, simple or branched. **Leaves** crowded, erect-spreading to recurved-patent; linear-lanceolate, flat above, more or less recurved below, 4.0–6.0 × 0.2–0.5 mm; apiculate at the apex; margins distinctly bordered, with 3–4 rows of linear and hyaline cells throughout, entire below, serrulate at least near apex; hyaline cells on ventral surface view quadrate to rectangular, rectilinear walls, 33–54 × 20–29 µm; hyaline cells of base lamina to 1/3 the length; costae smooth on the dorsal side of leaves; in cross section chlorocysts quadrangular, surrounded by one layer of hyaline cells, costael hyaline cells in 2 layers, sometimes in 3 layers near leaf base. **Sporophyte** not seen.

Additional illustration. – Gangulee (1969: 436, Fig. 205); Noguchi (1988: 245, Fig. 99A); Eddy (1990: 48, Fig. 196A–F); Promma & Chantanaorrapint (2013: 34–35, Fig. 8–9).

Thailand. – **NORTH-EASTERN:** Loei. **CENTRAL:** Nakhon Nayok. **SOUTH-EASTERN:** Chanthaburi. **PENINSULAR:** Ranong, Phuket, Nakhon Si Thammarat, Trang (Promma & Chantanaorrapint, 2013).

Distribution. – Brunei, Central African Republic, China, Gabon, India, Indonesia, Japan, Kampuchea, Malaysia, Mauritius, Myanmar, Nepal, New Guinea, Philippines, Seychelles, Sri Lanka, Sumatra, Taiwan, and Vietnam (O'shea, 2006; Promma & Chantanaorrapint, 2013).

Ecology. – On barks or rocks under shade, at 1,087–1,233 m elevation.

Specimens examined. – *P. Ajintaiyasil* 207, 446 (BCU).

2. OCTOBLEPHARUM

Hedw., Sp. Musc. Frond. 50. 1801; Gangulee, Mosses E. India 2: 439. 1969; Eddy, Handb. Males. Mosses 2: 31. 1991; Bang-juan & He, Moss Fl. China 1: 257. 1999.

Plants small to medium-sized, whitish to grayish green, in loose to rather dense cushions. **Stems** short, simple or sparsely branched. **Leaves** erect-patent, flexuose or reflexed from a slightly sheathing base; strap-shaped or ligulate; obtuse-apiculate to shortly mucronate apex, flattened or terete-triangular; margins entire to slightly serrulate at the apex; costae broad, thick, filling almost the entire upper

lamina, convex on dorsal side in cross section, costael leucocysts in 2–10 layers, enclosing a nearly centrally positioned chlorocyst layer; the chlorocysts triangular in the upper part of leaves, quadrangular at leaf base in cross section; hyaline lamina cells small, confined to both sides of costae at leaf base. **Autoicous** or dioicous. **Setae** terminal, short to elongate. **Capsules** erect, oblong-ovoid to cylindrical, symmetric, stomata superficial. **Opercula** conic-rostrate with a long oblique beak. **Peristome** teeth 8 or 16, broad-lanceolate, smooth to vertically striate-reticulate. **Calyptrae** cucullate, smooth, entire at base.

Key to the species

- 1a. Leaves sturdy, 2–6 mm long; basal sheath ca. 1/3 leaf length, long rectangular sheath cells; outer surface of the peristome ornamented with vertically striate.....
.....1. *Octoblepharum albidum*
- 1b. Leaves fragile, 8–13 mm long; basal sheath ca. 1/6 leaf length, short rectangular sheath cells; outer surface of the peristome smooth.....2. *Octoblepharum pocsii*

1. *Octoblepharum albidum* Hedw., Sp. Musc. Frond. 50. 1801; Gangulee, Mosses E. India 2: 441. 1969; Eddy, Handb. Males. Mosses 2: 31. 1991; Bang-juan & He, Moss Fl. China 1: 257. 1999. — *Octoblepharum minus* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 4, 1: 83. 1879. — *Octoblepharum albidum* var. *cuspidatum* Müll. Hal., Bot. Jahrb. Syst. 23: 318. 1896. (**Figure 5.12**)

Plants grayish green or green, somewhat glossy, in cushions, small, 2.0–5.0 mm high. **Stems** short, unbranched; central strand absent. **Leaves** erect-patent to curved spreading, flattened; strap-shaped from an oblong-ovate base, 3.0–6.0 mm long; apiculate at the apex; margins entire, with serrulate at the leaf apex; costae broad and thick, convex on ventral side in cross section, costael hyaline cells 2–3 layers on dorsal side, 1–4 layers on ventral side, supporting a nearly centrally positioned chlorocyst layer, chlorocysts in cross section triangular in the upper parts of leaves, quadrangular at the leaf base; basal sheath cells large, long rectangular, thin walled, $86\text{--}135 \times 21\text{--}30 \mu\text{m}$. **Autoicous**. **Setae** 2.5–5.0 mm long, pale yellow, smooth. **Capsules** erect, cylindrical. **Opercula** long rostrate. **Peristome** teeth 8, yellowish, broad base, vertically striate. **Calyptrae** cucullate, smooth, entire at the base. **Spores** spherical, yellow-green, weakly granulate.

Additional illustration. – Gangulee (1969: 441, Fig. 207); Eddy (1990: 32, Fig. 186A–F).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai, Nan, Tak, Phitsanulok. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Kanchanaburi. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Ranong, Surat Thani, Phuket, Trang (He, 1995).

Distribution. – Angola, Africa, Australia, Belize, Benin, Brazil, Brunei, Burundi, Cameroon, Central African Republic, China, Colombia, Comoros, Congo, Costa Rica, El Salvador, Equatorial Guinea, Gabon, Ghana, Guatemala, Guinea, Honduras, India, Indonesia, Ivory Coast, Kampuchea, Kenya, Liberia, Malawi,

Malaysia, Mauritius, Mexico, Mozambique, Myanmar, Nepal, New Guinea, Nicaragua, Nigeria, Panama, Philippines, São Tomé, Senegal, Seychelles, Sierra Leone, Sikkim, South Africa, Sri Lanka, Suriname, Swaziland, Taiwan, Tanzania, Togo, Uganda, United States, Vietnam, Zambia, and Zimbabwe (Bartram, 1949; Bowers, 1974; Breen & Reese, 1971; He, 1995; O'shea, 2006; Waard & Florschütz, 1979).

Ecology. – On all microhabitats except soils, at 466–1,257 m elevation.

Specimens examined. – *P. Ajintaiyasil* 092, 102, 119, 120 (BCU).

2. *Octoblepharum pocsii* Magill & B.H. Allen, Polish Bot. J. 58(1): 47. 2013. (Figure 5.13)

Plants glaucous green, in loose turfs, large, 0.5–1.5 mm high. **Stems** short, unbranched; central strand absent. **Leaves** curved spreading, flattened; long lingulate, reflexed above, oval base, 8–13 mm long; apiculate at the apex; margins plane, with weakly serrulate at the leaf apex; costae broad and thick, convex on ventral side in cross section, costae hyaline cells 3–4 layers on dorsal side, 2–3 layers on ventral side, supporting a nearly centrally positioned chlorocyst layer, chlorocysts in cross section triangular in the upper parts of leaves, quadrangular at the leaf base; basal sheath cells large, short rectangular, thin walled, 30–66 × 18–39 µm. **Autoicous**. **Setae** 2.5–5.0 mm long, pale yellow, smooth. **Capsules** erect, cylindrical. **Opercula** long rostrate. **Peristome** teeth 8, yellowish, broad base, trabeculae faint, smooth. **Calyptrae** cucullate, smooth, entire at the base. **Spores** spherical, yellow-green, weakly granulate. **Asexual reproduction** by rhizoidal bud, rhizoidal bud usually present at the leaf tips.

Additional illustration. – Magill & Allen (2013: 46, Fig. 1).

Thailand. – New record

Distribution. – Central African Republic, Guinea, Laos (He, 2014; Magill & Allen, 2013).

Ecology. – On rocks under shade of tree, at 552–1,250 m elevation.

Specimens examined. – *P. Ajintaiyasil* 274, 323 (BCU).

3. SYRRHOPODON

Schwägr., Sp. Musc. Frond., Suppl. 2: 110. 1824; Gangulee, Mosses E. India 3: 568. 1971; Noguchi, Ill. Moss Fl. Japan 2: 244. 1988; Eddy, Handb. Males. Mosses 2: 54. 1991; Bang-juan & Reese, Moss Fl. China 2: 82. 2001.

Plants slender to somewhat robust, in dense turfs. **Stems** erect; central strand lacking. **Leaves** contorted to involute when dry, spreading when wet; oblong to linear, usually bordered with elongate hyaline cells, border often thickened; teniolae or teniolae-like features absent or rarely present; leaf cells rather isodiametric, smooth to papillose. **Setae** elongate or rarely very short. **Capsules** mostly exserted but rarely immersed. **Peristome** present or lacking, often imperfectly developed. **Calyptrae**

deciduous, mostly cucullate, rarely mitrate. **Asexual reproduction** by gemmae, gemmae fusiform or filamentous; gemmiferous leaves sometimes differentiated from vegetative leaves.

Key to the species

- 1a. Margins at leaf shoulders spinose or serrate.....2
 2a. Margins at leaf shoulders hyaline spinose.....1. *Syrrhopodon armatus*
 2b. Margins at leaf shoulders serrate.....2. *Syrrhopodon gardneri*
 1b. Margins at leaf shoulders entire.....3. *Syrrhopodon parasiticus*

1. *Syrrhopodon armatus* Mitt., J. Proc. Linn. Soc., Bot. 7: 151. 1864; Bang-juan & Reese, Moss Fl. China 2: 85. 2001. — *Syrrhopodon fimbriatulus* Müll. Hal., J. Mus. Godeffroy 3(6): 52. 1874; Eddy, Handb. Males. Mosses 2: 77. 1991. — *Syrrhopodon larminatii* Broth. & Paris, Rev. Bryol. 28: 125. 1901. — *Syrrhopodon rubrotomentosus* Cardot, Rev. Bryol. 35: 65. 1908. — *Syrrhopodon cairnensis* Broth. & Watts, Proc. Linn. Soc. New South Wales 43: 551. 1918. (**Figure 5.14**)

Plants yellowish green, gregarious or in dense turfs, small, 2–5 mm high. **Stems** very short, forked; rhizoids dark-red. **Leaves** mostly tightly curled-contorted, involute when dry, often secund, involute, ascending when wet; oblong-linear above, slightly broader base, 1.7–2.5 × 0.2–0.3 mm; apiculate, cucullate at tips; margins somewhat involute distally, bordered all around with hyaline cells, sometimes weak and incomplete in distal part of leaf, bearing hyaline spinose or weakly teeth at shoulders; costae usually spinose dorsal and ventral; upper leaf cells isodiametric to short-rectangular, unipapillose, papillae often tall and conspicuous, 6–12 × 7–10 µm; cancellinae narrow, acute or narrowly rounded distally, hyaline cells large, quadrate to rectangular, 33–114 × 12–28 µm. **Sporophyte** not seen. **Asexual reproduction** by gemmae, gemmae on ventral surface of costae at leaf tip.

Additional illustration. — Mohamed & Reese (1985: 245, Fig. 74–79, as *S. fimbriatulus*); Eddy (1990: 77, Fig. 213A–F, as *S. fimbriatulus*).

Thailand. — NORTHERN: Chiang Mai. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. SOUTH-EASTERN: Trat. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. — Australia, Bangladesh, Brunei, Cameroon, China, Congo, Equatorial Guinea, Gabon, Guinea, Hong Kong, India, Indonesia, Ivory Coast, Japan, Malaysia, New Guinea, New Zealand, Nigeria, Philippines, Singapore, Taiwan, and Vietnam (Ellis & Tan, 1999; He, 1995; O'shea, 2006; Reese & Stone, 1995).

Ecology. — On log or bark of tree under shade, at 1,197–1,227 m elevation.

Specimens examined. — *P. Ajintaiyasil* 203, 351, 232 (BCU).

2. *Syrrhopodon gardneri* (Hook.) Schwägr., Sp. Musc. Frond., Suppl. 2: 110. pl. 131. 1824; Gangulee, Mosses E. India 3: 578. 1971; Eddy, Handb. Males. Mosses 2:

81. 1991; Bang-juan & Reese, Moss Fl. China 2: 89. 2001. — *Calymperes gardneri* Hook., Musci Exot. 2: 146. 1819. — *Calymperes hobsonii* Grev., Ann. Lyceum Nat. Hist. New York 1(2): 271. 23. 1825. — *Syrrhopodon hobsonii* (Grev.) Hook. & Grev., Edinburgh J. Sci. 3: 224. 1825. — *Calymperes welwitschii* Duby, Mém. Soc. Phys. Genève 21: 444. 4 f.8. 1872. — *Syrrhopodon aculeatoserratus* Besch., Ann. Sci. Nat., Bot., sér. 6, 9: 349. 1880. — *Syrrhopodon affinis* Broth., Hedwigia 50: 125. 1910. — *Syrrhopodon curranii* Broth., Philipp. J. Sci. 5(2): 142. 1910. (**Figure 5.15**)

Plants dark green, in dense turf, medium-sized, 0.7–2.0 cm high. **Stems** erect; rhizoids dark red. **Leaves** closely curled or only slightly contorted when dry, spreading when wet, linear above broader base, 2.3–3.5 × 0.2–0.5 mm; upper margins thickened, coarsely toothed in two rows, bearing hyaline serrate-toothed at leaf shoulders; costae covered with weakly papillose cells; upper leaf cells isodiametric to rectangular, papillose multifid ventral, 8–13 × 4–9 µm; cancellinae ending in acute angles distally, hyaline cells large, quadrate to rectangular, 18–43 × 14–22 µm. **Dioecious**. **Satae** brown, smooth, 4.2–5.7 mm long. **Capsule** brown, erect, cylindrical, 1.3–1.8 mm long. **Opercula** not seen. **Peristome** simple, composed of 16 undivided, narrow, coarsely papillose.

Additional illustration. — Eddy, (1990: 82, Fig. 217A–F); Mohamed & Reese (1985: 226, Fig. 1–6).

Thailand. — NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Phetchabun, Loei. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. — Angola, Australia, Brazil, Brunei, Burundi, Cameroon, China, Comoros, Costa Rica, Congo, Equatorial Guinea, Ethiopia, Guinea, Honduras, India, Indonesia, Ivory Coast, Japan, Kampuchea, Laos, Malawi, Malaysia, Mexico, Myanmar, Nepal, New Guinea, Nigeria, Philippines, Rwanda, Sao Tome, Sierra Leone, Sikkim, Sri Lanka, Taiwan, Tanzania, Vietnam, and Uganda (Ellis & Tan, 1999; He, 1995; O'shea, 2006; Reese & Stone, 1995).

Ecology. — On rocks, log or bark under shade of tree, at 1,113–1,233 m elevation.

Specimens examined. — *P. Ajintaiyasil* 109, 225 (BCU).

3. Syrrhopodon parasiticus (Sw. ex Brid.) Besch., Ann. Sci. Nat., Bot., sér. 8, 1(5–6): 298. 1895; Eddy, Handb. Males. Mosses 2: 88. 1991; Bang-juan & Reese, Moss Fl. China 2: 95. 2001. — *Bryum parasiticum* Sw. ex Brid., Muscol. Recent. 2(3): 54. 1803. — *Calymperes swartzii* Arn., Mém. Soc. Linn. Paris 5: 233. 1827. — *Calymperes filigerum* Austin, Bot. Gaz. 4: 151. 1879. — *Calymperes semilimbatulum* Müll. Hal., Hedwigia 39: 261. 1900. — *Syrrhopodon watsii* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 42: 93. 1900. (**Figure 5.16**)

Plants green, thin turfed, small, 3–7 mm high. **Stems** short; rhizoids brownish-red, conspicuous. **Leaves** involute-secund when dry, spreading and somewhat involute when moist; lanceolate to oblong-lanceolate, 2.3–2.8 × 0.2–0.3 mm; acute to acuminate at apex; margins of laminae narrowly throughout leaves with hyaline cells; border distinct, entire, margins of shoulder laminae bordered, entire;

costae covered with weakly papillose cells; cells of upper laminae pellucid, quadrate to subquadrate, unipapillose, $6-11 \times 5-8 \mu\text{m}$; cancellinae ending in acute angles distally, hyaline cells large, quadrate to rectangular, $25-91 \times 13-24 \mu\text{m}$. **Dioecious**. **Satae** brown, smooth, 2–3 mm long. **Capsules** brown, erect, cylindrical. **Opercula** not seen. **Peristome** simple, composed of 16 undivided, narrow, coarsely papillose.

Additional illustration. – Eddy (1990: 89, Fig. 222).

Thailand. – NORTHERN: Chiang Mai, Tak. CENTRAL: Saraburi (He, 1995).

Distribution. – Australia, Belize, Brazil, Cameroon, China, Colombia, Costa Rica, Guatemala, Honduras, India, Indonesia, Malaysia, Nicaragua, Panama, Philippines, Suriname, Vietnam and United States (Bartram, 1949; Ellis & Tan, 1999; He, 1995; O'shea, 2006; Reese & Stone, 1995; Steere, 1946).

Ecology. – On twig under shade of tree, at 1,188–1,248 m elevation.

Specimens examined. – *P. Ajintaiyasil 196A, 197* (BCU).



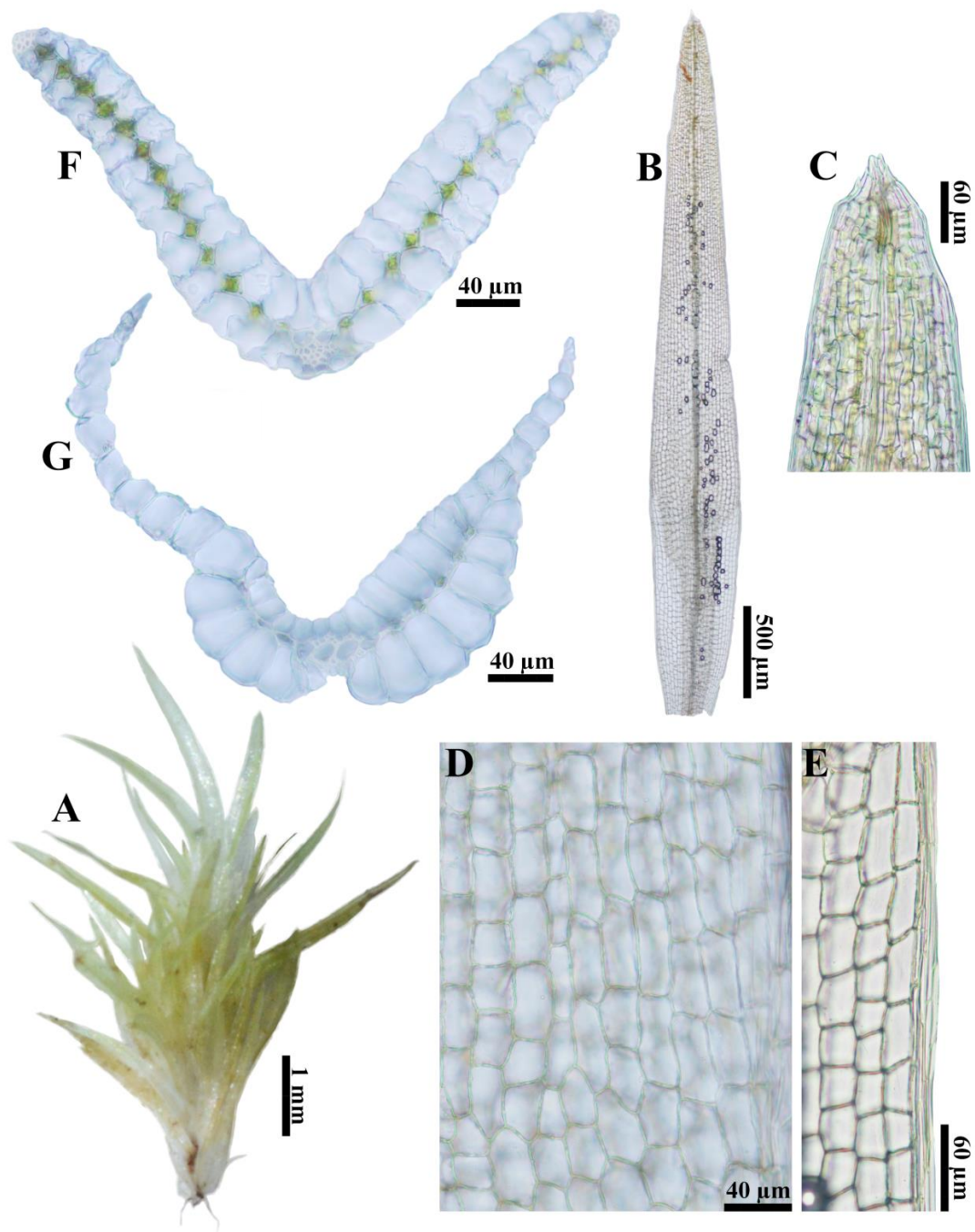


Figure 5.11 *Leucophanes octoblepharioides* Brid.

A. Gametophyte, B. Leaf, C. Dorsal view at leaf apex, D. Leaf cell, E. Leaf margin, F. Cross section of midleaf, G. Cross section of leaf base. Based on *P. Ajintaiyasil 446*.

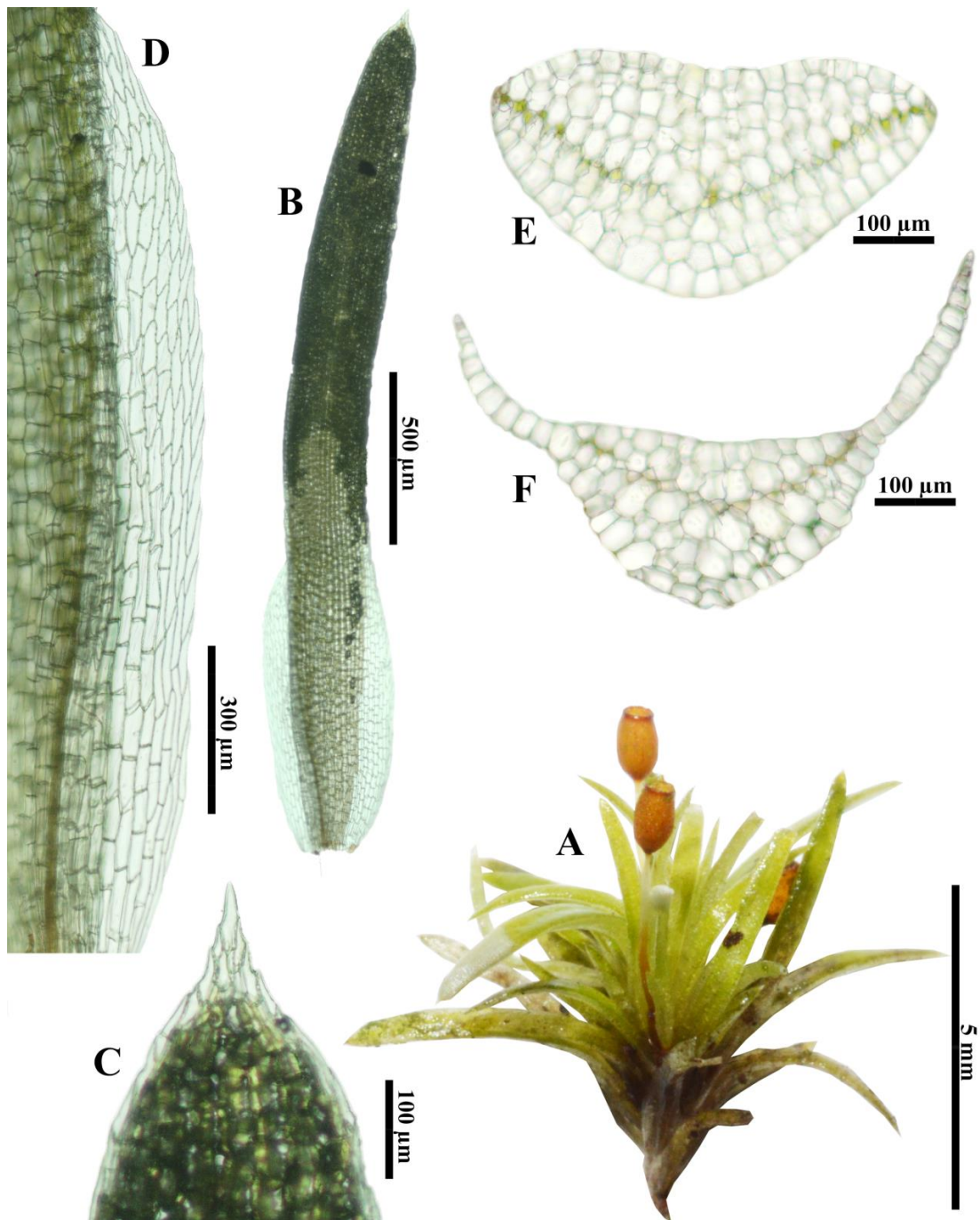


Figure 5.12 *Octoblepharum albidum* Hedw.

A. Gametophyte with sporophytes, B. Leaf, C. Leaf apex, D. Cells at basal sheath, E. Cross section of midleaf, F. Cross section of leaf base. Based on *P. Ajintaiyasil 092*.

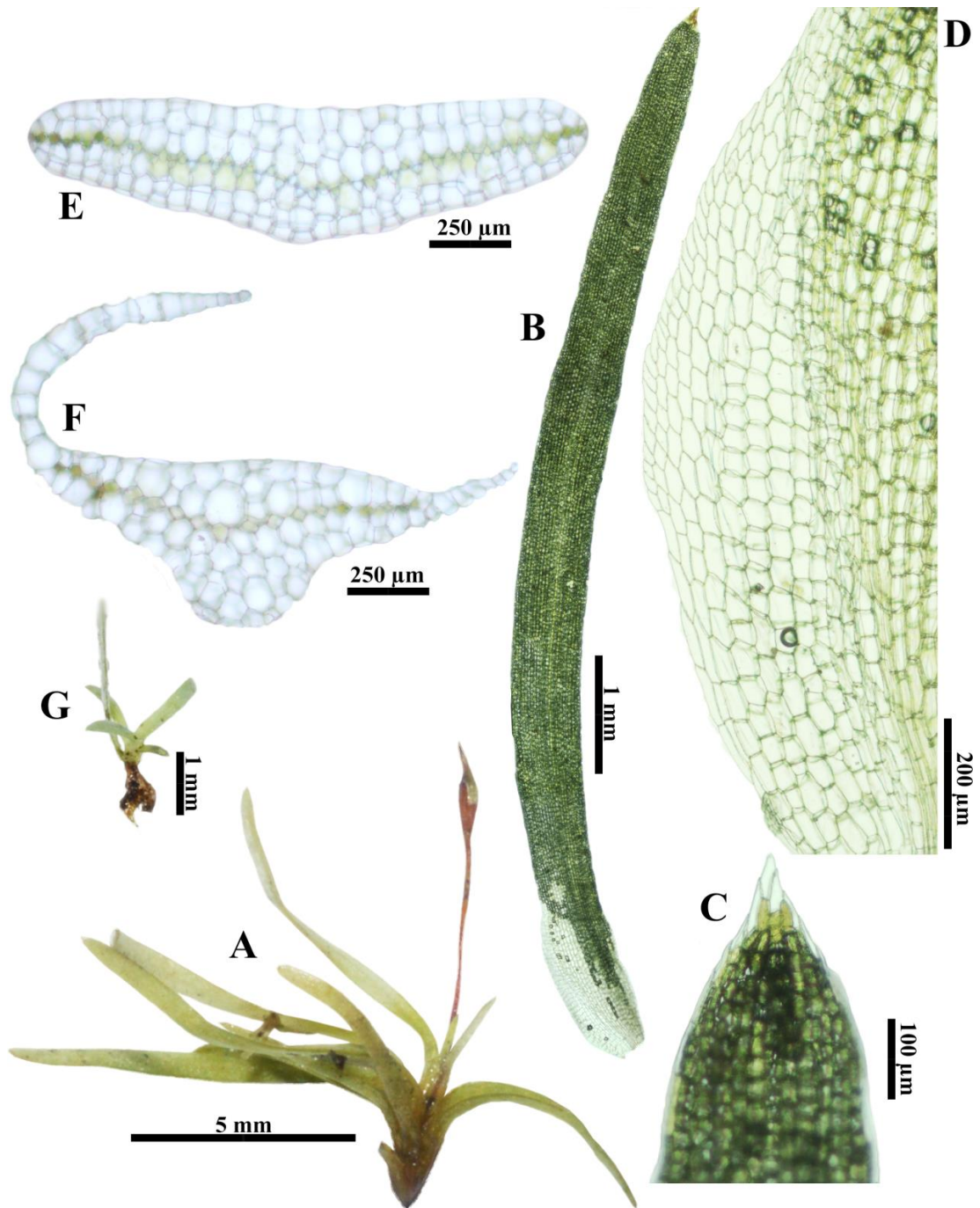


Figure 5.13 *Octoblepharum pocsii* Magill & B.H. Allen

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Cells at basal sheath, E. Cross section of midleaf, F. Cross section of leaf base, G. Rhizoidal bud at leaf tip. Based on *P. Ajintaiyasil* 323.

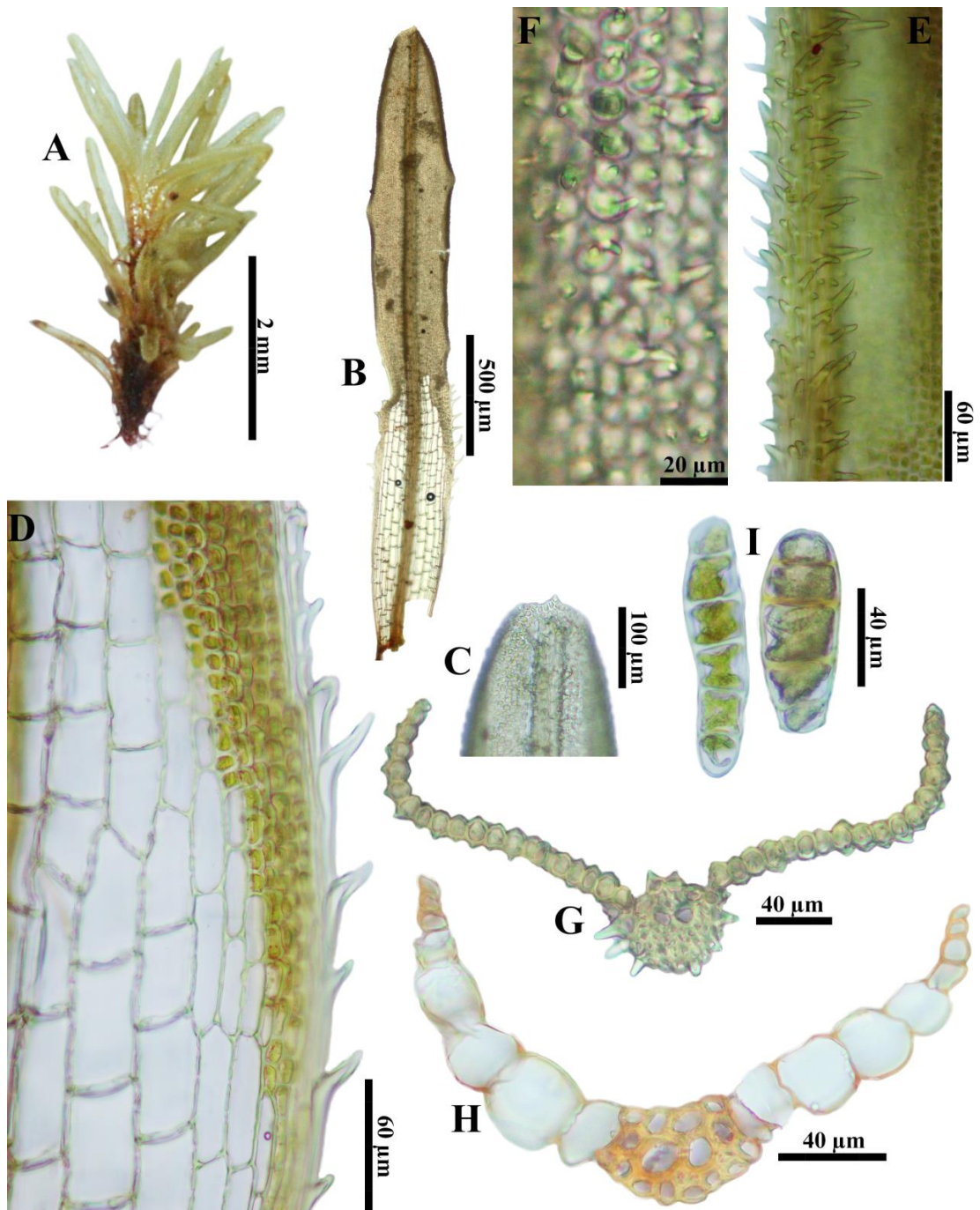


Figure 5. 14 *Syrrhopodon armatus* Mitt.

A. Gametophyte, B. Leaf, C. Leaf apex, D. Cells at leaf shoulder, E. Dorsal view on costae, F. Leaf cells with unipapillose, G. Cross section of leaf base, H. Cross section of midleaf, I. Gemmae. Based on *P. Ajintaiyasil* 323.

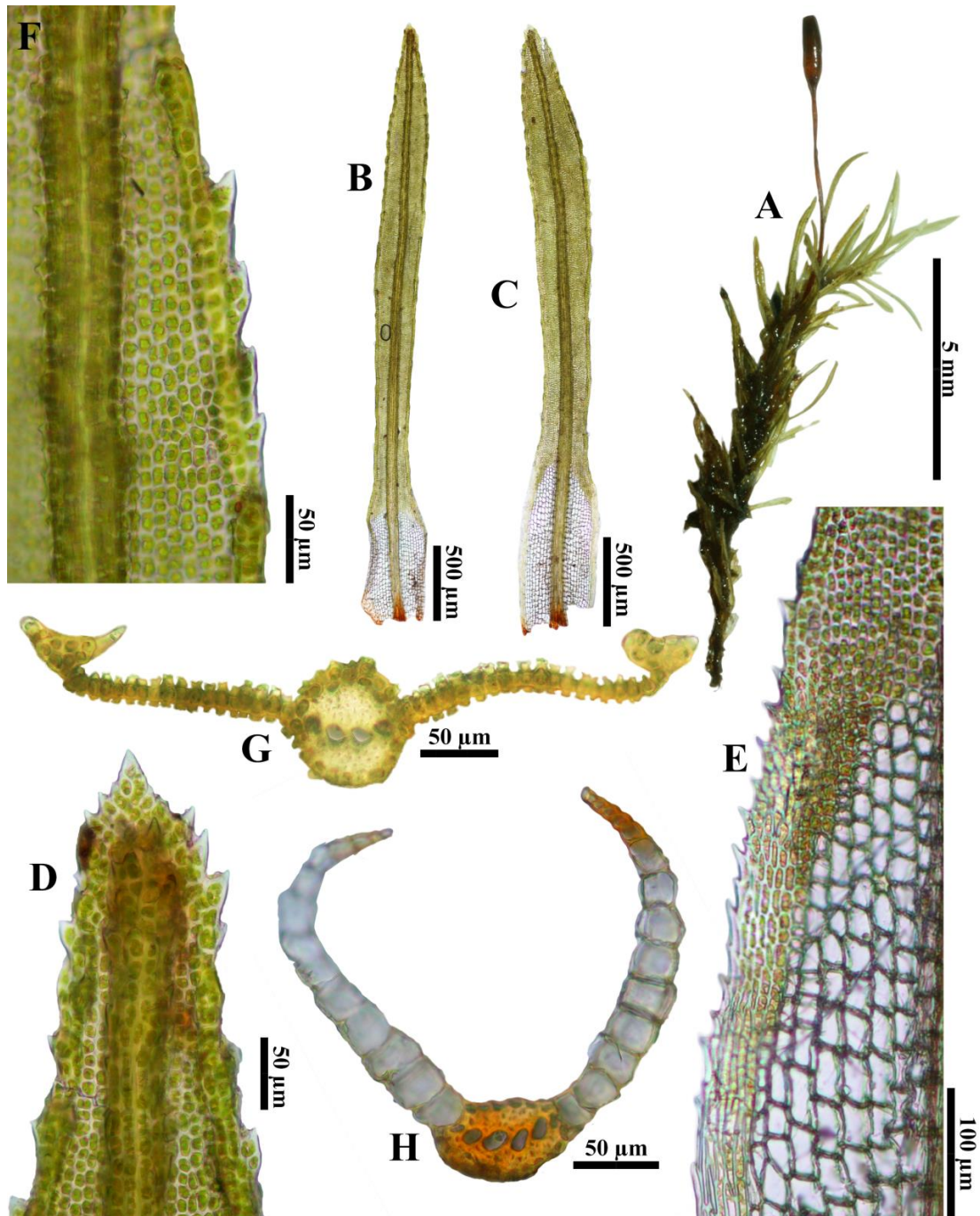


Figure 5.15 *Syrrhopodon gardneri* (Hook.) Schwägr.

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Cells at leaf shoulder, F. Leaf cells with multifid papillae, G. Cross section of midleaf, H. Cross section of leaf base. Based on *P. Ajintaiyasil* 109.

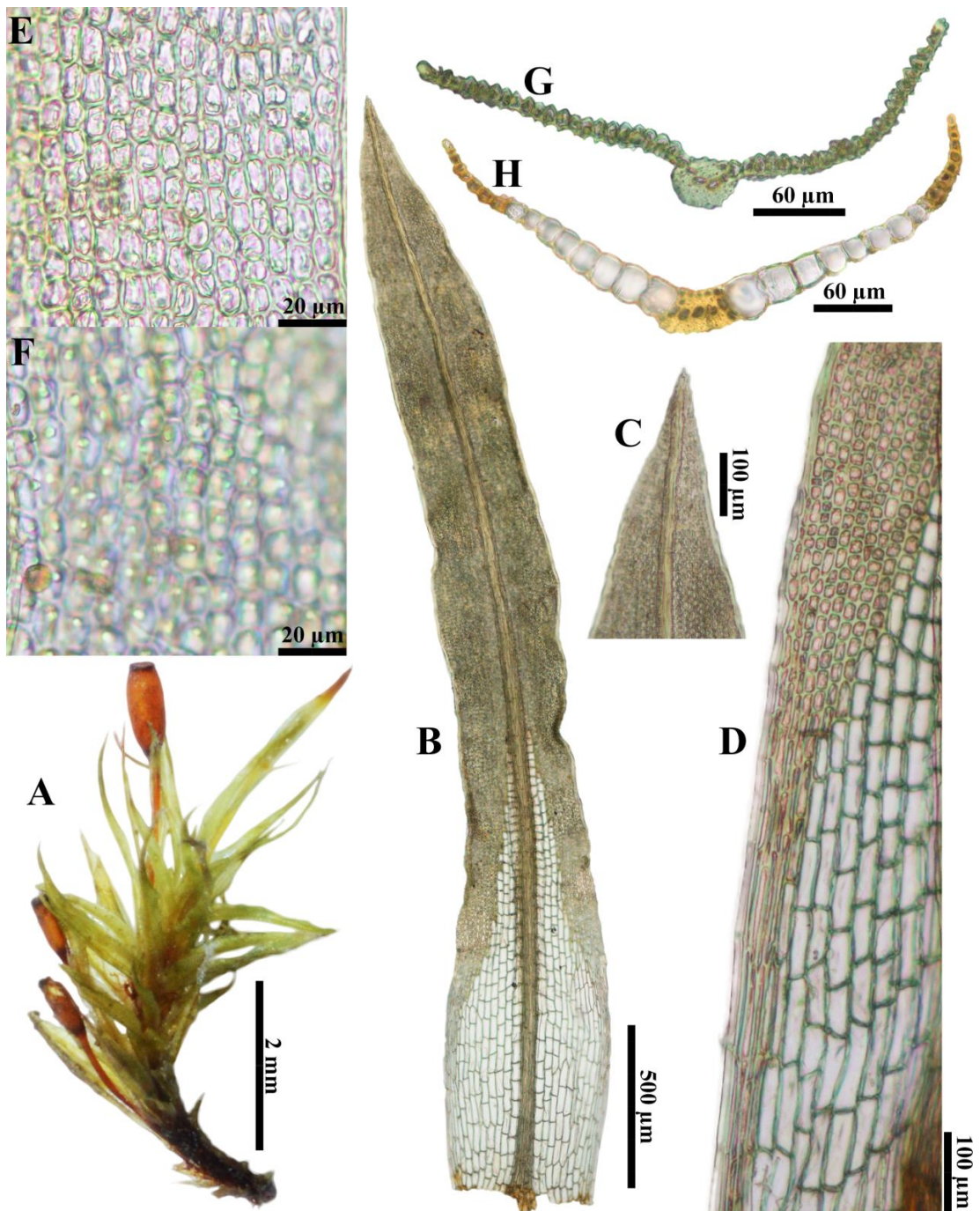


Figure 5. 16 *Syrrhopodon parasiticus* (Sw. ex Brid.) Besch.

A. Gametophyte with sporophytes, B. Leaf, C. Leaf apex, D. Cells at leafshoulder, E.-F. Cells with with unipapillose, G. Cross section of midleaf, H. Cross section of leaf base. Based on *P. Ajintaiyasil 109*.

4. DALTONIACEAE

Schimp., Syn. Musc. Eur. 478. 1860.

Plants small to occasionally medium sized, forming turfs or thin mats, glossy green to yellowish-green or golden. **Primary stems** short and inconspicuous, or conspicuous and creeping to spreading. **Secondary stems** erect to ascending, or stems and branches spreading or subspreading; radiculose below; pseudoparaphyllia absent or rarely filamentous. **Leaves** spirally arranged or complanate; ovate- to oblong-lanceolate or obovate-oblong and symmetric or asymmetric; apex acuminate, acute or obtuse-apiculate; base slightly decurrent on one or both sides; margins plane to recurved, entire to bluntly or sharply serrate or ciliate, limbate; costae single, 1/3–3/4 lamina length, sometimes forked along a short costae; cells oval to long-hexagonal, differentiated at leaf margins or rarely not. **Autoicous**, rarely dioicous. **Perichaetia** lateral, leaves differentiated, usually smaller than stem leaves. **Setae** elongate, slender to rather stout, smooth, papillose distally or throughout, or ciliate distally. **Capsules** exserted, erect to pendulous, urn ovoid, neck distinct or not; exothecial cells collenchymatous. **Opercula** conic-rostrate. **Peristome** double; exostome teeth 16, papillose or striate and furrowed; endostome basal membrane low or high, segments 16, cilia reduced or absent. **Calyptrae** unistratose at middle, fringed at base or not, usually naked but rarely densely hairy. **Spores** lightly to densely papillose, rarely smooth.

DISTICHOPHYLLUM

Dozy & Molk., Musc. Frond. Ined. Archip. Ind. 99. 1846; Gangulee, Mosses E. India 6: 1482. 1976; Noguchi, Ill. Moss Fl. Japan 4: 743. 1991; Bang-juan & Tan, Moss Fl. China 6: 14. 2002.

Plants soft, yellowish green to glossy green, in dense mats. **Stems** flat, sparingly branched; central strand absent. **Leaves** in 6–8 rows; crowded, complanate, lingulate, oblanceolate, obovate to spatulate; pointed or rounded at apex; margins plane, entire, a narrow border of elongated cells differentiated; costae single, ending near or above midleaf; upper leaf cells rounded to hexagonal, smooth, laxer at base. **Autoicous**. **Perichaetia** small, lingulate or ovate-lanceolate, border not differentiated, usually ecostaete. **Setae** slender, smooth or papillose, reddish brown. **Capsules** erect or inclined, ovoid to oblong-ovoid with a distinct neck. **Opercula** conic, long-rostrate. **Peristome** double; exostome teeth narrowly lanceolate, hookeroid with numerous cross-lamellae and a deep median groove; endostome segments lanceolate, papillose, perforate; basal membrane high; cilia absent. **Calyptrae** horn-shaped, finely fringed at base. **Spores** small, weakly to moderately papillose.

Distichophyllum nigricaula Mitt. ex Bosch & Sande Lac. var. **elmeri** (Broth.) B.C. Tan & H. Rob., Smithsonian Contr. Bot. 75: 22. 1990. — *Distichophyllum elmeri* Broth., Leafl. Philipp. Bot. 2: 656. 1909. — *Distichophyllum sinuosulum* Dixon, J. Siam Soc., Nat. Hist. Suppl. 10(1): 15. 1935; Gangulee, Mosses E. India 6: 1490. 1976. (Figure 5.17)

Plants small to medium-sized, mm long, in dense mats. **Stems** prostrate, irregularly branched, laxly foliate. **Leaves** strongly crisped and twisted lengthwise when dry; variable in shape, short-ovate to obovate, sometimes broadly oblong, 1.5–1.8 × 0.8–1.0 mm; apices shortly mucronate to round; margins entire; borders strongly differentiated, consisting of 2–4 rows of moderately thick-walled, linear cells and measuring; costae strong, never reach the leaf apices; cells hexagonal to polygonal, moderately thick-walled, with 3–6 rows of submarginal cells small, 17–22 × 14–22 μm, median cell 31–50 × 22–29 μm, clearly smaller than the juxtacostael cells, short-rectangular to hexagonal at base, 53–97 × 23–41 μm. **Sporophytes** not seen.

Additional illustration. – Lin & Tan (1995: 36, Fig. 27, E–H); Gangulee (1976: 1491, Fig. 745, as *D. sinuosulum*); Wu, Crosby & He (2002: 17, Pl. 400, Fig. 5–8, as *D. cirratum* var. *elmeri*); Juengprayoon (2017: 113, Fig. 4.26).

Thailand. – NORTH-EASTERN: Loei. PENINSULAR: Nakhon Si Thammarat, Phatthalung, Trang (Juengprayoon, 2017).

Distribution. – Brunei, China, Indonesia, Malaysia, Philippines, and Taiwan (He, 1995; Juengprayoon, 2017).

Ecology. – On humus or rocks under shade of tree, at 1,239 m elevation.

Specimens examined. – *P. Ajintaiyasil* 477 (BCU).

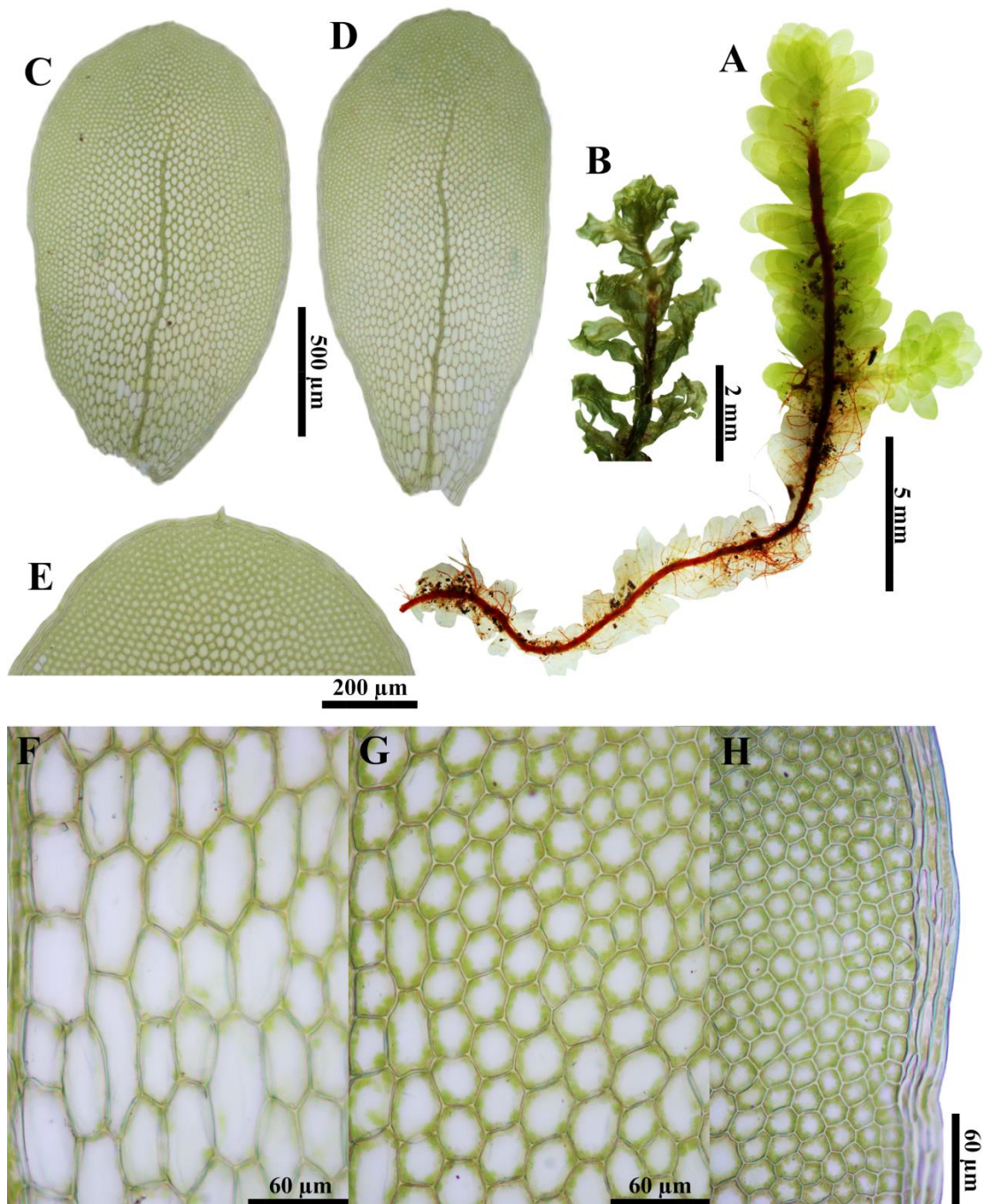


Figure 5. 17 *Distichophyllum nigricaulae* Mitt. ex Bosch & Sande Lac. var. *elmeri* (Broth.) B.C. Tan & H. Rob.

A. Gametophyte, B. Gametophyte when dry, C–D. Leaves, E. Leaf apex, F. Juxtacostael cells at leaf, F. Median cells of leaf, G. Submarginal cells of leaf. Based on *P. Ajintaiyasil* 477.

5. DICRANACEAE

Schimp., Coroll. Bryol. Eur. 11. 1856; Gangulee, Mosses E. India 2: 217. 1969; Noguchi, Ill. Moss Fl. Japan 2: 132. 1987; Eddy, Handb. Males. Mosses 1: 93. 1988; Chien, Vitt & He, Moss Fl. China 1: 90. 1999.

Plants small to large, generally robust, mostly forming loose to dense turf. **Stems** erect, simple to more often few to several branched by innovations, often densely tomentose; central strand present or not; rhizoids reddish-brown. **Leaves** mostly crowded, occasionally falcate or falcate-secund; narrowly to somewhat broadly lanceolate, often differentiated between a ovate to oblong base and limb lanceolate-linear to subulate, often inflexed to incurved; margins entire to more often serrate; costae single, percurrent to short excurrent, rarely hyaline, at base costae often 1/2 or more width of lamina, in cross section stereids above and below guide cells or with hyaline cells commonly above or occasionally below guide and stereid cells; laminal cells mostly smooth, occasionally bulging mammillose or papillose, cell walls smooth, occasionally porose or sinuose; lower and basal cells often elongate; alar region differentiated or not, when distinct cells enlarged, often golden or reddish-brown, border present in few species with linear hyaline cells. **Dioicous** or autoicous. **Perichaetia** terminal, or occasionally appearing lateral by stem innovations, leaves often elongate and sheathing. **Setae** generally elongate, smooth to rarely roughened distally, erect or flexuose or cygneous, usually twisted. **Capsule** immersed to more commonly exserted, inclined, to suberect or erect, symmetric to asymmetric, smooth or variously furrowed or ribbed. **Opercula** conic short- to long-rostrate. **Peristome** single, teeth 16, flat teeth divided in upper two-thirds, typically with vertically pitted outer surface. **Calyptrae** mitrate or cucullate smooth, base entire or fringed with hairs. **Spores** mostly spherical, lightly to somewhat coarsely papillose, rarely smooth

จุฬาลงกรณ์มหาวิทยาลัย LEUCOLOMA

Brid., Bryol. Univ. 2: 218. 1829; Gangulee, Mosses E. India 2: 406. 1969; Noguchi, Ill. Moss Fl. Japan 2: 230. 1987; Eddy, Handb. Males. Mosses 1: 176. 1988; Chien, Vitt & He, Moss Fl. China 1: 199. 1999.

Plants pale green or yellowish green, shiny, in compact or loose turfs. **Stems** reddish brown, blackish when dry, erect, usually branched; central strand absent. **Leaves** erect-spreading, ascending or appressed, falcate-secund or crispate; tapered to a very long subulate acumen from an ovate-lanceolate base; margins entire except at the apex, sometimes faintly serrulate; distinctly bordered by linear, non-papillose, pellucid, thick-walled cells, the borders wider near leaf base; costae narrow, percurrent to excurrent in a long setaceous point, smooth at back except at the very tips; cells small, obscure, subquadrate to rectangular, thick-walled, multipapillose; alar cells differentiated, not extending near costae, quadrate to rectangular, hyaline or reddish brown, thick-walled. **Dioicous**. **Setae** erect, elongate. **Capsules** erect, shortly cylindrical, symmetric, attenuate at base. **Opercula** long-rostrate. **Peristome** teeth linear-lanceolate, divided halfway down or lower, smooth. **Calyptrae** cucullate, entire at base. **Spores** papillose.

Key to the species

- 1a. Plants turfed; leaves ovate-lanceolate; bordered 1–5 cells wide.....
1. *Leucoloma mittenii*
- 1b. Plants lax, flexuose; leaves lanceolate; bordered 10–12 cells wide.....
2. *Leucoloma molle*

1. *Leucoloma mittenii* M. Fleisch., Musci Buitenzorg 1: 125. 1904; Eddy, Handb. Males. Mosses 1: 179. 1988. — *Syrrhopodon taylorii* Schwägr., Sp. Musc. Frond., Suppl. 2: 115. pl. 132. 1824. (**Figure 5.18**)

Plants yellowish-green or green, forming loose turfs, 3–5 mm high. **Stems** erect or arcuately ascending, branched; central strand absent. **Leaves** rather falcate-secund when moist, rather strongly curled when dry; ovate-lanceolate, 1.7–3.0 × 0.4–0.5 mm; apices very long subulate acumen; margins concave above; bordered by a single row of linear cells near the apex, 2–3 rows at the middle, up to 5 rows near the base; costae single, narrow, percurrent to shortly excurrent, scabrid at the apex; median cells subquadrate to rounded-rectangular, minutely papillose, 5–11 × 4–7 μm, basal cells rectangular, smooth, 14–32 × 5–10 μm; alar cells quadrate to short-rectangular, thick-walled, 15–50 × 13–20 μm. **Sporophytes** not seen.

Additional illustration. – Eddy (1988: 180, Fig. 156A–F).

Thailand. – NORTHERN: Chiang Mai, Phitsanulok. EASTHERN: Nakhon Ratchasima. SOUTH-EASTERN: Chanthaburi (He, 1995).

Distribution. – China, India, Kampuchea, Malaysia, Myanmar, Nepal, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 1,241 m elevation.

Specimens examined. – *P. Ajintaiyasil* 189 (BCU).

2. *Leucoloma molle* (Müll. Hal.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 13. 1859; Noguchi, Ill. Moss Fl. Japan 1: 234. 1987; Eddy, Handb. Males. Mosses 1: 177. 1988; Chien, Vitt & He, Moss Fl. China 1: 200. 1999. — *Dicranum molle* Müll. Hal., Syn. Musc. Frond. 1: 354. 1848. — *Dicranum insigne* Müll. Hal., Linnaea 36: 33. 1869. — *Leucoloma limbatulum* Besch., Bull. Soc. Bot. France 45: 54. 1898. (**Figure 5.19**)

Plants pale green to yellowish green, in loose turfs, slender, 1.6–2 cm high. **Stems** erect or arcuately ascending, branched; central strand absent. **Leaves** widely erect-spreading when moist, flexuose, falcate-secund when dry; broadly lanceolate, 1.1–5.1 × 0.4–0.6 mm; apices very long subulate acumen; margins involute above, bordered by a single row of linear cells near the apex, 10–15 rows at the middle, up to 20 rows near the base; costae narrow, long-excurrent, scabrid at the apex; median cells subquadrate to rounded-rectangular, minutely papillose, 5–8 × 3–5 μm, basal cells long-rectangular, smooth, 20–29 × 2–5 μm; alar cells quadrate to short-rectangular, brownish, thick-walled, 20–48 × 8–24 μm. **Sporophytes** not seen.

Additional illustration. – Noguchi (1987: 233, Fig. 94B); Eddy (1988: 178, Fig. 153A–F); Chien, Crosby & He (1999: 201, Pl. 51, Fig. 1–10).

Thailand. – NORTH-EASTERN: Loei. SOUTH-WESTERN: Prachuap Khiri Khan. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Nakhon Si Thammarat, Pattani (He, 1995).

Distribution. – Brunei, China, Indonesia, Japan, Kampuchea, Malaysia, Papua New Guinea, Philippines, Sri Lanka, Vietnam, and Taiwan (He, 1995).

Ecology. – On barks under shade of tree, near waterfall, at 1,187 m elevation.

Specimens examined. – *P. Ajintaiyasil* 494 (BCU).



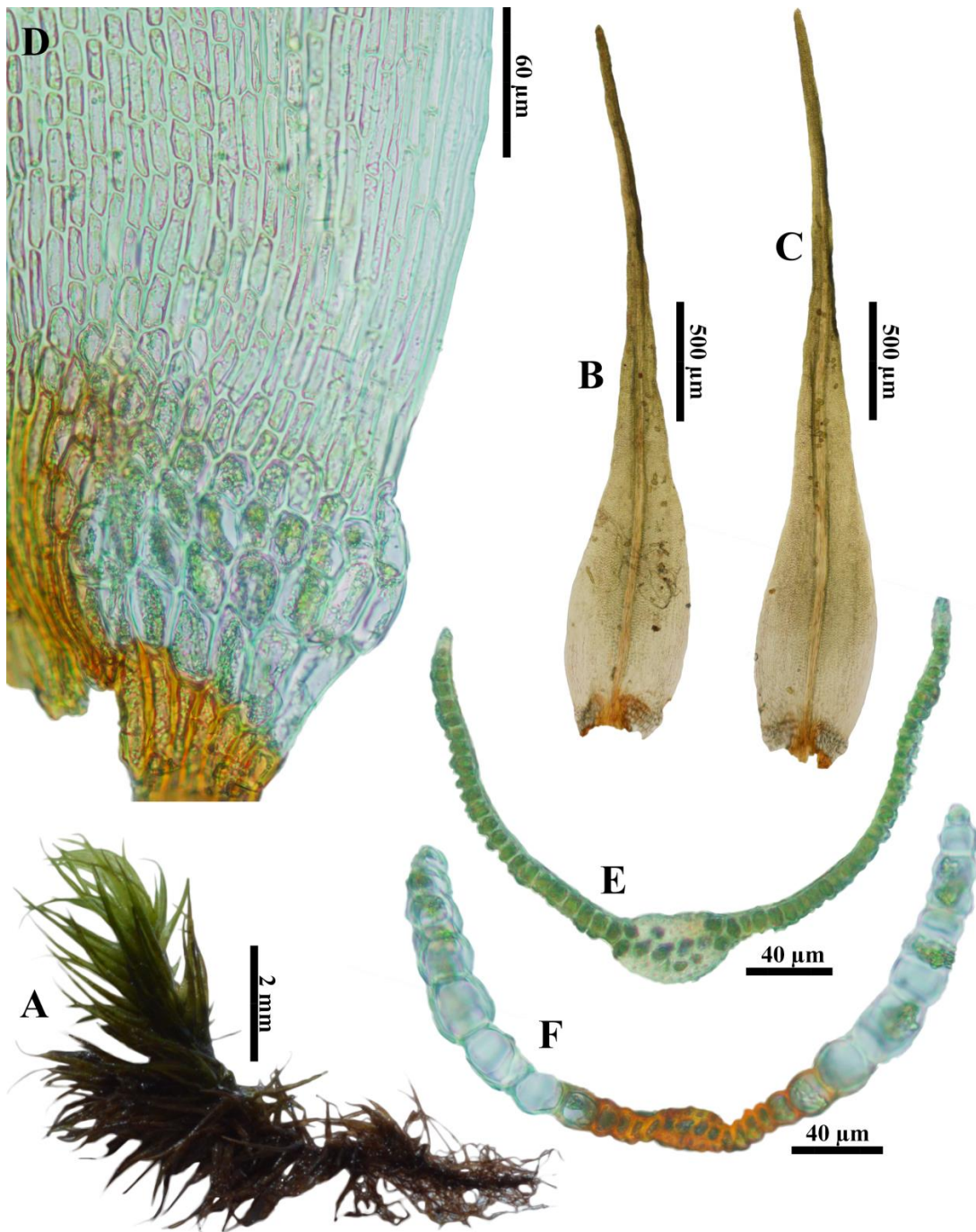


Figure 5.18 *Leucoloma mittenii* M. Fleisch.

A. Gametophyte, B–C. Leaves, C. Leaf base with alar cells, D. Cross section of midleaf, E. Cross section of leaf base. Based on *P. Ajintaiyasil* 189.

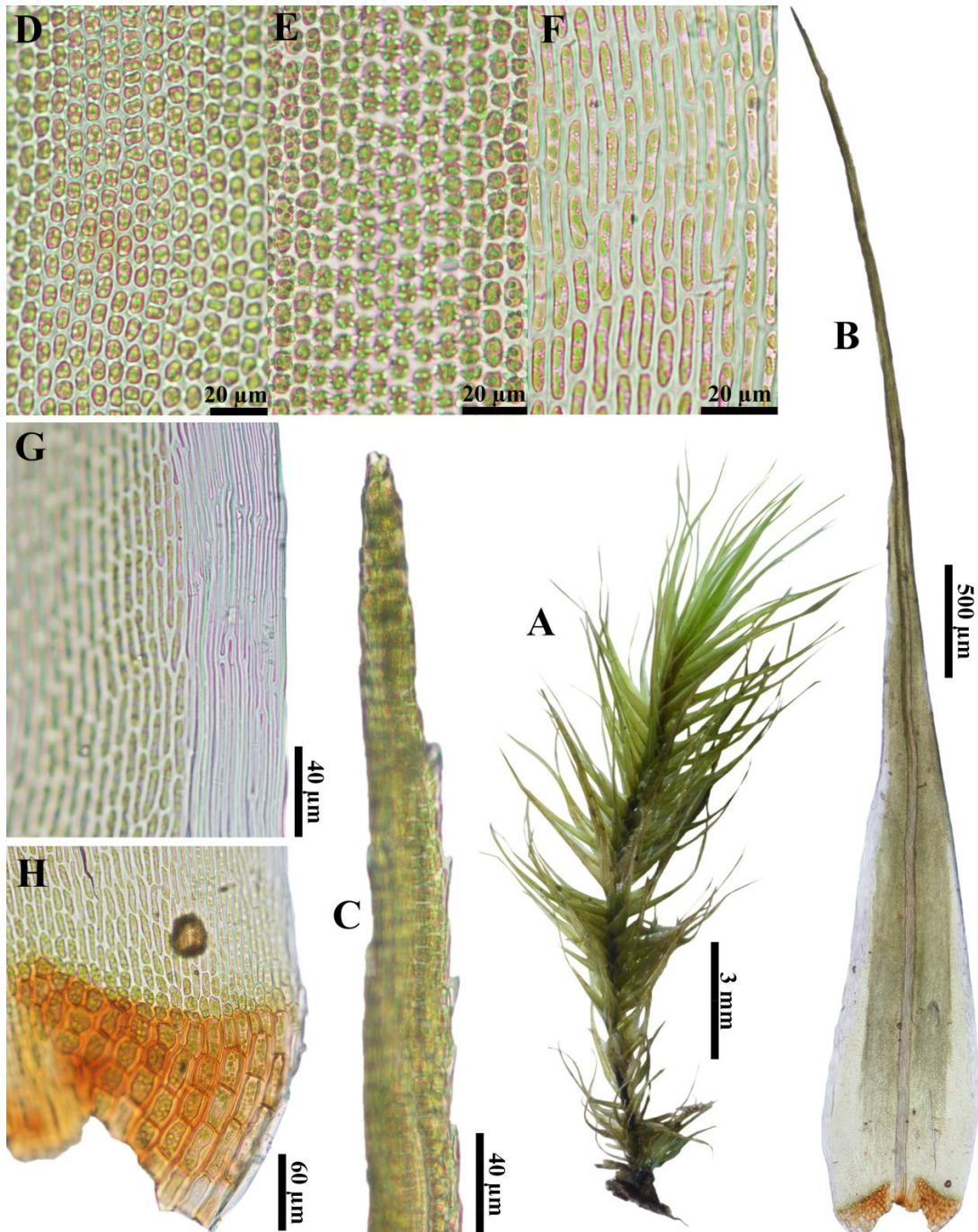


Figure 5.19 *Leucoloma molle* (Müll. Hal.) Mitt.

A. Gametophyte, B. Leaf, C. Leaf apex, D. Ventral surface of leaf, E. Dorsal surface of leaf, F. Cells at leaf base, G. Cell at margin, H. Leaf base with alar cells. Based on P. Ajintaiyasil 494.

6. DIPHYSCIACEAE

M. Fleisch., Syllabus 86. 1919; Gangulee, Mosses E. India 1: 59. 1969; Noguchi, Ill. Moss Fl. Japan 1: 10. 1994; Mei-zhi, Xing-jiang & He, Moss Fl. China 8: 292. 2005.

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

DIPHYSCIUM

D. Mohr, Observ. Bot. 34. 1803; Gangulee, Mosses E. India 1: 59. 1969; Noguchi, Ill. Moss Fl. Japan 1: 10. 1994; Eddy, Handb. Males. Mosses 2: 239. 1988; Mei-zhi, Xing-jiang & He, Moss Fl. China 8: 292. 2005.

Plants small, forming turfs, blackish-green. **Stem** erect, short, radiculose below; rhizoids papillose. **Leaves** crowded, crispate when dry, erect-spreading when wet; lingulate, weakly concave; apex acute, base slightly expanded and clasping, about 1/3–1/4 lamina long; margins plane; costae strong, ending wall below apex to shortly excurrent, in cross section with guide cells in a single row, stereids in several rows above and below guide cells, lamina often bistratose throughout; ventral surface cells ovate-rounded, dorsal surface cells smaller, subquadrate, very thick-walled, smooth; subsheathing base cells long rectangular, thick-walled, unistratose. **Dioicous**. **Perichaetia** terminal, leaves strongly differentiated, often several times longer than stem leaves, lanceolate and erose distally at juncture with costae, costae long excurrent. **Seta** very short. **Capsules** immersed among long perichaetial leaves, erect, urn strongly asymmetric, obliquely and broadly ovoid, narrowed toward mouth. **Opercula** conic-short rostrate to sharply high conic. **Peristome** double; exostome teeth short and irregular; endostome elongate, membrane high and conic, keeled, papillose. **Calyptra** short mitrate, smooth. **Spore** finely papillose.

Diphyscium mucronifolium Mitt., Bryol. Jav. 1(5): 35–36. 1854; Eddy, Handb. Males. Mosses 2: 243. 1988; Mei-zhi, Xing-jiang & He, Moss Fl. China 8: 298. 2005. — *Webera mucronifolia* (Mitt.) Broth., Nat. Pflanzenfam. I(3): 664. 1904. — *Diphyscium involutum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 149. 1859; Gangulee, Mosses E. India 1: 63. 1969; Noguchi, Ill. Moss Fl. Japan 1: 16. 1994. — *Diphyscium auriculatum* Besch., Ann. Sci. Nat., Bot., sér. 5, 18: 220. 1873. — *Webera integerrima* Broth., Leaflet. Philipp. Bot. 2: 653. 1909. (**Figure 5.20**)

Plants blackish-green, often in loose turf, small, 3–5 mm high. **Stems** simple. **Leaves** crispate when dry, erect-spreading when wet; lanceolate to ligulate, 3.0–4.0 × 0.4–1.0 mm; acute, mucronate to apiculate at apex; margins entire throughout, 4–6 cells thick in cross section; costae shortly excurrent, with two stereid bands; leaf lamina bistratose above base; median cells rounded to quadrate, smooth, 6–15 × 8–13 µm, basal cells long rectangular, hyaline, smooth, 31–61 × 10–16 µm. **Dioicous**. **Perichaetia** terminal; perichaetial leaves lanceolate, 4.0–5.4 × 0.5–1.0 mm; awn long excurrent, smooth; margins dissected above. **Setae** very short. **Capsules** oblong-ovoid, obliquely asymmetric, 2–3 mm long, abruptly narrowed at base and mouth. **Opercula** conic obtuse. **Peristome** double; exostome teeth short and irregular;

endostome elongate, membrane high and conic, keeled, papillose. **Calyptrae** conic, smooth.

Additional illustration. – Gangulee (1969: 63, Fig. 27, as *D. involutum*); Eddy (1988: 242, Fig. 323A–G); Wu, Crosby & He (2005: 300, Pl. 738, Fig. 1–7).

Thailand. – PENINSULAR: Trang (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Japan, Malaysia, Philippines, New Guinea, Sri Lanka, and Taiwan (He, 1995).

Ecology. – On rocks under shade of tree, near waterfall, at 1,226–1,239 m elevation.

Specimens examined. – *P. Ajintaiyasil* 148, 204 (BCU).



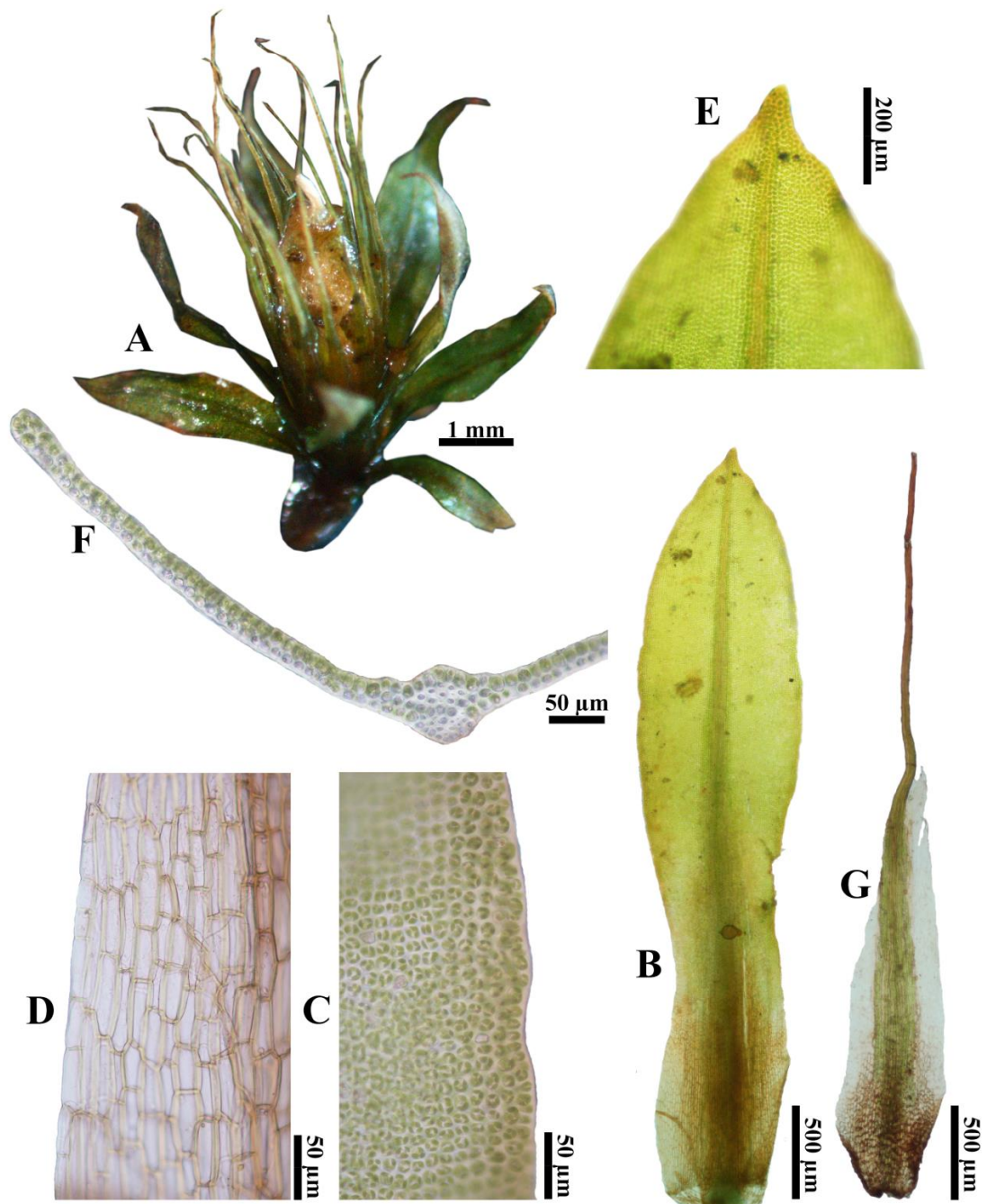


Figure 5. 20 *Diphyscium mucronifolium* Mitt.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf margin, D. Cell at leaf base, E. Leaf apex, F. Cross section of leaf, G. Perichaetial leaf. Based on *P. Ajintaiyasil* 148.

7. ENTODONTACEAE

Kindb., Gen. Eur. N.- Amer. Bryin. 7. 1897; Gangulee, Mosses E. India 8: 1753. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1013. 1994; Ren-liang & You-fang, Moss Fl. China 7: 168. 2008.

Plants medium-sized, forming loose to dense mats. **Stems** loosely to strongly complanate-foliate or julaceous, creeping to distally subscending, monopodially branched, radiculose beneath; central strand present; pseudoparaphyllia foliose. **Leaves** imbricate, appressed to erect; ovate to oval or ovate- to oblong-lanceolate, usually concave, smooth or plicate; apex acute to short acuminate, occasionally apices reflexed; base slightly clasping or not; margins entire or distally serrulate or serrate, elimbate; costae short and forked, or absent; leaf cells smooth, median cells linear to fusiform or rhomboidal; alar region differentiated, cells numerous, subquadrate, extending along margin 1/5–1/3 leaf length. **Autoicous**, less often dioicous. **Perichaetia** lateral, leaves elongate, mostly narrowly to somewhat broadly oblong-lanceolate. **Setae** elongate, smooth. **Capsules** long-exserted, erect, urn ovoid-cylindrical, symmetric; columella often exserted. **Opercula** conic short to long rostrate. **Peristome** double, inserted below mouth, exostome teeth 16, papillose or vertically to horizontally striate; endostome basal membrane mostly strongly reduced, segments usually narrow, perforate, cilia absent. **Calyptrae** cucullate, smooth and naked. **Spores** spherical, finely to coarsely papillose.

Key to the genera

- 1a. Stems and branches julaceous; leaves densely imbricate.....2. *Erythrodontium*
 1a. Stems and branches not julaceous; leaves complanate.....1. *Entodon*

1. ENTODON

Müll. Hal., Linnaea 18(6): 704. 1844; Gangulee, Mosses E. India 8: 1767. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1014. 1994; Ren-liang & You-fang, Moss Fl. China 7: 168. 2008.

Plants green to yellowish green, glossy, often in dense, complanate mats. **Stems** prostrate, regularly or irregularly branched, complanate branches. **Leaves** ovate, elliptical, or ovate-lanceolate; obtuse, acute, or acuminate at apex, concave; not or rather decurrent at base; margins plane or slightly recurved at base, entire or serrulate near apex; costae double, usually short; median leaf cells linear, often shorter at the apex; alar cells quadrate or shortly rectangular, in a triangular group, sometimes extending close to the costae at leaf base. **Autoicous**, rarely dioicous. **Perigonia** small, bud-like; perigonial leaves broadly ovate, concave, entire or serrate, involute above, ecostaete. **Perichaetia** ovate-lanceolate to lanceolate, sheathing at base. **Setae** elongate. **Capsules** erect, symmetric, cylindrical. **Opercula** long conic-rostrate. **Peristome** double, inserted well below the mouth; exostome teeth linear-lanceolate, cross-striolate or papillose at base; endostome segments linear, as long as or shorter than the teeth; basal membrane low; cilia absent. **Calyptrae** cucullate, smooth. **Spores** spherical, roughened to finely papillose.

Entodon macropodus (Hedw.) Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 193. 1898; Gangulee, Mosses E. India 8: 1789. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1017. 1994; Ren-liang & You-fang, Moss Fl. China 7: 187. 2008. — *Neckera macropoda* Hedw., Sp. Musc. Frond. 207. 1801. — *Cylindrothecium drummondii* Schimp. ex Sull., Manual 664. 1856. — *Entodon delavayi* Besch., Ann. Sci. Nat., Bot., sér. 7, 15: 87. 1892. — *Entodon excavatus* Broth., Symb. Sin. 4: 114. 1929. (**Figure 5.21**)

Plants pale green to yellowish green, sometimes brownish, glossy, in complanate mats. **Stems** prostrate, loosely pinnately branched. **Stem leaves** complanate; oblong, oblong-ovate, or ovate-lanceolate, concave, 1.3–1.4 × 0.4–0.5 mm; obtuse or mucronate at apex; margins plane, entire below, serrulate at apex; costae double, short; median leaf cells linear, 74–110 × 3–6 µm, apical cells shorter, 15–48 × 3–6 µm; alar cells quadrate, 18–40 × 13–21 µm, in 5–6 rows of cells along margins. **Branch leaves** narrower, dentate at apex. **Autoicous**. **Perichaetia** ovate-lanceolate, sheathing at base. **Setae** 1.0–1.4 cm long, yellowish. **Capsules** erect, cylindrical, 2–3 mm long, pale brownish. **Opercula** not seen. **Peristome** double; exostome teeth lanceolate, cross-striolate in basal 3–4 plates, vertically or obliquely striolate above; endostome segments linear, as long as teeth, vertically or obliquely striolate throughout. **Spores** minutely papillose.

Additional illustration. – Gangulee (1980: 1791, Fig. 907); Hu (1983: 197, Fig. 1–10); Noguchi (1994: 1019, Fig. 447).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai. NORTH-EASTERN: Loei. SOUTH-WESTERN: Ratchaburi. PENINSULAR: Nakhon Ratchasima (He, 1995).

Distribution. – Brazil, Bhutan, Celebes, China, Colombia, Guatemala, India, Japan, Laos, Mexico, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, Vietnam, and United States (He, 1995; Waard & Florschütz, 1979).

Ecology. – On log in the sun, at 945 m elevation.

Specimens examined. – *P. Ajintaiyasil* 123 (BCU).

2. ERYTHRODONTIUM

Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 3, 2: 279. 1870; Gangulee, Mosses E. India 8: 1795. 1980; Ren-liang & You-fang, Moss Fl. China 7: 206. 2008.

Plants green, yellowish green, or brownish, somewhat glossy, in dense mats. **Stems** prostrate, regularly pinnately branched; branches densely foliate, distinctly julaceous. **Leaves** rather small, stem and branch leaves similar; densely imbricate when dry or moist; broadly ovate or oblong-ovate, concave; apex abruptly acuminate or apiculate; margins plane, entire or minutely serrulate near apex; costae double, very short or absent; median leaf cells oblong-elliptical to rhomboidal, smooth, basal cells shorter; alar cells differentiated in groups, quadrate or oblate. **Autoicous**, rarely dioicous. **Perichaetia** sheathing at base, narrowly lanceolate above. **Setae** slender, reddish or yellowish. **Capsules** yellowish brown, erect, cylindrical. **Opercula** long

conic-rostrate; annuli not developed. **Peristome** inserted below the mouth; exostome teeth broadly lanceolate; endostome segments linear, fragile; basal membrane low. **Calyptrae** cucullate. **Spores** papillose.

Erythrodontium julaceum (Hook. ex Schwägr.) Paris, Index Bryol. 436. 1896; Gangulee, Mosses E. India 8: 1796. 1980; Ren-liang & You-fang, Moss Fl. China 7: 206. 2008. — *Neckera julacea* Hook. ex Schwägr., Sp. Musc. Frond., Suppl. 1(2): 245. 1828. — *Pterogonium squarrosulum* Mont., London J. Bot. 4: 9. 1845. — *Entodon squarrosulus* Müll. Hal., Linnaea 42: 435. 1879. — *Erythrodontium squarrosulum* (Mont.) Paris, Index Bryol. 437. 1896. (**Figure 5.22**)

Plants green, yellowish green, or brownish, stiff, glossy, in dense mats. **Stems** prostrate, densely branched; branches short, julaceous. **Leaves** imbricate; mostly ovate, 0.8–0.9 × 0.4–0.5 mm; clearly concave, often apiculate at apex; margins entire, or slightly serrulate at apex; costae double, indistinct or absent; median leaf cells linear-rhomboidal or narrowly elliptical, smooth, 42–50 × 5–10 µm, basal and alar cells differentiated into triangular groups at base, quadrate or oblate, 9–17 × 10–14 µm, often extending upward along margins. **Autoicous**. **Setae** 12–16 mm long, twisted when dry. **Capsules** oblong-ovoid, 2.0–3.0 mm. **Opercula** not seen. **Peristome** deeply inserted below the mouth; exostome teeth 16, reddish, broadly lanceolate, cross-striolate at base, longitudinal-striolate above; endostome segments poorly developed. **Spores** coarsely papillose.

Additional illustration. – Bartram (1939: Pl. 23, Fig. 388); Gangulee (1980: 1797, Fig. 910); Hu, Wang, Crosby, & He (2008: 207, Pl. 575, Fig. 1–12)

Thailand. – NORTHERN: Chiang Mai, Chiang Rai, Tak, Phitsanulok. NORTH-EASTERN: Loei. SOUTH-WASTERN: Ratchaburi. PENINSULAR: Surat Thani.

Distribution. – Bhutan, Brunei, China, India, Indonesia, Laos, Myanmar, Malaysia, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam.

Ecology. – On logs or barks of tree in the sunlight, at 533–1,031 m elevation.

Specimens examined. – *P. Ajintaiyasil 104, 182, 239* (BCU).

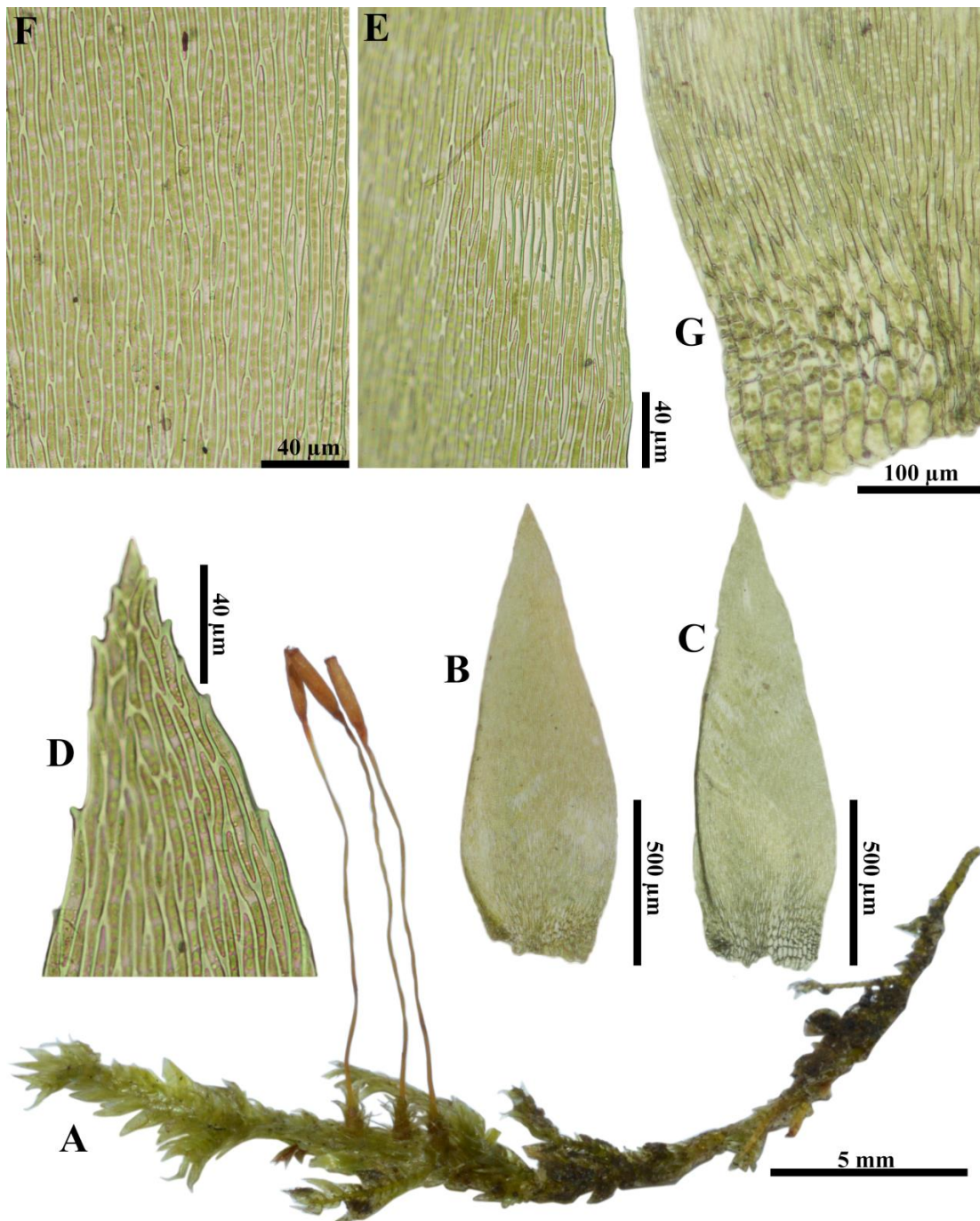


Figure 5. 21 *Entodon macropodus* (Hedw.) Müll. Hal.

A. Gametophyte with sporophytes, B–C. Stem leaves, D. Leaf apex, E. Leaf margin, F. Cells at median part of leaf, G. Leaf base with alar cells. Based on *P. Ajintaiyasil* 123.

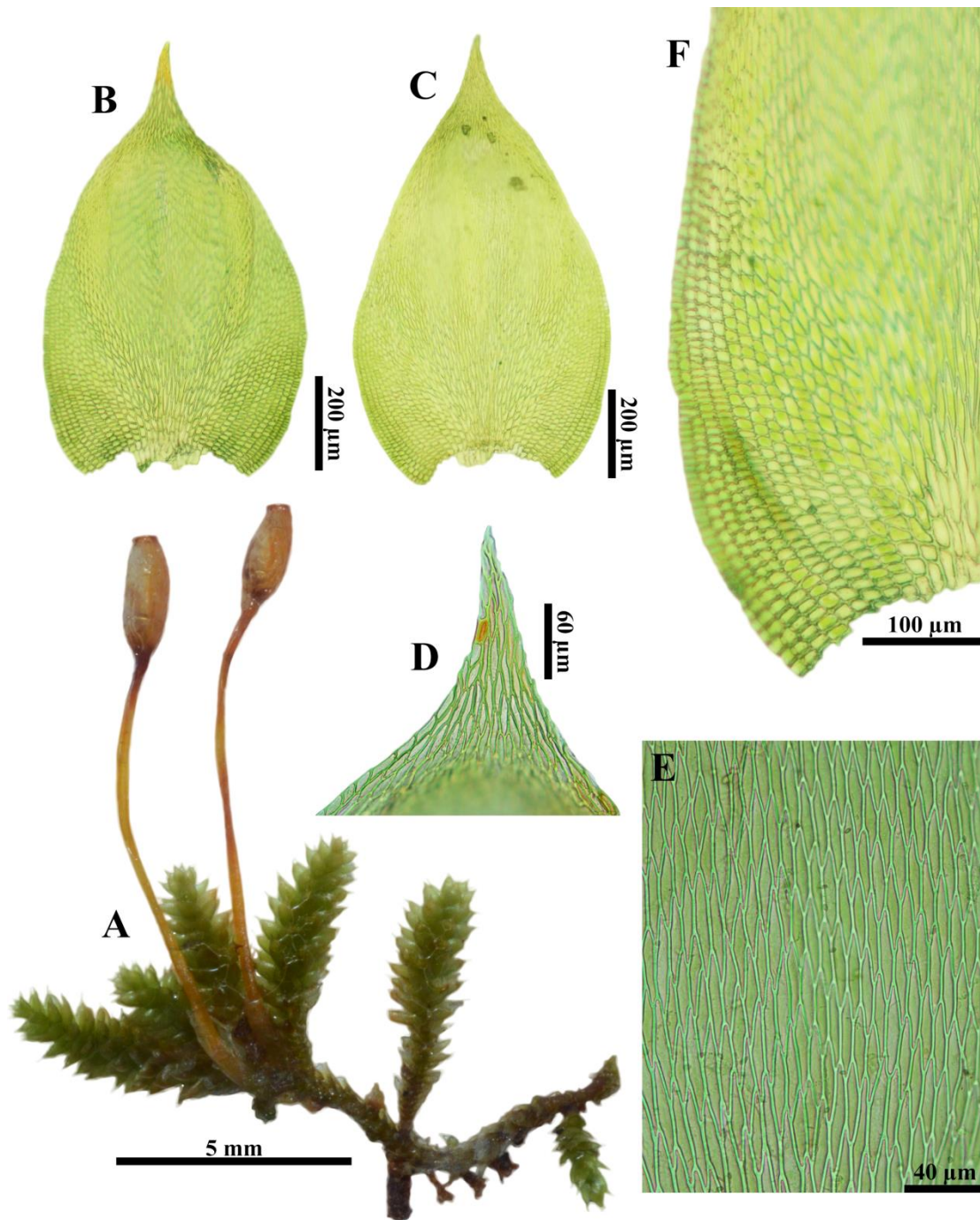


Figure 5.22 *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris

A. Gametophyte with sporophytes, B–C. Leaves, D. Leaf apex, E. Cells at median part of leaf, F. Leaf base with alar cells. Based on *P. Ajintaiyasil 104*.

8. ERPODIACEAE

Broth., Nat. Pflanzenfam. I(3): 706. 1905; Gangulee, Mosses E. India 5: 1136. 1974; Noguchi, Ill. Moss Fl. Japan 2: 385. 1988; Mei-zhi, Moss Fl. China 5: 3. 2011.

Plants somewhat small, in loose to somewhat dense mats, dull light to dark green. **Stems** creeping, irregularly pinnately branched, terminal stems and branches often ascending and curled, radiculose beneath. **Leaves** crowded, appressed to weakly complanate, occasionally appearing 4-ranked; ovate, oblong-ovate to nearly orbicular, symmetric to asymmetric; concave, apex acuminate to acute, obtuse-rounded, apiculate or subpiliferous or not; margins plane, entire or crenulate by projecting papillae; costae lacking; cells often papillose, apical cells elongate or isodiametric, median cells quadrate or rhombic to hexagonal and horizontally arranged or oblate; alar cells quadrate to oblong, oblately arranged. **Autoicous**. **Perichaetia** terminal on short lateral branches; leaves often enveloping Sporophytes, oval to oblong. **Setae** erect mostly short. **Capsules** immersed to short exserted, erect to subinclined. **Opercula** conic-rostrate or apiculate. **Peristome** absent or single, teeth 16, poorly developed short, papillose or irregular pale segments. **Calyptrae** mitrate, plicate, surface smooth to roughened. **Spores** spherical, smooth to finely papillose.

Key to the genera

- 1a. Leaves dimorphic, the apices of leaves rounded.....2. *Solmsiella*
 1a. Leaves dorsal and ventral similar in shape, apices of leaves acuminate.....
1. *Erpodium*

1. ERPODIUM

(Brid.) Brid., Bryol. Univ. 2: 788. 1827; Gangulee, Mosses E. India 5: 1137. 1974.

Plants somewhat small, in loose to dense mats, dull light to dark green. **Stems** creeping, irregularly pinnately branched, terminal stems and branches often spreading to ascending and curled, radiculose beneath. **Leaves** appressed to weakly complanate, occasionally appearing 4-ranked; ovate, ovate-oblong to nearly orbicular, symmetric to asymmetric; concave, apex acuminate to acute rounded, apiculate or piliferous; margins plane, entire; costae lacking; cell smooth or pluripapillose, apical cells elongate isodiametric, median cells quadrate- to hexagonal rounded and horizontally arranged or oblate; alar region differentiated, cells oblong, oblately arranged. **Perichaetial leaves** often enveloping sporophytes, oval to oblong. **Setae** short. **Capsules** immersed to short exserted, erect to subinclined, urn short-cylindrical. **Opercula** conic-rostrate. **Peristome** absent or poorly developed, papillose. **Calyptrae** mitrate-short campanulate, plicate and lobed at base, or appearing cucullate, roughened or not. **Spores** smooth to lightly papillose.

Erpodium mangiferae Müll. Hal., Linnaea 37: 178. 1872; Gangulee, Mosses E. India 5: 1138. 1974. — *Erpodium bellii* Mitt., J. Linn. Soc., Bot. 13: 307. 5B. 1873. (Figure 5.23)

Plants pale green or dark green, in dense mats. **Stems** creeping, irregularly pinnately branched, terminal stems and branches often spreading to ascending, radiculose beneath. **Leaves** in several rows, appressed to stem when dry, erecto-patent to erect-spreading when moist; ovate, 0.7–0.8 × 0.3–0.4 mm; concave, short acuminate; margins entire and flat; costae lacking; cell smooth, median cells rhomboid-luxagonal, 32–50 × 13–20 µm, comparatively large at middle, marginal cells oval hexagonal, transversely elongated at lower margins; alar region differentiated, alar cells rhomboid, 11–20 × 17–29 µm. **Sporophytes** not seen.

Additional illustration. – Gangulee (1976: 1139, Fig. 553); Wei *et al.* (2016: 627, Fig. 1).

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – China, India (He, 1995).

Ecology. – On bark under shade of tree, at 405 m elevation.

Specimens examined. – *P. Ajintaiyasil 449* (BCU).

2. SOLMSIELLA

Müll. Hal., Bot. Centralbl. 19: 149. 1884; Mei-zhi, Moss Fl. China 5: 7. 2011.

Plants light to yellow-green, becoming brownish with age, in dense mats. **Stems** creeping, irregularly pinnately branched. **Leaves** complanate both dry or wet, arranged in 4 rows, dimorphic, dorsal leaves larger, asymmetric, ventral leaves smaller, symmetric; laminal cells pluripapillose. **Perichaetial** leaves slightly enlarged, sheathing. **Setae** short. **Capsules** shortly exserted, oblong-cylindric, stomata few or absent; annulus narrow, persistent. **Peristome** absent. **Opercula** obliquely apiculate to rostellate. **Calyptrae** cucullate, papillose, non-plicate. **Spores** finely papillose.

Solmsiella biseriata (Austin) Steere, Bryologist 37: 100. 1935; Mei-zhi, Moss Fl. China 5: 7. 2011. — *Lejeunea biseriata* Austin, Proc. Acad. Nat. Sci. Philadelphia 21: 225. 1869. — *Erpodium ceylonicum* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 306. 5A. 1873. — *Solmsiella ceylonica* (Thwaites & Mitt.) Müll. Hal., Bot. Centralbl. 19: 149. 1884. — *Erpodium exsertum* Besch., J. Bot. (Morot) 5: 254. 1891. — *Erpodium latifolium* R.S. Williams, Contr. U.S. Natl. Herb. 20(13): 519, 38. 1924. (**Figure 5.24**)

Plants light green to dark green or yellowish brown, in loose mats, closely attached to substrate, small. **Stems** prostrate, 5–9 mm long, irregularly to subpinnately branched, often with complanate branchlets; with a few rhizoids on ventral surface; **Leaves** dimorphic; stem and branch leaves arranged in 4 rows, 2 dorsal and 2 ventral; imbricate when dry, complanate-spreading when moist; dimorphic. **Dorsal leaves** larger, ovate or oblong-ovate, asymmetric, 0.4–0.7 × 0.3–0.5 mm. **Ventral leaves** smaller, elliptical or oblong-lingulate, 0.2–0.3 × 0.07–0.2 mm; rounded-obtuse at the apex, more or less symmetric; margins entire, sometimes incurved at the base; costae none; median and upper leaf cells subquadrate to rounded-hexagonal, densely pluripapillose, 14–23 × 10–13 µm. **Autoicous**. **Setae** 0.7–0.8 mm long. **Capsules**

shortly cylindrical, 0.5–0.7 mm long. **Opercula** conic at the base, shortly rostrate. **Peristome** absent. **Calyptrae** not seen. **Spores** finely papillose.

Additional illustration. – Wu, Crosby, & He (2011: 8, Pl. 240, Fig. 1–12).

Thailand. – NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Loei (He, 1995).

Distribution. – Australia, China, India, Indonesia, Mexico, Paraguay, Philippines, Sri Lanka, Taiwan, Tanzania, United States, and Venezuela (He, 1995; Wu, Crosby & He, 2011).

Ecology. – On groove bark under shade of tree, at 585 m elevation.

Specimens examined. – *P. Ajintaiyasil* 330 (BCU).



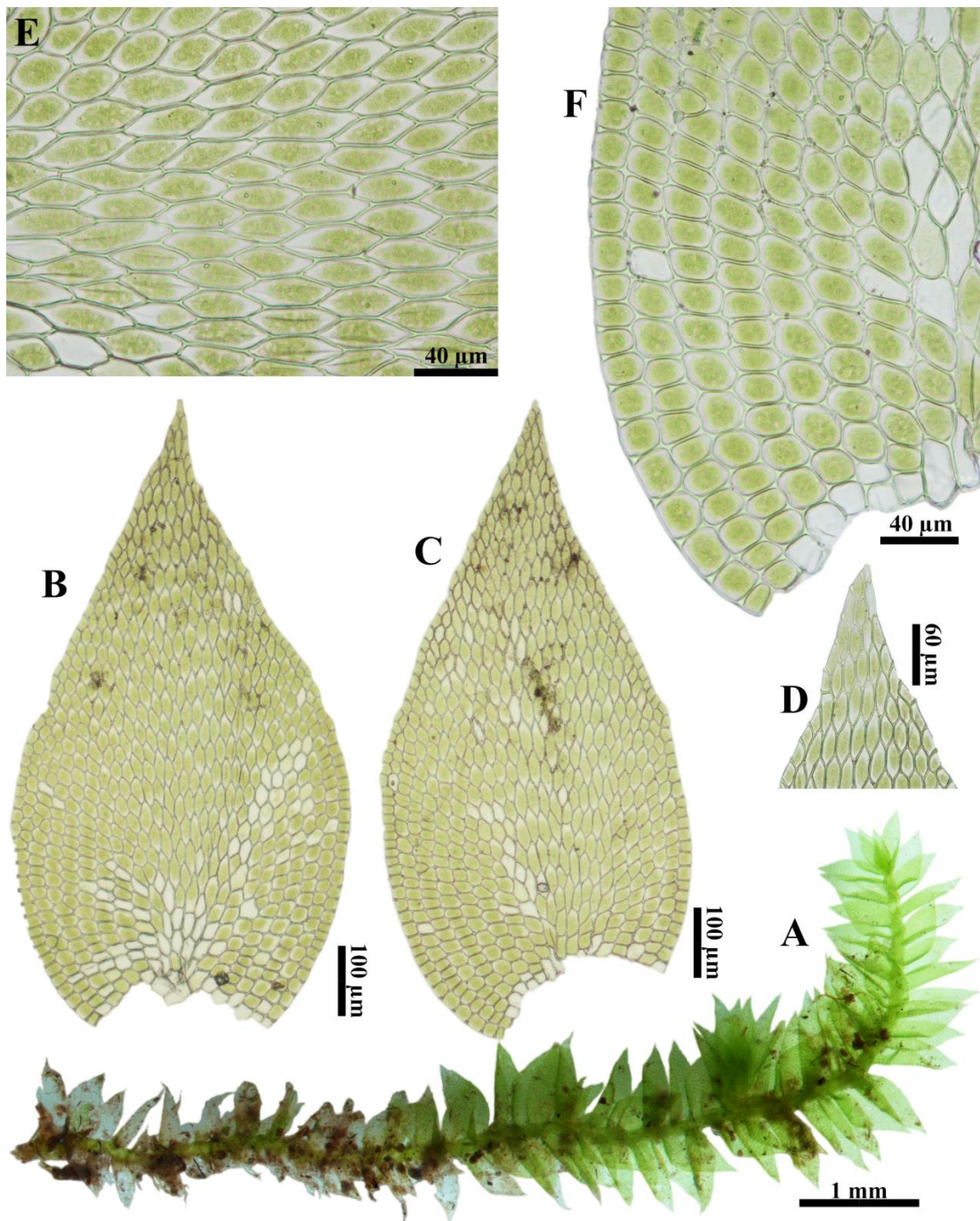


Figure 5.23 *Erpodium mangiferae* Müll. Hal.

A. Gametophyte, B–C. Leaves, C. Leaf apex, D. Cells at median part of leaf, E. Leaf base with alar cells. Based on *P. Ajintaiyasil* 449.

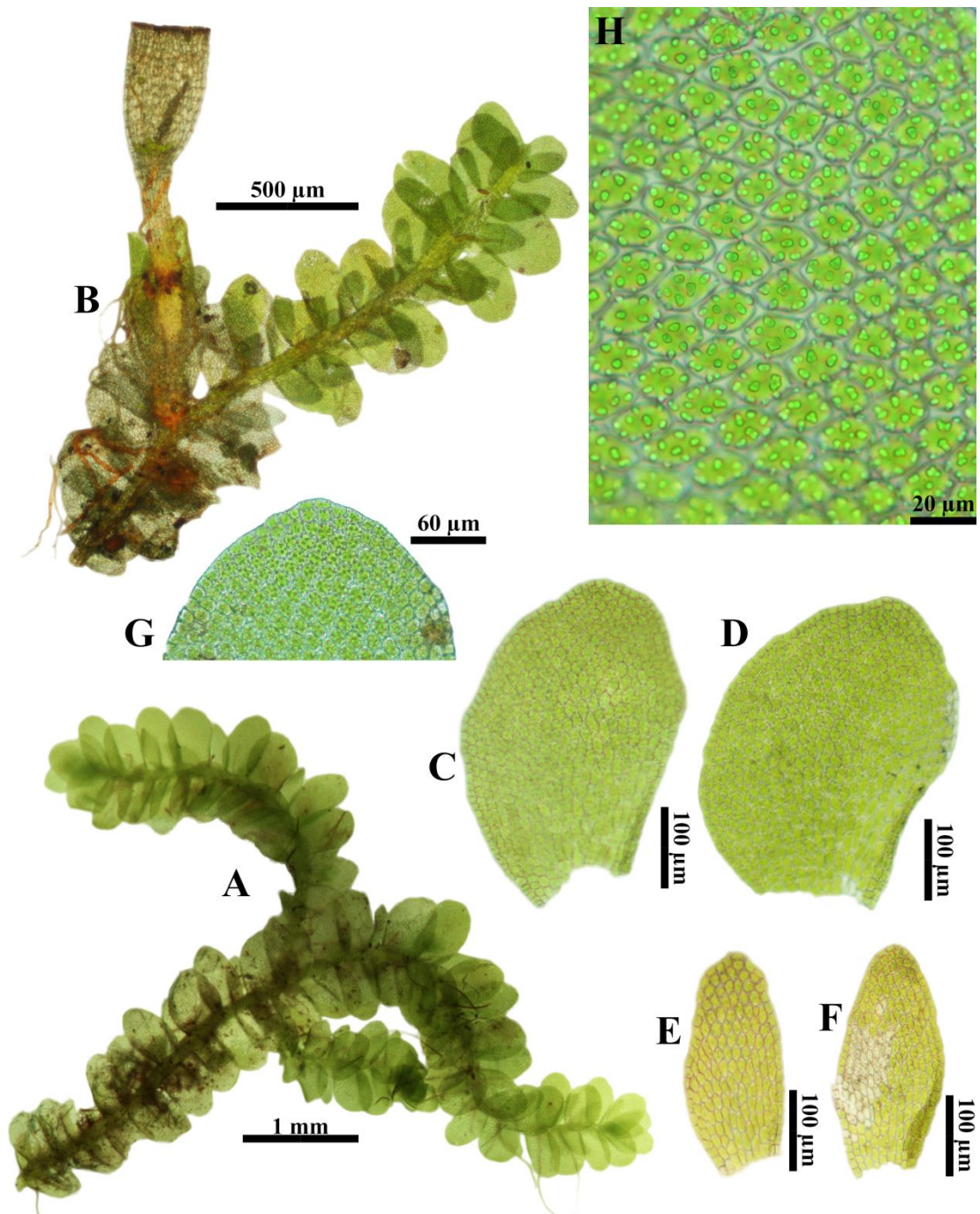


Figure 5. 24 *Solmsiella biseriata* (Austin) Steere

A. Sterile gametophyte, B. Gametophyte with sporophyte, C–D. Dorsal leaves, E–F. Ventral leaves, G. leaf apex, H. Cells at median part of dorsal leaf. Based on *P. Ajintaiyasil 330*.

9. FISSIDENTACEAE

Schimp., Coroll. Bryol. Eur. 20. 1856; Gangulee, Mosses E. India 2: 447. 1971; Noguchi, Ill. Moss Fl. Japan 1: 57. 1987; Eddy, Handb. Males. Mosses 1: 54. 1988; Zhi-hua & Iwatsuki, Moss Fl. China 2: 3. 2001.

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

FISSIDENS

Hedw., Sp. Musc. Frond. 152. 1801; Gangulee, Mosses E. India 2: 447. 1971; Noguchi, Ill. Moss Fl. Japan 1: 57. 1987; Eddy, Handb. Males. Mosses 1: 57. 1988; Zhi-hua & Iwatsuki, Moss Fl. China 2: 3. 2001.

Plants very small to medium-sized, mostly erect, forming turfs or solitary, dull to more commonly bright green, occasionally blackish-, reddish- or brownish-green. **Stems** simple or branched; in cross section central strand present or absent. **Leaves** distichous and complanate; median and upper leaves mostly oblong to ligulate or oblong-lanceolate, composed of vaginant laminae, with dorsal and ventral lamina; margins smooth, crenulate, or occasionally distally serrulate to irregularly sharply serrate, limbate, sometimes intramarginally, or elimbate, when limbate the limbidium uni- to multistratose; costae single, usually strong, percurrent or short to long excurrent; laminal cells smooth, mammillose or uni- or pluripapillose, border (marginal or intramarginal) cells when present linear and smooth. **Autoicous**, synoicous or dioicous. **Perichaetia** terminal, occasionally lateral, leaves often differentiated. **Setae** erect or variously curved, smooth. **Capsule** exserted, erect to horizontal, urn ovoid to broadly cylindrical; annulus absent. **Opercula** conic short to long rostrate. **Peristome** single, teeth 16, divided to half or more below, occasionally undivided or imperfectly divided, striate or papillose, occasionally peristome teeth absent. **Calyptrae** cucullate or short mitrate, naked, smooth or roughened. **Spores** spherical, smooth to lightly papillose.

Key to the species

- 1a. Leaves limbate or partially limbate.....2
 - 2a. Limbidia all around the leaf margins.....3
 - 3a. Cells of laminae irregularly rectangular to hexagonal.....
 -3. *Fissidens flaccidus* var. *flaccidus*
 - 3b. Cells of laminae quadrate to irregularly hexagonal.....
 -4. *Fissidens geppii*
 - 2b. Limbidia confined to the vaginant laminae.....4
 - 4a. Lamina cells with cluster of 2–5 high papillae.....6. *Fissidens incognitus*
 - 4b. Lamina cells numerous largely papillae.....1. *Fissidens ceylonensis*
- 1b. Leaves elimbate.....5

- 5a. Marginal cells different from the inner laminal cells, dark in color, 2 to several cells in thickness.....7. *Fissidens javanicus*
- 5b. Marginal cells not different from the inner laminal cells, one cell thick.....6
- 6a. Axillary hyaline nodules well-developed.....7
- 7a. Lamina cells unipapillose.....9. *Fissidens subangustus*
- 7b. Lamina cells slightly mammillose....2. *Fissidens crispulus* var. *robinsonii*
- 6b. Axillary hyaline nodules not developed.....8
- 8a. Plants more than 1.5 cm long.....8. *Fissidens polypodioides*
- 8b. Plants less than 1 cm long.....5. *Fissidens guangdongensis*

1. *Fissidens ceylonensis* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 304. 1844; Gangulee, Mosses E. India 2: 511. 1971; Noguchi, Ill. Moss Fl. Japan 1: 57. 1987; Eddy, Handb. Males. Mosses 1: 81. 1988; Zhi-hua & Iwatsuki, Moss Fl. China 2: 3. 2001. — *Fissidens bicolor* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 322. 1873. — *Fissidens pennatulus* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 325. 1873. — *Fissidens intromarginatulus* E.B. Bartram, Rev. Bryol. Lichénol. 23: 242. 1954; ; Gangulee, Mosses E. India 2: 510. 1971; Eddy, Handb. Males. Mosses 1: 83. 1988. — *Fissidens philonotulus* Besch., Bull. Soc. Bot. France 48: 13. 1901. — *Fissidens siamensis* Broth., Bot. Tidsskr. 24: 117. 1901. (**Figure 5.25**)

Plants green to dark green, forming turfs, 1.4–2.0 mm long. **Stems** simple or branched, hyaline nodules not to weakly differentiated; cenral strand weakly differentiated. **Leaves** broadly lanceolate to oblong-lanceolate, 0.6–0.7 × 0.2–0.3 mm; acute to broadly acute at apex; base not decurrent; margins nearly entire; limbidium limited on lower half of vaginant laminae, 1–2 rows of cells, one cell thick; costae slightly excurrent; vaginant lamina about 1/2–2/3 leaf length; cells quadrate to rounded-polygonal, thin-walled, pluripapillose with numerous largely papillae per cell, 10–14 × 9–14 µm. **Autoicous**. **Perichaetial** leaves narrower than those of other leaves. **Setae** smooth, 1.5–2.0 mm long. **Capsules** cylindrical, erect, symmetrical, 0.4–0.5 mm long. **Opercula** not seen. **Peristome** not seen. **Spores** not seen.

Additional illustration. — Gangulee (1971: 510–513, Fig. 239–240, as *F. intromarginatulus*); Eddy (1988: 82, Fig. 75–76, as *F. intromarginatulus*); Iwatsuki & Mohamed (1987: 346, Fig. II, 1–22); Wongkuna (2010: 45, Fig. 24).

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Tak, Phitsanulok. NORTH-EASTERN: Sakon Nakhon, Khon Kaen. EASTERN: Chaiyaphum, Ubon Ratchathani. SOUTH-WASTERN: Phetchaburi, Prachuap Khiri Khan. CENTRAL: Suphan Buri, Nakhon Nayok. SOUTH-EASTERN: Rayong, Chanthaburi, Trat. PENINSULAR: Ranong, Surat Thani, Krabi, Nakhon Sri Thammarat, Trang, Satun, Songkhla, Narathiwat (Wongkuna, 2010).

Distribution. — Australia, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, New Zealand, Philippines, Seychelles, Sikkim, Singapore, Sri Lanka, Sumatra, Taiwan, and Vietnam (Wongkuna, 2010).

Ecology. – On soils or molehill in sunlight, sometime under shade of tree with *F. incognitus* and *F. subangustus*, rarely on barks under shade of tree, at 294–1,221 m elevation.

Specimens examined. – *P. Ajintaiyasil* 054, 160, 174C, 248, 312, 321, 322, 431 (BCU).

2. *Fissidens crispulus* Brid. var. *robinsonii* (Broth.) Z. Iwats. & Z.H. Li, Moss Fl. China 2: 26. 2001. — *Fissidens robinsonii* Broth., Philipp. J. Sci. 13: 204. 1918; Gangulee, Mosses E. India 1: 534. 1969. (Figure 5.26)

Plants green to yellowish green, forming dense turfs, 2.1–3.0 mm long. **Stems** unbrached, hyaline nodules well-differentiated; central strand lacking. **Leaves** distinctly crisped when dry; the lowermost leaves much smaller than the leaves above, narrowly lanceolate, 1.5–1.6 × 0.2–0.3 mm; apex acute; base rounded; margins slightly crenulate, without limbate; costae percurrent to shortly excurrent; cells thin-walled, rounded or rounded-quadrate to rounded-polygonal, slightly mammillose, walls clear, 5–9 × 5–10 μm; vaginant lamina more than 1/2 leaf length, cells of vaginant lamina similar to those of other leaves. **Sporophytes** not seen.

Additional illustration. – Gangulee (1971: 534, Fig. 253, as *F. robinsonii*); Iwatsuki & Mohamed (1987: 355, Fig. VI, 1–14, as *F. robinsonii*); Li, Crosby, & He (2001: 27, Pl. 77, Fig. 1–14); Wongkuna (2010: 55, Fig. 29).

Thailand. – NORTHERN: Chiang Mai. SOUTH-WASTERN: Phetchaburi CENTRAL: Suphanburi, Nakhon Nayok. PENINSULAR: Ranong, Krabi, Nakhon Sri Thammarat (Wongkuna, 2010).

Distribution. – China, Hong Kong, India, Indonesia, Malaysia, Philippines, and Singapore (Wongkuna, 2010).

Ecology. – On soils under shade of tree or on rocks with *Thuidium pristocalyx* var. *pristocalyx* under shade of tree, at 979–1,262 m elevation.

Specimens examined. – *P. Ajintaiyasil* 236A, 257, 343A (BCU).

3. *Fissidens flaccidus* Mitt. var. *flaccidus*, Trans. Linn. Soc. London 23: 56. 6 f. 18. 1860; Zhi-hua & Iwatsuki, Moss Fl. China 2: 31. 2001. — *Fissidens macrophyllus* Mitt., J. Linn. Soc., Bot. 12: 600. 1869. — *Fissidens mollis* Mitt., J. Linn. Soc., Bot. 12: 600. 1869. — *Fissidens cellulosus* Mitt., J. Linn. Soc., Bot. 22: 319. 1886. — *Fissidens luridus* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 29(1): 172. 1890. — *Fissidens palmatulus* Besch., Rev. Bryol. 18: 50. 1891. — *Fissidens schwackeanus* Broth., Hedwigia 34: 119. 1895. (Figure 5.27)

Plants pale green, lower part brownish, forming turfs, 2.0–2.5 mm long. **Stems** simple, densely foliated; hyaline nodules not differentiated; central strand lacking. **Leaves** lowest leaves small, upper leaves much larger, lanceolate, 1.5–1.6 × 0.2–0.3 mm; apex acute; base not decurrent; margin entire; limbidia distinct, present throughout laminae, consisting of 2–3 rows of narrow and thick-walled cells, borders of vaginant laminae thicker, consisting 2–4 rows of linear cells; costae ending 6–10

cells below the apex; vaginant lamina about half of leaf length; cells of apical lamina irregularly rectangular to hexagonal and similar to dorsal lamina, smooth, thin-walled, $36\text{--}57 \times 15\text{--}23 \mu\text{m}$, cells of vaginant lamina, rectangular, smooth, $26\text{--}52 \times 12\text{--}21 \mu\text{m}$. **Dioicous**. **Perichaetial** leaves slightly wider than those of other leaves. **Setae** smooth, 3.5–4.0 mm long. **Capsules** ovate to cylindrical, erect, symmetrical, 0.4–0.5 mm long. **Opercula** not seen. **Peristome** single, teeth 16, divided to more below, striate. **Spores** not seen.

Additional illustration. – Wongkuna (2010: 65, Fig. 33).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTERN: Sakon Nakhon. SOUTH-WESTERN: Phetchaburi. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Rayong. PENINSULAR: Krabi (Wongkuna, 2010).

Distribution. – Antilles, Argentina, Bolivia, Brunei, Cape Verde, Central African Republic, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, French Guiana, Haiti Jamaica, Hong Kong, India, Indonesia, Japan, Malaysia, Mexico, Myanmar, Nepal, Netherland, Nevis, New Guinea, Nigeria, Peru, Philippines, Rodrigues, Saint Kitts, Saint Lucia, Seychelles, Sierra Leone, Singapore, Sri Lanka, Taiwan, Venezuela, Vietnam, and Zimbabwe (Wongkuna, 2010).

Ecology. – On soils under shade of tree, at 462 m elevation.

Specimens examined. – *P. Ajintaiyasil* 243 (BCU).

4. *Fissidens geppii* M. Fleisch., Musci Buitenzorg 1: 26. 1904; Noguchi, Ill. Moss Fl. Japan 1: 68. 1987; Eddy, Handb. Males. Mosses 1: 92. 1988; Zhi-hua & Iwatsuki, Moss Fl. China 2: 35. 2001. — *Fissidens hasskarlii* var. *irrigatus* M. Fleisch., Hedwigia 38: 1 8. 1899. (**Figure 5.28**)

Plants light to dark green, forming turfs, 2.0–2.5 mm long. **Stems** erect, hyaline nodules not differentiated; central strand lacking. **Leaves** narrowly lanceolate to lanceolate, $1.9\text{--}2.2 \times 0.5\text{--}0.6 \text{ mm}$; apex acute to mucronate; base decurrent; margin entire; costae prominent, reddish in older leaves, percurrent or shortly excurrent; limbidia very thick, and broad, yellowish-brown on older leaves, 2–3 rows of cell wide, 2–4 layers thick in cross-section; vaginant laminae about 1/2 of leaf-length; cells in apical portion of lamina quadrate to irregularly hexagonal, smooth, $8\text{--}11 \times 6\text{--}10 \mu\text{m}$, cells of vaginant laminae similar to those of other leaves. **Synicous**. **Perichaetial** leaves narrowly and slightly longer than upper stem leaves or nearly equal; limbidia on perichaetial leaves, with 3–7 rows of cells, 2–3 layer thick. **Setae** smooth, 3.5–4.4 mm long. **Capsules** urnceolate, erect, sometimes very slightly symmetrical, neck distinct, 0.8–1.0 mm long. **Opercula** not seen. **Peristome** single, spirally thickened above. **Spores** not seen.

Additional illustration. – Noguchi (1987; 69, Fig. 22A); Eddy (1988: 92, Fig. 88); Li, Crosby, & He (2001: 36, Pl. 80, Fig. 1–11); Wongkuna (2010: 65, Fig. 37).

Thailand. – NORTHERN: Chiang Mai (Wongkuna, 2010).

Distribution. – Brunei, China, Hong Kong, India, Indonesia, Japan, Malaysia, Nepal, and Taiwan (Wongkuna, 2010).

Ecology. – On rocks with *Philonotis hastata* under shade of tree, at 1,121 m elevation.

Specimens examined. – *P. Ajintaiyasil 340B* (BCU).

5. *Fissidens guangdongensis* Z. Iwats. & Z.H. Li, Acta Bot. Fenn. 129: 35. f. 15: n-x. 1985; Zhi-hua & Iwatsuki, Moss Fl. China 2: 37. 2001. (**Figure 5.29**)

Plants reddish brown to green, forming loosely turfs, 2.0–2.5 mm long. **Stems** usually simple, sometimes branched; hyaline nodules not differentiated. **Leaves** loosely arranged, lowest leaves small, middle and upper leaves much larger, lanceolate to oblong-lanceolate, 0.4–0.9 × 0.2–0.3 mm; apex broadly acute; base not decurrent; margin entire; without limbate; costae ending 4–6 cells below leaf apex; vaginant lamina about half to 2/3 of leaf length; cells of leaf apical similar to those on dorsal lamina, quadrate to polygonal, thin-walled, smooth, 13–18 × 7–12 µm, cells of vaginant lamina similar to those of the lamina, but larger. **Sporophyte** not seen.

Additional illustration. – Li, Crosby, & He (2001: 36, Pl. 80, Fig. 12–18); Wongkuna (2010: 75, Fig. 38).

Thailand. – NORTHERN: Chiang Mai, Phitsanulok. CENTRAL: Nakhon Nayok (Wongkuna, 2010).

Distribution. – China, Hong Kong, Japan, Malaysia, Singapore, and Taiwan (Wongkuna, 2010).

Ecology. – On soils under shade of tree, at 1,260 m elevation.

Specimens examined. – *P. Ajintaiyasil 201* (BCU).

6. *Fissidens incognitus* Gangulee, Bull. Bot. Soc. Bengal 11: 70. f. 9. 1957; Gangulee, Mosses E. India 2: 500. 1971; Zhi-hua & Iwatsuki, Moss Fl. China 2: 40. 2001. (**Figure 5.30**)

Plants yellow-green to green, forming loosely turfs, 3.5–4.0 mm long. **Stems** simple; hyaline nodules not differentiated; central strand not to weakly differentiated. **Leaves** loosely arranged, lower leaves small, upper leaves larger, lanceolate, 0.5–0.8 × 0.1–0.3 mm; apex acute; base rounded; margin serrate; intramarginal bordered confined to the vaginant laminae, with 1–2 rows of cells, and edged on outside by 1–2 row of pluripapillose cells with thickened walls; costae shortly excurrent; vaginant lamina about half of leaf length; cells of apical and dorsal laminae quadrate to polygonal, thin-walled, with cluster of 2–5 high papillae, 6–12 × 4–9 µm, cells of vaginant lamina similar to other leaf cells. **Sporophytes** not seen.

Additional illustration. – Gangulee (1971: 501, Fig. 233); Li, Crosby, & He (2001: 41, Pl. 81, Fig. 1–6); Wongkuna (2010: 83, Fig. 42).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTERN: Ubon Ratchathani. SOUTH-WESTERN: Kanchanaburi. CENTRAL: Suphan Buri, Nakhon Nayok. SOUTH-EASTERN: Rayong, Chanthaburi (Wongkuna, 2010).

Distribution. – Bangladesh, China, Hong Kong, India (Wongkuna, 2010).

Ecology. – On soils with *F. ceylonensis* and *F. subangustus* under shade of tree, at 1,221 m elevation.

Specimens examined. – *P. Ajintaiyasil 174A* (BCU).

7. *Fissidens javanicus* Dozy & Molke., Bryol. Jav. 1: 11. 3. 1855; Noguchi, Ill. Moss Fl. Japan 1: 88. 1987; Eddy, Handb. Males. Mosses 1: 83. 1988; Zhi-hua & Iwatsuki, Moss Fl. China 2: 42. 2001. — *Fissidens acutifolius* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 137. 1859. (**Figure 5.31**)

Plants dark green to yellowish-green, usually brownish when old, forming turfs, 4.0–5.0 mm long. **Stems** simple or branched; axillary hyaline nodules very distinctly differentiated; central strand weakly differentiated. **Leaves** densely arranged, the upper half of leaves usually more or less rugose, lanceolate to narrowly lanceolate, 1.4–1.7 × 0.2–0.3 mm; apex narrowly acute; base of dorsal lamina usually rounded, not decurrent; margins slightly crenulate, thick and dark, apical and dorsal laminae margins forming a thick band 2–3 cells wide and 2–3 cells thick; vaginant laminae margins forming a thinner band 2–3 cells wide and 1 cell thick; costae percurrent; vaginant lamina about 1/2 leaf length, apex oblique; cells subisodiametric or quadrate to hexagonal, mammillose, cells thick-walled, 4–10 × 6–11 μm, cells of vaginant laminae similar to those of the apical lamina, **Sporophytes** not seen.

Additional illustration. – Noguchi (1987: 91, Fig. 33B); Eddy (1988: 85, Fig. 79); Wongkuna (2010: 89, Fig. 45).

Thailand. – NORTH-EASTERN: Loei. SOUTH-WASTERN: Prachuap Khiri Khan. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Rayong, Trat. PENINSULAR: Phangnga, Nakhon Sri Thammarat (Wongkuna, 2010).

Distribution. – Bangladesh, Brunei, China, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Singapore, Sri Lanka, Sumatra, Taiwan, and Vietnam (Wongkuna, 2010).

Ecology. – On rocks under shade of tree, near waterfall, at 1,244 m elevation.

Specimens examined. – *P. Ajintaiyasil 078* (BCU).

8. *Fissidens polypodioides* Hedw., Sp. Musc. Frond.: 154. 1801; Zhi-hua & Iwatsuki, Moss Fl. China 2: 55. 2001. — *Skitophyllum polypodioides* (Hedw.) Bach. Pyl., J. Bot. Agric. 4: 153. 38 f. 10. 1815. — *Schistophyllum polypodioides* (Hedw.) Brid., Bryol. Univ. 2: 695. 1827. — *Fissidens areolatus* Griff., Calcutta J. Nat. Hist. 2: 506. 1842; Gangulee, Mosses E. India 2: 559. 560 f. 267. 1969.; Eddy, Handb. Males. Mosses 1: 62. 63 f. 51. 1988. — *Fissidens oerstedianus* Müll. Hal., Syn. Musc. Frond. 2: 529. 1851. — *Fissidens polypodioides* var. *areolatus* (Griff.) Wilson, Hooker's J. Bot. Kew Gard. Misc. 9: 294. 1857. — *Fissidens divisus* Hampe, Ann. Sci. Nat., Bot., sér. 5, 5: 332. 1866. — *Fissidens pseudopolypodioides* Müll. Hal., Bull. Herb. Boissier 5: 173. 1897. (**Figure 5.32**)

Plant usually yellowish green or dark green, brownish or reddish brown when old, forming densely turfs, 2.0–4.0 cm long. **Stem** simple, light green or dark brown; central strand well developed; axillary hyaline nodules not developed. **Leaves** more or less densely arranged; middle to upper leaves oblong-lanceolate, $0.3\text{--}0.5 \times 0.09\text{--}0.10$ cm; apex mucronate, occasionally acute; base of leaves usually round; margin slightly serrate to less entire; costae stout, ending few cells below apex; vaginant laminae mostly half of the leaf length, equal or slightly unequal; cell of apical quadrate to hexagonal, with thick-walled, slightly mammilose to smooth, walls clear, $42\text{--}69 \times 30\text{--}61$ μm , cell of vaginant laminae similar to those of apical laminae, but larger toward costae. **Sporophyte** not seen

Additional illustration. — Gangulee (1969: 560, Fig. 267, as *Fissidens areolatus*); Eddy (1988: 63, Fig. 51A–E, as *Fissidens areolatus*); Wongkuna (2010: 107, Fig. 53).

Thailand. — **NORTHERN:** Chiang Mai, Phitsanulok. **NORTH-EASTERN:** Loei. **CENTRAL:** Nakhon Nayok. **PENINSULAR:** Nakhon Si Thammarat, Krabi (Wongkuna, 2010).

Distribution. — Australia, Bangladesh, Belize, Brunei, China, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Hong Kong, India, Indonesia, Japan, Malaysia, Mexico, Myanmar, Nepal, New Guinea, Nicaragua, Panama, Peru, Philippines, Sikkim, Singapore, Sumatra, Taiwan, United States, Venezuela, and Vietnam (Wongkuna, 2010).

Ecology. — On soils or rocks under shade of tree, near waterfall or stream, at 470–1,239 m elevation.

Specimens examined. — *P. Ajintaiyasil* 012, 013, 053, 067, 075, 077, 240, 244, 478, 496 (BCU).

9. *Fissidens subangustus* M. Fleisch., Musci Buitenzorg 1: 47. 1904; Noguchi, Ill. Moss Fl. Japan 1: 88. 1987; Zhi-hua & Iwatsuki, Moss Fl. China 2: 59. 2001. (**Figure 5.33**)

Plants yellowish green or green to dark green, forming loosely turfs, 1.5–3.0 mm long. **Stems** usually simple; axillary hyaline nodules developed; central strand not differentiated. **Leaves** densely arranged, lower leaves small, upper leaves much larger, narrowly lanceolate, $1.6\text{--}2.0 \times 0.2\text{--}0.3$ mm, apex acute to narrowly acute; base not decurrent; margin crenulate; without limbate; costae percurrent to shortly excurrent; vaginant laminae half of leaf length; cells of apical and dorsal laminae quadrate to irregularly hexagonal, moderately thick-walled, unipapillose, $6\text{--}11 \times 6\text{--}12$ μm ; cells of vaginant laminae similar to those of the apical lamina, marginal cells of vaginant laminae of upper leaves often elongate. **Sporophytes** not seen.

Additional illustration. — Noguchi (1987: 91, Fig. 33A); Li, Crosby, & He (2001: 60, Pl. 88, Fig. 1–12); Wongkuna (2010: 117, Fig. 58).

Thailand. — **NORTHERN:** Chiang Mai (Wongkuna, 2010).

Distribution. — China, India, Indonesia, Japan, Malaysia, Philippines, Sumatra, and Taiwan (Wongkuna, 2010).

Ecology. – On soils with *F. ceylonensis* and *F. incognitus* under shade of tree, at 1,221 m elevation.

Specimens examined. – *P. Ajintaiyasil 174A* (BCU).



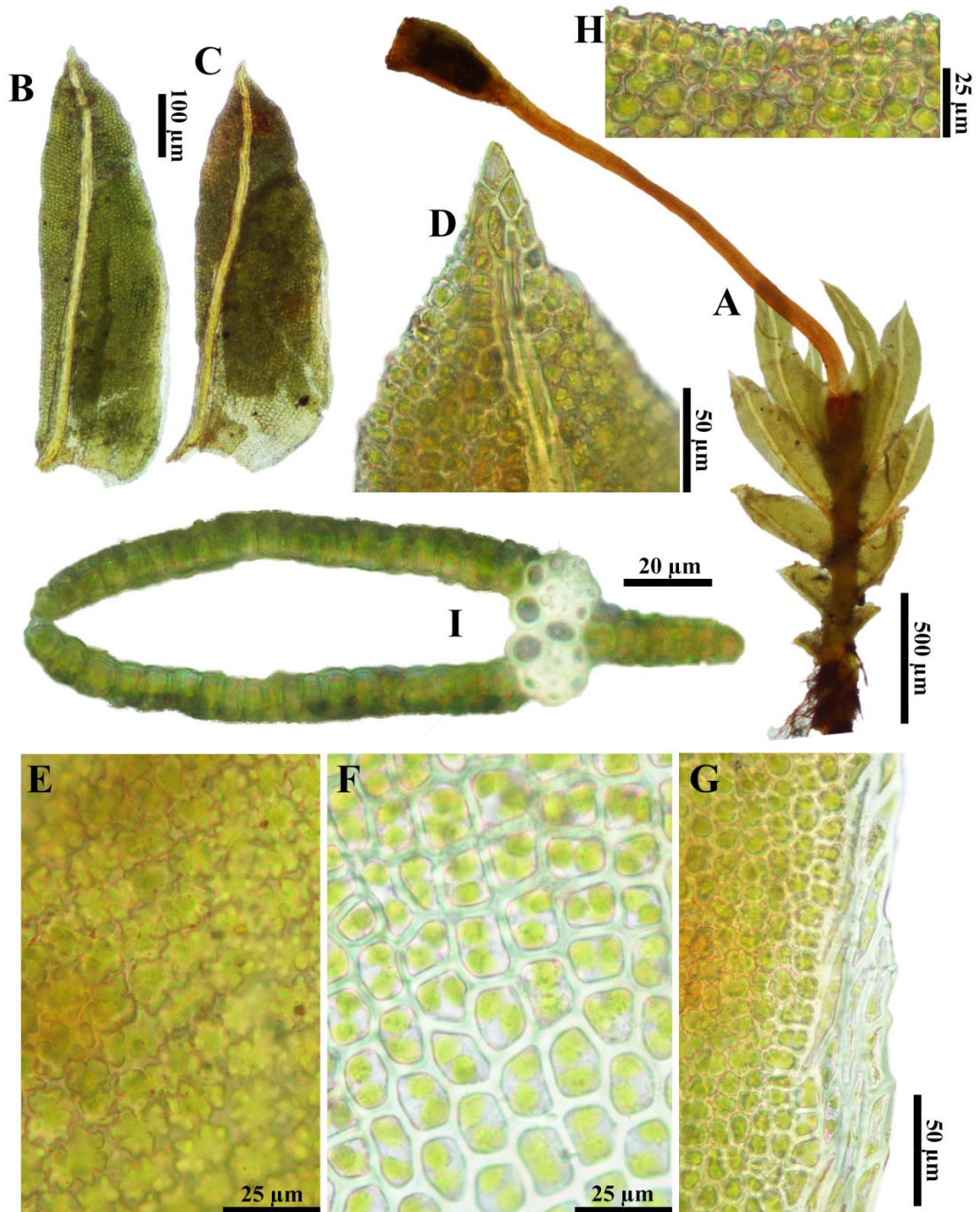


Figure 5.25 *Fissidens ceylonensis* Dozy & Molk.

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf cells showing pluripapillose, F. Inner vaginant lamina cells, G. Margin of vaginant lamina cells, H. Margin of upper leaf, I. Cross section of leaf. Based on *P. Ajintaiyasil 054*.

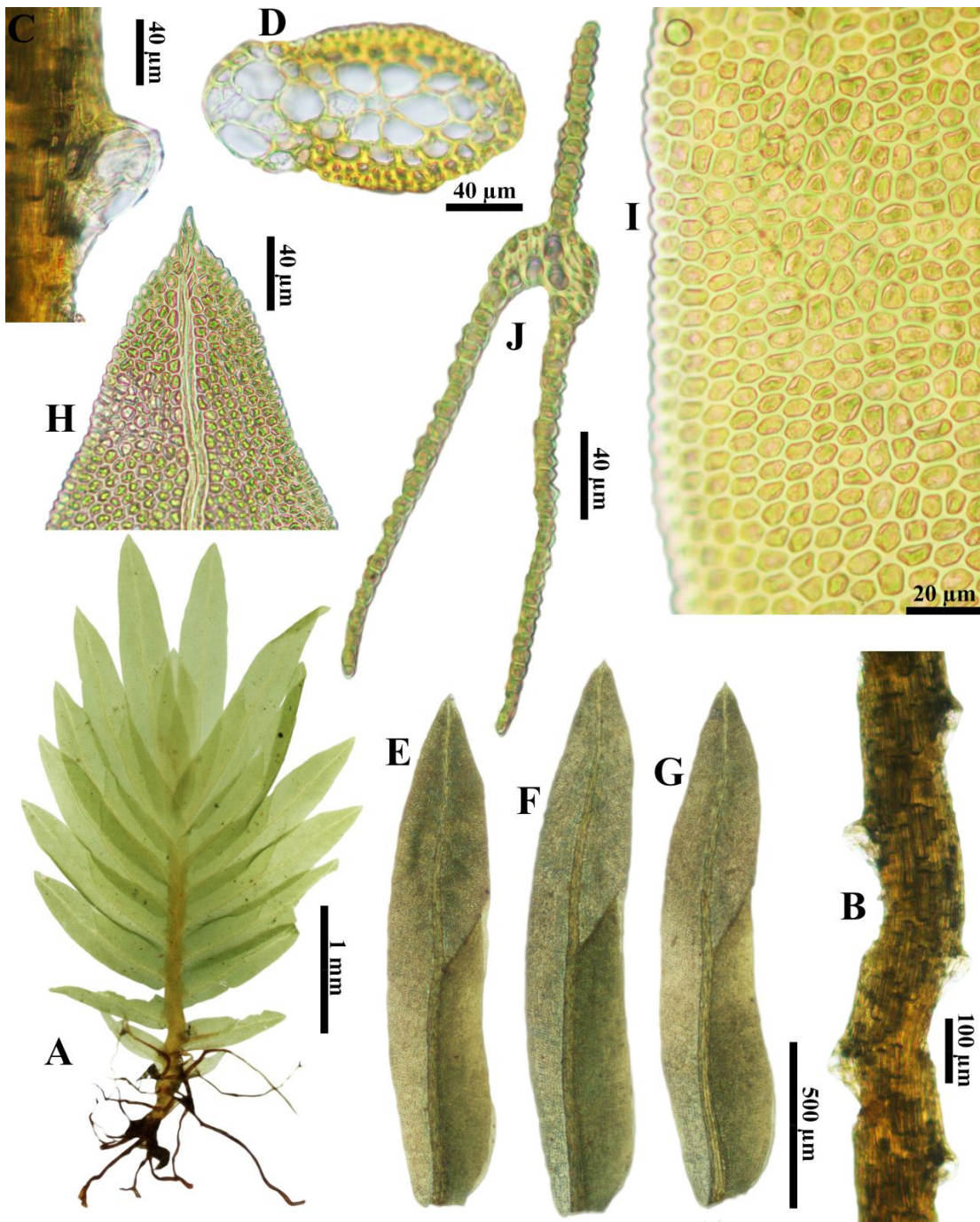


Figure 5.26 *Fissidens crispulus* Brid. var. *robinsonii* (Broth.) Z. Iwats. & Z.H. Li

A. Gametophyte, B. Hyaline nodules along stem, C. Closed up of hyaline nodule, D. Cross section of hyaline nodule, E–G. Leaves, H. Hyaline nodules along stem, I. Cells at leaf margin, J. Cross section of leaf. Based on *P. Ajintaiyasil 054*.

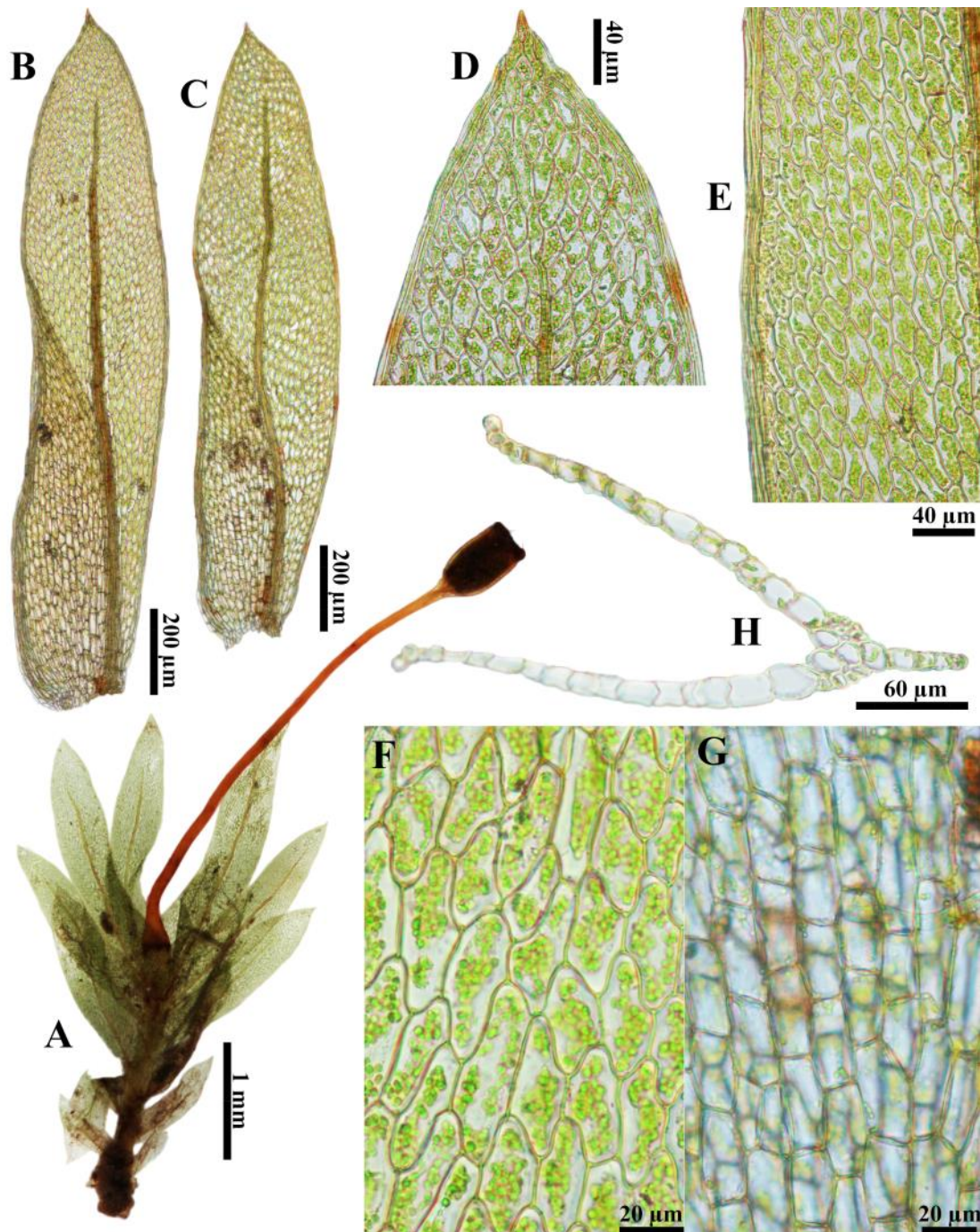


Figure 5.27 *Fissidens flaccidus* Mitt. var. *flaccidus*

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Cells at dorsal lamina, G. Cells at vaginant lamina, H. Cross section of leaf. Based on *P. Ajintaiyasil* 243.

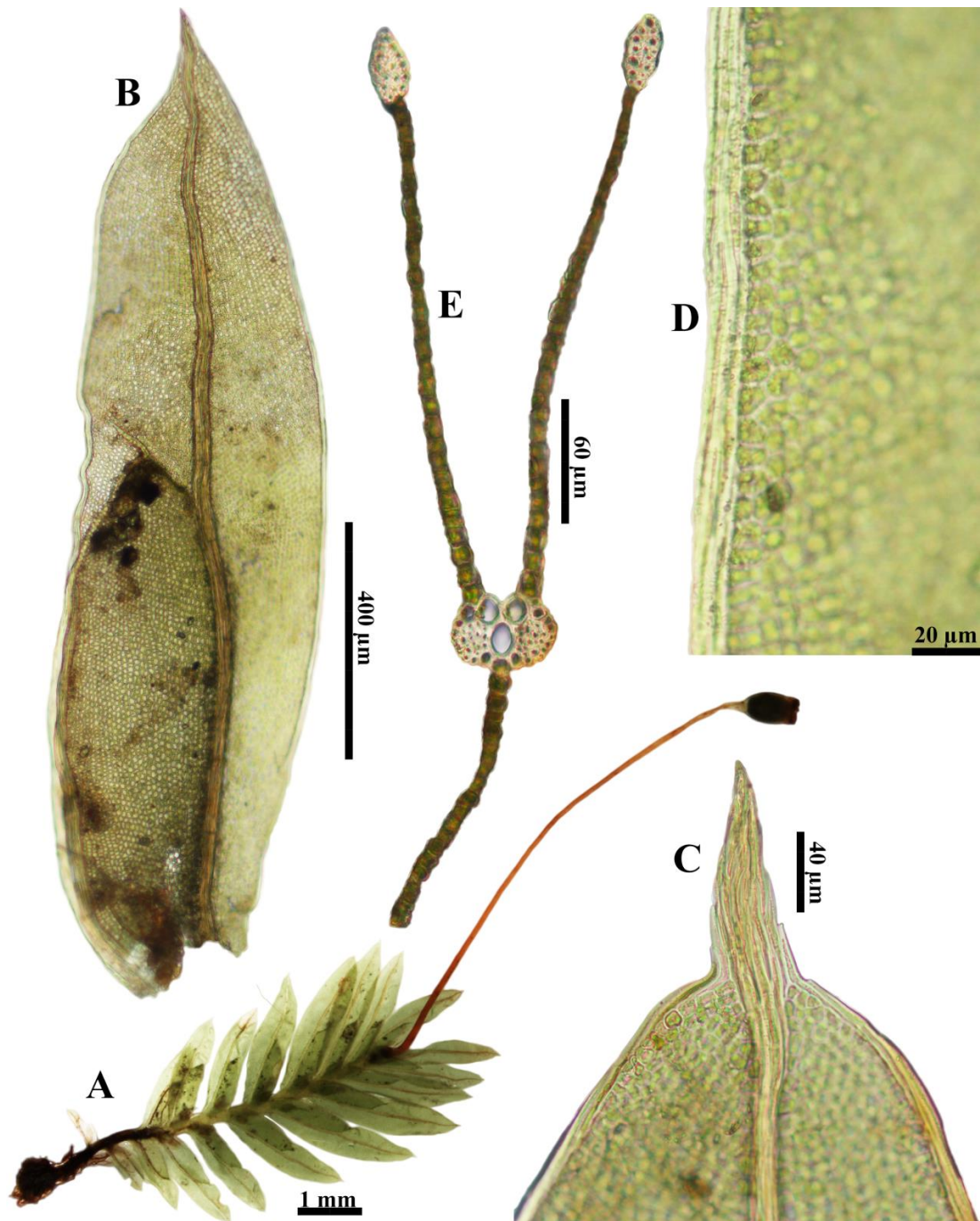


Figure 5.28 *Fissidens geppii* M. Fleisch.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Cross section of leaf. Based on *P. Ajintaiyasil 340B*.

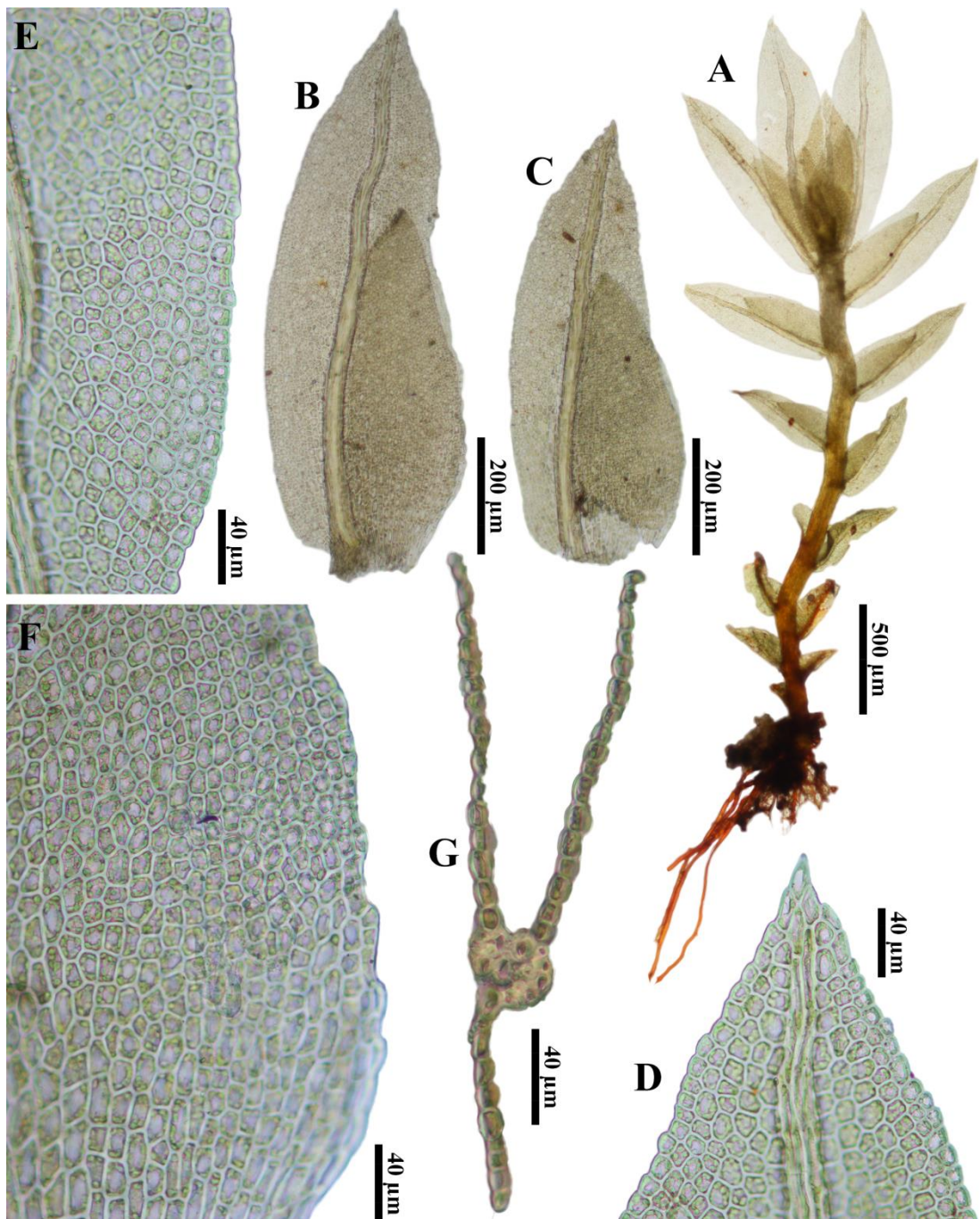


Figure 5. 29 *Fissidens guangdongensis* Z. Iwats. & Z.H. Li

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. Cells of dorsal lamina with margin, F. Cells of vaginant lamina with margin, G. Cross-section of leaf. Based on *P. Ajintaiyasil* 201.

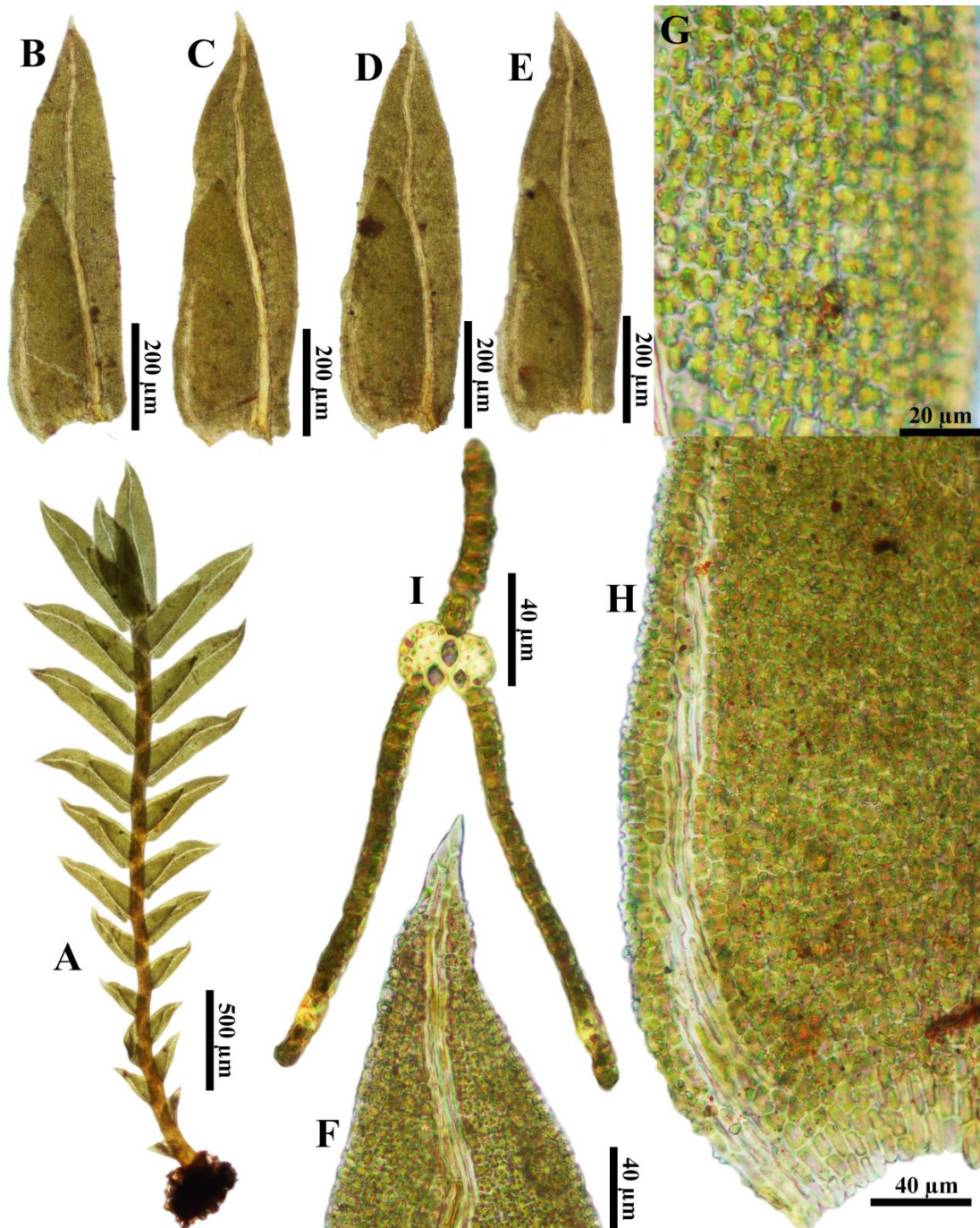


Figure 5.30 *Fissidens incognitus* Gangulee

A. Gametophyte, B–E. Leaves, F. Leaf apex, G. Cells of dorsal lamina, H. Cells of vaginant lamina with intramargin border, I. Cross section of leaf. Based on *P. Ajintaiyasil 174A*.

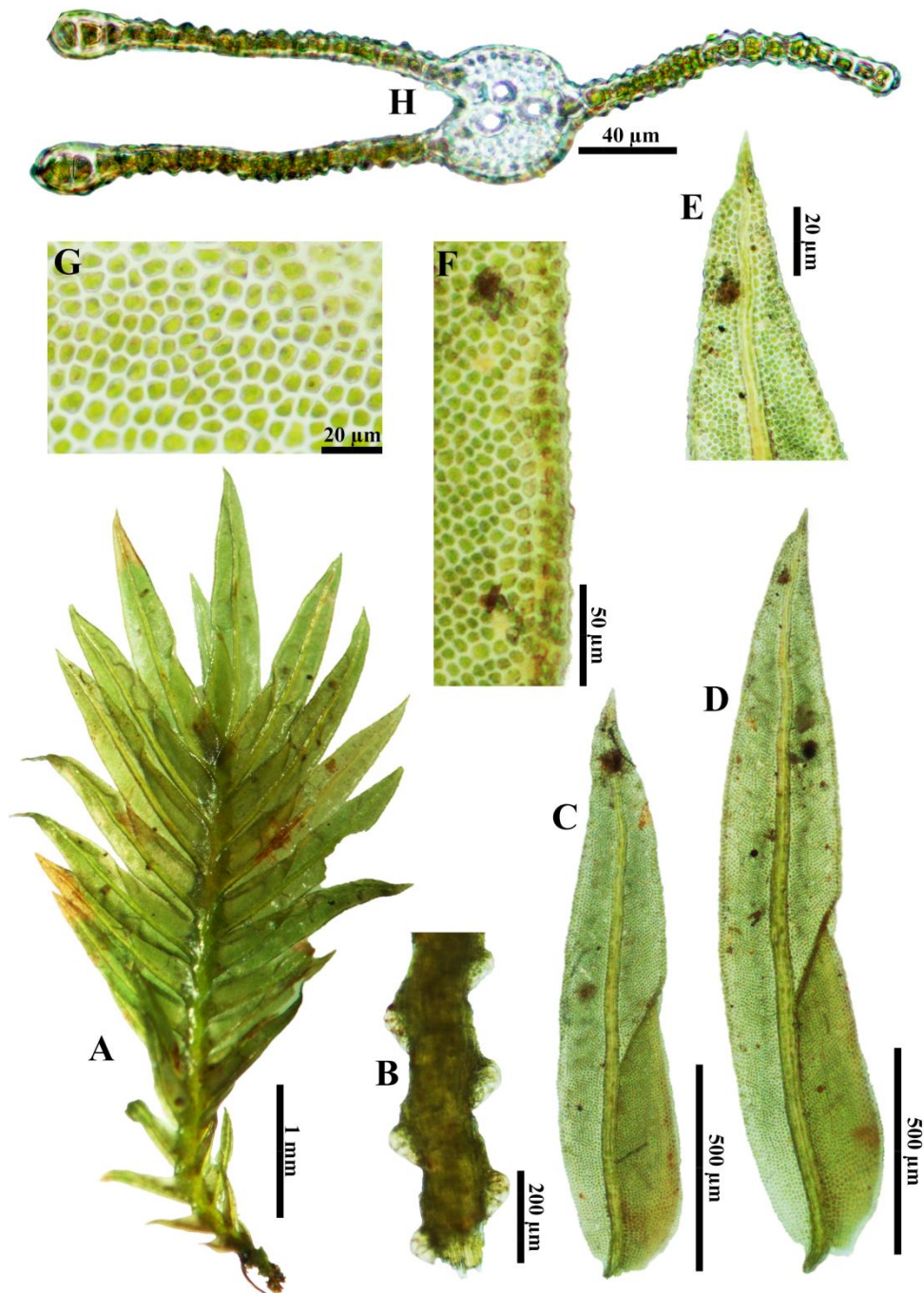


Figure 5.31 *Fissidens javanicus* Dozy & Molk.

A. Gametophyte, B. Hyaline nodules along stem, C–D. Leaves, E. Leaf apex, F. Leaf margin, G. Cells of dorsal lamina, H. Cross section of leaf. Based on *P. Ajintaiyasil 078*.

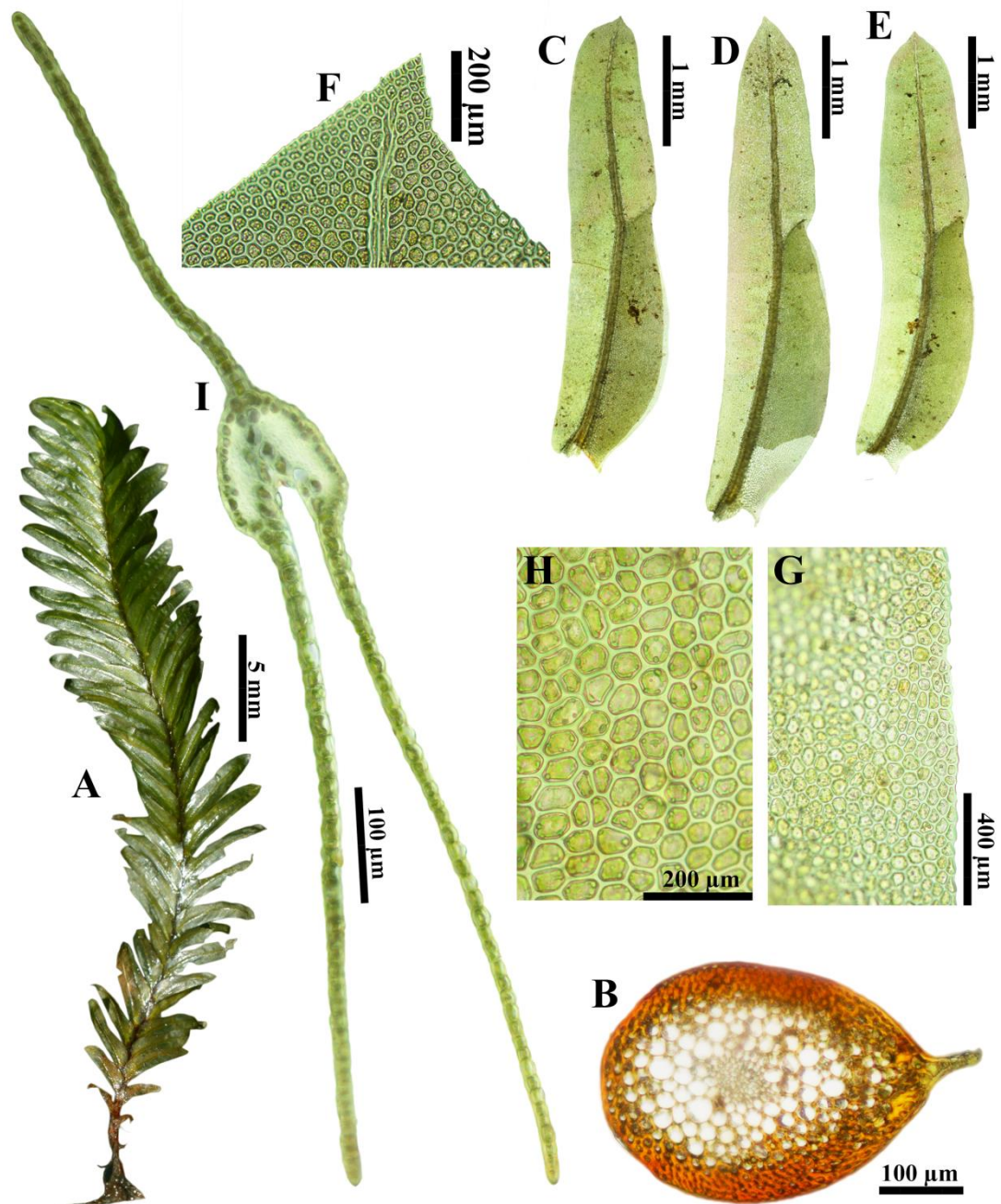


Figure 5.32 *Fissidens polypodioides* Hedw.

A. Gametophyte, B. Cross section of stem, C–E. Leaves, F. Leaf apex, G. Leaf margin, H. Cells at dorsal lamina, I. Cross section of leaf. Based on *P. Ajintaiyasil 012*.

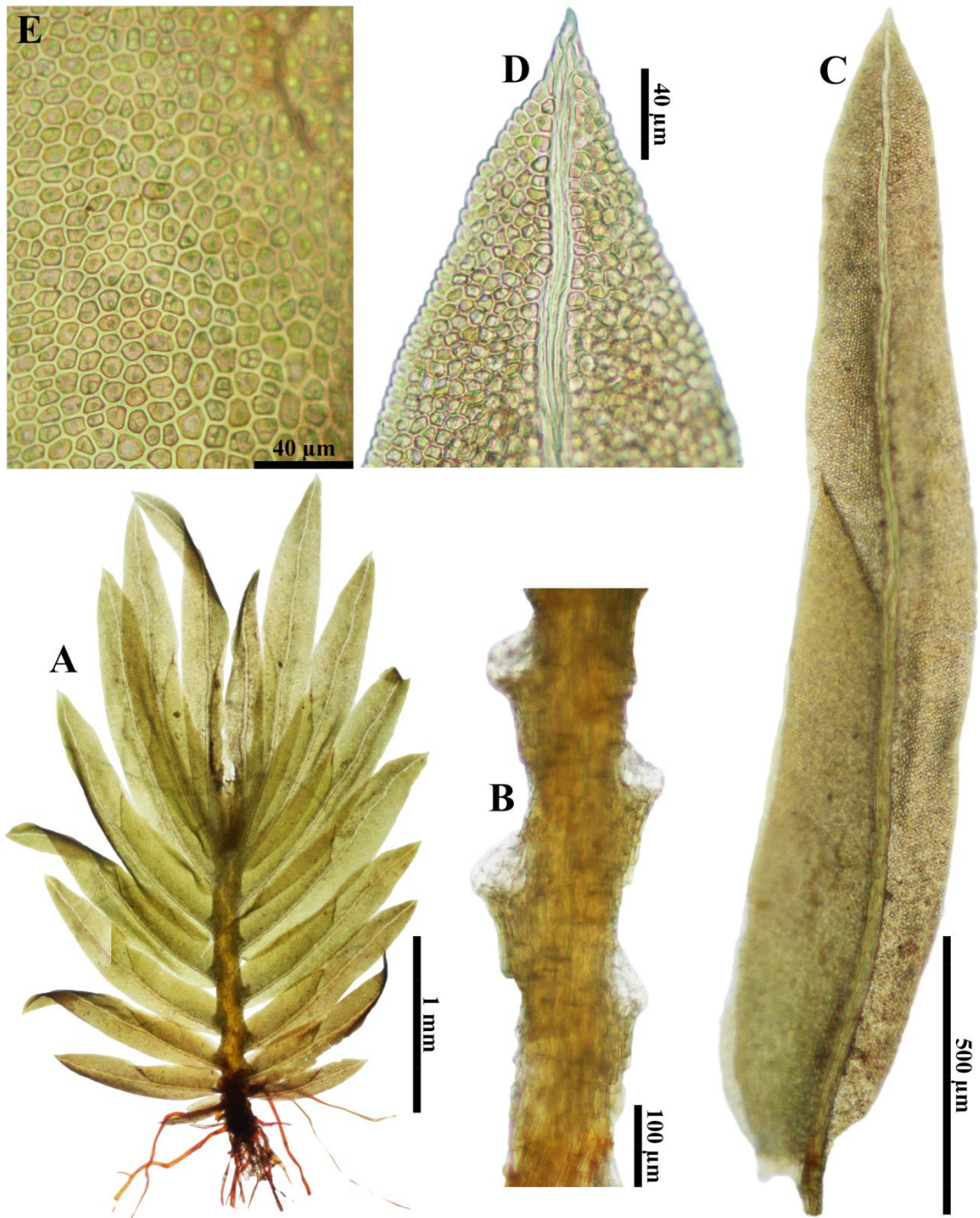


Figure 5.33 *Fissidens subangustus* M. Fleisch.

A. Gametophyte, B. Hyaline nodules along stem, C. Leaf, D. Leaf apex, E. Cells at dorsal lamina. Based on *P. Ajintaiyasil 174A*.

10. FUNARIACEAE

Schwägr., Sp. Musc. Frond. 5(2): 43. 1830; Gangulee, Mosses E. India 4: 836. 1974; Noguchi, Ill. Moss Fl. Japan 2: 397. 1988; Eddy, Handb. Males. Mosses 3: 107. 1996; Xing-jiang, He & Da-cheng, Moss Fl. China 3: 79. 2003.

Plants small to medium-sized, gregarious or forming loose turfs. **Stems** erect, short, simple or few branched, often weakly radiculose below; in cross section central strand present. **Leaves** reduced below distally crowded, often comose, usually contorted when dry; ovate- to oblong-lanceolate, obovate or oblanceolate; usually concave, apex acute or short acuminate to obtuse; margins plane to somewhat inflexed distally, entire to rather bluntly serrate, limbate or elimbate; costae single, narrow, 4/5 the lamina length to short excurrent; laminal cells smooth, upper and median cells broadly rhombic to hexagonal; lower and basal cells oblong to rectangular. **Autoicous. Perigonia** mostly bud-like, apex of paraphyses club-shaped. **Perichaetia** terminal. **Setae** elongate, rarely very short, erect or somewhat curved and hygroscopic, smooth or rarely papillose. **Capsules** exserted, rarely immersed, erect to pendent, urn pyriform or cupulate, symmetric and smooth to asymmetric and striate when dry; stomata 1-celled. **Opercula** flat to conic-rounded. **Peristome** double, single or absent, when double exostome teeth 16, papillose, trabeculate; endostome segments 16, cilia absent, or when peristome single to reduced, represented by the exostome. **Calyptrae** cucullate and usually inflated or mitrate and lobed below, smooth and naked. **Spores** mostly spherical, papillose or smooth.

FUNARIA

Hedw., Sp. Musc. Frond. 172. 1801; Gangulee, Mosses E. India 4: 855. 1974; Noguchi, Ill. Moss Fl. Japan 2: 402. 1988; Eddy, Handb. Males. Mosses 3: 107. 1996. 1988; Xing-jiang, He & Da-cheng, Moss Fl. China 3: 84. 2003.

Plants annual or biannual, small to medium-sized, green to yellowish green, in gregarious or dense turfs. **Stems** short, slender, often simple or sparsely branched at base. **Leaves** usually small, sparse below, larger and clustered, budlike at stem tips; ovate, lingulate, oblong-ovate to broadly obovate or ovate-lanceolate; concave, acute to acuminate at apex; margins plane, entire or denticulate above, sometimes marginal cells differentiated, forming a distinct border; costae percurrent or shortly excurrent; leaf cells large, lax, thin-walled, oblong-hexagonal above, rectangular below; alar cells not differentiated. **Autoicous. Perichaetia** located on short lateral branches just below perigonia, the short branches becoming main branches after perigonia dissolve. **Setae** elongate, slender. **Capsules** long-exserted, suberect to pendulose, broadly pyriform, usually very asymmetric, curved, sulcate or plicate when dry, necks often distinctly developed. **Opercula** nearly flat to low convex with a very short apiculus, rarely conic, usually not papillose; annuli usually inflated, revoluble, sometimes absent. **Peristome** double; exostome teeth narrowly lanceolate, yellowish red or reddish brown, papillose-striate at base, often strongly trabeculate; endostome segments shorter than or nearly as long as the teeth, yellowish, papillose; basal membrane present or lacking; cilia none. **Calyptrae** inflated-cucullate, long-rostrate, smooth. **Spores** spherical, yellowish brown, densely papillose.

Funaria hygrometrica Hedw., Sp. Musc. Frond. 172. 1801; Gangulee, Mosses E. India 4: 856. 1974; Noguchi, Ill. Moss Fl. Japan 2: 404. 1988; Eddy, Handb. Males. Mosses 3: 107. 1996; Xing-jiang, He & Da-cheng, Moss Fl. China 3: 87. 2003. — *Funaria calvescens* Schwägr., Sp. Musc. Frond., Suppl. 2: 77. pl. 65. 1816. — *Funaria sphaerocarpa* Müll. Hal., Bot. Zeitung (Berlin) 9: 546. 1851. — *Funaria connivens* Müll. Hal., Bot. Zeitung (Berlin) 13: 747. 1855. — *Funaria plagiostoma* Müll. Hal., Bot. Zeitung (Berlin) 13: 748. 1855. — *Funaria gracilescens* Schimp. ex Müll. Hal., Bot. Zeitung (Berlin) 16: 154. 1858. — *Funaria convoluta* Hampe, Linnaea 30: 455. 1860. — *Funaria papillata* Hampe, Linnaea 40: 302. 1876. — *Funaria ravenelii* Austin, Bot. Gaz. 1: 29. 1876. — *Funaria marginata* Kindb., Bih. Kongl. Svenska Vetensk.-Akad. Handl 7(9): 79. 1883. — *Funaria fuegiana* Müll. Hal., Flora 68: 396. 1885. — *Funaria megapoda* Müll. Hal., Bull. Herb. Boissier 5: 175. 1897. — *Funaria lonchopelma* Müll. Hal., Hedwigia 38: 61. 1899. — *Funaria flaviseta* Warnst., Hedwigia 57: 90. 26 c, d. 1915. — *Funaria intermedia* (Warnst.) Warnst., Hedwigia 57: 91. 1915. — *Tayloria henryae* Dixon, Proc. Roy. Soc. Queensland 53(2): 31. 1941. (**Figure 5.34**)

Plants yellowish green, in loose turfs, very small, 2–5 mm long. **Stems** simple or branched from the base. **Leaves** sparse at lower stems, crowded at stem tips, flexuous or contorted when dry, erect-patent when moist; oblong-ovate to broadly obovate, 3–4 × 1.2–1.4 mm, usually deeply concave; margins entire; costae percurrent or shortly excurrent; leaf cells thin-walled, upper cells irregularly rectangular to hexagonal, 48–84 × 24–33 µm; basal cells elongate, broadly rectangular, 90–135 × 24–30 µm. **Autoicous. Perichaetial leaves** oblong-obovate, 2.3–3.0 × 0.7–0.8 mm. **Setae** slender, light yellowish brown, 1.3–3.6 cm long; straight below, curved above. **Capsules** horizontal to pendulose, pyriform, asymmetric, 1.0–3.0 mm long, apophyses distinctly developed, sulcate when dry. **Opercula** flat-convex. **Peristome** double; exostome teeth lanceolate, papillose striate below, papillose above, strongly trabeculate; endostome segments lanceolate, nearly as long as exostome. **Calyptrae** inflated-cucullate, long-rostrate. **Spores** spherical, yellowish, smooth.

Additional illustration. – Gangulee (1974: 857, Fig. 410, as *F. hygrometrica* var. *calvescens*); Noguchi (1988: 406, Fig. 174); Eddy (1996: 108, Fig. 402A–J).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTERN: Phetchabun, Loei. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Australia, Brazil, China, Colombia, Costa Rica, Egypt, El Salvador, Guatemala, India, Iraq, Japan, Korea, Mongolia, Myanmar, New Zealand, Pakistan, Panama, Philippines, Siberia, Sri Lanka, Taiwan, Vietnam, and United States (Agnew & Vondráček, 1975; Bartram, 1949; El-Saadawi & Badawi, 1977; He, 1995; Noguchi, 1988; Waard & Florschütz, 1979).

Ecology. – On soils under shade of grasses, at 807 m elevation.

Specimens examined. – *P. Ajintaiyasil* 458 (BCU).

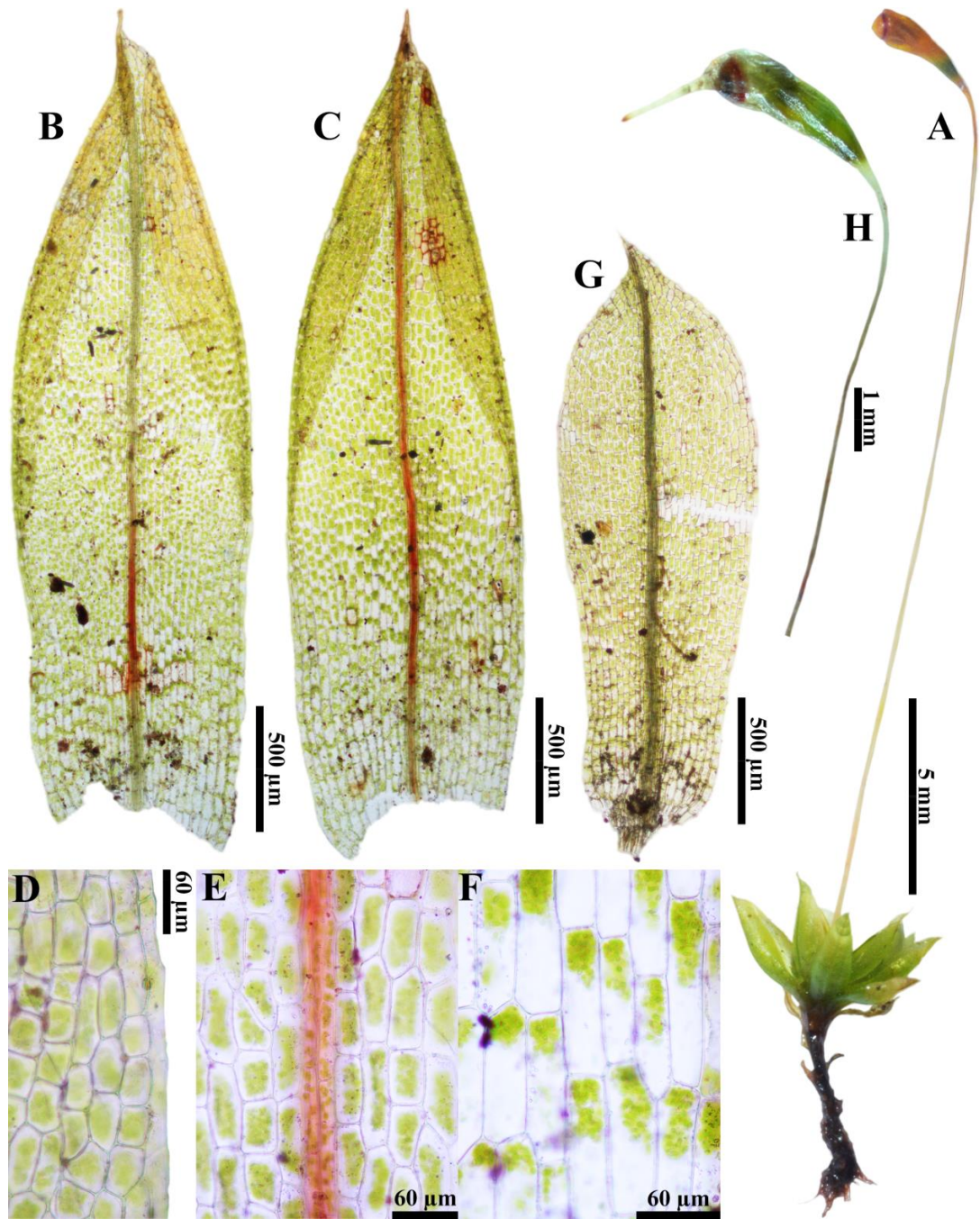


Figure 5. 34 *Funaria hygrometrica* Hedw.

A. Gametophyte with Sporophyte, B–C. Leaves, D. Leaf margin, E. Cells at median part of leaf, F. Cells at leaf base, F. Perichetial leaf, G. Young sporophytes with calyptra. Based on *P. Ajintaiyasil* 458.

11. HYPNACEAE

Schimp., Coroll. Bryol. Eur. 113. 1856; Gangulee, Mosses E. India 8: 1932. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1118. 1994; Man-xiang & He, Moss Fl. China 8: 80. 2005.

Plants small to mostly medium-sized, forming mats. **Stems** creeping and spreading to ascending, monopodially branched, branches mostly short, occasionally secund; pseudoparaphyllia foliose or rarely filamentous; paraphyllia none. **Leaves** ovate, ovate-lanceolate, lanceolate or triangular, falcate or homomallous; apex acute to long acuminate; base decurrent or not; margins plane, occasionally recurved below, entire to serrulate or serrate throughout or distally; costae short and forked, or less often absent; median cells mostly linear, smooth or papillose by projecting cell angles; alar region undifferentiated or more often differentiated with cells often oval, or small and quadrate, generally not inflated. **Autoicous** or dioicous. **Perichaetia** lateral, leaves mostly differentiated. **Setae** elongate, smooth, rarely roughened papillose distally. **Capsules** mostly inclined and asymmetric; ovoid or cylindrical to obloid-cylindrical, often curved. **Opercula** apiculate to short-rostrate, oblique. **Peristome** double, exostome teeth 16, cross-striate below, papillose distally; endostome basal membrane high, rarely low, segments 16, cilia 1-3, nodose, rarely rudimentary. **Calyptrae** cucullate, mostly naked, rarely hairy. **Spores** spherical, mostly finely papillose.

Key to the genera

- 1a. Alar cells differentiated, in a group of 1–3 inflated cells.....1. *Ectropothecium*
 1b. Alar cells not or scarcely differentiated.....2. *Taxiphyllum*

1. ECTROPOTHECIUM

Mitt., J. Linn. Soc., Bot. 10: 180. 1868; Gangulee, Mosses E. India 8: 1982. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1166. 1994; Man-xiang & He, Moss Fl. China 8: 103. 2005.

Plants yellowish green or brownish green, glossy or not glossy, in dense mats or wefts. **Stems** prostrate, sometimes pendulous, ascending or erect; radiculose; simple or pinnately branched, branches ascending, usually complanate; pseudoparaphyllia filamentous or foliose. **Leaves** dimorphic, or more or less similar; ovate- or obovate-lanceolate, somewhat asymmetric; often falcate-secund; not decurrent at base, usually dorsal, ventral, and lateral leaves differentiated; costae double, short, very weak, or distinct; leaf cells linear, sometimes distinctly prorate; basal cells shorter and broader; alar cells few, small, quadrate or shortly rectangular, usually not particularly inflated, but with one or three cells clearly distinct. **Autoicous** or dioicous. **Perichaetial leaves** broadly lanceolate, gradually acuminate or suddenly narrowed to a slender acumen. Setae elongate. **Capsules** horizontal to inclined, small to very small, ovoid to urceolate or shortly cylindrical, often constricted below the mouth when dry; exothecial cells sometimes mammillose. **Opercula** inflated, conic, apiculate to shortly rostrate. **Peristome** double; exostome teeth narrowly lanceolate,

not bordered, cross-striate on the outer surface, trabeculate on the inner surface; endostome segments linear-lanceolate, with a high basal membrane and 2–4 cilia. **Calyptrae** cucullate, smooth, sometimes hairy. **Spores** small, usually smooth.

Key to the species

- 1a. Leaf apex acuminate; setae 1.2–1.4 cm long.....1. *Ectropothecium dealbatum*
 1b. Leaf apex acute; setae 0.9–1.1 cm long.....2. *Ectropothecium monumentorum*

1. *Ectropothecium dealbatum* (Reinw. & Hornsch.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 264 (Gen. Sp. Musc. 2: 522). 1880; Gangulee, Mosses E. India 8: 1988. 1980; Man-xiang & He, Moss Fl. China 8: 106. 2005. — *Hypnum dealbatum* Reinw. & Hornsch., Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 14(2): 729. 1829. — *Hypnum ochron* Schwägr., Sp. Musc. Frond., Suppl. 2(2): 285a. 1830. (**Figure 5.35**)

Plants yellowish green, in dense wefts. **Stems** prostrate, irregularly branched, branches rather flattened. **Leaves** ovate-lanceolate, 0.8–1.0 × 0.3–0.4 mm, straight or slightly falcate; apex shortly acuminate; margins serrulate above the middle; costae double, short; leaf cells linear-rhomboidal, smooth, 52–78 × 3–4 μm, basal cells rectangular, 24–55 × 5–8 μm; alar cells subquadrate, 30–41 × 15–29 μm. **Autoicous**. **Setae** slender, reddish, 1.2–1.4 cm long, straight except bent at apex. **Capsules** ovoid, small, 0.7–0.8 mm long, horizontal or inclined. **Opercula** conic, shortly rostrate. **Peristome** hypnoid. **Spores** small, spherical, minutely papillose.

Additional illustration. – Bartram (1939: Pl. 27, Fig. 466); Gangulee (1980: 1988, Fig. 1029); Wu, Crosby, & He (2005: 108, Pl. 636, Fig. 1–13).

Thailand. – NORTHERN: Chiang Mai, Phistanulok. PENINSULAR: Nakhon Si Thammarat, Surat Thani (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Mauritius, Myanmar, Malaysia, Philippines, and Taiwan (He, 1995; O'shea, 2006).

Ecology. – On log under shade of tree, at 966 m elevation.

Specimens examined. – *P. Ajintaiyasil* 464 (BCU).

2. *Ectropothecium monumentorum* (Duby) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 259. 1880; Gangulee, Mosses E. India 8: 1986. 1980. — *Hypnum monumentorum* Duby, Syst. Verz. 1842–1844: 132. 1846. (**Figure 5.36**)

Plants yellowish green, in dense mats. **Stems** prostrate, irregularly branched. **Leaves** ovate-lanceolate, 0.8–0.9 × 0.2–0.3 mm, concave, slightly falcate; acute at apex; margins crenulate above the middle; costae double; leaf cells linear-rhomboidal, smooth, 60–97 × 3–5 μm, basal cells rectangular, 28–41 × 4–8 μm; alar cells subquadrate, 16–43 × 12–23 μm. **Autoicous**. **Setae** slender, reddish, 0.9–1.1 cm long, straight except bent at apex. **Capsules** urceolate, small, 1.0–1.1 mm long, horizontal

or inclined. **Opercula** conic, shortly rostrate. **Peristome** hypnoid. **Spores** small, spherical, minutely papillose.

Additional illustration. – Bartram (1939: Pl. 27, Fig. 467); Gangulee (1980: 1987, Fig. 1028).

Thailand. – NORTHERN: Chiang Mai. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, China, Hong Kong, India, Indonesia, Malaysia, Myanmar, Philippines, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 1,205–1,240 m elevation.

Specimens examined. – *P. Ajintaiyasil* 198, 361 (BCU).

2. TAXIPHYLLUM

M. Fleisch., Musci Buitenzorg 4: 1434. 1922; Gangulee, Mosses E. India 8: 1943. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1086. 1994; Man-xiang & He, Moss Fl. China 8: 241. 2005.

Plants flattened, bright green, glossy, in close interwoven mats. **Stems** remotely to irregularly branched, branches flattened. **Leaves** nearly 2 arranged; oblong-ovate; shortly to slenderly acuminate at apex; margins serrulate; costae double, short or indistinct; leaf cells rhomboidal to linear, often prorate; apical cells shorter. **Dioicous.** **Perichaetial leaves** oblong-lanceolate, abruptly narrowed to a filiform apex. **Setae** elongate. **Capsules** erect to horizontal, oblong-ovoid. **Opercula** long-rostrate. **Peristome** double; exostome teeth yellowish, cross-striate below, hyaline, papillose above, trabeculate on the inner surface; endostome segments pale yellowish, smooth, basal membrane high, cilia 2, nodulose, as long as the teeth. **Calyptrae** cucullate, smooth. **Spores** spherical, smooth or minutely papillose.

จุฬาลงกรณ์มหาวิทยาลัย

Taxiphyllum taxirameum (Mitt.) M. Fleisch., Musci Buitenzorg 4: 1435. 1922; Gangulee, Mosses E. India 8: 1945. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1068. 1994; Man-xiang & He, Moss Fl. China 8: 251. 2005. — *Stereodon taxirameus* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 105. 1859. — *Isopterygium elegantifrons* Müll. Hal., Hedwigia 37: 251. 1898. — *Isopterygium maniae* Renaud & Paris, Rev. Bryol. 29: 84. 1902. — *Hylocomium isopterygioides* Broth. & Paris, Rev. Bryol. 33: 27. 1906. — *Isopterygium cavernicola* Cardot, Rev. Bryol. 37: 56. 1910. (**Figure 5.37**)

Plants yellowish green, somewhat glossy. **Stems** prostrate, remotely branched; pseudoparaphyllia triangular-foliose. **Leaves** obliquely spreading, distichously arranged; ovate-lanceolate, 1.0–1.1 × 0.3–0.4 mm, asymmetric, concave; broadly acuminate; slightly decurrent at base; margins serrulate above; costae double, short or indistinct; median leaf cells rhomboidal, 62–84 × 5–7 µm, upper cells shorter, 14–51 × 4–8 µm; alar cells few, quadrate or shortly rectangular. **Sporophytes** not seen.

Additional illustration. – Bartram (1939: Pl. 28, Fig. 477); Gangulee (1980: 1945, Fig. 996); Noguchi (1994: 1068, Fig. 470).

Thailand. – NORTHERN: Chiang Mai, Tak. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Kanchanaburi. SOUTH-EASTERN: Chanthaburi (He, 1995).

Distribution. – Bangladesh, Bhutan, Brazil, China, Comoros, Honduras, India, Indonesia, Japan, Korea, Laos, Mexico, Myanmar, Nepal, New Guinea, Philippines, Siberia, Sri Lanka, Taiwan, Uganda, Vietnam, and United States (He, 1995; O'shea, 2006; Tan & Iwatsuki, 1991).

Ecology. – On soils or rocks under shade of tree, at 585–1,000 m elevation.

Specimens examined. – *P. Ajintaiyasil* 105, 247 (BCU).



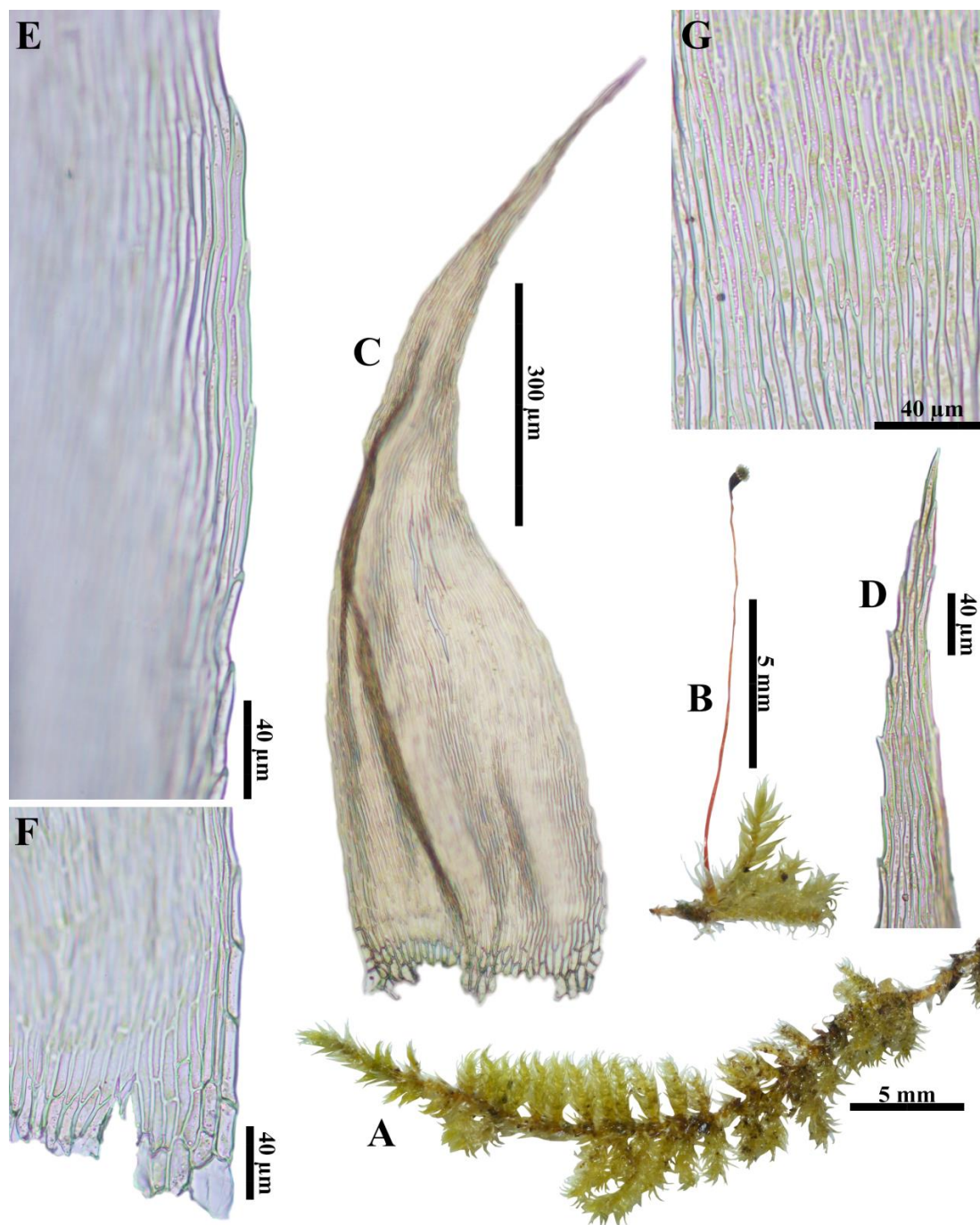


Figure 5.35 *Ectropothecium dealbatum* (Reinw. & Hornsch.) A. Jaeger

A. Sterile gametophyte, B. Gametophyte with sporophyte, C. Leaf, D. Leaf apex, E. Leaf margin, F. Leaf base, G. Cells at median part of leaf. Based on *P. Ajintaiyasil* 464.

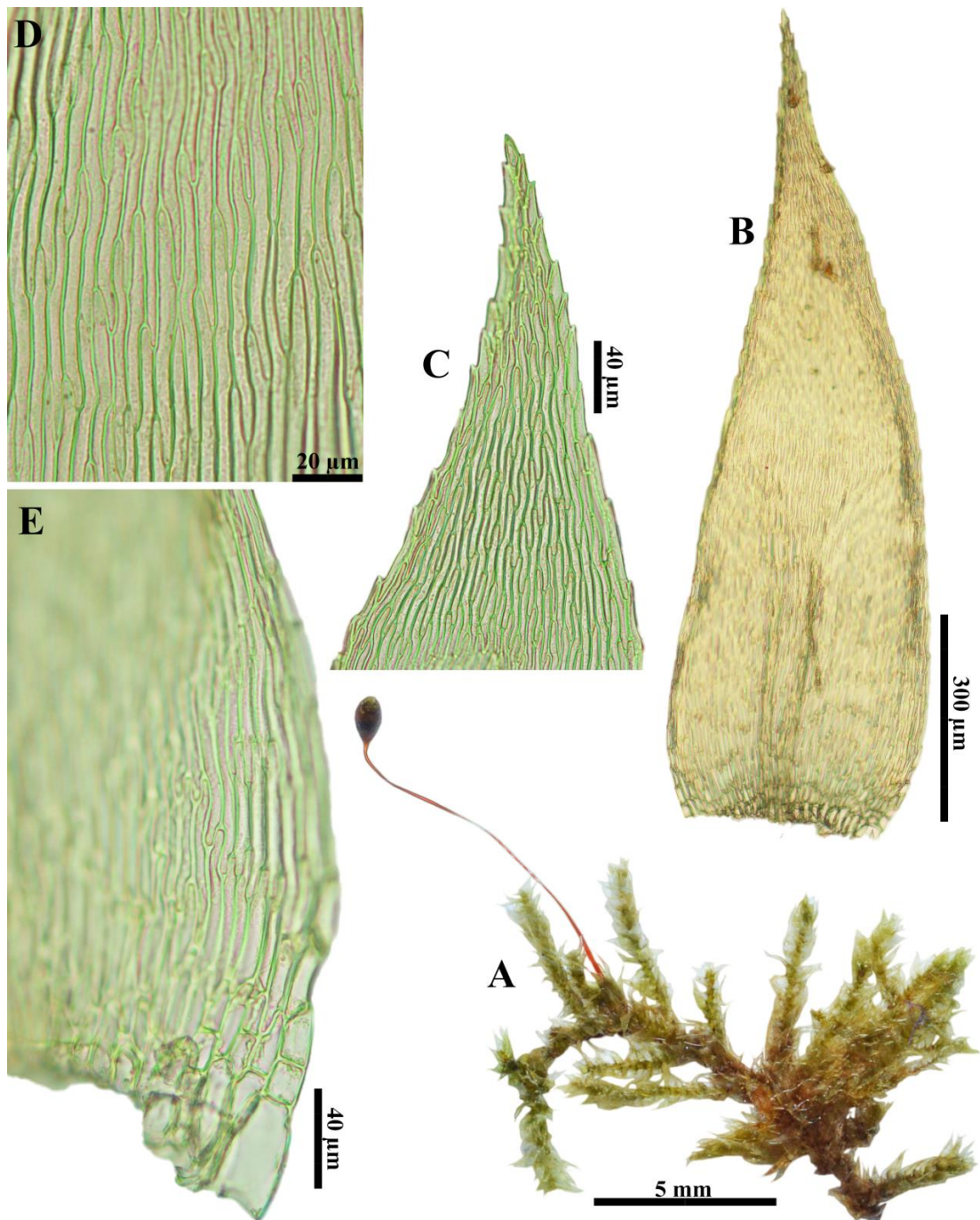


Figure 5.36 *Ectropothecium monumentorum* (Duby) A. Jaeger

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Cells at median part of leaf, E. Leaf base. Based on *P. Ajintaiyasil* 198.

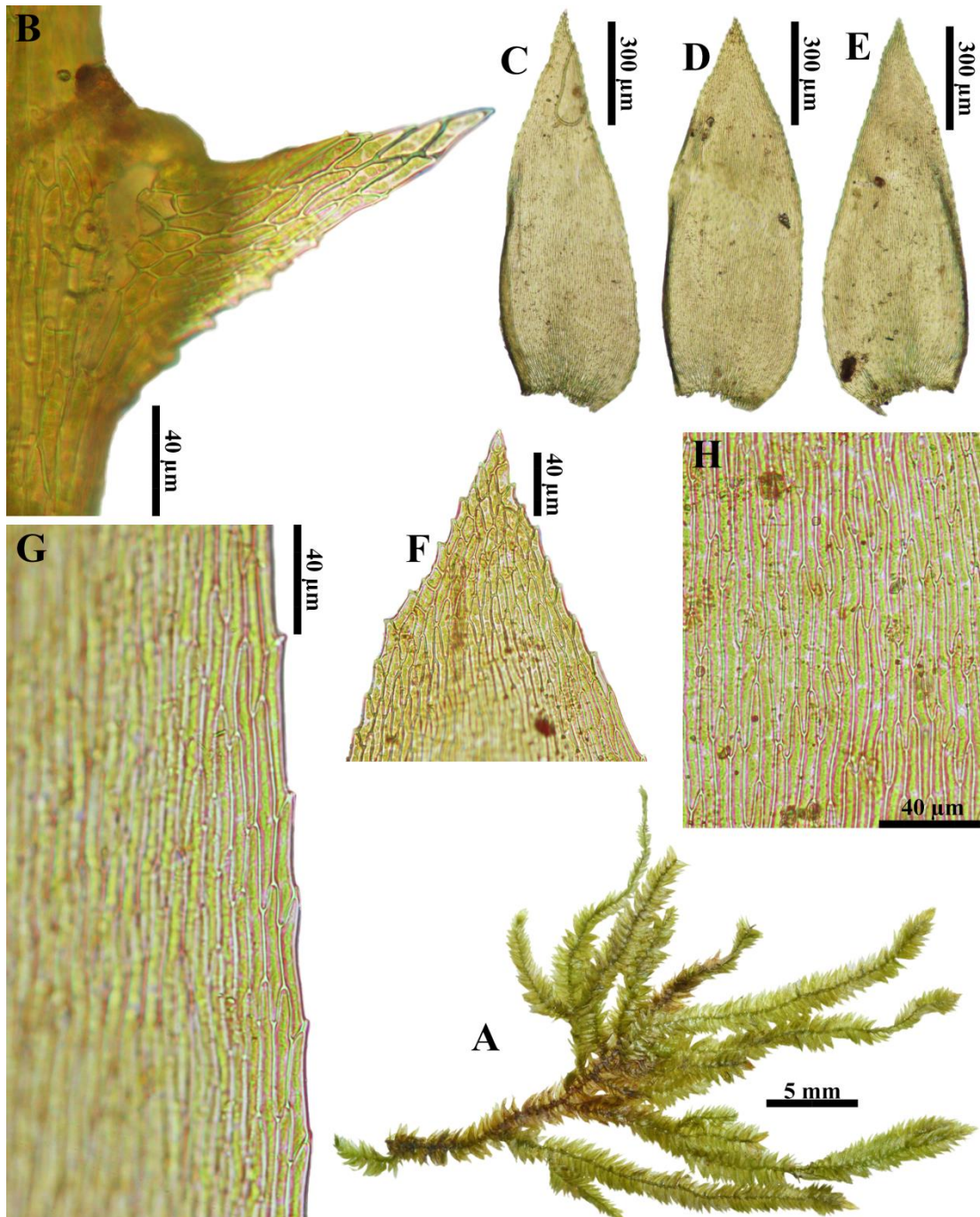


Figure 5.37 *Taxiphyllum taxirameum* (Mitt.) M. Fleisch.

A. Gametophyte, B. Pseudoparaphyllum, C–E. Leaves, F. Leaf apex, G. Leaf margin, H. Cells at median part of leaf. Based on *P. Ajintaiyasil* 105.

12. HYOPTERYGIACEAE

Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 147. 1859; Gangulee, Mosses E. India 6: 1530. 1976; Noguchi, Ill. Moss Fl. Japan 4: 758. 1991; Yu, Zhi-hua & Peng-cheng, Moss Fl. China 6: 43. 2002.

Plants medium-sized to somewhat large, forming loose frondose turfs, rather dark green to yellow or light golden-brown. **Primary stems** mostly elongate, creeping; tomentose, rhizoids weakly papillose. **Secondary stem** stipitate, 1(2)-pinnately branched; in cross section central strand present or absent. **Secondary stem leaves** differentiated; crispate when dry, erect spreading and complanate when wet. **Lateral leaves** ovate, asymmetric; apex short acuminate; base short decurrent on one side; margins plane, serrate distally, serrulation extending further down on acroscopic side; often limbate, border extending throughout; costae single, 2/3 lamina length to excurrent, often flexuose or forked: laminal cells short, mostly smooth, rhombic to hexagonal, basal cells oblong to broadly rectangular, weakly to strongly porose; marginal border cells linear, porose. **Amphigastrial leaves** smaller, symmetric; orbicular, ovate-triangular to lanceolate; costae ending below acumen or rather long excurrent. **Autoicous. Perichaetia** lateral on secondary stems or primary branches; leaves sheathing seta, broadly lanceolate to ovate-narrowly acuminate. **Setae** elongate to rather short, curved or erect, stout, smooth or roughened. **Capsules** pendent to suberect, um obloid to short cylindrical: exothecial cells collenchymatous. **Opercula** conic-long apiculate or rostrate. **Peristome** double, exostome teeth 16, cross striate-papillose, distally papillose; endostome finely papillose, basal membrane moderately high, segments 16, keeled, perforate, cilia present or absent. **Calyptrae** narrowly mitrate or cucullate, smooth, naked or sparsely hairy. **Spores** spherical, finely papillose.



LOPIDIUM

Hook. f. & Wilson, Fl. Nov.-Zel. 2: 119. 1854; Noguchi, Ill. Moss Fl. Japan 4: 758. 1991; Yu, Zhi-hua & Peng-cheng, Moss Fl. China 6: 61. 2002.

Plants slender, creeping. **Primary stems** mostly elongate, creeping; tomentose, rhizoids weakly papillose. **Secondary stems** erect, simple or regularly pinnately branched, yellowish green or dark green, not glossy; central strand absent. **Lateral leaves** ovate-ligulate, asymmetric; mostly obtuse, mucronate at apex; costae stout, ending below the apex; lamina cells small, oval or rounded, smooth, walls incrassate, collenchymatous; amphigastria small, triangular or ovate-lanceolate, symmetric, long acuminate toward apex, margins nearly entire. **Monoicous** or autoicous. **Perichaetial leaves** long, gradually narrowly acuminate at apex, with oblong leaf base, margins nearly entire; costae strong, ending near leaf apex or almost percurrent; leaf cells hexagonal, walls incrassate, porose. **Setae** short, finely papillose above. **Capsules** small, erect or slightly suberect. **Peristome** double; exostome teeth narrowly lanceolate, papillose above, densely striate below; endostome segments narrowly elongate; basal membrane low. **Calyptrae** small, cucullate. **Spores** small, minutely papillose.

Lopidium trichocladon (Bosch & Sande Lac.) M. Fleisch., Musci Buitenzorg 3: 1069. 1908; Yu, Zhi-hua & Peng-cheng, Moss Fl. China 6: 64. 2002. — *Hypopterygium trichocladon* Bosch & Sande Lac., Bryol. Jav. 2: 9 138. 1861. (**Figure 5.38**)

Plants dark green, not glossy. **Primary stems** elongate, often appressed. **Secondary stems** regularly branched to pinnate; axillary hairs present; central strand absent. **Lateral leaves** ligulate, $1.0\text{--}1.2 \times 0.3\text{--}0.4$ mm, asymmetric; with a short acuminate; costae percurrent; margins only partially differentiated, nearly entire, often bordered by 1–2 rows of linear cells in lower parts; cells mostly rounded-oval, less porose, slightly collenchymatous, $8\text{--}12 \times 6\text{--}14$ μm . **Amphigastria** ovate-lanceolate, symmetric, small, $0.4\text{--}0.6 \times 0.2\text{--}0.3$ mm; with elongate acute apex; margins nearly entire. **Sporophyte** not seen. **Asexual reproduction** by gemmaphores, gemmaphores usually present in clustered at the axil, reddish brown, 3–7 in clustered.

Additional illustration. – Mohamed & Robinson (1991: 42, Fig. 159–168); Wu, Crosby, & He (2002: 64, Pl. 422).

Thailand. – NORTH-EASTERN: Phetchabun, Loei. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, China, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, Philippines, Taiwan, and Vietnam (He, 1995).

Ecology. – On bark under shade of tree, at 1,248 m elevation.

Specimens examined. – *P. Ajintaiyasil 098B* (BCU).

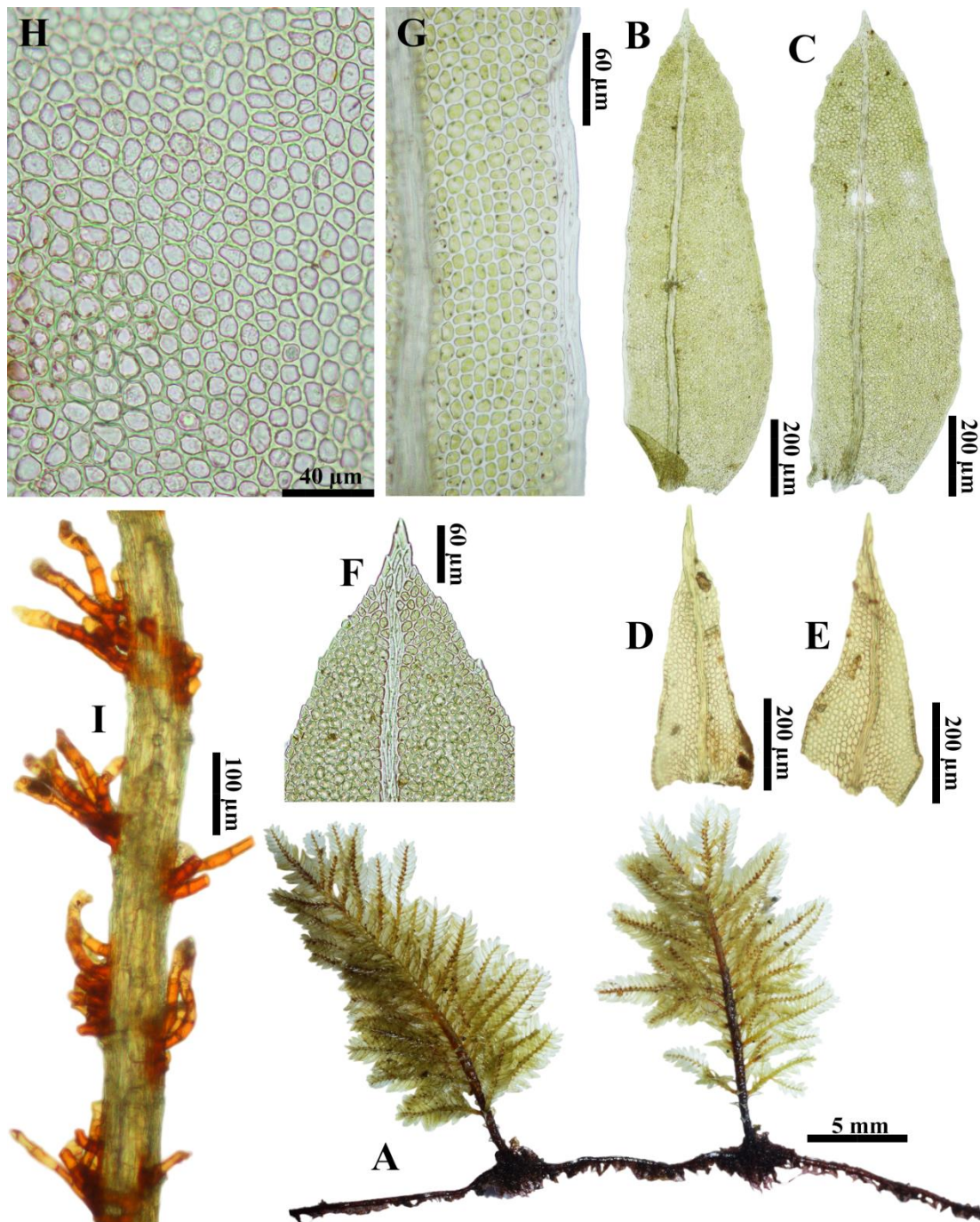


Figure 5.38 *Lopidium trichocladon* (Bosch & Sande Lac.) M. Fleisch.

A. Gametophyte, B–C. Lateral leaves, D–E. Amphigastria, F. Leaf apex, G. Leaf margin, H. Cells at median part of lateral leaf, I. Gemmaphores. Based on *P. Ajintaiyasil 098B*.

13. LESKEACEAE

Schimp., Coroll. Bryol. Eur. 109. 1856; Gangulee, Mosses E. India 7: 1559. 1978; Noguchi, Ill. Moss Fl. Japan 4: 793. 1991; Tong, Jun & Chien, Moss Fl. China 6: 99. 2002.

Plants small, forming loose to dense mats, dark green to yellowish or golden-brown. **Stems** coarse and stiff to rather lax and soft, monopodially branched, often terete-foliate; central strand present, weak; paraphyllia absent or present, if present not papillose. **Leaves** dimorphic or monomorphic; mostly ovate-lanceolate, often plicate; apex mostly short-acuminate; margins often reflexed below, plane above, serrulate or dentate above base; costae mostly single, ca. 2/3 lamina length, distally strong or weak or costae forked distally; median cells oval to oblong-oval or rhomboidal and smooth or indistinctly projecting at upper angle, or cells isodiametric and unipapillose, papillae confined to back; alar region weakly differentiated, cells subquadrate. **Autoicous. Perichaetia** lateral, leaves usually differentiated, long lanceolate. **Setae** elongate, smooth, often twisted. **Capsules** erect or inclined to horizontal, urn cylindrical and symmetric or ovoid-short cylindrical and asymmetric. **Opercula** conic or conic-short rostrate. **Peristome** double; exostome teeth 16, mostly cross-striate below and papillose at tips or nearly papillose throughout but cross-striate at extreme base, rarely smooth; endostome often reduced, basal membrane low or absent, rarely high, segments 16 or absent. **Calyptrae** cucullate, naked and smooth. **Spores** spherical, lightly to rather coarsely papillose.

Key to the genera

- 1a. Median leaf cells unipapillose or finely multipapillose.....1. *Claopodium*
 1b. Median leaf cells smooth.....2. *Leptopterigynandrum*

1. CLAOPODIUM

(Lesq. & James) Renauld & Cardot; Gangulee, Mosses E. India 7: 1597. 1978; Noguchi, Ill. Moss Fl. Japan 4: 843. 1991; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 159. 2002.

Plants small to medium-sized, yellowish green, brownish green when old, not shining, forming mats. **Stems** creeping or ascending, pinnately or irregularly branched, smooth or rarely papillose; central strand absent; paraphyllia mostly lacking. **Leaves** dimorphic, stem leaves and branch leaves slightly to clearly differentiated. **Stem leaves** loosely arranged, usually circinate when dry, ascending when moist; prolonged into a lanceolate or filiform acumen from an ovate or triangularly ovate base, rarely flexuous; leaf margins erect or slightly involute, serrate or serrulate; costae rigid, excurrent or vanishing below leaf apex, smooth or papillose on back; leaf cells rhomboidal, hexagonal or oblong ovate, opaque, unipapillose or finely multipapillose, marginal cells rather long and smooth, basal cells long and hyaline. **Branch leaves** rather small, short, rarely revolute or flexuous above. **Dioicous. Perichaetial leaves** ovate-lanceolate prolonged into a narrow acumen. **Setae** slender, smooth or roughened. **Capsules** oblong ovoid, brown, inclined to

pendulous. **Opercula** conic with beaks. **Peristome** double; exostome teeth lightly yellow, bordered, striate and trabeculate; endostome smooth or finely papillose, the segments as long as the teeth, lanceolate, keeled; cilia 2–3, nodulose. **Calyptrae** cucullate. **Spores** spherical, coarsely papillose.

Claopodium assurgens (Sull. & Lesq.) Cardot, Bull. Soc. Bot. Genève, Sér. 2 3: 283. 1911; Gangulee, Mosses E. India 7: 1600. 1978; Noguchi, Ill. Moss Fl. Japan 4: 846. 1991; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 161. 2002. — *Hypnum assurgens* Sull. & Lesq., Proc. Amer. Acad. Arts 4: 279. 1859. — *Thuidium ferriei* Broth. ex Paris, Rev. Bryol. 31: 59. 1904. — *Claopodium asperrimum* Cardot, Bull. Soc. Bot. Genève, Sér. 2 3: 283. 1911. (**Figure 5.39–5.40**)

Plants yellowish green to olive green, brownish green when old, in loose interwoven mats. **Stems** creeping, often irregularly pinnately branched; branches 0.2–1.0 cm long; central strand differentiated; paraphyllia absent. **Leaves** dimorphic, stem leaves different from the branch leaves. **Stem leaves** mostly crisped when dry, erect-spreading when moist; ovate to ovate-triangular from a wide base, 1.4–1.5 × 0.4–0.5 mm; toward a narrow acumen; margins serrate, revolute above the leaf middle; costae percurrent or slightly excurrent, smooth on back; leaf cells oval to rounded quadrate, papillose, 7–13 × 6–8 μm. **Branch leaves** ovate-lanceolate to triangularly ovate, 0.4–0.7 × 0.2–0.3 mm; margins serrate; costae single, percurrent; leaf cells hexagonal, unipapillose, median cells thin-walled, 6–13 × 6–9 μm. **Dioicous**. **Perichaetial leaves** narrowly elongate-lanceolate, suddenly narrowed into a setulose apex, margins serrate above; costae weak and short. **Setae** reddish brown, 0.4–1.0 cm long. **Capsules** cylindrical, . **Opercula** long beaked. **Peristome** double; exostome teeth lanceolate, striate at lower portion, finely papillose above; endostome segments nearly as long as the exostome teeth; basal membrane about 2/5 the height of segments; cilia mostly 2. **Calyptrae** cucullate. **Spores** finely papillose.

Additional illustration. – Watanabe (1972: 301, Pl. 35, Fig. 1–20); Gangulee (1978: 1601, Fig. 798); Noguchi (1964: 38, Fig. 38–42); Noguchi (1991: 847, Fig. 371); Wu, Crosby, & He (2002: 161, Pl. 451, Fig. 12–21).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai, Tak, Phitsanulok. NORTH-EASTERN: Loei. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – China, India, Indonesia, Japan, Kampuchea, Korea, Laos, Taiwan, and Vietnam (He, 1995).

Ecology. – On bark under shade of tree, at 1,183–1,250 m elevation.

Specimens examined. – *P. Ajintaiyasil* 065, 099, 358 (BCU).

2. LEPTOPTERIGYNANDRUM

Müll. Hal., Hedwigia 36(2): 114. 1897; Gangulee, Mosses E. India 7: 1581. 1978; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 189. 2002.

Plants greyish- to brownish green, moderately glossy, in loose interwoven mats. **Stems** procumbent, irregularly to moderately regularly pinnate, densely terete foliate; central strand present. **Leaves** imbricate-appressed when dry, erect to spreading when moist; broadly to narrowly ovate-lanceolate; longly and rather abruptly acuminate; rounded to base, inconspicuously decurrent; margin plane or narrowly recurved at leaf base, entire to weakly serrulate; costae double or more commonly forked, short to occasionally exceeding half upleaf; leaf cells moderately thick-walled, short-elongate rhomboidal, smooth; alar cells quadrate to transversely rectangular, at apex sometimes uniseriate, piliferous. **Dioicous. Perichaetial leaves** with oblong basal part, enlarged after fertilization, with double costae or ecostaete. **Setae** long, smooth. **Capsules** erect to suberect. **Opercula** conic to shortly rostrate. **Peristome** double; well developed, although endostome segments slightly shorter than exostome teeth, narrow. **Spores** small, finely papillose.

Leptopterigynandrum decolor (Mitt.) M. Fleisch., Musci Buitenzorg 4: 1496. 1923. — *Stereodon decolor* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 92. 1859. — *Pterigynandrum decolor* (Mitt.) Broth., Nat. Pflanzenfam. I(3): 892. 1907; Gangulee, Mosses E. India 8: 1765. 1980. (**Figure 5.41**)

Plants pale green to green, not glossy, in compact mats. **Stems** irregularly to subpinnately branched, branches numerous, julaceous. **Leaves** erecto-patent when moist, imbricate when dry; straight or one-sidedly turned, widely ovate or cordate base, 0.6–0.7 × 0.4–0.5 mm; suddenly shortly acuminate, acumen the leaf length; margins plane, minutely serrulate near apex, entire below; costae short, double or furcate near leaf base, weak; leaf cells with moderately thickened walls, rhomboidal in mid-leaf, 16–49 × 4–8 µm; alar cells in 4–7 rows toward costae transversely rectangular and quadrate, 7–15 × 8–19 µm. **Dioicous. Perichaetial leaves** erect, concave, not plicate, 1.9–2.1 × 0.4–0.5 mm, wide at base, from oblong base; gradually acuminate; margins weakly serrulate near apex; costae indistinct. **Setae** 8–9 mm. **Capsules** erect to weakly inclined, 1.7–2.0 mm long. **Opercula** conic to low conic, with short, erect or curved beak. **Peristome** double; exostome teeth inserted well below urn mouth, narrow, finely papillose throughout; endostome basal membrane, segments short. **Calyptrae** not seen. **Spores** finely papillose.

Additional illustration. — Gangulee (1978: 1766, Fig. 890); Khatun & Hadiuzzaman (2006: 135, Pl. 2); Ignatov *et al.* (2012: 214–215, Fig. 6).

Thailand. — New record

Distribution. — Bangladesh, China, India, and Russia (Ignatov *et al.*, 2012).

Ecology. — On barks under shade of tree, at 270–826 m elevation.

Specimens examined. — *P. Ajintaiyasil 180, 316, 318, 327* (BCU).

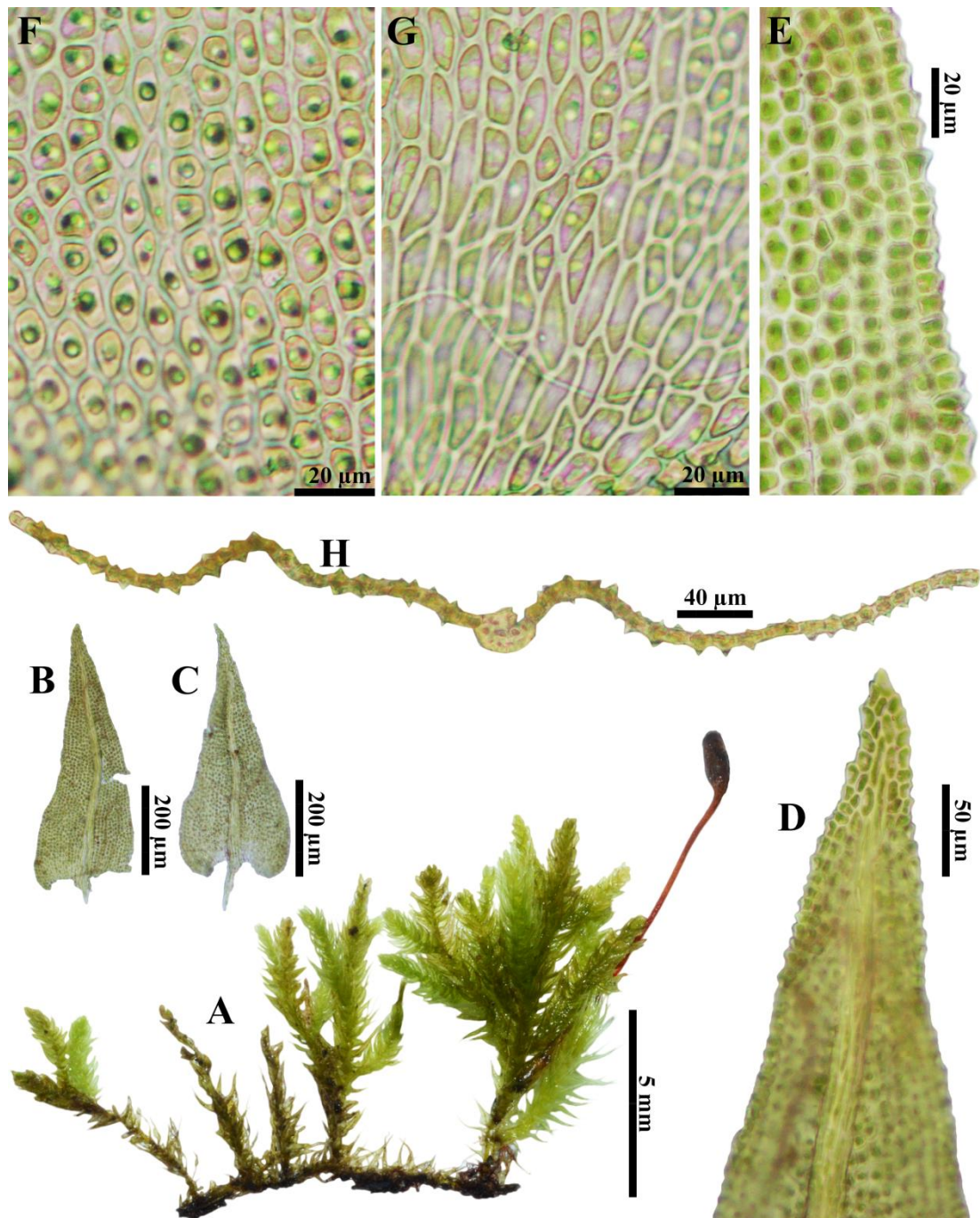


Figure 5.39 *Claopodium assurgens* (Sull. & Lesq.) Cardot

A. Gametophyte with sporophyte, B–C. Branch leaves, D. Branch leaf apex, E. Branch leaf margin, F. Cells at median part of branch leaf, G. Cells at branch leaf base, H. Cross section of branch leaf. Based on *P. Ajintaiyasil 099*.

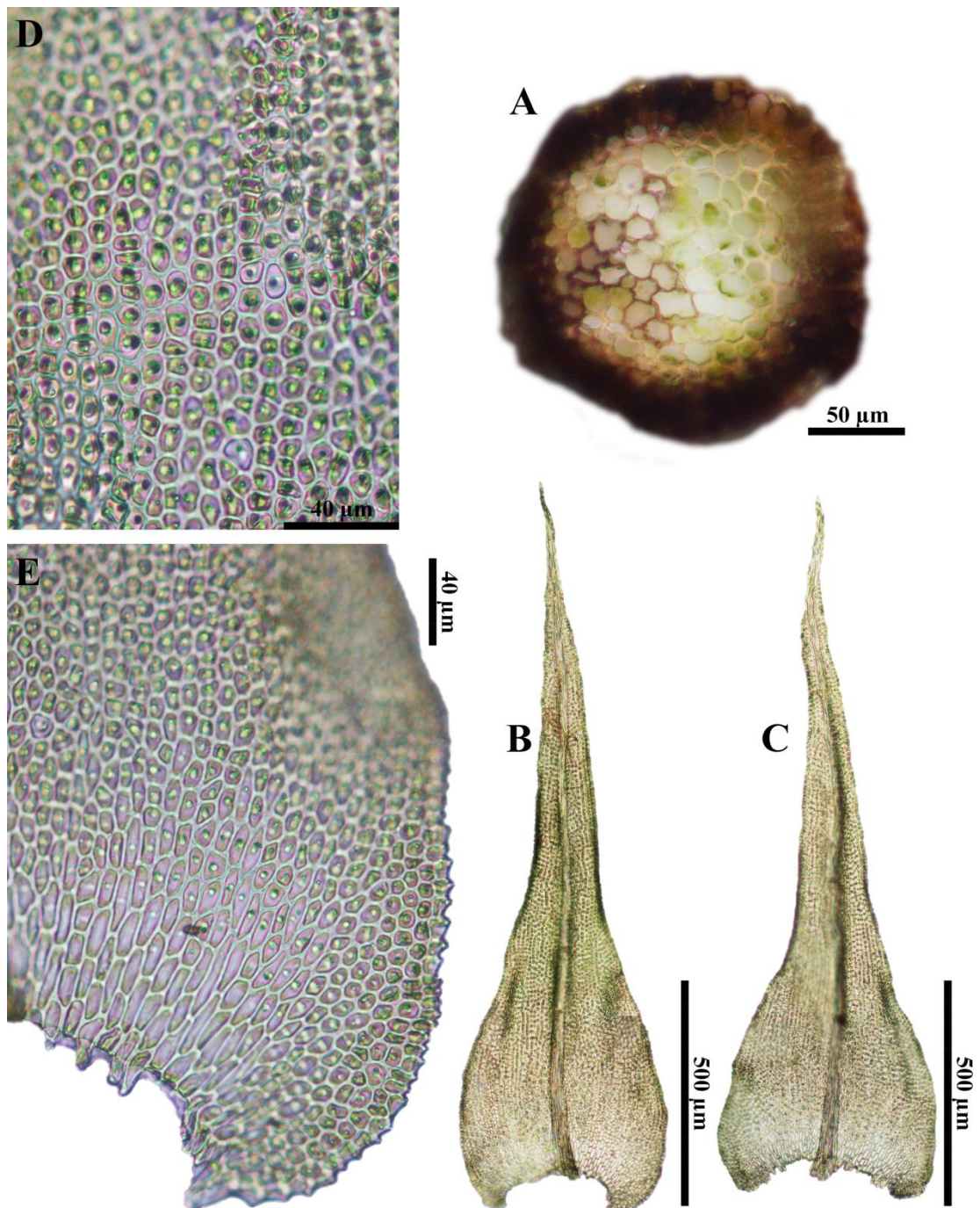


Figure 5. 40 *Claopodium assurgens* (Sull. & Lesq.) Cardot (continued)

A. Cross section of stem, B–C. Stem leaves, D. Cells at median part of stem leaf, E. Cells at stem leaf base. Based on *P. Ajintaiyasil 099*.

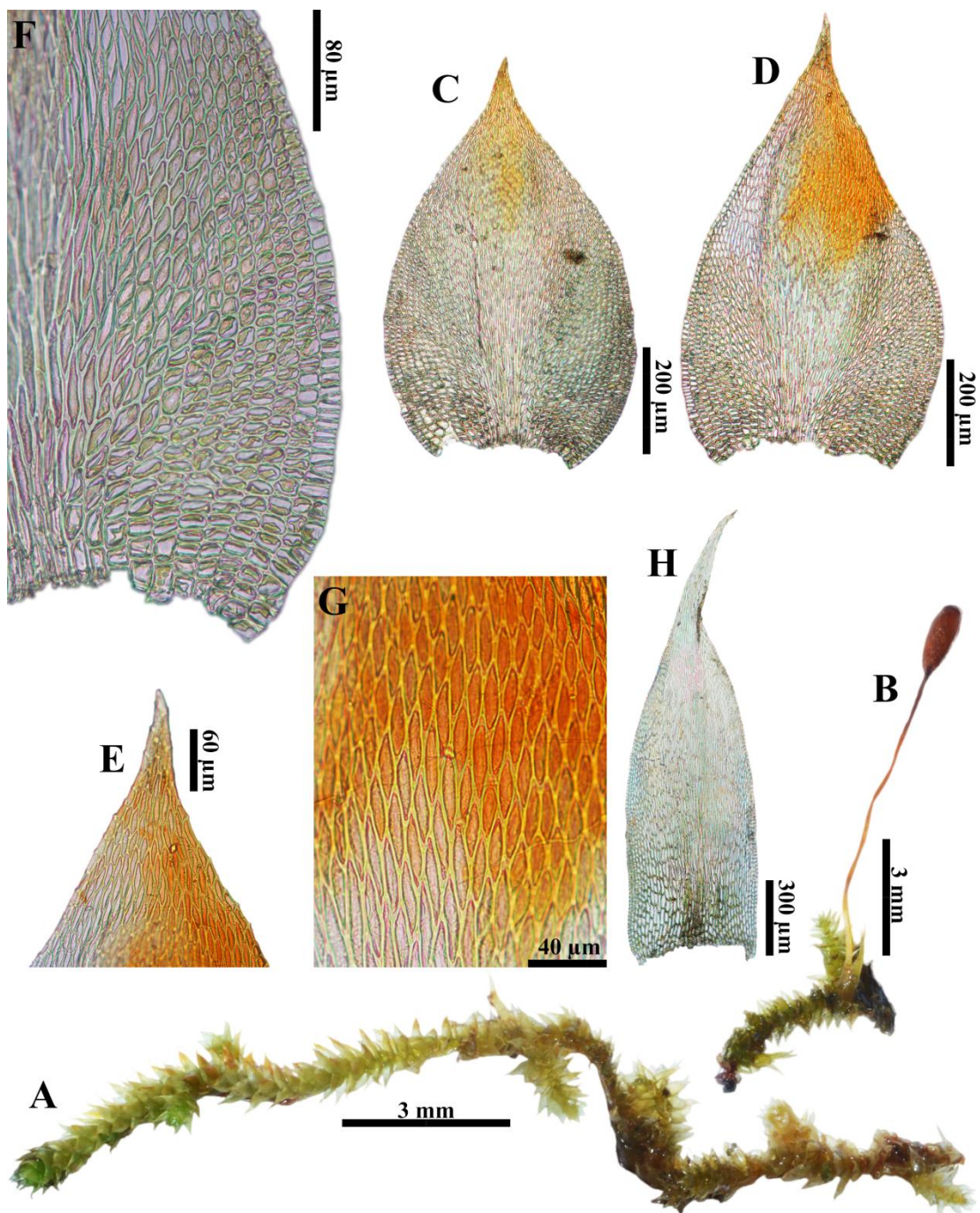


Figure 5. 41 *Leptopterigynandrum decolor* (Mitt.) M. Fleisch.

A. Sterile gametophyte, B. Gametophyte with sporophyte, C–D. Leaves, E. Leaf apex, F. Cells at median part of leaf, G. Alar region, H. Perichaetial leaf,. Based on *P. Ajintaiyasil 180*.

14. LEUCOBRYACEAE

Schimp., Coroll. Bryol. Eur. 19. 1856; Gangulee, Mosses E. India 2: 410. 1969; Noguchi, Ill. Moss Fl. Japan 1: 234. 1987; Eddy, Handb. Males. Mosses 2: 4. 1991; Bang-juan & He, Moss Fl. China 1: 242. 1999.

Plants rather small to large or robust, forming loose to dense cushions or turfs. **Stems** erect to suberect, simple or few branched by innovations; central strand lacking. **Leaves** crowded, mostly with an upper lingulate to ligulate or linear-lanceolate, limb from an expanded ovate or obovate to oblong base, limb channeled or flat, base often sheathing and concave; apex acute to rounded-apiculate; margins plane to erect or incurved, entire to weakly serrulate or dentate at apex; costae broad, occupying most of the leaf, in cross section composed of hyaline cells above and below internal smaller single row of green cells; cells smooth, mostly thin-walled, entire or porose. **Dioicous** or autoicous. **Perichaetia** terminal or appearing lateral by innovations. **Setae** erect, rather short to elongate, smooth. **Capsules** erect to inclined and curved, urn ovoid-cylindrical to cylindrical. **Opercula** rostrate. **Peristome** single or absent, teeth 8 or 16. entire to divided distally, smooth to variously ornamented. **Calyptrae** cucullate or mitrate, smooth, base entire or fringed. **Spores** mostly spherical. smooth or lightly papillose.

Key to the genera

- 1a. In cross section composed of hyaline cells and green cells.....2
 2a. In cross-section composed of hyaline cells dorsal and ventral internal smaller single row of quadrangular green cells.....3. *Leucobryum*
 2b. In cross-section composed of hyaline cells dorsal and ventral internal smaller single row of irregularly green cells.....1. *Brothera*
 1b. In cross-section of costae composed of stereid cells dorsal and ventral, rarely without stereid.....2. *Campylopus*

CHULALONGKORN UNIVERSITY

1. BROTHERA

Müll. Hal, Gen. Musc. Frond. 258. 1900; Gangulee, Mosses E. India 2: 342. 1969; Noguchi, Ill. Moss Fl. Japan 1: 175. 1987; Eddy, Handb. Males. Mosses 2: 2. 1991; Chien, Vitt & He, Moss Fl. China 1: 98. 1999.

Plants grayish green to yellowish green, in cushions. **Stems** erect, simple or sparsely branched; central strand absent. **Leaves** erect, linear-lanceolate, tubulose below, subtubulose above; costae 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, irregularly green cells, enclosed by a row of large, thin-walled, hyaline cells on both the dorsal and ventral surfaces; cells hyaline, rectangular, marginal cells somewhat elongate, laxer at the base; alar cells slightly differentiated. **Dioicous**. **Perichaetial leaves** not much differentiated from vegetative leaves. **Setae** elongate, smooth, straight and slightly twisted when dry, sinuous-flexuose when moist. **Capsules** oblong-ovoid, erect and symmetric. **Opercula** long-

rostrate. **Peristome** single, teeth 16, inserted below the mouth, undivided, papillose nearly throughout or more or less vertically striate at the base. **Calyptrae** cucullate or narrowly mitrate, ciliate-fringed at the base. **Spores** small, spherical, pale yellowish, smooth.

Brothera leana (Sull.) Müll. Hal., Gen. Musc. Frond. 259. 1900; Gangulee, Mosses E. India 2: 343. 1969; Noguchi, Ill. Moss Fl. Japan 1: 175. 1987; Eddy, Handb. Males. Mosses 2: 3. 1991; Chien, Vitt & He, Moss Fl. China 1: 99. 1999. — *Leucophanes leanum* Sull., Musci Allegh. 172. 1846. — *Campylopus leanus* (Sull.) Sull., Manual (ed. 2) 619. 1856. (**Figure 5.42**)

Plants green or yellowish green with grayish sheen, in cushions, small, 0.4–1.0 cm high. **Stems** radiculose at the base. **Leaves** linear-lanceolate, 1.7–1.9 × 0.2–0.3 mm; gradually narrowed from a short, tubulose base, subtubulose above; margins entire or slightly serrulate at the tips; costae broad, filling 1/3–1/2 or more of the leaf base width and nearly all of the subula; cells thin-walled, rectangular above, 19–57 × 9–13 µm, marginal cells somewhat elongate, 37–63 × 4–8 µm, laxer at the base; alar cells not clearly differentiated. **Sporophyte** not seen. **Asexual reproduction** by brood bodies, brood bodies clustered in axils of the upper leaves, with many small, spindle-shaped.

Additional illustration. – Noguchi (1987: 179, Fig. 71).

Thailand. – NORTHERN: Chiang Mai (He, 1995).

Distribution. – Bhutan, China, Guatemala, India, Japan, Korea, Malawi, Malaysia, Mexico, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Russia, Siberia, Sikkim, Taiwan, and United States (Bartram, 1949; He, 1995; Müller & Frahm, 1987; O'shea, 2006).

Ecology. – On bark under shade of tree, near waterfall, at 1,256 m elevation.

Specimens examined. – *P. Ajintaiyasil* 234 (BCU).

2. CAMPYLOPUS

Brid., Muscol. Recent. 4: 71. 1819; Gangulee, Mosses E. India 2: 275. 1969; Noguchi, Ill. Moss Fl. Japan 1: 162. 1987; Eddy, Handb. Males. Mosses 1: 119. 1988; Chien, Vitt & He, Moss Fl. China 1: 105. 1999.

Plants yellowish brown to reddish brown, usually silky, in dense turfs or cushions. **Stems** erect, simple or branched by innovations, comose or somewhat equally foliate, often densely radiculose below; central strand present. **Leaves** erect or flexuose-spreading; lanceolate to ovate-lanceolate or ovate-subulate; usually gradually narrowed to a subtubulose acumen; margins often plane, sometimes incurved, variable serrate toward the apex, nearly always denticulate at the extreme apex; costae broad, often occupying 1/2 or more the leaf base width, filling most of the subula, percurrent to long-excurrent, or in a hyaline hairpoint, often ribbed or denticulate at back above, in cross-section with either two stereid bands or a single

(dorsal) stereid band, rarely without stereid cells in cross section; upper cells quadrate to elongate-rhomboidal or rectangular, incrassate, smooth, lower cells short-rectangular to rhomboidal or linear, firm-walled, rarely porose, narrower toward the margins, sometimes forming a hyaline border; alar cells usually well marked, forming auricles, inflated, extending to the costae, hyaline or reddish brown. **Dioicous**. **Perichaetial leaves** usually enlarged, with wider basal portion and narrower costae. **Setae** elongate, usually cygneous, sometimes erect-flexuose when moist. **Capsules** erect or curved, ovoid to ellipsoid, usually furrowed when dry, sometimes strumose. **Opercula** rostrate. **Peristome** single, teeth 16, divided to the middle or little more, orange-brown and vertically striate below, hyaline and papillose above. **Calyptrae** cucullate, often fringed at base. **Spores** spherical, variously papillose, yellow to brown.

Key to the species

- 1a. In cross-section of costae, showing large lumina cells overlying the median guide cells.....1. *Campylopus ericoides*
 1b. In cross-section of costae, showing stereids overlying the median guide cells.....
2. *Campylopus serratus*

1. *Campylopus ericoides* (Griff.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870: 424. 1872; Gangulee, Mosses E. India 2: 296. 1969; Eddy, Handb. Males. Mosses 1: 121. 1988; Chien, Vitt & He, Moss Fl. China 1: 109. 1999. — *Dicranum ericoides* Griff., Calcutta J. Nat. Hist. 2: 499. 1842. (**Figure 5.43–5.45**)

Plants yellowish brown, somewhat shiny, in cushions. **Stems** reddish, erect, simple or rarely branched, comose foliate, radiculose at base. **Leaves** somewhat flexuose when dry, erect-patent when moist; lanceolate, contracted at base, 2.0–4.0 × 0.3–0.5 mm; gradually narrowed to a canaliculate subula; margins inflexed in the upper, serrulate in the upper; costae pale yellowish brown, occupying 1/3 the leaf base width, shortly excurrent; with dorsal stereid bands, the ventral large lumina cells well defined in transverse section; upper cells obliquely rectangular to rhomboidal, thick-walled, 14–36 × 5–16 μm, rectangular cells at the margins, 12–31 × 3–10 μm, basal cells yellowish, moderately long-rectangular, 34–77 × 12–22 μm, narrower toward the margins; alar cells moderately inflated, hyaline or reddish brown, 19–48 × 22–32 μm. **Dioicous**. **Setae** straight when dry, cygneous when moist; reddish brown, 4–6 mm long. **Capsules** erect, ovoid to short-cylindric, 1.1–1.5 mm long, symmetric. **Opercula** long-rostrate. **Peristome** teeth divided to the middle or lower, reddish and not vertically striate below. **Calyptrae** fringed at base. **Spores** yellow, smooth.

Additional illustration. – Eddy (1988: 120, Fig. 110A–D); Chien, Crosby, & He (1999: 109, Pl. 25, Fig. 6–11).

Thailand. – **NORTHERN:** Chiang Mai, Phitsanulok. **NORTHEASTERN:** Loei. **CENTRAL:** Nakhon Nayok (He, 1995).

Distribution. – Australia, China, India, Indonesia, Kampuchea, Myanmar, Nepal, Philippines, Sri Lanka, and Vietnam (Frahm, 1994; He, 1995).

Ecology. – On soils, rocks or bark in sunlight, at 1,191–1,290 m elevation.

Specimens examined. – *P. Ajintaiyasil* 023, 080, 200, 467, 079, 215, 267, 468, 484, 487A (BCU).

2. *Campylopus serratus* Sande Lac., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 13: 11. 7B. 1872; Eddy, Handb. Males. Mosses 1: 127. 1988. — *Campylopus singaporensis* M. Fleisch. ex Paris, Rev. Bryol. 33: 25. 1906. — *Campylopus demangei* Thér. & P. de la Varde, Rev. Bryol. 49: 28. f. 1. 1922. (**Figure 5.46**)

Plants yellowish brown, somewhat shiny, in turfs. **Stems** reddish, erect, simple or rarely branched, radiculose at base. **Leaves** spreading when moist; lanceolate, 3.0–4.0 × 0.6–0.9 mm; gradually to finely acute; margins denticulate in the upper; costae occupying 1/3 the leaf base width, excurrent in a serrate point, with dorsal stereid bands, 1–2 cells deep, overlying the guide cells, the ventral stereid bands well defined in transverse section; upper cells ovoid to elongate-ovoid, thick-walled, 34–65 × 7–10 µm, basal cells yellowish, moderately long-rectangular, thick-walled and porose, 31–95 × 10–30 µm; alar cells not inflated, hyaline or reddish brown, 27–49 × 20–32 µm. **Dioicous.** **Setae** straight when dry, cygneous when moist; reddish brown, 5–6 mm long. **Capsules** erect, ovoid to short-cylindric, symmetric, 1.0–1.2 mm long. **Opercula** long-rostrate. **Peristome** single, teeth 16, divided to the middle or little more, orange-brown and vertically striate below, hyaline and papillose above. **Calyptrae** fringed at base. **Spores** not seen.

Additional illustration. – Eddy (1988: 128, Fig. 114A–D).

Thailand. – EATHERN: Chaiyaphum. PENINSULAR: Ranong, Surat Thani (He, 1995).

Distribution. – Bangka, Brunei, China, Indonesia, Kampuchea, Malaysia, and Vietnam (He, 1995).

Ecology. – On soils in sunlight, near pond, at 1,237 m elevation.

Specimens examined. – *P. Ajintaiyasil* 058 (BCU).

3. LEUCOBRYUM

Hampe, Linnaea 13: 42. 1839; Gangulee, Mosses E. India 2: 414. 1969; Noguchi, Ill. Moss Fl. Japan 1: 234. 1987; Eddy, Handb. Males. Mosses 2: 5. 1991; Bang-juan & He, Moss Fl. China 1: 243. 1999.

Plants whitish, grayish or bluish green, in compact or loose cushions, sometime in dense turfs. **Stems** erect, simple or forked; central strand absent or 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, upper parts of leaves filled mostly by the multi-layered broad costae, 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. **Setae** erect, elongate, sometimes clustered. **Capsules** more or less cylindrical, asymmetric, inclined to horizontal, rarely erect, ribbed, often strumose. **Opercula** long-rostrate. **Peristome** single, 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. **Calyptrae** cucullate. **Spores** small to large, finely papillose.

Key to the species

- 1a. Leaves smooth above on dorsal side.....2
 2a. Stems with a central strand.....2. *Leucobryum bowringii*
 2b. Stems without a central strand.....4. *Leucobryum juniperoideum*
 1b. Leaves scabrous or undulate above on dorsal side.....3
 3a. Plants small; leaves less than 3 mm long...1. *Leucobryum aduncum* var. *scalare*
 3b. Plants robust; leaves more than 3 mm long.....3. *Leucobryum javense*

1. *Leucobryum aduncum* Dozy & Molk. var. **scalare** (Müll. Hal. ex M. Fleisch.) A. Eddy, Handb. Males. Mosses 2: 11. 1991; Eddy, Handb. Males. Mosses 2: 11. 1991; Bang-juan & He, Moss Fl. China 1: 246. 1999. — *Leucobryum scalare* Müll. Hal. ex M. Fleisch., Musci Buitenzorg 1: 143. 1904; Gangulee, Mosses E. India 2: 429. 1969. — *Leucobryum flavulum* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 28. 1905. — *Leucobryum perichaetiale* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9(1) : 11. 1932. **(Figure 5.47)**

Plants grayish to yellowish green, in cushioned, small to medium-sized, 1–2 cm high. **Stems** erect, branched, usually forming conical points at the apex; central strand absent. **Leaves** spirally arranged and usually closely imbricate; lanceolate, 1.8–2.4 × 0.5–0.6 mm, gradually narrowed to subtubulous tips from an ovate to elliptic base; acute at the apex, acumina channelled, filled mostly with costae, undulate and spinosely prorate on the dorsal side of the acumina; hyaline laminal cells narrowly rectangular, forming borders of 1–2 rows of cells; in cross section, costae leucocysts 1-layered on the upper parts of leaves, 2–3 layered on the lower parts of leaves enclosing a layer of median chlorocysts throughout leaves; cells rectangular, 18–43 × 10–27 µm. **Dioicous**. **Perichaetial leaves** similar to leaves. **Setae** 10–11 mm long. **Capsules** inclined, ovoid to ellipsoid, 1.0–1.3 mm long. **Opercula** long-rostrate. **Peristome** single, 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. **Calyptrae** cucullate. **Spores** finely papillose.

Additional illustration. – Gangulee (1969: 430, Fig. 202, as *L. scalare*); Eddy (1990: 10, Fig. 170A–E); Yamaguchi (1993: 82–85, Pl. XIX–XXII).

Thailand. – NORTHERN: Chiang Mai, Tak, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei. EASTERN: Nakhon Ratchasima. CENTRAL:

Nakhon Nayok. SOUTH-EASTERN: Chanthaburi, Trat. PENINSULAR: Surat Thani, Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, Cambodia, China, India, Indonesia, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On all habitat except twig in sunlight or under shade of tree, near waterfall or not, at 1,223–1,304 m elevation.

Specimens examined. – *P. Ajintaiyasil* 028, 064, 071, 073, 108, 121, 132B, 150, 169, 171, 185, 211, 429, 493 (BCU).

2. *Leucobryum bowringii* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 26. 1859; Gangulee, Mosses E. India 2: 418. 1969; Noguchi, Ill. Moss Fl. Japan 1: 236. 1987; Eddy, Handb. Males. Mosses 2: 16. 1991; Bang-juan & He, Moss Fl. China 1: 247. 1999. — *Ochrobryum ceylanicum* Besch., J. Bot. (Morot) 11: 148. 1897. — *Leucobryum yamatense* Besch., J. Bot. (Morot) 12: 288. 1898. — *Leucobryum nagasakense* Broth., Hedwigia 38: 208. 1899. — *Leucobryum brotheri* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 36. 1905. — *Leucobryum deciduum* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 42. 1905. — *Leucobryum stenobasis* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 31. 1905. (**Figure 5.48**)

Plants grayish green, often lustrous, in loose turfs or cushions, small to medium-sized, 1–2 cm high. **Stems** erect, simple or branched; central strand present. **Leaves** densely turfed, flexuose or contorted when dry; oblong-ovate to oblong-elliptic at base, lanceolate to linear-lanceolate above, 8.0–9.0 × 0.7–0.8 mm; gradually narrowed to subtubulose apices from oblong base; costae thin, filling almost the entire leaf acumina, dorsal side of leaf acumina smooth; in cross section, chlorocysts quadrangular, leucocysts in 1 layers on both sides of chlorocysts; cells rectangular, 64–114 × 16–22 μm, bordered cells linear, often thick-walled, porous, forming distinct. **Dioicous.** **Setae** slender, reddish, 1–2 cm long. **Capsules** horizontal to inclined, ovoid to ellipsoid. **Opercula** conic-rostrate with long beak. **Peristome** teeth 16, divided from tips to the middle, papillose. **Calyptrae** cucullate. **Spores** finely papillose.

Additional illustration. – Gangulee (1969: 419, Fig. 195); Noguchi (1987: 239, Fig. 96C); Eddy (1990: 16–17, Fig. 174–175); Yamaguchi (1993: 108–111, Pl. XLV–XLVIII).

Thailand. – NORTHERN: Chiang Mai, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Trat. PENINSULAR: Ranong, Surat Thani, Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, China, Hong Kong, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Mexico, New Guinea, Philippines, Sri Lanka, Taiwan, and Vietnam (He, 1995; Yamaguchi, 1993).

Ecology. – On soils or rocks under shade of tree, near waterfall, at 1,222–1,256 m elevation.

Specimens examined. – *P. Ajintaiyasil* 031, 052, 472, 476, 488 (BCU).

3. *Leucobryum javense* (Brid.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 25. 1859; Gangulee, Mosses E. India 2: 426. 1969; Noguchi, Ill. Moss Fl. Japan 1: 240. 1987; Eddy, Handb. Males. Mosses 2: 6. 1991; Bang-juan & He, Moss Fl. China 1: 251. 1999. — *Sphagnum javense* Brid., Bot. Zeitung (Regensburg) 1(13): 200. 1802. — *Leucobryum falcatum* Müll. Hal., Syn. Musc. Frond. 1: 79. 1848. — *Leucobryum laticaula* Müll. Hal., Hedwigia 36: 331. 1897. — *Leucobryum spinidorsum* Müll. Hal. Hedwigia 36: 331. 1897. — *Leucobryum strictifolium* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 40: 159. 1898. — *Leucobryum confusum* Thér., Bull. Soc. Bot. Genève Sér. 2 13: 224. 3. 1921. — *Leucobryum cyathifolium* Dixon, J. Linn. Soc., Bot. 45: 499. 1922. **(Figure 5.49)**

Plants whitish green tinged with yellow or purple, in loose turfs or cushions, usually robust, 4–6 cm high. **Stems** erect, simple or branched; central strand absent. **Leaves** crowded, often falcate-secund; broadly lanceolate to narrowly lanceolate, gradually narrowed to subtubulose apices from broadly ovate base, 6.0–11.0 × 2.0–3.0 mm; acute at apex, dorsal side of leaf acumina papillose prorate; margins bordered by 2–3 rows of linear cells on the upper parts of leaves, lamina near leaf base consisting of 4–6 rows of quadrate to rectangular cells; costael leucocysts 2–3 layers on both sides of a median layered chlorocysts. **Dioicous**. **Setae** 15–20 mm long. **Capsules** inclined and curved, strumose. **Peristome** single, 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. **Calyptrae** cucullate. **Spores** finely papillose.

Additional illustration. — Gangulee (1969: 429, Fig. 201); Noguchi (1987: 242, Fig. 98); Eddy (1990: 7–8, Fig. 167–168); Yamaguchi (1993: 64–66, Pl. I–III).

Thailand. — **NORTHERN:** Chiang Mai. **NORTH-EASTERN:** Loei. **EASTERN:** Nakhon Ratchasima. **CENTRAL:** Nakhon Nayok. **SOUTH-EASTERN:** Chon Buri (He, 1995).

Distribution. — Brunei, China, Hong Kong, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Taiwan, and Vietnam (He, 1995; Yamaguchi, 1993).

Ecology. — On all habitat except twig under shade of tree, near waterfall, at 1,113–1,251 m elevation.

Specimens examined. — *P. Ajintaiyasil* 015, 046, 100, 232B, 233, 347 (BCU).

4. *Leucobryum juniperoideum* (Brid.) Müll. Hal., Linnaea 18: 689. 1844; Gangulee, Mosses E. India 2: 420. 1969; Eddy, Handb. Males. Mosses 2: 20. 1991; Bang-juan & He, Moss Fl. China 1: 252. 1999. — *Dicranum juniperoideum* Brid., Bryol. Univ. 1: 409. 1826. — *Leucobryum triviale* Müll. Hal., Linnaea 36: 30. 1869. — *Leucobryum retractum* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 334. 1893. — *Leucobryum altiusculum* Besch., J. Bot. (Morot) 12: 285. 1898. — *Leucobryum humile* Broth. ex Besch., J. Bot. (Morot) 12: 286. 1898. — *Leucobryum lacteolum* Besch., J. Bot.

(Morot) 12: 286. 1898. — *Leucobryum ferriei* Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 28. 1905. — *Leucobryum rhizophyllum* Warnst., Hedwigia 57: 81. 17. 1915. — *Leucobryum angustissimum* Broth., Symb. Sin. 4: 28. 1929. (**Figure 5.50**)

Plants whitish green, in dense turfs or compact cushions, small to medium-sized, 1–3 cm high. **Stems** erect, simple or branched; central strand absent, somewhat flexuose when dry, erect-spreading to slightly falcate-secund when moist; lanceolate, gradually narrowed to subtubulous apices from a slightly shorter ovate base, **Leaves** 5–8 × 1–2 mm; acute at the apex, dorsal side of leaf acuminate smooth; margins entire, bordered by 1–3 rows of linear cells; lamina near leaf base consisting of 5–10 rows of quadrate to rectangular cells; costae in cross section, leucocysts 2–4 layers on dorsal side and 1–2 layers on ventral side, sandwiching a layer of chlorocysts. **Dioicous**. **Setae** 15–1.3 mm long. **Capsules** inclined, strumose. **Peristome** single, 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. **Calyptrae** cucullate. **Spores** finely papillose.

Additional illustration. — Gangulee (1969: 420, Fig. 196); Eddy (1990: 19, Fig. 176A–F); Yamaguchi (1993: 93–98, Pl. XXX–XXXV).

Thailand. — NORTHERN: Chiang Mai, Phitsanulok. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Chumphon (He, 1995).

Distribution. — Bhutan, Brunei, China, India, Indonesia, Japan, Kampuchea, Korea, Laos, Malaysia, Mauritius, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Taiwan, Turkey, and Vietnam (He, 1995; Yamaguchi, 1993).

Ecology. — On soils, rocks or bark under shade of tree, near waterfall, at 1,184–1,249 m elevation.

Specimens examined. — *P. Ajintaiyasil* 018, 027, 034, 061, 194, 353, 357, 362 (BCU).

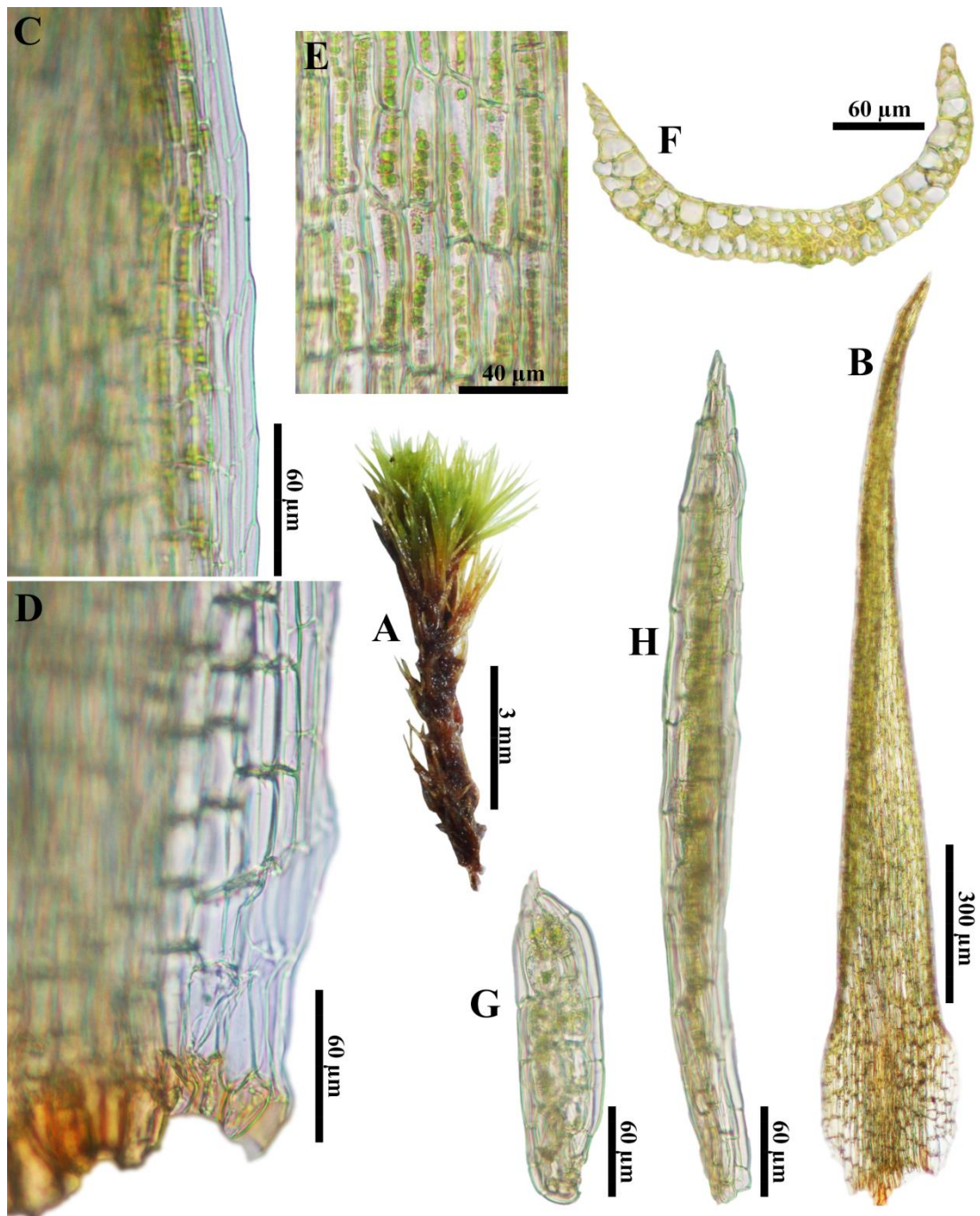


Figure 5.42 *Brothera leana* (Sull.) Müll. Hal.

A. Gametophyte, B. Leaf, C. Leaf margin, D. Alar region, E. Cells at median part of leaf, F. Cross section of leaf, G–H. Brood bodies. Based on *P. Ajintaiyasil* 234.

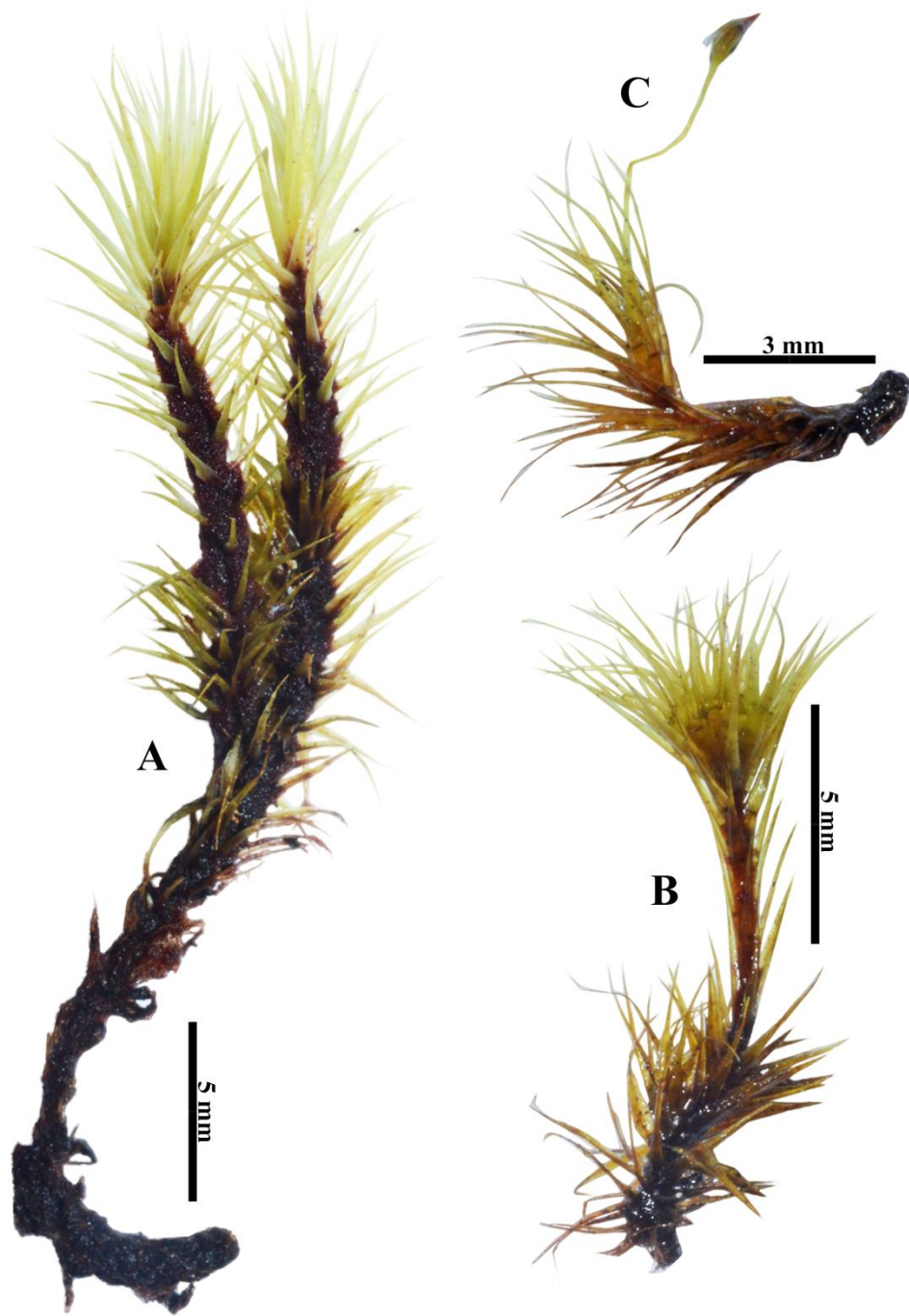


Figure 5. 43 *Campylopus ericoides* (Griff.) A. Jaeger

A–B. Sterile gametophyte, C. Gametophyte with sporephyte. Based on *P. Ajintaiyasil* 215 & 487A.

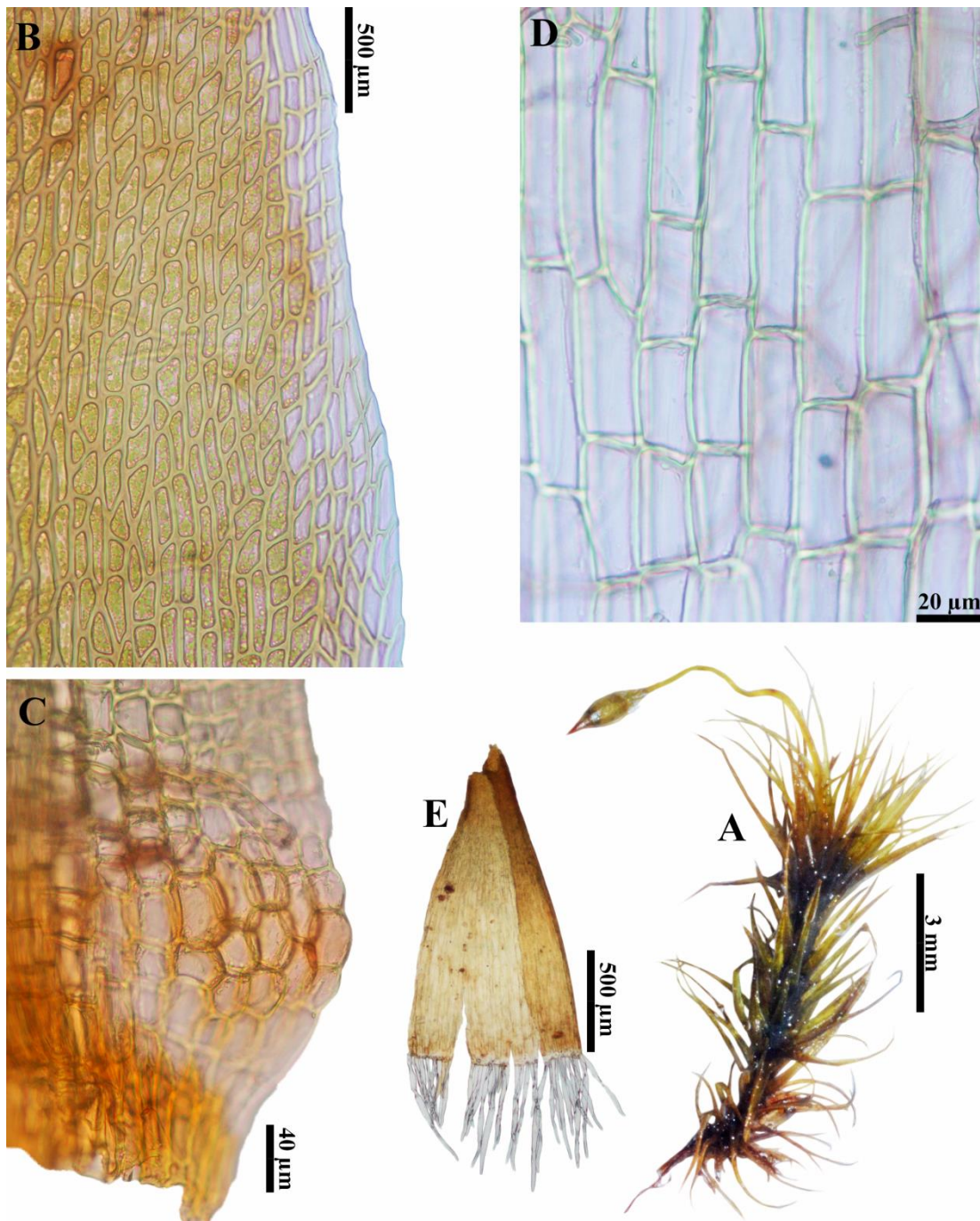


Figure 5.44 *Campylopus ericoides* (Griff.) A. Jaeger (continued)

A. Gametophyte with sporophyte, B. Lower leaf margin, C. Alar region, D. Cells at median part of leaf, E. Calyptra. Based on *P. Ajintaiyasil 023*.

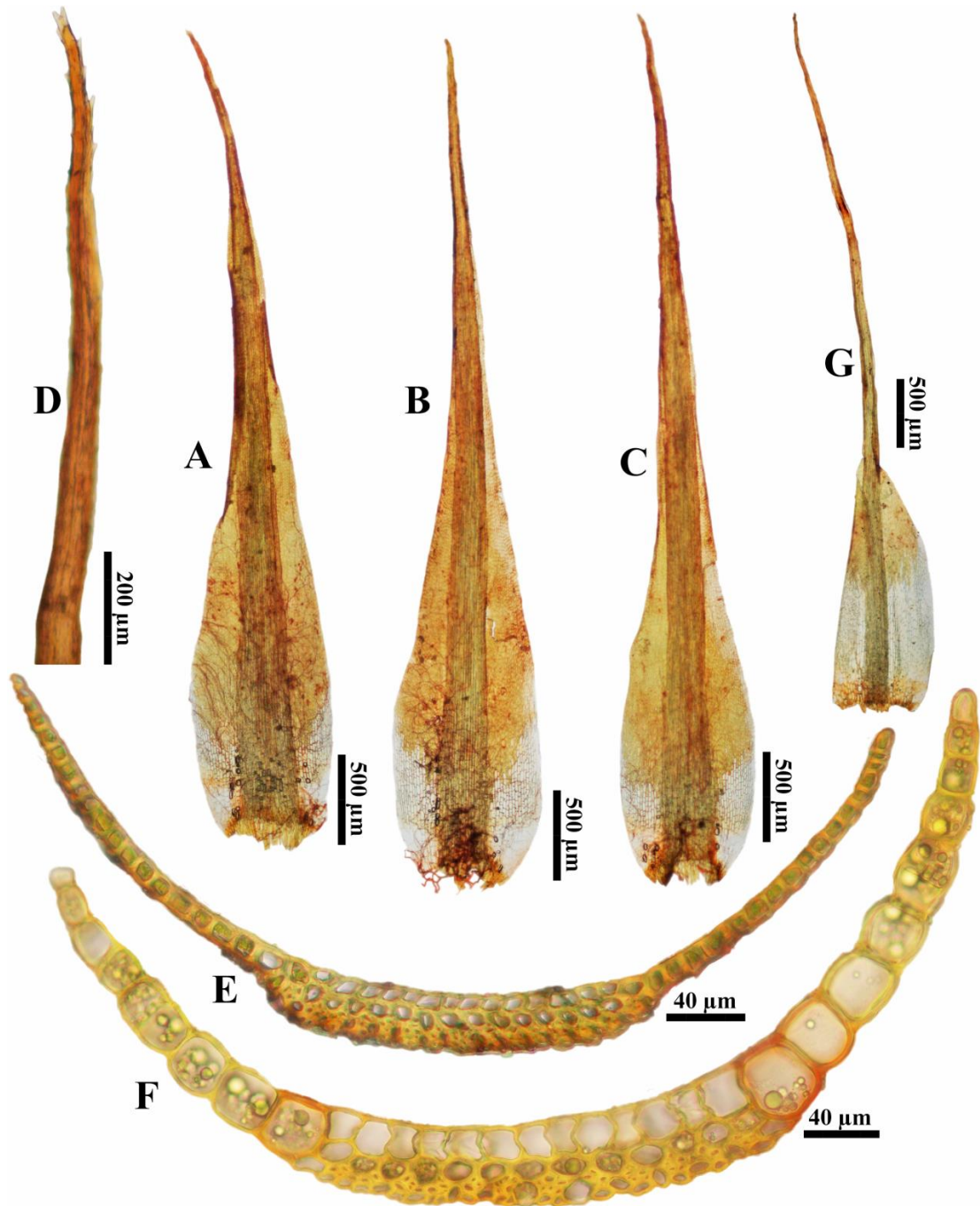


Figure 5.45 *Campylopus ericoides* (Griff.) A. Jaeger (continued)

A–C. Leaves, D. Leaf ax, E. Cross section of median leaf, F. Cross section of lower leaf, G. Perichaetial leaf. Based on *P. Ajintaiyasil 013*.

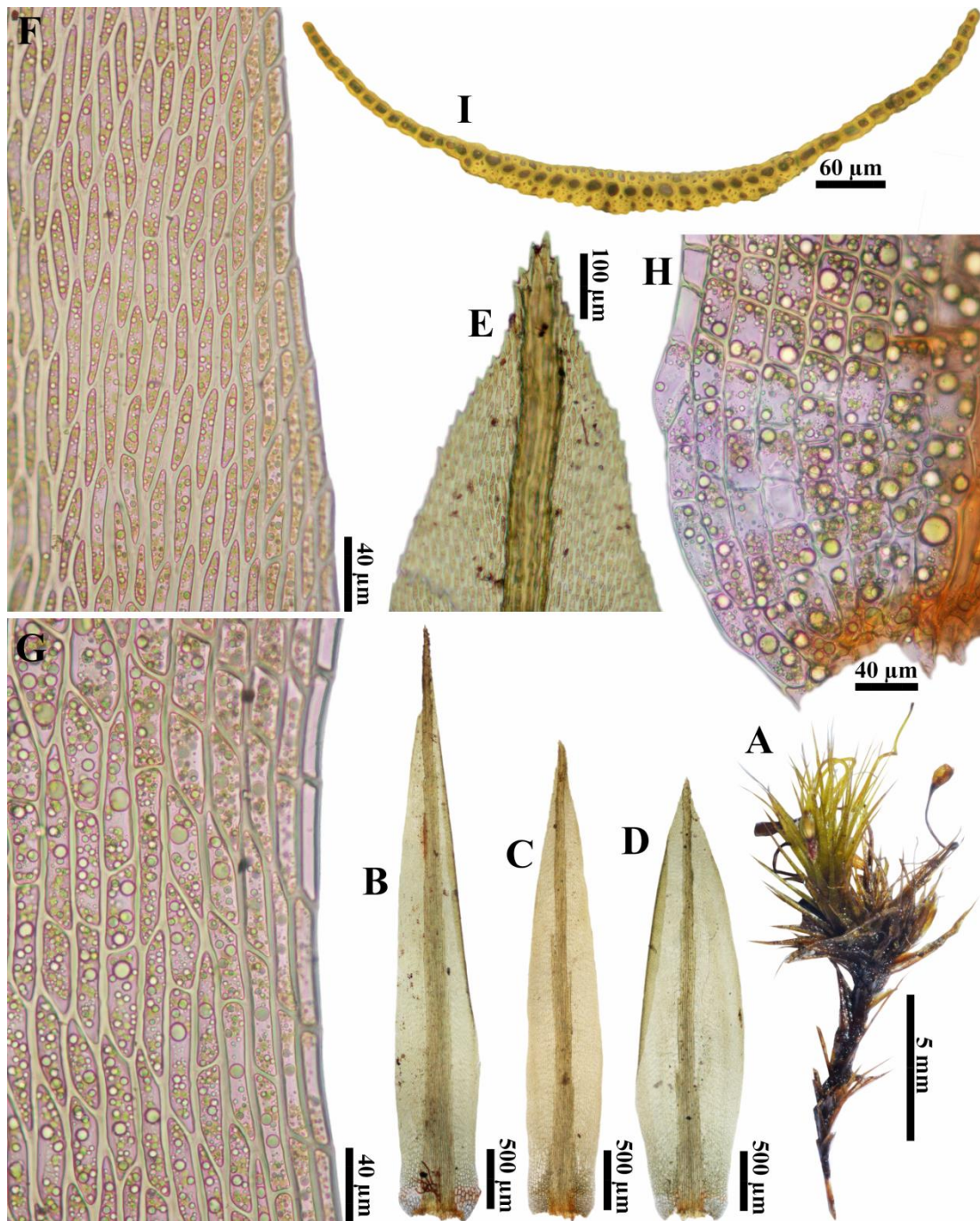


Figure 5.46 *Campylopus serratus* Sande Lac.

A. Gametophyte, B–D. Leaves, E. Leaf apex, F. Cells at upper part of leaf, G. Cells at lower part of leaf, H. Cross section of middle leaf, I. Alar region. Based on *P. Ajintaiyasil 058*.

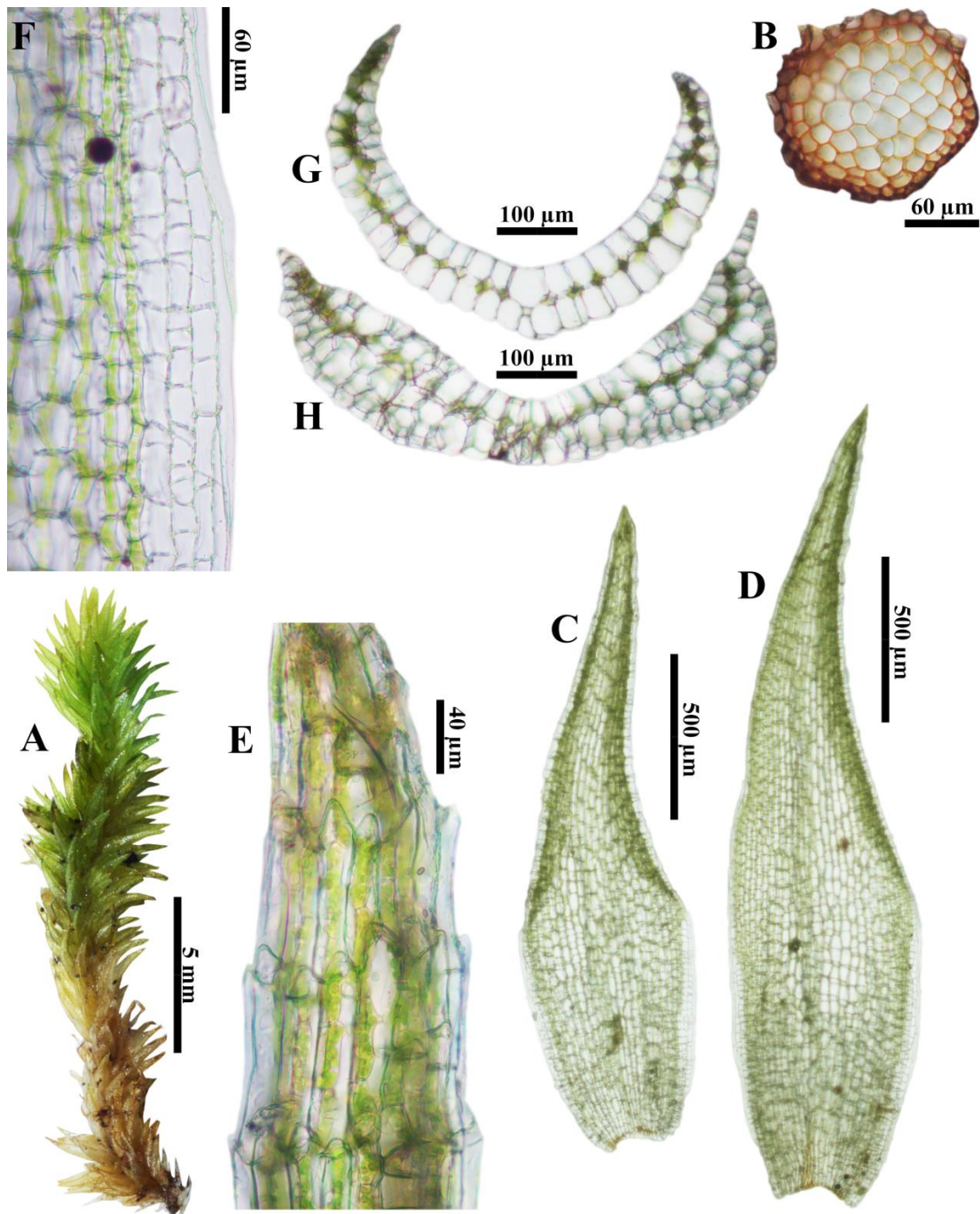


Figure 5.47 *Leucobryum aduncum* Dozy & Molk. var. *scalare* (Müll. Hal. ex M. Fleisch.) A. Eddy

A. Gametophyte, B. Cross section of stem, C–D. Leaves, E. Leaf apex, F. Cells at border, G. Cross section of leaf apex, H. Cross section of lower part of leaf. Based on *P. Ajintaiyasil* 493.

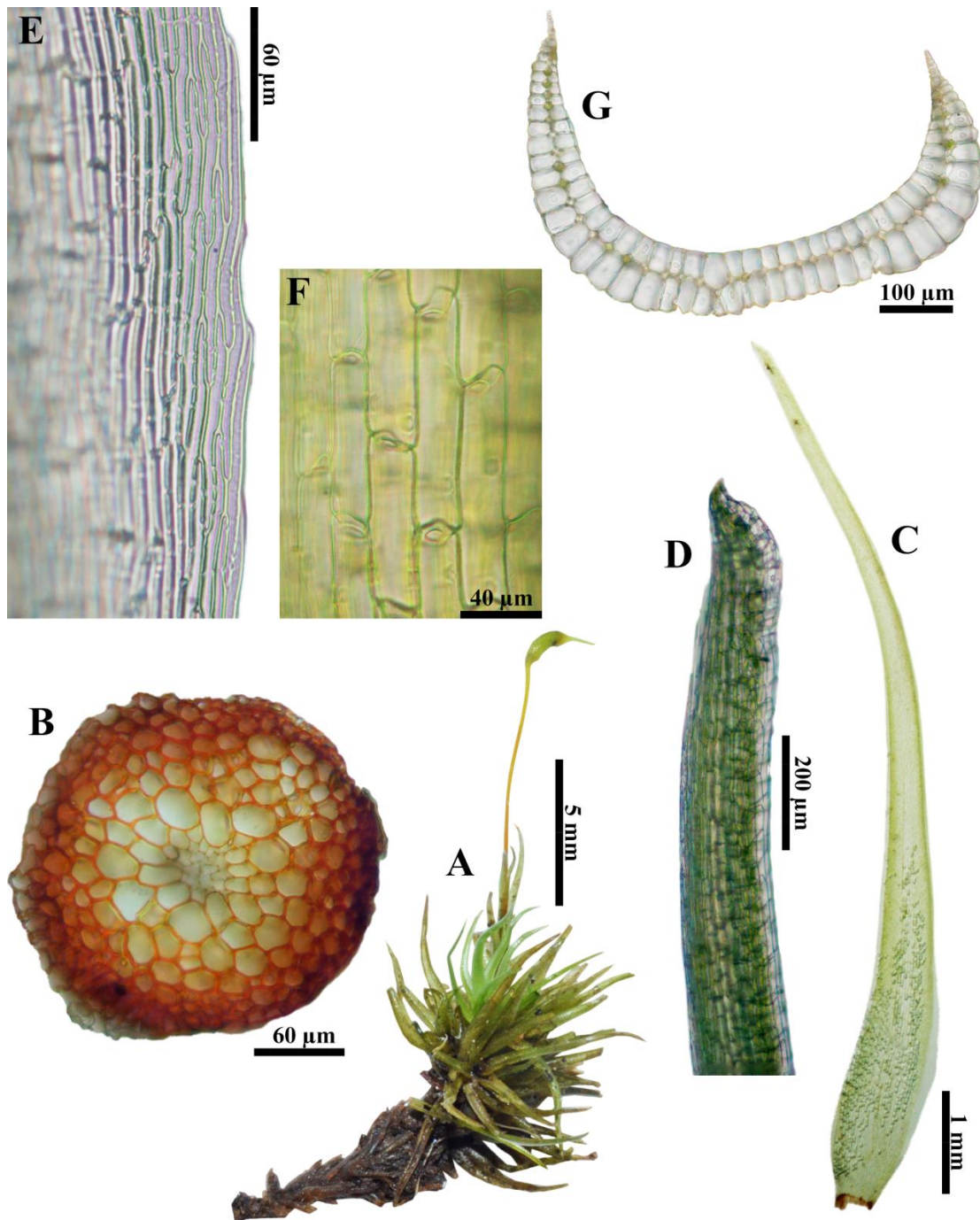


Figure 5. 48 *Leucobryum bowringii* Mitt.

A. Gametophyte with sporophyte, B. Cross section of stem, C. Leaf, D. Leaf apex, E. Cells at border, F. Cells at median part of leaf, G. Cross section of leaf apex. Based on *P. Ajintaiyasil* 472.

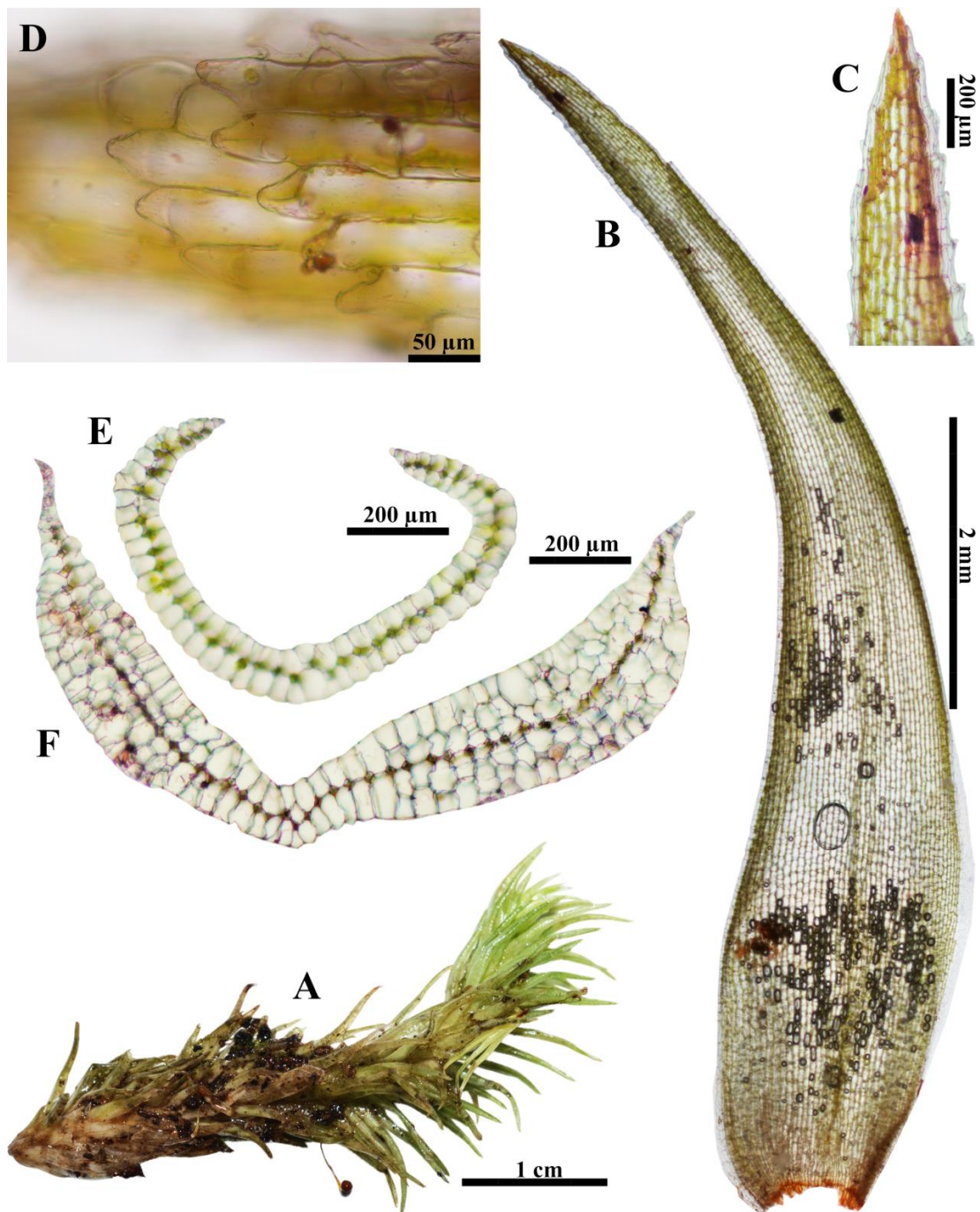


Figure 5.49 *Leucobryum javense* (Brid.) Mitt.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Cells at apical part of leaf, E. Cross section of leaf apex, F. Cross section of lower leaf. Based on *P. Ajintaiyasil 046*.

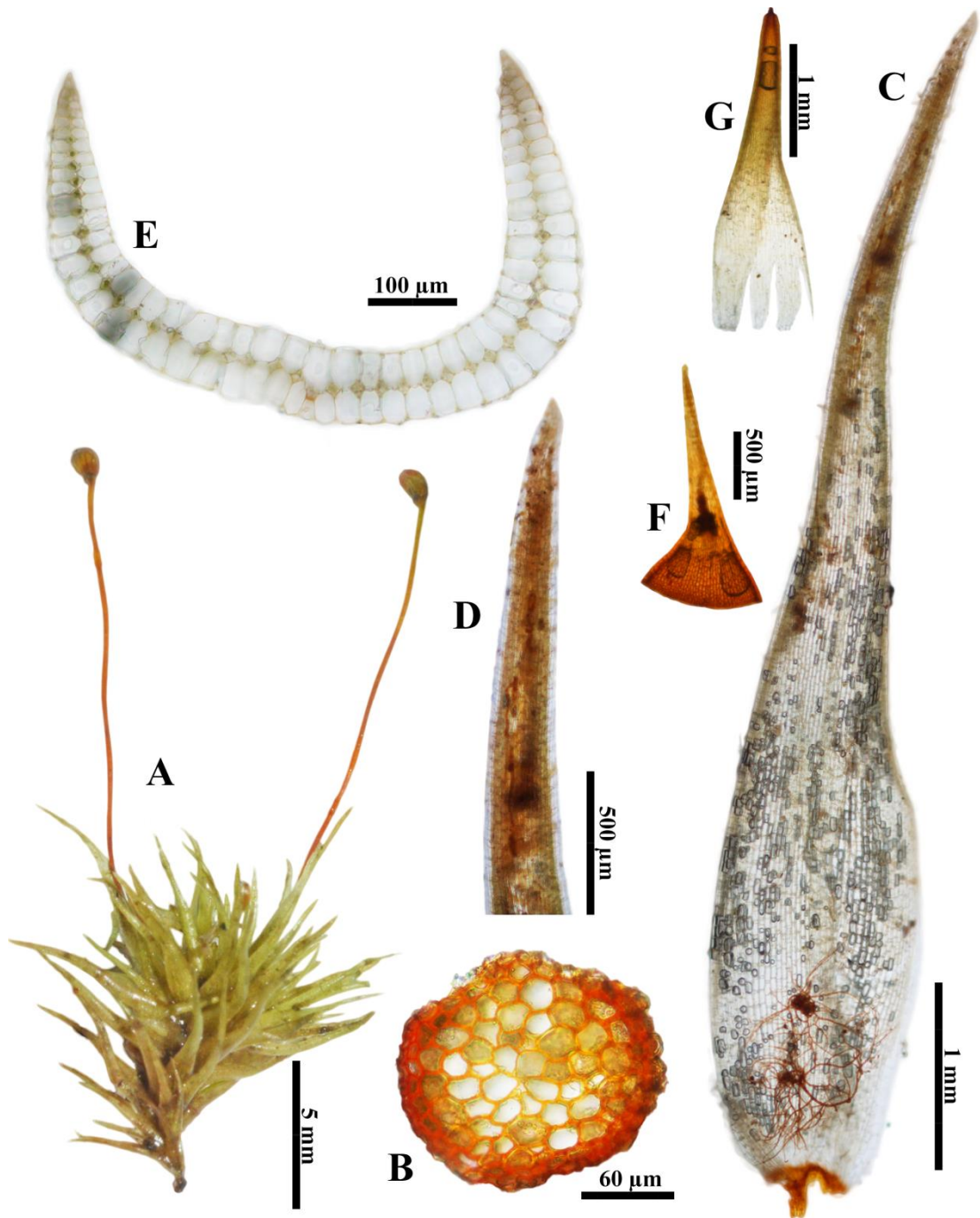


Figure 5.50 *Leucobryum juniperoideum* (Brid.) Müll. Hal.

A. Gametophyte with sporophyte, B. Cross section of stem, C. Leaf, D. Leaf apex, E. Cross section of leaf apex, F. Opercula, G. Calyptra. Based on *P. Ajintaiyasil 018*.

15. METEORIACEAE

Kindb., Gen. Eur. N.- Amer. Bryin. 7. 1897; Gangulee, Mosses E. India 5: 1281. 1976; Noguchi, Ill. Moss Fl. Japan 3: 661. 1994; Peng-cheng & Lin-ying, Moss Fl. China 5: 258. 2011.

Plants mostly medium-sized to rather large, often pendent. **Primary stems** creeping or spreading. **Secondary stems** often pendent or spreading, irregularly to regularly pinnately branched, flagellate branches frequent; in cross section outer 3-6 rows of cells small, thick-walled, inner cells thin- to somewhat thick walled; central strand present or more often absent; rhizoids often clustered beneath. **Leaves** often differentiated between stem and branch, erect to wide-spreading; broadly ovate to lanceolate, concave or not; apex short acute to more commonly acuminate; costae short and double or single; median cells mostly elongate, sometimes short, often variously papillose; alar cells not or weakly differentiated. **Dioicous**, rarely autoicous. **Perichaetia** lateral, leaves often differentiated. **Setae** often short, roughened. **Capsules** often immersed, erect, symmetric. **Opercula** rostrate. **Peristome** double, exostome teeth 16, cross striolate to papillose; endostome often reduced. **Calyptrae** mitrate or cucullate, often hairy. **Spores** usually spherical, smooth to papillose.

Key to the genera

- 1a. Leaves monomorphic.....1. *Aerobryidium*
 1b. Leaves dimorphic, differentiated between stem and branch leaves.....3
 3a. Plants rigid; leaf cells pluripapillose.....2. *Cryptopapillaria*
 3b. Plants soft; leaf cells unipapillose.....3. *Neodicladiella*

1. AEROBRYIDIUM

M. Fleisch. ex Broth., Nat. Pflanzenfam. 1(3): 820. 1906; Gangulee, Mosses E. India 5: 1320. 1976; Peng-cheng & Lin-ying, Moss Fl. China 5: 259. 2011.

Plants green, yellowish green, or brownish green, slightly glossy. **Primary stems** creeping. **Secondary stems** pendulous, regularly or irregularly pinnately branched, with turfed rhizoids. **Leaves** oblong, oblong-ovate, or ovate-lanceolate, usually erect-patent; often with slender, flexuose hairy apices; margins nearly entire or serrulate above; costae slender, reaching above mid-leaf; median leaf cells rhomboidal, elongate-rhomboidal to linear, unipapillose, usually thin-walled, basal cells lax; alar cells not or scarcely differentiated; axillary hairs 6–8 cells long, hyaline. **Dioicous**. **Setae** slender, usually reddish brown, sometimes papillose. **Capsules** ovoid or oblong-ovoid, usually erect. **Opercula** conic, obliquely rostrate. **Peristome** double; exostome teeth lanceolate, densely papillose, often striolate at the base; endostome segments narrowly lanceolate, finely papillose; basal membrane low or high; cilia short or absent. **Calyptrae** cucullate, sparsely hairy. **Spores** spherical, finely papillose.

Aerobryidium filamentosum (Hook.) M. Fleisch., Nat. Pflanzenfam. I(3): 821. 1906; Gangulee, Mosses E. India 5: 1322. 1976; Peng-cheng & Lin-ying, Moss Fl. China 5: 262. 2011. — *Neckera filamentosa* Hook., Musci Exot. 2: 158. 1819. — *Aerobryidium taiwanense* Nog., J. Hattori Bot. Lab. 3: 71. 27. 1948. (**Figure 5.51**)

Plants green to yellowish green, or yellowish brown, slightly glossy. **Primary stems** creeping. **Secondary stems** pendulous, loosely irregularly pinnately branched; branches 0.5–1 cm long with leaves; obtuse or attenuate at the apex. **Leaves** oblong-lanceolate, 2.1–3.2 × 0.6–0.9 mm, concave; flexuose and undulate or rugose at the apex, the hair-pointed apices 1/3–1/2 or longer than the total leaf length; margins slightly serrulate above, entire below; costae single, slender or weak, reaching above mid-leaf; median leaf cells elongate-rhomboidal to linear, centrally unipapillose, thin-walled, 32–49 × 4–6 μm, basal cells shorter and wider, nearly rectangular, thick-walled, slightly porose or smooth, 41–60 × 5–8 μm; alar cells differentiated, small, irregular, 13–23 × 8–11 μm. **Sporophytes** not seen.

Additional illustration. – Gangulee (1976: 1323, Fig. 644–646); Wu, Crosby, & He (2011: 260, Pl. 353, Fig. 7–14)

Thailand. – **NORTHERN:** Chiang Mai. **NORTH-EASTERN:** Phetchabun, Loei (He, 1995).

Distribution. – Bhutan, Brunei, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 945 m elevation.

Specimens examined. – *P. Ajintaiyasil 461* (BCU).

2. CRYPTOPAPILLARIA

M. Menzel, Willdenowia 22: 181. 1992; Peng-cheng & Lin-ying, Moss Fl. China 5: 280. 2011.

Plants slender, grayish green, dark green or blackish when old, not or slightly glossy, usually in pendulous or loose mats. **Stems** elongate, remotely and irregularly pinnately branched, pendulous; branches usually simple; obtuse or attenuate at the apex. **Stem leaves** imbricate, appressed when dry; broadly ovate to oblong-ovate, somewhat concave, distinctly plicate; gradually to rather abruptly acuminate at the apex, strongly auriculate, often clasping at the base; margins serrulate, especially auriculate bases; costae single, ending at mid-leaf or slightly longer; leaf cells elongate-rhomboidal, pluripapillose with papillae on the longitudinal cell wall; cells at auriculate bases rhomboidal, smooth. **Branch leaves** similar to stem leaves; rather abruptly and shortly acuminate, slightly twisted at the apex; axillary hairs consisting of 3 short; brownish basal cells; 3 rectangular, hyaline, upper cells. **Dioicous.** **Perichaetial leaves** linear-lanceolate, plicate. **Setae** very short, roughened. **Capsules** immersed, cylindrical. **Opercula** conic, obliquely long rostrate. **Peristome** double; exostome teeth narrowly lanceolate, minutely papillose, more or less hyaline, perforate near the apex; endostome segments linear, nearly as long as the teeth; basal membrane very low; cilia none. **Calyptrae** campanulate, small, densely hairy. **Spores** spherical, minutely papillose.

Key to the species

- 1a. Leaves with long flexuose at the apex.....1. *Cryptopapillaria chrysoclada*
 1b. Leaves acuminate at the apex.....2
 2a. Plants slender.....3. *Cryptopapillaria fuscescens*
 2b. Plants thick.....2. *Cryptopapillaria feae*

1. *Cryptopapillaria chrysoclada* (Müll. Hal.) M. Menzel, Willdenowia 22: 182. 1992. — *Neckera chrysoclada* Müll. Hal., Syn. Musc. Frond. 2: 139. 1850. — *Meteorium chrysocladum* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 818. 1906. **(Figure 5.52)**

Plants yellowish green to light green, blackish when old, glossy. **Stems** elongate, loosely and irregularly unipinnately branched; branches 0.3–3.0 cm long. **Stem leaves** erect-patent when dry, erect-spreading when moist; oblong-ovate, 2.0–2.2 × 0.7–0.8 mm, somewhat concave, slightly plicate; rather gradually acuminate at the apex, with long flexuose, twisted, piliferous acumen; strongly auriculate at the base; margins entire throughout to the base; costae single, ending above mid-leaf; leaf cells narrowly rhomboidal, lax, densely pluripapillose along longitudinal cell wall, 20–31 × 5–8 µm, basal juxtacostael cells hyaline, smooth, porose, 46–80 × 5–6 µm; cells at auriculate base irregularly rectangular or hexagonal, not papillose, 19–39 × 4–7 µm. **Branch leaves** similar to stem leaves, smaller, with rounded-obtuse at apex. **Sporophytes** not seen.

Additional illustration. – Nathi (2009: 128, Fig. 5.42).

Thailand. – NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Phetchabun, Loei. EASTERN: Chaiyaphum (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Malaysia, Myanmar, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On twigs under shade of tree, near waterfall, at 1,087–1,113 m elevation.

Specimens examined. – *P. Ajintaiyasil* 228 (BCU).

2. *Cryptopapillaria feae* (Müll. Hal. ex M. Fleisch.) M. Menzel, Willdenowia 22: 182. 1992; Peng-cheng & Lin-ying, Moss Fl. China 5: 280. 2011. — *Papillaria feae* Müll. Hal. ex M. Fleisch., Musci Buitenzorg 3: 761. 1908. **(Figure 5.53)**

Plants dark green or blackish when old, glossy. **Stems** elongate, loosely and irregularly unipinnately branched; branches 0.5–4.0 cm long, flexuose, terete. **Stem leaves** densely appressed when dry, erect-spreading when moist; oblong-ovate, plicate, 1.4–1.6 × 0.7–0.8 mm; widest and strongly auriculate at the base; rather abruptly narrowed to a slender, often twisted apex; margins serrulate, undulate at various portions; costae single, slender, reaching 2/3 the leaf length; leaf cells narrowly rhomboidal, pluripapillose along longitudinal cell wall, 24–35 × 3–5 µm,

basal juxtacostael cells hyaline, smooth, porose, $54\text{--}116 \times 5\text{--}7 \mu\text{m}$; cells at the auriculate base linear-rhomboidal, not papillose, $22\text{--}34 \times 3\text{--}4 \mu\text{m}$. **Branch leaves** similar to stem leaves, but smaller, with a shorter leaf apex. **Sporophytes** not seen.

Additional illustration. – Nathi (2009: 129, Fig. 5.43); Wu, Crosby, & He (2011: 281, Pl. 359, Fig. 7–15).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai, Lamphun. NORTH-EASTERN: Phetchabun, Loei. SOUTH-WESTERN: Ratchaburi (He, 1995).

Distribution. – China, Myanmar, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 1,262 m elevation.

Specimens examined. – *P. Ajintaiyasil* 369 (BCU).

3. Cryptopapillaria fuscescens (Hook.) M. Menzel, Willdenowia 22: 183. 1992; Peng-cheng & Lin-ying, Moss Fl. China 5: 282. 2011. — *Neckera fuscescens* Hook., Musci Exot. 2: 157. 1819. — *Daltonia fuscescens* (Hook.) Arn., Mém. Soc. Linn. Paris 5: 296. 1827. (**Figure 5.54**)

Plants yellowish green or grayish green, blackish when old, glossy. **Stems** slender, elongate, loosely and irregularly pinnately branched; branches 0.3–1.5 cm long. **Stem leaves** erect-patent when dry, erect-spreading when moist; oblong-ovate, $1.4\text{--}1.8 \times 0.6\text{--}0.7 \text{ mm}$, somewhat concave, plicate; rather gradually acuminate at the apex; strongly auriculate at the base; margins irregularly serrulate throughout to the base; costae single, ending above mid-leaf; leaf cells narrowly rhomboidal, densely pluripapillose along longitudinal cell wall, $19\text{--}26 \times 4\text{--}5 \mu\text{m}$, basal juxtacostael cells hyaline, smooth, porose, $54\text{--}81 \times 5\text{--}7 \mu\text{m}$; cells at auriculate base irregularly rectangular or hexagonal, not papillose, $18\text{--}27 \times 3\text{--}5 \mu\text{m}$. **Branch leaves** similar to stem leaves, smaller, with shorter leaf apices. **Sporophytes** not seen.

Additional illustration. – Nathi (2009: 130, Fig. 5.44).

Thailand. – NORTHERN: Chiang Mai, Lamphun, Tak. NORTH-EASTERN: Phetchabun. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Ratchaburi. SOUTH-EASTERN: Chanthaburi (He, 1995).

Distribution. – Bhutan, Brunei, China, India, Indonesia, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On rocks under shade of pine trees, at 1,191 m elevation.

Specimens examined. – *P. Ajintaiyasil* 214 (BCU).

3. NEODICLADIELLA

(Nog.) W.R. Buck, J. Hattori Bot. Lab. 75: 61. 1994; Peng-cheng & Lin-ying, Moss Fl. China 5: 300. 2011.

Plants yellowish green or light yellowish brown, not or slightly glossy, forming pendulous. **Primary stems** creeping. **Secondary stems** slender, filiform,

pendulous, rarely branched; branches often somewhat complanately foliate or filiform, with very slender tips. **Stem leaves** narrowly ovate-lanceolate; gradually long-acuminate, with a slender or piliferous apex; margins serrulate above, entire below; costae single, slender, reaching at mid-leaf; leaf cells linear, unipapillose or with 2–3 fine papillae on each cell, thin-walled; alar cells quadrate or irregularly quadrate. **Branch leaves** smaller than stem leaves; more often piliferous at the apex; axillary hairs hyaline, consisting of 4 short cells. **Dioicous**. **Setae** short, 1.5–3.0 mm long, slightly scabrose, almost smooth. **Capsules** erect, ovoid or oblong-ovoid, with an indistinct apophysis. **Opercula** conic, shortly beaked. **Peristome** double; exostome teeth linear-lanceolate, densely papillose throughout, sometimes finely cross-striolate at the base; endostome segments linear, keeled, perforate, papillose; basal membrane moderately high. **Calyptrae** mitrate, smooth. **Spores** spherical, minutely papillose.

Neodiciadiella flagellifera (Cardot) Huttunen & D. Quandt, Syst. Assoc. Special Vol. 71: 159. 2007; Peng-cheng & Lin-ying, Moss Fl. China 5: 300. 2011. — *Meteorium flagelliferum* Cardot, Beih. Bot. Centralbl., Abt. 19(2): 120. 18. 1905. (**Figure 5.55**)

Plants dark green or yellowish green, not glossy. **Primary stems** creeping. **Secondary stems** elongate, loosely branched, with slender, pendulous branches; branches complanately foliate, 0.5–4.0 cm long. **Stem leaves** similar to stem leaves, narrower; with a longer piliferous apex. **Branch leaves** appressed or loosely spreading when dry; often flexuose, narrowly ovate-lanceolate or oblong-lanceolate, 1.2–2.8 × 0.4–0.6 mm, slightly concave; long-acuminate or gradually narrowed to a piliferous apex; often constricted at the base; margins indistinctly serrulate throughout, usually narrowly recurved at the base; costae slender, weakened, reaching above mid-leaf; leaf cells narrowly rhomboidal to linear, unipapillose, evenly thick-walled, 49–63 × 4–8 μm; alar cells well defined, quadrate or subquadrate, hyaline, thick-walled, porose, 10–30 × 10–18 μm. **Sporophytes** not seen.

Additional illustration. – Wu, Crosby, & He (2011: 299, Pl. 364, Fig. 9–16).

Thailand. – NORTHERN: Tak (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. – On twigs under shade of tree, near waterfall, at 1,087–1,113 m elevation.

Specimens examined. – *P. Ajintaiyasil* 227 (BCU).

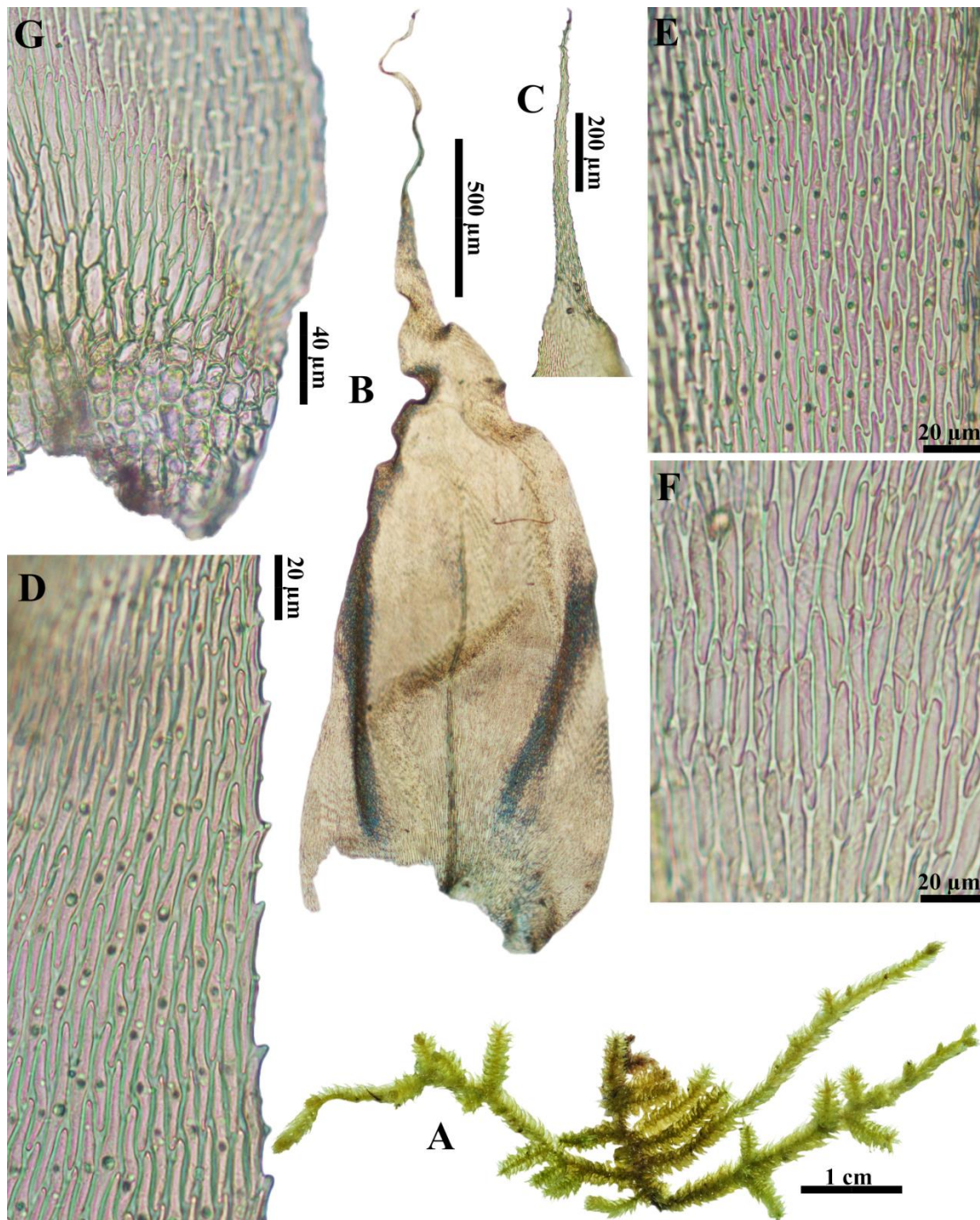


Figure 5.51 *Aerobryidium filamentosum* (Hook.) M. Fleisch.

A. Gametophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Cells at median part of leaf, F. Cells at leaf base, G. Alar region. Based on *P. Ajintaiyasil* 461.

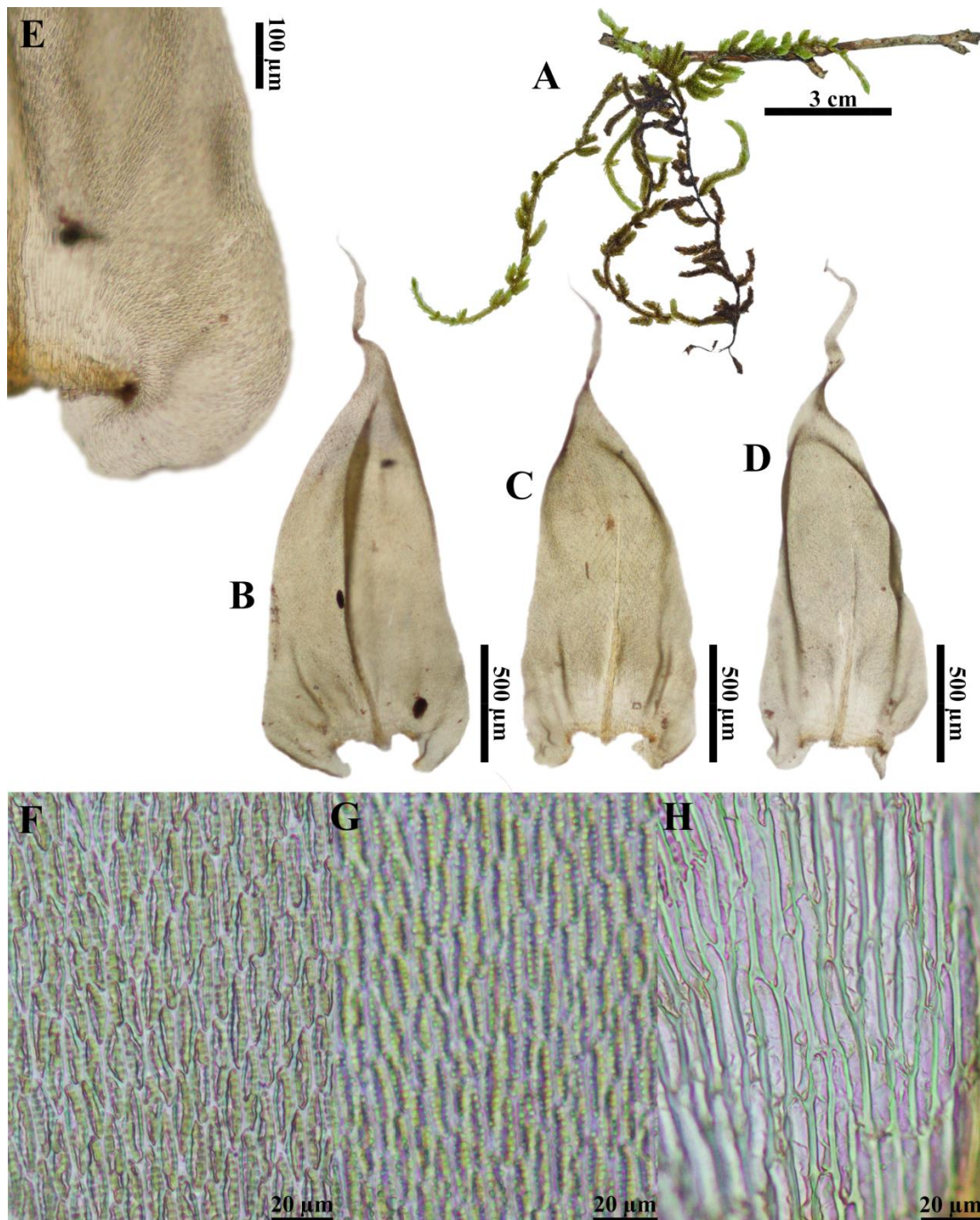


Figure 5.52 *Cryptopapillaria chrysoclada* (Müll. Hal.) M. Menzel

A. Gametophyte, B–D. Leaves, E. Leaf base, F. Cells at median part of leaf, G. Leaf cells showing pluripapillose, H. Juxtacostael cells at leaf. Based on *P. Ajintaiyasil* 228.

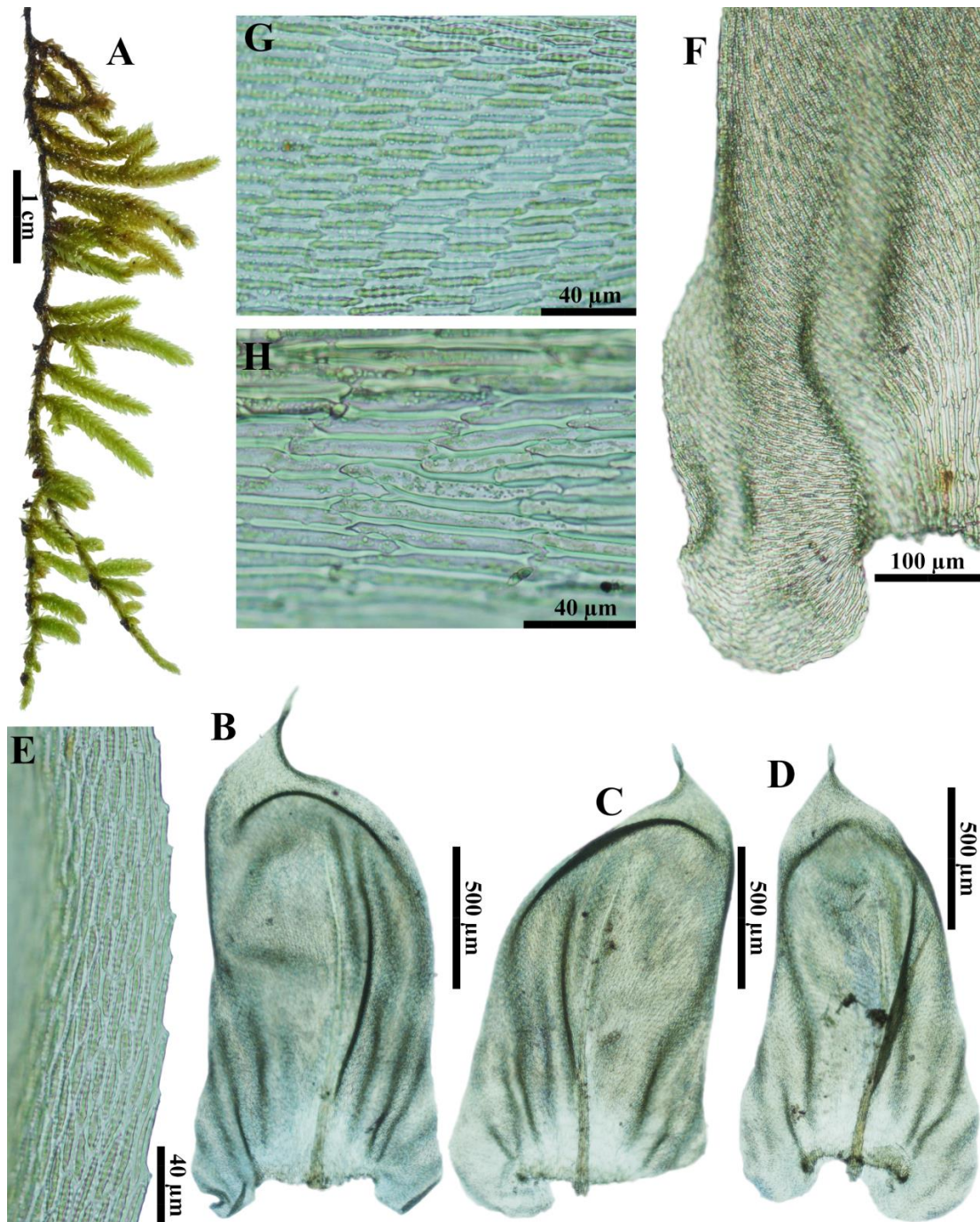


Figure 5.53 *Cryptopapillaria feae* (Müll. Hal. ex M. Fleisch.) M. Menzel

A. Gametophyte, B–D. Leaves, E. Leaf margin, G. Leaf base, H. Cells at median part of leaf, F. Juxtacostael cells at leaf. Based on *P. Ajintaiyasil* 369.

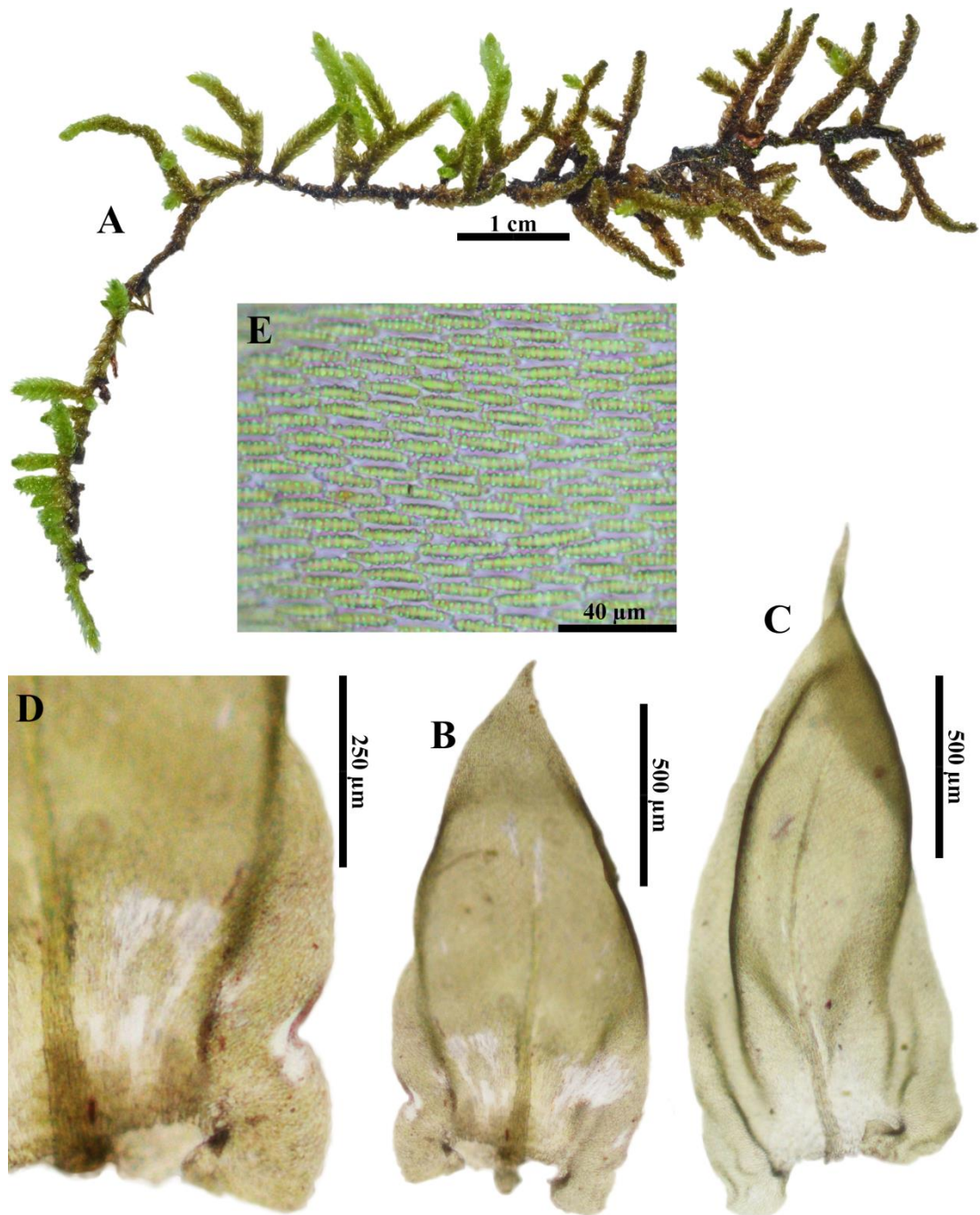


Figure 5. 54 *Cryptopapillaria fuscescens* (Hook.) M. Menzel

A. Gametophyte, B–C. Leaves, D. Leaf base, E. Cells at median part of leaf. Based on *P. Ajintaiyasil* 214.

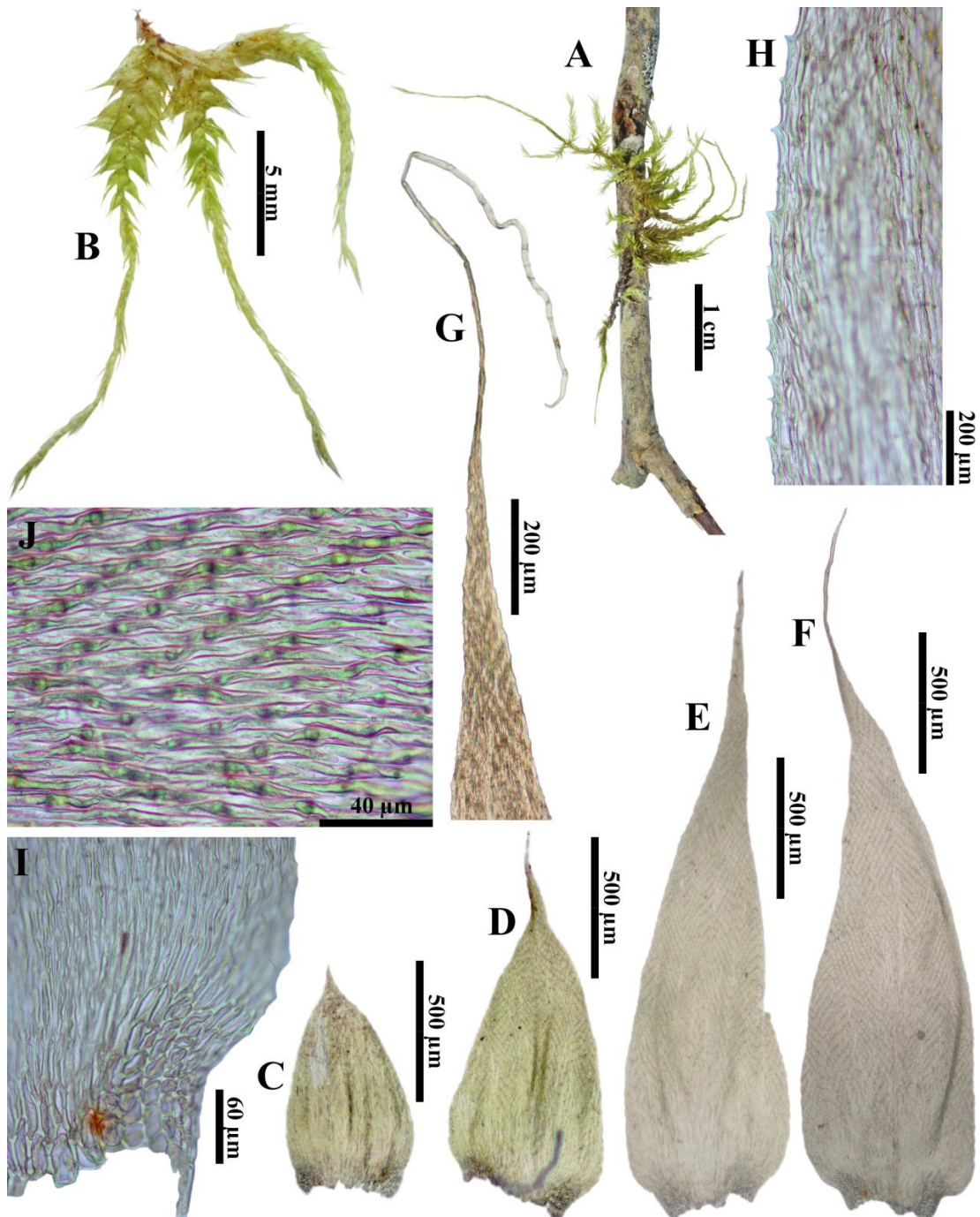


Figure 5.55 *Neodicladiella flagellifera* (Cardot) Huttunen & D. Quandt

A–B. Gametophytes, C–D. Branch leaves, E–F. Stem leaves, G. Leaf apex, H. Leaf margin, I. Leaf base, J. Cells at median part of leaf. Based on *P. Ajintaiyasil* 227.

16. MIYABEACEAE

Enroth, S. Olsson, Buchb., Hedenäs, Huttunen & D. Quandt, *Bryologist* 112(3): 463. 2009.

Plants small to medium-sized. **Stems** creeping, producing irregularly to subpinnately; without a central strand; paraphyllia absent. **Leaves** appressed-imbriate to complanate when dry; ovate to ligulate or nearly rounded; broadly acute to obtuse or rounded; base distinctly decurrent or lobed; margins entire below and crenulate to toothed near apex, or entire throughout; costae absent or indistinct, reaching to mid-leaf; cells smooth, cells quadrate or rounded-rhombic, incrassate, especially mid-leaf; base cells distinctly porose; marginal cells not differentiated, sometime towards base rather transverse in several rows; alar cells indistinct. **Diocious**. **Setae** elongate, smooth, twisted or not. **Capsules** symmetric, cylindrical to obovoid. **Opercula** conical, obliquely long-rostrate. **Peristome** reduced; exostome teeth smooth to papillose, sometime lamellate at front, strongly trabeculate at back and with cristate margins; endostome fragmentary or absent to strongly reduced with fragile segments often adhering to exostome. **Calyptrae** cucullate, naked or with few hairs. **Spores** small, round.

HOMALIADELPHUS

Dixon & P. de la Varde, *Rev. Bryol.*, n.s. 4(3): 142. 1931; Gangulee, *Mosses E. India* 6: 1430. 1977; Noguchi, *Ill. Moss Fl. Japan* 3: 716. 1989; Peng-cheng, *Moss Fl. China* 5: 325. 2011.

Plants yellow to brownish green when old, distinctly glossy, in small, forming fans. **Primary stems** slender, creeping. **Secondary stems** erect-patent, not branched below, or irregularly branched above. **Leaves** densely appressed when dry, slightly spreading when moist; rounded or rounded-ovate, often with a narrow lobe along the proximal margins; margins entire or serrulate at the apex; costae absent; cells quadrate or rounded-rhombic, basal juxtacostael cells elongate, narrowly rhombic, thick-walled, porose. **Diocious**. **Perichaetial leaves** oblong at the base, becoming narrowly lingulate above; serrulate at the apex. **Setae** short, brown, smooth. **Capsules** oblong-cylindrical. **Opercula** conic, with an oblique beak. **Peristome** double; exostome teeth light yellow, hyaline, smooth; endostome segments linear-lanceolate; basal membrane low. **Calyptrae** cucullate, sparsely hairy. **Spores** spherical, finely papillose.

Homaliadelphus targionianus (Mitt.) Dixon & P. de la Varde, *Rev. Bryol. Lichénol.* 4(3): 142. 1931; Gangulee, *Mosses E. India* 6: 1431. 1977; Noguchi, *Ill. Moss Fl. Japan* 3: 716. 1989; Peng-cheng, *Moss Fl. China* 5: 326. 2011. — *Neckera targioniana* Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1: 117. 1859. (**Figure 5.56**)

Plants light green, brownish green when old, glossy, forming fans. **Primary stems** creeping. **Secondary stems** densely branched, 0.9–1.0 cm long. **Leaves** closely appressed; rounded-ovate to oblong-ovate, asymmetric, 0.7–0.9 × 0.5–0.8 mm, usually lobed along the proximal margins at the base; margins entire; costae absent; upper leaf cells rounded-quadrate or rhombic, smooth, 8–16 × 9–13 μm, median cells

elliptic, thick-walled, basal cells slightly elongate, porose, $22\text{--}56 \times 7\text{--}10 \mu\text{m}$; marginal cells shorter, quadrate. **Sporophytes** not seen.

Additional illustration. – Iwatsuki (1958: 78–79, Fig. 1–10, 36–42); Gangulee (1977: 1431, Fig. 708); Noguchi (1989: 719, Fig. 317A); Wu, Crosby, & He (2011: 327, Pl. 371, Fig. 1–8).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTERN: Loei, Udon Thani (He, 1995).

Distribution. – Bhutan, China, India, Japan, Taiwan, and Vietnam (He, 1995).

Ecology. – On barks under shade of tree, at 979 m elevation.

Specimens examined. – *P. Ajintaiyasil* 256 (BCU).



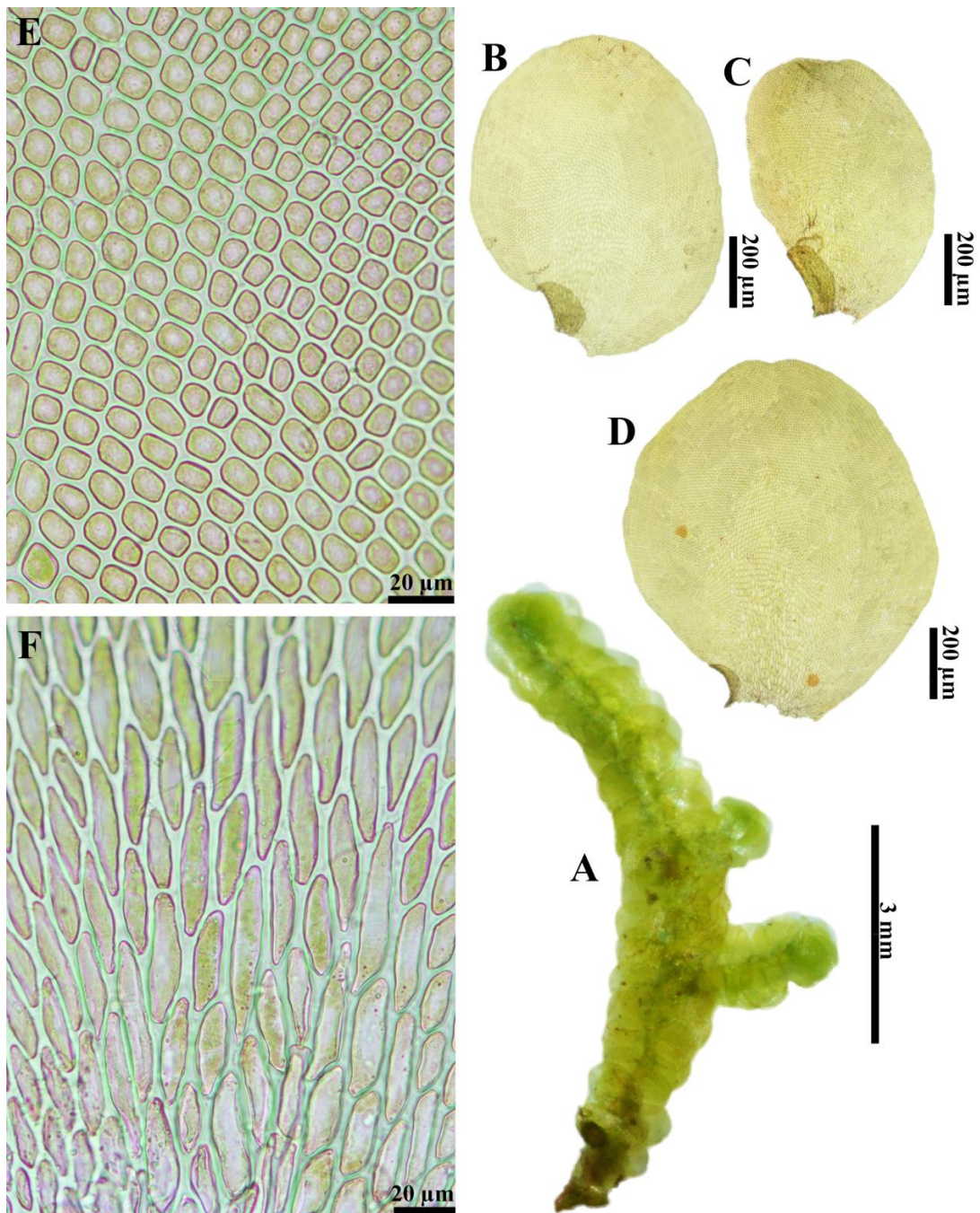


Figure 5.56 *Homaliadelphus targionianus* (Mitt.) Dixon & P. de la Varde

A. Gametophyte, B–D. Leaves, E. Cells at median part of leaf, F. Cells at leaf base.
Based on *P. Ajintaiyasil* 256.

17. NECKERACEAE

Schimp., Coroll. Bryol. Eur. 99. 1856; Gangulee, Mosses E. India 6: 1362. 1977; Noguchi, Ill. Moss Fl. Japan 3: 692. 1989; Peng-cheng, Moss Fl. China 5: 319. 2011.

Plants medium-sized to rather large, forming turfs or mats, light to dark green, yellowish-green to golden-brown. **Primary stems** short to long creeping, leaves scale-like or eroded. **Secondary stems** ascending to pendent, irregularly to regularly pinnately branched, radiculose along primary stems; paraphyllia present or absent; pseudoparaphyllia foliose. **Leaves** mostly crowded, mostly complanate; ovate- to oblong-lanceolate, oblong-lingulate, or cultriform, smooth or more commonly undulate, usually strongly asymmetric; apex obtuse to acute, truncate or acuminate; base often short decurrent on one side; margins plane to more commonly folded at base (usually along one side), entire below, distally entire or dentate, serrulate to serrate; costae typically single, sometimes short and double; cell fusiform to linear, rarely shorter, mostly smooth, rarely prorulose or papillose; alar cells not differentiated. **Autoicous** or dioicous. **Perichaetia** lateral, leaves usually sheathing, strongly differentiated, with or without linear leaf-like rameta on vaginula. **Setae** short to somewhat elongate, smooth. **Capsules** immersed or long exserted, erect, rarely horizontal or pendulous, urn ovoid to short cylindrical. **Opercula** short to long rostrate, occasionally oblique. **Peristome** double; exostome teeth 16, papillose, often pale, usually cross-striolate at least at extreme base, papillose above; endostome often reduced. **Calyptrae** mostly cucullate, smooth and naked. **Spores** spherical, usually papillose.

Key to the genera

- 1a. Stems usually irregularly pinnately branched.....2
 2a. Leaves obtuse or truncate or rounded at the apex.....3
 3a. Leaves rounded-obtuse or obtuse at the apex.....1. *Himantocladium*
 3b. Leaves mostly truncate or rounded at the apex.....3. *Neckeropsis*
 2b. Leaves broadly acute or shortly acuminate at the apex.....4. *Pinnatella*
 1b. Stems usually tripinnately branched.....2. *Homaliodendron*

1. HIMANTOCLADIUM

(Mitt.) M. Fleisch., Musci Buitenzorg 3: 883. 1908; Gangulee, Mosses E. India 6: 1405. 1977; Noguchi, Ill. Moss Fl. Japan 3: 718. 1989; Peng-cheng, Moss Fl. China 5: 319. 2011.

Plants dark green or yellowish green, slightly glossy, forming fans. **Primary stems** creeping, naked or often covered with a few small stipe leaves, rhizoids sparse. **Secondary stems** loosely or densely pinnately or irregularly pinnately branched, often erect or dendroid, rarely with pendent flagelliform branches. **Leaves** densely, narrowed from a widely ovate base to a broadly lingulate; often apiculate, or rounded-obtuse to nearly truncate apex, sometimes undulate; margins usually serrulate above;

costae single, rigid, ending in the upper parts of leaves to leaf apex; upper leaf cells rounded-quadrate or oblong-rhombic, median and basal cells elongate, narrowly rhomboidal, thick-walled. **Dioicous** or autoicous. **Perichaetial leaves** smaller than vegetative ones, sheathing at the base, gradually narrowed toward the apex. **Setae** short, smooth. **Capsules** ovoid, slightly exserted. **Opercula** conic, obliquely rostrate. **Peristome** double; exostome teeth narrowly lanceolate, roughened or finely papillose; endostome segments nearly as long as the teeth, perforate, densely papillose; basal membrane low; cilia none. **Calyptrae** cucullate, sparsely hairy. **Spores** spherical, roughened or papillose.

1. *Himantocladium cyclophyllum* (Müll. Hal.) M. Fleisch., Musci Buitenzorg 3: 887. 1908; Gangulee, Mosses E. India 6: 1410. 1977; Peng-cheng, Moss Fl. China 5: 320. 2011. — *Neckera cyclophylla* Müll. Hal., Syn. Musc. Frond. 2: 664. 1851. — *Neckera loriformis* Bosch & Sande Lac., Bryol. Jav. 2: 63. 183. 1863. — *Neckera bicolorata* Müll. Hal., Bot. Jahrb. Syst. 5: 85. 1883. — *Himantocladium elegantulum* Nog., J. Hattori Bot. Lab. 4: 21. 50. 1950. (**Figure 5.57**)

Plants yellowish green, somewhat glossy, forming fans. **Primary stems** creeping, slender. **Secondary stems** erect-patent, irregularly pinnately branched, 3.0–7.0 cm long, often with flagelliform branches at branch tips. **Leaves** ovate at the base, gradually narrowed to a lingulate apex, 1.7–1.8 × 0.6–0.7 mm, undulate above; rounded or apiculate at the apex; margins irregularly toothed above, serrulate below; costae single, strong, vanishing below leaf apex; apical leaf cells rounded-hexagonal, 12–24 × 6–9 µm, median and lower cells elongate, thick-walled, 28–47 × 7–11 µm. **Dioicous**. **Perichaetial leaves** acuminate above. Setae smooth, 1.0–2.0 mm long. **Capsules** exserted, erect, cylindrical, 1.5–2.0 mm long. **Peristome** double; exostome teeth lanceolate, finely papillose; endostome segments linear; membrane low. **Spores** spherical, papillose.

Additional illustration. – Gangulee (1977: 1411, Fig. 696); Wu, Crosby & He (2011: 316, Pl. 368, Fig. 6–13).

Thailand. – **NORTHERN:** Chiang Mai. **NORTH-EASTERN:** Loei. **SOUTH-WESTERN:** Phetchabun. **CENTRAL:** Nakhon Nayok. **SOUTH-EASTERN:** Chanthaburi. **PENINSULAR:** Chumphon, Phangnga, Phuket, Krabi, Nakhon Si Thammarat, Phatthalung, Trang, Satun (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Japan, Laos, Malaysia, New Guinea, Papua New Guinea, Philippines, Sikkim, Seychelles, and Vietnam (He, 1995).

Ecology. – On barks under shade of tree, near waterfall, at 1,178 m elevation.

Specimens examined. – *P. Ajintaiyasil 444D* (BCU).

2. *Himantocladium plumula* (Nees) M. Fleisch., Musci Buitenzorg 3: 889. 1908; Gangulee, Mosses E. India 6: 1406. 1977; Noguchi, Ill. Moss Fl. Japan 3: 718. 1989; Peng-cheng, Moss Fl. China 5: 321. 2011. — *Pilotrichum plumula* Nees, Bryol. Univ.

2: 759. 1827. — *Neckera arbuscula* Hampe ex Müll. Hal., Flora 61: 83. 1878. — *Pinnatella lingulata* Dixon, Bull. Torrey Bot. Club 51: 236. 3 f. 11. 1924. (**Figure 5.58**)

Plants grayish green, slightly glossy, forming fans. **Primary stems** creeping, slender. **Secondary stems** dendroid, densely branched; branches obliquely spreading, 3.0–4.0 cm long, obtuse at the apex; in cross section a central strand absent. **Leaves** broadly ovate at the base, shortly lingulate above, 1.6–1.8 × 0.6–0.9 mm, often irregularly undulate; broadly acute at the apex; margins irregularly serrulate at the apex, often incurved on the distal side of basal margins; costae single, strong, ending below leaf apex; leaf cells quadrate or rounded-ovate to rounded-hexagonal, 12–18 × 7–12 µm, basal cells narrowly rectangular, evenly thick-walled, 15–24 × 6–8 µm. **Synoicous. Perichaetial leaves** small. **Setae** 1.5–2.0 mm long. **Capsules** exserted, oblong-ovoid to shortly cylindrical, 1.0–1.5 mm long. **Peristome** double; exostome teeth lanceolate, finely papillose; endostome segments linear, perforate. **Spores** green, finely papillose.

Additional illustration. – Gangulee (1977: 1407, Fig. 694); Noguchi (1989: 721, Fig. 318A); Wu, Crosby & He (2011: 322, Pl. 369, Fig. 9–14).

Thailand. – NORTH-EASTERN: Loei. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Chumphon, Ranong, Surat Thani, Nakhon Si Thammarat (He, 1995).

Distribution. – Bangladesh, Brunei, China, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, New Guinea, Philippines, Taiwan, and Vietnam (He, 1995).

Ecology. – On barks with *Lopidium trichocladon* under shade of tree, near waterfall, at 1,248 m elevation.

Specimens examined. – *P. Ajintaiyasil* 98A (BCU).

จุฬาลงกรณ์มหาวิทยาลัย CHULALONGKORN UNIVERSITY

2. HOMALIODENDRON

M. Fleisch., Hedwigia 45: 72. 1906; Gangulee, Mosses E. India 6: 1411. 1977; Noguchi, Ill. Moss Fl. Japan 3: 710. 1989; Peng-cheng, Moss Fl. China 5: 328. 2011.

Plants yellow to brownish green, somewhat to strongly glossy, often complanately frondose, in fans. **Primary stems** creeping, leaves deciduous, or with scale-like leaves and reddish brown rhizoids. **Secondary stems** often 1–3-pinnately branched, sometimes with flagelliform branches; a central strand absent. **Stem leaves** complanately appressed; ovate, oblong-ovate, or lingulate, rarely broadly ovate with the upper part wider than the lower; acute, obtuse to rounded at the apex; margins entire below, crenulate, serrulate to irregularly toothed at the apex; costae single, often strong, reaching beyond mid-leaf, sometimes shorter, forked. **Branch leaves** broadly obovate, oblong-ovate to oblong or narrowly lingulate; upper and median leaf cells rounded-quadrate or elongate-rhombic to shortly rhomboidal, more or less thick-walled; basal cells narrowly rectangular, thick-walled, porose. **Dioicous. Perichaetial leaves** sheathing at the base, lanceolate above. **Setae** short, straight, light yellow, smooth. **Capsules** ovoid to oblong-ovoid, shortly exserted. **Opercula** conic, with a

short beak, smooth. **Peristome** double; exostome teeth lanceolate, finely papillose, striolate below on outer surface, trabeculate on inner surface; endostome segments linear, keeled, perforate; basal membrane low; cilia absent. **Calyptrae** cucullate, often hairy, rarely smooth. **Spores** spherical, roughened or finely papillose.

Homaliodendron microdendron (Mont.) M. Fleisch., *Hedwigia* 45: 78. 1906; Gangulee, *Mosses E. India* 6: 1444. 1977; Noguchi, *Ill. Moss Fl. Japan* 3: 712. 1989; Peng-cheng, *Moss Fl. China* 5: 333. 2011. — *Homaliodendron excisum* M. Fleisch., *Hedwigia* 45: 78. 1906. — *Homaliodendron elegantulum* Thér., *Rev. Bryol.* 49: 7. 1. 1922. (**Figure 5.59**)

Plants yellowish green, strongly glossy, distinctly complanate, in fans. **Secondary stems** 2–3-pinnately branched, frondose, 2.5–5.0 cm long; pseudoparaphyllia usually filamentous. **Stem leaves** similar to branch leaves. **Branch leaves** broadly lingulate or spatulate, often curved above, narrowed at the base, 0.5–0.8 × 0.2–0.7 mm; broadly rounded or truncate at the apex; margins entire below, only crenulate or irregularly serrulate at the apex, sometime incurved on proximal side; costae single, slender, reaching 2/3 the leaf length; apical and upper leaf cells rounded-quadrate or polygonal, thick-walled, 5–9 × 4–7 μm, median cells elongate-hexagonal or oblong-rhomboidal, thinner-walled, 12–15 × 5–6 μm, basal juxtacostael cells narrowly rectangular, thick-walled, porose, 21–29 × 5–7 μm. **Sporophytes** not seen.

Additional illustration. – Gangulee (1977: 1415, Fig. 698); Noguchi (1989: 715, Fig. 315B); Wu, Crosby & He (2011: 335, Pl. 373, Fig. 1–6).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai, Lamphun, Tak. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Phetchabun. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Ranong, Krabi, Nakhon Si Thammarat, Trang, Yala (He, 1995).

Distribution. – Bhutan, Brunei, China, India, Indonesia, Japan, Kampuchea, Malaysia, Myanmar, Philippines, Sikkim, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, near waterfall, at 1,087– 1,113 m elevation.

Specimens examined. – *P. Ajintaiyasil* 226 (BCU).

3. NECKEROPSIS

Reichardt, *Verh. K.K. Zool.-Bot. Ges. Wien* 18: 192. 1868; Gangulee, *Mosses E. India* 6: 1391. 1977; Noguchi, *Ill. Moss Fl. Japan* 3: 707. 1989; Peng-cheng, *Moss Fl. China* 5: 358. 2011.

Plants yellowish green or dark green, more or less glossy, forming densely fans. **Primary stems** creeping, with brownish rhizoids. **Secondary stems** simple or irregularly to pinnately branched; branches complanately foliate; obtuse at the apex. **Leaves** usually oblong, broadly ovate-lingulate, asymmetric, strongly undulate above,

sometimes longitudinally plicate or obliquely undulate; often truncate or obtuse or apiculate at the apex, narrowed at the base, often widely curved on distal side, straight or incurved on proximal side; margins entire below, serrulate or irregularly serrulate above, sometimes forming submarginal borders or indistinct marginal borders; costae usually single, stout, reaching midleaf or above, rarely short, weak, absent or sometimes forked; upper leaf cells oval, oblate-rectangular, rhombic, or polygonal; median cells hexagonal or rhomboidal; basal cells rectangular or linear. **Autoicous** or dioicous. **Perichaetial leaves** large, ovate-lanceolate, concave, sheathing at the base, acuminate above. **Setae** very short. **Capsules** ovoid to shortly cylindrical. **Opercula** conic at the base, with a short or oblique beak. **Peristome** double; exostome teeth narrowly lanceolate, sometimes perforate, finely papillose; endostome segments often reduced, hyaline, papillose; basal membrane low. **Calyptrae** mitrate or cucullate, smooth or hairy. **Spores** spherical, light yellow or brown, finely papillose.

Neckeropsis exserta (Hook. ex Schwägr.) Broth. var. **exserta**, Nat. Pflanzenfam. 11: 188. 1925; Gangulee, Mosses E. India 6: 1396. 1977; Peng-cheng, Moss Fl. China 5: 361. 2011. — *Neckera exserta* Hook. ex Schwägr., Sp. Musc. Frond., Suppl. 1(2): 244. 1828. — *Neckera elegantula* Griff., Not. Pl. Asiat. 464. 1849. (**Figure 5.60**)

Plants yellowish green, very glossy, forming densely fans. **Primary stems** creeping; rhizoids sparse. **Secondary stems** complanately foliate, sparsely branched or pinnately branched, 2.0–4.0 cm long, with branches 0.9–1 cm long; obtuse or attenuate at the apex. **Leaves** oblong-lingulate or broadly ovate-lingulate, asymmetric, strongly undulate; truncate or rounded at the apex, widened at the base; margins irregularly serrulate at the apex, entire below; costae single, ending at 3/4 the leaf length, rarely forked above; upper and apical cells irregularly quadrate or oval, thick-walled, 16–30 × 8–10 μm, basal cells obliquely rhomboidal, 25–39 × 6–8 μm. **Autoicous**. **Perichaetial leaves** sheathing at the base, acuminate at the apex. **Setae** 0.9–2.0 mm long. **Capsules** exserted, cylindrical, brown. **Opercula** conic, with an oblique beak. **Peristome** double; exostome teeth yellowish green, lanceolate, finely papillose, coarsely trabeculate, sometimes perforate at the apex; endostome segments yellowish green, linear, finely papillose. **Calyptrae** not seen. **Spores** green, 15–20 μm in diameter, finely papillose.

Additional illustration. – Gangulee (1977: 1396, Fig. 688); Touw (1962: 398, Pl. 9, Fig. 1–8); Wu, Crosby & He (2011: 362, Pl. 384, Fig. 1–8).

Thailand. – NORTHERN: Chiang Mai, Tak, Phitsanulok. NORTH-EASTERN: Loei. PENINSULAR: Trang (He, 1995).

Distribution. – Bhutan, China, India, Malaysia, Myanmar, Nepal, Philippines, and Sikkim (He, 1995).

Ecology. – On barks or rocks under shade of tree, near waterfall, at 447 m elevation.

Specimens examined. – *P. Ajintaiyasil 436* (BCU).

4. PINNATELLA

M. Fleisch., Hedwigia 45: 79. 1906; Gangulee, Mosses E. India 6: 1432. 1977; Noguchi, Ill. Moss Fl. Japan 3: 722. 1989; Peng-cheng, Moss Fl. China 5: 371. 2011.

Plants yellowish green or dark green, not glossy, in loose fans. **Primary stems** creeping. **Secondary stems** erect or ascending, 1–2-pinnately branched; pseudoparaphyllia foliose; central strand well differentiated or absent. **Leaves** ovate or oblong-ovate, rarely broadly lingulate, usually strongly concave, sometimes transversely undulate; broadly acute, or shortly acuminate at the apex; margins serrate above; costae single, ending near leaf apex, rarely shorter and double; upper leaf cells rounded-quadrate, rounded-hexagonal, rhombic, moderately thick-walled, sometimes papillose, median cells slightly elongate, basal cells rectangular to oblong, somewhat thick-walled, sometimes porose; alar cells few, quadrate to shortly rectangular; intramarginal cells below the mid-leaf more or less differentiated, porose. **Dioicous**. **Perichaetia** laterally on secondary stems. **Setae** short, straight, smooth or scabrose. **Capsules** ovoid to oblong-ovoid, erect to slightly inclined, symmetric. **Opercula** conic, obliquely rostrate. **Peristome** double; exostome teeth 16, lanceolate, densely papillose, often perforate; endostome segments narrowly lanceolate, slightly shorter or as long as the teeth, densely papillose; basal membrane moderately high; cilia absent. **Calyptrae** cucullate, grayish brown, sparsely hairy. **Spores** spherical, finely papillose.

Key to the species

- 1a. Leaves incurved, lingulate, broadly ovate at the base, intramarginal cells in several rows of narrowly rectangular cells, porose.....1. *Pinnatella alopecuroides*
 1b. Leaves ovate-lanceolate or broadly oblong-ovate to nearly triangularly, ovate at the base; intramarginal cells absent.....2. *Pinnatella ambigua*

1. *Pinnatella alopecuroides* (Mitt.) M. Fleisch., Hedwigia 45: 84. 1906; Gangulee, Mosses E. India 6: 1439. 1977; Peng-cheng, Moss Fl. China 5: 372. 2011. — *Neckera alopecuroides* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 123. 1859. — *Pinnatella intralimbata* M. Fleisch., Hedwigia 45: 82. 4. 1906. (**Figure 5.61**)

Plants yellowish green, brownish green when old, not glossy, in loose fans. **Primary stems** creeping, covered with scale-like leaves. **Secondary stems** pendulous, pinnately branched or irregularly pinnately branched; central strand present; pseudoparaphyllia few, foliose. **Leaves** incurved, lingulate, broadly ovate at the base, 1.4–1.7 × 0.5–0.9 mm; narrowly acute at the apex; margins entire below, serrulate at the apex; costae single, subpercurrent; upper and median leaf cells similar, rounded-hexagonal or rounded-quadrate, smooth, evenly thick-walled, 5–13 × 7–12 μm, basal cells oblong-rectangular to sublinear, 12–40 × 7–10 μm; intramarginal cells in several rows of narrowly rectangular cells clearly differentiated below the leaf apex, porose, 14–35 × 4–8 μm. **Sporophytes** not seen.

Additional illustration. – Gangulee (1977: 1440, Fig. 713); Wu, Crosby, & He (2011: 370, Pl. 387, Fig. 10–17).

Thailand. – NORTHERN: Chiang Mai, Lamphun, Tak, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei. SOUTH-WESTERN: Kanchanaburi. EASTERN: Chanthaburi, Nakhon Ratchasima. CENTRAL: Nakhon Nayok. PENINSULAR: Chumphon, Surat Thani, Trang (He, 1995).

Distribution. – Bhutan, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 446 m elevation.

Specimens examined. – *P. Ajintaiyasil 440A* (BCU).

2. *Pinnatella ambigua* (Bosch & Sande Lac.) M. Fleisch., *Hedwigia* 45: 81. 1906; Gangulee, *Mosses E. India* 6: 1434. 1977; Peng-cheng, *Moss Fl. China* 5: 373. 2011. — *Thamnum ambiguum* Bosch & Sande Lac., *Bryol. Jav.* 2: 72. 192. 1863. — *Porotrichum alopecuroides* var. *donghamense* Besch., *Bull. Soc. Bot. France* 34: 97. 1887. (Figure 5.62)

Plants dark yellowish green, in fans. **Primary stems** slender, creeping. **Secondary stems** erect, irregularly pinnately branched; central strand present; pseudoparaphyllia few, foliose. **Leaves** ovate-lanceolate or broadly oblong-ovate to nearly triangularly, ovate at the base, 0.9–1.0 × 0.4–0.6 mm; narrowly acute at the apex; margins remotely serrate above; costae single, percurrent; upper and median leaf cells similar, rounded-hexagonal or rounded-quadrate, smooth, 10–12 × 4–7 μm, basal leaf cells long-rectangular, 14–18 × 5–7 μm; intramarginal cells absent. **Sporophytes** not seen

Additional illustration. – Gangulee (1977: 1436, Fig. 710); Wu, Crosby, & He (2011: 370, Pl. 387, Fig. 18–22).

Thailand. – NORTHERN: Chiang Mai. PENINSULAR: Ranong, Surat Thani, Phangnga, Phuket (He, 1995).

Distribution. – Bhutan, Brunei, China, India, Indonesia, Japan, Malaysia, Myanmar, Philippines, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, at 446 m elevation.

Specimens examined. – *P. Ajintaiyasil 433* (BCU).

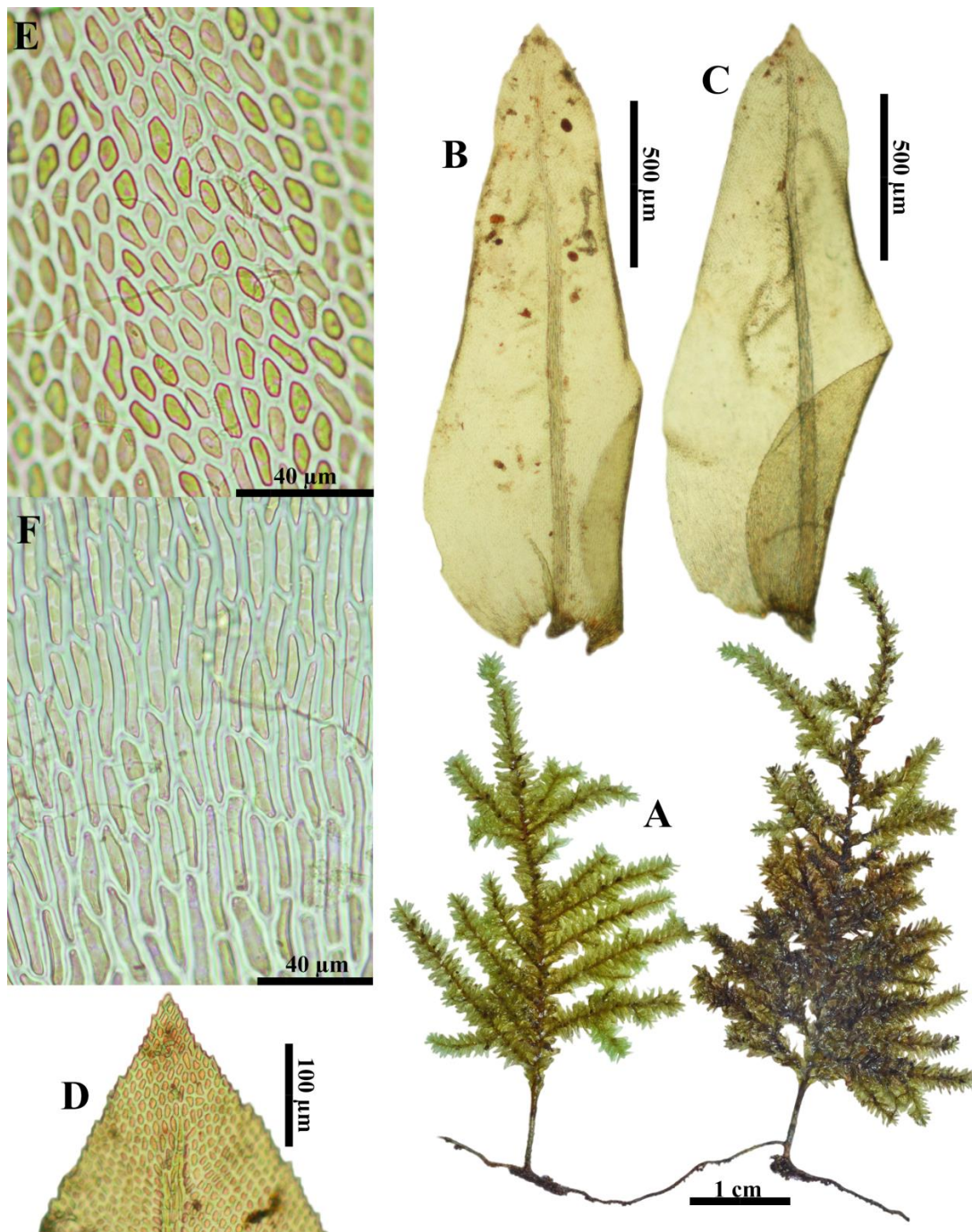


Figure 5.57 *Himantocladium cyclophyllum* (Müll. Hal.) M. Fleisch.

A. Gametophyte with sporophytes, B–C. Leaves, D. Leaf apex, D. Cells at median part of leaf, E. Cells at leaf base. Based on *P. Ajintaiyasil 444D*.

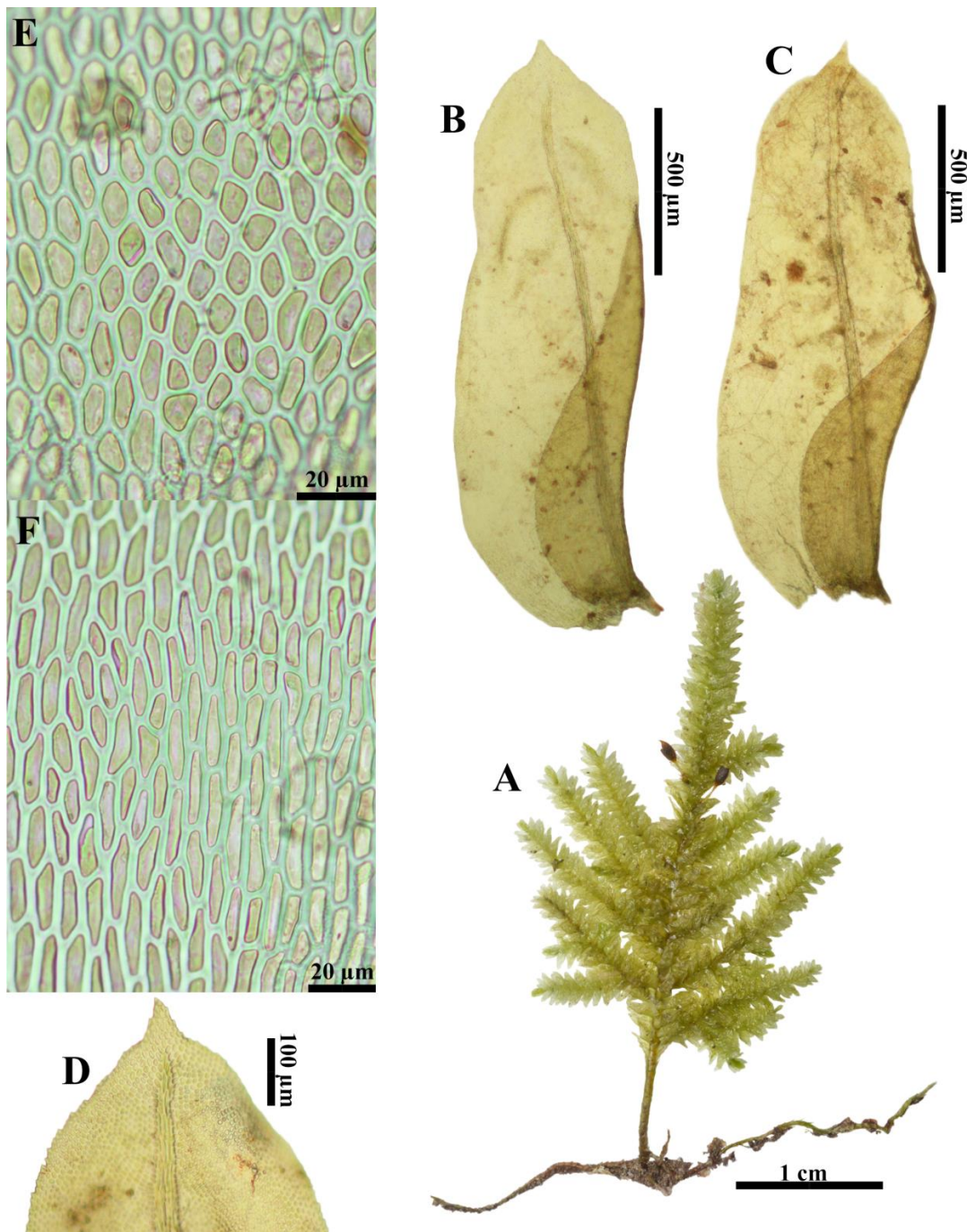


Figure 5. 58 *Himantocladium plumula* (Nees) M. Fleisch.

A. Gametophyte with sporophytes, B–C. Leaves, D. Leaf apex, D. Cells at median part of leaf, E. Cells at leaf base. Based on *P. Ajintaiyasil 098A*.

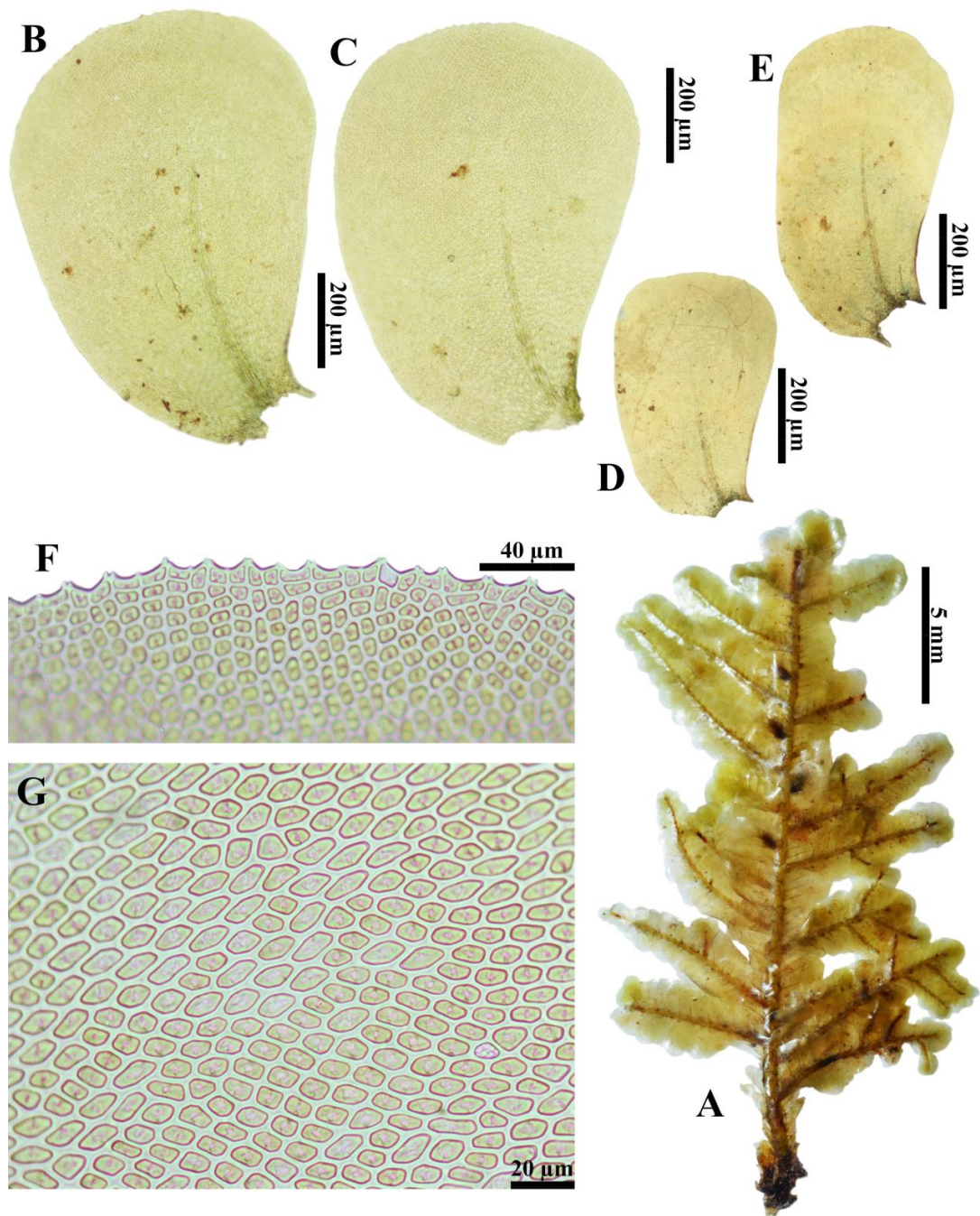


Figure 5.59 *Homaliodendron microdendron* (Mont.) M. Fleisch.

A. Gametophyte, B. Stem leaves, C. Branch leaves, D. Leaf apex, E. Cells at median part of leaf. Based on *P. Ajintaiyasil* 226.

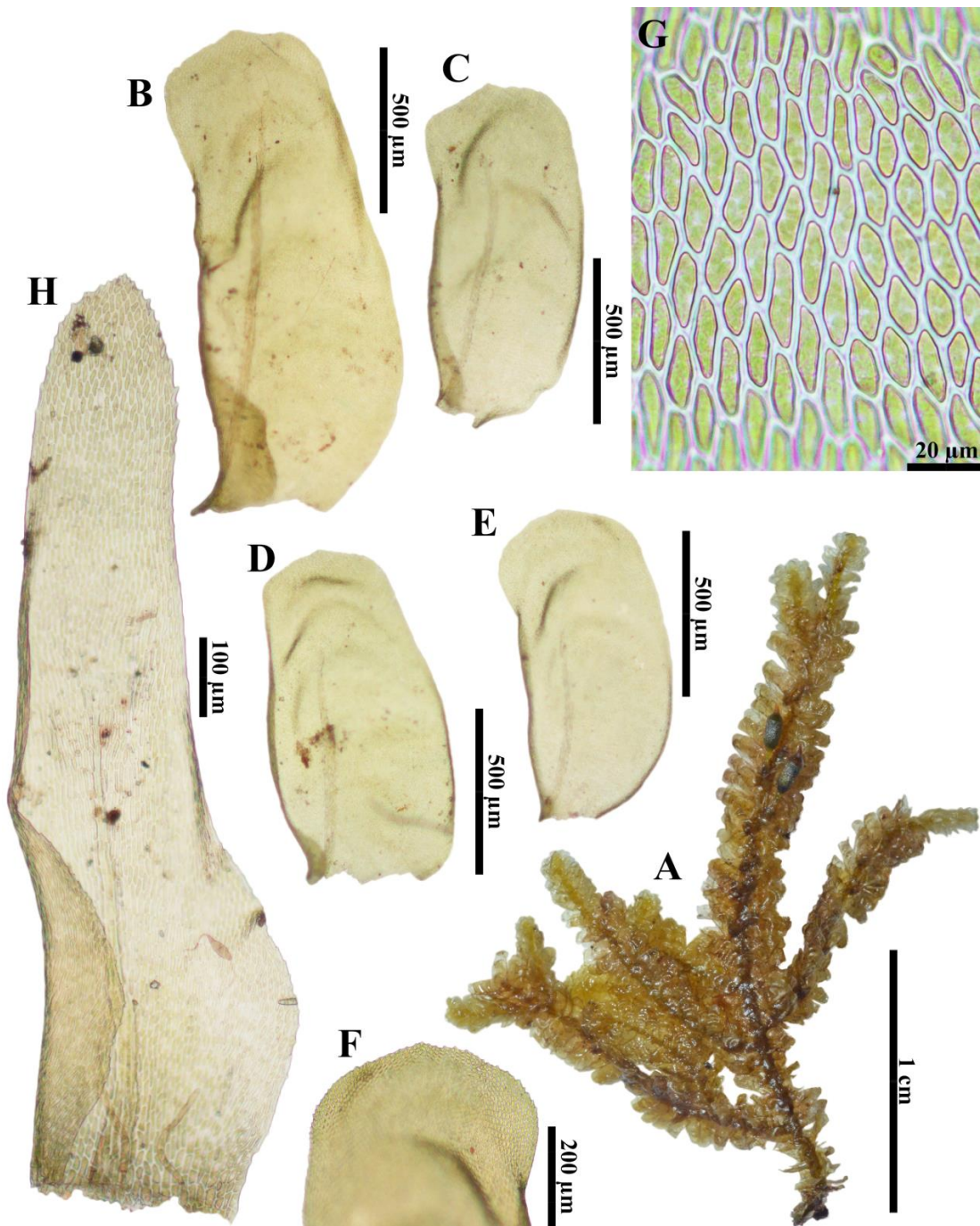


Figure 5.60 *Neckeropsis exserta* (Hook. ex Schwägr.) Broth. var. *exserta*

A. Gametophyte with sporophytes, B–E. Leaves, F. Leaf apex, G. Cells at median part of leaf, E. Perichaetial leaf. Based on *P. Ajintaiyasil* 436A.

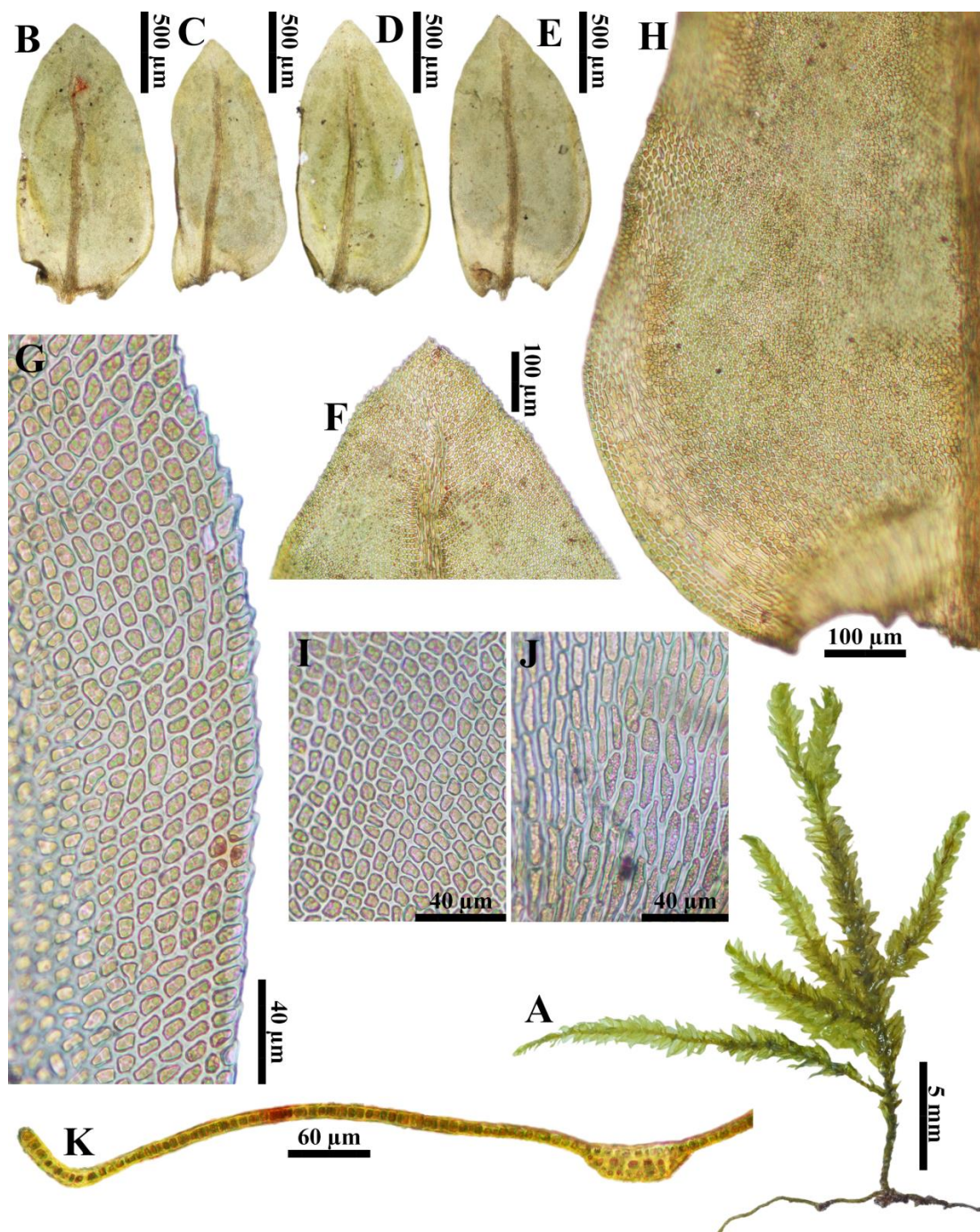


Figure 5.61 *Pinnatella alopecuroides* (Mitt.) M. Fleisch.

A. Gametophyte, B–E. Leaves, F. Leaf apex, G. Leaf margin, H. Leaf base with intramargin, I. Cells at median part of leaf, J. Cells at leaf base, K. Cross section of leaf. Based on *P. Ajintaiyasil* 440A.

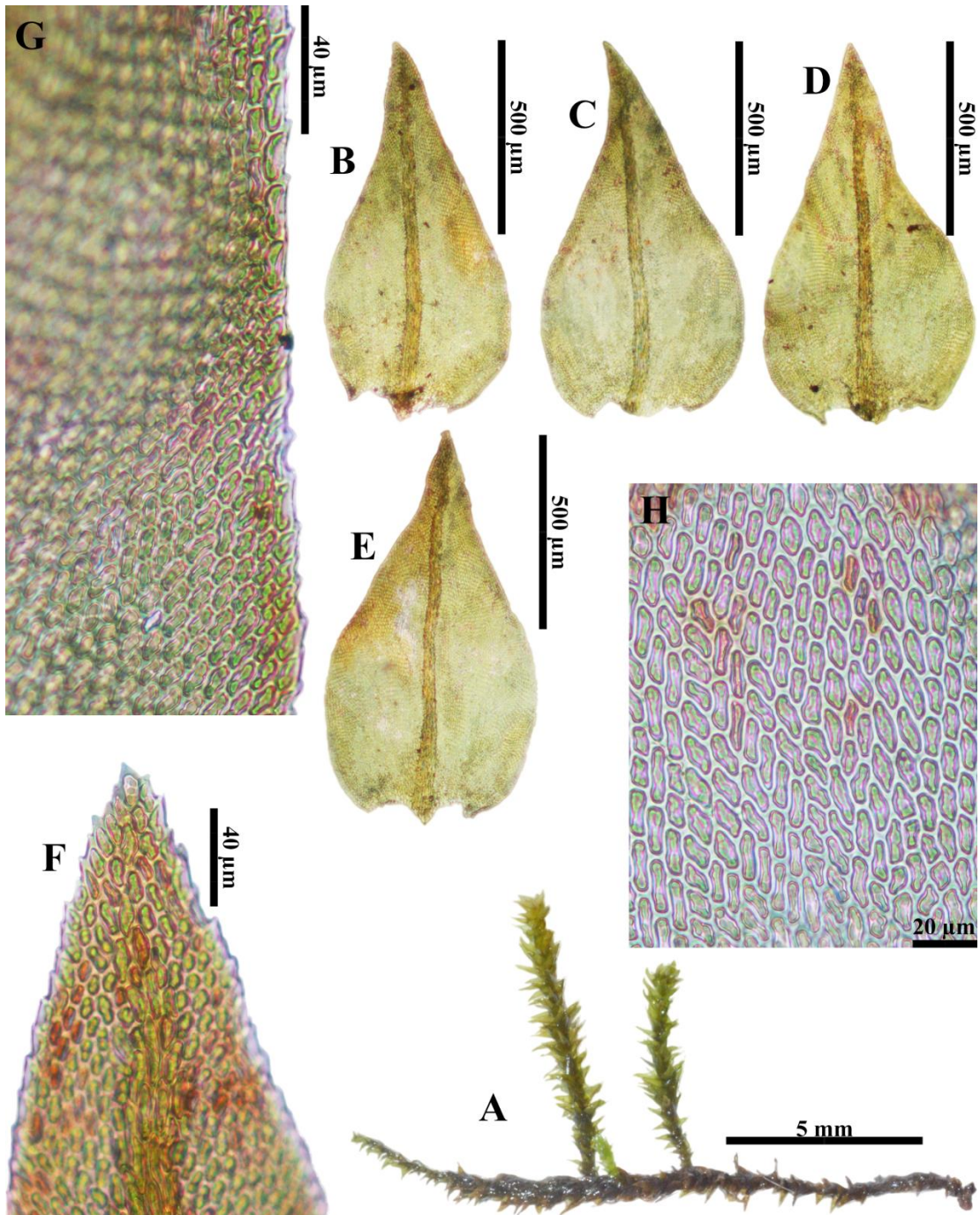


Figure 5.62 *Pinnatella ambigua* (Bosch & Sande Lac.) M. Fleisch.

A. Gametophyte, B–E. Leaves, F. Leaf apex, G. Leaf margin, H. Cells at median part of leaf. Based on *P. Ajintaiyasil* 433.

18. ORTHOTRICHACEAE

Arn., Disp. Méth. Mousses 13. 1825; Gangulee, Mosses E. India 5: 1147. 1976; Noguchi, Ill. Moss Fl. Japan 3: 576. 1989; Eddy, Handb. Males. Mosses 3: 12. 1996; Yu, He & Shui-liang, Moss Fl. China 5: 22. 2011.

Plants small to large and robust, forming tufts. **Stems** simple or branched, erect or creeping with erect branches; innovating branches lateral. **Leaves** often crispate or flexuose when dry; linear- to oblong-lanceolate or oblong-lingulate, smooth to occasionally rugose, undulate, plicate or smooth; apex acute to acuminate, rarely obtuse; base occasionally decurrent; margins plane to reflexed or recurved, entire to serrulate or serrate; costae single, usually strong, ending well below apex to long excurrent, cells thick-walled; upper and median cells mostly isodiametric, smooth, mammillose or papillose, basal cells usually elongate; alar cells rarely differentiated. **Autoicous** or dioicous. **Perichaetia** terminal on stems, leaves often differentiated. **Setae** short to elongate, smooth, often twisted. **Capsules** erect, rarely immersed, urn ovoid or ovoid-cylindrical, symmetric, smooth or more often ribbed or furrowed, neck usually distinct. **Opercula** short to long rostrate, less often mammillate. **Peristome** double, single or variously reduced to absent; exostome teeth 16 or in 8 pairs, smooth to more often papillose; endostome often reduced, smooth or papillose. **Calyptrae** cucullate or mitrate to campanulate with base usually lobed, typically plicate and hairy. **Spores** spherical, usually papillose.

Key to the genera

- 1a. Leaf base cells rectangular to linear, thick-walled, smooth or papillose on the side walls.....1. *Macromitrium*
 1b. Leaf base cells elongate, linear-rhomboidal, thick-walled, often porose.....2. *Schlotheimia*

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1. MACROMITRIUM

Brid., Muscol. Recent. Suppl. 4: 132. 1819; Gangulee, Mosses E. India 5: 1169. 1976; Noguchi, Ill. Moss Fl. Japan 3: 602. 1989; Eddy, Handb. Males. Mosses 3: 30. 1996; Yu, He & Shui-liang, Moss Fl. China 5: 29. 2011.

Plants medium-sized to rather large, dark green, yellowish brown or reddish brown, in large flattened mats. **Stems** elongate, prostrate, irregularly or freely branched, with erect or creeping, short or elongate branches; branches simple or forked; rhizoids numerous, red. **Leaves** often variously contorted to crisped or squarrose, occasionally erect, appressed when dry, plicate, erect-spreading or squarrosely-recurved when moist; often lanceolate, oblong- to ovate-lanceolate or lingulate, sometimes linear to linear-lanceolate or funiculate; apex acuminate, acute, apiculate, or blunt to obtuse; costae single, stout, subpercurrent to percurrent, or shortly excurrent to long hair-pointed; upper leaf cells rounded-quadrate or rounded-hexagonal, often papillose, rarely smooth, basal cells rectangular to linear, thick-walled, smooth or papillose on the side walls, basal juxtacostael cells often thin-walled, lax, hyaline, never prorate, smooth or with tubercle. **Autoicous** or dioicous.

Perichaetial leaves similar to or larger than the vegetative ones. **Setae** elongate, rarely very short, smooth or sometimes roughened. **Capsules** exserted, subglobose to elongate-ovoid, or shortly cylindrical, smooth or more or less plicate, sometimes puckered at the mouth. **Opercula** conic, often slenderly long-rostrate; annuli not or weakly differentiated. **Peristome** double or single, rarely absent. **Calyptrae** mitrate or cucullate, plicate, naked or hairy, splitting or lobed at the base. **Spores** spherical, papillose.

Key to the species

- 1a. Leaf cells rounded-quadrate, strongly bulging.....1. *Macromitrium densum*
 1b. Leaf cells hexagonal or rounded, with 4–6 papillae.....2. *Macromitrium ferriei*

1. *Macromitrium densum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 51. 1859; Gangulee, Mosses E. India 5: 1175. 1976. — *Macromitrium brevissimum* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 19. 1932. (**Figure 5.63**)

Plants yellowish to brown or yellowish to green, in mats, small to medium-sized. **Stems** covered by numerous rhizoids, with densely short erect branches; branches up to 2–3 mm long. **Leaves** dense, spiral around the branch when dry, erect-spreading to wide-spreading when moist; lanceolate to lingulate, 1.1–1.2 × 0.3–0.4 mm, cucullate above, rugose and often plicate; obtuse to retuse with a mucro; margins entire; upper and median leaf cells similar, rounded-quadrate, strongly bulging, 6–15 × 10–14 μm, basal leaf cells short-rhombic to elliptic-rhombic, slightly tuberculate, moderately thick-walled along costae, but elongate with distinctively thickened-walls toward the leaf margin, 13–33 × 4–9 μm; the extreme basal marginal cells differentiated, often pellucid, rectangular, thin-walled, 20–26 × 7–10 μm. **Sporophyte** not seen.

Additional illustration. – Gangulee (1976: 1175, Fig. 569); Yu, Yong & Guo (2014: 438, Fig. 1).

Thailand. – NORTHERN: Mae Hong Son, Chiang Mai, Phitsanulok. NORTH-EASTERN: Loei, Udon Thani, Khon Kaen. CENTRAL: Nakhon Phanom, Nakhon Nayok. SOUTH-EASTERN: Prachin Buri (He, 1995).

Distribution. – India, Malaysia, Myanmar, Nepal, and Vietnam (He, 1995).

Ecology. – On rocks in sunlight, at 556 m elevation.

Specimens examined. – *P. Ajintaiyasil* 324 (BCU).

2. *Macromitrium ferriei* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 18: 250. 1908; Noguchi, Ill. Moss Fl. Japan 3: 608. 1989; Yu, He & Shui-liang, Moss Fl. China 5: 36. 2011. — *Macromitrium inflexifolium* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 20. 1932. (**Figure 5.64**)

Plants yellowish green to brown above, in dense mats. **Stems** creeping, densely branched; branches erect, short and simple, 1–1.5 cm long, densely foliate, obtuse at the apex. **Stem leaves** suberect to squarrose when dry; lanceolate, 1.0–1.2 × 0.3–0.4 mm; acuminate at the apex; margins reflexed; costae subpercurrent; median leaf cells hexagonal or shortly rectangular, thick-walled, hyaline, with 3–5 papillae, 6–12 × 9–11 µm; basal cells sublinear, strongly tuberculate, 17–24 × 4–7 µm. **Branch leaves** contorted when dry; oblong-lanceolate to linear-lanceolate, 1.4–1.9 × 0.2–0.3 mm, keeled, more or less plicate at base; acuminate or obtuse at the apex; margins subentire or papillose crenulate, recurved, especially in the lower half; costae percurrent; median leaf cells hexagonal or rounded, inflated, thin-walled, 7–13 × 8–12 µm, but collenchymatous, with 4–6 small papillae, basal cells short rectangular, strongly tuberculate, 11–25 × 5–9 µm. **Sporophytes** not seen.

Additional illustration. – Noguchi (1989: 609, Fig. 270A–B); Yu, He & Shui-liang (2011: 37, Pl. 253, 1–25).

Thailand. – SOUTH-WESTERN: Kanchanaburi (He, 1995).

Distribution. – China, Japan, Korea, Taiwan, and Vietnam (He, 1995).

Ecology. – On barks under shade of tree, near waterfall, at 1,223–1,227 m elevation.

Specimens examined. – *P. Ajintaiyasil 349* (BCU).

2. SCHLOTHEIMIA

Brid., Muscol. Recent. Suppl. 2: 16–22. 1812; Gangulee, Mosses E. India 5: 1190. 1976; Noguchi, Ill. Moss Fl. Japan 3: 620. 1989; Eddy, Handb. Males. Mosses 3: 84. 1996; Yu, He & Shui-liang, Moss Fl. China 5: 94. 2011.

Plants yellowish green to brown, dark red or rusty reddish when dry, in dense mats, small to medium-sized, elongate, slender or rather robust. **Stems** extensively creeping, with abundant rhizoids throughout stem, simple or branched; branches simple or forked. **Leaves** appressed, often spirally arranged when dry, erect to erect spreading, flexuose at the apex when moist; usually undulate in the upper part, mostly elongate-lingulate; shortly cuspidate, long acuminate; margins usually entire; costae shortly excurrent, sometimes ending in awns; upper leaf cells rounded or shortly rhombic, often thick-walled, smooth, basal cells elongate, linear-rhomboidal, thick-walled, often porose. **Dioicous.** **Perichaetial leaves** not differentiated or only slightly larger, shortly acute or ending in a short awn. **Setae** straight, rarely curved, sometimes very short. **Capsules** erect, symmetric, ovoid or cylindrical, smooth or furrowed. **Opercula** shortly conic, with a slender and long rostrate. **Peristome** double; exostome teeth red, reflexed when dry, narrowly lanceolate, obtuse, with dense ridges and papillae, longitudinally splitting along the median line; endostome segments short and narrow, pale, longitudinally striolate, sometimes reduced. **Calyptrae** mitrate, not plicate, mostly naked, rarely hairy, usually lobed at the base. **Spores** spherical, papillose.

Schlotheimia ferruginea (Bruch ex Hook. & Grev.) Brid., Bryol. Univ. 1: 743. 1826; J. Bryol. 30. 196. 2008. — *Orthotrichum ferrugineum* Bruch ex Hook. & Grev., Edinburgh J. Sci. 1: 118. 5. 1824. — *Schlotheimia grevilleana* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 53. 1859; Gangulee, Mosses E. India 5: 1191. 1976; Eddy, Handb. Males. Mosses 3: 85. 1996; Yu, He & Shui-liang, Moss Fl. China 5: 95. 2011. — *Schlotheimia laetevirens* Broth., Bot. Jahrb. Syst. 20: 185. 1894. — *Schlotheimia rigescens* Broth., Bot. Jahrb. Syst. 20: 186. 1894. — *Schlotheimia calycina* Broth. & Paris, Rev. Bryol. 34: 30. 1907. — *Schlotheimia japonica* Besch. & Cardot, Bull. Herb. Boissier, sér. 2, 8: 336. 1908. — *Schlotheimia japonica* var. *sulcata* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 18: 250. 1908. — *Schlotheimia latifolia* Cardot & Thér., Bull. Acad. Int. Géogr. Bot. 18: 250. 1908. — *Schlotheimia purpurascens* Paris, Rev. Bryol. 35: 44. 1908. — *Schlotheimia bequaertii* Thér. & Naveau, Bull. Soc. Roy. Bot. Belgique 60: 52. 1927. — *Schlotheimia brachypodia* Thér. & Naveau, Bull. Soc. Roy. Bot. Belgique 60: 53. 1927. (**Figure 5.65**)

Plants rather robust, yellowish brown, glossy. **Stems** creeping, with erect branches or forked, branches 0.2–1.0 cm or longer, with rhizoids at the base. **Leaves** densely arranged, often spirally twisted when dry; ovate-lanceolate, $1.7\text{--}2.1 \times 0.5\text{--}0.7$ mm; margins plane, entire; costae shortly excurrent; upper leaf cells rhombic or obliquely oval, slightly thick-walled, smooth, becoming longer at the base, $7\text{--}25 \times 8\text{--}12$ μm , basal cells linear-rhomboidal, thick-walled, porose, $24\text{--}49 \times 6\text{--}8$ μm . **Dioicous**. **Perichaetial** leaves 2.0–3.0 mm long; shortly acuminate. **Setae** smooth, 3–6 mm long. **Capsules** cylindrical, 2.0–3.0 mm long, smooth or slightly furrowed when dry. **Opercula** shortly conic, with a slender rostrate. **Peristome** double; exostome teeth red, reflexed when dry, narrowly lanceolate, obtuse, with dense ridges and papillae, longitudinally splitting along the median line; endostome segments short and narrow, pale, longitudinally striolate. **Calyptrae** smooth and lobed at the base, coarsely scabrous at the top. **Spores** spherical, papillose, 20–40 μm in diameter.

Additional illustration. – Eddy (1996: 86, Fig. 388, A–J, as *S. grevilleana*); Gangulee (1976: 1191, Fig. 579, as *S. grevilleana*); Wu, Crosby, & He (2011: 97, Pl. 282, 1–8, as *S. grevilleana*); Wilbraham (2008: 197, Fig. 1).

Thailand. – NORTHERN: Chiang Mai (He, 1995).

Distribution. – Angola, China, Hong Kong, India, Indonesia, Kenya, Malawi, Philippines, Rwanda, South Africa, Sri Lanka, Swaziland, Tanzania, Togo, Uganda, Zaire, Zambia, and Zimbabwe (He, 1995; O'shea, 2006; Wilbraham, 2008).

Ecology. – On brak under shade or sunlight of tree, at 1,240–1,288 m elevation.

Specimens examined. – *P. Ajintaiyasil* 303, 485 (BCU).

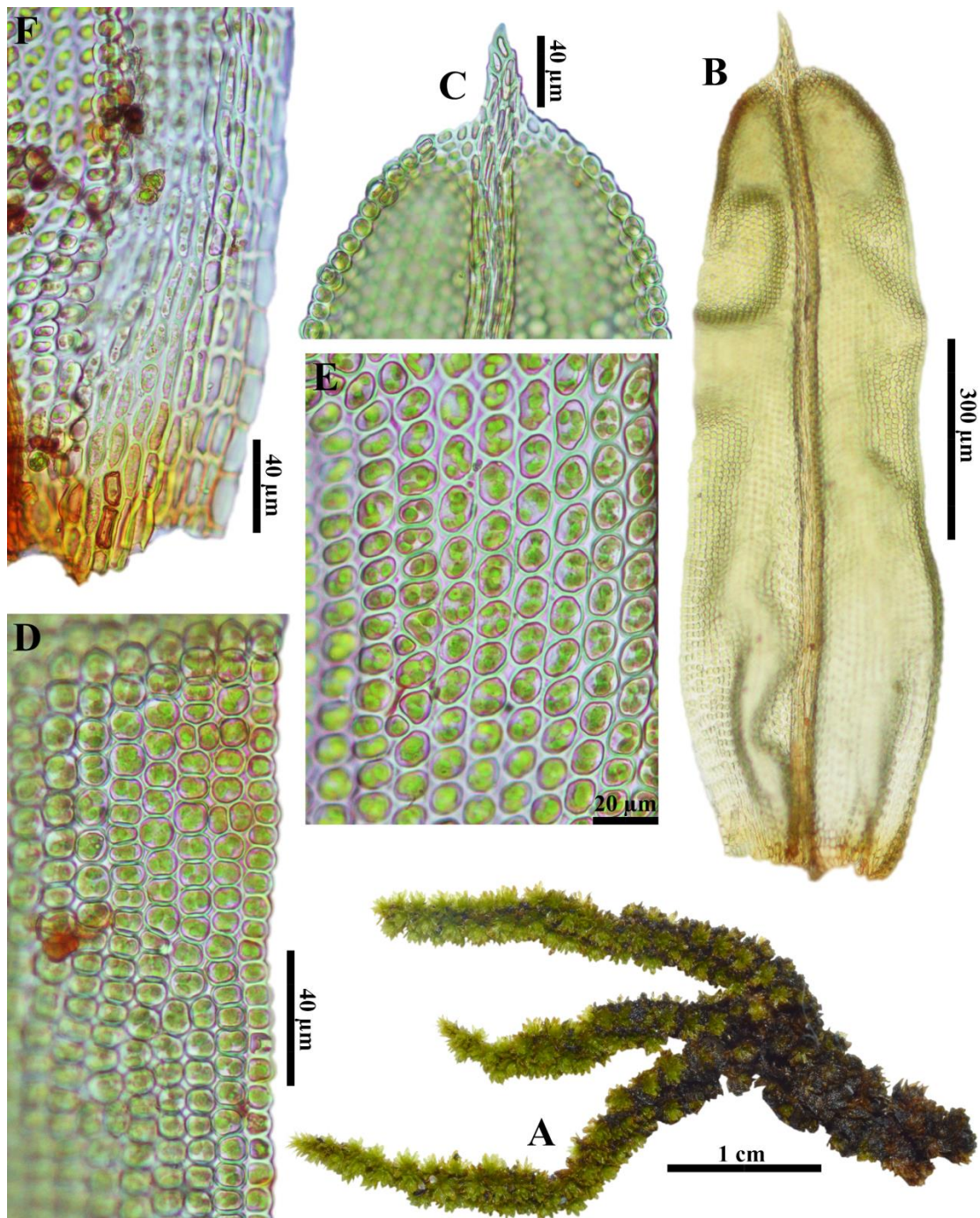


Figure 5.63 *Macromitrium densum* Mitt.

A. Gametophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Cells at median part of leaf, F. Cells at leaf base. Based on *P. Ajintaiyasil* 324.

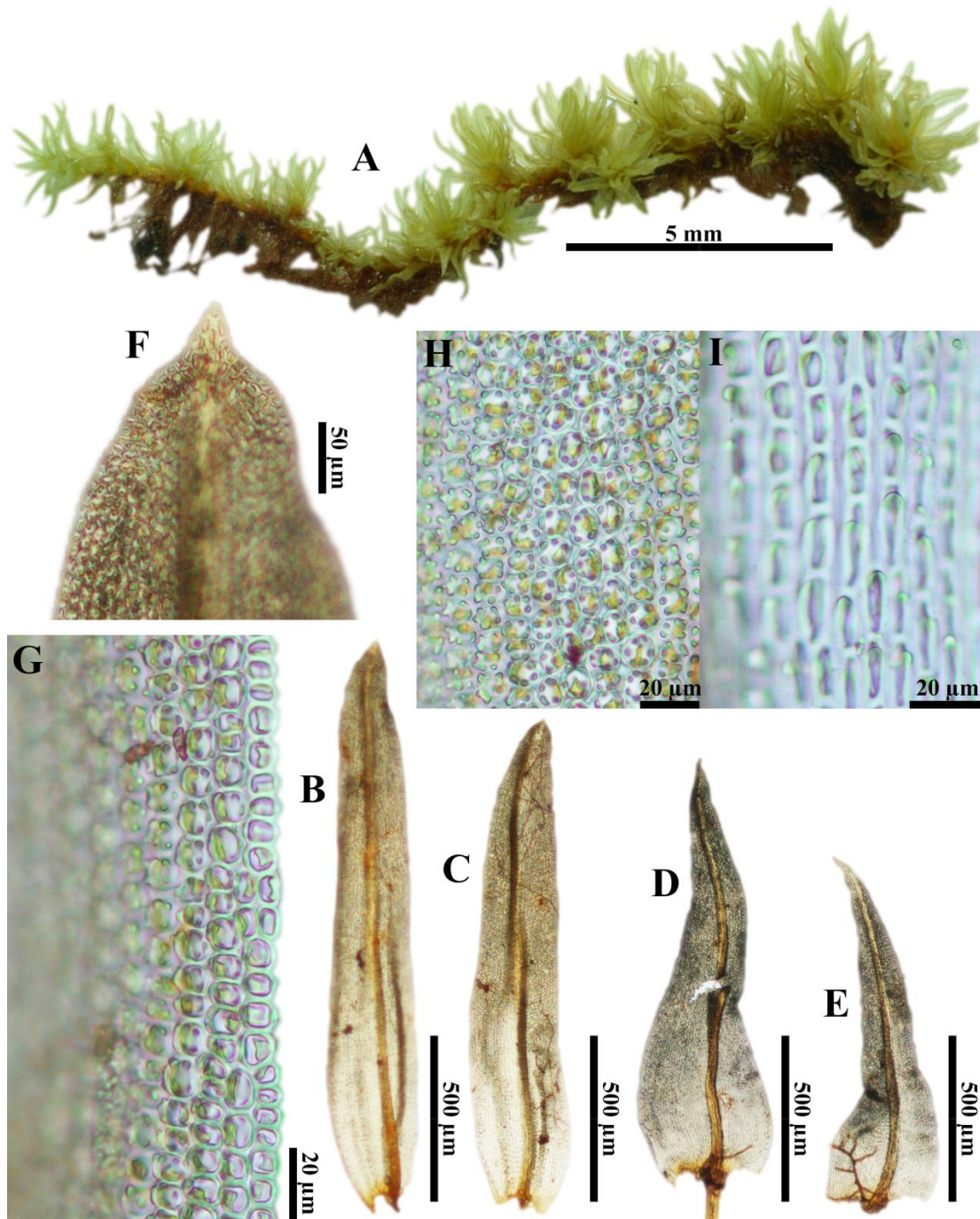


Figure 5. 64 *Macromitrium ferriei* Cardot & Thér.

A. Gametophyte, B–C. Branch leaves, D–E. Stem leaves, F. Branch leaf apex, G. Leaf margin, H. Cells at median part of branch leaf, I. Cells at branch leaf base. Based on *P. Ajintaiyasil* 349.

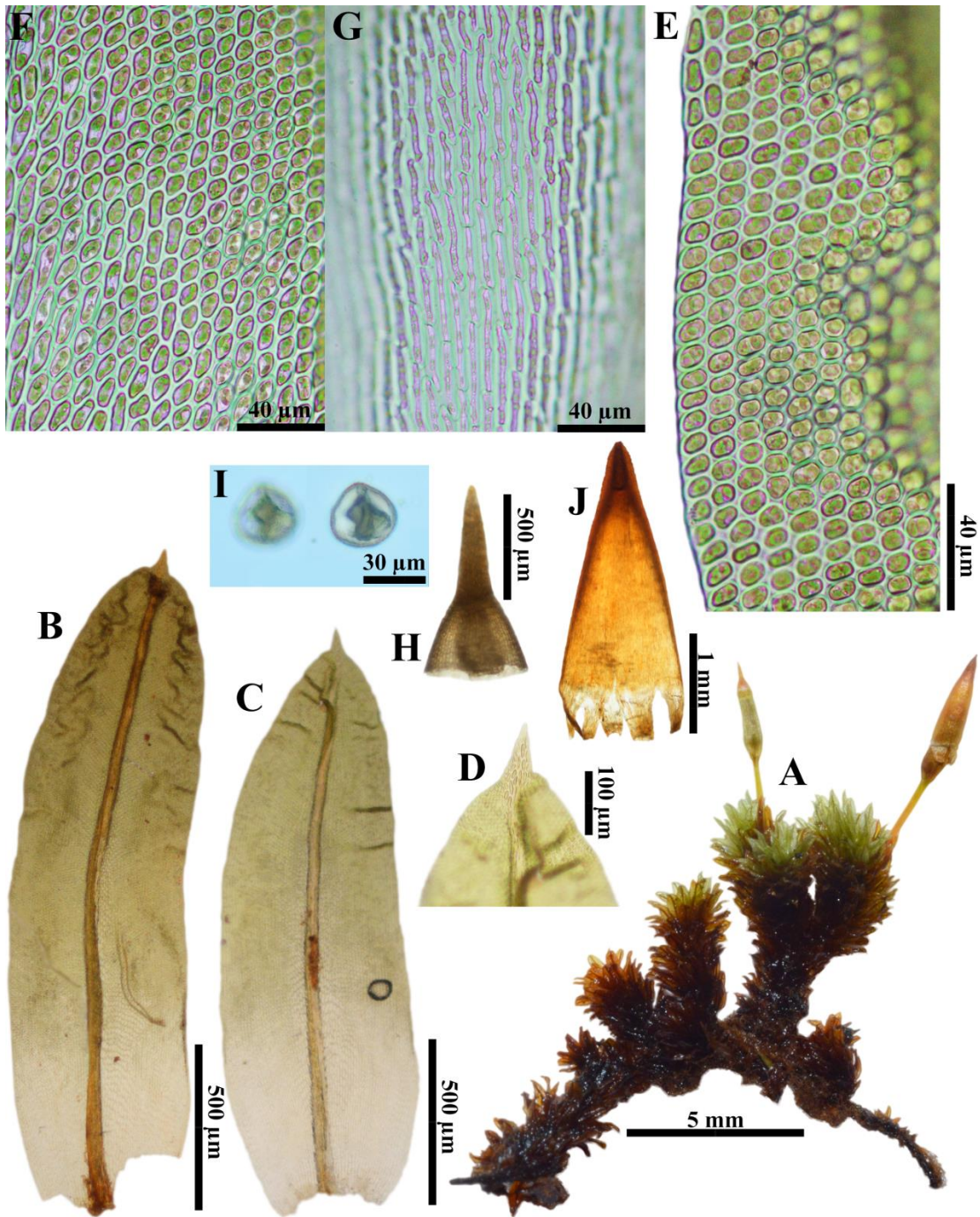


Figure 5. 65 *Schlotheimia ferruginea* (Bruch ex Hook. & Grev.) Brid.

A. Gametophyte with sporophytes, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Cells at median part of leaf, G. Cells at leaf base, H. Operculum, I. Calyptra, J. Spores. Based on *P. Ajintaiyasil* 471.

19. PLAGIOTHECIAEAE

M. Fleisch., Nova Guinea 8(2): 748. 1912; Gangulee, Mosses E. India 8: 1801. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1036. 1994; Deng-ke & Ireland, Moss Fl. China 7: 219. 2008.

Plants green or yellowish green, usually glossy, in loose or dense mats. **Stems** prostrate, complanate, irregularly branched, sometimes with flagelliform branches; central strand differentiated or absent. **Leaves** symmetric or asymmetric, appressed or erect, broadly ovate, elliptical, or ovate-lanceolate, sometimes concave; obtuse, acute or acuminate at apex; margins entire or serrulate; broader, usually distinctly decurrent; costae double, forked, unequal, rarely absent; median leaf cells elliptical, rhombic or rhomboidal, all smooth, rarely with minute, cuticular papillae on dorsal surfaces; alar cells distinctly differentiated, shorter; broader consisting of 1–8 rows of quadrate to rectangular cells. **Autoicous** or dioicous. **Perichaetial leaves** small, erect, acuminate, often sheathing at base. **Setae** slender, straight or curved, smooth, usually reddish. **Capsules** erect, inclined or horizontal, asymmetric, ovoid, ellipsoidal, or cylindrical; often constricted below the mouth. **Opercula** conic at base, obliquely rostrate. **Peristome** double; exostome teeth 16, mostly united at base, lanceolate, cross-striolate below; endostome segments divided, keeled; basal membrane high; cilia developed or absent. **Calyptrae** cucullate, smooth. **Spores** spherical, yellowish green, smooth or finely papillose.

PSEUDOTAXIPHYLLUM

Z. Iwats., J. Hattori Bot. Lab. 63: 448–450, f. 1e–h, 2c–d. 1987; Noguchi, Ill. Moss Fl. Japan 5: 1053. 1994; Man-xiang & He, Moss Fl. China 8: 222. 2005.

Plants small to fairly robust, in dense mats. **Stems** prostrate, irregularly branched; in cross section epidermal cells small, thick-walled. **Leaves** somewhat rigid, crowded and imbricate, erect-spreading to squarrose, often complanate, smooth or undulate, flat or concave, symmetric to asymmetric, lanceolate, ovate, ovate-lanceolate or oblong-lanceolate; apex acute to acuminate, sometimes abruptly; margins plane, more or less serrulate near the apex. **Dioicous**. **Setae** elongate, smooth. **Capsules** inclined or horizontal. **Peristome** double; hypnoid. **Spores** spherical, minutely papillose. **Asexual reproduction** by brood bodies, brood bodies present in leaf axils.

Key to the species

1. Brood bodies short, non-twisted, virgulate to fusiform, with 2–8 young leaf at the apex, 0.05–0.13 mm long.....1. *Pseudotaxiphyllum arquifolium*
1. Brood bodies elongate, fusiform, composed of spirally twisted, with 2–4 small projections at the apex, 0.35–0.50 mm long.....2. *Pseudotaxiphyllum pohliaecarpum*

1. *Pseudotaxiphyllum arquifolium* (Bosch & Sande Lac.) Z. Iwats., J. Hattori Bot. Lab. 63: 449. 1987. — *Hypnum arquifolium* Bosch & Sande Lac., Bryol. Jav. 2: 186. pl. 284. 1867. (**Figure 5.66**)

Plants pale green or reddish, glossy, in dense mats. **Stems** prostrate, irregularly branched. **Leaves** lax, erect-spreading, oblong-ovate, 1.0–1.5 × 0.4–0.5 mm; acuminate at apex; margins crenulate above; costae double, rarely absent; median leaf cells linear-rhomboidal, thin-walled, 55–92 × 6–9 μm, apical cells shorter, rhomboidal, 23–38 × 6–10 μm, basal cells rectangular or rhomboidal, more or less thick-walled, 40–66 × 6–8 μm. **Sporophytes** not seen. **Asexual reproduction** by brood bodies, brood bodies few, short, non-twisted, virgulate to fusiform, with 2–8 young leaf at the apex, 0.05–0.13 mm long.

Additional illustration. — Dozy & Molkenboer (1855: Tab. 284, as *Hypnum arquifolium*)

Thailand. — NORTH-EASTERN: Loei (He, 1995).

Distribution. — China, India, Japan, Malaysia, and Philippines (He, 1995).

Ecology. — On soils under shade of tree, near waterfall, at 1,262 m.

Specimens examined. — *P. Ajintaiyasil 470A* (BCU).

2. *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z. Iwats., J. Hattori Bot. Lab. 63: 449. 1987; Noguchi, Ill. Moss Fl. Japan 5: 1054. 1994; Man-xiang & He, Moss Fl. China 8: 223. 2005. — *Hypnum pohliaecarpum* Sull. & Lesq., Proc. Amer. Acad. Arts 4: 280. 1859. — *Isopterygium pohliaecarpum* (Sull. & Lesq.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 442. 1878; Gangulee, Mosses E. India 8: 1956. 1980. (**Figure 5.67**)

Plants rather robust, pale green, reddish or purple, glossy, in dens mats. **Stems** prostrate, irregularly branched; pseudoparaphyllia absent. **Leaves** lax, erect-spreading, oblong-ovate, 0.8–1.1 × 0.4–0.5 mm; acuminate at apex; margins slightly serrulate above; costae double, rarely single or absent, short; median leaf cells linear-rhomboidal, thin-walled, 64–98 × 6–8 μm, apical cells shorter, rhomboidal, 8–31 × 6–9 μm, basal cells rectangular or rhomboidal, more or less thick-walled, 31–49 × 8–19 μm. **Sporophytes** not seen. **Asexual reproduction** by brood bodies, brood bodies often clustered, elongate, fusiform, composed of spirally twisted, with 2–4 small projections at the apex, 0.35–0.50 mm long.

Additional illustration. — Gangulee (1980: 1956, Fig. 1004, as *Isopterygium pohliaecarpum*); Noguchi (1994: 1055, Fig. 463B); Wu, Crosby, & He (2005: 225, Pl. 701, Fig. 1–12).

Thailand. — NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Loei. SOUTH-WESTERN: Kanchanaburi. CENTRAL: Nakhon Nayok. PENINSULAR: Ranong, Krabi, Nakhon Si Thammarat (He, 1995).

Distribution. — Brunei, China, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, Philippines, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. — On soils under shade of tree, near stream, at 1,262 m elevation.

Specimens examined. — *P. Ajintaiyasil 344* (BCU).

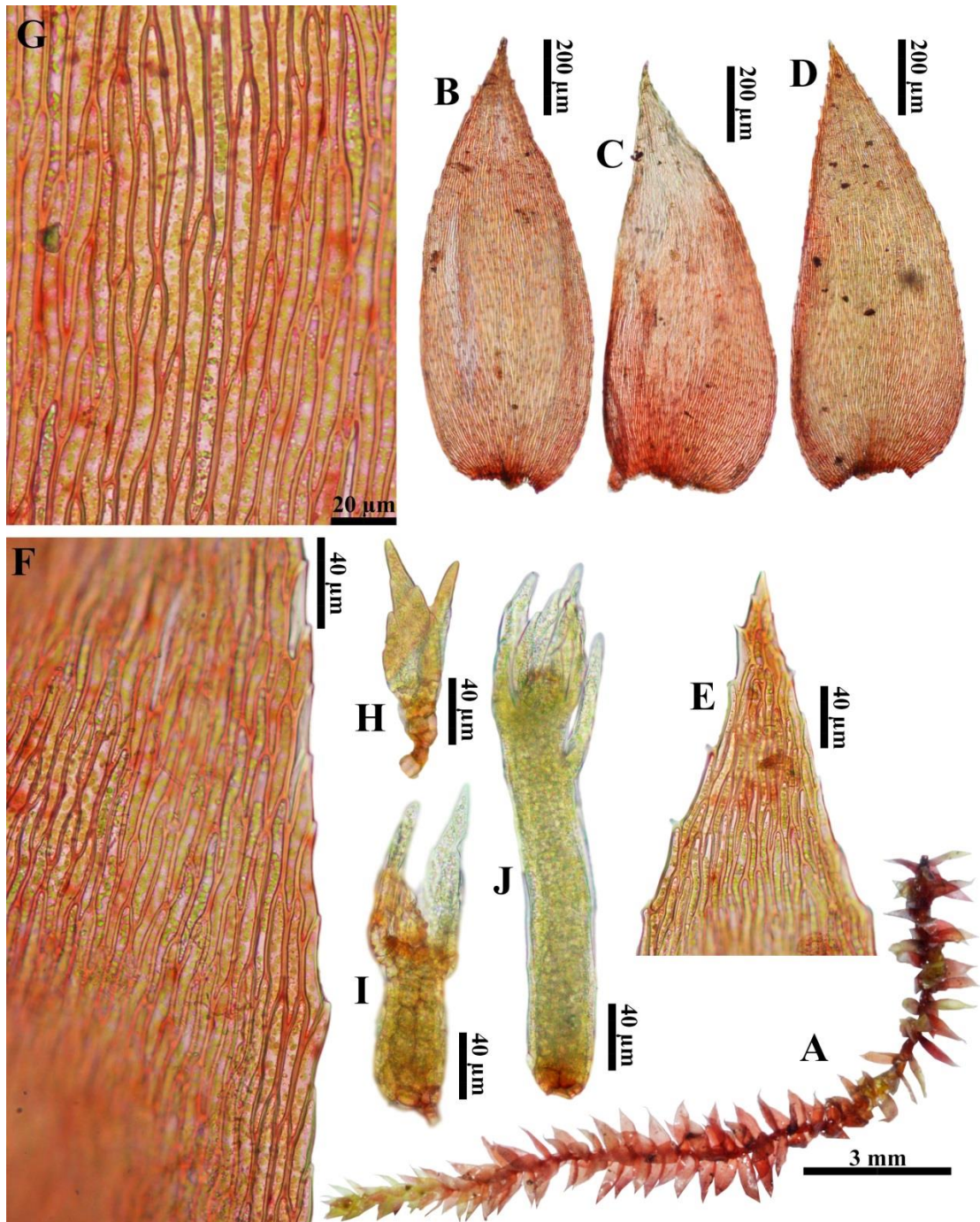


Figure 5. 66 *Pseudotaxiphyllum arquifolium* (Bosch & Sande Lac.) Z. Iwats.

A. Gametophyte, B–D. Leaves, E. Leaf apex, F. Leaf margin, G. Cells at median part of leaf, H–J. Brood bodies. Based on *P. Ajintaiyasil* 470A.

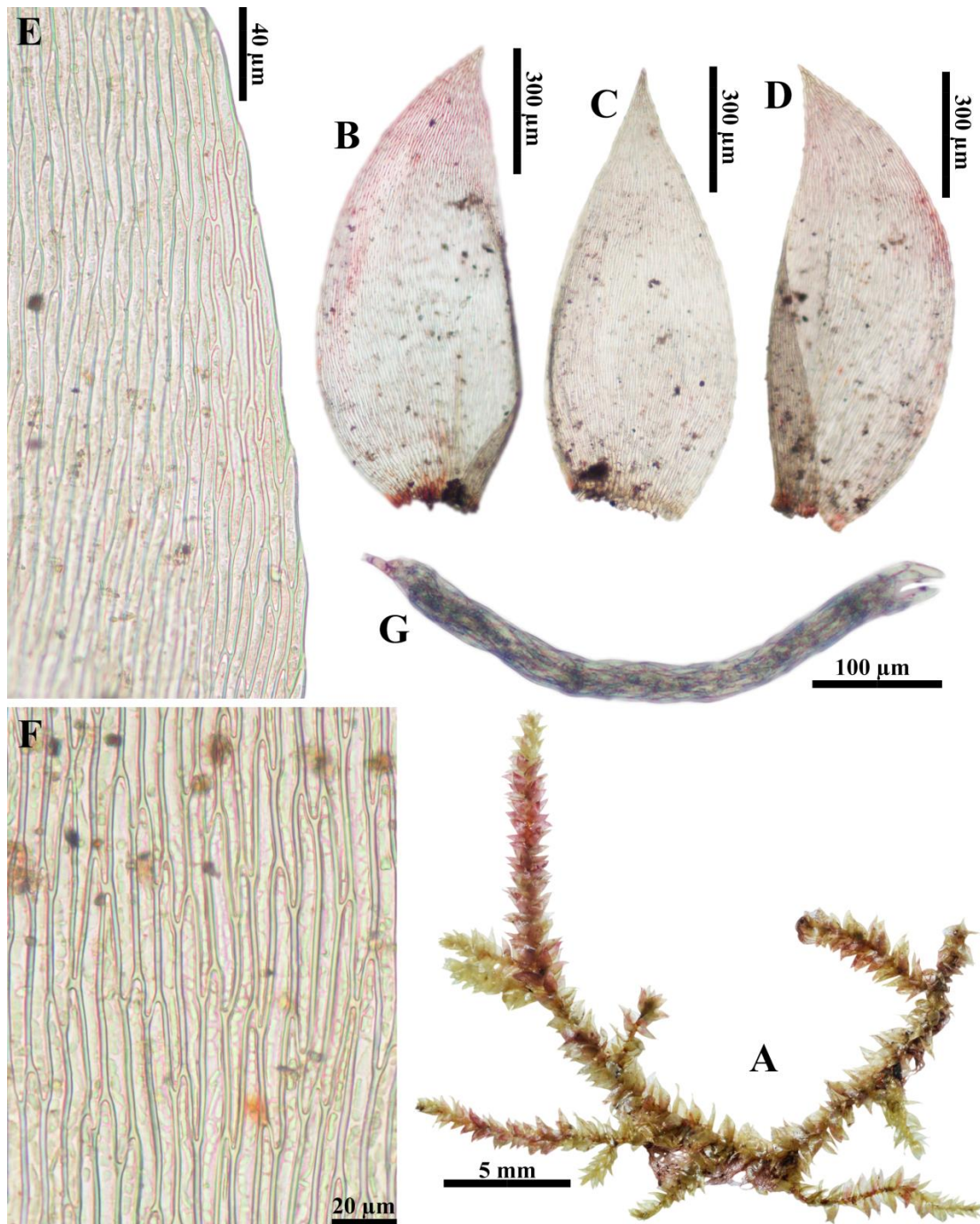


Figure 5.67 *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z. Iwats.

A. Gametophyte, B–D. Leaves, E. Leaf margin, F. Cells at median part of leaf, G. Brood body. Based on *P. Ajintaiyasil* 344.

20. POLYTRICHACEAE

Schwägr., Sp. Musc. Frond. 1. 1830; Gangulee, Mosses E. India 1: 69. 1969; Noguchi, Ill. Moss Fl. Japan 1: 18. 1987; Eddy, Handb. Males. Mosses 1: 29. 1988; Peng-cheng & Mei-zhi, Moss Fl. China 8: 306. 2005.

Plants small to very large and typically robust. **Stems** erect, solitary or few branched, typically rhizomatous; in cross section central strand present. **Leaves** oblong- to lingulate-lanceolate or differentiated with a narrow to broad lanceolate limb from a clasping sheathing base that is broadly oblong to obovate-oblong; margins plane, erect or incurved or folded, often serrate to spine, teeth single or double, sometimes limbate; costae single, usually strong, narrow to nearly width of limb, percurrent to somewhat long excurrent, often with teeth on dorsal side; sheathing base cells mostly elongate-rectangular; limb cells isodiametric, thick-walled; lamellae on ventral side, in continuous or discontinuous rows over the costa, few to several cells high, terminal lamellae cells rounded, truncate, U-shaped or pyriform, smooth or papillose. **Dioicous**, rarely autoicous. **Perichaetia** terminal; leaves differentiated. **Setae** mostly elong, stout and wiry. **Capsules** suberect to inclined, urn subglobose to cylindrical, terete or 2–4 sided. **Opercula** usually long rostrate. **Peristome** nematodontous, mostly of (16)32–64 teeth, joined terminally to an exerted columella (epiphragm). **Calyptrae** smooth to slightly scabrous distally, or densely hairy. **Spores** variously ornamented.

POGONATUM

P. Beauv., Mag. Encycl. 9(5[19]): 329. 1804; Gangulee, Mosses E. India 1: 94. 1969; Noguchi, Ill. Moss Fl. Japan 1: 32. 1987; Eddy, Handb. Males. Mosses 1: 29. 1988; Peng-cheng & Mei-zhi, Moss Fl. China 8: 328. 2005.

Plants small to large, solitary or forming turfs, dark green to reddish-brown or blackish. **Stems** mostly erect, occasionally distally curved. **Leaves** rather crowded, contorted or crispate when dry; ovate to short oblong, limb oblong-lanceolate or lingulate-lanceolate; margins plane, dentate to somewhat sharply serrate; mostly weakly differentiated between sheath and limb, base slightly expanded and slightly sheathing, or not; costae weak to mostly strong, percurrent; median cells isodiametric, thick-walled; lamellae extending over lamina and costae, terminal cells single or paired, truncate, rounded or pear-shaped. **Dioicous**. **Perichaetia** terminal. **Setae** elongate, stout and smooth. **Capsules** suberect to inclined, urn short to long cylindrical, terete, not angular, symmetrical. **Opercula** conic-mammillate. **Peristome** teeth 32. **Calyptrae** densely hairy. **Spores** variously ornamented.

Key to the species

- 1a. Leaf margin at least the outer row is mostly bistratose.....2
 2a. Lamellae 2–3 cells high, sometime up to 4 cells high; shoulder leaf distinct....
1. *Pogonatum cirratum* subsp. *fuscatum*
 2b. Lamellae 1–2 cells high; shoulder leaf indistinct.....

.....2. *Pogonatum cirratum* subsp. *macrophyllum*
 1b. Leaf margin at least the outer row is always unistratose.....3. *Pogonatum neesii*

1. *Pogonatum cirratum* (Sw.) Brid. subsp. ***fuscatum*** (Mitt.) Hyvönen, Acta Bot. Fenn. 138: 32. 1989; Peng-cheng & Mei-zhi, Moss Fl. China 8: 332. 2005. — *Pogonatum fuscatum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 154. 1859; Gangulee, Mosses E. India 1: 108. 1969. — *Pogonatum spuriocirratum* Broth., Philipp. J. Sci. 5: 150. 1910; Noguchi, Ill. Moss Fl. Japan 1: 42. 1987. (**Figure 5.68**)

Plants dark green or green, in loose turfs, medium, 2.5–3.0 cm high. **Stems** erect, not branched; in cross section central strand present. **Leaves** widely spreading when moist, strongly crisped with incurved when dry; lanceolate with blade mostly rather narrow and sheathing base, 7–8 mm long, not greatly widened; shoulder leaf distinct; blade gradually tapered above to narrowly acute, dentate tips, the teeth tipped with brown; margins 2–3 stratose; costae broad, dentate at back towards leaf apex; lamellae in upper half of limb 2–3(–4) cell high, apical cells obtuse, partially in pair; leaf marginal cells rounded or oval, thick-walled. **Diocous.** **Setae** single, 2.0–2.5 cm long, brownish red. **Capsules** cylindrical, 2–4 mm long, suberect. **Opercula** conic-mammillate. **Peristome** 32. **Calyptrae** densely hairy. **Spores** 8–10 µm in diameter.

Additional illustration. — Gangulee (1969: 110, Fig. 44, as *P. fuscatum*); Noguchi (1987: 43, Fig. 14A, as *P. spuriocirratum*); Hyvönen (1989: 31, Fig. 9E).

Thailand. — NORTHERN: Chiang Mai. NORTH-EASTERN: Phetchabun, Loei. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. — Bhutan, Brunei, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Philippines, Sikkim, Taiwan, and Vietnam (He, 1995; Hyvönen, 1989).

Ecology. — On soils under shade of tree, at 1,222 m elevation.

Specimens examined. — *P. Ajintaiyasil 471* (BCU).

2. *Pogonatum cirratum* (Sw.) Brid. subsp. ***macrophyllum*** (Dozy & Molk.) Hyvönen, Acta Bot. Fenn. 138: 33. 1989. — *Pogonatum macrophyllum* Dozy & Molk., Bryol. Jav. 1: 45. pl. 35. 1856; Eddy, Handb. Males. Mosses 1: 34. 1988. — *Pogonatum flexuosum* Mitt., Trans. Linn. Soc. London 23: 56. 6 f. 20. 1860. — *Pogonatum submacrophyllum* Herzog, Hedwigia 57: 236. 1916. (**Figure 5.69**)

Plants dark green, in loose turfs, tall and robust, 4.0–9.0 cm high. **Stems** erect, not branched; in cross section central strand present. **Leaves** widely spreading when moist, inrolled and incurved-flexuose when dry; lanceolate with sheathing base, 0.6–0.9 mm long, not greatly widened; shoulder leaf indistinct; blade gradually tapered above to acute, spinose-dentate tips, the teeth tipped with brown; margins 2–3 stratose; costae broad, spinose at back towards leaf apex; lamellae low, in upper half of limb 1–2(–3) cell high, becoming indistinct below, apical cells smooth and

otherwise unmodified, partially in pair. **Diocous**. **Setae** single, 2.5–3.5 cm long, brownish red. **Capsules** cylindrical, 2.0–2.9 mm long, suberect to inclined. **Opercula** conic-mammillate. **Peristome** 32. **Calyptrae** densely hairy. **Spores** 8–10 μm in diameter.

Additional illustration. — Eddy (1988: 35, Fig. 22A–G, as *Pogonatum macrophyllum*); Hyvönen (1989: 31, Fig. 9F–I).

Thailand. — NORTH-EASTERN: Loei. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. — Brunei, India, Indonesia, Kampuchea, Malaysia, Nigeria, Peninsula, Papua New Guinea, Philippines, Sumatra, and Vietnam (He, 1995; Hyvönen, 1989).

Ecology. — On soils in sunlight or under shade of tree, at 1,200–1,246 m elevation.

Specimens examined. — *P. Ajintaiyasil* 043, 076, 287 (BCU).

3. *Pogonatum neesii* (Müll. Hal.) Dozy, Ned. Kruidk. Arch. 4(1): 75. 1856; Eddy, Handb. Males. Mosses 1: 30. f. 19. 1988; Peng-cheng & Mei-zhi, Moss Fl. China 8: 342. 341 f. 762. 2005. — *Polytrichum neesii* Müll. Hal., Syn. Musc. Frond. 2: 563. 1851. — *Polytrichum australasicum* Müll. Hal. & Hampe, Linnaea 26: 500. 1853. — *Pogonatum junghuhnianum* (Dozy & Molk.) Dozy & Molk., Bryol. Jav. 1: 41: 31. 1856; Gangulee, Mosses E. India 1: 103. 1969. — *Pogonatum junghuhnianum* var. *incurvum* (Dozy & Molk.) Dozy & Molk., Bryol. Jav. 1: 41. 1856. — *Catharinea nietneri* Müll. Hal., Linnaea 36: 36. 1869. — *Polytrichum albo-marginatum* Müll. Hal., Linnaea 37: 172. 1872. — *Pogonatum circinatum* Besch., Ann. Sci. Nat., Bot., sér. 5, 18: 220. 1873. — *Pogonatum aloides* var. *longicolle* Mitt., Trans. Linn. Soc. London, Bot. 3: 192. 1891. — *Pogonatum yunnanense* Besch., Rev. Bryol. 18: 89. 1891. — *Pogonatum akitense* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 354. 1893; Gangulee, Mosses E. India 1: 106. 1969. — *Pogonatum rhopalophorum* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 354. 1893. — *Pogonatum junghuhnianum* var. *sikkimense* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 34(2): 65. 1896. — *Pogonatum leucopogon* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 34(2): 64. 1896; Gangulee, Mosses E. India 1: 121. 1969. — *Pogonatum stevensii* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 34(2): 65. 1896; Gangulee, Mosses E. India 1: 119. 1969. — *Polytrichum brachypodium* Müll. Hal., Hedwigia 36: 812. 1897. — *Polytrichum camarae* Müll. Hal., Hedwigia 36: 341. 1897. — *Polytrichum colleanum* Müll. Hal., Hedwigia 36: 342. 1897. — *Polytrichum gippslundiae* Müll. Hal., Hedwigia 36: 341. 1897. — *Polytrichum nanocarpum* Müll. Hal., Hedwigia 36: 340. 1897. — *Pogonatum ochromitrium* Paris, Index Bryol.: 984. 1898. — *Polytrichum ochromitrium* Müll. Hal., Index Bryol.: 984. 1898. — *Catharinella benguetiae* Müll. Hal., Index Bryol. Suppl.: 277. 1900. — *Catharinella rufinota* Müll. Hal., Index Bryol. Suppl.: 278. 1900. — *Pogonatum benguetiae* Paris, Index Bryol. Suppl.: 277. 1900. — *Pogonatum lao-kayense* Paris & Broth., Rev. Bryol. 27: 77. 1900. — *Pogonatum rufinotum* Paris, Index Bryol. Suppl.: 278. 1900. — *Pogonatum pygmaeum* Cardot, Bull. Soc. Bot. Genève 1: 130. 1909. — *Pogonatum papillosulum*

Cardot & Dixon, J. Bot. 50: 146. 517 f. 1. 1912; Gangulee, Mosses E. India 1: 129. 1969. — *Pogonatum klossii* Dixon, J. Linn. Soc., Bot. 45: 483. 1922. (**Figure 5.70**)

Plants dark green, in loose turfs, small, 1–2 cm high. **Stems** erect, not branched; in cross section central strand present. **Leaves** erect patent when moist, incurved when dry; lanceolate from an distinct sheathing base, 4.0–5.0 mm long; margins plane, unistratose, sharply toothed, each tooth consisting of 1–3 cells; costae green, dentate on leaf back at upper 1/3 the leaf length; lamellae 3–5 cells high, rarely up to 6 cells high, apical cells of lamellae rarely differentiated, oblong or rounded quadrate, slightly obtuse. **Dioicous**. **Setae** single, 15–25 mm long, dark brown. **Capsules** cylindrical, 2.0–4.0 mm long, suberect to inclined. **Opercula** conic-mammillate. **Peristome** 32. **Calyptrae** densely hairy. **Spores** 1–11 μm in diameter.

Additional illustration. — Eddy (1988: 31, Fig. 19A–H); Hyvönen (1989: 51, Fig. 15A–C); Wu, Crosby, & He (2005: 341, Pl. 762, Fig. 8–22).

Thailand. — NORTERN: Chiang Mai, Phitsanulok. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Chanthaburi. PENINSULAR: Ranong (He, 1995).

Distribution. — Australia, Bhutan, Brunei, Celebes, China, India, Indonesia, Japan, Kampuchea, Korea, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, and Vietnam (He, 1995; Hyvönen, 1989).

Ecology. — On soils in sunlight or under shade of tree, at 1,190–1,242 m elevation.

Specimens examined. — *P. Ajintaiyasil* 040, 057, 060 (BCU).

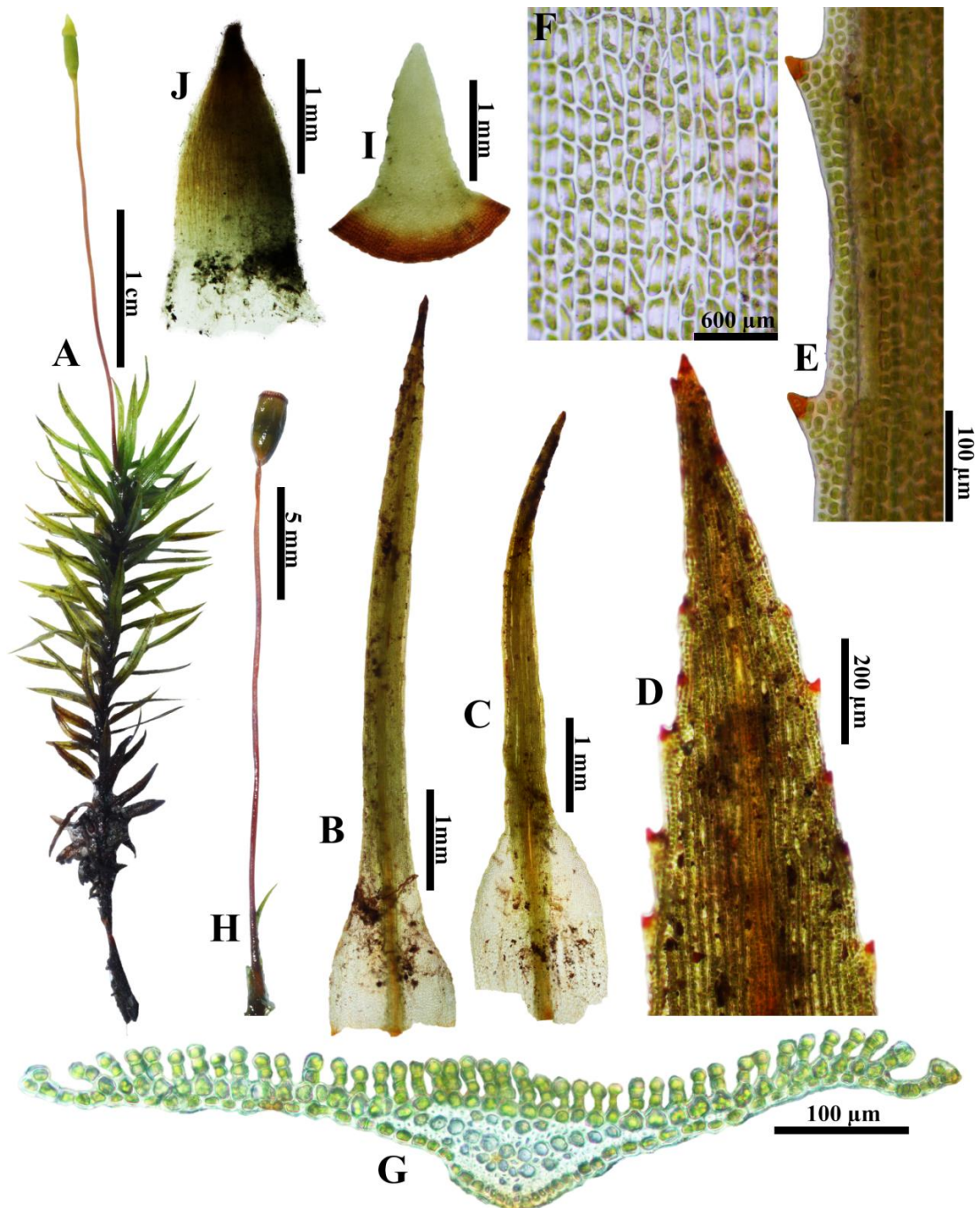


Figure 5.68 *Pogonatum cirratum* (Sw.) Brid. subsp. *fuscatum* (Mitt.) Hyvönen

A. Gametophyte with sporophyte, B–C. Leaves, D. Cells at sheathing base, D. Leaf margin, E. Leaf apex, F. Cross section of leaf, G. Operculum, H. Calyptra, I. Seta and capsule. Based on *P. Ajintaiyasil* 471.

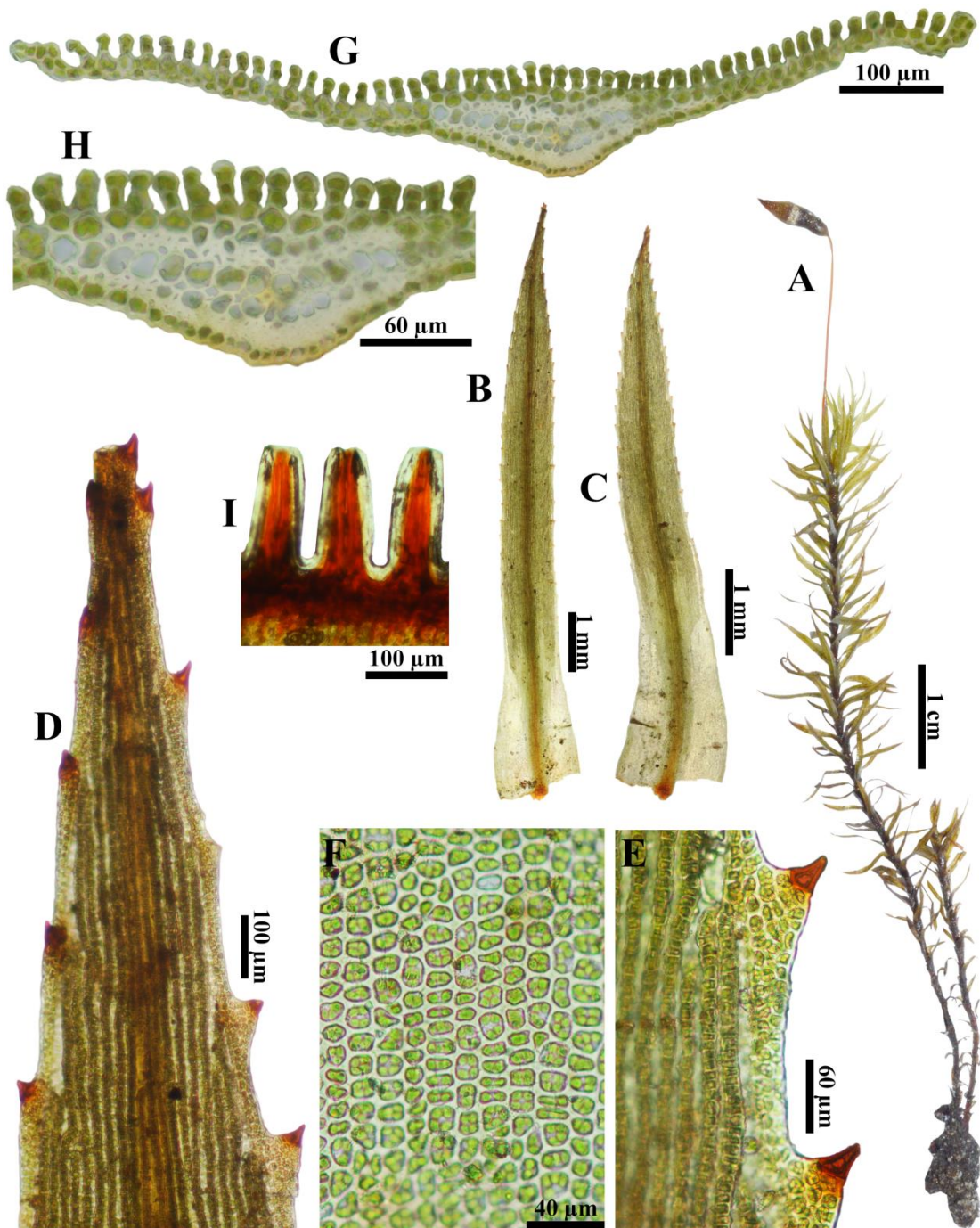


Figure 5.69 *Pogonatum cirratum* (Sw.) Brid. subsp. *macrophyllum* (Dozy & Molk.) Hyvönen

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Cells at dorsal leaf, G. Cross section of leaf, H. Closed up of costa, I. Part of peristome. Based on *P. Ajintaiyasil* 287.

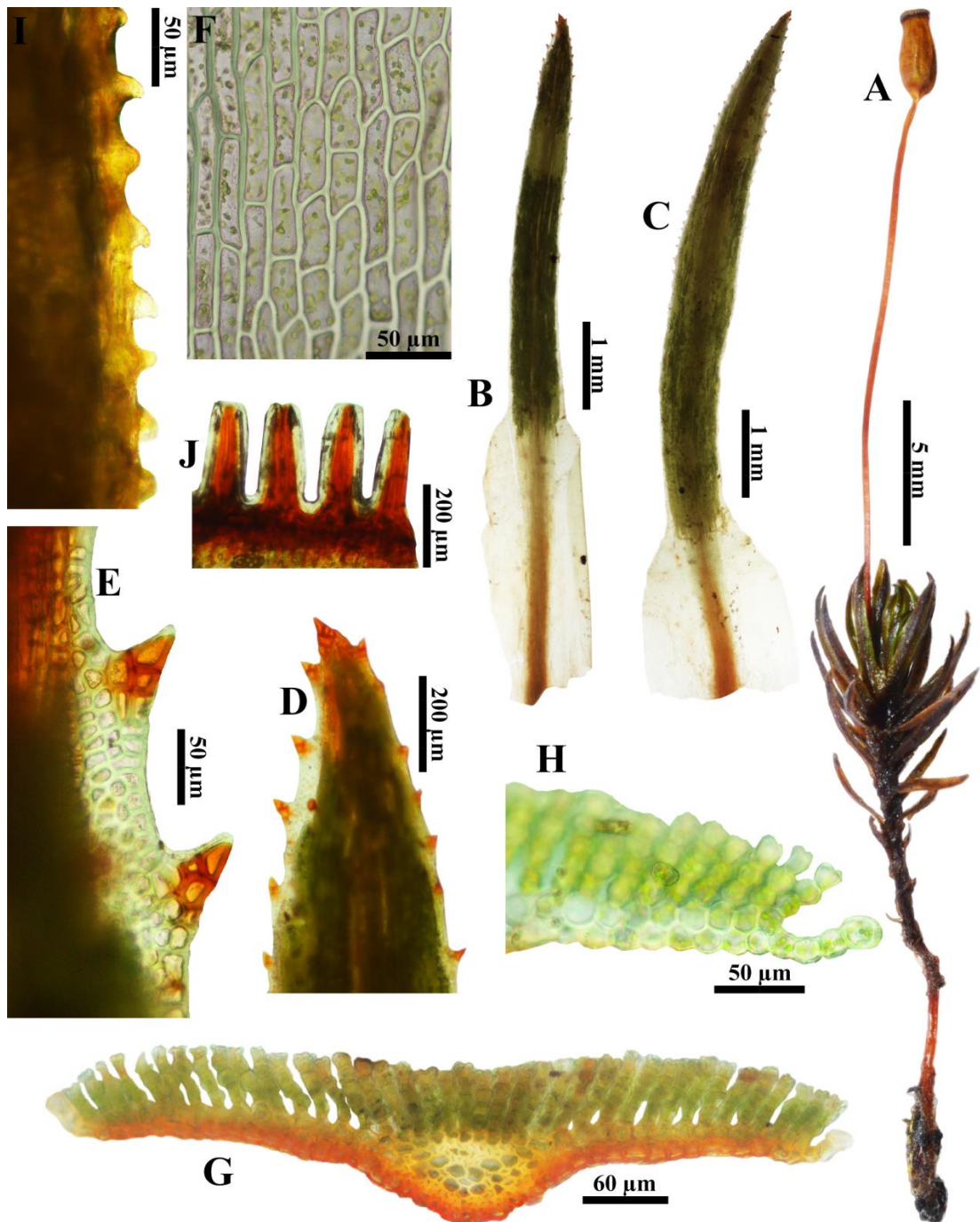


Figure 5.70 *Pogonatum neesii* (Müll. Hal.) Dozy

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Cells at sheathing base, G. Cross section of leaf, H. Closed up of lamellae at margin, I. Capsule wall, J. Part of peristome. Based on *P. Ajintaiyasil* 060.

21. POTTIACEAE

Hampe, Bot. Zeitung (Berlin) 11(18): 329. 1853; Gangulee, Mosses E. India 3: 624. 1972; Noguchi, Ill. Moss Fl. Japan 2: 257. 1988; Eddy, Handb. Males. Mosses 2: 149. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 114. 2001.

Plants small to medium-sized, rarely large, forming short turfs or dense to loose turfs, often dark green to brown or black. **Stems** erect, simple to few branched by innovations, radiculose; in cross section hyalodermis present or absent, outer cortical cells differentiated or not; central strand often present. **Leaves** mostly crowded, narrowly lanceolate to ligulate; apex acute to acuminate, occasionally obtuse-rounded; base decurrent or more often not; margins plane to more commonly recurved or incurved, entire to crenulate or irregularly serrate; limbate or more commonly elimbate; costae single, strong, subpercurrent to excurrent, occasionally as a hyaline, smooth or toothed awn, superficial cells quadrate to rectangular, in cross section with 1 or 2 stereid bands, guide cells in 1–2, rarely more layers; lamellae, filaments or a pad of cells absent or present on upper surface of costae; median and distal cells mostly isodiametric, typically papillose, uni- to pluripapillose, thin- or more commonly thick-walled, lower and basal cells commonly elongate, uniform across or extending along the margin, mostly rectangular, thin- or less commonly thick-walled. **Monoicous** or dioicous. **Perichaetia** terminal; rarely lateral on short terminal branches, leaves often differentiated. **Setae** short to more commonly elongate, smooth, twisted or not. **Capsules** immersed to mostly exserted, erect to suberect, stegocarpous or occasionally cleistocarpous, mostly cylindrical, less often short to long ovoid-cylindrical or subglobose. **Opercula** mostly conic short- or long-rostrate, often oblique. **Peristome** 16 or 32 segments, commonly divided to near base, erect or spirally twisted, papillose to spiculose, occasionally with a low or less frequently high basal membrane. **Calyptrae** cucullate, naked, smooth. **Spores** spherical, usually variously papillose.

Key to the genera

- 1a. Margin involute; costae shortly excurrent.....4. *Weissia*
 1b. Margin plane; costae percurrent to shortly excurrent.....2
 2a. Basal leaf cells forming a V-shaped region with hyaline cells.....3. *Tortella*
 2b. Basal leaf cells not forming a V-shaped region with hyaline cells.....3
 3a. Leaves ligulate to spatulate.....2. *Hyophila*
 3b. Leaves ovate-lanceolate to linear-lanceolate.....1. *Barbula*

1. BARBULA

Hedw., Sp. Musc. Frond. 115. 1801; Gangulee, Mosses E. India 3: 690. 1972; Noguchi, Ill. Moss Fl. Japan 2: 300. 1988; Eddy, Handb. Males. Mosses 2: 173. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 126. 2001.

Plants green, yellowish green to yellowish brown or reddish brown, in loose or dense turfs, or forming cushions. **Stems** erect, simple or irregularly branched, often radiculose at base; central strand differentiated. **Leaves** appressed or contorted when dry, erect-spreading, sometimes squarrose, when moist; ovate-lanceolate to linear-lanceolate; apex gradually acuminate to abruptly acute or rounded obtuse; margins entire, often recurved in lower; costae stout, percurrent to shortly excurrent, seldom short-awned, rarely ending below apex, in cross section often with two stereid bands; upper leaf cells small, usually rounded-hexagonal or quadrate to short-rectangular, rather thick-walled, obscure, unipapillose or multi-papillose, sometimes mammillose or occasionally smooth, basal cells usually differentiated, often larger, short-rectangular, smooth, hyaline. **Dioicous**. **Perichaetial leaves** similar to stem leaves, but slightly larger and often sheathing at the base. **Setae** elongate, yellowish to sometimes reddish, smooth. **Capsules** erect, rarely inclined, oblong-ovoid to long-cylindrical, rarely curved. **Opercula** conic, short- to long-rostrate. **Peristome** teeth 32, slender, filiform, usually twisted counterclockwise, rarely straight, densely papillose. **Calyptrae** cucullate, smooth. **Spores** small, spherical, usually yellowish green, rarely light reddish brown, smooth or weakly papillose.

Key to the species

- 1a. Leaf cells smooth, sometimes with faintly papillae.....1. *Barbula consanguinea*
 1b. Leaf cells with prominent multipapillose.....2. *Barbula javanica*

1. *Barbula consanguinea* (Thwaites & Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–78: 409. 1880; Eddy, Handb. Males. Mosses 2: 178. 1991. — *Tortula consanguinea* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 300. 1873. — *Barbula louisadum* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 42: 97. 1899. — *Barbula obscuriretis* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 18. 1932. (**Figure 5.71**)

Plants yellowish green to brownish, in loose turfs, 0.8–1.0 cm long. **Stems** erect, simple, often radiculose at base; central strand differentiated. **Leaves** spreading when moist, curled when dry; ovate-lanceolate, 1.6–1.7 × 0.2–0.4 mm, opaque in upper, pellucid in lower; apex obtuse, mucronate; margins entire, revolute below mid-leaf, rarely almost plane throughout; costae prominent, excurrent, scabrid dorsally, cells elongate-rectangular, smooth, sometimes with faintly papillae, cross section with 4–6 guide cells, two stereid band cells; apical to median leaf cells quadrate, densely and obscurely multi-papillose, 4–7 × 6–8 μm, basal leaf cells elongate-rectangular except at margins, pellucid, 9–36 × 7–11 μm. **Dioicous**. **Setae** 8–9 mm long. **Capsules** cylindrical, erect, 1.5–2.0 mm long. **Opercula** rostrate. **Peristome** consisting of 32 teeth, reddish, papillose, spirally-twisted. **Spores** small, spherical, yellowish green, smooth or weakly papillose.

Additional illustration. – Eddy (1991: 179, Fig. 278).

Thailand. – NORTHERN: Chiang Mai (Printarakul, 2015).

Distribution. – Burundi, Cape Verde, Guinea, Ivory Coast, Malaysia, and Nigeria (Eddy, 1991; O'shea, 2006).

Ecology. – On soils with *Philonotis mollis*, *Hyophila involuta* and *Bryum coronatum* or on rocks with *Hyophila involuta* on sunlight, sometime under shade of tree at 403–585 m elevation.

Specimens examined. – *P. Ajintaiyasil* 245B, 246C, 331, 451A (BCU).

2. *Barbula javanica* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 300. 1844; Noguchi, Ill. Moss Fl. Japan 2: 302. 1988; Eddy, Handb. Males. Mosses 2: 174. 1991. (**Figure 5.72**)

Plants yellowish green to blackish green, forming turfs, 5–8 mm long. **Stems** erect, simple, often radiculose at base; central strand differentiated. **Leaves** lingulate, 1.6–1.9 × 0.6–0.7 mm; apex obtuse; base truncate; margins entire, plane in lower part, obscurely serrulate, sometimes concave in upper part; costae percurrent; apical and median leaf cells quadrate to hexagonal, thick-walled, with prominent multipapillose, 4–14 × 7–9 µm, basal leaf cells elongated-rectangular, 16–68 × 8–15 µm. **Dioicous**. **Setae** 0.6–1.0 cm long. **Capsules** cylindrical, 1.2–2.0 mm long. **Opercula** rostrate. **Peristome** 32 ciliate, reddish, papillose, spirally-twisted. **Spores** small, spherical, yellowish green, smooth or weakly papillose.

Additional illustration. – Noguchi (1988: 299, Fig. 125B).

Thailand. – NORTHERN: Chiang Mai. SOUTH-WESTERN: Kanchanaburi. CENTRAL: Nakhon Nayok, Krung Thep Mahanakhon. PENINSULAR: Chumphon, Surat Thani (He, 1995).

Distribution. – Bangladesh, Brunei, China, India, Indonesia, Japan, Kampuchea, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks under shade of tree, near waterfall, at 590–1,234 m elevation.

Specimens examined. – *P. Ajintaiyasil* 143, 425 (BCU).

2. HYOPHILA

Brid., Bryol. Univ. 1: 760. 1827; Gangulee, Mosses E. India 3: 677. 1972; Noguchi, Ill. Moss Fl. Japan 2: 289. 1988; Eddy, Handb. Males. Mosses 2: 196. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 191. 2001.

Plants green above, red to reddish brown or dark green below, in dense turfs. **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 apex; margins entire or serrulate; costae 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. **Setae** elongate, straight. **Capsules** erect, oblong-cylindrical. **Opercula** conic-rostrate, usually with long oblique beak. **Peristome** absent. **Calyptrae** cucullate, smooth. **Spores** spherical, small, smooth.

Key to the species

- 1a. Leaf apices apiculate to mucronate; leaf margins entire throughout.....
1. *Hyophila apiculata*
- 1b. Leaf apices obtuse to acute; leaf margins serrate in the upper half.....
2. *Hyophila involuta*

1. *Hyophila apiculata* M. Fleisch., Musci Buitenzorg 1: 325. 1904; Eddy, Handb. Males. Mosses 2: 200. 1991. (**Figure 5.73**)

Plants yellowish-green, forming turfs, 3.0–5.0 mm long. **Stems** erect, simple. **Leaves** involute to subtubulose when dry, erect- to wide-spreading when moist; obovate-oblong to spatulate, 1.3–1.9 × 0.5–0.7 mm; apex apiculate to mucronate; base cuneate; margins entire throughout; costae single, ending below leaf apex to shortly excurrent; apical leaf cells rounded-quadrate, slightly mamilllose, median leaf cells isodiametric-quadrate, thin-walled, slightly mamilllose, 5–12 × 4–12 μm, basal leaf cells rectangular, thin-walled, smooth, 17–40 × 6–14 μm. **Dioicous**. **Setae** 6–7 mm long, yellowish green, not twisted. **Capsules** erect, cylindrical. **Opercula** conic-rostrate with a long beak. **Peristome** absent. **Spores** spherical, small, smooth.

Additional illustration. – Eddy (1991: 200, Fig. 294).

Thailand. – NORTHERN: Chiang Mai, Chiang Rai (He, 1995).

Distribution. – Australia, Brasil, Indonesia, and Melaysia (Brito, Conceição & Peralta, 2009; He, 1995).

Ecology. – On soils under shade of tree, at 285 m elevation.

Specimens examined. – *P. Ajintaiyasil 241* (BCU).

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2. *Hyophila involuta* (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1871–72: 354. 1873; Gangulee, Mosses E. India 3: 681. 1972; Noguchi, Ill. Moss Fl. Japan 2: 290. 1988; Eddy, Handb. Males. Mosses 2: 199. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 191. 2001. — *Gymnostomum involutum* Hook., Musci Exot. 2: 154. 1819. — *Barbula spathulata* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 300. 1844. — *Pottia contermina* Müll. Hal., Syn. Musc. Frond. 2: 623. 1851. — *Pottia zollingeri* Müll. Hal., Bot. Zeitung (Berlin) 14: 419. 1856. — *Barbula lingulata* Warnst., Hedwigia 24: 93. 1885. — *Hyophila martinicae* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 29(1): 173. 1890. — *Hyophila micholitzii* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 35: 39. 1893. — *Pottia reflexifolia* Müll. Hal., Bull. Herb. Boissier 5: 190. 1897. — *Hyophila stenocarpa* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 38(1): 10. 1900. — *Hyophila moutieri* Paris & Broth., Rev. Bryol. 28: 38. 1901. — *Hyophila mollis* Broth., Symb. Antill. 3: 424. 1903. — *Hyophila flavipes* Broth., Philipp. J. Sci. 3: 14. 1908. — *Hyophila tsunodae* Broth. ex Yasuda, Bot. Mag. (Tokyo) 29: 151. 1–2. 1915. (**Figure 5.74**)

Plants yellowish green, in dense turfs, 3.0–6.0 mm long. **Stems** erect, simple. **Leaves** involute to subtubulose when dry, erect- to wide-spreading when moist; oblong-ovate to oblong-spatulate, 1.7–3.0 × 0.6–0.8 mm; apex broadly acute to obtusely apiculate; slightly reflexed at the base; margins serrate in the upper half; costae stout, percurrent to shortly excurrent; upper leaf cells small, subquadrate to rounded hexagonal, somewhat thick-walled, smooth, 4–10 × 4–9 µm, basal cells short-rectangular, pale or hyaline, 21–66 × 8–13 µm. **Dioicous**. **Setae** 10–12 mm long, yellowish green to reddish brown, not twisted. **Capsules** erect, cylindrical. **Opercula** conic-rostrate with a long beak. **Peristome** absent. **Spores** spherical, small, smooth. **Asexual reproduction** by gemmae, gemmae oval, yellowish green.

Additional illustration. – Gangulee (1972: 682, Fig. 322); Noguchi (1988: 291, Fig. 120B); Eddy (1991: 198, Fig. 293).

Thailand. – **NORTHERN:** Chiang Mai, Chiang Rai, Phitsanulok. **NORTH-EASTERN:** Loei, Khon Kaen. **SOUTH-WESTERN:** Kanchanaburi. **CENTRAL:** Nakhon Nayok, Krung Thep Mahanakhon. **SOUTH-EASTERN:** Chanthaburi. **PENINSULAR:** Chumphon, Trang (He, 1995).

Distribution. – Australia, Benin, Brunei, Brazil, Canada, Cape Verde, Celebes, Central African Republic, China, Democratic Republic of the Congo, Equatorial Guinea, India, Indonesia, Japan, Kampuchea, Kenya, Korea, Laos, Lesotho, Malaysia, Malawi, Mexico, Mozambique, Myanmar, Nepal, New Guinea, Philippines, Russia, Seychelles, Sikkim, Sierra Leone, South Africa, Sri Lanka, Suriname, Swaziland, Taiwan, Tanzania, Togo, Uganda, Vietnam, United States, Zambia, and Zimbabwe (Forzza, 2010; He, 1995; O'shea, 2006; Tan & Iwatsuki, 1991).

Ecology. – On soils or rocks on sunlight, at 294–1,179 m elevation.

Specimens examined. – *P. Ajintaiyasil* 055, 124, 217A, 218B, 242, 245A, 246A, 315, 329A, 332, 374, 426, 448 (BCU).

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3. TORTELLA

(Müll. Hal.) Limpr., Laubm. Deutschl. 1: 599. 1888; Gangulee, Mosses E. India 3: 662. 1972; Noguchi, Ill. Moss Fl. Japan 2: 274. 1988; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 224. 2001.

Plants green to dark green or reddish brown, in loose or dense turfs. **Stems** erect, simple or branched; central strand absent or weak to strong. **Leaves** often crowded, appressed or contorted-curved to strongly crisped when dry, spreading or reflexed when moist; ligulate to oblong or linear-lanceolate or oblong-lanceolate, often channeled above; apex narrowly to broadly acute; somewhat sheathing at base; margins plane or somewhat undulate or narrowly incurved, entire to weakly serrulate or crenulate with projecting papillae; costae subpercurrent to percurrent or excurrent as a short awn; in cross section 2 stereid bands present; upper leaf cells quadrate to hexagonal, green, often unistratose, sometimes bistratose, pluripapillose, with either

branched or simple papillae, basal cells often sharply differentiated, rectangular, smooth, forming a V-shaped base. **Dioicous** or autoicous. **Setae** slender, yellowish to reddish brown. **Capsules** erect or slightly inclined, oblong-ovoid to cylindrical. **Opercula** long conic-rostrate. **Peristome** teeth 32, linear to filiform, often twisted counterclockwise, densely papillose; basal membrane low or absent. **Calyptrae** cucullate, smooth. **Spores** spherical, yellowish brown, smooth or papillose.

Tortella cyrtobasis Dixon, J. Siam Soc., Nat. Hist. Suppl. 10: 7. 1935. (Figure 5.75)

Plants green to dark green, in loose or dense turfs, 6.0–7.0 mm long. **Stems** erect, simple; central strand present. **Leaves** strongly crisped when dry, spreading or reflexed when moist; linear-lanceolate or oblong-lanceolate, 4.0–5.0 × 0.3–0.4 mm, often channeled above; apex acute; somewhat sheathing at base; margins plane, crenulate with projecting papillae; costae shortly excurrent, in cross section 2 stereid bands present; upper leaf cells quadrate to hexagonal, green, unistratose, simple pluripapillose, 6–15 × 8–11 μm; basal cells often sharply differentiated, rectangular, smooth, forming a V-shaped base, 51–96 × 14–18 μm. **Sporophytes** not seen.

Additional illustration. – Not seen.

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – Myanmar (He, 1995).

Ecology. – On rocks under shade of tree, at 966 m elevation.

Specimens examined. – *P. Ajintaiyasil* 463 (BCU).

4. WEISSIA

Hedw., Sp. Musc. Frond. 64. 1801; Noguchi, Ill. Moss Fl. Japan 2: 260. 1988; Eddy, Handb. Males. Mosses 2: 161. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 244. 2001.

Plants bright green or yellowish green, in dense turfs. **Stems** erect, short, simple or irregularly branched; central strand present. **Leaves** often crowded at stem tips, contorted-curved or crisped when dry, spreading or occasionally reflexed when moist; long-ligulate, oblong- or triangular-lanceolate to narrowly lanceolate; upper lamina often channeled, sharply acute or acuminate at apex; sheathing at base; margins strongly incurved or involute above the leaf base, entire or crenulate by projecting papillae; costae rather stout, usually shortly excurrent, ending in sharply mucronate tips, in cross section 2 stereid bands present; upper leaf cells subquadrate to hexagonal, thin- to evenly thick-walled, papillose, with bifid or branched papillae, basal cells sharply differentiated, rectangular, mostly thin-walled, smooth, hyaline. **Autoicous** or dioicous. **Perichaetial leaves** not much differentiated from stem leaves. **Setae** short or elongate, straight, yellowish brown. **Capsules** erect or slightly inclined, oblong-ovoid to oblong-elliptic or cylindrical. **Opercula** conic-rostrate, with a rather

long, straight or obliquely beak. **Peristome teeth** 16, short or rudimentary, papillose. **Calyptrae** cucullate, smooth. **Spores** spherical, yellowish brown to brown, papillose.

Weissia edentula Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 27. 1859; Noguchi, Ill. Moss Fl. Japan 2: 262. 1988; Eddy, Handb. Males. Mosses 2: 163. 1991; Xing-jiang, He & Iwatsuki, Moss Fl. China 2: 247. 2001. (**Figure 5.76**)

Plants dark green, in dense turfs, 2.0–5.0 mm long. **Stems** erect, usually irregularly branched. **Leaves** often crowded at stem tips, contorted-curved when dry, spreading when moist; narrowly lanceolate, 1.6–2.0 × 2.0–3.0 mm; upper lamina often channeled, acuminate at apex; sheathing at base; margins moderately incurved, entire or crenulate by projecting papillae; costae rather stout, shortly excurrent, ending in sharply mucronate tips; upper leaf cells subquadrate to rounded hexagonal, evenly thick-walled, densely pluripapillose, with bifid, 7–11 × 6–9 μm; basal cells sharply differentiated, shortly rectangular or oblong-elliptic, mostly thin-walled, smooth, hyaline, 6–25 × 4–8 μm. **Autoicous**. **Setae** straight, 3.5–4.0 mm long. **Capsules** erect, oblong-ovoid, 1.0–1.5 mm long. **Peristome** none. **Calyptrae** cucullate, smooth. **Spores** not seen.

Additional illustration. – Noguchi (1988: 263, Fig. 107A); Eddy (1990: 164, Fig. 269A–F).

Thailand. – NORTHERN: Phitsanulok. SOUTH-WESTERN: Ratchaburi. PENINSULAR: Chumphon (He, 1995).

Distribution. – Australia, Benin, China, Japan, Kampuchea, Malaysia, Philippines, and Vietnam (He, 1995; X. Li, Crosby & He, 2001; O'shea, 2006; Tan & Iwatsuki, 1991).

Ecology. – On soils on sunlight, at 470–719 m elevation.

Specimens examined. – *P. Ajintaiyasil* 125, 247, 253, 453, 454 (BCU).

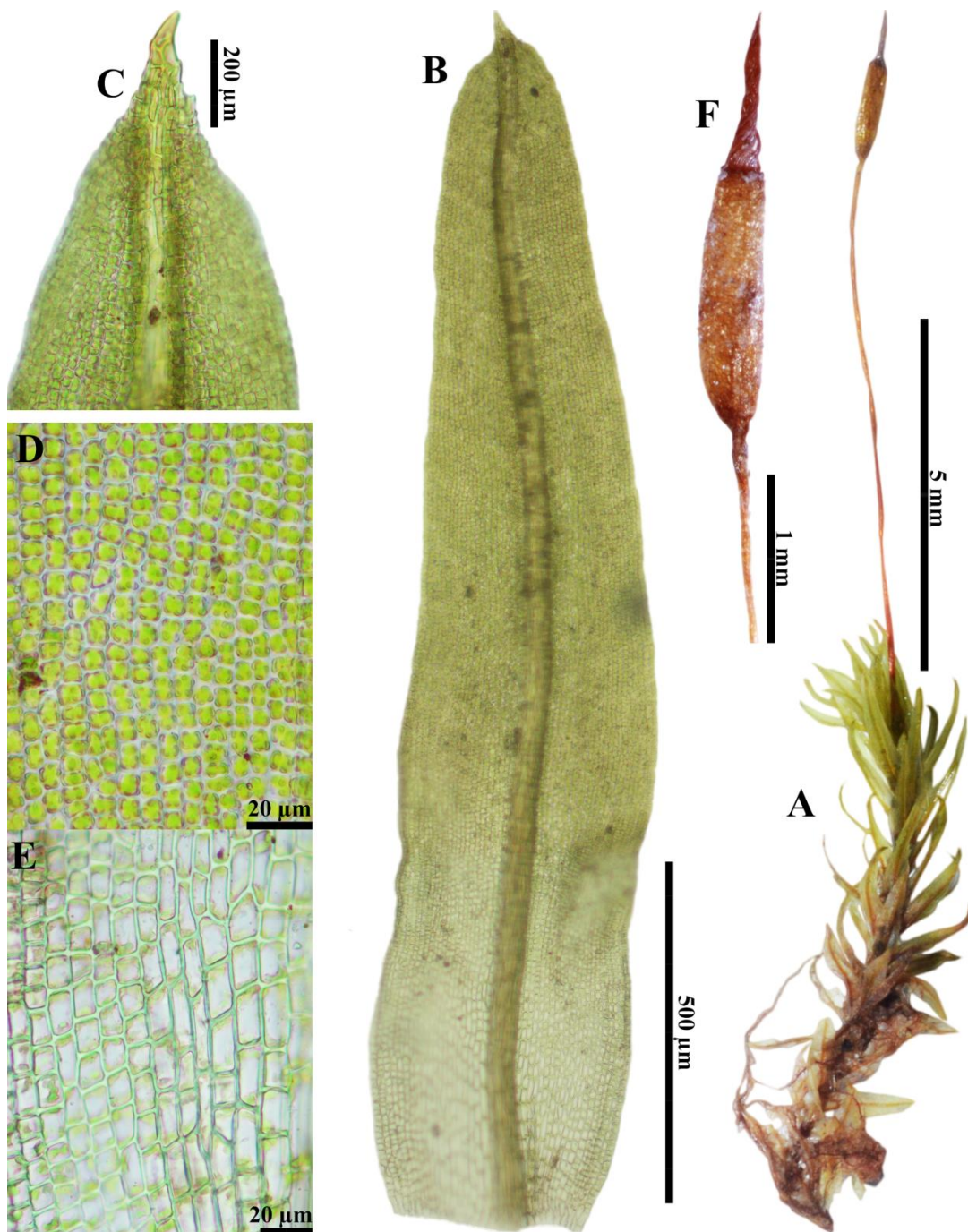


Figure 5.71 *Barbula consanguinea* (Thwaites & Mitt.) A. Jaeger

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Cells at median part of leaf, E. Cells at leaf base, F. Capsule with peristome. Based on *P. Ajintaiyasil* 245B.

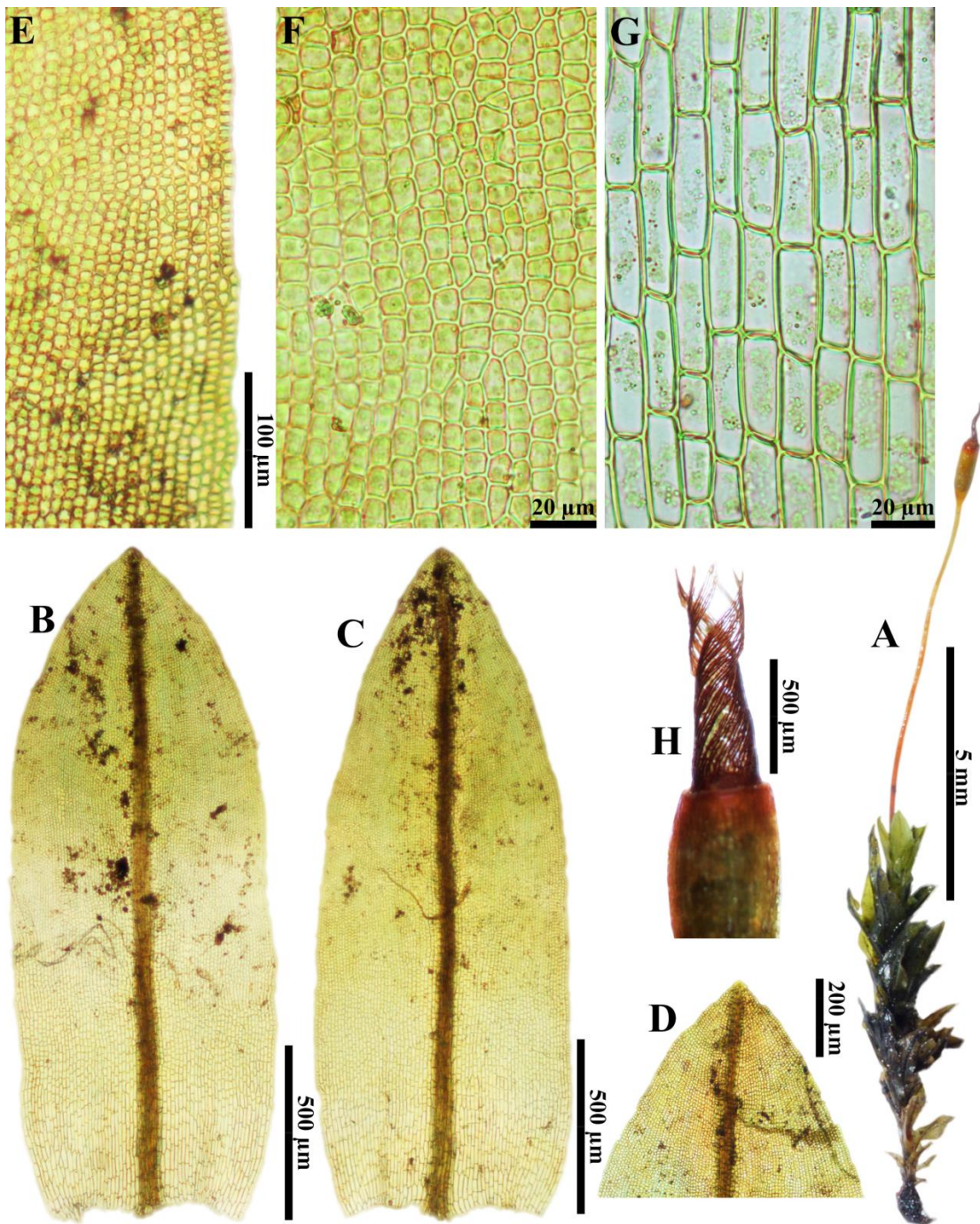


Figure 5.72 *Barbula javanica* Dozy & Molk.

A. Gametophyte with sporophyte, B–C. Leaves, C. Leaf apex, D. Leaf margin, E. Cells at median part of leaf, F. Cells at leaf base, G. Capsule with peristome. Based on *P. Ajintaiyasil 143*.

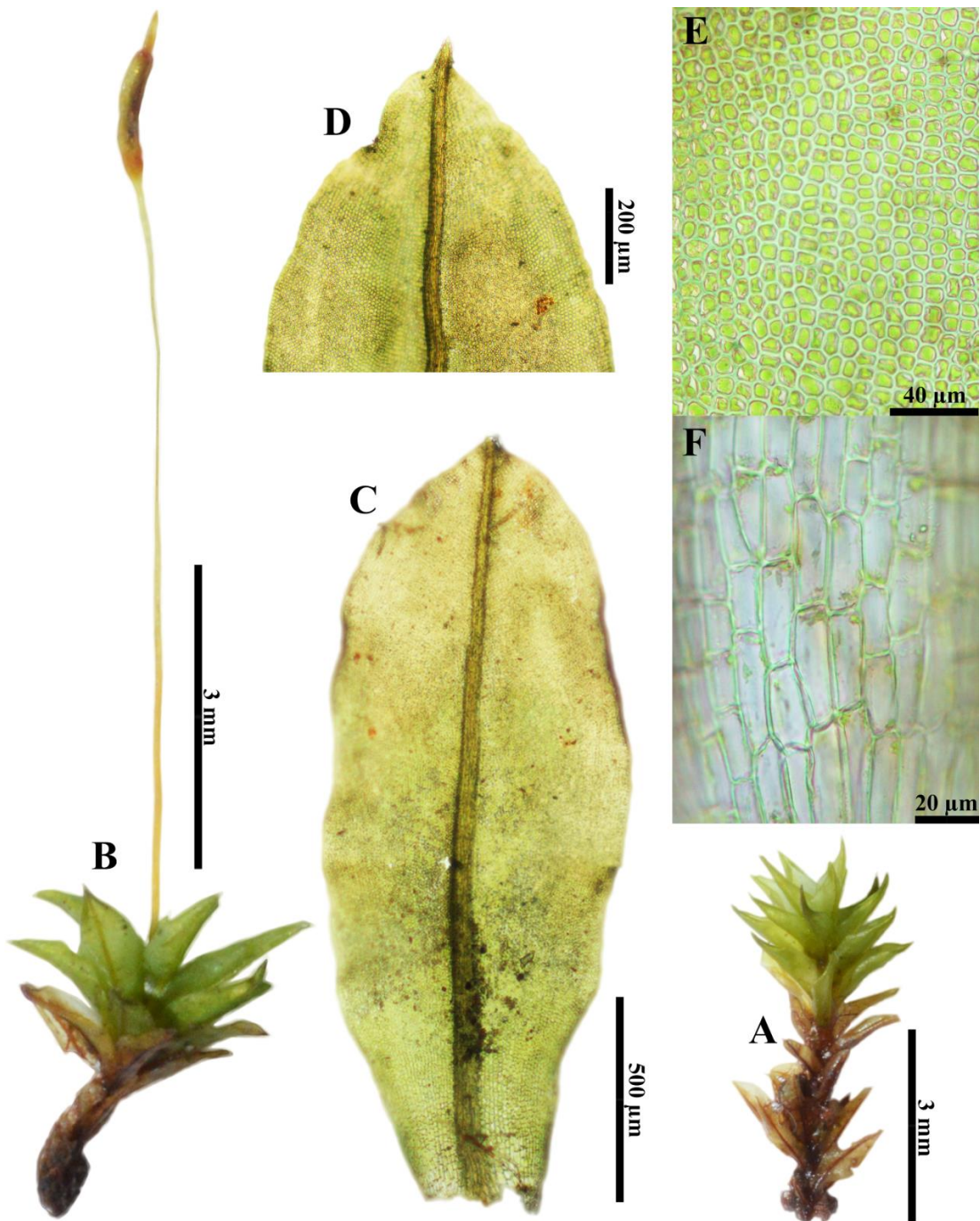


Figure 5.73 *Hyophila apiculata* M. Fleisch.

A. Sterile gametophyte, B. Gametophyte with sporophyte, C. Leaf, D. Leaf apex, E. Cells at median part of leaf, F. Cells at leaf base. Based on *P. Ajintaiyasil* 241.

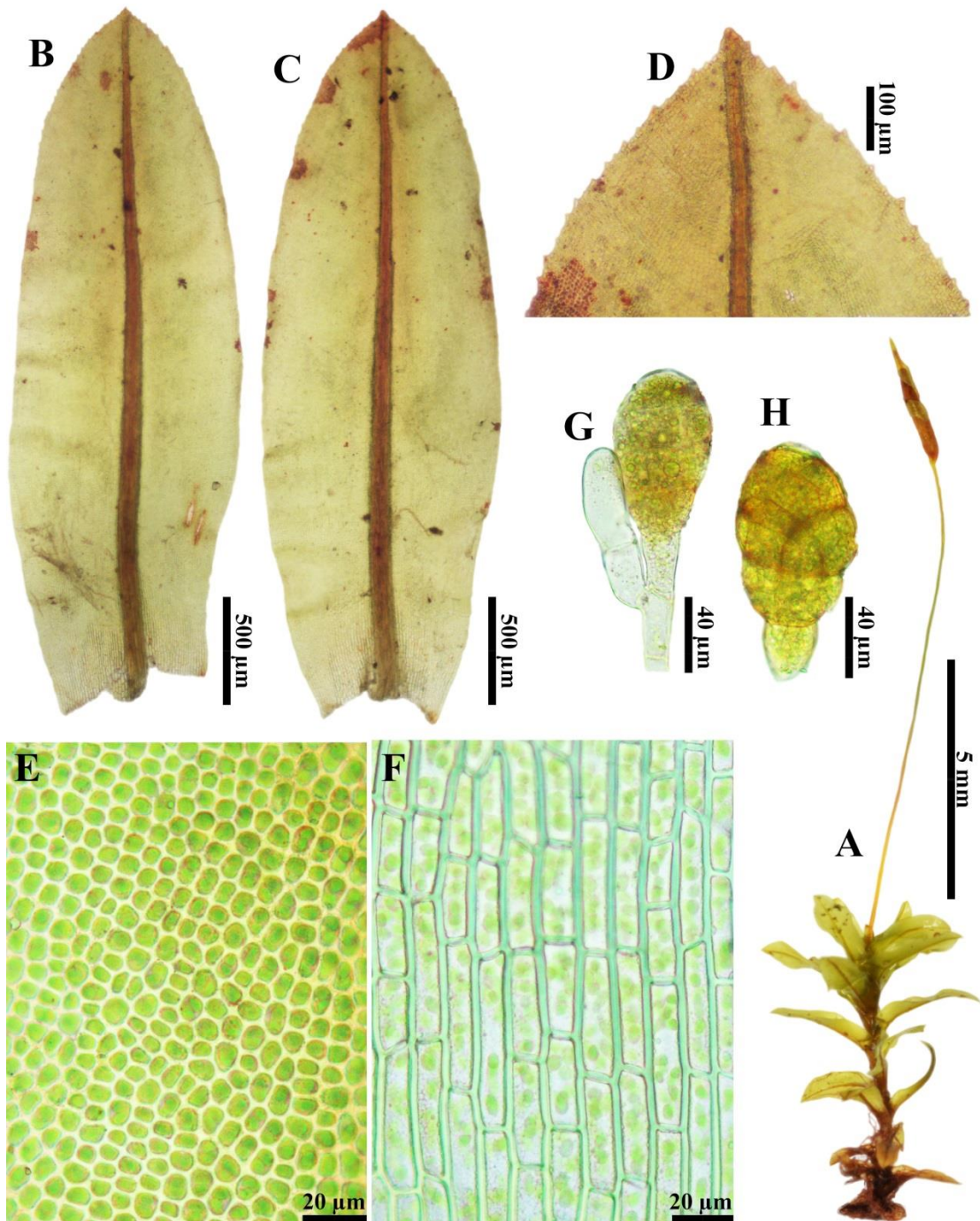


Figure 5. 74 *Hyophila involuta* (Hook.) A. Jaeger

A. Gametophyte with sporophyte, B–C. Leaf, D. Leaf apex, E. Cells at median part of leaf, F. Cells at leaf base, G. Immature gemma, H. Mature gemma. Based on *P. Ajintaiyasil* 374.

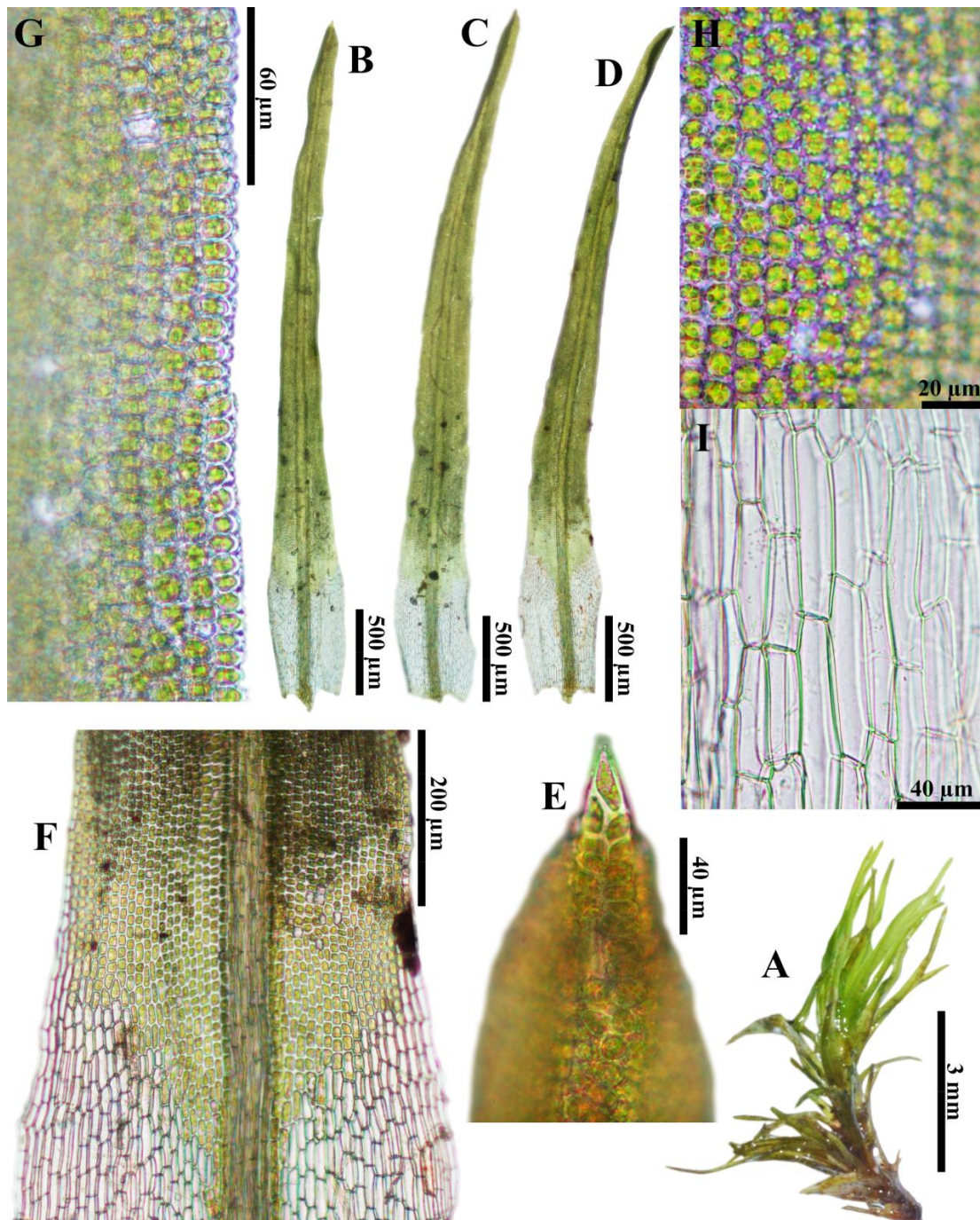


Figure 5.75 *Tortella cyrtobasis* Dixon

A. Gametophyte, B–D. Leaves, E. Leaf apex, F. V-shaped of leaf base, E. Leaf margin, F. Cells at median part of leaf, G. Cells at leaf base. Based on *P. Ajintaiyasil* 463.

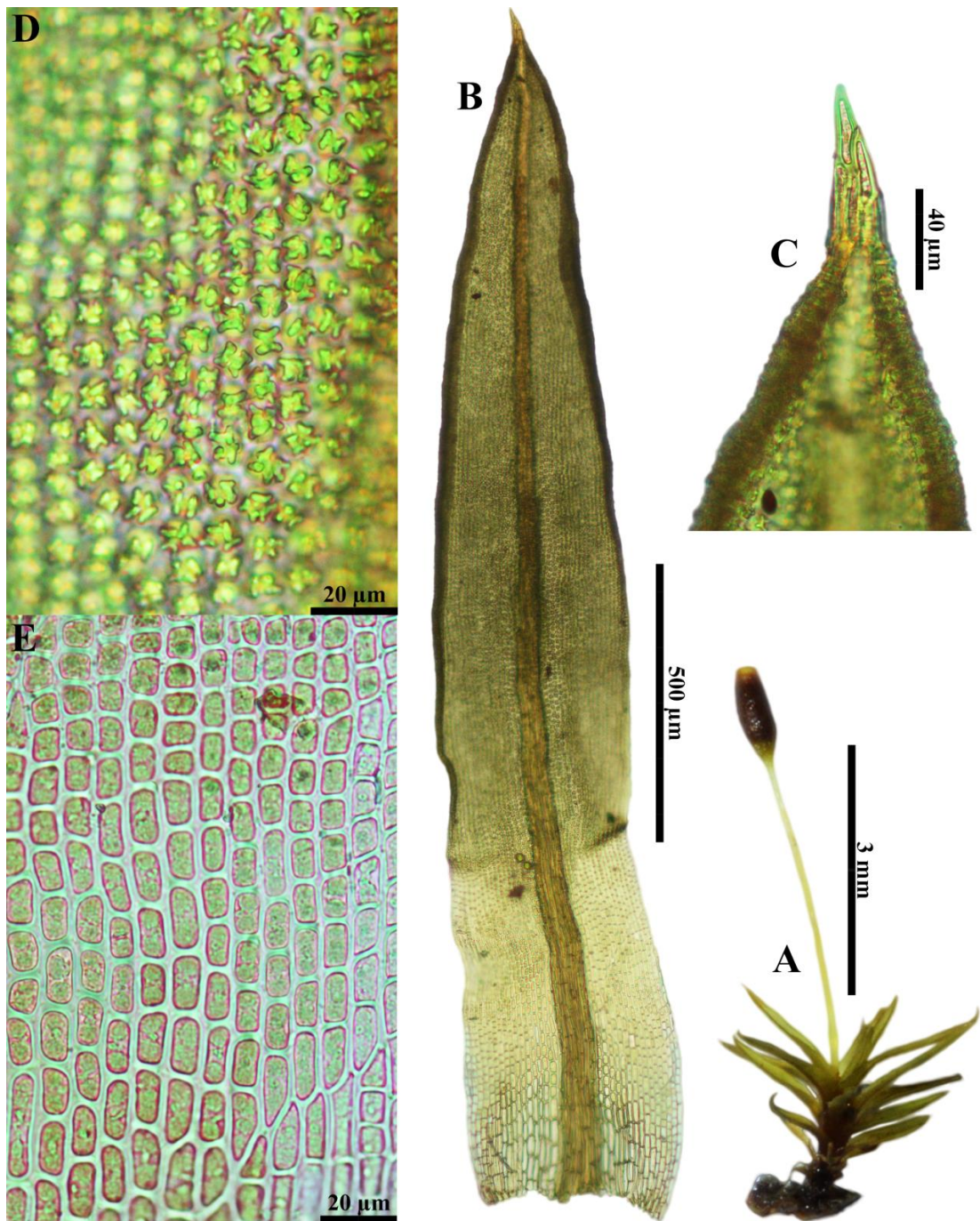


Figure 5.76 *Weissia edentula* Mitt.

A. Gametophyte with sporophyte, B. leaf, C. leaf apex, D. Cells at median part of leaf, E. Cells at leaf base. Based on *P. Ajintaiyasil* 253.

22. PTERIGYNANDRACEAE

Schimp., Syn. Musc. Eur. CXIII, 618. 1876.

Plants mostly relatively small, forming rough mats or wefts; dark or olive green to yellowish. **Stems** creeping, pinnately to subpinnately branched, mostly terete-foliate, branches often curved; in cross section without central strand; pseudoparaphyllia foliose or filamentous. **Leaves** ovate-lanceolate to broadly ovate; apiculate to long-acuminate; margin almost entire to serrulate or serrulate above; costae short and double, usually well developed, cells short, quadrate, rhomboidal, or elliptical to oblong-rhomboidal, prorate to papillose; alar cells differentiated. **Dioicous**. **Setae** elongate, smooth. **Capsules** long-exserted, often erect. **Opercula** short-rostrate or conic, cucullate. **Peristome** complete or reduced; exostome teeth almost smooth; endostome segments slender. **Calyptrae** cucullate, smooth. **Spores** spherical, finely papillose.

TRACHYPHYLLUM

A. Gepp, Cat. Afr. Pl. 2(2): 298. 1901; Gangulee, Mosses E. India 8: 1760. 1980; Ren-liang & You-fang, Moss Fl. China 7: 211. 2008.

Plants yellowish to brownish, in large, dense mats or wefts, small to medium-sized, slender, somewhat stiff. **Stems** prostrate, irregularly pinnately branched; branches short, julaceous, blunt at tips, often curved when dry. **Leaves** erect-spreading, ovate, concave; often with apiculate apex; margins plane, mostly entire, or minutely serrulate near leaf apex; costae short, forked or double; median leaf cells elliptical to oblong-rhomboidal, often prorate; basal alar cells differentiated in a small group, consisting of quadrate to oblate cells, extending upward along margins. **Dioicous**. **Setae** slender. **Capsules** oblong-ovoid. **Peristome** double; exostome teeth cross-striolate at base, papillose above; endostome segments narrowly lanceolate; basal membrane high; cilia 2. **Calyptrae** cucullate, smooth. **Spores** spherical, finely papillose.

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Key to the species

- 1a. Leaves cordate to ovate.....1. *Trachyphyllum inflexum*
 1b. Leaves lanceolate-ovate.....2. *Trachyphyllum touwianum*

1. *Trachyphyllum inflexum* (Harv.) A. Gepp, Cat. Afr. Pl. 2(2): 299. 1901; Gangulee, Mosses E. India 8: 1762. 1980; Ren-liang & You-fang, Moss Fl. China 7: 211. 2008. — *Hypnum inflexum* Harv., Icon. Pl. 1: pl. 24: f. 6. 1836. — *Platygyrium pertenuae* Sande Lac., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 13: 12. 1872. — *Pterigynandrum ferricola* Müll. Hal., Linnaea 39: 454. 1875. — *Pterogonium curvifolium* Mitt., Philos. Trans. 168: 392. 37 c. 1879. — *Leptohymerium fabronioides* Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 293. 1880. — *Leptohymerium ferriezii* Marie, Ann. Sci. Nat., Bot., sér. 7, 2: 95. 1885. — *Leptohymerium papuanum* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 40: 183. 1898. —

Trachyphyllum curvifolium (Mitt.) A. Gepp, Cat. Afr. Pl. 2(2): 300. 1901. — *Trachyphyllum fabronioides* (Besch.) A. Gepp, Cat. Afr. Pl. 2(2): 299. 1901. — *Trachyphyllum ferricola* (Müll. Hal.) A. Gepp, Cat. Afr. Pl. 2(2): 299. 1901. — *Trachyphyllum ferriezii* (Marie) A. Gepp, Cat. Afr. Pl. 2(2): 300. 1901. — *Leptohymenium ferriezii* var. *imbricatum* Renaud & Paris, Rev. Bryol. 29: 83. 1902. — *Leptohymenium ferriezii* var. *abbreviatum* Renaud & Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 90. 1905. — *Trachyphyllum papuanum* (Broth.) Broth., Nat. Pflanzenfam. I(3): 890. 1907. (**Figure 5.77**)

Plants yellowish green to dark green, in large or wefts. **Stems** prostrate, elongate, irregularly branched; branches short, erect or ascending, julaceous, often curved when dry. **Leaves** dense, appressed when dry, erect-spreading when moist; concave, cordate to ovate, $0.5\text{--}0.7 \times 0.3\text{--}0.5$ mm; abruptly narrowed to a slender apex; margins plane, entire; costae double, forked; median leaf cells elliptical to oblong-rhombic, papillae very prominent, $21\text{--}32 \times 3\text{--}6$ μm ; alar region ending 1/2 the leaf length, alar cells shortly rectangular, becoming quadrate at basal angles in a small group, $5\text{--}12 \times 8\text{--}12$ μm , sometimes with a few inflated cells decurrent forming a small auricle. **Dioicous**. **Setae** slender, 14–15 mm long, yellowish brown, smooth, straight or slightly curved above. **Capsules** oblong-ovoid, horizontal to inclined, 1.5–1.7 mm long. **Opercula** long conic-rostrate. **Peristome** double; exostome teeth cross-striolate at base, papillose above; endostome segments narrowly lanceolate; basal membrane high; cilia 2. **Spores** spherical, finely papillose.

Additional illustration. — Bartram (1939: Pl. 23, Fig. 389); Buck (1979: 383, Fig. 1–7); Gangulee (1980: 1763, Fig. 888); Hu, Wang, Crosby, & He (2008: 210, Pl. 577, Fig. 12–19).

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Lampang, Tak, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei, Khon Kaen. SOUTH-WESTERN: Kanchanaburi, Ratchaburi, Prachuap Khiri Khan. SOUTH-EASTERN: Prachin Buri. PENINSULAR: Narathiwat (He, 1995).

Distribution. — Aldabra, Australia, Bangladesh, Cambodia, China, Comoros, India, Indonesia, Kampuchea, Kenya, Laos, Madagascar, Malawi, Mauritius, Mozambique, Myanmar, Nepal, New Caledonia, New Guinea, Philippines, Reunion, Rodrigues, Sikkim, Sudan, Tanzania, Vietnam, Uganda, and Zambia (Buck, 1979; He, 1995; O'shea, 2006).

Ecology. — On barks or log under sunlight, sometime under shade of tree, at 294–778 m elevation.

Specimens examined. — *P. Ajintaiyasil* 056, 250, 252, 254, 314, 319, 320, 326, 328, 450 (BCU).

2. *Trachyphyllum touwianum* W.R. Buck, Brittonia 31: 392. f. 25–27. 1979. (**Figure 5.78**)

Plants reddish-golden, slender, often in loose mats. **Stems** prostrate, elongate, irregularly branched; branches erect or ascending, julaceous. **Leaves** dense, appressed when dry, erect-spreading when moist; concave, lanceolate-ovate, $0.4\text{--}0.7 \times 0.2\text{--}0.3$ mm; apex gradually acuminate, frequently fragile; margins plane, entire, slightly

serrulate near the apex; costae double, forked; median leaf cells linear-rhombic, often prorate, $16\text{--}37 \times 4\text{--}9 \mu\text{m}$; alar cells shortly rectangular, becoming quadrate at basal angles in a small group, $6\text{--}20 \times 6\text{--}15 \mu\text{m}$, sometimes with a few inflated cells decurrent forming a small auricle. **Sporophytes** not seen.

Additional illustration. – Buck (1979: 391, Fig. 25–27).

Thailand. – New record

Distribution. – Myanmar (Buck, 1979).

Ecology. – On twigs and rocks under shade of tree, at 548 m elevation.

Specimens examined. – *P. Ajintaiyasil* 452 (BCU).



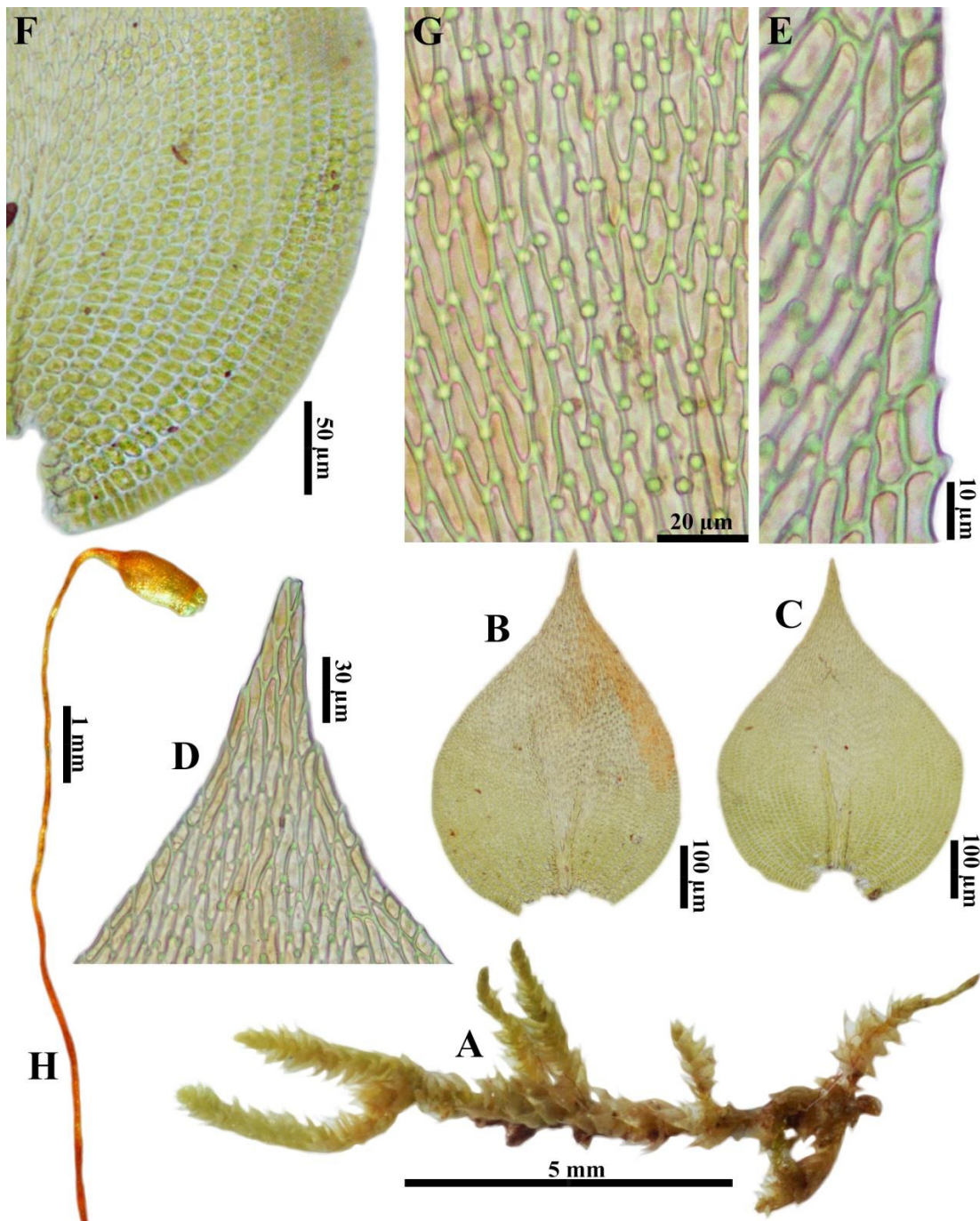


Figure 5.77 *Trachyphyllum inflexum* (Harv.) A. Gepp

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Alar region, G. Cells at median part of leaf, H. Seta with capsule. Based on *P. Ajintaiyasil* 056.

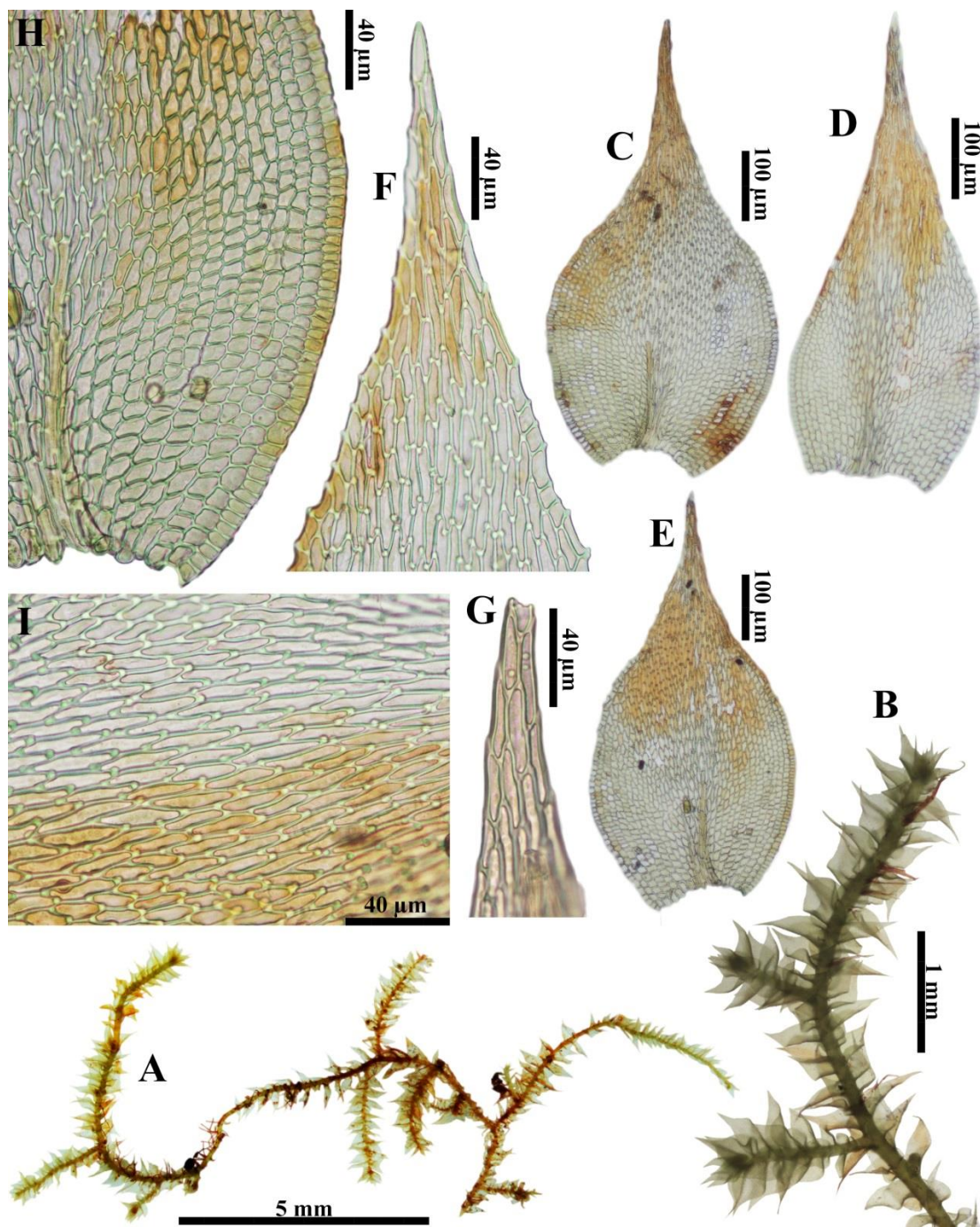


Figure 5.78 *Trachyphyllum touwianum* W.R. Buck

A. Gametophyte, B. Branch at main stem, C–E. Leaves, F. Leaf apex, G. Fragile leaf apex, H. Alar region, I. Cells at median part of leaf. Based on *P. Ajintaiyasil 056*.

23. PTEROBRYACEAE

Kindb., Eur. N. Amer. Bryin. 15. 1897; Gangulee, Mosses E. India 5: 1245. 1976; Noguchi, Ill. Moss Fl. Japan 3: 651. 1989; Yu & He, Moss Fl. China 5: 215. 2011.

Plants small to more commonly medium-sized or large and robust, forming turfs or mats. **Primary stems** creeping, leaves usually differentiated, often scale like. **Secondary stems** erect and frondose or dendroid, occasionally simple, or spreading and often pendulous, radiculose beneath; in cross section outer 2-5 or more rows of cells, central strand absent; pseudoparaphyilia filamentous. **Leaves** imbricate, complanate, equally spirally arranged or 5-ranked; broadly to narrowly ovate- to oblong-lanceolate, mostly symmetric, smooth or plicate; apex acute to acuminate, occasionally piliferous; base often auriculate; margins plane to recurved, entire or serrulate to sharply serrate; costae single to short and double or absent, when single 1/2 lamina length to percurrent; median cells oblong to linear, smooth to weakly unipapillose or prorulose, often porose; alar cells usually differentiated, subquadrate, porose. **Dioicous** or rarely autoicous. **Perichaetial leaves** usually differentiated. **Setae** short to somewhat elongate, smooth or roughened distally, **Capsules** immersed to exserted, erect to suberect, urn ovoid to ovoid-cylindrical, smooth; annulus absent to differentiated and revoluble. **Opercula** conic short to long rostrate. **Peristome** generally single, often reduced, rarely double; exostome teeth 16, often fused, often smooth, distally papillose; endostome rudimentary. **Calyptrae** cucullate or mitrate, often hairy. **Spores** mostly spherical. usually papillose or granulate, occasionally large and polymorphic.

PTEROBRYOPSIS

M. Fleisch., Hedwigia 45: 56. 1905; Gangulee, Mosses E. India 5: 1260. 1976; Yu & He, Moss Fl. China 5: 245. 2011.

Plants yellowish green, dark green to brown below, often fan. **Primary stems** prostrate, elongate, with brownish rhizoids. **Secondary stems** erect-ascending or pendulous, irregularly branched, sometimes with flagelliform branches, rarely branches attenuate at the apex. **Leaves** imbricate or loosely appressed when dry; usually ovate, strongly concave; shortly acuminate, rarely acute at the apex; margins entire or denticulate near the apex; costae single, extending to mid-leaf, rarely double or absent; leaf cells rhomboidal or linear, smooth; basal cells lax, reddish brown, porose; alar cells often differentiated, thick-walled. **Dioicous**. **Setae** short or elongate. **Capsules** exserted, oblong-ovoid. **Opercula** conic, shortly rostrate. **Peristome** double; exostome teeth lanceolate, trabeculate on the inner surface; endostome segments often reduced or absent, sometimes linear, as long as the teeth; basal membrane very low. **Calyptrae** mitrate or cucullate. **Spores** spherical, large, finely papillose.

Key to the species

- 1a. Secondary stems dendroid, pinnately branched.....2
 2a. Leaf apices cucullate.....3
 3a. Branch loosely irregularly or somewhat pinnately branched.....
1. *Pterobryopsis acuminata*
 3b. Branch densely pinnately branched.....2. *Pterobryopsis orientalis*
 2b. Leaf apices plane.....3. *Pterobryopsis scabriuscula*
 1b. Secondary stems usually simple, curved, pendulous.....4. *Pterobryopsis tumida*

1. *Pterobryopsis acuminata* (Hook.) M. Fleisch., *Hedwigia* 45: 59. 1905; Gangulee, *Mosses E. India* 5: 1273. 1976; Yu & He, *Moss Fl. China* 5: 245. 2011. — *Neckera acuminata* Hook., *Musci Exot.* 2: 15. 151. 1819. — *Pterobryopsis handelii* Broth., *Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1*, 133: 572. 1924. — *Garovaglia conchophylla* Renauld & Cardot, *Bull. Soc. Roy. Bot. Belgique* 41(1): 69. 1905. — *Pterobryopsis conchophylla* (Renauld & Cardot) Broth., *Nat. Pflanzenfam.* I(3): 803. 1906; Gangulee, *Mosses E. India* 5: 1263. 1976. — *Pterobryopsis morrisonicola* Nog., *Journal of the Hattori Botanical Laboratory* 2: 69. 16 f. 3–5. 1948. (**Figure 5.79**)

Plants yellowish green, brown below. **Primary stems** prostrate, slender. **Secondary stems** loosely irregularly or somewhat pinnately branched, branches rigid, flagelliform branchlets absent. **Leaves** dense, imbricate when dry, erect-spreading when moist; ovate-cordate, 6.0–7.0 × 1.8–2.0 mm, concave, plicate; cucullate and shortly acuminate at the apex; not decurrent at the base; margins plane, entire; costae single, ending at mid-leaf or below; leaf cells linear, thick-walled, porose at the leaf base, 34–59 × 3–6 μm; cells gradually becoming shorter toward basal margins; alar cells deeply reddish brown, subquadrate, 18–27 × 5–16 μm. **Dioicous**. **Perichaetial leaves** erect, narrowly ovate-lanceolate. **Setae** 4–5 mm long. **Capsules** erect, oblong-ovoid to cylindrical, 1.5–2 mm long. **Peristome** segments double; exostome smooth, trabeculate on the inner surface; endostome absent. **Opercula** not seen. **Calyptrae** not seen. **Spores** spherical, faintly papillose.

Additional illustration. – Gangulee (1976: 1273, Fig. 617); Wu, Crosby, & He (2011: 246, Pl. 348, 1–17).

Thailand. – NORTHERN: Chiang Mai (He, 1995).

Distribution. – China, India, Myanmar, Nepal, Taiwan, and Thailand (He, 1995).

Ecology. – On barks under shade of tree, at 1,178 m elevation.

Specimens examined. – *P. Ajintaiyasil* 444C, 444E (BCU).

2. *Pterobryopsis orientalis* (Müll. Hal.) M. Fleisch., *Hedwigia* 59: 217. 1917; Gangulee, *Mosses E. India* 5: 1272. 1976; Yu & He, *Moss Fl. China* 5: 249. 2011. — *Neckera orientalis* Müll. Hal., *Bot. Zeitung (Berlin)* 14: 437. 1856. (**Figure 5.80**)

Plants yellowish green or dark green. **Primary stems** creeping. **Secondary stems** erect or dendroid, pinnately branched, with slender branches; without flagelliform branches. **Leaves** densely imbricate, patent to spreading, oblong-ovate, 14.0–16.0 × 4.0–7.0 mm, concave, plicate; cucullate above, slenderly acuminate at the apex; not decurrent at the base; margins plane, weakly denticulate above; costae single, extending to 2/3 the leaf length; leaf cells linear, thick-walled, porose at the apex, 37–49 × 4–6 µm; alar cells reddish brown, rectangular, 13–34 × 7–13 µm. **Sporophytes** not seen.

Additional illustration. – Gangulee (1976: 1272, Fig. 616).

Thailand. – NORTHERN: Chiang Mai, Tak. CENTRAL: Nakhon Nayok. NORTH-EASTERN: Loei (He, 1995).

Distribution. – China, India, Indonesia, Myanmar, Nepal, Taiwan, Thailand, and Vietnam (He, 1995).

Ecology. – On barks under shade of tree, at 1,177 m elevation.

Specimens examined. – *P. Ajintaiyasil* 499 (BCU).

3. *Pterobryopsis scabriuscula* (Mitt.) M. Fleisch., *Hedwigia* 45: 61. 1905; Yu & He, *Moss Fl. China* 5: 250. 2011. — *Meteorium scabriusculum* Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1: 85. 1859. (**Figure 5.81**)

Plants yellowish green, glossy. **Primary stems** prostrate. **Secondary stems** pinnately branched, frondose, sometimes flattened, obtuse at branch tips; flagelliform branches absent. **Leaves** densely imbricate, erect-patent, cordate-ovate, 1.3–1.4 × 0.3–0.4 mm, concave; plicate above, not cucullate at the apex, shortly acuminate; margins plane, denticulate above; costae single, but often forked at the tips, sometimes double, extending to 2/3–3/4 the leaf length; leaf cells rhomboidal to linear, not particularly thick-walled, 52–82 × 4–7 µm, basal cells short-rectangular to quadrate, porose, 51–75 × 4–8 µm; alar cells enlarged, reddish brown, 28–62 × 5–12 µm. **Dioicous**. **Perichaetial leaves** erect, narrowly lanceolate. **Setae** 4–5 mm long. **Capsules** erect, shortly cylindrical, 2–3 mm long. **Peristome** double; exostome teeth linear-lanceolate, gray, smooth; endostome segments linear, as long as the teeth. **Opercula** not seen. **Calyptrae** not seen. **Spores** spherical, papillose.

Additional illustration. – Noguchi (1986: 153, Fig. 3A–H).

Thailand. – PENINSULAR: Satun (Noguchi, 1986).

Distribution. – China, India, Myanmar, Sri Lanka and Thailand (He, 1995; Noguchi, 1986).

Ecology. – On barks under shade of tree, at 1,178–1,247 m elevation.

Specimens examined. – *P. Ajintaiyasil* 442, 444F (BCU).

4. *Pterobryopsis tumida* (Dicks. ex Hook.) Dixon, *J. Bot.* 75: 122. 1937; Gangulee, *Mosses E. India* 5: 1269. 1976. — *Neckera tumida* Dicks. ex Hook., *Musci Exot.* 2:

158. 1819. — *Aerobryum willisii* M. Fleisch., Musci Buitenzorg 3: 846. 1908. — *Pterobryopsis maxwellii* Cardot & Dixon, J. Bot. 47: 160. 1909. (**Figure 5.82**)

Plants robust, yellowish green, brown below. **Primary stems** prostrate, slender. **Secondary stems** usually simple, curved, pendulous; obtuse at the apex; flagelliform branchlets absent. **Leaves** spreading when dry and moist; concave, ovate or ovate-cordate, $2.5\text{--}2.6 \times 1.1\text{--}1.3$ mm, distinctly plicate; acute to acuminate at the apex; less auriculate at the base; margins finely crenulate, somewhat plane; costae single, reaching near to leaf apex, ending $3/4$ the leaf length; leaf cells rhomboid, smooth, thick walled, $80\text{--}130 \times 5\text{--}6$ μm , basal cells irregularly rectangular with thickened, porose walled, $80\text{--}130 \times 5\text{--}6$ μm . **Sporophyte** not seen.

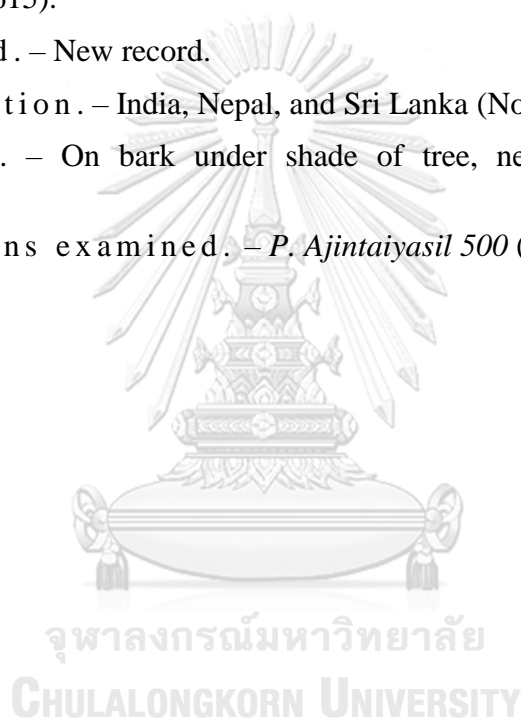
Additional illustration. — Noguchi (1975: 337, Fig. 2); Gangulee (1976: 1269, Fig. 615).

Thailand. — New record.

Distribution. — India, Nepal, and Sri Lanka (Noguchi, 1975).

Ecology. — On bark under shade of tree, near waterfall, at 1,177 m elevation.

Specimens examined. — *P. Ajintaiyasil* 500 (BCU).



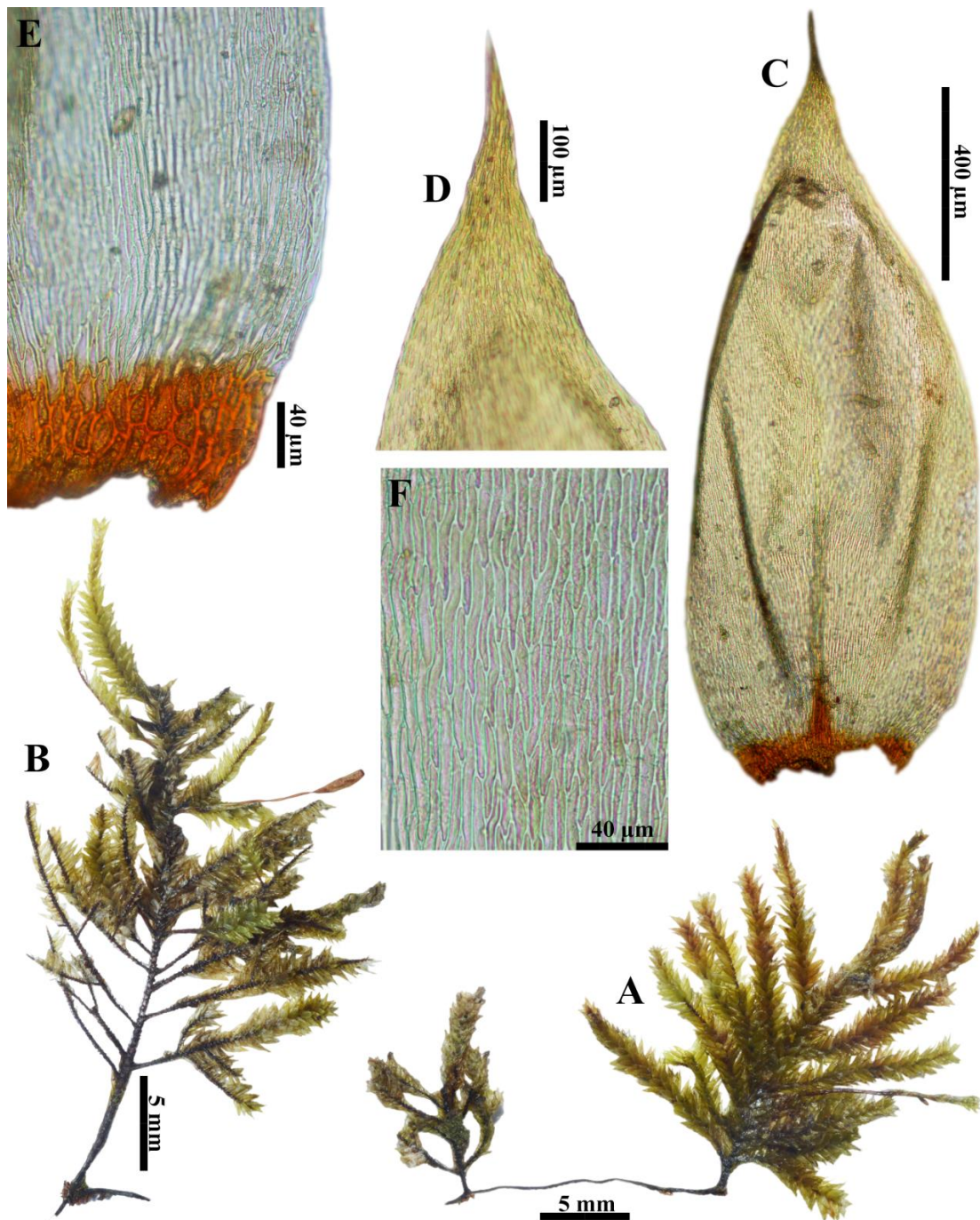


Figure 5.79 *Pterobryopsis acuminata* (Hook.) M. Fleisch.

A. Sterile gametophyte, B. Gametophyte with sporophyte, C. Leaf, D. Leaf apex, E. Leaf base with alar region, F. Cells at median part of leaf. Based on *P. Ajintaiyasil* 444C.

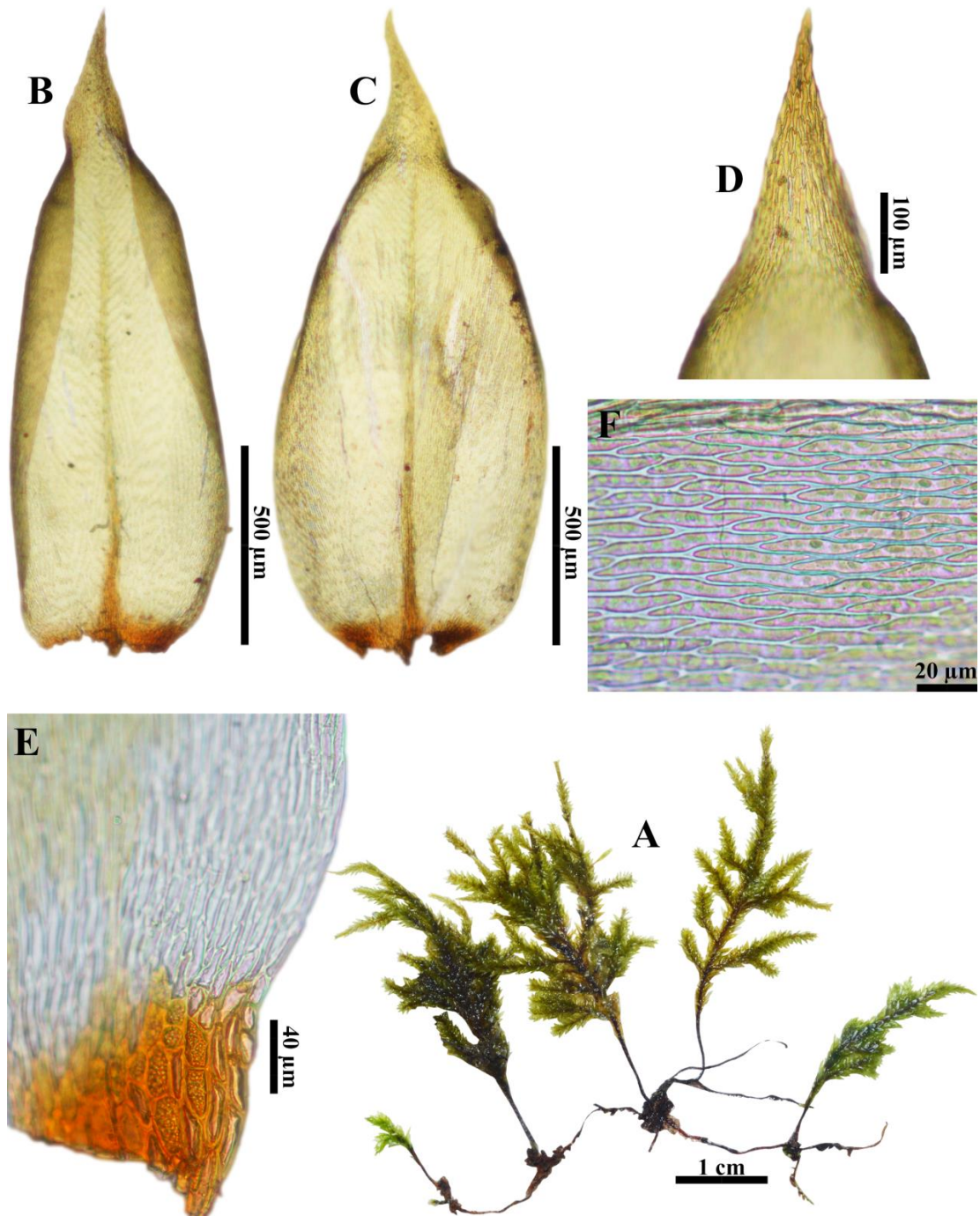


Figure 5. 80 *Pterobryopsis orientalis* (Müll. Hal.) M. Fleisch.

A. Gametophyte, B–C. Leaves, D. Leaf apex, E. Cells at median part of leaf, F. Leaf base with alar region. Based on *P. Ajintaiyasil* 499.

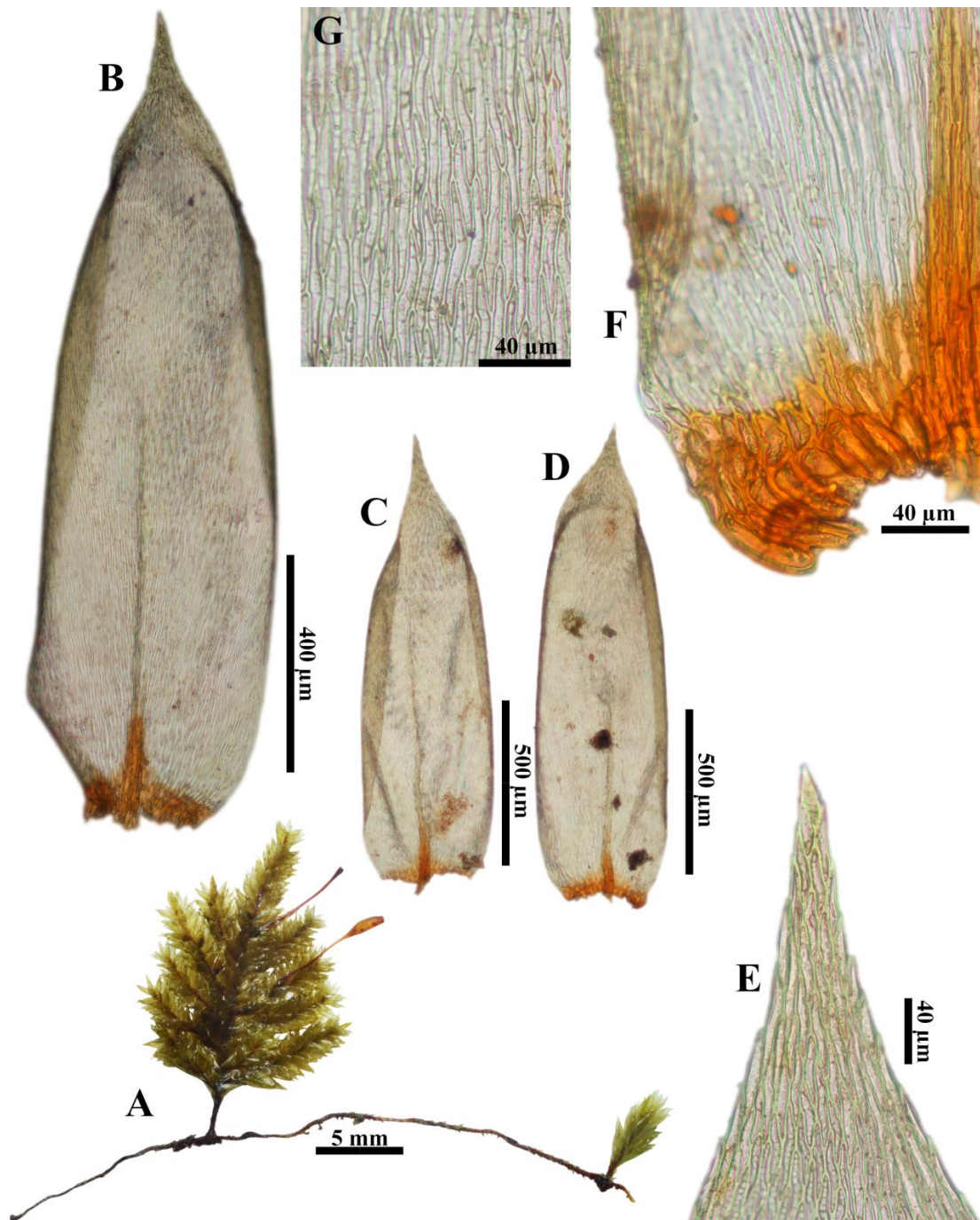


Figure 5.81 *Pterobryopsis scabriuscula* (Mitt.) M. Fleisch.

A. Gametophyte with sporophyte, B–D. Leaves, E. Leaf apex, F. Leaf base with alar region, G. Cells at median part of leaf. Based on *P. Ajintaiyasil* 442.

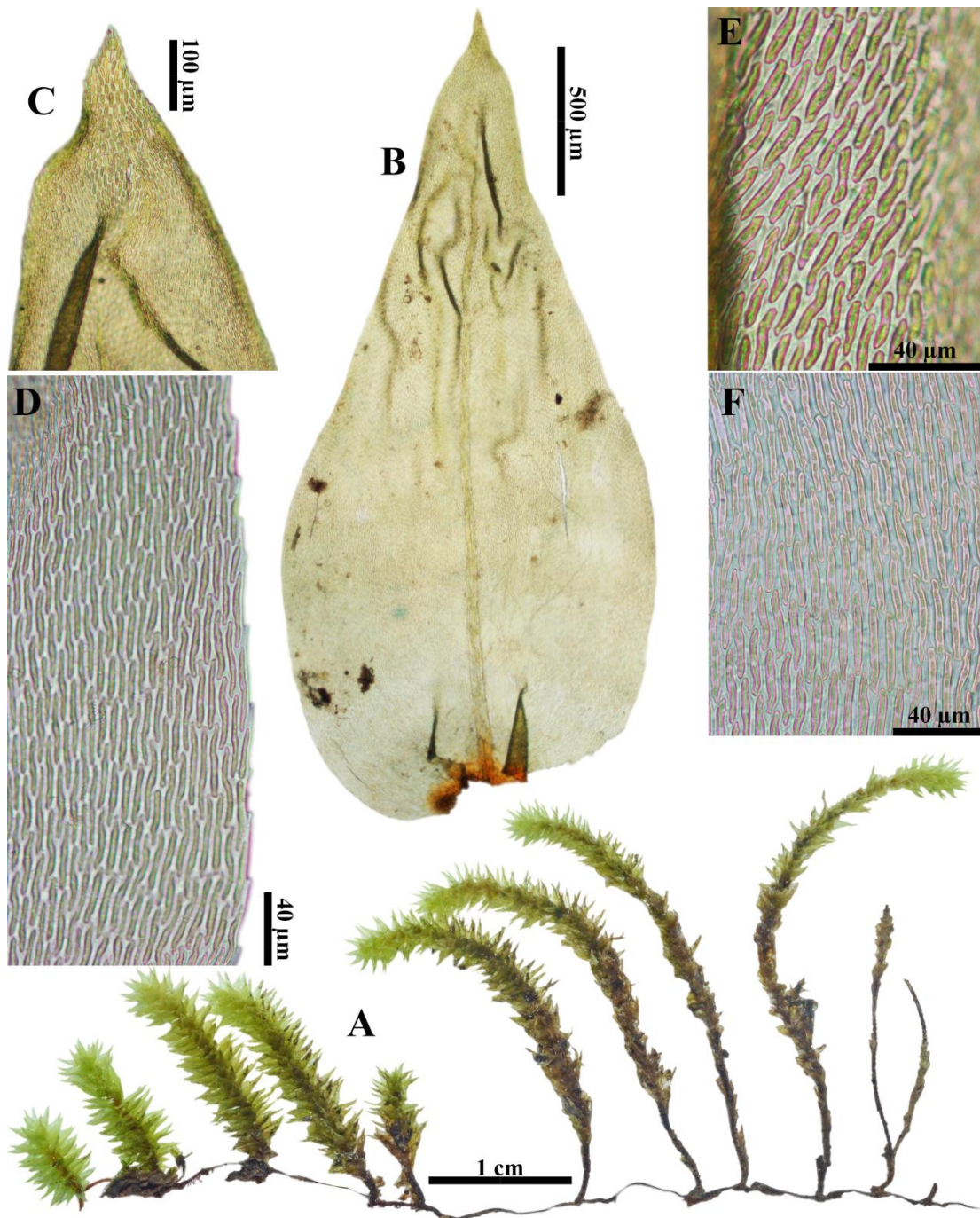


Figure 5.82 *Pterobryopsis tumida* (Dicks. ex Hook.) Dixon

A. Gametophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Cells at median part of leaf, F. Cells at leaf base. Based on *P. Ajintaiyasil* 500.

24. PYLAISIADELPHACEAE

Goffinet & W.R. Buck, Monogr. Syst. Bot. Missouri Bot. Gard. 98: 238. 2004.

Plants slender to robust, glossy, forming compact yellowish or green mats. **Stems** creeping, pale to orange-red, elongate, pinnately branched, in cross section with an outer sclerodermis; central strand usually absent; rhizoids smooth, papillose, red; pseudoparaphyllia filamentous or absent. **Leaves** appressed to erect-spreading or complanate; ovate to lanceolate, usually not falcate; apex acute or long-acuminate; costae short and double or none; cells mostly linear, mostly smooth, sometimes papillose; alar cells thin to thick-walled, with a few non-inflated quadrate cells, or basal alars well differentiated and inflated. **Autoicous** or, rarely, dioicous. **Perigonia** on branches. **Perichaetia** on stems or at the base of branches; inner perichaetial leaves often long-acuminate. **Setae** long-exserted. **Capsules** suberect to inclined; exothecial cells non-collenchymatous. **Opercula** often straight-rostrate. **Peristome** double; exostome of 8 or 16 lanceolate papillose teeth; endostome segments 8 or 16, papillose, the same length as the exostome teeth. **Spores** small, thin-walled. **Calyptrae** cucullate, smooth.

Key to the genera

- 1a. Pseudoparaphyllia filamentous; brood bodies present.....1. *Isopterygium*
 1b. Pseudoparaphyllia foliose; brood bodies absent.....2. *Taxiphyllum*

1. ISOPTERYGIUM

Mitt., J. Linn. Soc., Bot. 12: 21, 497. 1869; Gangulee, Mosses E. India 8: 1948. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1049. 1994; Man-xiang & He, Moss Fl. China 8: 204. 2005.

Plants pale green or yellowish green, rarely silver-white, glossy, forming flat mats, small to medium-sized. **Stems** prostrate, radiculose at base, irregularly branched; in cross section central strand somewhat developed; pseudoparaphyllia filamentous. **Leaves** symmetric, lateral leaves more or less asymmetric; oblong-ovate, oblong- or ovate-lanceolate, not decurrent; acuminate or suddenly acute; margins plane, serrulate above or entire; costae indistinct, very short or absent; median leaf cells linear, thin-walled, lower cells shorter; alar cells not differentiated. **Autoicous** or dioicous. **Perichaetial** leaves oblong-lanceolate, straight. **Setae** erect, smooth. **Capsules** suberect to horizontal, oblong-ovoid, often with long neck. **Opercula** conic, shortly rostrate. **Peristome** 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 1–2(–3). **Calyptrae** cucullate, smooth. **Spores** small, smooth or minutely papillose. **Asexual reproduction** by brood bodies.

Key to the species

- 1a. Plants often whitish, leaves ovate to ovate-oblong, narrower acuminate.....
1. *Isopterygium albescens* var. *smallii*
- 1b. Plants not whitish, leaves triangularly lanceolate, acuminate.....
2. *Isopterygium lignicola*

1. *Isopterygium albescens* (Hook.) A. Jaeger var. ***smallii*** (Sull. & Lesq.) Z. Iwats., J. Hattori Bot. Lab. 29: 62. 1966; Gangulee, Mosses E. India 8: 1960. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1052. 1994. — *Hypnum smallii* Sull. & Lesq., Proc. Amer. Acad. Arts 4: 281. 1859. — *Isopterygium subalbescens* Broth. Hedwigia 38: 231. 1899. (**Figure 5.83**)

Plants pale green, often silver-white, glossy, forming flat mats. **Stems** flattened; pseudoparaphyllia filamentous. **Leaves** rounded ovate or ovate-lanceolate, 0.4–0.7 × 0.1–0.2 mm; narrower acuminate, ending with filiform apices, concave; margins entire below, scarcely serrulate above; costae double, short or indistinct; upper and median leaf cells linear, thick-walled, 54–112 × 3–9 μm, basal cells shorter and broader, thick-walled; alar cells not distinctly differentiated, with a few non-inflated quadrate cells, 1–3 cells, 19–43 × 8–13 μm. **Sporohyte** not seen. **Asexual reproduction** by brood bodies, brood bodies often present, usually in clusters in leaf axils, filiform, papillose, simple or branched.

Additional illustration. – Gangulee (1980: 1961, Fig. 1008).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTHEN: Loei. PENINSULAR: Satun (He, 1995).

Distribution. – India, Indonesia, Japan, Myanmar, Philippines, Singapore, Thailand, and Vietnam (Gangulee, 1980; He, 1995).

Ecology. – On barks under shade of tree, at 966 m elevation.

Specimens examined. – *P. Ajintaiyasil* 465 (BCU).

2. *Isopterygium lignicola* (Mitt.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 432. 1878; Gangulee, Mosses E. India 8: 1964. 1980. — *Hypnum lignicola* Mitt., Hooker's J. Bot. Kew Gard. Misc. 8: 355. 1856. (**Figure 5.84**)

Plants pale green or yellowish green, forming wefts. **Stems** densely and regularly branched; pseudoparaphyllia filamentous. **Leaves** dense, complanate, triangularly lanceolate, 1–1.1 × 0.2–0.3 mm; gradually acuminate; margins plane; costae short and indistinct; median leaf cells linear, thin-walled, 82–135 × 4–6 μm, apical cells broader, apices formed by uniseriate or biseriate cells, basal cells shortly rectangular or subquadrate; alar cells indistinct, with a few non-inflated quadrate cells, 1–3 cells, 16–22 × 7–11 μm. **Autoicous.** **Perichaetial** leaves sheathing at base, gradually acuminate. **Setae** 0.9–1.2 mm long. **Capsules** inclined, shortly cylindrical, 1.0–1.3 mm long, with a neck. **Opercula** conic, bluntly and shortly rostrate. **Peristome** 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 1–2(–3). **Spores** 9–12 μm in diameter.

Additional illustration. – Gangulee (1980: 1964, Fig. 1011).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTHEN: Loei. CENTRAL: Nakhon Nayok (He, 1995).

Distribution. – India, Myanmar, Sikkim, Sri Lanka, and Vietnam (He, 1995).

Ecology. – On rocks or twig under shade of tree, near waterfall, at 1,233–1,266 m elevation.

Specimens examined. – *P. Ajintaiyasil* 209A, 350 (BCU).

2. TAXITHELIUM

Spruce ex Mitt., J. Linn. Soc., Bot. 12: 21. 1869; Gangulee, Mosses E. India 8: 1918. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1086. 1994; Man-xiang & He, Moss Fl. China 8: 241. 2005.

Plants green, yellow or grayish, not glossy or slightly glossy, in interwoven mats, slender or somewhat robust. **Stems** elongate, prostrate, with loose rhizoids, often regularly branched; branches short, complanate; slightly blunt or attenuate at apex; pseudoparaphyllia foliose. **Leaves** appressed, slightly concave, ventral and dorsal leaves smaller, lateral leaves larger, slightly asymmetric; rounded ovate or oblong-ovate; shortly acuminate, or ovate-lanceolate, shortly or long piliform at apex; margins serrulate, sometimes serrate above, rarely entire; costae absent; leaf cells narrowly rhomboidal, multipapillose, or prorate, rarely nearly smooth; basal cells shorter, loosely arranged; alar cells clearly differentiated. **Autoicous** or dioicous. **Perichaetial** leaves erect, ovate or ovate-lanceolate, acute or acuminate at apex; margins weakly serrulate. **Setae** slender, elongate, mostly smooth. **Capsules** ovoid, slightly inclined, arcuate, apophysis short, constricted below the mouth. **Opercula** conic, slightly acute or obtuse at tips. **Peristome** double; exostome teeth fusing at base, lanceolate above, yellowish brown, cross-striate below, hyaline and papillose above on outer surface, trabeculate on inner surface; endostome segments broadly lanceolate, papillose, keeled, perforate along the median line; basal membrane high; cilia often 1, rarely 2, usually shorter than segments. **Spores** irregularly spherical, brownish, smooth.

Taxithelium nepalense (Schwägr.) Broth., Monsunia 1: 51. 1899; Gangulee, Mosses E. India 8: 1920. 1980. — *Hypnum nepalense* Schwägr., Sp. Musc. Frond., Suppl. 1(2): 226. 1828. — *Hypnum turgidellum* Müll. Hal., Bot. Jahrb. Syst. 5: 87. 1883. — *Taxithelium trachaelophyllum* Dixon, Bull. Torrey Bot. Club 51: 243. f. 3: 17. 1924. (**Figure 5.85**)

Plants yellowish green or green, not glossy or slightly glossy, in dense mats. **Stems** prostrate, elongate, irregularly branched with short and long branches. **Leaves** densely arranged, erect-spreading, strongly concave, broadly ovate, 0.6–1.0 \times 0.3–0.5

mm; acute at apex; margins plane, slightly crenulate below, crenulate near apex; costae absent; leaf cells fusiform, $35\text{--}51 \times 4\text{--}6 \mu\text{m}$, clearly multipapillose in one row, basal cells similar to the upper cells, but with larger papillae; alar cells smooth, rectangular, not inflated, $12\text{--}29 \times 7\text{--}17 \mu\text{m}$. **Perichaetial** leaves long, narrow, erect; leaf cells fusiform, basal cells rectangular. **Setae** erect, 1.2–1.7 cm long, smooth. **Capsules** inclined to horizontal, slightly curved, constricted below mouth when dry; ovoid, $1.0\text{--}1.28 \times 0.4\text{--}0.5 \text{ mm}$. **Opercula** conic, slenderly rostrate. **Peristome** double; hypnoid; exostome teeth 250–330 μm long; basal membrane high; cilium 1. **Calyptrae** not seen. **Spores** 16–18 μm in diameter.

Additional illustration. – Bartram (1939: Pl. 26, Fig. 445); Gangulee (1980: 1921, Fig. 983).

Thailand. – **NORTHERN:** Chiang Mai, Tak, Phitsanulok, Nakhon Sawan. **EASTERN:** Nakhon Ratchasima. **CENTRAL:** Bangkok. **SOUTH-EASTERN:** Chanthaburi, Trat. **PENINSULA:** Chumphon, Ranong, Surat Thani, Phuket, Trang, Satun, Pattani (He, 1995).

Distribution. – Australia, Bangladesh, Brunei, China, India, Indonesia, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, and Vietnam (He, 1995; Pollawatn, 2008).

Ecology. – On rocks under shade of tree, near waterfall, at 446 m elevation.

Specimens examined. – *P. Ajintaiyasil* 434 (BCU).

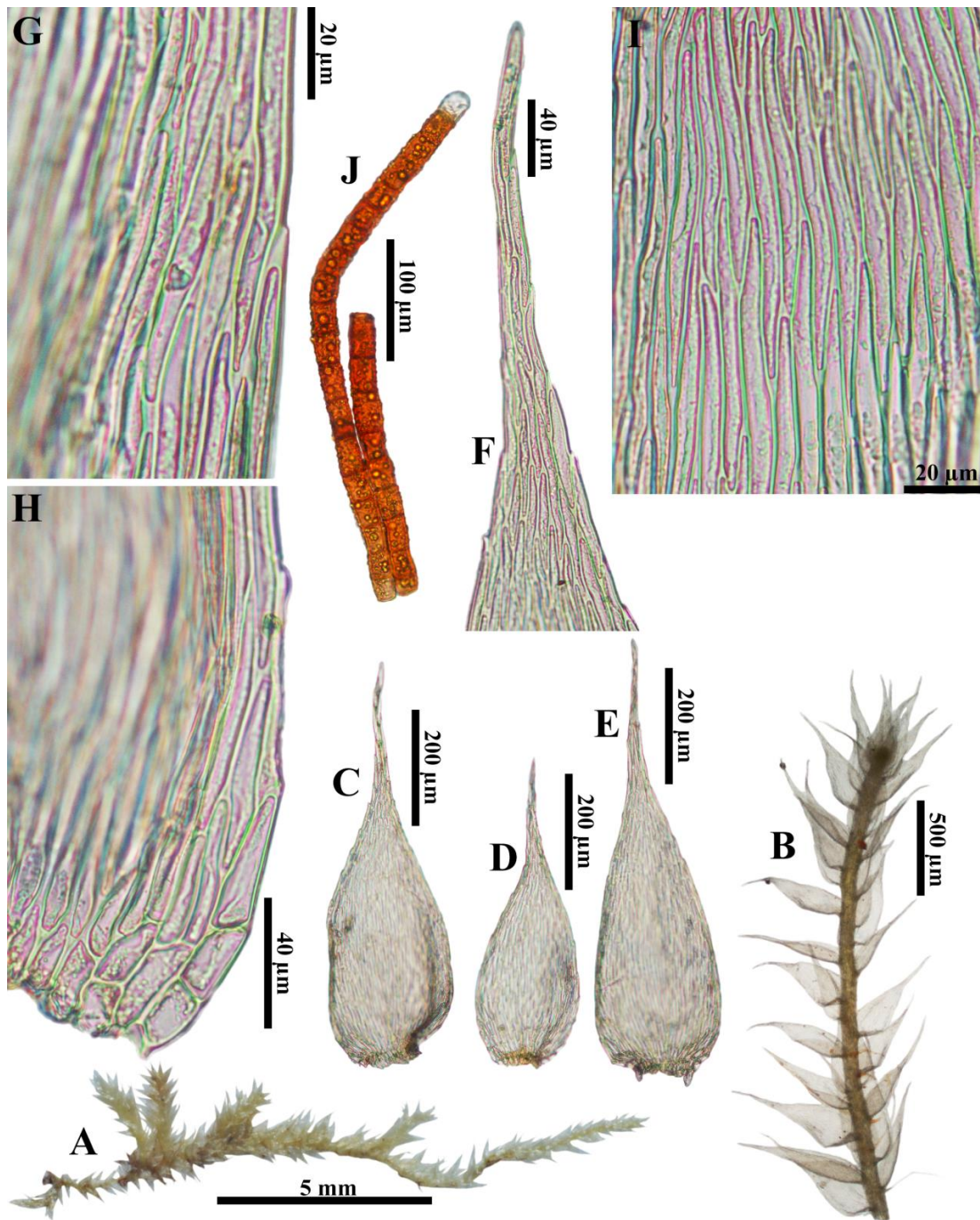


Figure 5.83 *Isopterygium albescens* (Hook.) A. Jaeger var. *smallii* (Sull. & Lesq.) Z. Iwats.

A. Gametophyte, B. Branch on main stem, C–E. Leaves, F. Leaf apex, G. Leaf margin, H. Leaf base with alar region, I. Cells at median part of leaf, J. Gemma. Based on *P. Ajintaiyasil* 465.

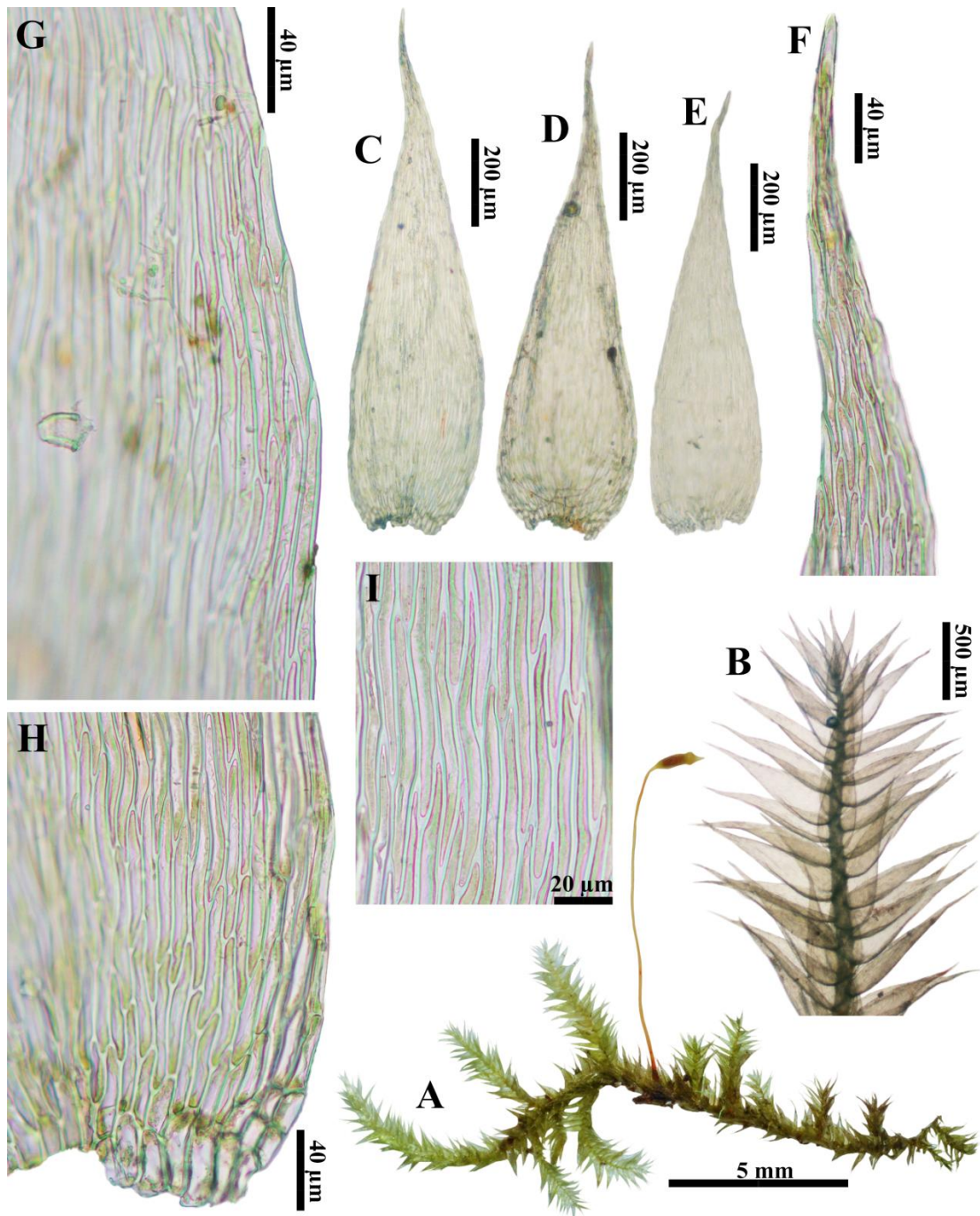


Figure 5. 84 *Isopterygium lignicola* (Mitt.) A. Jaeger

A. Gametophyte with sporophyte, B. Branch on main stem, C–E. Leaves, F. Leaf apex, G. Leaf margin, H. Leaf base with alar region, I. Cells at median part of leaf. Based on *P. Ajintaiyasil* 209A.

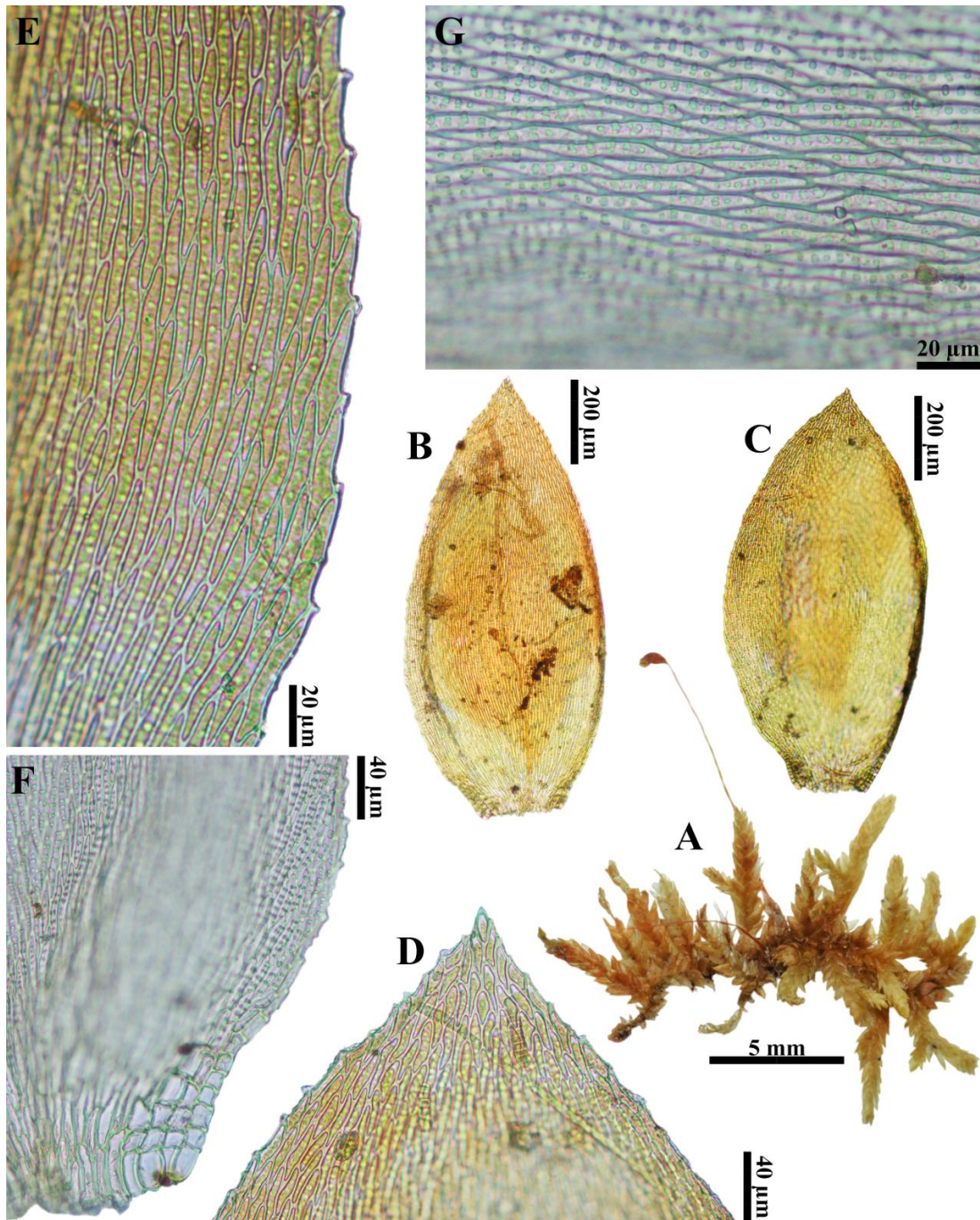


Figure 5. 85 *Taxithelium nepalense* (Schwägr.) Broth.

A. Gametophyte with sporophyte, B–C. Leaves, D. leaf apex, E. leaf margin, F. Leaf base with alar region, G. Cells at median part of leaf. Based on P. Ajintaiyasil 434.

25. RACOPILACEAE

Kindb., Bot. Centralbl. 76(3): 85. 1898; Gangulee, Mosses E. India 5: 1197. 1976; Noguchi, Ill. Moss Fl. Japan 3: 543. 1989; Mei-zhi, Moss Fl. China 5: 118. 2011.

Plants green, dark green, yellowish green or brown, often with dense rhizoids on the ventral surface, in creeping mats. **Stems** irregularly pinnately or irregularly branched, leaves dimorphic, with two rows of ventral leaves, larger, on both sides of stems and two rows of dorsal leaves, smaller, on middle of stems, appearing to be in one row. **Ventral leaves** twisted or curled when dry, spreading when moist; oblong-ovate, asymmetric; margins entire below, often serrulate above; costae single, strong, often long excurrent, ending in long awns, sometimes nearly as long as the leaf length; cells subquadrate, hexagonal or irregular, usually elongate toward the base, smooth or unipapillose. **Dorsal leaves** oblong-ovate, triangular- or cordate-lanceolate, almost symmetric; costae long excurrent, ending in long awns, sometimes dentate. **Dioicous**, rarely autoicous. **Perichaetia** lateral, leaves ovate at the base, abruptly or gradually acuminate at the apex; costae ending in long awns. **Setae** elongate. **Capsules** erect, inclined or horizontal, oblong-ovoid or cylindrical, constricted at the neck. **Opercula** long rostrate; annuli deciduous. **Peristome** double; exostome teeth cross-striolate at the base, papillose above; endostome segments usually as long as the teeth, perforate; basal membrane high; cilia 2–3, rudimentary or absent. **Calyptrae** cucullate, rarely mitrate. **Spores** spherical, papillose.

RACOPILUM

P. Beauv., Prodr. Aethéogam. 36–37, 87. 1805; Gangulee, Mosses E. India 5: 1198. 1976; Noguchi, Ill. Moss Fl. Japan 3: 543. 1989; Mei-zhi, Moss Fl. China 5: 118. 2011.

Plants mostly dark green, forming dense mats. **Stems** creeping and spreading, irregularly to regularly pinnately branched, often densely tomentose; in cross section outer 2-3 rows of cells, central strand present; rhizoids red, smooth or appearing lightly papillose, leaves dimorphic. **Ventral leaves** ovate- to oblong-lanceolate; apex acute to broadly acuminate; margins plane, serrate distally; costae single, short excurrent; median cells irregularly isodiametric, hexagonal or rhomboidal, thick-walled, smooth to weakly papillose. **Dorsal leaves** small, narrowly triangular; apex narrowly acuminate; margins distally serrate; costae single, long excurrent. **Monoicous** or dioicous. **Perichaetia** lateral, leaves ovate-long acuminate. **Setae** elongate, smooth. **Capsules** often curved, urn cylindrical, smooth to furrowed, neck short. **Opercula** short or long rostrate. **Peristome** double, exostome striate below, papillose distally, endostome basal membrane short to high, cilia 2-4, nodose. **Calyptrae** cucullate, sparsely hairy. **Spores** spherical, lightly papillose.

Key to the species

- 1a. Shape and size of leaf cells irregular; capsules inclined to horizontal, curved.....
1. *Racopilum cuspidigerum*

1b. Shape and size of leaf cells rather regular; capsules erect, not curved.....
2. *Racopilum orthocarpum*

1. *Racopilum cuspidigerum* (Schwägr.) Ångström, Öfvers. Förh. Kongl. Svenska Vetensk.-Akad. 29(4): 20. 1872; Gangulee, Mosses E. India 5: 1200. 1976; Mei-zhi, Moss Fl. China 5: 119. 2011. — *Hypnum cuspidigerum* Schwägr., Voy. Uranie 229. 1828. — *Racopilum amboinense* Broth., Philipp. J. Sci. 12: 79. 1917. (**Figure 5.86**)

Plants pale yellowish green to brown, with dense brownish rhizoids, in mats. **Stems** usually irregularly or irregularly pinnately branched, leaves dimorphic. **Ventral leaves** twisted when dry, spreading when moist; mostly oblong-ovate, 1.3–1.5 × 0.5–0.6 mm; margins serrulate or dentate near the apex; costae single, strong, often long excurrent; cells irregular in shape, subquadrate, hexagonal, 4–15 × 5–15 µm, smooth, sometimes basal cells elongate, lax. **Dorsal leaves** smaller, mostly cordate- or triangular-lanceolate, 0.7–1.6 × 0.3–0.5 mm; margins sometimes serrulate above; costae long-excurrent, ending in long awns; cells similar ventral leaf. **Diocious**, rarely autoicous. **Perichaetia** lateral, leaves ovate at the base, abruptly or gradually acuminate; costae long excurrent. **Setae** reddish brown, 1.5–2.0 cm long. **Capsules** oblong-ovoid to cylindrical, 1.5–3.5 mm long, often inclined to horizontal, curved. **Peristome** double; exostome teeth lanceolate, cross-striolate at the base, papillose; endostome segments well developed, as long as the teeth, keeled, perforate; basal membrane high; cilia 2–3. **Calyptrae** not seen. **Spores** finely papillose.

Additional illustration. – Gangulee (1976: 1201, Fig. 583); Wu, Crosby, & He (2011: 120, Pl. 293).

Thailand. – NORTHERN: Chiang Mai, Lamphun, Tak, Phitsanulok. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Ratchaburi. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Chanthaburi (He, 1995).

Distribution. – Australia, Brunei, China, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, New Caledonia, Philippines, Sri Lanka, Thailand, Vietnam, United States (He, 1995).

Ecology. – On barks under shade of tree, at 1,218 m elevation.

Specimens examined. – *P. Ajintaiyasil 210* (BCU).

2. *Racopilum orthocarpum* Wilson ex Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 136. 1859; Gangulee, Mosses E. India 5: 1198. 1976; Mei-zhi, Moss Fl. China 5: 121. 2011. — *Racopilum siamense* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 34. 1932. (**Figure 5.87**)

Plants yellowish green, creeping, in large mats, often with dense, brownish rhizoids. **Stems** more or less pinnately branched, leaves dimorphic. **Ventral leaves** usually twisted when dry, spreading when moist; rather ovate, 1.5–1.6 × 0.6–0.7 mm; abruptly or gradually acute; upper margins often serrulate or dentate; costae single, strong, long excurrent, often ending in long awns; leaf cells subquadrate to hexagonal, smooth, 7–18 × 6–13 µm; basal cells elongate. **Dorsal leaves** smaller, mostly cordate-

lanceolate or triangular-lanceolate, 1.2–1.3 × 0.4–0.7 mm; costae long excurrent, ending in long awns; leaf cells similar ventral leaf. **Dioicous**. **Setae** reddish brown, 1.2–1.5 cm long. **Capsules** oblong-ovoid to cylindrical, 3–4 mm long, erect. **Peristome** double; endostome segments as long as the teeth, keeled, perforate; basal membrane high; cilia rudimentary or absent. **Calyptrae** cucullate, sometimes sparsely hairy at the base. **Spores** finely papillose.

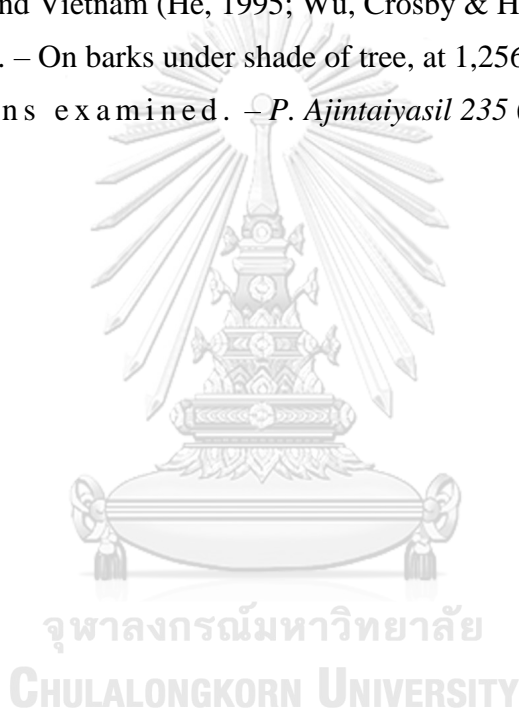
Additional illustration. – Gangulee (1976: 1199, Fig. 582); Wu, Crosby, & He (2011: 122, Pl. 294).

Thailand. – NORTHERN: Chiang Mai, Tak. NORTH-EASTERN: Loei. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Bhutan, China, India, Myanmar, Nepal, Sikkim, Sri Lanka, Thailand, and Vietnam (He, 1995; Wu, Crosby & He, 2011).

Ecology. – On barks under shade of tree, at 1,256 m elevation.

Specimens examined. – *P. Ajintaiyasil* 235 (BCU).



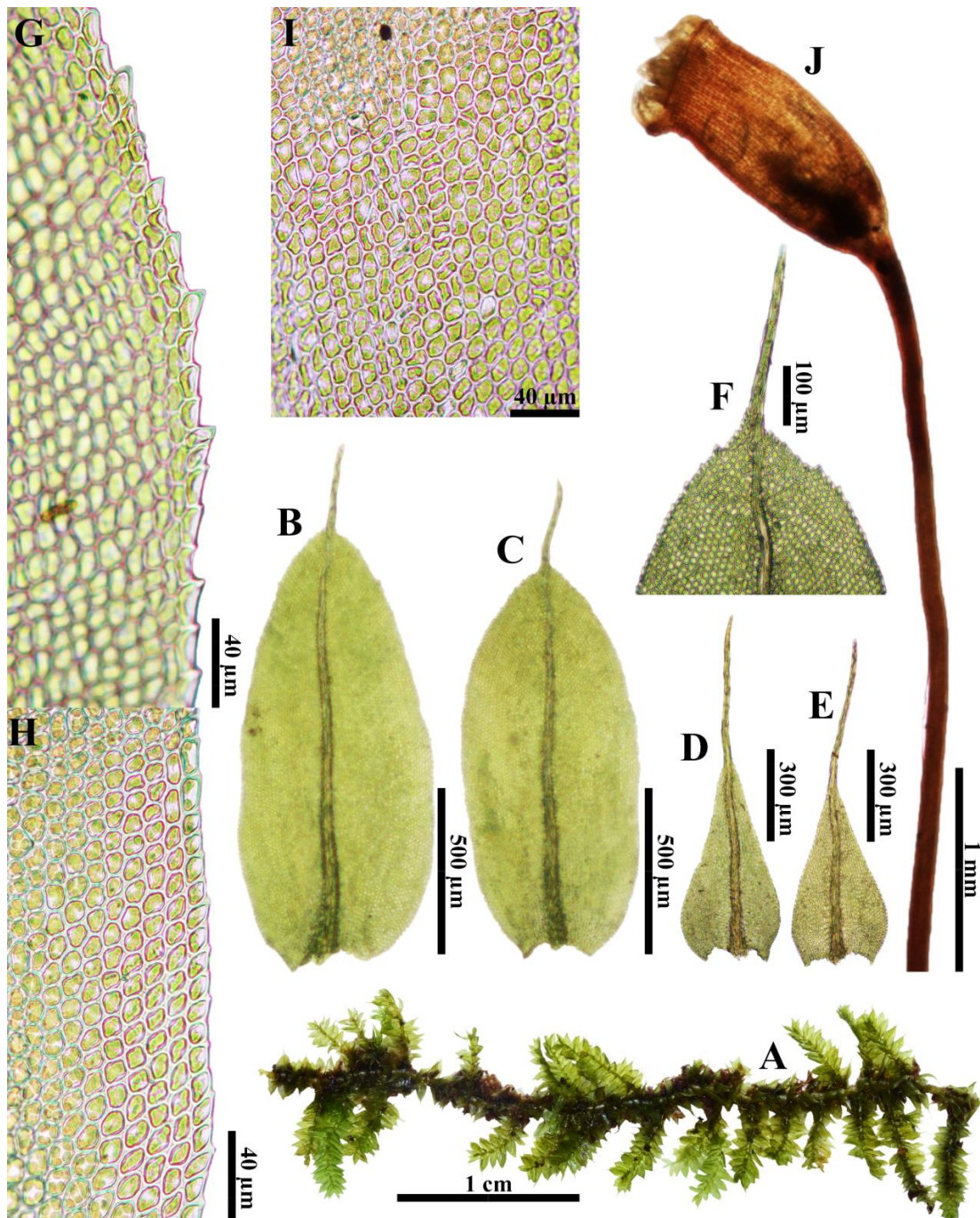


Figure 5.86 *Racopilum cuspidigerum* (Schwägr.) Ångström

A. Gametophyte, B–C. Ventral leaves, D–E. Dorsal leaves, F. Ventral leaf apex, G. Upper ventral leaf margin, H. Lower ventral leaf margin, I. Cells at median part of ventral leaf, J. Seta with capsule. Based on *P. Ajintaiyasil* 210.

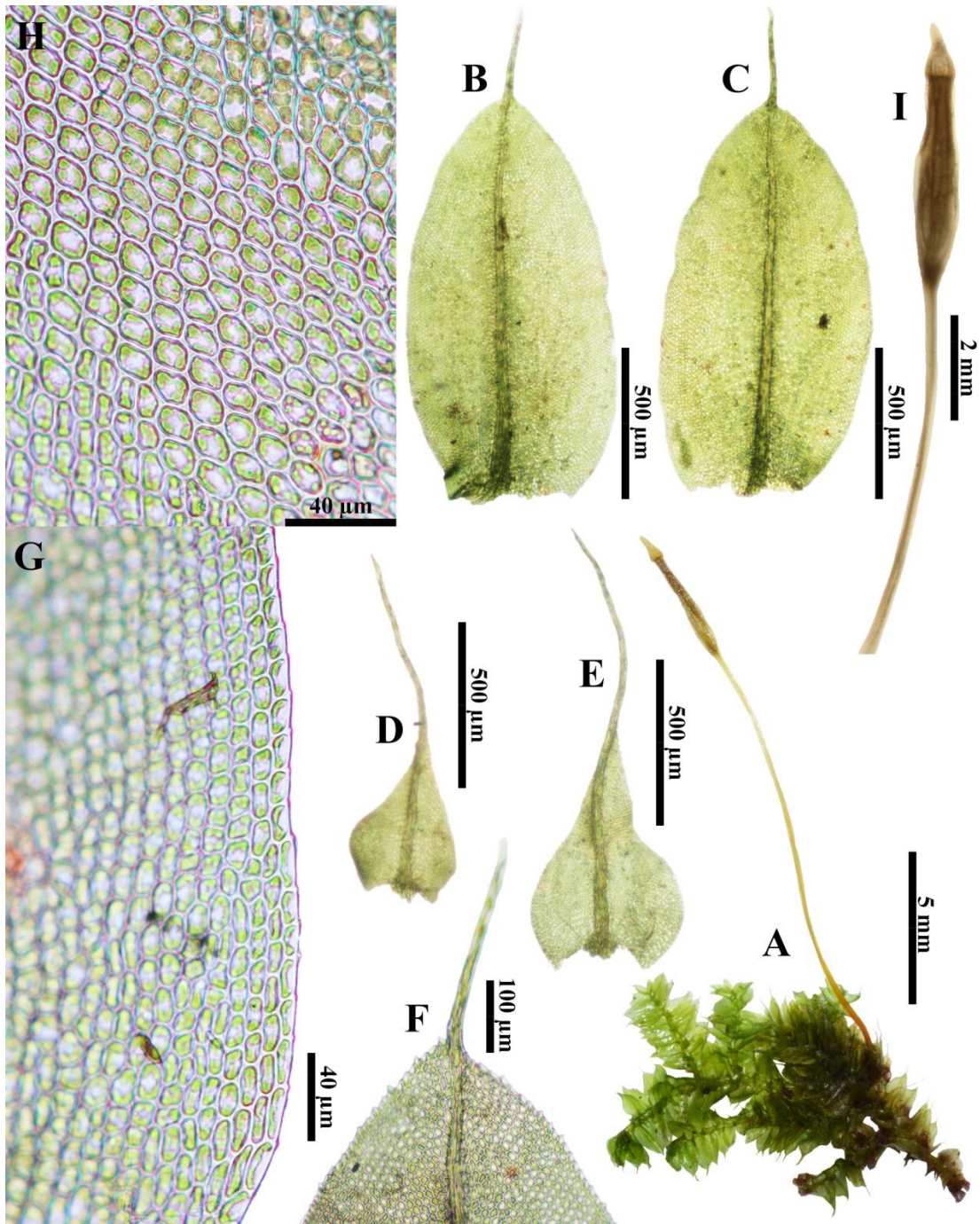


Figure 5. 87 *Racopilum orthocarpum* Wilson ex Mitt.

A. Gametophyte with sporophyte, B–C. Ventral leaves, D–E. Dorsal leaves, F. Ventral leaf apex, G. Cells at median part of ventral leaf, H. Lower ventral leaf margin, I. Seta with capsule. Based on *P. Ajintaiyasil* 235.

26. RHIZOGONIACEAE

Broth., Nat. Pflanzenfam. 219: 614. 1904; Eddy, Handb. Males. Mosses 3: 197. 1996; Gangulee, Mosses E. India 3: 1066. 1849; Xing-jiang & He, Moss Fl. China 4: 145. 2007.

Plants small to large, forming loose to dense. **Stem** mostly erect, few branched; central strand present. **Leaves** spirally arranged or appearing 2-ranked, distant to rather crowded, ovate to narrowly or broadly oblong-lanceolate, or linear-lanceolate; apex acute to acuminate; base decurrent or not; margins plane, marginal cells often differentiated, bi- or multistratose, often toothed; costae typically toothed above; cells mostly isodiametric and smooth, or bulging mammillose, walls firm and entire. **Autoicous** or dioicous. **Perigonia** bud-like, usually below perichaetia. **Perichaetia** lateral at base or at mid stem, or terminal, leaves small and differentiated. **Setae** elongate, wiry, smooth. **Capsules** generally smooth, erect to horizontal, urn short to rather long cylindrical, symmetric to asymmetric, curved or straight. **Opercula** conic or short rostrate, oblique. **Peristome** double; exostome teeth 16, cross-striate below, papillose above, or papillose throughout; endostome basal membrane moderately high, segments 16, cilia usually present or peristome absent. **Calyptra** cucullate, naked and smooth. **Spore** spherical, lightly papillose.

PYRRHOBRYUM

Mitt., J. Linn. Soc., Bot. 10: 174–175. 1868; Eddy, Handb. Males. Mosses 3: 204. 1996; Xing-jiang & He, Moss Fl. China 4: 145. 2007.

Plants medium to large. **Stem** erect or curved; in cross section central strand present; rhizoids dense tomentum below. **Leaves** linear-lanceolate to broadly lanceolate; apex acuminate; margins plane, bistratose and doubly-serrate to near base; costae strong, percurrent to excurrent, toothed on back, in cross section stereids above and below guide cell; cells uniform throughout except at base, isodiametric, thick-walled, smooth; juxtacostael basal cells often weakly differentiated, enlarged, short to rather long rectangular. **Synoiicous**. **Perichaetia** lateral, confined to base or lower part of stem; leaves oblong-lanceolate; marginal teeth single or double, upper cells elongate, oblong-rectangular, lower cells larger, lax, golden. **Setae** elongate, smooth. **Capsules** inclined to horizontal, urn cylindrical, usually curved; exothelial cell quadrate- to rectangular-rounded, moderately thick-walled, somewhat weakly collenchymatous at base. **Opercula** conic-rostrate, oblique. **Peristome** double; exostome teeth lanceolate, appearing cross-striate, distally papillose; endostome basal membrane rather high, segments keeled and perforate, cilia 2-3. **Calyptra** cucullate, smooth. **Spores** spherical, lightly papillose.

Pyrrhobryum spiniforme (Hedw.) Mitt., J. Linn. Soc., Bot. 10: 174. 1868; Eddy, Handb. Males. Mosses 3: 206. 207 f. 472. 1996; Xing-jiang & He, Moss Fl. China 4: 147. 2007. — *Hypnum spiniforme* Hedw., Sp. Musc. Frond.: 236. 1801. — *Rhizogonium spiniforme* (Hedw.) Bruch, Flora 29: 134. 1846; Gangulee, Mosses E.

India 3: 1068. f. 520. 1971. 1849. — *Mnium spiniforme* (Hedw.) Müll. Hal., Syn. Musc. Frond. 1: 175. 1848. — *Rhizogonium spiniferum* Brid. ex Hampe, Linnaea 22: 583 — *Rhizogonium pervilleanum* Besch., Ann. Sci. Nat., Bot., sér. 6, 10: 242. 1880. **(Figure 5.88)**

Plants yellowish green or dark green, stiff, 2.0–4.5 cm high. **Stems** simple, erect-flexuose, branched from base, dense rhizoids. **Leaves** crispate when dry, erect-spreading when moist; linear-lanceolate to linear, slender, 2.6–4.5 × 0.2–0.4 cm; margins differentiated, with 2–4 layers of thick-walled cells, double-toothed nearly throughout; leaf cells rounded-quadrate, rounded-hexagonal, thick-walled, smooth, 6–22 × 5–16 µm; costae shortly excurrent, dentate at back; in section costae with a band of guide cells and thick upper and lower stereid bands. **Synoicous**. **Perichaetia** bud-like on stem; outer leaves triangular-ovate to triangular-lanceolate, 2.3–3.2 × 0.6–0.7 cm; acute to acuminate; margin toothed by single teeth. **Setae** solitary, arising from the base of stems, slender, 3–5 cm long. **Capsules** inclined, oblong-ovoid to short-cylindrical, longitudinally plicate. **Opercula** rostrate. **Peristome** double; exostomal striate below, distally papillose; endostomal basal membrane high; cilia 2–3, well developed, nodulose. **Calyptrae** cucullate, smooth. **Spores** typical of the genus.

Additional illustration. — Eddy (1996: 207, Fig. 472A–K); Gangulee (1971: 1068, Fig. 520, as *Rhizogonium spiniforme*).

Thailand. — NORTHERN: Phitsanulok. CENTRAL: Nakhon Nayok. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. SOUTH-EASTERN: Chanthaburi, Trat. PENINSULAR: Surat Thani, Nakhon Si Thammarat, Satun.

Distribution. — Australia, Bioko, Brunei, Brazil, Cameroon, Caribbean, Celebes, China, Colombia, Comoros, Democratic Republic of the Congo, Equatorial Guinea, Gabon, India, Indonesia, Japan, Kampuchea, Kenya, Korea, Malaysia, Malawi, Mauritius, Mexico, Mozambique, Myanmar, Nepal, New Caledonia, New Guinea, New Zealand, Paraguay, Philippines, Reunion, Rwanda, Sao Tome, Seychelles, Sikkim, South Africa, Sri Lanka, Sumatra, Tahiti, Taiwan, Tania, Tanzania, Thailand, Uganda, Vietnam, and Zimbabwe (Gangulee, 1971; He, 1995; O'shea, 2006; Tan & Iwatsuki, 1991; Wu, Crosby & He, 2011).

Ecology. — On soils, rocks or tree trunks under shade of tree, at 1,248–1,255 m elevation.

Specimens examined. — *P. Ajintaiyasil 022, 026* (BCU).

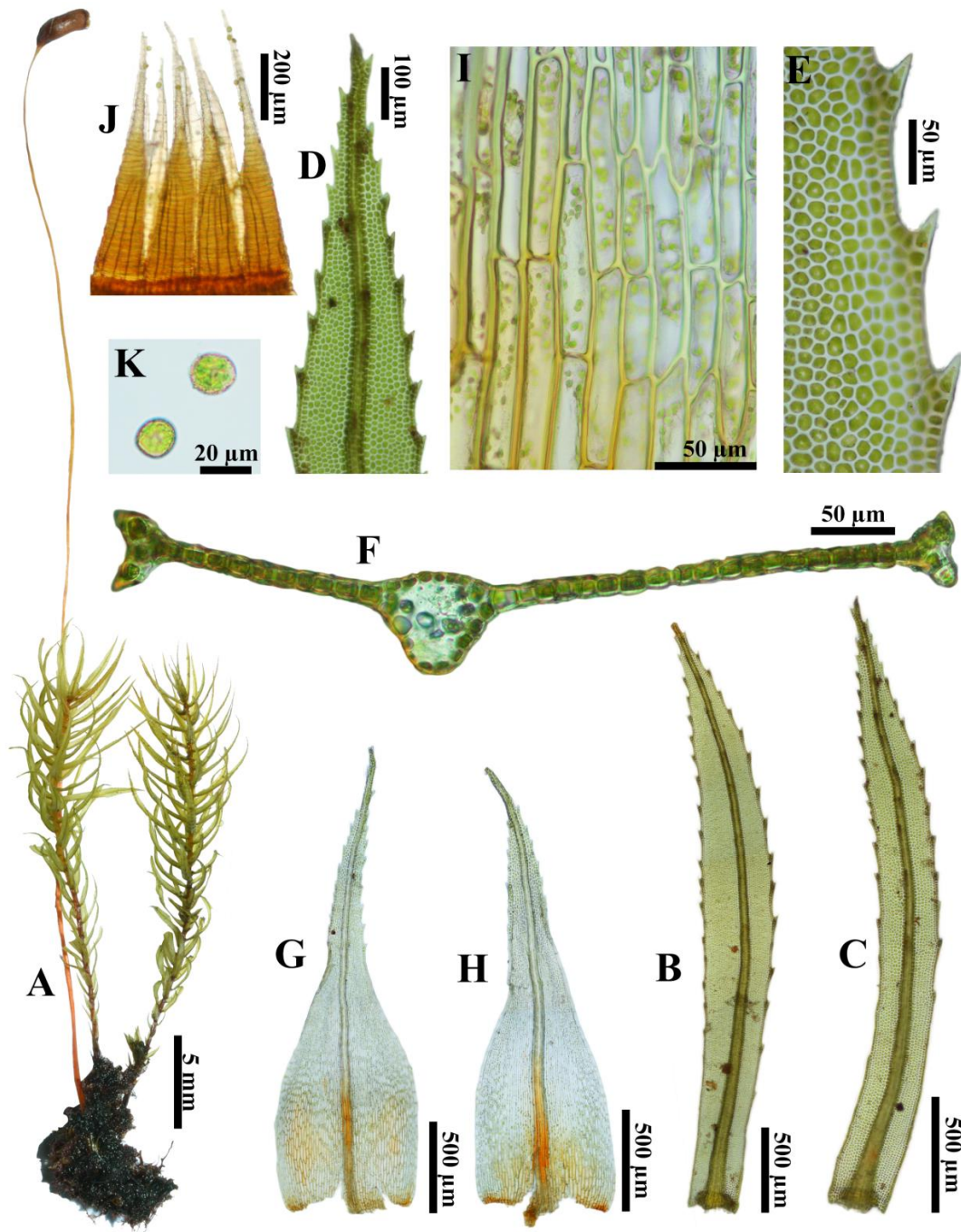


Figure 5.88 *Pyrrhobryum spiniforme* (Hedw.) Mitt.

A. Gametophytes with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Cross section of leaf, G–H. Perichaetial leaf, I. Cells at median part of perichaetial leaf, J. Part of peristome, K. Spores. Based on *P. Ajintaiyasil* 022, 026.

27. SEMATOPHYLLACEAE

Broth., Nat. Pflanzenfam. 1(3): 706. 1905; Gangulee, Mosses E. India 8: 1824. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1078. 1994; Yu, Peng-cheng & Tan, Moss Fl. China 8: 3. 2005.

Plants small to somewhat large, forming loose to dense mats or wefts, often glossy light to dark green or yellowish-green to golden. **Stems** short to long creeping or spreading to ascending, irregularly short or long branched, julaceous or homomalous, rarely complanate, radiculose. **Leaves** crowded, erect to erect-spreading, linear to broadly lanceolate, ovate, ovate-oblong; often falcate, apex narrowly to broadly acuminate or acute, rarely obtuse; base undifferentiated or slightly auriculate; margins plane to reflexed or recurved, entire to serrulate or serrate distally; costae short and double or none; cell mostly linear, smooth or papillose, papillae single or several in a row, walls firm; alar region well differentiated, cells usually inflated, oval to oblong-oval, thick-walled, often reddish-orange or golden. **Dioicous** or autoicous. **Perichaetia** lateral, leaves often differentiated, elongate. **Setae** elongate, smooth or distally papillose. **Capsules** exserted, inclined or occasionally erect, urn ovoid or short cylindrical, often slightly curved and asymmetric, often constricted below mouth when deoperculate; exothecial cells mostly collenchymatous. **Opercula** mostly obliquely rostrate. **Peristome** double, or reduced and often single (exostome present); exostome teeth 16, cross-striate below, distally papillose, trabeculate, usually with a zig-zag median line, occasionally furrowed; or exostome single and smooth or papillose; endostome basal membrane generally high, segments keeled, cilia 1-3. **Calyptrae** cucullate, smooth and naked. **Spores** spherical, smooth or lightly papillose.

Key to the genera

- 1a. Cells smooth.....2.
 2a. Exostome teeth non-striate.....2. *Chionostomum*
 2b. Exostome teeth striate.....3.
 3a. Leaves strongly concave, margins involute.....1. *Acroporium*
 3b. Leaves flat or slightly concave, margins plane.....3. *Sematophyllum*
 1b. Cells strongly to weakly unipapillose, papillae over cell lumen.....4. *Trichosteleum*

1. ACROPORIUM

Mitt., J. Linn. Soc., Bot. 10: 182. 1868; Gangulee, Mosses E. India 8: 1875. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1116. 1994; Yu, Peng-cheng & Tan, Moss Fl. China 8: 5. 2005.

Plants slender or robust, soft, rarely stiff, somewhat glossy in interwoven patches. **Stems** elongated, densely foliate, often densely and pinnately branched, erect or ascending; frequently cuspidate at tips; rhizoids few or absent. **Leaves** in several ranks, erect or erect-spreading, sometimes clearly secund, oblong-ovate or lanceolate,

concave; cordate at base; cells narrowly rhomboidal, mostly thick-walled, pitted, lumen narrower, smooth, rarely somewhat papillose in some cells; alar region consisting of one row of inflated, hyaline or yellowish cells, rarely deeply brown. **Dioicous**, rarely autoicous. **Perichaetial leaves** erect, sheathing at base, acute or acuminate above. **Setae** slender and elongate, usually mammillose above, rarely smooth. **Capsules** erect or inclined, ovoid or cylindrical, apophyses short; exothecial cells sometimes mammillose. **Opercula** conic, slenderly rostrate. **Peristome** double; exostome teeth lanceolate, bordered, outer surface cross-striate below, papillose above, inner surface clearly trabeculate; endostome segments as high as the teeth, keeled, yellowish; basal membrane high; cilia simple, short, sometimes reduced. **Spores** yellowish green, spherical, finely papillose.

Key to the species

- 1a. Leaf apex acuminate to subtubular.....2. *Acroporium laosianum*
 1b. Leaf apex acute.....1. *Acroporium brevipes*

1. *Acroporium brevipes* (Broth.) Broth., Nat. Pflanzenfam. (ed. 2) 11: 437. 1925; Gangulee, Mosses E. India 8: 1876. 1980. — *Sematophyllum brevipes* Broth., Philipp. J. Sci. 8: 95. 1913. (**Figure 5.89**)

Plants golden, glossy, forming loose wefts. **Stems** creeping or ascending branching regularly pinnately; branches erect, usually up to 1 cm long. **Leaves** dense, erecto-patent when moist, erect-squarrose cuspidate when dry; concave, ovate-lanceolate, 1.1–1.3 × 0.3–0.5 mm; apex acute, cuspidate; above margin denticulate, sometime revolute on margin near apex; ecostaete; cells linear to narrowly rhomboidal, 51–109 × 4–6 μm, wall irregularly thickened; with porose walls and rarely papillose cell tips in lower leaf, gradually shorter near extreme base; alar very conspicuous, tinted, with about 3–4 cells curved oblong, inflated, 33–42 × 20–32 μm. **Autoecious**. **Perichaetial leaves** narrow, erect. **Setae** slender, erect, 8–10 mm long. **Capsules** horizontal to nodding, ovate to cylindrical, 1–2 mm long. **Opercula** conic, slenderly rostrate. **Peristome** normal. **Calyptrae** not seen. **Spores** not seen.

Additional illustration. – Bartram (1939: Fig. 433); Gangulee (1980: 1877, Fig. 955).

Thailand. – NORTHERN: Phitsanulok. NORTH-EASTERN: Loei. SOUTH-EASTERN: Prachin Buri, Chanthaburi (Pollawatn, 2008).

Distribution. – Brunei, Indonesia, Malaysia, Philippines, Thailand, and Vietnam (Pollawatn, 2008).

Ecology. – On barks under shade of tree, near waterfall, at 1,231 m elevation.

Specimens examined. – *P. Ajintaiyasil 490* (BCU).

2. Acroporium laosianum (Broth. & Paris) Broth., Nat. Pflanzenfam. 11: 437. 1925. — *Stereodon planifrons* Broth. & Paris, Bulletin de l'Herbier Boissier, sér. 2, 2: 991. 1902. — *Sematophyllum laosianum* Broth. & Paris, Rev. Bryol. 35: 53. 1908. — *Glossadelphus planifrons* (Broth. & Paris) M. Fleisch., Musci Fl. Buitenzorg 4: 1357. 1923. (Figure 5.90)

Plants glossy green, yellowish-green or golden, usually forming wefts. **Stems** elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches suberect, rigid, spreading, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. **Leaves** in several ranks, mostly falcate leaves, narrowly ovate to ovate-lanceolate, 1.2–1.3 × 0.4–0.5 mm; recurved, apex acute to acuminate to subtubular; base usually auriculate; margin plane, entire slightly enrolled near apex; ecostaete; upper and median cells linear to oblong, 52–81 × 4–5 µm; basal cells shorter, smooth, often pitted near base; alar region consisting of one row of 3–4 inflated hyaline to yellowish brown cells, 52–82 × 20–34 µm. **Autoicous**. **Perichaetia** leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. **Setae** 0.8–1.0 cm long, slender and wiry, red, smooth. **Capsules** erect, ovoid to elongate, 0.8–1.0 × 0.4–0.5 mm. **Opercula** conic, long-rostrate. **Peristome** double normal. **Calyptrae** cucullate, smooth and naked. **Spores** yellowish green, spherical, 18–24 µm in diameter, finely papillose.

Additional illustration. – Unknown.

Thailand. – NORTHERN: Phitsanulok. NORTH-EASTERN: Loei. EASTERN: Chiyaphum. SOUTH-EASTERN: Prachin Buri (Pollawatn, 2008).

Distribution. – Indonesia, Laos, and Vietnam (Pollawatn, 2008).

Ecology. – On barks under shade of tree, near waterfall, at 1,231 m elevation.

Specimens examined. – *P. Ajintaiyasil 068* (BCU).

2. CHIONOSTOMUM

Müll. Hal., Linnaea 36: 21. 1869; Gangulee, Mosses E. India 8: 1830. 1980; Yu, Peng-cheng & Tan, Moss Fl. China 8: 21. 2005.

Plants pale green, yellowish green or yellowish brown, glossy, in wefts. **Stems** elongate, prostrate, with dense rhizoids at base; somewhat irregularly pinnately branched; branches erect, blunt at apex, short and unbranched, or elongate and remotely branched. **Leaves** dense, loosely appressed when dry, erect or erect-spreading when moist; sometimes slightly falcate, elongate-oblong, spatulately concave; shortly lanceolate at apex; leaf margins slightly recurved, entire; costae double, short or very weak; cells smooth, rhomboidal above, becoming longer and thinner below, basal cells shorter, pitted, golden yellowish; alar region consisting of one row of inflated, hyaline or yellowish brown cells with a few smaller and subquadrate cells above the inflated cells. **Autoicous**. **Perichaetial** leaves erect, lanceolate, margins recurved, smooth. **Setae** slender, elongate, reddish, smooth. **Capsules** erect or slightly suberect, elongated cylindrical. **Opercula** conic at base,

slender and long-rostrate; **Peristome** double; exostome teeth evidently bordered at margins, densely trabeculate on inner surface; endostome segments adhering to exostome teeth, linear, as long as the teeth, papillose; basal membrane low. **Calyptrae** cucullate, smooth. **Spores** small.

Chionostomum pinicola Tixier, Rev. Bryol. Lichénol. 43: 430. f. 13: 2. 1977. (Figure 5.91)

Plants greenish brown, forming wefts. **Stems** closely, irregularly branched; branches densely foliate. **Leaves** slightly secund, laxly erect when dry, more spreading when wet; oblong to lanceolate, 1.1–1.3 × 0.2–0.3 mm, strongly concave; acuminate apex; margin entire, slightly toothed and curled; costae double, very short or weak; cells narrowly elongate to linear, 38–60 × 5–7 µm, becoming narrowly rhomboidal near apex, thin-walled, smooth; alar region of a single basal row of much inflated, slightly enlarged, 26–54 × 20–26 µm, with a few quadrate to rectangular supra-alar cells, 17–33 × 17–23 µm. **Monoicous**. **Perichaetial** leaves narrowly lanceolate. **Setae** red, smooth, 7–8 mm long. **Capsules** inclined, cylindrical, 1.2–1.3 × 0.5–0.7 mm. **Opercula** long rostrate. **Peristome** double; exostome with 16 teeth, squat, trapezic at the base, slim at the top; end of the tooth finely granulous, with peaks thin, papillose, alternating with smooth parts; endostome finely granulous. **Spores** spherical.

Additional illustration. – not seen.

Thailand. – NORTHERN: Chiang Mai (Pollawatn, 2008).

Distribution. – Vietnam (Pollawatn, 2008).

Ecology. – On barks under shade of tree, at 1,248 m elevation.

Specimens examined. – *P. Ajintaiyasil 144* (BCU).

3. SEMATOPHYLLUM

Mitt., J. Linn. Soc., Bot. 8: 5. 1864; Gangulee, Mosses E. India 8: 1877. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1110. 1994; Yu, Peng-cheng & Tan, Moss Fl. China 8: 53. 2005.

Plants slender or robust, glossy, often in wefts or mats. **Stems** prostrate, irregularly or pinnately branched; rhizoids usually present. **Leaves** patent-spreading, sometimes slightly secund, ovate, oblong-ovate, or ovate-lanceolate, slightly concave; acute, acuminate or constricted into a filiform acumen, sometimes obtuse with short points; margin plane; costae weak or absent; cells narrowly rhomboidal, sometimes rhomboidal or oblong-oval, smooth; alar region clearly differentiated, consisting of elongate-inflated cells. **Autoicous**, rarely dioicous. **Perichaetial leaves** elongate, filiform at apex. **Setae** elongate, reddish, smooth. **Capsules** erect or horizontal, ovoid or oblong-ovoid. **Opercula** conic at base, very slenderly rostrate at apex. **Peristome** double; exostome teeth narrowly lanceolate, outer surface cross-striate, inner surface trabeculate; endostome segments as high as the exostome teeth, keeled along median

line, yellowish; basal membrane high; cilia 1–2, sometimes reduced. **Spores** irregularly globose, green or yellowish, smooth.

Sematophyllum humile (Mitt.) Broth., Nat. Pflanzenfam. 11: 431. 1925; Gangulee, Mosses E. India 8: 1885. 1980. — *Stereodon humilis* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 102. 1859. — *Rhaphidostegium humile* (Mitt.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876–77: 397. 1878. (**Figure 5.92**)

Plants yellow-green, glossy, in mats. **Stems** creeping; branches irregularly branched, but may be fasciculate. **Leaves** dense, imbricate, more spreading when wet, appressed when dry; highly concave, ovate-lanceolate, 1.1–1.3 × 0.2–0.3 mm; apex narrow acute; margin plane, smooth; ecostaete; cells narrowly rhomboidal, 42–87 × 4–6 μm, lower cells showing slightly papillose development of cell tips; alar differentiated by about three large, ovate-oblong, 44–66 × 15–33 μm, inflated cells at extreme angle and a few small irregular cells on top. **Autoicous**. **Perichaetial** leaves ovate-lanceolate, filiform at apex. **Setae** slender, 1.2–1.4 cm long, almost smooth. **Capsules** oblong-ovate, 1.0–1.3 mm long. **Opercula** conic at base, very slenderly rostrate at apex. **Peristome** double; exostome teeth 16 incurved, lanceolate; endostome segment yellow, densely papillose, not perforated; cilia absent or single. **Spores** globose, green or yellowish, papillose.

Additional illustration. – Gangulee (1980: 1885, Fig. 960).

Thailand. – NORTH-EASTERN. Phetchabun (Pollawatn, 2008).

Distribution. – China, India, Nepal, and Sri Lanka (Pollawatn, 2008).

Ecology. – On rocks or barks under shade of tree, near waterfall, at 1,184–1,224 m elevation.

Specimens examined. – *P. Ajintaiyasil 072, 359* (BCU).

4. TRICHOSTELEUM

Mitt., J. Linn. Soc., Bot. 10: 181. 1868; Gangulee, Mosses E. India 8: 1906. 1980; Noguchi, Ill. Moss Fl. Japan 5: 1103. 1994; Yu, Peng-cheng & Tan, Moss Fl. China 8: 65. 2005.

Plants light green to yellowish-green or golden, forming loose to dense mats or wefts. **Stems** and branches spreading to short ascending; in cross-section central strand absent; radiculose. **Leaves** erect to erect-spreading, occasionally falcate, oblong to oblong-lanceolate; apex acute to short or long acuminate, often abruptly so; margins usually reflexed or at base recurved, dentate to more commonly serrate or serrulate; ecostaete; median cells linear, often vermicular, or fusiform to rhomboidal, strongly to weakly unipapillose, papillae over cell lumen; alar region differentiated, cells inflated, oval to oblong, often golden red. **Autoicous**. **Perichaetial** leaves differentiated. **Setae** elongate, slender and wiry, often twisted, smooth or weakly papillose distally. **Capsules** inclined to horizontal, urn ovoid, constricted below urn mouth; exothelial cells collenchymatous. **Opercula** conic-rostrate. **Peristome** double, exostome teeth 16, cross-striate below, distally papillose; endostome segments keeled,

lightly papillose. **Calyptrae** cucullate, smooth and naked. **Spores** spherical, lightly papillose.

Trichosteleum pseudomammosum M. Fleisch., Musci Buitenzorg 4: 1319. 213. 1923. (Figure 5.93)

Plants yellowish brown, glossy, in dense wefts. **Stems** elongate, irregularly branched; branches loosely foliate, spreading. **Leaves** erect-spreading, ovate to oblong-lanceolate, 1.1–1.3 × 0.2–0.3 mm, concave; abruptly acuminate apex, often falcate; margins plane below, reflexed above, crenulate to serrulate at apex; cells elongate-rhomboidal to linear, thin to occasionally thick-walled, with large papillae, 42–63 × 3–12 μm; alar cells ovoid to oblong, 2–3 cells, inflated, thick walled, often colored, 47–53 × 24–31 μm. **Autoicous**. **Perchaetial leaves** oblong-lanceolate; long acuminate or cuspidate, serrate above; cells clearly papillose. **Setae** 0.9–1.0 cm long, smooth, usually hooked. **Capsules** oval 0.8–1.2 × 0.4–0.5 mm, horizontal to pendent; exothecial cells mammillose. **Peristome** double; exostome teeth 16, cross-striate below, distally papillose; endostome segments keeled, lightly papillose. **Calyptrae** cucullate, smooth and naked. **Spores** spherical, lightly papillose.

Additional illustration. – not seen.

Thailand. – EASTERN. Nakhon Ratchasima (Pollawatn, 2008).

Distribution. – Brunei, China, Indonesia, Kampuchea, Laos, Malaysia, and Vietnam (Pollawatn, 2008).

Ecology. – On rocks under shade of tree, near waterfall, at 1,087 m elevation.

Specimens examined. – *P. Ajintaiyasil* 222 (BCU).

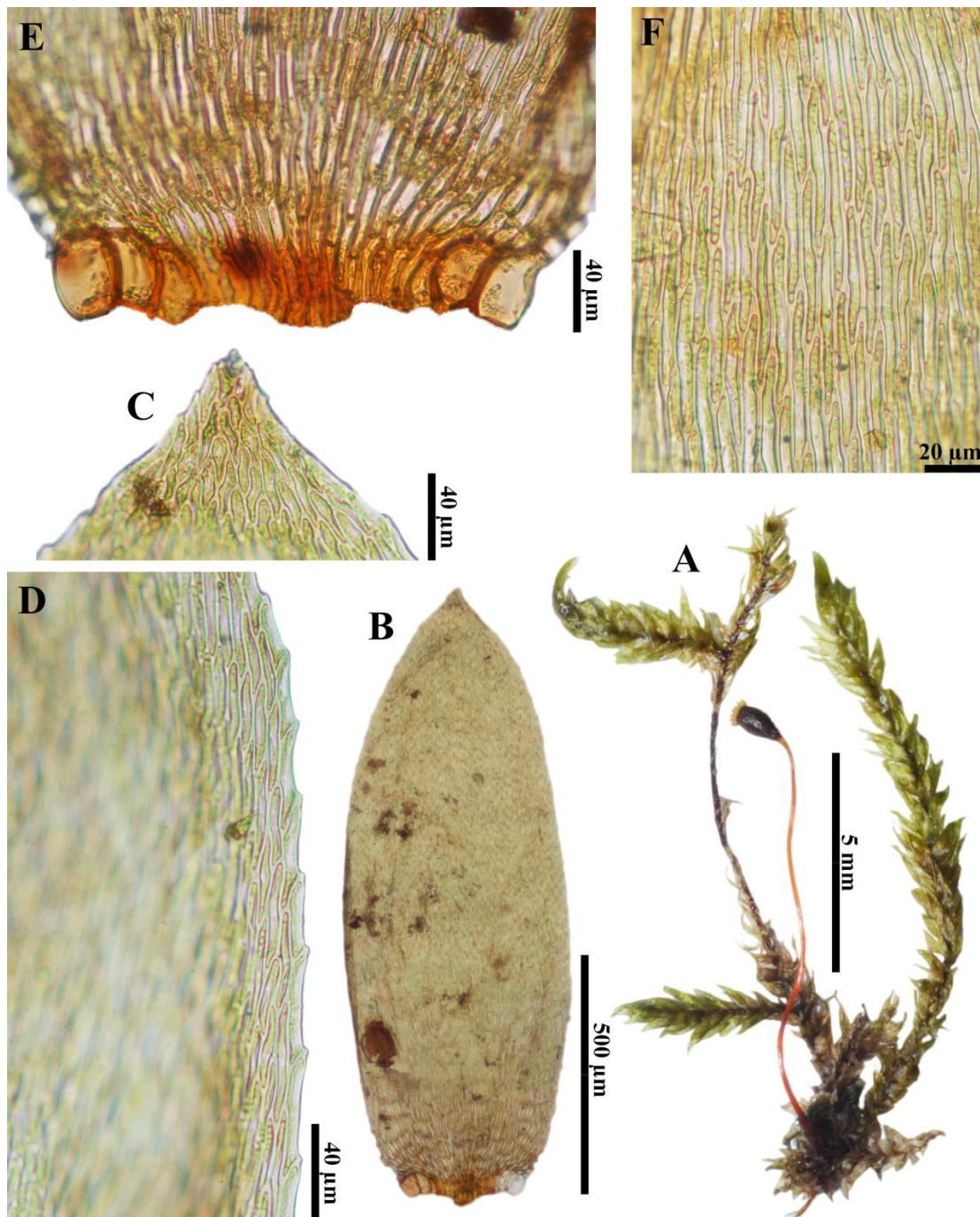


Figure 5. 89 *Acroporium brevipes* (Broth.) Broth.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Leaf base with alar region, F. Cells at median part of leaf. Based on *P. Ajintaiyasil* 490.

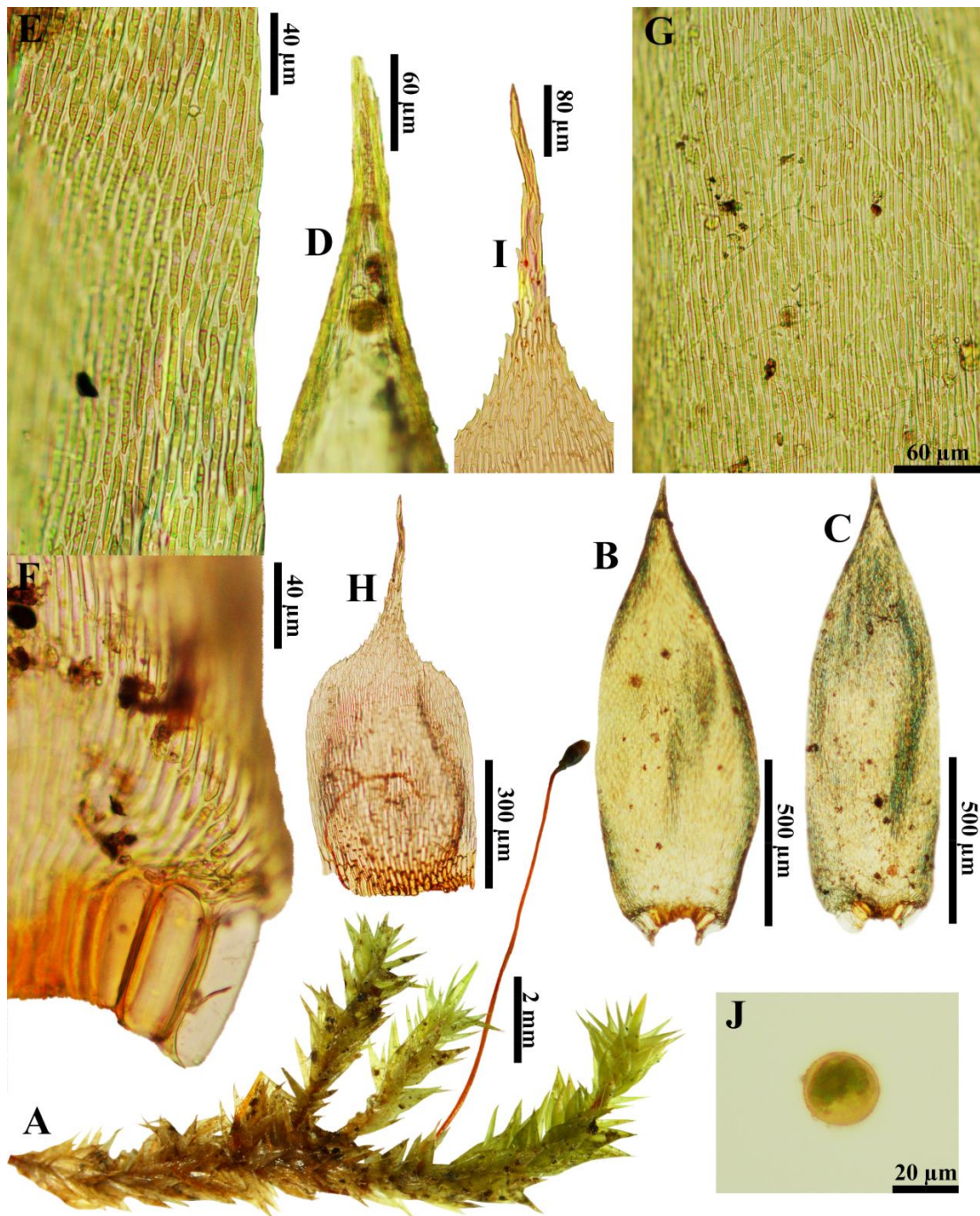


Figure 5.90 *Acroporium laosianum* (Broth. & Paris) Broth.

A. Gametophyte with sporophyte, B–C. Leaves, D. Leaf apex, E. Leaf margin, F. Leaf base with alar region, G. Cells at median part of leaf, H. Perichaetia leaf, I. Perichaetia leaf apex, J. Spore. Based on *P. Ajintaiyasil 068*.

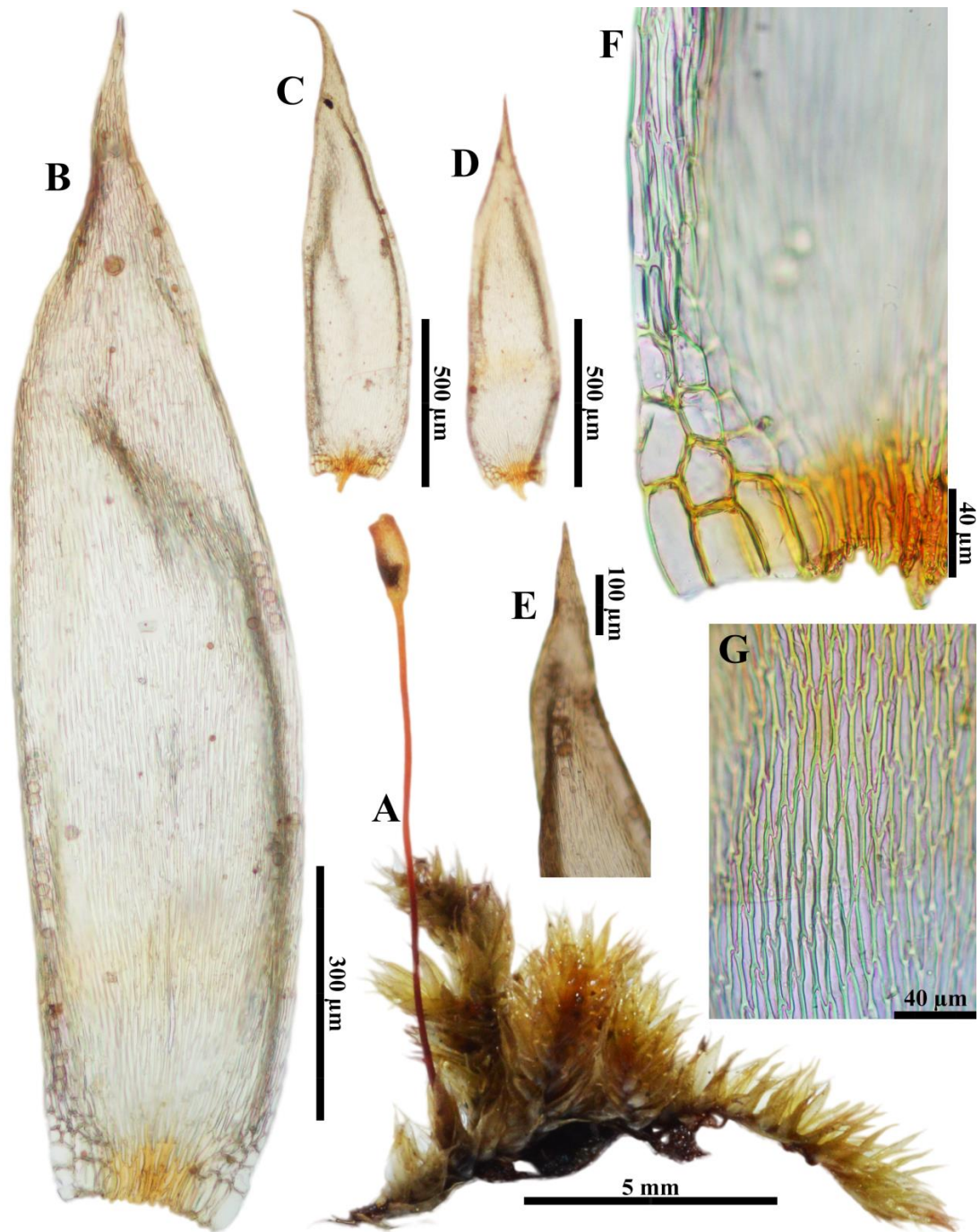


Figure 5.91 *Chionostomum pinicola* Tixier

A. Gametophyte with sporophyte, B–D. Leaves, E. Leaf apex, F. Leaf base with alar region, G. Cells at median part of leaf. Based on *P. Ajintaiyasil 144*.

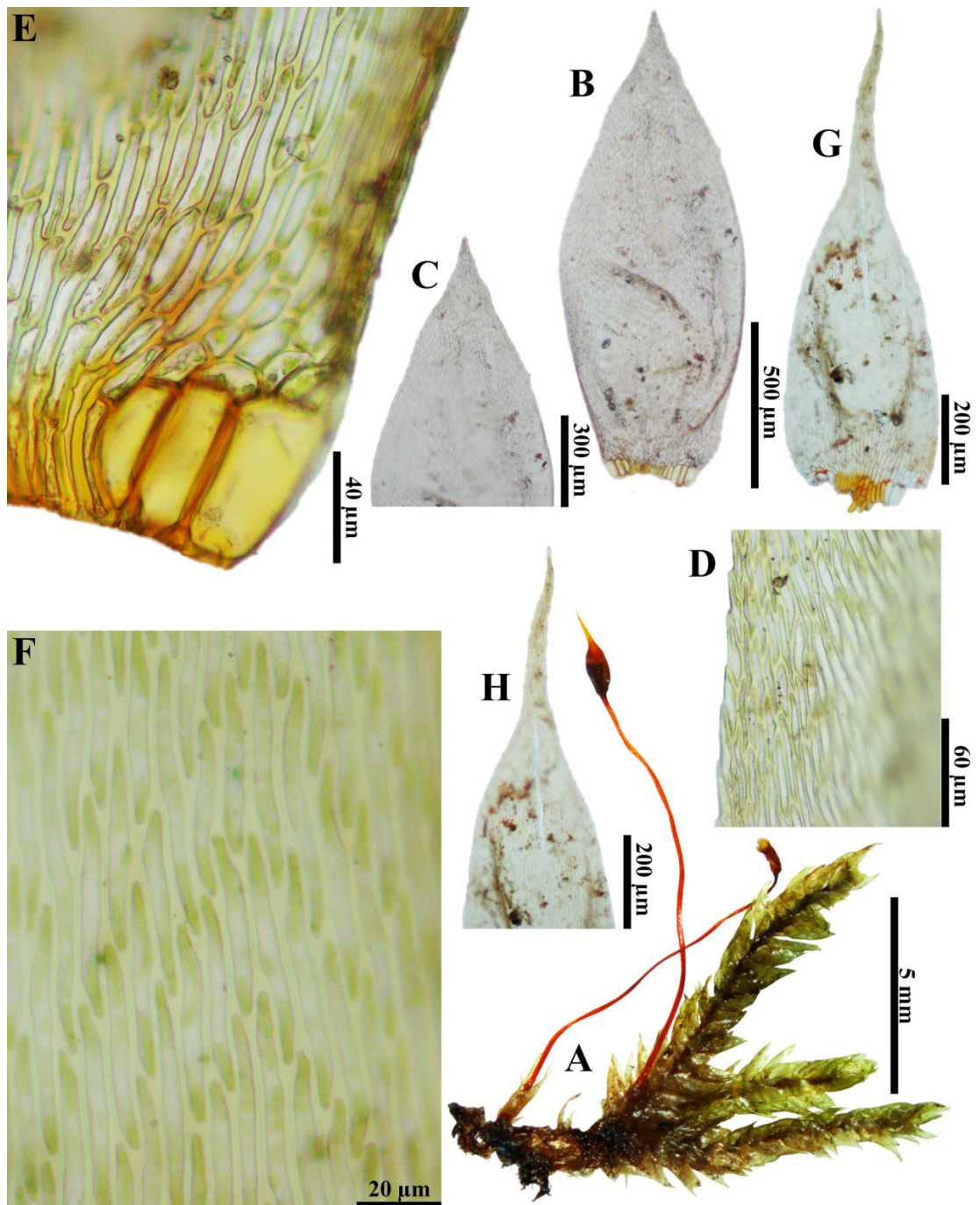


Figure 5.92 *Sematophyllum humile* (Mitt.) Broth.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Leaf base with alar region, F. Cells at median part of leaf, G. Perichaetial leaf, H. Perichaetial leaf apex. Based on *P. Ajintaiyasil* 072.

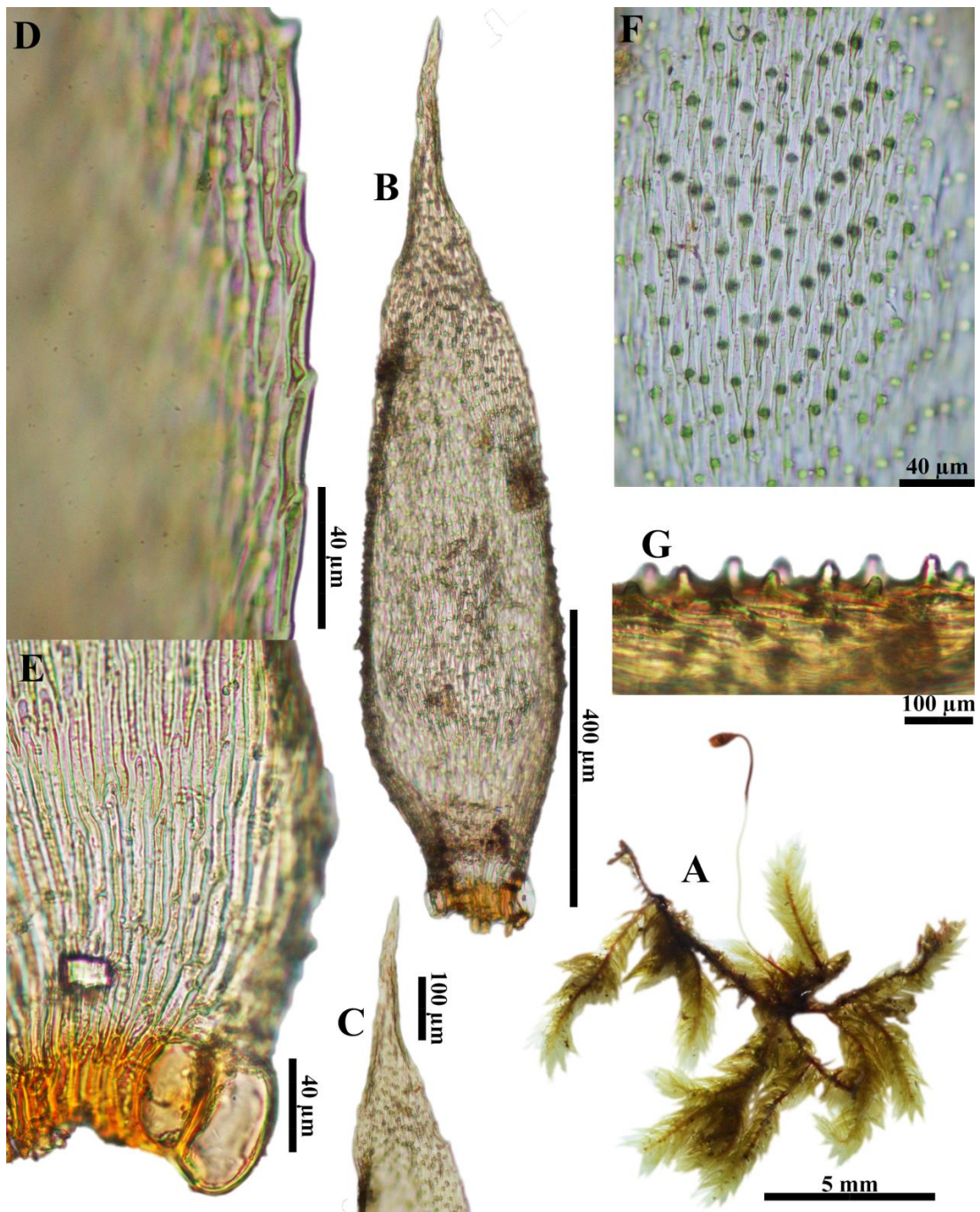


Figure 5.93 *Trichosteleum pseudomammosum* M. Fleisch.

A. Gametophyte with sporophyte, B. Leaf, C. Leaf apex, D. Leaf margin, E. Leaf base with alar region, F. Cells at median part of leaf, G. Leaf cells showing large unipapillose. Based on *P. Ajintaiyasil* 222.

28. SPHAGNACEAE

Dumort., Anal. Fam. Pl 68. 1829; Gangulee, Mosses E. India 1. 1. 1969; Eddy, Handb. Males. Mosses 1: 4. 1988; Xing-jiang & He, Moss Fl. China 1: 3. 1999.

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

SPHAGNUM

L., Sp. Pl. 2: 1106. 1753; Gangulee, Mosses E. India 1. 1. 1969; Eddy, Handb. Males. Mosses 1: 4. 1988; Xing-jiang & He, Moss Fl. China 1: 3. 1999.

Plants medium sized to rather robust, mostly branched, with branches in fascicles. **Stems** suberect to erect, sparsely forked or solitary; in cross section with 2 or more layers of large, hyaline cortical cells, spirally fibrillose and pore on outer wall or not, pore when present retort or not, with wood cylinder. **Stem leaves** appressed, unistratose, broadly oblong or ovate; ecostaete. **Branch leaves** differentiated from stem leaves in shape and size, usually larger, broadly elliptic to ovate or ovate to lanceolate, concave or not; ecostaete; cells alternating between hyaline cells and photosynthetic cells (green cells), hyaline cells rhomboidal or vermiculate, fibrils present or absent, in cross section plane or convex, photosynthetic cells exposed equally on both surfaces, or exclusively or partially on either the outer or inner leaf surface, or completely included, shape typically elliptical, triangular, or trapezoidal. **Dioicous** or monoicous. **Perichaetial** branches short, near apex, leaves enlarged. **Antheridia** subglobose. **Archegonia** terminal on branches. **Pseudopodium** elongating at maturity mostly exerted, urn globose. **Capsules** ovoid, when deoperculate ovoid-cylindrica. **Opercula** flat to slightly convex. **Peristome** absent. **Spores** tetrahedral.

Key to the species

- 1a. Hyaline cells of stems and branches with spiral fibrils; branch leaves cucullate-concave, broadly ovate, dorsal apex appearing scabrid.....2
- 2a. Photosynthetic cells of branch leaves in cross section narrowly elliptic, exposed on both surfaces; hyaline cells of stem with a single pore on the external wall.....8. *S. perichaetiale*
- 2b. Photosynthetic cells of branch leaves in cross section triangular, exposed entirely on the ventral surfaces; hyaline cells of stem with several pores on the external walls.....3
- 3a. Photosynthetic cells of branch leaves narrowly triangular; stems and branches long and slender.....6. *S. palustre* subsp. *palustre*
- 3b. Photosynthetic cells of branch leaves equilaterally triangular; stems and branches short and stout.....7. *S. palustre* subsp. *pseudocymbifolium*
- 1b. Hyaline cells of stems and branches without spiral fibrils; branch leaves not cucullate-concave, usually narrowly ovate, dorsal apex not appearing scabrid.....4
- 4a. Photosynthetic cells of branch leaves in cross section triangular.....5

- 5a. Photosynthetic cells exposed on the ventral surfaces.....4. *S. junghuhnianum*
 5b. Photosynthetic cells exposed on the dorsal surfaces.....6
 6a. Hyaline cells of stem leaves with spiral fibrils.....7
 7a. Stem leaves oblong-triangular or triangular; stem cortex without large pores.....8
 8a. Branch leaves short, broadly lanceolate, 1.5–1.8 mm long.....
 3. *S. cuspidatum* subsp. *subrecurvum* var. *subrecurvum*
 8b. Branch leaves long, narrowly ovate-lanceolate, 2.7–2.8 mm long....
 2. *S. cuspidatum*
 7b. Stem leaves ovate-triangular; stem cortex with 1–2 large pores.....
 5. *S. luzonense*
 6b. Hyaline cells of stem leaves without spiral fibrils.....1. *S. cuspidatum*
 4b. Photosynthetic cells of branch leaves in cross section elliptic or rectangular....9
 9a. Stem cortex usually in 2 layers.....10. *S. robinsonii*
 9b. Stem cortex in 1 layers.....10
 10a. Branch leaves usually as long as the stem leaves, photosynthetic cells narrowly elliptic.....6. *S. ovatum*
 10b. Branch leaves long more than the stem leaves, photosynthetic cells narrowly rectangular.....11. *S. subsecundum*

1. *Sphagnum cuspidatum* Müll. Hal., Linnaea. 38: 549. 1874; Gangulee, Mosses E. India 1: 40. 40, fig. 17. 1969; Eddy, Bull. Brit. Mus. (Nat. Hist.), Bot. 5 No. 7: 419. 420, fig. 18. 1977; Eddy, Handb. Males. Mosses 1: 14. 17, fig. 9. 1988; Xing-jiang & He, Moss Fl. China 1: 12. 13, Pl. 2. 1999. — *Sphagnum rufulum* Müll. Hal., Linnaea 38: 548. 1874. — *Sphagnum malaccense* Warnst., Hedwigia 31: 175. pl. 16: f. 4–6. 1892. — *Sphagnum acutum* Warnst., Allg. Bot. Z. Syst. 1: 136. 1895. — *Sphagnum cuspidatum* var. *fibrosum* Warnst., Pflanzenr. 51: 187. 1911. — *Sphagnum cuspidatum* var. *fuscescens* Warnst., Pflanzenr. 51: 188. 1911. (**Figure 5.94**)

Plants stout, robust, whitish green tinged with brownish. **Stem** mutistratose cortex in 1–3 layers; hyaline cells narrow, thin-walled, without fibrils; central cylinder not clearly differentiated. **Branches** in fascicles of 4–6, with 2–3 spreading; often slender and curved at the apex. **Stem leaves** triangular-ligulate, 1.1–1.3 × 1.0–1.1 mm; 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. **Branch leaves** ovate-lanceolate, 1.4 × 0.4–0.5 mm; gradually narrowed to a channelled 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. **Sporophytes** not seen.

Additional illustration. – Eddy (1977: 420, Fig. 18A–J); Eddy (1988: 17, Fig. 9A–J); Gangulee (1969: 40, Fig. 17); Chien, Crosby, & He (1999: 13, Pl. 2, Fig. 1–10).

Thailand. – NORTHERN: Chiang Mai, Uttaradit; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, China, India, Indonesia, Laos, Malaysia, Myanmar, New Guinea, Philippines, Rwanda (Bartram, 1939; He, 1995; O'shea, 2006).

Ecology. – Wet sandy soil area, near waterfalls at 1,250 m elevation.

Specimens examined. – *P. Ajintaiyasil* 420 (BCU).

2. *Sphagnum cuspidatum* Ehrh. ex Hofin. subsp. ***cuspidatum***, *Deutschl. Fl.* 2: 22. 1796; Gangulee, *Mosses E. India* 1: 36. 37, fig. 15. 1969; Eddy, *Bull. Brit. Mus. (Nat. Hist.) Bot.* 5 No. 7: 409. 411, fig. 15. 1977; Eddy, *Handb. Males. Mosses* 1: 14. 15, fig. 7. 1988; Xing-jiang & He, *Moss Fl. China* 1: 12. 1999. — *Sphagnum alpinum* Schrank, *Baier. Fl.* 2: 435. 1789. — *Sphagnum laxifolium* Müll. Hal., *Syn. Musc. Frond.* 1: 97. 1848. — *Sphagnum lonchophyllum* Müll. Hal., *Hedwigia* 36: 152. 1897. — *Sphagnum subundulatum* Müll. Hal. & Warnst., *Hedwigia* 36: 152. 1897. — *Sphagnum virginianum* Warnst., *Hedwigia* 39: 101. 1900. — *Sphagnum aloysii-sabaudiae* G. Negri, *Ann. Bot. (Rome)* 7: 161. 1908. — *Sphagnum faxonii* Warnst., *Hedwigia* 47: 117. 1908. — *Sphagnum gabonense* Besch., *Pflanzenr.* 51: 269. 258 f. 47 E. 1911. — *Sphagnum lehmannii* Warnst., *Pflanzenr.* 51: 232. 1911. — *Sphagnum pusillum* Warnst., *Pflanzenr.* 51: 259. 250 f. 46 D. 1911. (**Figure 5.95**)

Plants slender, soft, yellowish green. **Stem** multistratose cortex in 2–3 layers; hyaline cells thin-walled, without fibrils; central cylinder yellowish green, clearly distinguished from the cortical cells. **Branches** in fascicles of 3, with 2 spreading. **Stem leaves** oblong-triangular, 1.2–1.4 × 0.5–0.6 mm; acute and dentate at the apex; borders narrow, wide from the middle to the base; hyaline cells narrow, undivided, with fibrils. **Branch leaves** very narrowly ovate-lanceolate, 2.7–2.8 × 0.3–0.4 mm; gradually narrowed to a blunt, dentate at apex; margins bordered by a 1–2 rows of linear cells; hyaline cells narrowly elongate-rhomboidal, the inner walls adjacent to green cells smooth; the photosynthetic cells in cross section trapezoidal, more broadly exposed on the dorsal surface. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 411, Fig. 15A–J); Eddy (1988: 15, Fig. 7A–J); Gangulee (1969: 37, Fig. 15).

Thailand. – NORTHERN: Chiang Mai; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Australia, Brunei, Brazil, Canada, China, Colombia, Costa Rica, Indonesia, Japan, Kampuchea, Malaysia, Myanmar, New Guinea, Paraguay, Philippines, United States, and Vietnam (Eddy, 1977; Forzza, 2010; He, 1995; Waard & Florschütz, 1979).

Ecology. – Bog or wet sand under fern and along nature trail, occur in montane forests at 1,239–1,350 m elevation

Specimens examined. – *P. Ajintaiyasil 048, 069, 402* (BCU).

3. *Sphagnum cuspidatum* Ehrh. ex Hofin. subsp. *subrecurvum* (Warnst.) Eddy var. *subrecurvum*, Bull. Brit. Mus. (Nat. Hist.), Bot. 5: 413. 1977. — *Sphagnum subrecurvum* Warnst., Allg. Bot. Z. Syst. 1: 134. 1895. — *Sphagnum javanicum* Warnst., Hedwigia 47: 120. 1907. (**Figure 5.96**)

Plants slender, soft, yellowish green. **Stem** multistratose cortex in 2–3 layers; hyaline cells thin-walled, without fibrils; central cylinder yellowish green, clearly distinguished from the cortical cells. **Branches** in fascicles of 3, with 2 spreading. **Stem leaves** oblong-triangular, 1.2–1.4 × 0.5–0.6 mm; acute and dentate at the apex; borders narrow, wide from the middle to the base; hyaline cells narrow, undivided, with fibrils. **Branch leaves** short, broadly lanceolate, 1.5–1.8 mm long; gradually narrowed to a blunt, dentate at apex; margins bordered by a 1–2 rows of linear cells; hyaline cells narrowly elongate-rhomboidal, the inner walls adjacent to green cells smooth; the photosynthetic cells in cross section triangular, immersed on dorsal surface. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 414, Fig. 16A–K); Eddy (1988: 16, Fig. 8A–k).

Thailand. – NORTH-EASTERN: Phetchabun, Loei (He, 1995).

Distribution. – Brunei, Indonesia, Malaysia, and New Guinea (He, 1995).

Ecology. – Bog or wetland along nature trail, occur in montane forests at 1,100–1,400 m elevation

Specimens examined. – *P. Ajintaiyasil 086, 093, 095* (BCU).

4. *Sphagnum junghuhnianum* Dozy & Molk., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 2(2): 5–9, t. 1, fig. 3. 1854; Gangulee, Mosses E. India 1: 24. 25, fig. 9. 1969; Eddy, Bull. Brit. Mus. (Nat. Hist.) Bot. 5 No. 7: 426. 427, fig. 20. 1977; Eddy, Handb. Males. Mosses 1: 8. 9, fig. 2. 1988; Xing-jiang & He, Moss Fl. China 1: 20. 21, Pl. 3. 1999. — *Sphagnum gedeanum* Dozy & Molk., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 2(5): 7, 1 fig. 1–2. 1854. — *Sphagnum thomsonii* Müll. Hal., Linnaea 38: 545. 1874. — *Sphagnum acutifolioides* Warnst., Hedwigia 29: 192. 4 f. 4; 7 f. 16. 1890. — *Sphagnum pseudomolle* Warnst., Beih. Bot. Centralbl. 16: 247. 1904. — *Sphagnum junghuhnianum* var. *typicum* Warnst., Pflanzenr. 51: 116. 1911. (**Figure 5.97**)

Plants rather robust, yellowish green to pale brown. **Stem** multistratose cortex in 2–3 layers; hyaline cells large, thin-walled, without fibrils; central cylinder reddish pink. **Branches** in fascicles of 3–5, with 2–3 spreading. **Stem leaves** oblong isosceles-triangular, 1.3–1.6 × 0.6–0.7 mm; gradually narrowed to an involute, blunt, and dentate apex; borders narrowly and evenly differentiated to the base; hyaline cells narrowly rhomboidal, fibrillose in the upper half, efibrillose at the lower half. **Branch**

leaves ovate-lanceolate, $1.5 \times 0.6\text{--}0.7$ mm; gradually narrowed and involute to a blunt, denticulate apex; appressed at leaf base; borders differentiated; hyaline cells narrowly rhomboidal, unringed pores near leaf base and margins on the dorsal surface, rounded pores in opposite pairs on the ventral surface, ringed pores in commissural rows and a few large; photosynthetic cells in cross section triangular, exposed on the ventral surface, enclosed by hyaline cells on the dorsal surface. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 427, Fig. 20A–L); Eddy (1988: 9, Fig. 2A–H); Gangulee (1969: 25, Fig. 9); Chien, Crosby, & He (1999: 21, Pl. 3, Fig. 1–9).

Thailand. – NORTH-EASTERN: Loei. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Brunei, Canada, China, Columbia, India, Indonesia, Japan, Malaysia, New Guinea, Philippines, Taiwan, and Vietnam (Eddy, 1977; He, 1995).

Ecology. – Bog or wet sand under fern and along nature trail, occur in montane forests at 1,239–1,400 m elevation

Specimens examined. – *P. Ajintaiyasil 021, 062* (BCU).

5. *Sphagnum luzonense* Warnst., Bot. Centralbl. 76: 388. 1898; Eddy, Bull. Brit. Mus. (Nat. Hist.) Bot. 5 No. 7: 396. 397, fig. 8. 1977; Eddy, Handb. Males. Mosses 1: 8. 11, fig. 4. 1988; Xing-jiang & He, Moss Fl. China 1: 24. 33, Pl. 8. 1999. — *Sphagnum subsecundum* var. *luzonense* (Warnst.) C.E.O. Jensen, Symb. Sin. 4: 8. 1929. — *Sphagnum subsecundum* var. *luzonense* (Warnst.) C.E.O. Jensen, Symb. Sin. 4: 8. 1929. — *Sphagnum densirameum* Dix., J. Siam Soc., Nat. Hist. Suppl. 9(1): 4. 1932. (**Figure 5.98**)

Plants rather small, yellow to brown. **Stem** unistratose cortex in 1 layer; hyaline cells thin-walled, without fibrils, with 1–2 large pores; central cylinder orange. **Branches** in fascicles of 3–4, with 1–2 spreading. **Stem leaves** ovate-triangular, $2.4\text{--}2.7 \times 1.4\text{--}1.5$ mm; rounded-obtuse apex; narrower at base; margins involute to cucullate at the apex; hyaline cells densely fibrillose, with large pores on both surfaces, ringed pores at the opposite ends along commissural rows on the ventral surface. **Branch leaves** ovate-lanceolate, $1.5\text{--}1.7 \times 0.8\text{--}0.9$ mm; secund and cucullate at the apex; margins slightly involute; hyaline cells densely fibrillose, with pores at the opposite ends along commissural rows on both surfaces, similar to the stem leaves, fibrils sometimes indistinct in the upper cells; photosynthetic cells in cross section narrowly trapezoidal, thick-walled, exposed on both surfaces, more broadly to the dorsal surface. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 397, Fig. 8A–H); Eddy (1988: 11, Fig. 4A–H); Chien, Crosby, & He (1999: 33, Pl. 8, Fig. 1–3).

Thailand. – NORTHERN: Phitsanulok, Uttaradit. NORTH-EASTERN: Loei (He, 1995).

Distribution. – China, Philippines, and Vietnam (Eddy, 1977; He, 1995).

Ecology. – on wet sand under fern and along nature trail, at 950–1,300 m elevation

Specimens examined. – *P. Ajintaiyasil* 408 (BCU).

6. *Sphagnum ovatum* Hampe, *Linnaea*. 38: 546. 1874; Gangulee, *Mosses E. India* 1: 46. 47, fig. 20. 1969; Eddy, *Bull. Brit. Mus. (Nat. Hist.) Bot.* 5 No. 7: 394. 395, fig. 7. 1977; Xing-jiang & He, *Moss Fl. China* 1: 30. 31, Pl. 7. 1999. (**Figure 5.99**)

Plants soft, rather slender, pale green. **Stem** unistratose cortex in 1 layer; hyaline cells large, thin-walled, without fibrils and pores; central cylinder yellowish red. **Branches** in fascicles of 3–4, with 2 spreading. **Stem leaves** ovate to ovate-ligulate with a narrower base, 1.0–1.4 × 0.5–0.6 mm; rounded and margins involute at the apex; hyaline cells densely fibrillose, with small, ringed pores at the opposite ends along commissural rows on the dorsal surface, with pores at the corners in the upper cells on the ventral surface. **Branch leaves** ovate, 1.0–1.4 mm long, strongly concave; blunt at the apex; margins involute and borders differentiated; hyaline cells with numerous ringed pores at the opposite ends along commissural rows on the dorsal surface, with pores at the corners in the upper cells on the ventral surface; photosynthetic cells in cross section narrowly elliptic, centrally located, narrowly exposed on both surfaces. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 395, Fig. 7A–H); Eddy (1969: 47, Fig. 20); Xing-jiang and He (1999: 31, Pl. 7, Fig. 1–12).

Thailand. – NORTHERN: Chiang Mai; NORTH-EASTERN: Loei (He, 1995).

Distribution. – China, India, and Nepal (Eddy, 1977; He, 1995).

Ecology. – on wet sand under fern and along nature trail with stream, occur in montane forests at 1,245–2,540 m elevation

Specimens examined. – *P. Ajintaiyasil* 036B, 066, 085, 378 (BCU).

7. *Sphagnum palustre* L. subsp. **palustre**, *Sp. Pl.*, ed. 2. 1106. 1753; Gangulee, *Mosses E. India* 1: 7. 8, fig. 1. 1969; Xing-jiang & He, *Moss Fl. China* 1: 32. 1999. — *Sphagnum palustre* var. *cymbifolium* Ehrh., *Hannover. Mag.* 18: 235. 1780. — *Sphagnum vulgare* Michx., *Fl. Bor.-Amer.* 2: 285. 1803. — *Sphagnum cymbifolioides* Breutel, *Flora* 7: 435. 1824. — *Sphagnum obtusifolium* Ehrh., *Hannover. Mag.* 18: 235. 1780. — *Sphagnum subbicolor* Hampe, *Flora* 63: 440. 1880. — *Sphagnum glaucum* H. Klinggr., *Schriften Naturf. Ges. Danzig* 5(1): 207. 1881. — *Sphagnum japonicum* Warnst., *Allg. Bot. Z. Syst.* 1: 230. 1895. — *Sphagnum lonchocladum* Müll. Hal., *Flora* 82: 436. 1896. — *Sphagnum klinggraeffii* Röhl, *Hedwigia* 36: 330. 1897. — *Sphagnum sulphureum* Warnst., *Hedwigia* 47: 77. 1907. (**Figure 5.100**)

Plants grayish green to yellowish green. **Stem** multistratose cortex in 3–4 layers; hyaline cells fibrillose, each with 2–4 pores; central cylinder yellowish brown. **Branches** in fascicles of 3–5, with 2–3 spreading branches. **Stem leaves** oblong-ligulate, 1.8–1.9 × 0.8–0.9 mm; rounded at the apex; upper marginal cells hyaline,

forming broad borders. **Branch leaves** ovate-circular, 2.0–2.3 × 1.2–1.7 mm; cucullate-concave, dorsally roughened at the apex; hyaline cells rhomboidal, often with large, rounded, unringed, central pores, few pores in the corners on the ventral surface, with half-round, ringed pores along commissural rows and a few pores at the opposite corners on the dorsal surface; photosynthetic cells in cross section narrowly triangular or trapezoidal, enclosed by hyaline cells, exposed on the ventral surface. **Sporophyte** not seen.

Additional illustration. – Gangulee (1969: 8, Fig. 1).

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – China, India, Indonesia, Japan, Malaysia, Myanmar, Philippines, and Taiwan (Eddy, 1977; He, 1995).

Ecology. – on wet sand under fern and along nature trail with stream, occur in montane forests at 1190 m elevation

Specimens examined. – *P. Ajintaiyasil* 020, 049, 094, 096, 103, 106, 113 (BCU).

8. *Sphagnum palustre* L. subsp. *pseudocymbifolium* (Müll. Hal.) A. Eddy, Bull. Brit. Mus. (Nat. Hist.), Bot. 5 No. 7: 376. 1977; Xing-jiang & He, Moss Fl. China 1: 33. 33, Pl. 8. 1999. — *Sphagnum pseudocymbifolium* Müll. Hal., Linnaea 38: 547. 1874; Gangulee, Mosses E. India 1: 10. 10, fig. 2. 1969. — *Sphagnum assamicum* Müll. Hal., Flora 70: 411. 1887. — *Sphagnum siamense* Dix., J. Siam Soc., Nat. Hist. Suppl. 9(1): 3. 1932. (**Figure 5.101**)

Plants grayish green to yellowish green. **Stem** multistratose cortex in 3–4 layers; hyaline cells fibrillose, each with 2–4 pores; central cylinder yellowish brown. **Branches** in fascicles of 3–5, with 2–3 spreading branches. **Stem leaves** oblong-ligulate, 1.8–1.9 × 0.8–0.9 mm; rounded at the apex; upper marginal cells hyaline, forming broad borders. **Branch leaves** ovate-circular, 2.0–2.3 × 1.2–1.7 mm; cucullate-concave, dorsally roughened at the apex; hyaline cells rhomboidal, often with large, rounded, unringed, central pores, few pores in the corners on the ventral surface, with half-round, ringed pores along commissural rows and a few pores at the opposite corners on the dorsal surface; photosynthetic cells in cross section equilateral-triangular, enclosed by hyaline cells, exposed more broadly on the ventral surface. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 377–378, Fig. 1–2); Gangulee (1969: 10, Fig. 2).

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – Bhutan, India, Nepal, China, and Taiwan (Eddy, 1977; He, 1995).

Ecology. – on wet sand under fern and along nature trail with stream, occur in montane forests at 1,205–1,239 m elevation

Specimens examined. – *P. Ajintaiyasil* 035 (BCU).

9. Sphagnum perichaetiale Hampe, *Linnaea*. 20: 66. 1847; Eddy, *Bull. Brit. Mus. (Nat. Hist.) Bot.* 5 No. 7: 380. 381382, fig. 3–4. 1977; Eddy, *Handb. Males. Mosses* 1: 6. 7, fig. 1. 1988; Xing-jiang & He, *Moss Fl. China* 1: 35. 1999. — *Sphagnum erythrocalyx* Hampe, *Syn. Musc. Frond.* 1: 92. 1848. — *Sphagnum peruvianum* Mitt., *J. Linn. Soc., Bot.* 12: 625. 1869. — *Sphagnum husnotii* Schimp., *Ann. Sci. Nat., Bot.*, sér. 6, 3: 264. 1876. — *Sphagnum cymbifolium* var. *ludovicianum* Renault & Cardot, *Bull. Soc. Roy. Bot. Belgique* 26(1): 42. 1887. — *Sphagnum puiggari* Müll. Hal., *Flora* 70: 409. 1887. — *Sphagnum wrightii* Müll. Hal., *Flora* 70: 411. 1887. — *Sphagnum antillarum* Schimp. ex Warnst., *Hedwigia* 30: 147. 15 f. 11: 21 f. o. 1891. — *Sphagnum balfourianum* Warnst., *Hedwigia* 30: 153. 17 f. 21; 22 f. 2. 1891. — *Sphagnum griffithianum* Warnst., *Hedwigia* 30: 151. 16 f. 19; 22 f. 10. 1891. — *Sphagnum ludovicianum* (Renault & Cardot) Warnst., *Hedwigia* 30: 161. 18 f. 2b; 28g. 1891. — *Sphagnum paucifibrosus* Warnst., *Hedwigia* 30: 152. 12 f. 20; 22y. 1891. — *Sphagnum vitjianum* Schimp., *Hedwigia* 30: 144. 14 f. 8; 21 f. 1. 1891. — *Sphagnum arbogastii* Renault & Cardot, *Bull. Soc. Roy. Bot. Belgique* 32(2): 8. 1893. — *Sphagnum brachycladum* Müll. Hal. ex Warnst., *Hedwigia* 36: 170. 1897. — *Sphagnum carneum* Müll. Hal. & Warnst., *Hedwigia* 36: 145. 1897. — *Sphagnum kegelianum* Müll. Hal. ex Warnst., *Hedwigia* 36: 175. 1897. — *Sphagnum ouropretense* Müll. Hal. & Warnst., *Hedwigia* 36: 172. 1897. — *Sphagnum subtursum* Müll. Hal., *Hedwigia* 36: 171. 1897. — *Sphagnum sintenesii* Müll. Hal., *Hedwigia* 37: 219. 1898. — *Sphagnum heterophyllum* Warnst., *Bot. Jahrb. Syst.* 27: 254. 1899. — *Sphagnum subbrachycladum* Müll. Hal., *Bot. Jahrb. Syst.* 27: 255. 1899. — *Sphagnum suberythrocalyx* Müll. Hal. ex Warnst., *Hedwigia* 30: 158. 1899. — *Sphagnum brevicaule* Warnst., *Hedwigia* 39: 108. 1900. — *Sphagnum grandifolium* Warnst., *Bot. Centralbl.* 82: 8. 1900. — *Sphagnum pauciporosum* Warnst., *Hedwigia* 39: 109. 1900. — *Sphagnum harperi* Warnst., *Beih. Bot. Centralbl.* 16: 250. 1904. — *Sphagnum macroporum* Warnst., *Allg. Bot. Z. Syst.* 11: 98. 1905. — *Sphagnum paranae* Warnst., *Allg. Bot. Z. Syst.* 11: 97. 1905. — *Sphagnum allionii* Warnst., *Pflanzenr.* 51: 502. 82 b. 1911. — *Sphagnum bahiense* Warnst., *Pflanzenr.* 51: 502. 81 F. 1911. — *Sphagnum biforme* Warnst., *Pflanzenr.* 51: 493. 1911. — *Sphagnum derrumbense* Warnst., *Pflanzenr.* 51: 508. 1911. — *Sphagnum discrepans* Warnst., *Pflanzenr.* 51: 510. 1911. — *Sphagnum earlei* Warnst., *Pflanzenr.* 51: 449. 1911. — *Sphagnum glaucovirens* Warnst., *Pflanzenr.* 51: 501. 1911. — *Sphagnum huntii* Warnst., *Pflanzenr.* 51: 521. 1911. — *Sphagnum japonicum* var. *philippinense* Warnst., *Pflanzenr.* 51: 520. 1911. — *Sphagnum leratianum* Paris & Warnst., *Pflanzenr.* 51: 476. 51 A. 1911. — *Sphagnum marlothii* Warnst., *Pflanzenr.* 51: 471. 1911. — *Sphagnum orgaosense* Warnst., *Pflanzenr.* 51: 500. 1911. — *Sphagnum tijucae* Müll. Hal., *Pflanzenr.* 51: 487. 1911. — *Sphagnum tijucae* Warnst., *Pflanzenr.* 51: 503. 1911. — *Sphagnum fleischeri* Warnst., *Hedwigia* 57: 77. 1915. (**Figure 5.102**)

Plants moderately robust, pale green or yellowish brown, in dense turfs. **Stem** multistratose cortex in 2–3 layers; hyaline cells thin-walled; central cylinder reddish brown. **Branches** in fascicles of 2–5, with 1–3 spreading. **Stem leaves** short and small, flat, short ligulate, 1.0–1.3 × 0.5–0.7 mm; rounded and dentate at the apex; hyaline cells broadly rhomboidal, often divided, fibrillose and porose in the upper cells. **Branch leaves** broadly ovate, 2.2–2.5 × 0.8–1.2 mm, strongly concave; cucullate-concave and dorsally roughened at the apex; margins involute in the upper

half; hyaline cells rhomboidal, with large, rounded, unringed pores on the ventral surface, more pores in the upper cells, with few elliptic, ringed pores at the opposite ends on the dorsal surface; photosynthetic cells in cross section narrowly elliptic, centrally located, slightly and equally exposed on both surfaces. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 381–382, Fig. 3–4); Eddy (1988: 7, Fig. 1A–F); Gangulee (1969: 12, Fig. 3, as *S. beccarii*).

Thailand. – NORTH: Chiang Rai. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima (He, 1995).

Distribution. – Angola, Brunei, Brazil, China, India, Indonesia, Kampuchea, Madagascar, Malaysia, Mauritius, New Guinea, New Zealand, Panama, Philippines, Reunion, Sarawak, Sikkim, South Africa, Sumatra, United States and Vietnam (Fife, 1996; He, 1995; O'shea, 2006).

Ecology. – Bog or wet sand under fern and along nature trail, at 1,187–1,300 m elevation

Specimens examined. – *P. Ajintaiyasil* 016, 017, 019, 029, 036A, 038, 041, 042, 044, 059, 070, 082, 087, 089, 091, 418 (BCU).

10. *Sphagnum robinsonii* Warnst., Philipp. J. Sci. 7: 256. 1912; Eddy, Bull. Brit. Mus. (Nat. Hist.) Bot. 5 No. 7: 400. 399, fig. 9–10. 1977; Eddy, Handb. Males. Mosses 1: 10. 12, fig. 5. 1988. — *Sphagnum personatum* B. Hansen, Dansk Bot. Ark. 20, 1: 99. 4, fig. 8. 1961. — *Sphagnum thailandense* B. Hansen, Dansk Bot. Ark. 20, 2: 204. 1962. (**Figure 5.103**)

Plants robust, brownish. **Stem** multistratose cortex in usually 2 layers; hyaline cells without fibrils, each with 1 pores; central cylinder brown. **Branches** in fascicles of 3–4, with 2–3 spreading branches. **Stem leaves** typically lingulate and fibrillose only in the upper half, 1.0–1.2 × 0.5–0.7 mm. **Branch leaves** large, 1.1–1.6 × 0.5–0.9 mm, broad and very concave; apex often somewhat hooded, dentate or erose; hyaline cells with few to numerous but rarely seriate pores on the dorsal side; ventral side with pores mainly to the cell angles; photosynthetic cells in cross section narrowly elliptic, centrally located. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 399–400, Fig. 9–10); Eddy (1988: 12, Fig. 5A–J).

Thailand. – NORTH-EASTERN: Loei (He, 1995).

Distribution. – Malaysia, Philippines, and Vietnam (Eddy, 1977; He, 1995).

Ecology. – Wetland along streams, at 1254 m elevation

Specimens examined. – *P. Ajintaiyasil* 441 (BCU).

11. *Sphagnum subsecundum* Nees, Deutschl. Fl., Abt. II, Crypto. 5(17): pl. 3. 1819; Gangulee, Mosses E. India 1: 42. 44, fig. 18. 1969; Eddy, Bull. Brit. Mus. (Nat. Hist.) Bot. 5 No. 7: 391. 392, fig. 6. 1977; Eddy, Handb. Males. Mosses 1: 8. 10, fig. 3.

1988; Xing-jiang & He, Moss Fl. China 1: 46. 1999. — *Sphagnum khasianum* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 156. 1859. — *Sphagnum dasyphyllum* Warnst., Hedwigia 31: 176. 16 f. 1–9. 1892. — *Sphagnum simile* Warnst., Hedwigia 33: 326. 1894. — *Sphagnum langloisii* Warnst., Hedwigia 36: 166. 1897. — *Sphagnum xerophilum* Warnst., Hedwigia 36: 167. 1897. — *Sphagnum bushii* Warnst. & Cardot, Hedwigia 47: 94. 1907. — *Sphagnum bakeri* Warnst., Pflanzenr. 51: 414. 1911. — *Sphagnum bostonense* Warnst., Pflanzenr. 51: 348. 1911. — *Sphagnum cochlearifolium* Warnst., Pflanzenr. 51: 323. 1911. — *Sphagnum contortulum* Müll. Hal. ex Warnst., Pflanzenr. 51: 321. 1911. — *Sphagnum cordifolium* Warnst., Pflanzenr. 51: 357. 1911. — *Sphagnum fluitans* Warnst., Pflanzenr. 51: 351. 1911. — *Sphagnum nicholsii* Warnst., Pflanzenr. 51: 384. 1911. — *Sphagnum pseudosquarrosus* Warnst., Pflanzenr. 51: 353. 1911. — *Sphagnum smithianum* Warnst., Pflanzenr. 51: 397. 70D. 1911. — *Sphagnum validum* Warnst., Pflanzenr. 51: 417. 1911. **(Figure 5.104)**

Plants rather robust, grayish green to often yellow. **Stem** unistratose cortex in 1 layer; hyaline cells without fibrils and pores; central cylinder rather thick, dark brown. **Branches** in fascicles of 4–5, with 2 spreading, branch tips curved. **Stem leaves** rather small, triangular-ligulate, 1.3–1.6 × 0.6–0.8 mm; rounded apex; borders narrow above, somewhat widened near the base; hyaline cells with fibrils, with rounded pores along commissural rows in the upper on the ventral surface. **Branch leaves** broadly ovate-lanceolate, 1.5–2.0 × 0.8–1.0 mm, strongly concave; blunt and dentate at the apex; margins involute, borders narrowly differentiated; hyaline cells fibrillose, with a single, numerous pores along commissural rows near the margins on the ventral surface, ringed pores along commissural rows on the dorsal surface; photosynthetic cells in cross section narrowly rectangular or narrow-elliptic, centrally located, exposed on both surfaces. **Sporophyte** not seen.

Additional illustration. – Eddy (1977: 392, Fig. 6A–J); Eddy (1988: 10, Fig. 3A–H); Gangulee (1969: , Fig. 18).

Thailand. – NORTHERN: Chiang Rai, Uttaradit. NORTH-EASTERN: Phetchabun, Loei (He, 1995).

Distribution. – Brazil, Canada, China, Colombia, Costae Rica, Greenland, Guatemala, India, Japan, Kazakhstan, Korea, Mongolia, Myanmar, New Guinea, New Zealand, Siberia, United States and Vietnam (Bartram, 1949; Eddy, 1977; Forzza, 2010; He, 1995; Waard & Florschütz, 1979).

Ecology. – on humid sandy rocks or wet sand under fern and along pond, at 1,242–1,300 m elevation

Specimens examined. – *P. Ajintaiyasil 081* (BCU).

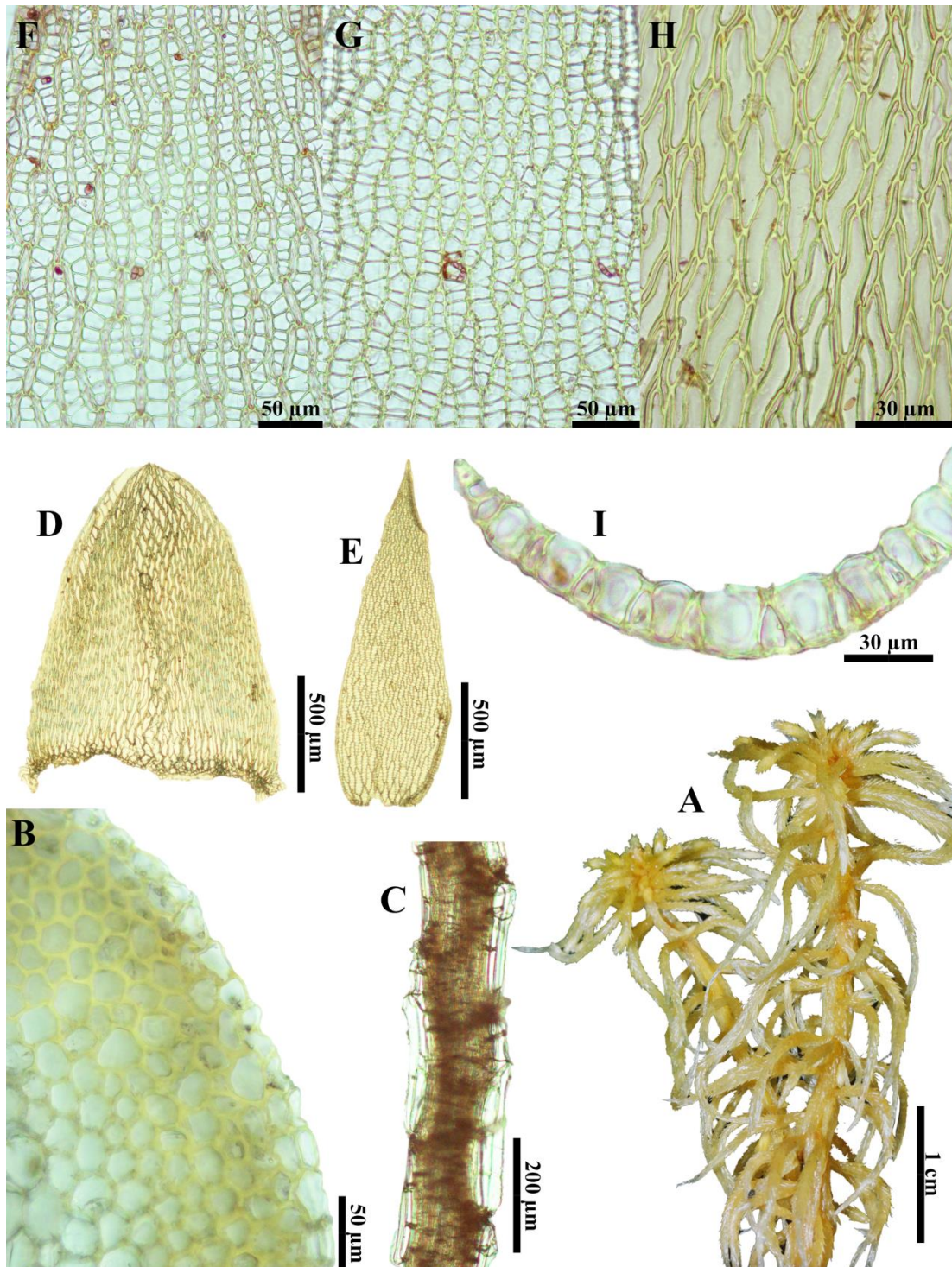


Figure 5.94 *Sphagnum cuspidatum* Müll. Hal.

A. Gametophyte, B. Cross section of stem cortex, C. Closed up of branch, D. Stem leaf, E. Branch leaf, F. Cells at median part of branch leaf, dorsal side, G. Cells at median part of branch leaf, ventral side, H. Median cells of stem leaf, I. Cross section of branch leaf. Based on *P. Ajintaiyasil* 420.

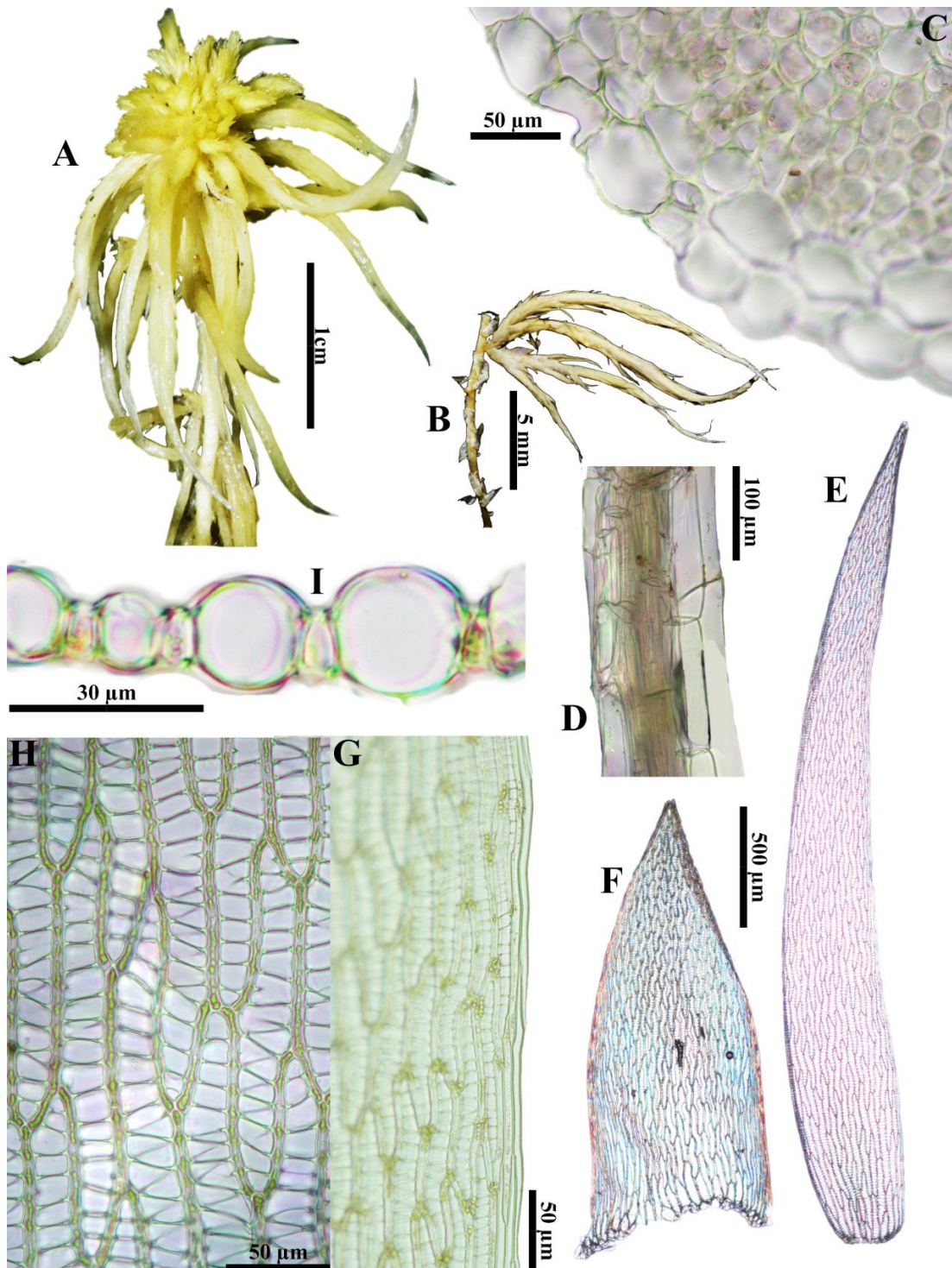


Figure 5.95 *Sphagnum cuspidatum* Ehrh. ex Hofin.

A. Gametophyte, B. Fascicle of branches, C. Cross section of stem, D. Closed up of branch, E. Branch leaf, F. Stem leaf, G. Branch leaf margin, H. Cells at median part of branch leaf, I. Cross section of branch leaf. Based on *P. Ajintaiyasil 069*.

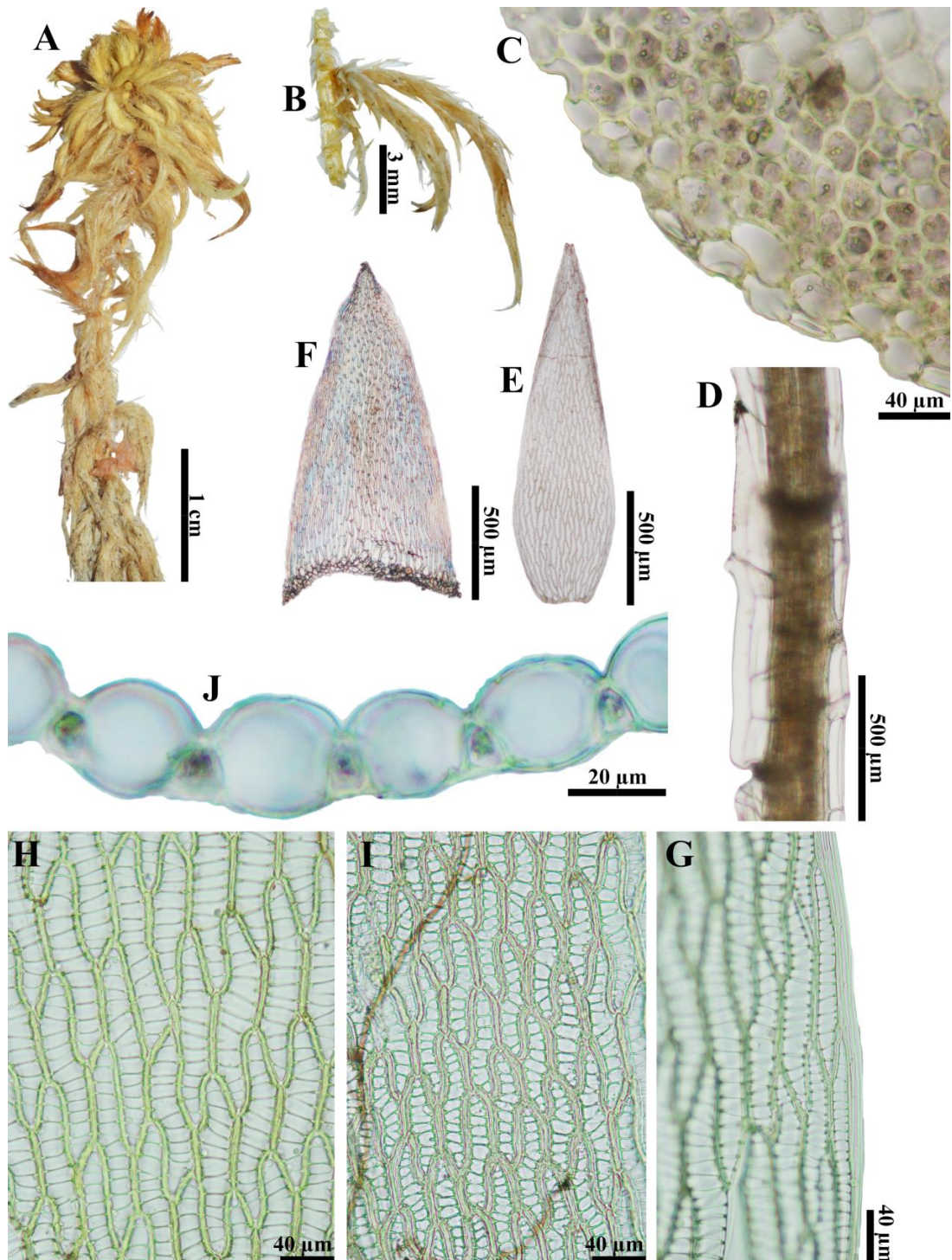


Figure 5.96 *Sphagnum cuspidatum* Ehrh. ex Hofin. subsp. *subrecurvum* (Warnst.) Eddy var. *subrecurvum*

A. Gametophyte, B. Fascicle of branches, C. Cross section of stem cortex, D. Closed up of branch, E. Branch leaf, F. Stem leaf, G. Branch leaf margin, H. Cells at median part of branch leaf, ventral side, I. Cells at median part of branch leaf, dorsal side, J. Cross section of branch leaf. Based on *P. Ajintaiyasil 086*.

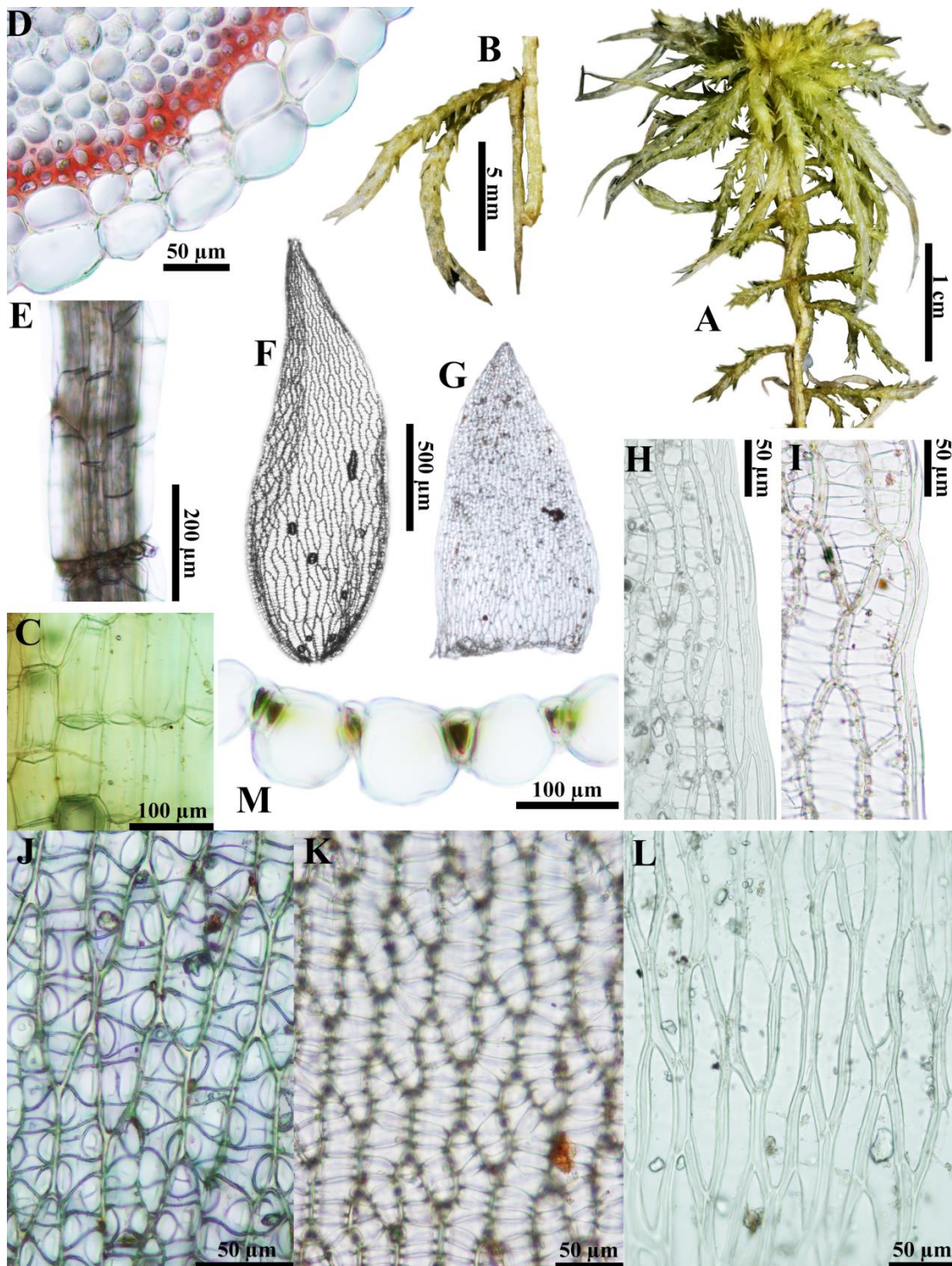


Figure 5.97 *Sphagnum junghuhnianum* Dozy & Molk.

A. Gametophyte, B. Fascicle of branches, C. Closedup of stem cortex, D. Cross section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Stem leaf margin, I. Branch leaf margin, J. Cells at median part of branch leaf, ventral side, K. Cells at median part of branch leaf, dorsal side, L. Cells at stem leaf base, M. Cross section of branch leaf. Based on *P. Ajintaiyasil 062*.

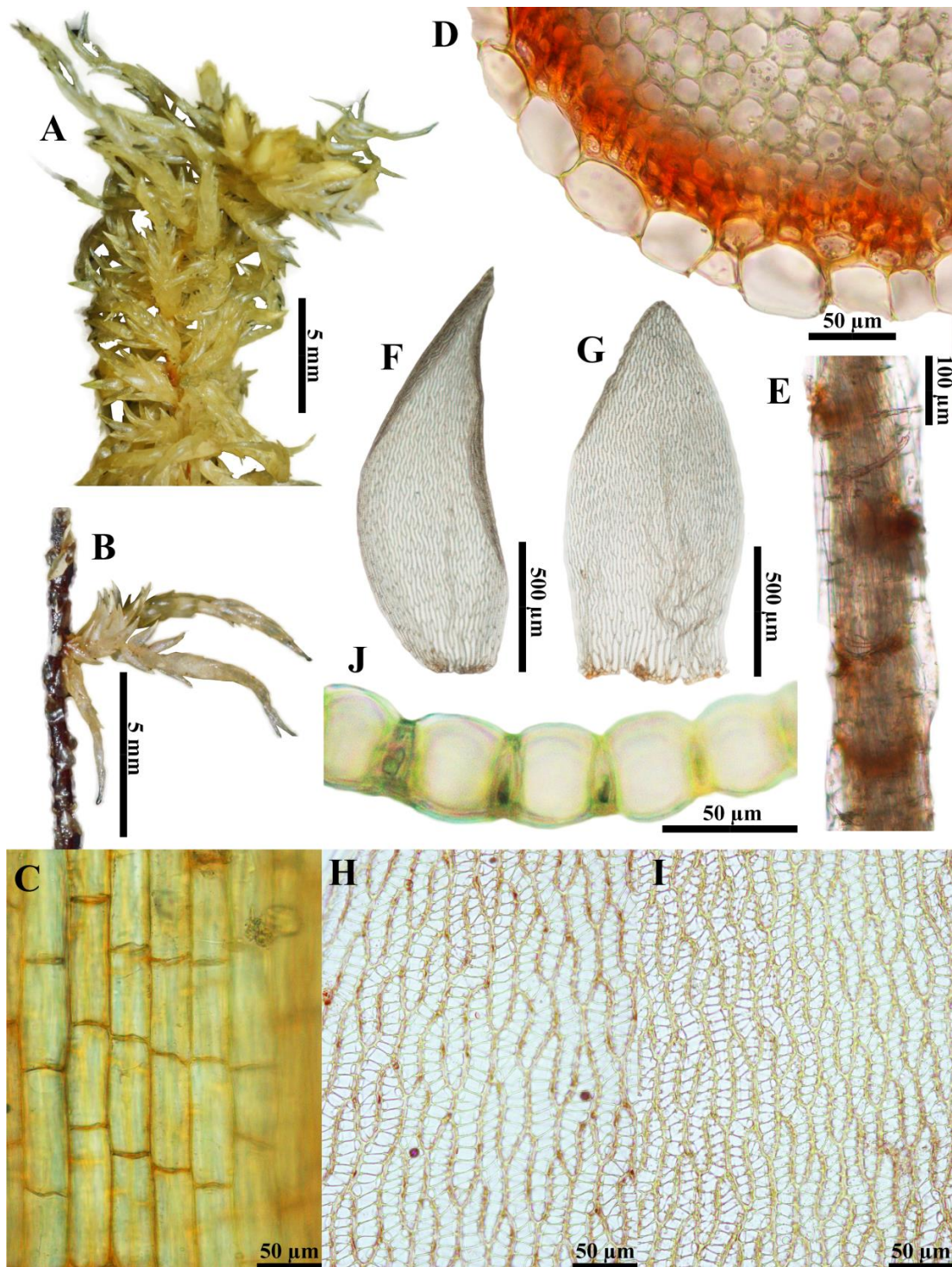


Figure 5.98 *Sphagnum luzonense* Warnst.

A. Gametophyte, B. Fascicle of branches, C. Closed up of stem cortex, D. Cross section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Cells at median part of leaf, dorsal side, I. Cells at median part of leaf, ventral side, J. Cross section of branch leaf. Based on *P. Ajintaiyasil 408*.

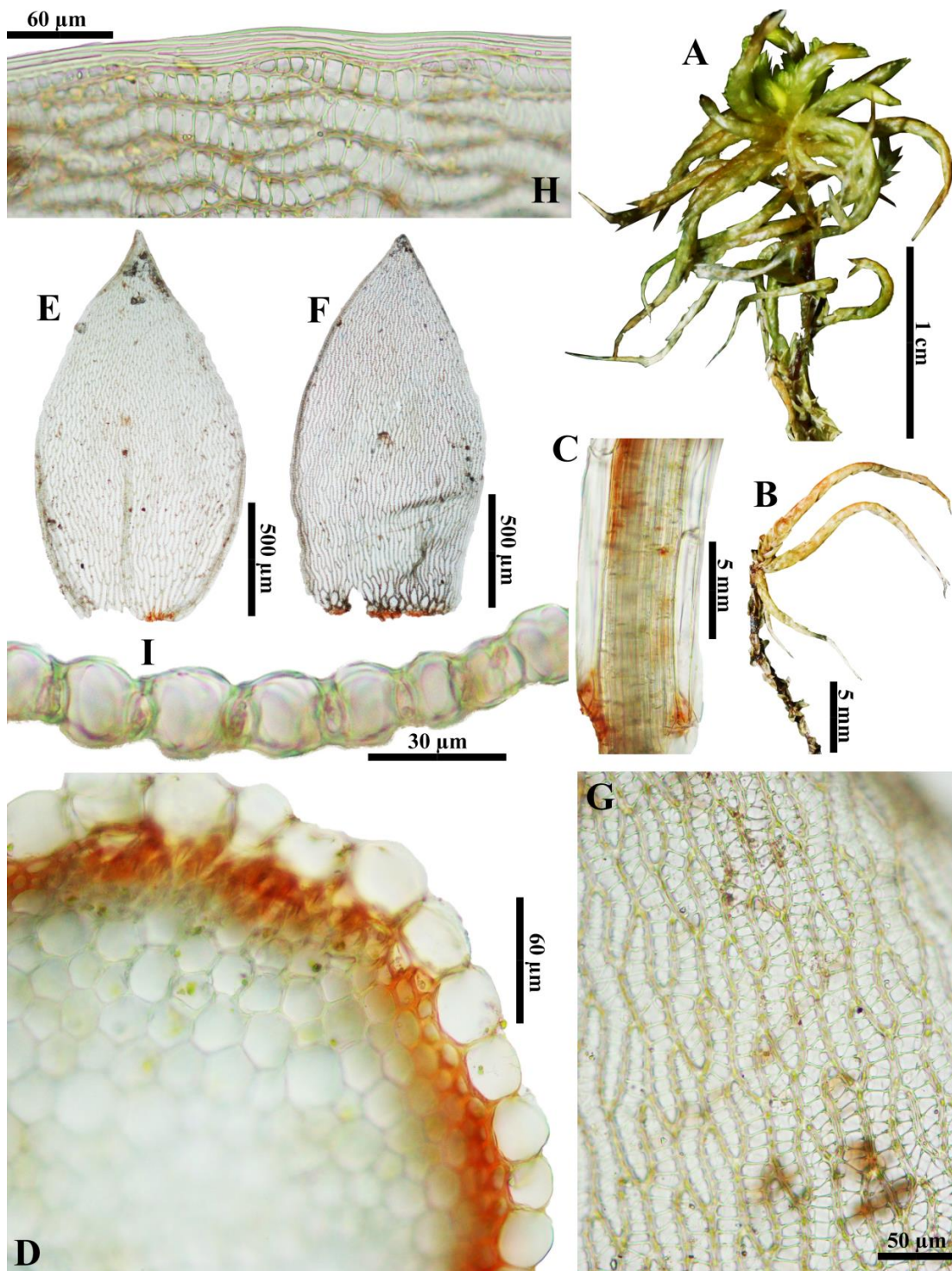


Figure 5.99 *Sphagnum ovatum* Hampe

A. Gametophyte, B. Fascicle of branches, C. Closed up of branch, D. Cross section of stem, E. Branch leaf, F. Stem leaf, G. Cells at median part of branch leaf, H. Branch leaf margin, I. Cross section of branch leaf. Based on *P. Ajintaiyasil* 085.

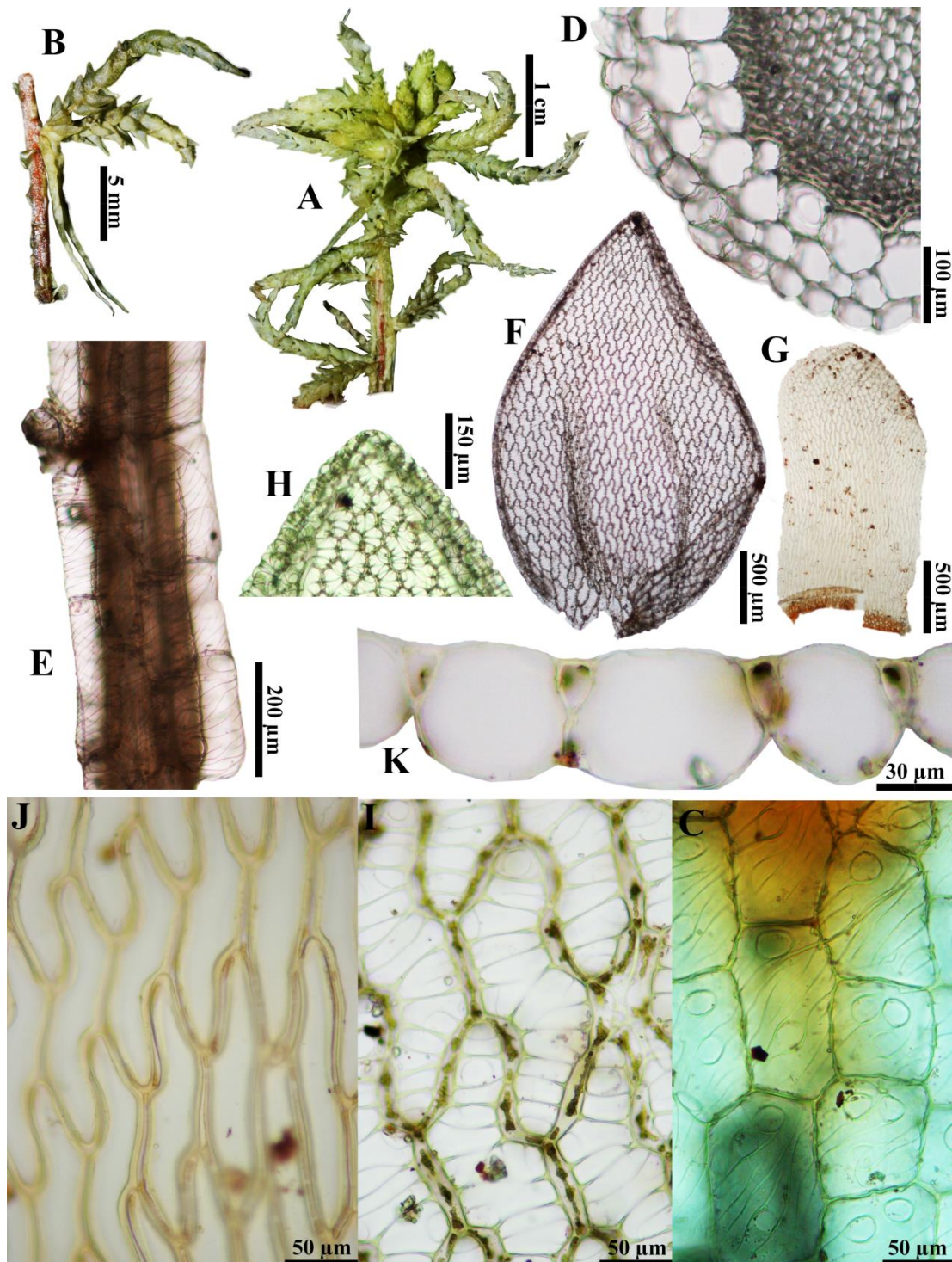


Figure 5. 100 *Sphagnum palustre* L. subsp. *palustre*

A. Gametophyte, B. Fascicle of branches, C. Closed up of stem cortex, D. Cross section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Branch leaf apex, I. Cells at median part of branch leaf, J. Cells at stem leaf base, K. Cross section of branch leaf. Based on *P. Ajintaiyasil 020*.

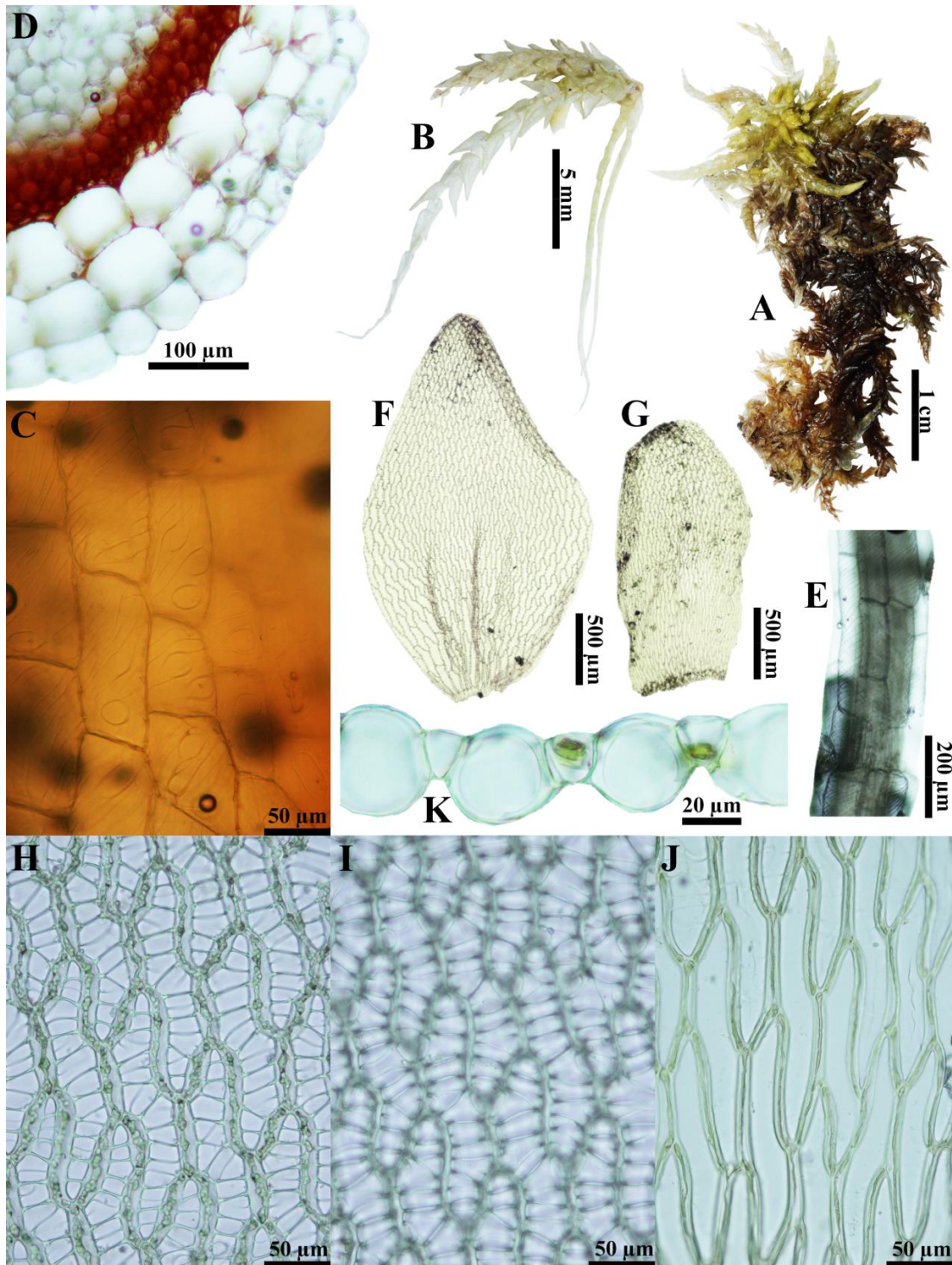


Figure 5. 101 *Sphagnum palustre* L. subsp. *pseudocymbifolium* (Müll. Hal.) A. Eddy
 A. Gametophyte, B. Fascicle of branches, C. Closed up of stem cortex, D. Cross
 section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Cells at
 median part of branch leaf, ventral side, I. Median cells of branch leaf, dorsal side, J.
 Cells at stem leaf base, K. Cross section of branch leaf. Based on *P. Ajintaiyasil 035*.

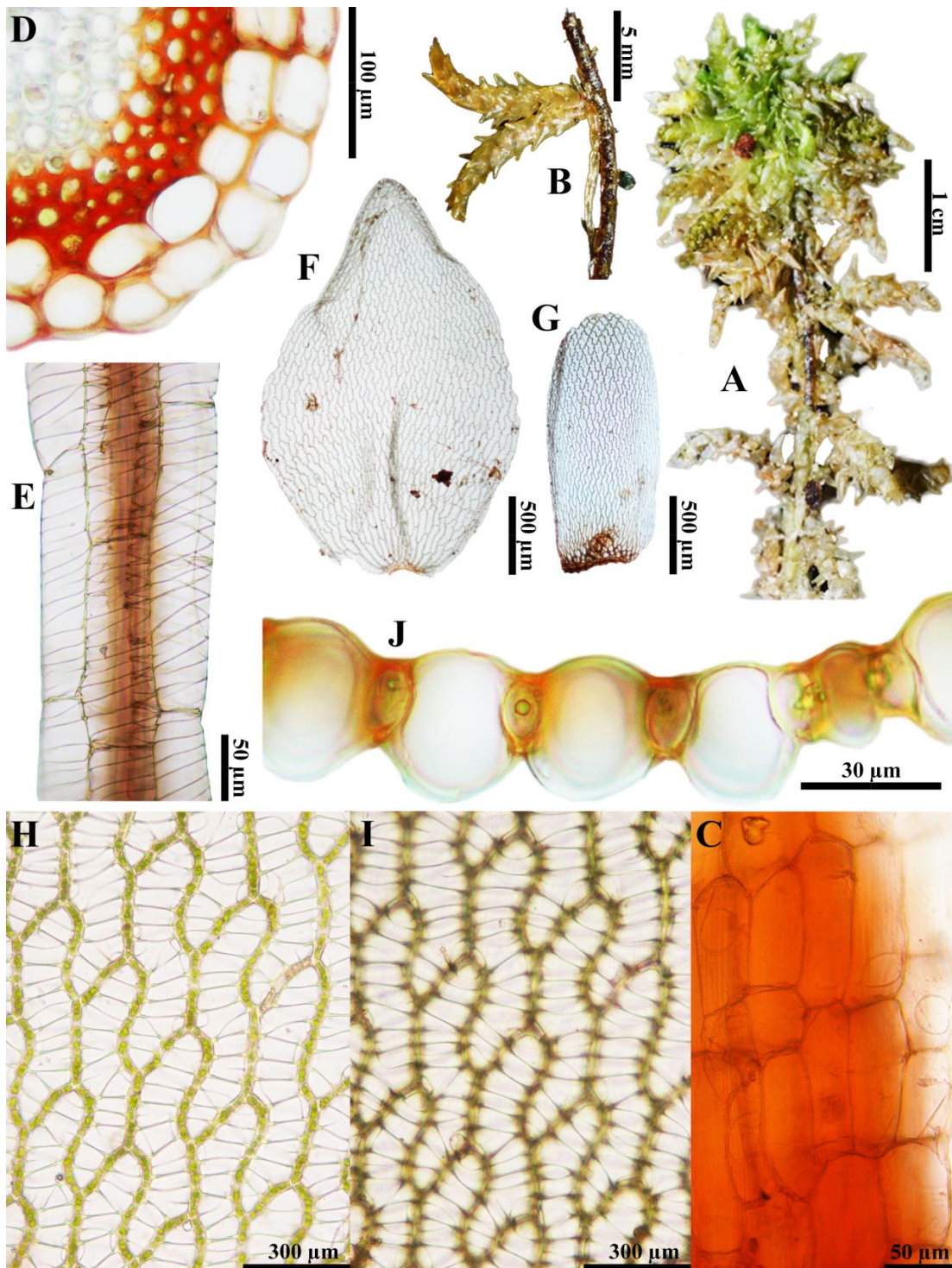


Figure 5.102 *Sphagnum perichaetiale* Hampe

A. Gametophyte, B. Fascicle of branches, C. Closed up of stem cortex, D. Cross section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Cells at median part of branch leaf, ventral side, I. Cells at median part of branch leaf, dorsal side, J. Cross section of branch leaf. Based on *P. Ajintaiyasil 016*.

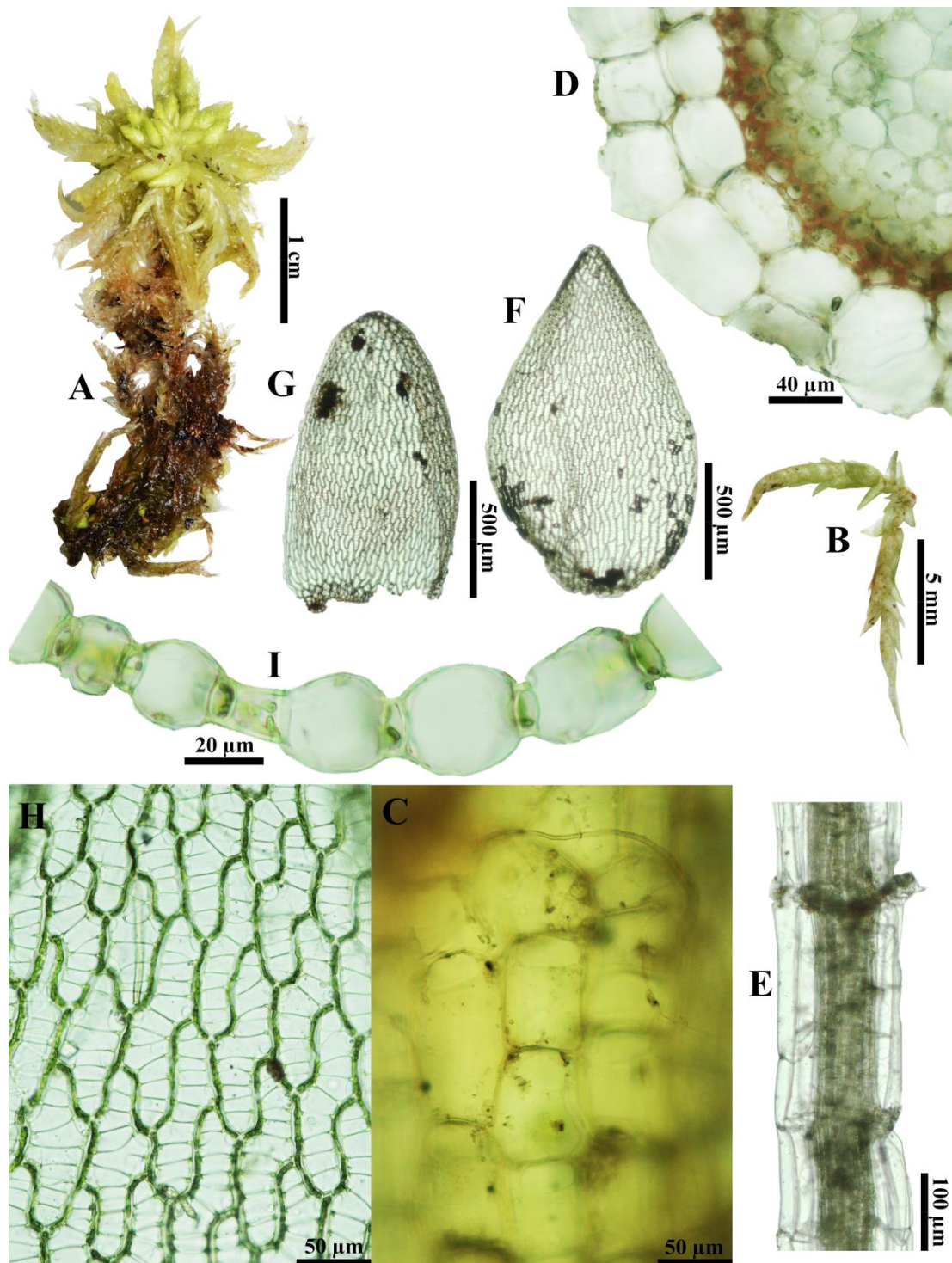


Figure 5.103 *Sphagnum robinsonii* Warnst.

A. Gametophyte, B. Fascicle of branches, C. Closed up of stem cortex, D. Cross section of stem, E. Closed up of branch, F. Branch leaf, G. Stem leaf, H. Cells at median part of branch leaf, I. Cross section of branch leaf. Based on *P. Ajintaiyasil* 441.

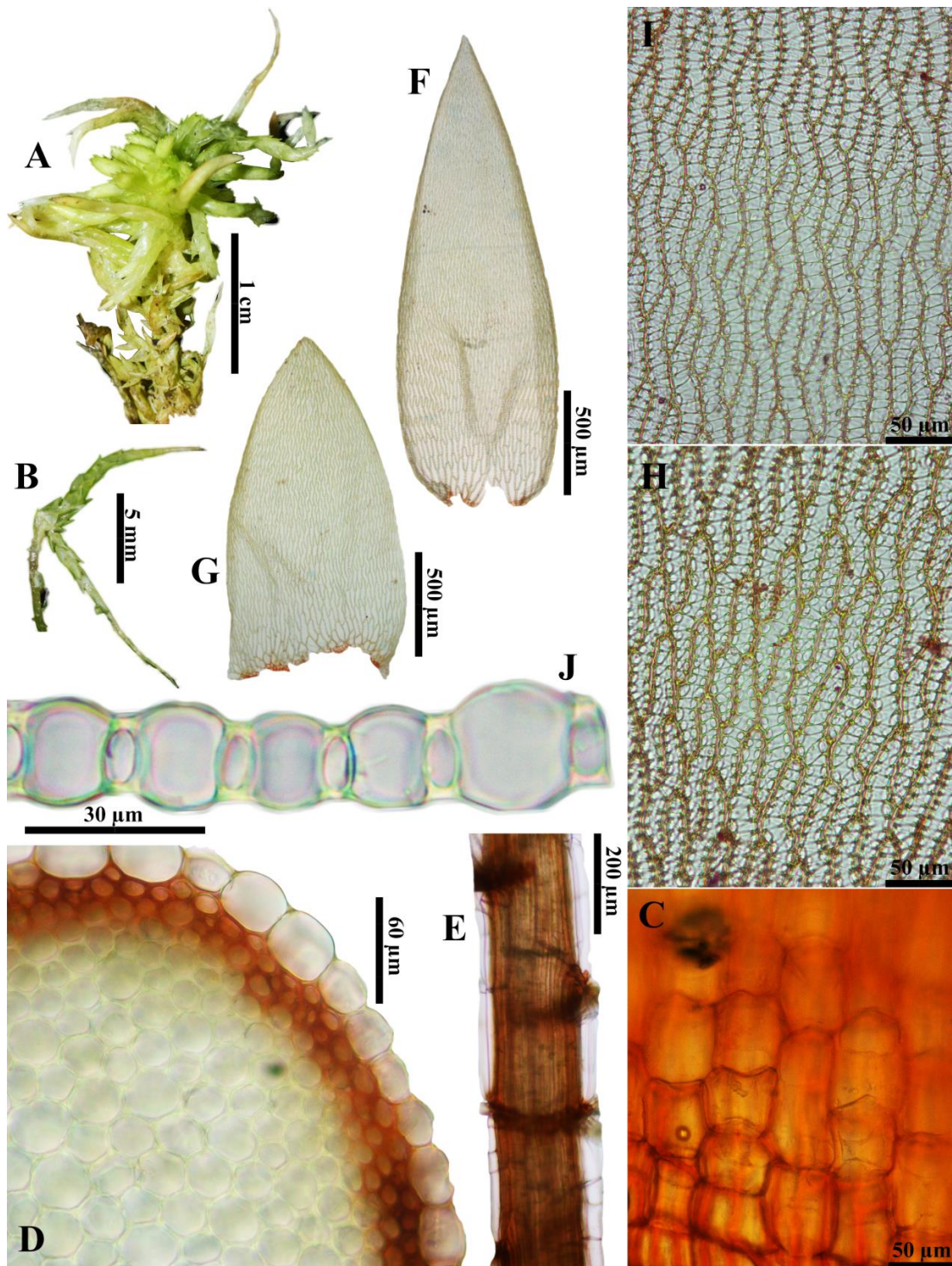


Figure 5. 104 *Sphagnum subsecundum* Nees

A. Plant, B. Fascicle of branches, C. Stem cortex, D. Cross section of stem, E. Branch cortex, F. Branch leaf, G. Stem leaf, H. Median cells of branch leaf, dorsal side, I. Median cells of branch leaf, ventral side, J. Cross section of branch leaf. Based on *P. Ajintaiyasil 081*.

29. STEREOPHYLLACEAE

W.R. Buck & Ireland, *Nova Hedwigia* 41: 95. 1985; Deng-ke, *Moss Fl. China* 7: 212. 2008.

Plants small to medium-sized, forming loose to dense mats, mostly glossy light to dark green, or yellowish. **Stems** creeping and spreading, occasionally subscending, simple to few irregularly pinnately branched, radiculose below; central strand present or absent; rhizoids smooth or papillose. **Leaves** weakly to strongly complanate or terete, lanceolate, oblong or oblong-ovate; apex acute to acuminate or obtuse; margins plane, occasionally reflexed at base, entire to serrulate distally; costae single, 1/2–2/3 lamina length, or both none and weak, short and forked; median cells elongate, mostly smooth, rarely unipapillose, papillae over cell lumen or projecting at angles, angles tapering or obtuse-rounded; alar region differentiated, asymmetric with cells often more numerous on one side, alar cells often extending to or over costae, quadrate to short rectangular. **Autoicous. Perichaetia** lateral, leaves elongate, lanceolate. **Setae** elongate smooth. **Capsules** inclined to erect, urn ovoid-short cylindrical to cylindrical, asymmetric. **Opercula** conic-short rostrate, usually oblique. **Peristome** double; exostome teeth 16, cross-striolate to papillose; endostome slightly to distinctly shorter than the exostome, mostly finely papillose, basal membrane high to occasionally low, segments 16, keeled and perforate, cilia 1-3 or rudimentary to absent. **Calyptrae** cucullate, naked and smooth. **Spores** spherical, finely to coarsely papillose.

ENTODONTOPSIS

Broth., *Nat. Pflanzenfam.* 227/228[I,3]: 895–896, f. 657. 1907; Deng-ke, *Moss Fl. China* 7: 212. 2008.

Plants small to medium-sized, pale green or yellowish green, glossy, in loose or dense mats. **Stems** prostrate, complanate or julaceous, simple or irregularly, remotely branched; in cross section cortical cells thick-walled; central strand weakly differentiated; pseudoparaphyllia few, filamentous. **Leaves** densely or loosely arranged, symmetric or asymmetric, erect-spreading when moist, imbricate when dry; slightly falcate, sometimes secund, elliptical-lanceolate, narrowly ovate or ovate-lanceolate, sometimes ligulate; acuminate, abruptly acute or obtusely apiculate at apex; margins plane or slightly involute, entire or serrulate above; costae single, reaching 1/3–1/2 the leaf length; median leaf cells narrowly rhombic to rhomboidal, thin-walled, usually smooth, rarely prorate; alar cells distinctly differentiated, consisting of several rows of quadrate or shortly rectangular cells, uneven in numbers on both sides of angle. **Autoicous. Perichaetial leaves** bluntly acuminate, entire or serrulate; costaete or ecostaete. **Setae** straight or twisted, yellowish or yellowish brown, smooth. **Capsules** erect or slightly curved, cylindrical, ellipsoidal or ovoid, constricted below the mouth when dry. **Opercula** conic, shortly rostrate. **Peristome** double; exostome teeth indistinctly bordered, cross-striolate below, papillose above; endostome segments keeled, perforate, smooth or papillose; basal membrane low or high; cilia often reduced or rarely 1–3. **Calyptrae** cucullate, smooth. **Spores** spherical, papillose.

Entodontopsis anceps (Bosch & Sande Lac.) W.R. Buck & R.R. Ireland, *Nova Hedwigia* 41: 103. 1985; Deng-ke, *Moss Fl. China* 7: 213. 2008. — *Hypnum anceps* Bosch & Sande Lac., *Bryol. Jav.* 2: 161. pl. 260. 1867. — *Hypnum llanosii* Duby, *Flora* 60: 92. 1877. — *Stereophyllum anceps* (Bosch & Sande Lac.) Broth., *Nat. Pflanzenfam.* I(3): 898. 1907; Gangulee, *Mosses E. India* 8: 1821. 1980. (**Figure 5.105**)

Plants yellowish green, glossy, in loose mats. **Stems** prostrate, irregularly branched, with shortly blunt branches, complanately foliate; central strand absent. **Leaves** loosely imbricate, somewhat larger, slightly asymmetric, spreading, in 2 ranks, elliptical, 1.4–1.9 × 0.4–0.6 mm, concave; narrowed toward base, slightly decurrent at base; margins serrulate near the apex; costae slender, reaching 1/2 the leaf length; median leaf cells narrowed rhomboidal to fusiform, thin-walled, smooth, 67–115 × 6–8 µm, apical cells shorter; alar cells differentiated, irregularly quadrate or shortly rectangular, 13–26 × 13–20 µm. **Autoicous. Perichaetial leaves** ovate-lanceolate, 1.3–1.9 × 0.4–0.6 mm; narrowly acuminate, serrulate in the upper margins. **Setae** 5–7 mm long, reddish brown, smooth. **Capsules** erect, oblong-ovoid, symmetric, neck distinct. **Opercula** not seen. **Peristome** inserted above the mouth; exostome teeth broadly lanceolate, blunt at apex, reflexed when dry, with zig-zag median line, cross-striolate below, papillose above; endostome segments shorter than the teeth, perforate, papillose; basal membrane 1/3 the endostome height. **Calyptrae** not seen. **Spores** spherical, papillose.

Additional illustration. – Bartram (1939: Pl. 23, Fig. 396); Gangulee (1980: 1822, Fig. 924, as *Stereophyllum anceps*); Hu *et al.* (2008: 214, Pl. 578, 1–10).

Thailand. – NORTHERN: Chiang Mai, Lampang, Tak. NORTH-EASTERN: Phetchabun, Loei, Khon Kaen. EASTERN: Nakhon Ratchasima. SOUTH-WESTERN: Ratchaburi. CENTRAL: Nakhon Nayok. PENINSULAR: Yala (He, 1995).

Distribution. – Bangladesh, China, India, Indonesia, Myanmar, Philippines, Sri Lanka, Thailand, Vietnam (He, 1995).

Ecology. – On bark under sunlight, at 281–288 m elevation.

Specimens examined. – *P. Ajintaiyasil* 438, 439 (BCU).

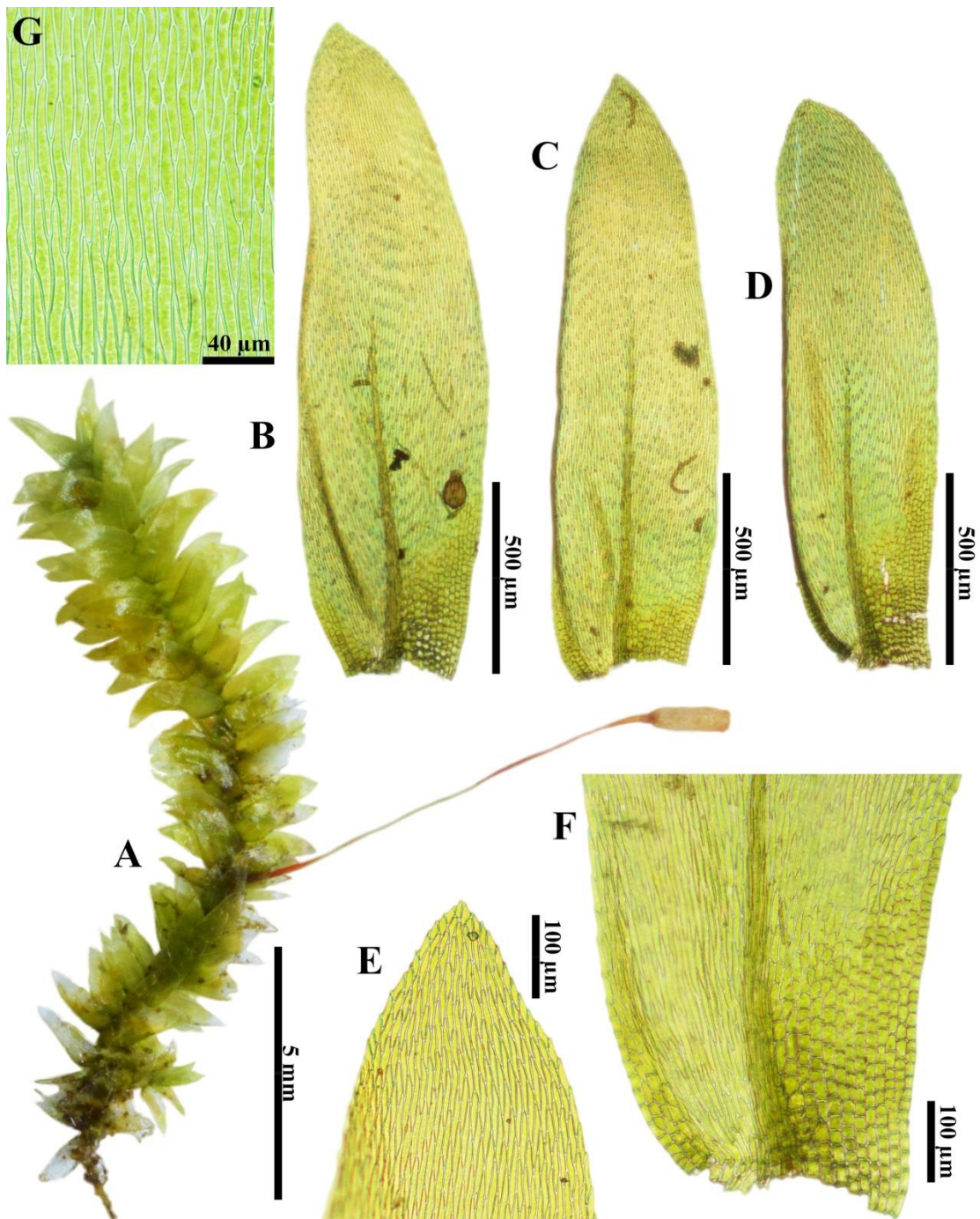


Figure 5.105 *Entodontopsis anceps* (Bosch & Sande Lac.) W.R. Buck & R.R. Ireland

A. Gametophyte with sporophyte, B–D. leaf, E. Leaf apex, F. Leaf base with alar region, G. Cells at median part of leaf. Based on *P. Ajintaiyasil* 438.

30. THUIDIACEAE

Schimp., Syn. Musc. Eur. 493. 1860; Gangulee, Mosses E. India 7: 1578. 1978; Noguchi, Ill. Moss Fl. Japan 4: 842. 1991; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 150. 2002.

Plants small to large and rather robust, forming loose to somewhat dense mats or wefts, dull light to dark green, yellowish-green to –brown, or golden. **Stems** 1-3 pinnately branched, often rather densely tomentose; central strand present; paraphyllia scattered or dense, simple to more commonly branched, papillose. **Leaves** usually strongly dimorphic. **Stem leaves** appressed to erect reading, ovate- or cordate (triangular)-lanceolate or -subulate; apex short to long acuminate; margins plane distally, recurved or reflexed below, entire to serrulate- or crenulate-papillose; costae single, usually strong and projecting on back, percurrent to excurrent; median cells oval to isodiametric, uni- or pluripapillose on back or both surfaces, papillae low or long and often curved. **Branch leaves** broadly to somewhat narrowly ovate or ovate-short lanceolate; apex acute to obtuse; costae often ending below apex. **Autoicous** or dioicous. **Perichaetial leaves** usually differentiated, long ovate-lanceolate to lanceolate; margins ciliate or not. **Setae** elongate, often roughened. **Capsules** typically curved and asymmetric. **Opercula** short to long rostrate, oblique. **Peristome** double; exostome teeth 16, densely cross-striolate below, distally papillose; endostome lightly papillose, basal membrane high, segments 16, keeled and perforate, cilia 2-3(4). **Calyptrae** cucullate, naked or sparsely hairy. **Spores** spherical, smooth to more commonly papillose.

THUIDIUM

Schimp., Bryol. Eur. 5: 157. 1852; Gangulee, Mosses E. India 7: 1618. 1978; Noguchi, Ill. Moss Fl. Japan 4: 860. 1991; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 197. 2002.

Plants green, yellowish green or brownish green, often in loosely interwoven wefts. **Stems** procumbent to climbing, bi- to tripinnately branched; paraphyllia abundant on stems and branches, filamentous or foliose, often papillose; central strand present. **Stem leaves** ovate or ovate-cordate; usually with slender apex, narrowed at base, decurrent, multiplicate; margins revolute, serrulate above; costae not extending to leaf apex, rarely excurrent; cells isomorphic, mostly hexagonal or rounded to rounded-hexagonal, equally thick-walled, uni- or multipapillose. **Branch leaves** minute, mostly ovate or oblong-ovate, concave; leaf margins erect; costae weak and short. **Autoicous** or dioicous. **Perichaetial leaves** lanceolate or ovate-lanceolate, with slender apices, sometimes leaf margins with long cilia; costae ending at leaf apex or slightly excurrent; leaf cells rectangular, smooth or papillose. **Setae** slender, smooth or densely papillose above. **Capsules** horizontal or declining, ovoid or cylindrical, slightly curved, brownish, smooth. **Opercula** acute to conical, obliquely beaked; stomata present. **Peristome** double; exostome teeth yellowish or yellowish brown; basal membrane high, at least 1/3 the length of endostome segments; cilia 2–4, mostly

nodulose, rarely rudimentary or lacking. **Calyptrae** cucullate or campanulate, smooth, rarely scabrous. **Spores** spherical, smooth to more commonly papillose.

Key to the species

- 1a. Stem leaves ovate or widely ovate.....2. *Thuidium pristocalyx* var. *pristocalyx*
 1b. Stem leaves triangular or cordate.....2
 2a. Stem leaves triangular.....3. *Thuidium pristocalyx* var. *samoanum*
 2b. Stem leaves cordate.....1. *Thuidium plumulosum*

1. *Thuidium plumulosum* (Dozy & Molk.) Dozy & Molk., Bryol. Jav. 2: 118. 223. 1865; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 203. 2002. — *Hypnum plumulosum* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 308. 1844. — *Leskea ramentosa* Mitt., Bonplandia (Hannover) 9: 366. 1861. — *Hypnum lasiomitrium* Müll. Hal., Bot. Zeitung (Berlin) 20: 393. 1882. (**Figure 5.106**)

Plants dark green, lightly brownish green when old, in loose wefts, medium-sized, 2.5–6.0 cm long, slightly rigid. **Stems** usually bipinnately branched; in cross section central strand present; paraphyllia dense, filamentous, forked, papillose; branches 2.0–5.0 cm long. **Stem leaves** remote, slightly plicate, with ovate-triangular or ovate-cordate bases, 0.3–0.4 × 0.2–0.3 mm; suddenly narrowed to piliferous apices; costae vanishing below leaf apex; margins serrate. **Branch leaves** ovate-triangular, younger leaves ovate to widely ovate, 0.2–0.3 × 0.1–0.2 mm; with narrowly obtuse apices; cells rounded hexagonal, oblong, median cells rather thick-walled, with single, sharp papilla on dorsal surfaces. **Dioicous**. **Perichaetial leaves** gradually narrowed from oblong bases to lanceolate, piliferous apices, margins long ciliate. **Setae** densely papillose, 2–3 cm long. **Capsules** reddish brown, oblong ovoid. **Opercula** shortly beaked. **Peristome** double; exostome teeth lightly yellowish to lightly red, densely transversely striate, hyaline at apex, papillose; endostome segments lightly yellowish; basal membrane ca. 1/2 the height of segments, papillose; cilia 3–4, nodulose. **Spores** nearly smooth.

Additional illustration. — Touw (2001: 8, Fig. 1).

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Phitsanulok, Tak. NORTH-EASTERN: Loei, Khon Kaen. EASTERN: Nakhon Ratchasima. SOUTH-WASTHERN: Kanchanaburi, Ratchaburi, Prachuap Khiri Khan. CENTRAL: Nakhon Nayok. SOUTH-EASTERN: Prachin Buri, Chanthaburi. PENINSULAR: Chumphon, Surat Thani, Nakhon Si Thammarat, Phatthalung, Trang, Yala, Narathiwat (He, 1995).

Distribution. — Bangladesh, Brunei, China, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Sumatra, Taiwan, Vanuatu, and Vietnam (He, 1995).

Ecology. — On soils or bark under shade of tree, near waterfall, at 766–1,250 m elevation.

Specimens examined. – *P. Ajintaiyasil* 255, 457, 469, 475 (BCU).

2. *Thuidium pristocalyx* (Müll. Hal.) A. Jaeger var. ***pristocalyx*** (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 257. 1878; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 204. 2002. — *Hypnum pristocalyx* Müll. Hal., Bot. Zeitung (Berlin) 12: 573. 1854. (**Figure 5.107**)

Plants pale green or yellowish green, rarely dark green, in loosely wefts. **Stems** usually regularly pinnately branched; central strand undifferentiated; paraphyllia sparse, foliose or filamentous, branched, sometimes lacking. **Stem leaves** appressed when dry; ovate to triangularly ovate, 0.6–0.7 × 0.5–0.6 mm, concave; margins serrate; costae reaching 2/3 the leaf length, rarely forked above, usually smooth on the back, rarely papillose; median leaf cells oval to rhomboidal, thick-walled, stellately papillose. **Branch leaves** ovate to widely ovate, 0.3–0.5 × 0.3–0.4 mm; leaf cells similar to those stem leaves. **Dioicous**. **Perichaetial leaves** narrowly ovate-lanceolate, leaf margins serrate at the apex, entire at lower portion. **Setae** reddish brown or yellowish brown, up to 5 cm long. **Capsules** long cylindrical. **Peristome** double; exostome teeth broadly lanceolate, reddish brown, papillose above; endostome segments as long as the exostome teeth, finely papillose; basal membrane about 1/2 the length of endostome segments; cilia 2–3. **Spores** finely papillose.

Additional illustration. – Touw (2001: 36, Fig. 7); Wu, Crosby, & He (2002: 204, Pl. 468, Fig. 9–15).

Thailand. – NORTHERN: Mae Hong Son, Chiang Mai, Tak, Phitsanulok. NORTH-EASTERN: Phetchabun, Loei. EASTERN: Nakhon Ratchasima. CENTRAL: Nakhon Nayok. PENINSULAR: Chumphon (He, 1995).

Distribution. – Bhutan, China, India, Indonesia, Japan, Kampuchea, Korea, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam (He, 1995).

Ecology. – On rocks or barks under shade of tree, near waterfall, at 1,183–1,694 m elevation.

Specimens examined. – *P. Ajintaiyasil* 195, 236B, 356 (BCU).

3. *Thuidium pristocalyx* (Müll. Hal.) A. Jaeger var. ***samoanum*** (Mitt.) Touw, J. Hattori Bot. Lab. 91: 41. 2001. — *Thuidium samoanum* Mitt., J. Linn. Soc., Bot. 10: 186. 1868. — *Thuidium glaucinoides* Broth., Philipp. J. Sci. 3: 26. 1908; Noguchi, Ill. Moss Fl. Japan 4: 870. 1991; Peng-cheng, Mei-zhi & Ben-gu, Moss Fl. China 6: 201. 2002. — *Thuidium himantophyllum* Herzog, Hedwigia 57: 239. 1916. — *Thuidium scabribracteatum* Dixon, J. Linn. Soc., Bot. 45: 489. 28 f. 7. 1922. — *Thuidium samoanum* var. *laevius* Dixon, Proc. Linn. Soc. New South Wales 55: 292. 1930. (**Figure 5.108**)

Plants lightly brownish green or yellowish green, in wefts, large, 9–10 cm long. **Stems** regularly bipinnately branched; branches 3–10 mm long; central strand present; paraphyllia densely growing on stems or branches, filamentous, papillose.

Stem leaves appressed when dry, erect-patent when moist; broadly ovate to ovate-triangular, 1.0–1.2 × 0.5–0.6 mm; with a short apex; margins serrate, mostly flat or narrowly recurved; costae well developed, reaching 3/4 the leaf length, almost smooth to papillose on back; median leaf cells oblong-ovate to elliptic, thick-walled, uni- to multipapillose, upper cells rounded hexagonal. **Branch leaves** ovate to widely ovate, 0.2–0.3 × 0.1–0.2 mm; acute or obtuse; costae reaching 2/3 the leaf length. **Sporophytes** not seen

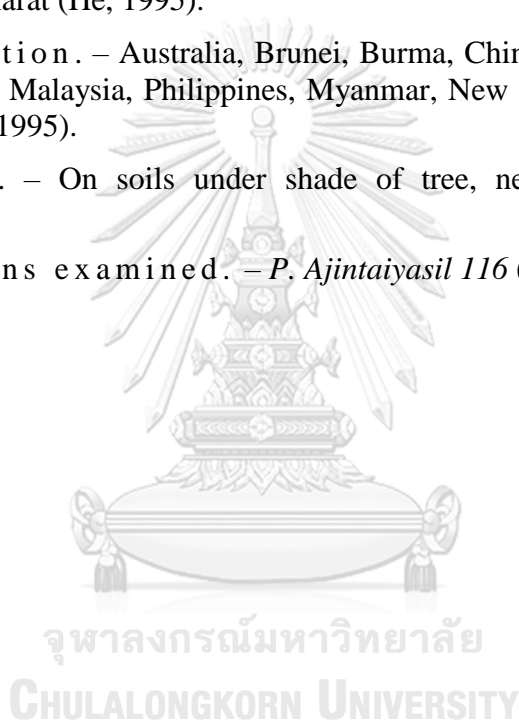
Additional illustration. – Noguchi (1991: , Fig. 382A, as *T. glaucinoides*); Touw (2001: 42–48, Fig. 9–11).

Thailand. – NORTHERN: Chiang Mai. NORTH-EASTERN: Loei. EASTERN: Nakhon Ratchasima. CENTRAL: Nakhon Nayok. PENINSULAR: Nakhon Si Thammarat (He, 1995).

Distribution. – Australia, Brunei, Burma, China, India, Indonesia, Japan, Kampuchea, Laos, Malaysia, Philippines, Myanmar, New Guinea, Taiwan, Thailand, and Vietnam (He, 1995).

Ecology. – On soils under shade of tree, near waterfall, at 1,242 m elevation.

Specimens examined. – *P. Ajintaiyasil 116* (BCU).



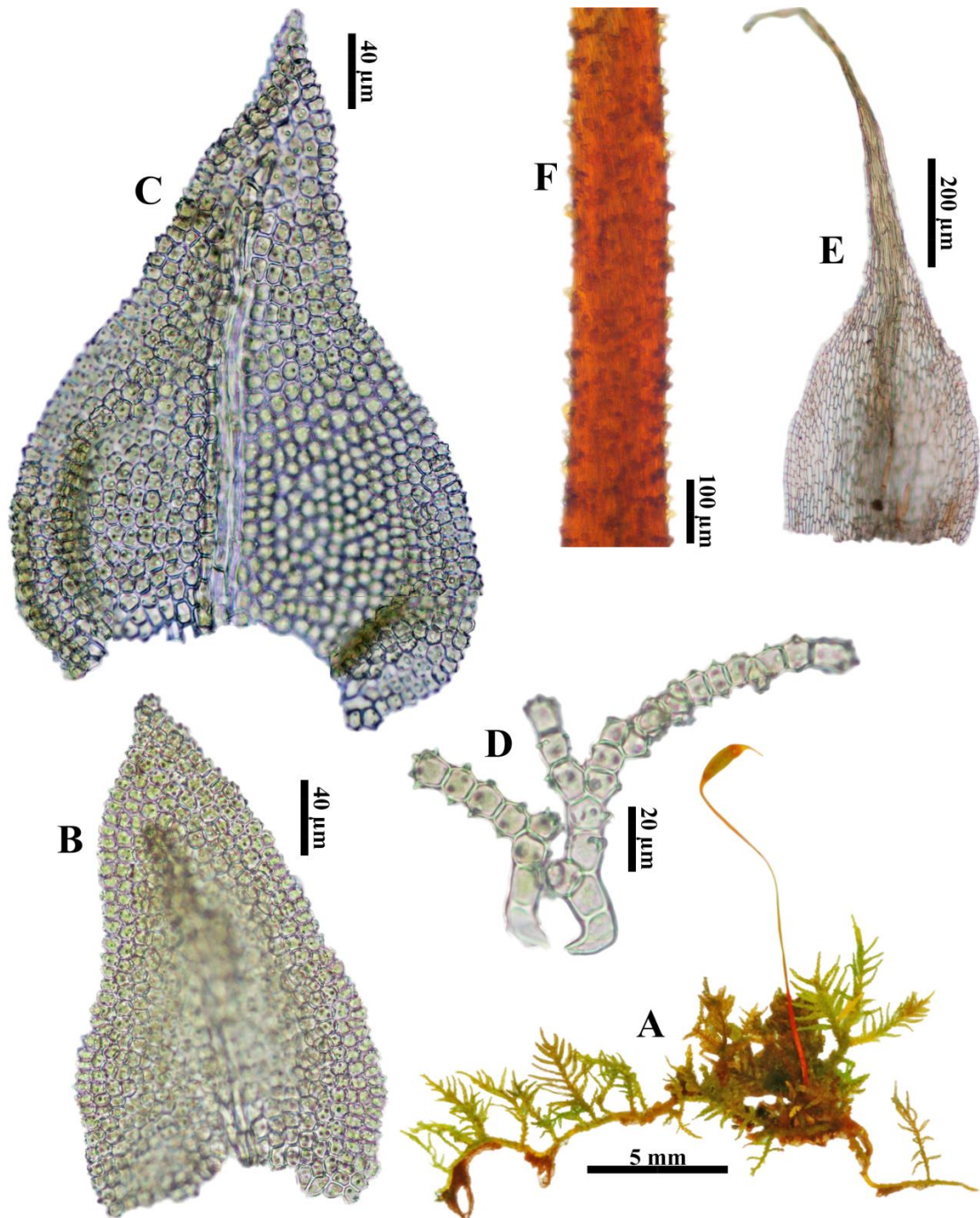


Figure 5. 106 *Thuidium plumulosum* (Dozy & Molck.) Dozy & Molck.

A. Gametophyte with sporophyte, B. Branch leaf, C. Stem leaf, D. Paraphyllum, E. Perichaetial leaf, F. Seta. Based on *P. Ajintaiyasil* 457.

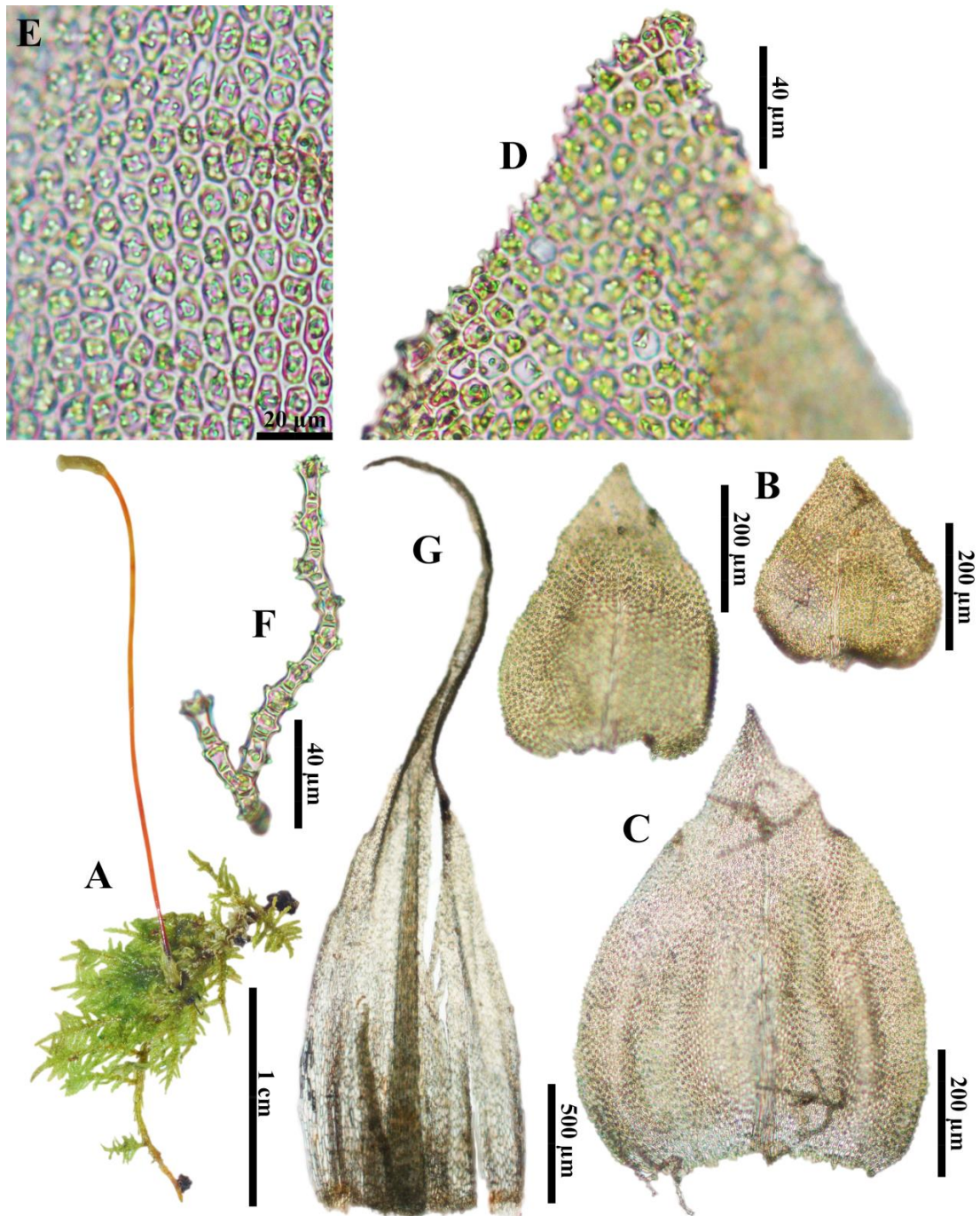


Figure 5.107 *Thuidium pristocalyx* (Müll. Hal.) A. Jaeger var. *pristocalyx* (Müll. Hal.) A. Jaeger

A. Gametophyte with sporophyte, B. Branch leaf, C. Stem leaf, D. Leaf apex, E. Cells at median part of branch leaf, F. Paraphyllium, G. Perichaetial leaf. Based on *P. Ajintaiyasil* 195.

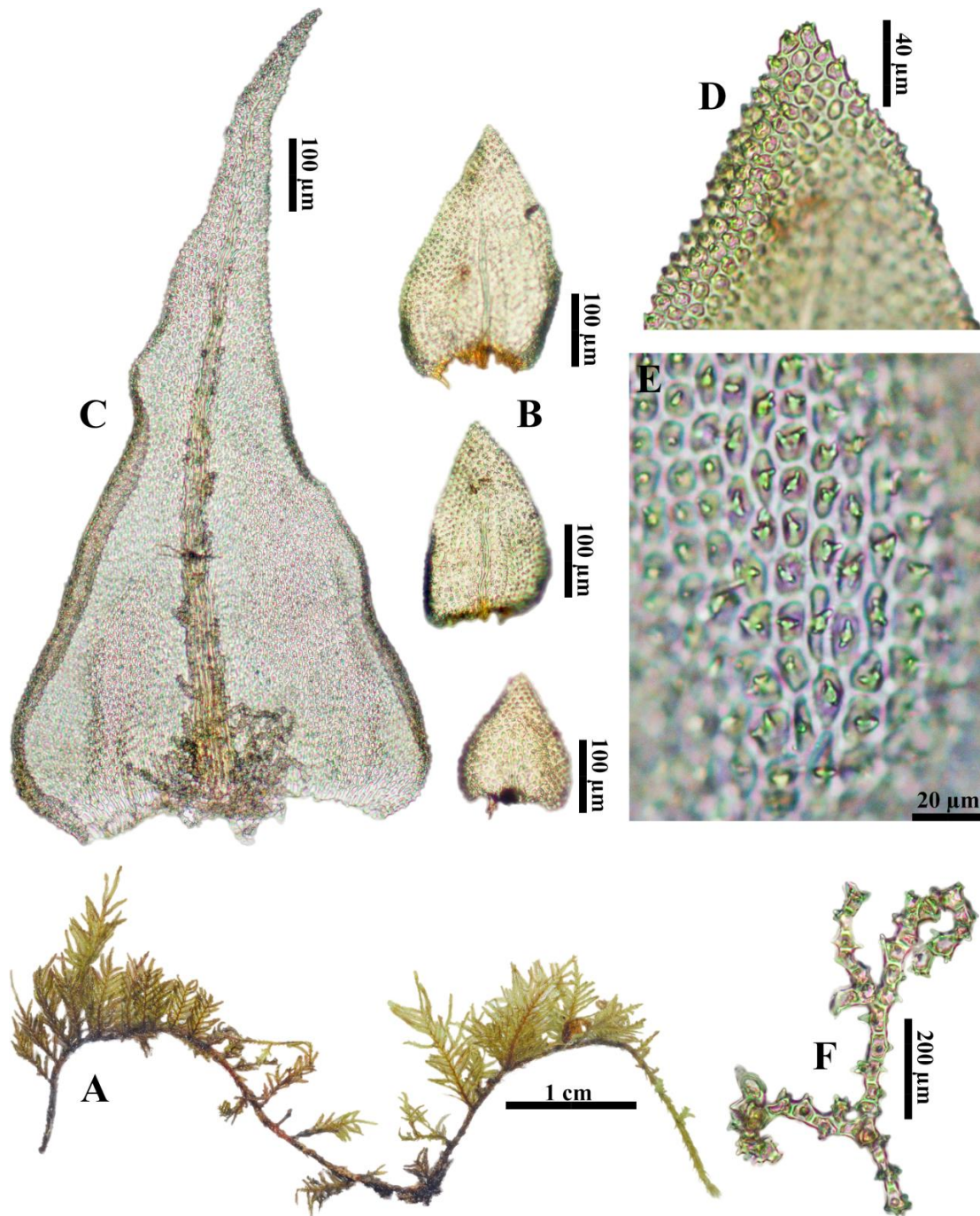


Figure 5.108 *Thuidium pristocalyx* (Müll. Hal.) A. Jaeger var. *samoanum* (Mitt.) Touw

A. Gametophyte, B. Branch leaf, C. Stem leaf with paraphyllum at base leaf, D. Leaf apex, E. Cells at median part of branch leaf, F. Paraphyllum. Based on *P. Ajintaiyasil* 116.

5.5 Distribution of mosses in Phu Kradueng National Park

Floristic regions can be divided into three sub-regions: Indo-Burmese sub-region on the north and northwest, Indo-Chinese sub-region on the northeast and Malaysian sub-region on the south (Smitinand, 1958). This study showed that most species are members of Indo-Burmese sub-region (19 species), followed by Indo-Chinese sub-region (eight species) and Malaysian sub-region (seven species). Additionally, 40 species can be found in all sub-region (Table 5.2).

Table 5. 2 Distribution and phytogeographical patterns of mosses in Phu Kradueng National Park.

Symbol: *=New record species, **=New localities

Distributed patterns: Co=Cosmopolitan, Pt=Pantropical, Pl=Palaeotropical, Ta=Tropical Asian, Tto=Tropical Asian-Tropical Australian-Oceanian, Aao=Asian- Australian-Oceanian, Ea=Eastern Asian, Es=Eastern and Southern Asian, Tr=Transpacific

Taxa	Indo-Burmese subregion	Indo-Chinese subregion	Malayan subregion	Distributed patterns
<i>Acroporium brevipes</i> (Broth.) Broth.	-	✓	-	Ta
<i>Acroporium laosianum</i> (Broth. & Paris) Broth.	-	✓	-	Ta
<i>Aerobryidium filamentosum</i> (Hook.) M. Fleisch.	✓	-	-	Ta
<i>Barbula consanguinea</i> (Thwaites & Mitt.) A. Jaeger**	-	-	✓	Pl
<i>Barbula javanica</i> Dozy & Molk.**	✓	✓	✓	Aao
<i>Brachymenium systylium</i> (Müll. Hal.) A. Jaeger	✓	-	-	Pt
<i>Brothera leana</i> (Sull.) Müll. Hal.	✓	✓	✓	Co
<i>Bryum argenteum</i> Hedw.	✓	✓	✓	Co
<i>Bryum coronatum</i> Schwägr.**	✓	✓	✓	Pt
<i>Campylopus ericoides</i> (Griff.) A. Jaeger**	✓	✓	-	Tto
<i>Campylopus serratus</i> Sande Lac.	✓	-	✓	Ta
<i>Chionostomum pinicola</i> Tixier**	-	✓	-	Ta
<i>Claopodium assurgens</i> (Sull. & Lesq.) Cardot	-	✓	-	Ta
<i>Cryptopapillaria chrysoclada</i> (Müll. Hal.) M. Menzel	✓	-	-	Ta
<i>Cryptopapillaria feae</i> (Müll. Hal. ex M. Fleisch.) M. Menzel	✓	-	-	Ta
<i>Cryptopapillaria fuscescens</i> (Hook.) M. Menzel**	✓	✓	✓	Ta

Taxa	Indo-Burmese subregion	Indo-Chinese subregion	Malayan subregion	Distributed patterns
<i>Diphyscium mucronifolium</i> Mitt.	✓	-	✓	Aao
<i>Distichophyllum nigricaulis</i> Mitt. ex Bosch & Sande Lac. var. <i>elmeri</i> (Broth.) B.C. Tan & H. Rob.	-	-	✓	Ta
<i>Ectropothecium dealbatum</i> (Reinw. & Hornsch.) A. Jaeger**	✓	-	-	Pl
<i>Ectropothecium monumentorum</i> (Duby) A. Jaeger**	✓	-	✓	Ta
<i>Entodon macropodus</i> (Hedw.) Müll. Hal.	✓	✓	-	Tr
<i>Entodontopsis anceps</i> (Bosch & Sande Lac.) W.R. Buck & R.R. Ireland	✓	✓	-	Ta
<i>Erpodium mangiferae</i> Müll. Hal.	✓	-	-	Ta
<i>Erythrodontium julaceum</i> (Hook. ex Schwägr.) Paris	✓	✓	-	Ta
<i>Fissidens ceylonensis</i> Dozy & Molk.**	✓	✓	✓	Tto
<i>Fissidens crispulus</i> Brid. var. <i>robinsonii</i> (Broth.) Z. Iwats. & Z.H. Li**	✓	✓	✓	Ta
<i>Fissidens flaccidus</i> Mitt. var. <i>flaccidus</i> **	✓	✓	✓	Pt
<i>Fissidens geppii</i> M. Fleisch.**	✓	✓	✓	Ea
<i>Fissidens guandongensis</i> Z. Iwats. & Z.H. Li**	-	✓	✓	Ta
<i>Fissidens incognitus</i> Gangulee**	✓	✓	-	Ta
<i>Fissidens javanicus</i> Dozy & Molk.**	✓	✓	✓	Ta
<i>Fissidens polypodioides</i> Hedw.	✓	✓	✓	Tr
<i>Fissidens subangustus</i> M. Fleisch.**	-	-	✓	Ta
<i>Funaria hygrometrica</i> Hedw.	✓	✓	-	Pt
<i>Himantocladium cyclophyllum</i> (Müll. Hal.) M. Fleisch.	✓	✓	✓	Pl
<i>Himantocladium plumula</i> (Nees) M. Fleisch.	✓	✓	✓	Aao
<i>Homaliadelphus targionianus</i> (Mitt.) Dixon & P. de la Varde	✓	✓	-	Ta
<i>Homaliodendron microdendron</i> (Mont.) M. Fleisch.	✓	✓	✓	Ta
<i>Hyophila apiculata</i> M. Fleisch.**	-	-	✓	Tr
<i>Hyophila involuta</i> (Hook.) A. Jaeger	✓	✓	✓	Co

Taxa	Indo-Burmese subregion	Indo-Chinese subregion	Malayan subregion	Distributed patterns
<i>Isopterygium albescens</i> (Hook.) A. Jaeger var. <i>smallii</i> (Sull. & Lesq.) Z. Iwats.	-	✓	-	Ea
<i>Isopterygium lignicola</i> (Mitt.) A. Jaeger	✓	✓	-	Ta
<i>Leptopterigynandrum decolor</i> (Mitt.) M. Fleisch.*	✓	-	-	Ea
<i>Leucobryum aduncum</i> Dozy & Molk. var. <i>scalare</i> (Müll. Hal. ex M. Fleisch.) A. Eddy	✓	✓	✓	Tto
<i>Leucobryum bowringii</i> Mitt.	✓	✓	✓	Tr
<i>Leucobryum javense</i> (Brid.) Mitt.	✓	✓	✓	Aao
<i>Leucobryum juniperoideum</i> (Brid.) Müll. Hal.	✓	✓	✓	Pl
<i>Leucoloma mittenii</i> M. Fleisch.**	✓	✓	-	Ta
<i>Leucoloma molle</i> (Müll. Hal.) Mitt.	-	✓	✓	Ta
<i>Leucophanes octoblepharioides</i> Brid.	✓	✓	✓	Pl
<i>Lopidium trichocladon</i> (Bosch & Sande Lac.) M. Fleisch.	✓	✓	-	Ta
<i>Macromitrium densus</i> Mitt.**	✓	-	-	Ta
<i>Macromitrium ferriei</i> Cardot & Thér.**	-	✓	-	Es
<i>Neckeropsis exserta</i> (Hook. ex Schwägr.) Broth. var. <i>exserta</i>	✓	-	✓	Ta
<i>Neodictyella flagellifera</i> (Cardot) Huttunen & D. Quandt**	✓	✓	-	Aao
<i>Octoblepharum albidum</i> Hedw.	✓	✓	✓	Pt
<i>Octoblepharum pocsii</i> Magill & B.H. Allen*	-	✓	-	Pl
<i>Philonotis hastata</i> (Duby) Wijk & Margad.	✓	✓	✓	Pt
<i>Philonotis mollis</i> (Dozy & Molk.) Mitt.	✓	✓	✓	Aao
<i>Pinnatella alopecuroides</i> (Mitt.) M. Fleisch.	✓	-	✓	Tto
<i>Pinnatella ambigua</i> (Bosch & Sande Lac.) M. Fleisch.**	✓	✓	✓	Ta
<i>Pogonatum cirratum</i> (Sw.) Brid. subsp. <i>fuscatum</i> (Mitt.) Hyvönen	✓	✓	✓	Ea
<i>Pogonatum cirratum</i> (Sw.) Brid. subsp. <i>macrophyllum</i> (Dozy & Molk.) Hyvönen	-	-	✓	Pl
<i>Pogonatum neesii</i> (Müll. Hal.) Dozy	✓	✓	✓	Aao
<i>Pseudotaxiphyllum arquifolium</i> (Bosch & Sande Lac.) Z. Iwats.	✓	✓	✓	Ta

Taxa	Indo-Burmese subregion	Indo-Chinese subregion	Malayan subregion	Distributed patterns
<i>Pseudotaxiphyllum pohliaecarpum</i> (Sull. & Lesq.) Z. Iwats.	✓	✓	✓	Aao
<i>Pterobryopsis acuminata</i> (Hook.) M. Fleisch.**	✓	-	-	Ta
<i>Pterobryopsis orientalis</i> (Müll. Hal.) M. Fleisch.	✓	-	-	Ta
<i>Pterobryopsis scabriuscula</i> (Mitt.) M. Fleisch.**	✓	-	-	Ta
<i>Pterobryopsis tumida</i> (Dicks. ex Hook.) Dixon*	✓	-	-	Ta
<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	✓	✓	✓	Pt
<i>Racopilum cuspidigerum</i> (Schwägr.) Ångström	✓	✓	✓	Tr
<i>Racopilum orthocarpum</i> Wilson ex Mitt.	✓	-	-	Ta
<i>Rhodobryum ontariense</i> (Kindb.) Paris**	✓	✓	-	Pt
<i>Rosulabryum billarderii</i> (Schwägr.) J.R. Spence	✓	✓	-	Tr
<i>Rosulabryum capillare</i> (Hedw.) J.R. Spence	✓	✓	✓	Co
<i>Schlotheimia ferruginea</i> (Bruch ex Hook. & Grev.) Brid.**	✓	✓	✓	Pl
<i>Sematophyllum humile</i> (Mitt.) Broth.**	✓	-	-	Ta
<i>Solmsiella biseriata</i> (Austin) Steere	✓	-	-	Pt
<i>Sphagnum cuspidatum</i> Müll. Hal.	✓	-	✓	Pl
<i>Sphagnum cuspidatum</i> Ehrh. ex Hofin. subsp. <i>cuspidatum</i>	-	✓	✓	Tr
<i>Sphagnum cuspidatum</i> Ehrh. ex Hofin. subsp. <i>subrecurvum</i> (Warnst.) Eddy var. <i>subrecurvum</i>	-	-	✓	Tto
<i>Sphagnum junghuhnianum</i> Dozy & Molk.	-	✓	✓	Tr
<i>Sphagnum luzonense</i> Warnst.	-	✓	-	Ta
<i>Sphagnum ovatum</i> Hampe	✓	-	-	Ea
<i>Sphagnum palustre</i> L. subsp. <i>palustre</i>	✓	-	✓	Ea
<i>Sphagnum palustre</i> L. subsp. <i>pseudocymbifolium</i> (Müll. Hal.) A. Eddy	✓	-	-	Es
<i>Sphagnum perichaetiale</i> Hampe	-	✓	✓	Pt
<i>Sphagnum robinsonii</i> Warnst.	-	✓	✓	Ta
<i>Sphagnum subsecundum</i> Nees	✓	✓	✓	Tr
<i>Syrrhopodon armatus</i> Mitt.	-	✓	✓	Pl
<i>Syrrhopodon gardneri</i> (Hook.) Schwägr.	✓	✓	✓	Pl

Taxa	Indo-Burmese subregion	Indo-Chinese subregion	Malayan subregion	Distributed patterns
<i>Syrrhopodon parasiticus</i> (Sw. ex Brid.) Besch.**	-	-	✓	Pt
<i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.**	✓	✓	✓	Pt
<i>Taxithelium nepalense</i> (Schwägr.) Broth.**	✓	✓	✓	Pl
<i>Thuidium plumulosum</i> (Dozy & Molk.) Dozy & Molk.	✓	✓	✓	Aao
<i>Thuidium pristocalyx</i> (Müll. Hal.) A. Jaeger var. <i>pristocalyx</i>	✓	✓	✓	Ta
<i>Thuidium pristocalyx</i> (Müll. Hal.) A. Jaeger var. <i>samoanum</i> (Mitt.) Touw	✓	✓	✓	Aao
<i>Tortella cyrtobasis</i> Dixon	✓	-	-	Ta
<i>Trachyphyllum inflexum</i> (Harv.) A. Gepp	✓	✓	-	Pl
<i>Trachyphyllum touwianum</i> W.R. Buck*	✓	-	-	Ta
<i>Trichosteleum pseudomammosum</i> M. Fleisch.**	-	✓	-	Ta
<i>Weissia edentula</i> Mitt.**	-	✓	✓	Pl

5.6 Distributed patterns of mosses in Phu Kradueng National Park

This study found that phytogeographical patterns of mosses in Phu Kradueng National Park thrive in nine geographical areas (as was described in Zhang and Corlett, 2003). Among 103 taxa, there are 41 Tropical Asian species, 14 Palaeotropical species, 12 Pantropical species, 10 Asian-Australian-Oceanian species, nine Transpacific species, six Eastern Asian species, five Tropical Asian-Tropical Australian-Oceanian species, four Cosmopolitan species, and two Eastern and Southern Asian species. The data of mosses that distributed in each sub-region are showed in Table 5.2.

1. Cosmopolitan: This pattern is found worldwide. There are four species (Table 5.2), i.e. *Brothera leana*, *Bryum argenteum*, *Hyophila involuta* and *Rosulabryum capillare*.

2. Pantropical: This pattern is widely found throughout all tropical regions, only few species reach subtropical regions. There are 12 species (Table 5.2), for example *Brachymenium systylium*, *Fissidens flaccidus* var. *flaccidus*, *Octoblepharum albidum*, and *Pyrrhobryum spiniforme*.

3. Palaeotropical: This pattern is found in all tropical regions (like Africa and the Tropical Asia) except tropical America. There are 14 species (Table 5.2), for

example *Leucobryum juniperoideum*, *Pogonatum cirratum* subsp. *macrophyllum*, *Schlotheimia ferruginea*, and *Syrrhopodon gardneri*.

4. Tropical Asian: This pattern is widely found in tropical regions from Sri Lanka and India to Indochina, the Malaysia, and Indonesia, but not reaching the Oceanian Islands or Australia. A small number of species reach subtropical China or Southern Japan. There are 41 species (Table 5.2), for example *Acroporium laosianum*, *Campylopus serratus*, *Claopodium assurgens*, *Entodontopsis anceps*, *Fissidens crispulus* var. *robinsonii*, *Homaliadelphus targionianus*, *Leucoloma molle*, *Racopilum orthocarpum*, *Sematophyllum humile*, and *Sphagnum robinsonii*.

5. Tropical Asian-Tropical Australian-Oceanian: This pattern is found from Sri Lanka, India, Indochina, Malaysia, and Indonesia, to tropical Australia and/or the Oceania Islands. The northern distribution boundary is generally not beyond the South China. There are five species (Table 5.2), for example *Campylopus comosus*, *Fissidens ceylonensis*, and *Leucobryum aduncum* var. *scalare*.

6. Asian-Australian-Oceanian: This pattern is widely found from Sri Lanka, India, Indochina, Malaysia, and Indonesia, to tropical Australia and/or the Oceanian Islands. The distribution boundary is usually covers the whole of China, Japan, Korea, the Russian Far East and Siberia. There are 10 species (Table 5.2), for example *Barbula javanica*, *Campylopus umbellatus*, *Diphyscium mucronifolium*, *Himantocladium plumula*, and *Leucobryum javense*.

7. Eastern Asian: This pattern is found from the Eastern Himalayas to Japan, occasionally reaching southward to central Indochina or the Philippines, northward to Russian Siberia or the Far East. There are six species (Table 5.2), for example *Pogonatum nesii*, and *Isopterygium albescens* var. *smallii*.

8. Eastern and Southern Asian: This pattern is found from Sri Lanka, India to Indochina and Eastern Asia, but not reaching Malesia. There are two species (Table 5.2), i.e. *Sphagnum palustre* subsp. *pseudocymbifolium*, and *Macromitrium ferriei*.

9. Transpacific: This pattern is mainly found disjunctly in East Asia and America, but sometimes extending to Australia or the Oceania Islands. There are nine species (Table 5.2), for example *Leucobryum bowringii*, *Fissidens polypodioides*, and *Racopilum cuspidigerum*.

CHAPTER VI

DISCUSSION AND CONCLUSION

The diversity of mosses in Phu Kradueng National Park, Loei province was explored. A total of 501 specimens were collected. Thirty families, 55 genera, 100 species, five subspecies, and nine varieties were reported. Among these, 12 families, 22 genera, 52 species, five subspecies, and four varieties are acrocarpic mosses, while 16 families, 33 genera, 48 species, and five varieties are pleurocarpic mosses. The predominant families, in terms of the number of species are Sphagnaceae (11 taxa), the second most was Fissidentaceae (nine taxa), and the third most was Leucobryaceae (seven taxa). On the contrary, families which include only one species are also found, i.e. Daltoniaceae, Diphyssiaceae, Funariaceae, Hypopterygiaceae, Miyabeaceae, Rhizogoniaceae, and Stereophyllaceae.

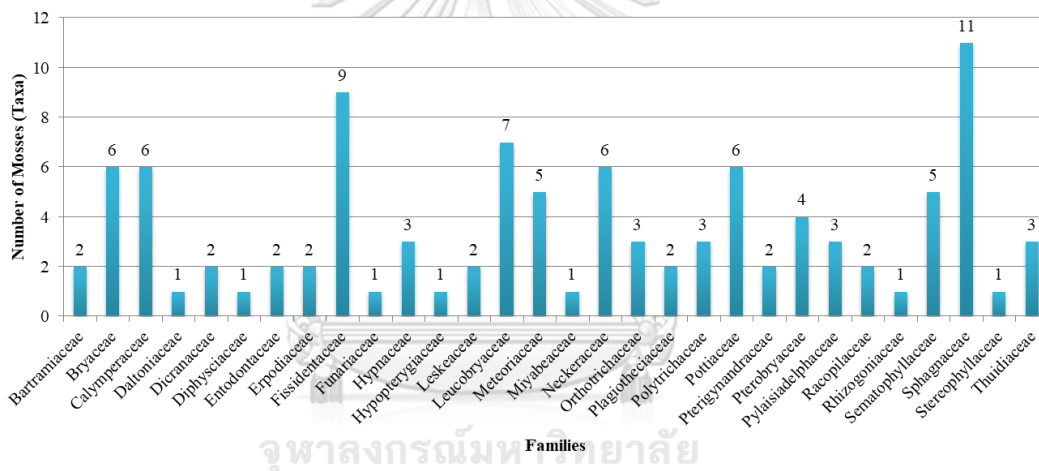


Figure 6. 1 Moss diversity in terms of number of family and species therein at Phu Kradueng National Park.

6.1 Moss diversity and trails in Phu Kradueng National Park

This study presented a field collection of 501 specimens along six trails. The highest species diversity of mosses was found in the trail from Ban Si Than to Lang Pae to Visitor Center (trail number one), ranging in elevations from 200 to 1,200 m. Fifty species were collected (Figure 6.2). High number of species along trail number one may due to various forest types and habitats from lowest to highest elevations: deciduous dipterocarp, mixed deciduous, dry evergreen and lower montane forests. The species number is usually varied in each forest type. This route is rather steep and exposed to sunlight. Some forest types usually have forest fire during the dry months, example included deciduous forest at altitude ranging from 200 to 800 m. Moss

species adapted their morphological structures and/or habits to avoid water loss in drought condition, such as growing in short and dense clusters to decrease the driving force for transpiration; forming various life-forms (cushion, mat, or weft); developing special structures (hyaline cells, alar cells, or paraphyllia) or colonizing hydric or massively shaded ecological niches (Charron & Quatrano, 2009; Frahm *et al.*, 2003). There were many species found only in this trail (Table 5.1), such as *Bryum coronatum*, *Solmsiella biseriata*, *Fissidens incognitus*, *Pinnatella alopecuroides*, and *Entodontopsis anceps*. However, common species in this trail included *Erythrodontium julaceum*, *Fissidens ceylonensis*, *Hyophila involuta* and *Trachyphyllum inflexum*.

A total of 36 species in trail number two was the second runner up in species number (Figure 6.2). This route starting from Visitor Center to nearby waterfalls: Wang Kwang Waterfalls, Pen Pob Mai Waterfalls, Phon Pob Waterfalls, and Tham Yai Waterfalls, ranging in elevations from 1,000 to 1,200 m. Vegetation of this route is the lower montane forest, usually having high air humidity, low temperatures all year round together with moist soils rich in humus, light shade condition are appropriate environmental factors to promote moss growth. Moss species confined to this trail, i.e. *Leucoloma molle*, *Fissidens javanicus*, *Lopidium trichocladon*, *Meteorium polytrichum*, and *Macromitrium ferriei*. Moss namely: *Fissidens polypodioides*, *Syrrhopodon gardneri*, and *Pyrrhobryum spiniforme* are common species.

The third runner up in species number was found in trail number three. This route starting from Visitor Center-Anodard Pond-Tham Sor Nuo Waterfall-Lom Sak Cliff, ranging in elevations from 1,100 to 1,300 m. There were 32 species in this trail (Figure 6.2). This trail passes through pine forests and grassland together with Tham Sor Nuo Waterfalls and small pond, i.e. Anodard Pond. This trail is rather an open area, exposed with full sunlight and usually having both low air and soil humidity. Some moss has adapted to exist in seasonal drought periods. Common species included *Campylopus comosus*, *Leucobryum juniperoideum*, *Pogonatum neesii*, *Sphagnum cuspidatum* subsp. *subrecurvum* var. *subrecurvum*, and *S. perichaetiale*.

Trail number five, starting from Visitor Center and terminated at Song Lok Cliff, there were 19 species (Figure 6.2) in this trail. The trail passes through pine forests and grassland as well as sandstone outcrops from place to place. That is why, there are low number of species as compare with trail number three. Common species included: *Campylopus comosus*, and *Leucobryum aduncum* var. *scalare*.

Trail number four, beginning from Visitor Center via Hongtong Waterfall and ending at Khun Pong Waterfalls and trail number six, starting from Visitor Center via Mak Dook Cliff and terminated at Lom Sak Cliff. There are 15 and seven species (Figure 6.2), respectively. The trail number four passed through lower montane forest

which included a waterfalls. Number of collected species is lower than trail number two, caused by heavy rain while on an expedition and working time limits. On the other hand, the trail number six have many cliffs, such as Mak Duk Cliff, Jum Sil Cliff, Na Noi Cliff, Yiap Mek Cliff, Daeng Cliff, and Lom Sak Cliff. These trails passed through pine forests and grassland. This route is passing a fire prone area during dry months. Therefore, trail number has lower in species number than the others. However some species acclimated to withstand this periodic drought. Common species included *Octoblepharum albidum* and *Leucobryum aduncum* var. *scalare*.

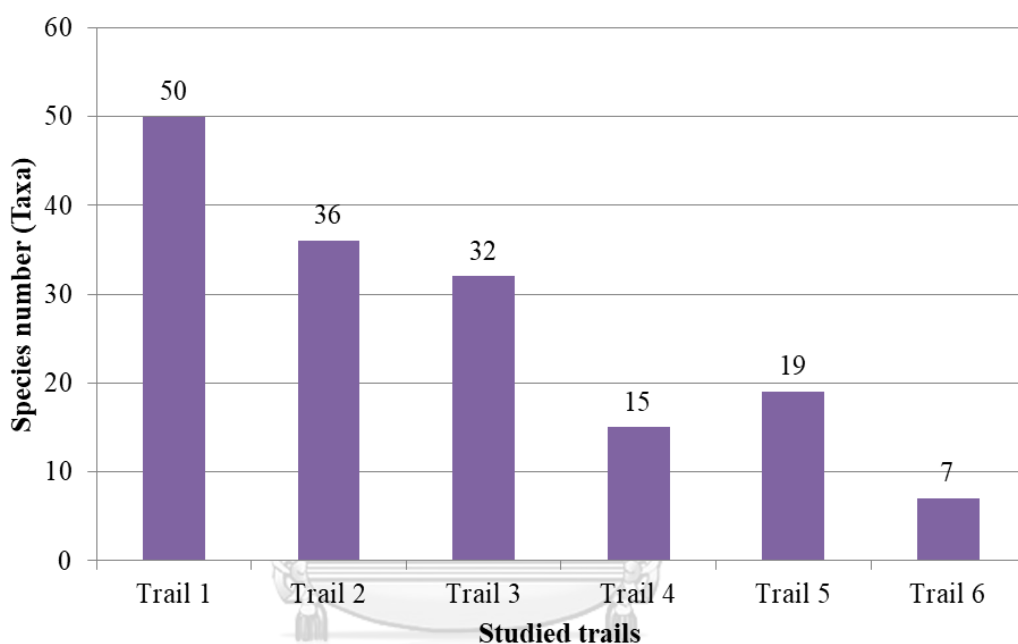


Figure 6. 2 Moss diversity in terms of species number in each trail.

6.2 Diversity of mosses and microhabitat

Mosses in Phu Kradueng National Park colonized mainly on five main microhabitats. Among 103 taxa, there are 45 saxicolous mosses, 43 terrestrial mosses, 37 corticolous mosses, 10 lignicolous mosses and six ramicolous mosses (Figure 6.3).

6.2.1 Saxicolous mosses

The saxicolous mosses usually occur on shady or half-shady rocks covered with thin soil particularly near streams and waterfalls (Pócs, 1982). They are found in dry evergreen forest and lower montane rainforest. Forty-five saxicolous mosses were found in this study, examples included *Rhodobryum ontariense*, *Syrrhopodon armatus*, *Leucoloma mittenii*, and *Fissidens javanicus*. Conversely, some species grown on open space in the sun, such as rocky space in lower montane scrub. They

usually face to the drought condition but they had many morphological adaptations to reduce the loss of water. For example, hyaline or colorless cells are typical of leaves of *Leucobryum* spp., *Leucophanes* spp. and *Octoblepharum* spp. The leaves were very succulent because of the hyaline cells appeared among the photosynthetic cells. Moreover, the leaf had several cells thick and the hyalocysts gave them a whitish appearance (Glime, 2017d). Another adaptation character is papillae, that are a minute projections on cell surface, that help to conduct water (Glime, 2017d), found in *Philonotis hastata*, *Aerobryidium filamentosum*, *Cryptopapillaria fuscescens*, *Barbula consanguinea*, and *Taxithelium nepalense*.

6.2.2 Terrestrial mosses

A total of 43 terrestrial mosses were found. They were found in deciduous dipterocarp forest, mixed deciduous forest, and lower montane coniferous forest. There are small number of mosses in dry evergreen forest and lower montane rainforest. Terrestrial mosses can be further separated into two groups according to soil types: sandy loam and wet sandy soil.

6.2.2.1 Sandy loam group

Mosses thrive on sandy loam soil can be found on the mountain slopes of Phu Kradueng National Park, such as *Bryum coronatum*, *Fissidens* spp., *Funaria hygrometrica*, *Barbula* spp., and *Hyophila* spp. These mosses are miniature plants, they grow fast and produce sporophyte rapidly. These mosses grow in dense group and hence serve as soil binders on mountain slopes, where soil erosion usually taken place caused from heavy rain and flash flood. This finding correspond to a previous study (Pócs, 1982; Bahuguna *et al.*, 2013). They showed that bryophytes, especially mosses had a great capacity to stabilize soils. For examples, the genus *Barbula*, *Bryum*, and *Funaria* are very effective and successful soil binder and nutrient trapper.

6.2.2.2 Wet sandy soil group

Mosses inhabited wet sandy soils can be found on summit of Phu Kradueng National Park, such as *Sphagnum* spp., *Campylopus* spp., and *Pogonatum* spp. These mosses can survive over dry months by owning hyaline or colorless cells on stems, branches and leaves, especially in *Sphagnum*. They had pores in their stem and branch and had very rapid movement of water externally up the plant by capillary action. Some species had special retort cells for absorbing water (Glime, 2017d). Moreover, *Sphagnum* spp. had fascicles (groups of branches) along stem, which can be divided into two branch types: spreading and pendant branches. All branches help to preserve stem water and maintain the wick effect as water level drops (Li, Glime & Liao, 1992). Leaves of *Sphagnum* had two types of leaf cells, small

photosynthetic cells and large hyaline cells. It is likely that hyaline cells serve as water supplier to the photosynthetic cells (Andrus, 1986).

6.2.3 Corticolous mosses

Thirty-seven corticolous mosses are found in this study. Common families included Leskeaceae, Leucobryaceae, Pterobryaceae, and Sematophyllaceae. They can be grown on bark that has slit or groove with thin litter. This microhabitat has the moist and light shade from canopy tree. Only the physical and chemical properties of bark cause diversification in their composition (Pócs, 1982). For this reason, the corticolous mosses are not usually host-specific. However, tree bark texture has important influence on number and composition of corticolous mosses (Frahm *et al.*, 2003). Many mosses were found in fissured and cracked bark because the barks retain water and litter better. The next tree bark textures are flaky and dippled scaly bark due to these tree bark textures retain water and little less than fissured and cracked bark. On the other hand, mosses cannot grow on pine bark due to the continually peeling bark and the accumulation of dry undecomposed detritus (Pócs, 1982). Abundant species were found in lower montane rainforest, such as *Claopodium assurgens*, *Leucobryum javense*, and *L. juniperoideum*.

6.2.4 Lignicolous mosses

Ten lignicolous mosses were found in this study. Lignicolous mosses usually grow on fallen log in the initial phase of decomposition. These mosses absorb water from decaying woods which heavily rely on decomposing fungi that decomposed and softened cellulose and lignin as well as offer a physically and chemically specialized substrate. Otherwise, they are able in some other way to uptake the nutrients of decomposed woods (Pócs, 1982). Most species were found in lower montane rainforest, such as *Syrrhopodon armatus*, *S. gardneri*, *Leucobryum aduncum* var. *scalare*, *L. javense*, and *Pyrrhobryum spiniforme*. This habitat is found low number of species, probably due to small number of fallen trees left in natural sites and probably was removed from the forest and was further used by park staff.

6.2.5 Ramicolous mosses

Ramicolous mosses included *Syrrhopodon parasiticus*, *Cryptopapillaria chrysoclada*, *Neodicladiella flagellifera*, *Trachyphyllum touwianum*, and *Isopterygium lignicola*. They were found in lower montane rainforest, in moist shady places, especially near waterfalls or streams. However, ramicolous mosses usually found in very high moist places, such as summit of cloud forest (Frahm *et al.*, 2003). They obtained water only from the air, so species number of ramicolous mosses at Phu Kradueng National Park were rather low as compare with the other high mountainous areas.

Additionally, twenty-seven species of mosses found in Phu Kradueng National Park can adapt themselves growing in more than one habitat. For example, *Trachyphyllum inflexum*, and *Syrrhopodon gardneri* were found to be saxicolous, corticolous and lignicolous mosses. Another species is *Octoblepharum albidum* Hedw. was found to be saxicolous, corticolous, lignicolous and ramicolous mosses. Furthermore, *Pyrrhobryum spiniforme* was found to be terrestrial, saxicolous, and lignicolous mosses.

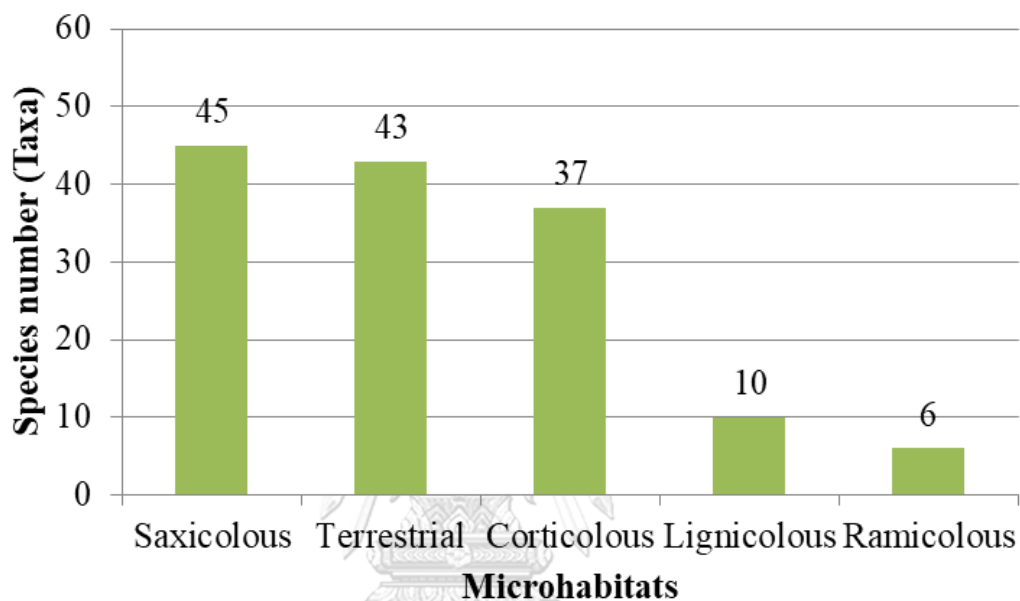


Figure 6. 3 Diversity of mosses according to microhabitats.

6.3 Life-form of Mosses

From the results, it was found that life-form of mosses in Phu Kradueng National Park thrive in six forms followed Bates (1998), there are turf 49 taxa (45%), followed by mat 19 taxa (18%), weft 13 taxa (12%), cushion 10 taxa (9%), fan 12 taxa (11%) and pendant five taxa (5%) (Figure 6.4). Life-forms are adaptation of special ecological niches and reflect habitat. They are especially related to moisture and light (Frahm *et al.*, 2003).

Turf mosses (Figure 6.4) can be separated into two forms: short turfs and tall turfs. Short turfs have vertical stem which shoots less than 2 cm tall (Grace, 2010). They can be found on soils with full sunlight in deciduous dipterocarp forest, mixed deciduous forest and dry evergreen forest, such as *Barbula consanguinea*, *Fissidens ceylonensis*, *Bryum coronatum*, and *Hyophila involuta*. Tall turfs have vertical stem which shoots more than 2 cm tall (Grace, 2010). They can be found on wet sandy soils in open places with full sunlight at lower montane coniferous forest, such as

Pogonatum neesii, *Sphagnum perichaetiale*, *S. cuspidatum* subsp. *subrecurvum* var. *subrecurvum*, and *Campylopus comosus*. Both forms correspond to that short turf mosses are growing on dry soils with full sunlight. Also, tall turf mosses are growing on wet soils with full sunlight. However, some short turf mosses can be found on soils in shaded or half-shaded places, such as *Fissidens flaccidus* var. *flaccidus*. and *F. incognitus*. It is probably due to less water retention or transportation.

Mosses occur in mat form usually being member of plurocarpic mosses (Figure 6.4). They are typically found in lowland forest (Frahm *et al.*, 2003). At Phu Kradueng National Park, they can be observed in deciduous dipterocarp forest, mixed deciduous forest and lower montane coniferous forest, such as *Erythrodonium julaceum*, *Claopodium assurgens*, *Isopterygium albescens* var. *smallii*, and *Entodontopsis anceps*. This life-form is particularly effective in storing water by capillary action from creeping close to the surface (Glime, 2017a). Moreover, they developed special structure, such as alar region and papillae on the leaf surface. As a result, mat mosses are characteristics of habitat with occasional desiccation (Frahm *et al.*, 2003).

Mosses occur in weft form usually being a member of pleurocarpous mosses (Figure 6.4). They are also found in lowland forest (Frahm *et al.*, 2003). This life-form can be found in dry evergreen forest and lower montane rainforest, such as *Ectropothecium dealbatum*, *Trachyphyllum inflexum*, *Thuidium plumulosum*, *T. pristocalyx* var. *pristocalyx*, and *T. pristocalyx* var. *samoanum*. Weft mosses can be found in shaded areas of trees and grass, and this habitat had occasional full sunlight. This corresponds to Bates (1998) that they grow on a broad substrate with rather moist and full sunlight. Similar to mat form, weft form is particularly effective in storing water by capillary action from loosely intertwining of branches (Glime, 2017).

Cushion form (Figure 6.4) is highly adapted for water preservation (Bates, 1998; Frahm *et al.*, 2003; Glime, 2017a). This life-form can be found on sandstone outcrops in lower montane scrub or open places that sometimes come across strong wind in lower montane coniferous forest, such as *Bryum argenteum*, *Octoblepharum albidum*, *Leucobryum aduncum* var. *scalare*, and *Campylopus ericoides*. It corresponds to Bates (1998) that they grow on dry soils or hard substrate with full sunlight. Additionally to architectural properties, mostly species in this life-form are adapted morphological structures to avoid water loss from drought condition (Charron & Quatrano, 2009; Frahm *et al.*, 2003), by having hyaline layers in the leaves, alar region or hair-points of the leaves.

Similar to previous studies of Bates (1998), fan life-form (Figure 6.4) usually occurs on tree trunks in lower montane rainforest with high moisture and deep shade, such as *Lopidium trichocladon*, *Homaliadelphus targionianus*, *Homaliodendron microdendron*, and *Pterobryopsis scabriuscula*. Mosses species in fan life-form may

have some adaptations for a gas exchange and avoid wetting on tree trunks or rocks, which reduces gas exchange (Frahm *et al.*, 2003). The branches of mosses in fan life-form extended broad are similar to folding fan. These extended branches can increase surface areas to receive more light for photosynthesis (Hassama, 2014). In contrast, some species can be found on rocks that had low moisture and full sunlight, such as *Neckeropsis exserta* var. *exserta*, *Pinnatella alopecuroides*, and *P. ambigua*. It was observed that these plants are growing very close together, and sometime the primary stem are intertwining. Hence, these may be help in storing water.

Pendant life-form (Figure 6.4) can be found on tree branches, rocks or twigs in moist and shade of lower montane rainforest or dry evergreen forest, such as *Cryptopapillaria feae*, *C. fuscescens*, *Meteorium polytrichum*, and *Neodictyella flagellifera*. They can effectively trap moisture from atmosphere due to this life form has the main shoots hang down form the point of attachment (Frahm *et al.*, 2003). Some species can be found as epiphyte along streams with occasional full sunlight, such as *Aerobryidium filamentosum*, and *Cryptopapillaria chrysoclada*.

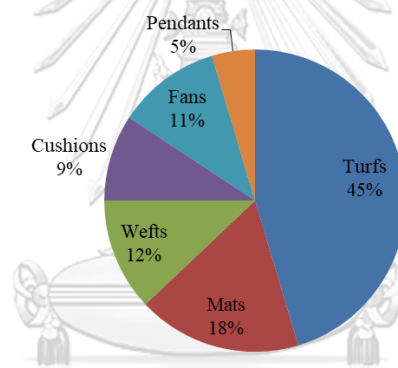


Figure 6. 4 Percent of mosses according to life-form.

6.4. Moss diversity in vegetations

Vegetation at Phu Kradueng National Park can be divided into 6 types depending on climate, edaphic factors, elevation and other biological factors (Santisuk, 1994). The species diversity of mosses were found in various forest types such as lower montane rainforest (59 taxa), lower montane coniferous forest (35 taxa), deciduous dipterocarp forest (24 taxa), dry evergreen forest (18 taxa), mixed deciduous forest (5 taxa), and lower montane scrub (6 taxa) (Figure 6.5).

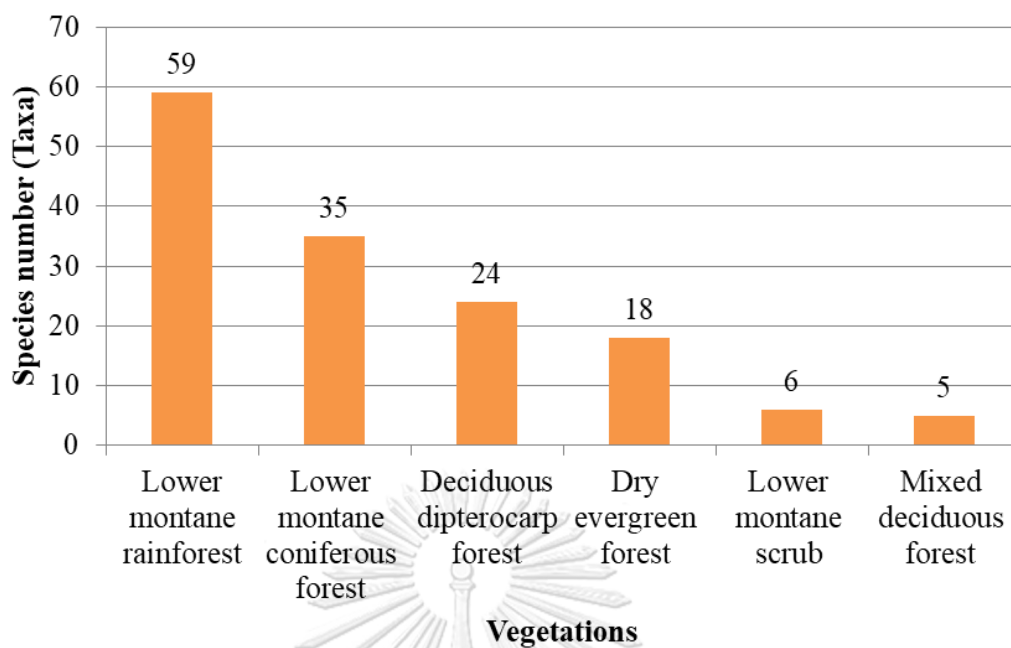


Figure 6. 5 Diversity of mosses according to vegetations.

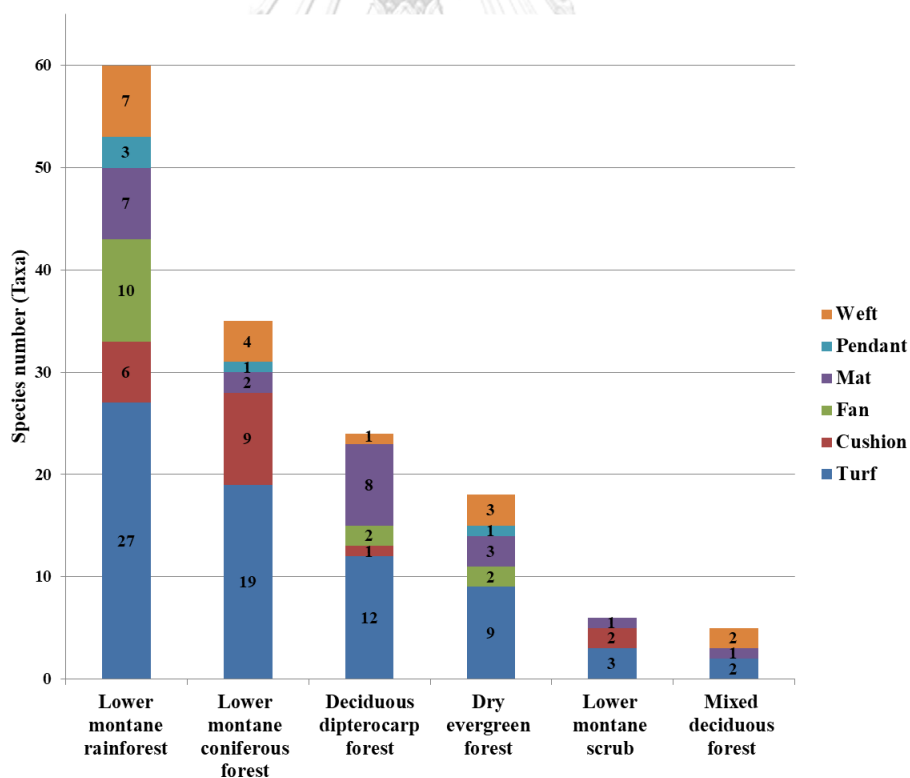


Figure 6. 6 Diversity of mosses according to vegetation types and life forms.

The greatest species diversity (59 taxa) was found in lower montane rainforest. It can be found on the summit of the mountain at 1,000–1,300 AMSL. The crown cover was dense and continuous. This forest is also a source of many waterfalls such as Phen Phob Mai Waterfalls, Tham Yai Waterfalls, Tham Sor Nuo Waterfalls, etc. So, this area is a suitable sites for dwelling of mosses because there are high humidity and cool temperature. The most common species that found in lower montane rainforest are turf forms such as *Fissidens polypodioides*, *Syrrhopodon gardneri*, and *Pyrrhobryum spiniforme*. Moreover, nearly most fan forms were found in this forest type (Figure 6.5), due to they usually can be grown in area that high moisture and deep shaded along tree trunks e.g. *Himantocladium cyclophyllum*, *Lopidium trichocladon*, and *Pinnatella ambigua*. The abundant species of pendant forms were found on tree branches, because of moisture and half shaded in this forest such as *Cryptopapillaria chrysoclada* and *Neodicladiella flagellifera*

The second vegetation type that show highest number of species (35 taxa) is lower montane coniferous forest. It can be found together with lower montane scrub on the summit of the mountain at 1,000–1,300 AMSL. The trees are scattered and most of the area is covered by grasses. Mostly turf mosses can be grown on wet sandy soils, such as *Sphagnum* spp. Due to this forest type is often windy and low humidity, cushion mosses were found in large number (Figure 6.5), such as *Octoblepharum albidum* and *Leucobryum aduncum* var. *scalare*. However, some species can found in transition area between lower montane coniferous and lower montane rainforest (ecotone). This area is wet sandy loam with deep shade from trees, sometime there are streams flowing through. It usually found *Fissidens polypodioides*, *Leucobryum javense*, and *Pogonatum neesii*.

Twenty four taxa were found in deciduous dipterocarp forest (Figure 6.6). It can be found on mountain slopes at 200–600 amsl. Trees and shrubs are dominant in this vegetation. Due to this forest type is often a wildfire, small turf mosses that rapidly grow and development were usually found (Parminter & Bedford, 2006), such as *Hyophila involuta*, *Barbula consanguinea*, *Bryum coronatum* and *Weissia edentula*.

For dry evergreen forest, 18 taxa can be found in the small area at 800–1,000 amsl. It was completely cleared by scattered small or large rocks. Tree crowns are close together forming shaded area. This forest type usually low moist soil. So, most mosses were found on soil or rock in deep shaded area, such as *Fissidens ceylonensis*, *F. incognitus*, and *Tortella cyrtobasis*. Furthermore, there was a pendant form of *Aerobryidium filamentosum* that had main stem grew on rock and secondary stem grew to prolong pendulous branches.

Then, there are five taxa in lower montane scrub. It often occurred in rocky open areas on the summit of the mountain at 1,000–1,300 amsl. It consists of small

trees and shrubs in rock crevices. This area is windy and sunlight shines throughout the day. A mat form of *Pseudotaxiphyllum pohliaecarpum* is rather common on soil. Most species of turf forms have special structure liked hyaline cells on leaves as well as mosses in lower montane coniferous forest, such as *Fissidens crispulus* var. *robinsonii*, *Sphagnum palustre* subsp. *palustre* and *Sphagnum perichaetiale*. The cushion forms of *Campylopus ericoides* and *Bryum argenteum* were common species in this forest.

The last forest type is mixed deciduous forest (6 taxa). It can be found on mountain slopes at 600–800 AMSL. In general, this forest type is similar to deciduous dipterocarp forest but dominant species were different. This forest is low humidity with a lot of bamboo. Turf mosses such as *Funaria hygrometrica* and *Weissia edentula* can be found on soil. Mat and weft forms often found on trees, such as *Erythrodontium julaceum*, *Thuidium plumulosum* and *Trachyphyllum inflexum*.

6.5 Status of mosses in Phu Kradueng National Park

The diversity of mosses in Phu Kradueng National Park, Loei Province during December 2014 to December 2016 was explored. The studies showed different status of mosses in this area (Table 5.1).

6.6.1 An abundance species

Eight species were the abundance species that found in many trails with numerous plants in each area. They are *Campylopus ericoides*, *Fissidens ceylonensis*, *Hyophila involuta*, *Leucobryum aduncum* var. *scalare*, *Pogonatum neesii*, *Pyrrhobryum spiniforme*, and *Sphagnum perichaetiale*, all of them were terrestrial mosses, while *Octoblepharum albidum* can be found in every microhabitats excepted terrestrial.

6.6.2 New record species

Four new recorded species were found, their diagnostic characters were compared with those related species.

Trachyphyllum touwianum W.R. Buck previously recorded from Myanmar (Buck, 1979). This new record has affinity with *T. carinatum* Dixon and *T. jeyporensis* Thér. & Dixon but differ in branch apex, feature of leaf apex, length of costae, alar region, color of leaf base, and propagules (Table 6.1, Figure 5.78).

Table 6. 1 Comparison between *Trachyphyllum carinatum*, *T. jeyporeense*, and *T. touwianum*.

Characters	<i>T. touwianum</i>	<i>T. carinatum</i>	<i>T. jeyporeense</i>
Branch apex	leafy branch	leafless branch	leafy branch
Feature of leaf apex	fragile	sturdy	sturdy
Length of costae	1/4–1/3 lamina long	1/4 lamina long	1/3–1/2 lamina long
Alar region	mostly reaching the costae	not reaching the costae	mostly reaching the costae
Color of leaf base	concolorous	commonly yellow	concolorous
Propagules	absent	uniseriate propagulae with reddish-brown and numerous	absent

Leptopterigynandrum decolor (Mitt.) M. Fleisch. was known from Bangladesh, China, India, and Russia (He, 2005; Ignatov *et al.*, 2012). This new record is similar to *Erythrodonium julaceum* that also occurs in Phu Kradueng National Park but differ in leaf orientation, leaf character, leaf apex, median cell shape and peristome (Table 6.2, Figure 5.22 and Figure 5.41).

Table 6. 2 Comparison between *Leptopterigynandrum decolor* and *Erythrodonium julaceum*.

Characters	<i>L. decolor</i>	<i>E. julaceum</i>
Leaf orientation	erecto-patent when moist and imbricate when dry	imbricate when dry or moist
Leaf character	plane	concave
Leaf apex	shortly acuminate	apiculate
Median cell shape	rhomboid	linear-rhomboid or narrowly elliptic
Peristome	double, well developed; narrow exostome teeth, absent cilia; endostome segments shorter than exostome	inserted below the mouth; broadly lanceolate exostome teeth; linear and fragile endostome segments

Pterobryopsis tumida (Dicks. ex Hook.) Dixon was recorded from India, Nepal, and Sri Lanka (Noguchi, 1975). This moss is similar to *Pterobryopsis divergens* (Mitt.) Nog. that is also found in Thailand but differ in flagelliform branch, length of costae and leaf apex (Figure 5.82).

Table 6. 3 Comparison between *Pterobryopsis tumida* and *P. divergens*.

Characters	<i>P. tumida</i>	<i>P. divergens</i>
Flagelliform branch	many	absent
Length of costae	covering only half of leaf, ending c. 1/2 the leaf length	reaching near to leaf apex, ending c. 3/4 the leaf length
Leaf apex	broad acuminate	acute to acuminate

Octoblepharum pocsii Magill & B.H. Allen was previously reported from Central African Republic, Guinea, and Laos (He, 2014; Magill & Allen, 2013). This new record has affinity with *O. albidum* that has pantropical distribution. Both species are differed in their habitat, feature of leaf, leaf size, length of basal sheath, sheath cell shape, and ornamentation of peristome (Table 6.4, Figure 5.12 and Figure 5.13).

Table 6. 4 Comparison between *Octoblepharum pocsii* and *O. albidum*.

Characters	<i>O. pocsii</i>	<i>O. albidum</i>
Habitat	on rocks	on rocks, log, bark, or twig
Feature of leaf	fragile leaf	sturdy leaf
Leaf size	8–13 mm long	2–6 mm long
Length of basal sheath	1/6 lamina long	1/3 lamina long
Sheath cell shape	short rectangular	long rectangular
Outer surface of peristome	smooth	vertically striate

6.6.3 New localities

There are 33 species (Table 5.1) that had never been reported from Phu Kradueng National Park. Among them, 11 species were found in north-eastern, eastern and upper central of Thailand. It isn't surprised to found them in this area because diaspores may disperse by wind from neighboring areas. On the other hand, some species that might already exist, but had never been reported previously, for example *Bryum coronatum*, *Fissidens ceylonensis*, *F. incognitus*, *Campylopus ericoides*, *Neodictyella flagellifera*, and *Sematophyllum humile*. The remaining 22 species are found in northern, south-western, lower central, south-eastern and peninsular Thailand. However, distribution from a distant location may require a carrier. The bird that fly across the barrier or migrate in breeding season may in charge of conveying diaspore to this area (Glime, 2017c). This is why some species were found in this area, for example *Philonotis mollis*, *Leucoloma mittenii*, *Pinnatella ambigua*, *Taxithelium nepalense*, *Syrrhopodon parasiticus*, *Ectropothecium dealbatum*, *E. monumentorum*, and *Schlotheimia ferruginea*.

6.6 Moss Diversity Comparison

Comparison of moss diversity from this study and Bryophytes in Thailand (Sornsamran & Thaitong, 1995). Fifty-six taxa that ever reported in the previous checklist was not found (Table 6.3). These may cause from many factors.

Firstly, the name changed, six taxa reported in Bryophytes in Thailand (Sornsamran & Thaitong, 1995) were considered to be synonyms, there are 1) *Bryum siamense* Dixon is synonyms of *Rosulabryum capillare* (Spence, 2014). 2) *Funaria hygrometrica* var. *calvescens* (Schwägr.) Mont. is synonyms of *Funaria hygrometrica* (Eddy, 1996). 3) *Taxithelium lindbergii* (A. Jaeger) Renaud & Cardot is synonyms of *Taxithelium vernieri* (Duby) Besch. (Tan & Iwatsuki, 1991). 4) *Racopilum schmidii* (Müll. Hal.) Mitt. is synonyms of *Racopilum cuspidigerum* (B. O. v. Zanten, 2006). 5) *Trachypus bicolor* var. *hispidus* (Müll. Hal.) Cardot is synonyms of *Trachypus bicolor* Reinw. & Hornsch. (He, 1995). And 6) *Pogonatum flexicaule* Mitt. is synonyms of *Pogonatum cirratum* subsp. *fuscatum* (Hyvönen, 1989).

The next factor is human activity that occurs many times in Phu Kradueng National Park. Human disturbances often act quickly and with great effect, to alter the physical structure or arrangement of biotic and abiotic elements at both global and local scales. Examples included global warming, pollution, biological invasions, and deforestation that found in both agriculture, construction, and timber harvest (Vanderpoorten & Goffinet, 2009). The tourist statistics information during 2008 to 2017 (Figure 6.7) demonstrate that tourists are increasing each year. This may result in depletion of some moss species due to trampling by tourists which usually increasing in number during October to March. Extensions of forest trails as well as addition of building construction for tourists may has direct effect on habitat loss and habitat fragmentations in both short and long terms. Genetic drift may have severe long-term demographic consequences for self-incompatible or dioicous species. Effects of habitat fragmentations on the genetic diversity and structure were studied in the peat moss, *Polytrichum commune* Hedw. This moss is dioicous species, it was found that genetic diversity values in completely cut bogs had lower values than in uncut peatlands (Wilson & Provan, 2003). Additionally, increased inbreeding due to reduction of gene flow among fragmented populations may lead to reduce fitness (Oostermeijer, Luijten & Den-Nijs, 2003). So, these may be the reason why number of species were decreased in number of individuals or disappeared in some rare species.

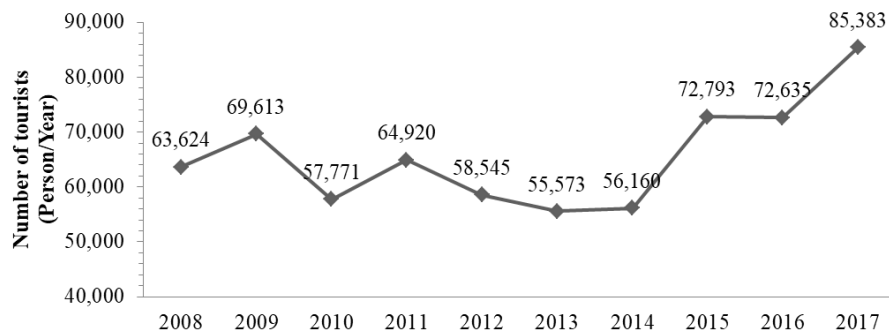


Figure 6. 7 The tourist statistics information during 2008 to 2017 (Department of National Parks Wildlife and Plant Conservation, 2017).

Moreover, there are fire prone areas where forest floors were burned every year. This natural event is more or less reducing number of individuals and/or species therein. The data from Loei Forest Fire Control Station showed that 877 times of forest fire and 21,724.30 rai was damaged from 2002 to 2015 (Loei Forest Fire Control Station, 2016). Because Phu Kradueng National Park has the deciduous forest, grassland, and *Sphagnum* places, which can be flammable. In general, forest fire showed no effect on above ground vegetation, especially shrubs and trees. Soil moisture, bulk density, and particle density were decreased but porosity, pH, organic matters, inorganic matters (phosphorus, potassium, calcium, magnesium) and cation exchange capacity were increased. Although it showed no effect on trees but it can kill saplings (Sutthicht, 1996). However, knowledge about fire impact on mosses has been poorly studied. Most report has done in the northern hemisphere, there is little studies in subtropical and tropical zones. The studies in Western Victoria Region, Australia showed that frequently-burned grasslands generally had lower bryophyte species richness than longer-unburned sites (specifically mosses). This results demonstrated that frequent fire may reduce the species richness (Morgan, 2004). In contrast, some bryophytes can respond to forest fire. Some species on burned areas can survive as diaspores in the soils or can recover after fire from neighboring areas by dispersal of diaspores (Parminter & Bedford, 2006; Yamagichi *et al.*, 2005). These may be the reasons why some species appearing or missing.

Another factor that may cause changing in number of taxa is drought. Drought escape is an adaptive mechanism which involves speedy plant development to permit the accomplishment of the full life-cycle prior to a coming drought event. This strategy is widely used in populations of native plants, and is also valid to cereal crops such as wheat (Shavrukov *et al.*, 2017). Drought escape leads to the ability to skip periods of drought, especially during the most sensitive periods of development (Levitt, 1972). Some bryophytes that are drought escape called shuttle species. The shuttle species may be adapted to cyclic habitat conditions by producing a few, large

spores. These species avoid the dry season by producing spores that have the ability to remain in the diaspore bank until above-ground conditions become favourable for growth again (Vanderpoorten & Goffinet, 2009). This study found only one species that showed drought escape. It was *Funaria hygrometrica* Hedw. (Funariaceae). During December 2014 to December 2015, it was disappeared from collected trails but reappeared again in December 2016. This finding corresponded to previous studies that spores of *F. hygrometrica* were still viable in soils for two years (During, 1987). So, it is possible that some species don't permanently disappear. However, it may be recovered from neighboring areas by dispersal of diaspores.

The next factor is the closing of the park due to rehabilitation during June to September every year. Since this period is the rainy season, many dangers can be taken place. Examples included flash flood from heavy rains and injuring from wild animals, especially wild elephants. This period match the growing season of the bryophytes. So collected specimens cannot be carried out in all season. Likewise, some area can be visited only once because the park rangers are not available to accompany a collected team.

However, this study reported new locality for 31 species from Phu Kradueng National Park and three new records, as compared with Sornsamran & Thaitong (1995). It implied that database of Thai mosses are still incomplete and further area-based studies is still necessary. In addition, an updated account of each genus would be considered (Sukkharak & Chantanaorrapint, 2014). For all these reasons, Phu Kradueng National Park should has the perception to the forest fire effects and transfer information to the adjacent communities. The people in adjacent communities could help to preserve nature in order to support the ecotourism in the future. Furthermore, the results obtaining from this study provide an updated account of mosses in north-eastern Thailand and can be used for tourism management in this area.

Table 6. 5 Comparison of moss diversity in Phu Kradueng National Park during December 2014 to December 2016 and Bryophytes in Thailand (Sornsamran and Thaitong, 1995).

Note: “✓” = present, “-” = absent

Symbol: *=New record species, **=New localities

No.	Taxon	Sornsamran and Thaitong (1995)	This study
1	<i>Acroporium baviense</i> (Besch.) Broth.	✓	✓
2	<i>Acroporium downii</i> (Dixon) Broth.	✓	-
3	<i>Acroporium lamprophyllum</i> Mitt.	✓	-
4	<i>Acroporium laosianum</i> (Broth. & Par.) Broth.	✓	✓
5	<i>Acroporium secundum</i> (Reinw. & Hornsch.) M. Fleisch.	✓	-
6	<i>Aerobryidium aureonitens</i> (Hook. ex Schwägr.) Broth.	✓	-
7	<i>Aerobryidium filamentosum</i> (Hook.) M. Fleisch.	-	✓
8	<i>Aerobryopsis wallichii</i> (Brid.) M. Fleisch.	✓	-
9	<i>Barbella convolvens</i> (Mitt.) Broth.	✓	-
10	<i>Barbella flagellifera</i> (Cardot) Nog.	✓	-
11	<i>Barbellopsis trichophora</i> (Mont.) W.R. Buck	✓	-
12	<i>Barbula consanguinea</i> (Thwaites & Mitt.) A. Jaeger**	-	✓
13	<i>Barbula javanica</i> Dozy & Molk.**	-	✓
14	<i>Brachymenium systylium</i> (Müll. Hal.) A. Jaeger	✓	✓
15	<i>Brothera leana</i> (Sull.) Müll. Hal.	-	✓
16	<i>Bryum argenteum</i> Hedw.	✓	✓
17	<i>Bryum coronatum</i> Schwägr.**	-	✓
18	<i>Calymperes serratum</i> A. Braun ex Müll. Hal.	✓	-
19	<i>Campylopodium medium</i> (Duby) Giese & J.-P. Frahm	✓	-
20	<i>Campylopus comosus</i> (Schwägr.) Bosch & Sande Lac.	✓	-
21	<i>Campylopus ericoides</i> (Griff.) A. Jaeger**	-	✓

No.	Taxon	Sornsamran and Thaitong (1995)	This study
22	<i>Campylopus savannarum</i> (Müll. Hal.) Mitt.	✓	-
23	<i>Campylopus serratus</i> Sande Lac.	✓	✓
24	<i>Campylopus umbellatus</i> (Schwägr. & Gaudich. ex Arn.) Paris	✓	-
25	<i>Chaetomitriopsis glaucocarpa</i> (Reinw. ex Schwägr.) M. Fleisch.	✓	-
26	<i>Chionostomum pinicola</i> Tixier**	-	✓
27	<i>Claopodium assurgens</i> (Sull. & Lesq.) Cardot	✓	✓
28	<i>Clastobryophilum bogoricum</i> (Bosch & Sande Lac.) M. Fleisch.	✓	-
29	<i>Cryptopapillaria chrysoclada</i> (Müll. Hal.) M. Menzel	-	✓
30	<i>Cryptopapillaria feae</i> (Müll. Hal. ex M. Fleisch.) M. Menzel	-	✓
31	<i>Cryptopapillaria fuscescens</i> (Hook.) M. Menzel**	-	✓
32	<i>Cyathophorum adiantum</i> (Griff.) Mitt.	✓	-
33	<i>Dicranodontium uncinatum</i> (Harv.) A. Jaeger	✓	-
34	<i>Diphyscium longifolium</i> Griff.	✓	-
35	<i>Diphyscium mucronifolium</i> Mitt.	-	✓
36	<i>Distichophyllum nigricaula</i> var. <i>elmeri</i> (Broth.) B.C. Tan & H. Rob.	-	✓
37	<i>Ectropothecium dealbatum</i> (Reinw. & Hornsch.) A. Jaeger**	-	✓
38	<i>Ectropothecium monumentorum</i> (Duby) A. Jaeger**	-	✓
39	<i>Entodon macropodus</i> (Hedw.) Müll. Hal.	✓	✓
40	<i>Entodontopsis anceps</i> (Bosch & Sande Lac.) W.R. Buck & R.R. Ireland	✓	✓
41	<i>Erpodium mangiferae</i> Müll. Hal.		✓
42	<i>Erythrodonium julaceum</i> (Hook. ex Schwägr.) Paris	✓	✓
43	<i>Fissidens anomalus</i> Mont.	✓	-

No.	Taxon	Sornsamran and Thaitong (1995)	This study
44	<i>Fissidens ceylonensis</i> Dozy & Molk.**	-	✓
45	<i>Fissidens crispulus</i> Brid.	✓	-
46	<i>Fissidens crispulus</i> var. <i>robinsonii</i> (Broth.) Z. Iwats. & Z.H. Li**	-	✓
47	<i>Fissidens flaccidus</i> var. <i>flaccidus</i> Mitt.**	-	✓
48	<i>Fissidens gardneri</i> Mitt.	✓	-
49	<i>Fissidens geppii</i> M. Fleisch.**	-	✓
50	<i>Fissidens guangdongensis</i> Z. Iwats. & Z.H. Li**	-	✓
51	<i>Fissidens incognitus</i> Gangulee**	-	✓
52	<i>Fissidens javanicus</i> Dozy & Molk.**	-	✓
53	<i>Fissidens polypodioides</i> Hedw.	✓	✓
54	<i>Fissidens subangustus</i> M. Fleisch.**	-	✓
55	<i>Foreauella orthothecia</i> (Schwägr.) Dixon & P. de la Varde	✓	-
56	<i>Funaria hygrometrica</i> Hedw.	✓	✓
57	<i>Garovaglia powellii</i> subsp. <i>densifolia</i> var. <i>densifolia</i> (Thwait. & Mitt.) During	✓	-
58	<i>Himantocladium cyclophyllum</i> (Müll. Hal.) M. Fleisch.	-	✓
59	<i>Himantocladium plumula</i> (Nees) M. Fleisch.	✓	✓
60	<i>Homaliadelphus targionianus</i> (Mitt.) Dixon & P. de la Varde	✓	✓
61	<i>Homaliodendron flabellatum</i> (Sm.) M. Fleisch.	✓	-
62	<i>Homaliodendron microdendron</i> (Mont.) M. Fleisch.	✓	✓
63	<i>Hyophila apiculata</i> M. Fleisch.**	-	✓
64	<i>Hyophila involuta</i> (Hook.) A. Jaeger	-	✓
65	<i>Hyophila nymaniana</i> (M. Fleisch.) M. Menzel	✓	-
66	<i>Isopterygium albescens</i> var. <i>smallii</i> (Sull. & Lesq.) Z. Iwats.	✓	✓
67	<i>Isopterygium lignicola</i> (Mitt.) A. Jaeger	-	✓
68	<i>Leptopterigynandrum decolor</i> (Mitt.) M. Fleisch.*	-	✓

No.	Taxon	Sornsamran and Thaitong (1995)	This study
69	<i>Leucobryum aduncum</i> var. <i>scalare</i> (Müll. Hal. ex M. Fleisch.) A. Eddy	✓	✓
70	<i>Leucobryum bowringii</i> Mitt.	✓	✓
71	<i>Leucobryum javense</i> (Brid.) Mitt.	✓	✓
72	<i>Leucobryum juniperoideum</i> (Brid.) Müll. Hal.	✓	✓
73	<i>Leucobryum sanctum</i> (Nees ex Schwägr.) Hampe	✓	-
74	<i>Leucobryum sericeum</i> Broth. ex Geh.	✓	-
75	<i>Leucoloma mittenii</i> M. Fleisch.**	-	✓
76	<i>Leucoloma molle</i> (Müll. Hal.) Mitt.	✓	✓
77	<i>Leucomium strumosum</i> (Hornsch.) Mitt.	✓	-
78	<i>Leucophanes octoblepharioides</i> Brid.	✓	✓
79	<i>Lopidium trichocladon</i> (Bosch & Sande Lac.) M. Fleisch.	✓	✓
80	<i>Macromitrium brevissimum</i> Dixon	✓	-
81	<i>Macromitrium concinnum</i> Mitt. ex Bosch & Sande Lac.	✓	-
82	<i>Macromitrium densum</i> Mitt.**	-	✓
83	<i>Macromitrium ferriei</i> Cardot & Thér.**	-	✓
84	<i>Macromitrium sulcatum</i> (Hook.) Brid.	✓	-
85	<i>Neckeropsis exserta</i> var. <i>exserta</i> (Hook. ex Schwägr.) Broth.	✓	✓
86	<i>Neodictyella flagellifera</i> (Cardot) Huttunen & D. Quandt **	-	✓
87	<i>Octoblepharum albidum</i> Hedw.	✓	✓
88	<i>Octoblepharum pocsii</i> Magill & B.H. Allen*	-	✓
89	<i>Papillidiopsis complanata</i> (Dixon) W.R. Buck & B.C. Tan	✓	-
90	<i>Philonotis hastata</i> (Duby) Wijk & Margad.	✓	✓
91	<i>Philonotis mollis</i> (Dozy & Molk.) Mitt.**	-	✓
92	<i>Pinnatella alopecuroides</i> (Mitt.) M. Fleisch.	✓	✓
93	<i>Pinnatella ambigua</i> (Bosch & Sande Lac.) M. Fleisch.**	-	✓

No.	Taxon	Sornsamran and Thaitong (1995)	This study
94	<i>Pogonatum cirratum</i> subsp. <i>fuscatum</i> (Mitt.) Hyvönen	✓	✓
95	<i>Pogonatum cirratum</i> subsp. <i>macrophyllum</i> (Dozy & Molk.) Hyvönen	✓	✓
96	<i>Pogonatum neesii</i> (Müll. Hal.) Dozy	✓	✓
97	<i>Pseudoleskeopsis zippelii</i> (Dozy & Molk.) Broth.	✓	-
98	<i>Pseudotaxiphyllum arquifolium</i> (Bosch & Sande Lac.) Z. Iwats.	-	✓
99	<i>Pseudotaxiphyllum pohliaecarpum</i> (Sull. & Lesq.) Z. Iwats.	-	✓
100	<i>Pterobryopsis acuminata</i> (Hook.) M. Fleisch.**	-	✓
101	<i>Pterobryopsis orientalis</i> (Müll. Hal.) M. Fleisch.	-	✓
102	<i>Pterobryopsis scabriuscula</i> (Mitt.) M. Fleisch.**	-	✓
103	<i>Pterobryopsis tumida</i> (Dicks. ex Hook.) Dixon*	-	✓
104	<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	✓	✓
105	<i>Racopilum cuspidigerum</i> (Schwägr.) Ångström	✓	✓
106	<i>Racopilum orthocarpum</i> Wilson ex Mitt.	✓	✓
107	<i>Rhaphidostichum chaetomitriopsis</i> (Dixon) A. Touw	✓	-
108	<i>Rhodobryum ontariense</i> (Kindb.) Paris**	-	✓
109	<i>Rhodobryum huillense</i> (Welw. & Duby) A. Touw	✓	-
110	<i>Rhynchostegium celebicum</i> (Sande Lac.) A. Jaeger	✓	-
111	<i>Rosulabryum billarderi</i> (Schwägr.) J.R. Spence	✓	✓
112	<i>Rosulabryum capillare</i> (Hedw.) J.R. Spence	✓	✓
113	<i>Schlotheimia ferruginea</i> (Bruch ex Hook. & Grev.) Brid.**	-	✓
114	<i>Sematophyllum humile</i> (Mitt.) Broth.**	-	✓
115	<i>Sematophyllum tristiculum</i> (Mitt.) M. Fleisch.	✓	-
116	<i>Solmsiella biseriata</i> (Austin) Steere	✓	✓
117	<i>Sphagnum cuspidatum</i> Müll. Hal.	-	✓
118	<i>Sphagnum cuspidatum</i> Ehrh. ex Hofin.	✓	✓

No.	Taxon	Sornsamran and Thaitong (1995)	This study
119	<i>Sphagnum cuspidatum</i> subsp. <i>subrecurvum</i> var. <i>subrecurvum</i> (Warnst.) Eddy	-	✓
120	<i>Sphagnum junghuhnianum</i> Dozy & Molk.	✓	✓
121	<i>Sphagnum luzonense</i> Warnst.	✓	✓
122	<i>Sphagnum ovatum</i> Hampe	-	✓
123	<i>Sphagnum palustre</i> subsp. <i>palustre</i> L.	✓	✓
124	<i>Sphagnum palustre</i> subsp. <i>pseudocymbifolium</i> (Müll. Hal.) A. Eddy	-	✓
125	<i>Sphagnum perichaetiale</i> Hampe	✓	✓
126	<i>Sphagnum robinsonii</i> Warnst.	✓	✓
127	<i>Sphagnum subsecundum</i> Nees	✓	✓
128	<i>Syrrhopodon armatus</i> Mitt.	-	✓
129	<i>Syrrhopodon gardneri</i> (Hook.) Schwägr.	✓	✓
130	<i>Syrrhopodon langbianensis</i> (Tixier) W.D. Reese	✓	-
131	<i>Syrrhopodon confertus</i> Sande Lac.	✓	-
132	<i>Syrrhopodon parasiticus</i> (Sw. ex Brid.) Besch.	-	✓
133	<i>Syrrhopodon semiliber</i> (Mitt.) Besch.	✓	-
134	<i>Syrrhopodon spiculosus</i> Hook. & Grev.	✓	-
135	<i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.**	-	✓
136	<i>Taxithelium nepalense</i> (Schwägr.) Broth.**	-	✓
137	<i>Taxithelium vernieri</i> (Duby) Besch.	✓	-
138	<i>Thuidium plumulosum</i> (Dozy & Molk.) Dozy & Molk.	✓	✓
139	<i>Thuidium pristocalyx</i> var. <i>pristocalyx</i> (Müll. Hal.) A. Jaeger	✓	✓
140	<i>Thuidium pristocalyx</i> var. <i>samoanum</i> (Mitt.) Touw	✓	✓
141	<i>Thuidium cymbifolium</i> (Dozy & Molk.) Dozy & Molk.	✓	-
142	<i>Tortella cyrtobasis</i> Dixon	✓	✓
143	<i>Trachyloma indicum</i> Mitt.	✓	-
144	<i>Trachyphyllum inflexum</i> (Harv.) A. Gepp	-	✓

No.	Taxon	Sornsamran and Thaitong (1995)	This study
145	<i>Trachyphyllum touwianum</i> W.R. Buck*	-	✓
146	<i>Trachypodopsis serrulata</i> var. <i>crispatula</i> (Hook.) Zanten	✓	-
147	<i>Trachypus bicolor</i> Reinw. & Hornsch.	✓	-
148	<i>Trichosteleum pseudomamosum</i> M. Fleisch.**	-	✓
149	<i>Weissia edentula</i> Mitt.**	-	✓
150	<i>Wijkia filipendula</i> (Dixon) H.A. Crum	✓	-
151	<i>Wijkia laxa</i> (Dixon) H.A. Crum	✓	-
Total (Taxa)		96	103

6.7 Distribution of mosses in Phu Kradueng National Park

Thailand is included in the Indochinese subdivision of the continental Southeast Asia, and phytogeographically, is situated between two floristic regions, viz. Malesian and Indochinese regions including Myanmar and South China. This area is considered as a collective centre of botanic diversity designated by three floristic subregions: Indo-Burmese, Indo-Chinese, and Malesian subregions (Forest Herbarium Department of National Parks Wildlife and Plant Conservation, 2017). Phu Kradueng National Park is located on northeast Thailand. It is unique table mountain sandstone with the plain foothills surrounded. There are steep mountain edges and steep cliffs towards the summit. Thus wind is an important physical factor in spore distribution. It is found from this study that 19 species are members of Indo-Burmese subregion. Eight species are members of Indo-Chinese subregion, and seven species are member of Malaysian subregion. The example of species that distributed from each subregion are refer as below.

6.6.1 Indo-Burmese subregion

Nineteen species are Indo-Burmese elements (Table 5.2), these species also occur in India, Nepal, Bhutan, Bangladesh, Myanmar and the southern China, such as *Macromitrium densum*, this species also occurs in India, Myanmar, Nepal, and Vietnam (Gangulee, 1976). Likewise, *Erpodium mangiferae* occurs in India and China (Wei *et al.*, 2016).

6.6.2 Indo-Chinese subregion

Eight species are found in Indo-Chinese subregion (Table 5.2), including most of mainland Southeast Asia, Thailand, Laos, Vietnam, Cambodia and Japan, as well as the southern China. *Acroporium laosianum* is an example, this species occurs in Laos, Thailand (Phitsanulok, Loei, Chiyaphum, Prachin Buri), and Vietnam (He, 1995; Pollawatn, 2008).

6.6.3 Indo-Malayan subregion

Seven moss species are found in Malesia or Indo-Malayan subregion (Table 5.2). The area includes most of the south of southeast Asia and southern parts of East Asia. For example, *Hyophila apiculata* occurs in Australia, Indonesia, and Malaysia (Eddy, 1991; He, 1995).

Additionally, 40 species have wide distribution throughout Indo-Burmese, Indo-Chinese and Indo-Malayan subregions were found at Phu Kradueng National Park (Table 5.2), for example *Fissidens ceylonensis* Dozy & Molk. was found in Australia, Cambodia, China, Hong Kong, India, Indonesia, Kampuchea, Laos,

Malaysia, Myanmar, Nepal, New Guinea, New Zealand, Philippines, Seychelles, Sikkim, Singapore, Sri Lanka, Sumatra, Taiwan, and Vietnam (Wongkuna, 2010).

From the results demonstrated that Phu Kradueng National Park is the suitable places for mosses growing, the various vegetation types were help mosses to choose their habitats. This area is showed a transitional region forming a bridge between the Malayan-Philippine and Sino-Himalayan floras (Iwatsuki 1972). They were possibility of common species distributed from Indo-Burmese and Indo-Chinese subregion because this place is nearby the southern China and northern Myanmar. All environment and growth factors are similar. There were interesting, which some species that distributed from Indo-Malayan subregion, they can grow in this place because of their specific habitats. As a result, Phu Kradueng National Park shares its flora with the neighbouring countries.

6.8 Distributed patterns of mosses in Phu Kradueng National Park

Nine categories of phytogeographical patterns were recognized for mosses in Phu Kradueng National Park (Table 5.2 and Table 6.6). The most common pattern was Tropical Asian (32 taxa, 30.5 %). This result demonstrated that most mosses in Phu Kradueng National Park also occur in Sri Lanka and India through Indochina, Malaysia, and Indonesia. It corresponds to subregion distribution, that are most mosses are distributed from Indo-Burmese subregion (19 species). Besides, some species have cosmopolitan and pantropical distribution. These mosses are more or less adapted to the severe environment, that have direct effects to their physiology and morphology (Lewis, 1999). Furthermore, some species have Palaeotropical pattern of distribution. They were found in tropical African and tropical Asian. These areas usually have species and closely related species in common (Zanten & Pócs 1981). Transpacific pattern occur disjunctively in East Asia and America. This pattern may require a carrier to convey diaspore from a distant location, like bird or human (Glime, 2017b).

Table 6. 6 Phytogeographical patterns of mosses in Phu Kradueng National Park

Patterns	Mosses (Taxa)	Mosses (%)
1. Cosmopolitan	4	3.9
2. Pantropical	12	11.7
3. Palaeotropical	14	13.6
4. Tropical Asian	41	39.8
5. Tropical Asian–Tropical Australian–Oceania	5	4.9
6. Asian–Australian–Oceania	10	9.7
7. Eastern Asian	6	5.8
8. Eastern and Southern Asian	2	1.9
9. Transpacific	9	8.7
Total	103	100

6.8 Benefits of this research

1. Basic information of moss diversity, such as diversity, ecology and distribution are added.
2. Key to families, genera and species of mosses in Phu Kradueng National Park can be used for adjacent area, such as Phu Luang Wildlife Sanctuary or Nam Nao National Park.
3. Numbers of moss specimens were gain to Forest Herbarium (BKF) and Professor Kasin Suvatabhanhu Herbarium (BCU). It will be useful for further study in related work.
4. The current status of each species is obtained and can be used as a basis for a suitable measure for conservation of this vulnerable protected area.

6.9 Problems in this research

1. Collecting and taking photograph of living specimens in the fields during heavy rain is a hard job.
2. As some moss species are very small. It can be easily overlooked in field collection.
3. The taxonomic literatures on mosses are rather scared. Thus, species identification is very limited.
4. Due to time limit for survey and collection, sporophytes which are importance morphological characters for identification cannot be collected.
5. Voucher herbarium specimens are not available in Thai herbaria. So, the comparison with the known specimens was not complete.
6. Some areas cannot be accessed or can be visited only once due to time limit in a one-day trip. It is too dangerous to set a camp in habitats of wild elephant which require vast area of the park to roam in order to find adequate supplies of food.

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APPENDIX



จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

Table 1 List of Abbreviation in Taxonomic Literature

Abbreviation Title	Full Title
Acta Bot. Fenn.	Acta Botanica Fennica
Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt.	Akademie der Wissenschaften in Wien, Sitzungsberichte, Mathematisch- naturwissenschaftliche Klasse, Abteilung
Allg. Bot. Z. Syst.	Allgemeine Botanische Zeitschrift für Systematik, Floristik, Pflanzengeographie
Anal. Fam. Pl	Analyse des Familles des Plantes
Ann. Bot. (Rome)	Annali di Botanica (Rome)
Ann. Lyceum Nat. Hist. New York	Annals of the Lyceum of Natural History of New York
Ann. Sci. Nat., Bot.	Annales des Sciences naturelles, Botanique
Baier. Fl.	Baiersche Flora
Beih. Bot. Centralbl., Abt.	Beihefte zum Botanischen Centralblatt. Zweite Abteilung, Systematik, Pflanzengeographie, angewandte Botanik
Ber. Thätigk. St. Gallischen Naturwiss. Ges.	Bericht über die Thätigkeit der St. Gallischen Naturwissenschaftlichen Gesellschaft
Bih. Kongl. Svenska Vetensk.- Akad. Handl	Bihang till Kongliga Svenska Vetenskaps-Akademiens Handlingar
Bonplandia	Bonplandia
Bot. Centralbl.	Botanisches Centralblatt
Bot. Gaz.	Botanical Gazette
Bot. Jahrb. Syst.	Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie
Bot. Mag. (Tokyo)	Botanical Magazine, Tokyo
Bot. Tidsskr.	Botanisk Tidsskrift
Bot. Zeitung (Berlin)	Botanische Zeitung (Berlin)
Brittonia	Brittonia
Bryol. Eur.	Bryologia Europaea
Bryol. Jav.	Bryologia Javanica
Bryol. Univ.	Bryologia Universa

Abbreviation Title	Full Title
Bryologist	The Bryologist
Bull. Acad. Int. Géogr. Bot.	Bulletin de l'Académie Internationale de Géographie Botanique
Bull. Bot. Soc. Bengal	Bulletin of the Botanical Society of Bengal
Bull. Brit. Mus. (Nat. Hist.), Bot.	Bulletin of the British Museum (Natural History), Botany
Bull. Herb. Boissier	Bulletin de l'Herbier Boissier
Bull. New York Bot. Gard.	Bulletin of the New York Botanical Garden
Bull. Soc. Bot. France	Bulletin de la Société Botanique de France
Bull. Soc. Bot. Genève	Bulletin de la Société Botanique de Genève
Bull. Soc. Roy. Bot. Belgique	Bulletin de la Société Royale de Botanique de Belgique
Bull. Torrey Bot. Club	Bulletin of the Torrey Botanical Club
Calcutta J. Nat. Hist.	Calcutta Journal of Natural History and Miscellany of the Arts and Sciences in India
Cat. Afr. Pl.	Catalogue of the African Plants collected by Dr. F. Welwitsch in 1853–61
Contr. U.S. Natl. Herb.	Contributions from the United States National Herbarium
Coroll. Bryol. Eur.	Corollarium Bryologiae Europaeae
Dansk Bot. Ark.	Dansk Botanisk Arkiv
Deutschl. Fl.	Deutschlands Flora oder Botanisches Taschenbuch
Deutschl. Fl., Abt. II, Crypto.	Deutschlands Flora, Abtheilung II, Cryptogamie
Disp. Méth. Mousses	Disposition Méthodique des Espèces de Mousses
Edinburgh J. Sci.	Edinburgh Journal of Science
Eur. N. Amer. Bryin.	European and N. American Bryineae (Mosses)
Fl. Bor.-Amer.	Flora Boreali-Americana (Michaux)

Abbreviation Title	Full Title
Fl. Nov.-Zel.	Flora Novae-Zelandiae
Fl. Vit.	Flora Vitiensis
Flora	Flora
Gen. Eur. N.- Amer. Bryin.	Genera of European and North American Bryineae (Mosses)
Gen. Musc. Frond.	Genera Muscorum Frondosorum
Handb. Males. Mosses	A Handbook of Malesian Mosses
Hannover. Mag.	Hannoverisches Magazin
Hedwigia	Hedwigia
Hooker's J. Bot. Kew Gard. Misc.	Hooker's Journal of Botany and Kew Garden Miscellany
Ill. Moss Fl. Japan	Illustrated Moss Flora of Japan
Index Bryol.	Index Bryologicus
Index Bryol. Suppl.	Index Bryologicus Supplementum Primum
J. Bot.	Journal of Botany, British and Foreign
J. Bot. (Morot)	Journal de Botanique (Morot)
J. Bot. Agric.	Journal de Botanique, Appliquée à l'Agriculture, à la Pharmacie, à la Médecine et aux Arts
J. Hattori Bot. Lab.	Journal of the Hattori Botanical Laboratory
J. Linn. Soc., Bot.	Journal of the Linnean Society, Botany
J. Mus. Godeffroy	Journal des Museums Godeffroy
J. Proc. Linn. Soc., Bot., Suppl.	Journal of the Proceedings of the Linnean Society, Botany, Supplement
J. Siam Soc., Nat. Hist. Suppl.	Journal of the Siam Society, Natural History Supplement
Laubm. Deutschl.	Die Laubmoose Deutschlands, Oesterreichs und der Schweiz
Leafl. Philipp. Bot.	Leaflets of Philippine Botany
Linnaea	Linnaea
London J. Bot.	London Journal of Botany
Mag. Encycl.	Magasin Encyclopédique

Abbreviation Title	Full Title
Manual	A Manual of the Botany of the Northern United States
Mém. Soc. Linn. Paris	Mémoires de la Société Linnéenne de Paris
Mém. Soc. Phys. Genève	Mémoires de la Société de Physique et d'Histoire Naturelle de Genève
Monogr. Syst. Bot. Missouri Bot. Gard.	Monographs in Systematic Botany from the Missouri Botanical Garden
Monsunia	Monsunia, Beiträge zur Kenntniss der Vegetation des Süd- und Ostasiatischen Monsungebietes
Moss Fl. China	Moss Flora of China, English Version
Mosses E. India	Mosses of Eastern India and Adjacent Regions
Musc. Frond. Ined. Archip. Ind.	Musci Frondosi Inediti Archipelagi Indici
Musci Allegh.	Musci Alleghanienses
Musci Buitenzorg	Die Musci der Flora von Buitenzorg
Musci Exot.	Musci Exotici
Muscol. Recent.	Muscologia Recentiorum
Nat. Pflanzenfam.	Die Natürlichen Pflanzenfamilien
Ned. Kruidk. Arch.	Nederlandsch Kruidkundig Archief. Verslangen en Mededelingen der Nederlandsche Botanische Vereeniging
Not. Pl. Asiat.	Notulae ad Plantas Asiaticas
Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur.	Nova Acta Physico-medica Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum Exhibentia Ephemerides sive Observationes Historias et Experimenta
Nova Guinea	Nova Guinea
Nova Hedwigia	Nova Hedwigia
Nuovo Giorn. Bot. Ital., n.s.	Nuovo Giornale Botanico Italiano, Nuova Serie
Observ. Bot.	Observationes Botanicae
Öfvers. Finska Vetensk.-Soc. Förh.	Öfversigt af Finska Vetenskaps-Societetens Förhandlingar

Abbreviation Title	Full Title
Öfvers. Förh. Kongl. Svenska Vetensk.-Akad.	Öfversigt af Förhandlingar: Kongl. Svenska Vetenskaps-Akademien
Ottawa Naturalist	Ottawa Naturalist
Pflanzenr.	Das Pflanzenreich
Philipp. J. Sci.	Philippine Journal of Science
Philos. Trans.	Philosophical Transactions of the Royal Society of London
Polish Bot. J.	Polish Botanical Journal
Proc. Acad. Nat. Sci. Philadelphia	Proceedings of the Academy of Natural Sciences of Philadelphia
Proc. Amer. Acad. Arts	Proceedings of the American Academy of Arts and Sciences
Proc. Linn. Soc. New South Wales	Proceedings of the Linnean Society of New South Wales
Proc. Roy. Soc. Queensland	Proceedings of the Royal Society of Queensland
Prodr. Aethéogam.	Prodrome des Cinquième et Sixième Familles de l'Aethéogamie
Rev. Bryol.	Revue Bryologique
Rev. Bryol. Lichénol.	Revue Bryologique et Lichénologique
Schriften Naturf. Ges. Danzig	Schriften der Naturforschenden Gesellschaft in Danzig
Smithsonian Contr. Bot.	Smithsonian Contributions to Botany
Sp. Musc. Frond.	Species Muscorum Frondosorum
Sp. Musc. Frond., Suppl.	Species Muscorum Frondosorum, Supplementum
Sp. Pl.	Species Plantarum
Syllabus	Syllabus der Pflanzenfamilien . . . Achte Auflage
Symb. Antill.	Symbolae Antillanae seu Fundamenta Florae Indiae Occidentalis
Symb. Sin.	Symbolae Sinicae
Syn. Musc. Eur.	Synopsis Muscorum Europaeorum
Syn. Musc. Frond.	Synopsis Muscorum Frondosorum omnium hucusque Cognitorum

Abbreviation Title	Full Title
Syst. Assoc. Special Vol.	Systematics Association Special Volume
Syst. Verz. 1842–1844	Systematisches Verzeichniss der von H. Zollinger in den Jahren 1842–1844
Taxon	Taxon
Thai Forest Bull., Bot.	Thai Forest Bulletin (Botany)
Trans. Linn. Soc. London	Transactions of the Linnean Society of London
Trans. Linn. Soc. London, Bot.	Transactions of the Linnean Society of London, 2nd series: Botany
Verh. K.K. Zool.-Bot. Ges. Wien	Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien
Verh. Kon. Akad. Wetensch., Afd. Natuurk.	Verhandelingen der Koninklijke Akademie van Wetenschappen, Afdeeling Natuurkunde
Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn	Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjøbenhavn
Voy. Uranie	Voyage autour du monde, entrepris par ordre du roi, . . . exécuté sur les corvettes de S. M. l'Uranie et la Physicienne, pendant les années 1817, 1818, 1819 et 1820; . . . Botanique
Willdenowia	Willdenowia

VITA

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