

# **Systematic treatment of Sematophyllaceae (Musci) in Thailand**

## **Dissertation**

zur

Erlangung des Doktorgrades (Dr. rer. nat.)

der

Mathematisch-Naturwissenschaftlichen Fakultät

der

Rheinischen-Friedrich-Wilhelms-Universität Bonn

vorgelegt von

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Trang / Thailand

Bonn 2008

Angefertigt mit Genehmigung der Mathematisch – Naturwissenschaftlichen Fakultät der Rheinischen-Friedrich-Wilhelms-Universität Bonn.

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Tag der Promotion: 02 June 2008

**To my dear parents and family,  
Zu meinen lieben Eltern und Familie  
แต่ พ่อแม่ที่รัก และครอบครัว,**

**To my respective teachers,  
Zu meinen jeweiligen Lehrern,  
แต่ ครู-อาจารย์ที่เคารพ**

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## 1 INTRODUCTION

### 1.1 GENERAL INTRODUCTION TO FAMILY SEMATOPHYLLACEAE

The Sematophyllaceae is a large constitution of species rich pleurocarpous moss family. There are 53 genera and ca. 600 species that is most diverse in tropical and subtropical zones (Buck 1982). Although a few genera (e.g. *Sematophyllum*, *Wijkia*, *Warburgiella*) extend into temperate zones, diversity there is more limited. Distribution is mainly in humid forests with plants epiphytic on bark of branches, stems and logs, occasionally as epiphylls and more rarely on rock or damp forest floor. (Ramsey *et al.* 2002)

The family is characterized by ecostate leaves with linear or rhombic cells, a well differentiated alar region with cells often seriate, inflated and vesiculose; the stem is usually red and lacks a central strand; pseudoparaphyllia are usually foliose; exothecial cells are usually collenchymatous or sometimes sub-collenchymatous. The peristome is usually well developed with both exostome and endostome. Often the genera have been differentiated by peristomial characters such as endostome development (reduced to absent in *Meiothecium* and longer than exostome in *Macrohymenium*). Some genera are separated on leaf cell papillosity difference (seriately papillose, e.g., *Radulina*, *Taxithelium* and *unipapillose*, e.g., *Rhaphidostichum*, *Trichosteleum*), although in other genera a range in papillosity exist even within a species (e.g., *Acroporium*, *Wijkia*). The degree of alar development frequently distinguishes particular genera (e.g., *Gammiella*, *Meiothecium* and *Sematophyllum*).

The completed works on the family had been presented from many localities in the world e.g., Borneo (Dixon 1934), Philippines (Bartram 1939), Mexico (Grout 1973), Eastern India and adjacent regions (Gangulee 1980), Japan (Seki 1968, Noguchi 1994), West Indies (Buck 1998), Africa (O'Shea 1999), Britain and Ireland (Smith 2004), Australia (Ramsay *et al.* 2002a, 2002b, 2004), North America (Schofield 2005), China (Jia *et al.* 2005) and Huon Peninsula, Papua New Guinea (Tan *et al.* 2005, 2007). From all floras, the species from subtropical regions are presented nearly most different from Thailand. Recently, the reports concentrated in some genera from Malay Peninsula, Borneo, Java, and Philippines were showing many species have distributions throughout Thailand, but they are not completed works at this present.

On the classification system of family Sematophyllaceae, Brotherus (1925) separated the family into 4 sub-families, Sematophylloideae, Clatobryoideae, Heterophylloideae and Macrohymenioideae. Gangulee (1980), Buck and Tan (1989), Tan and But (1997), Tan and Jia (1998, 1999) Ramsay *et al.* (2004) and Jia *et al.* (2005) supported the four subfamilies although they suggested some re-arrangement of genera within them.

Among the various subfamilies of Sematophyllaceae, Tan and Jia (1999) had described comments on certain morphological characters of various genera from China. They suggested, the Heterophylloideae is distally related to the Macrohymenioideae, Clatobryoideae and Sematophylloideae. It is probably best to recognize the group as constituting its own family in order to define the Sematophyllaceae monophyletically. Within the family, they consider the group Heterophylloideae to be more closely related to Myuriaceae and Pterobryaceae than to Sematophyllaceae.

There are many cladistic analyses within and between its relative families to place the right genera in Sematophyllaceae. A critical analysis and establishment of monophyletic taxa is needed on a worldwide scale for subfamilies and genera; this has, in part, been initiated by Hedenäs (1996). A report by Tan and Jia (1998) based on their studies on 33 characters in 24 Chinese genera and warned that the value of analyses depend on the interpretation of characters and character states, noted that one clade, *Brotherella-Warburgiella-Acanthorrhynchium-Wijkia* was distantly related to the *Sematophyllum* clade. Recently, a cladistic and phylogenetic analysis by Hedenäs and Buck (1999) based on 83 characters, including gametophytic and sporophytic, has produced a more extensive review of the family. They found no firm evidence for subdividing the Sematophylloideae into group corresponding to Clastobryoideae or Macrohymenioideae and no clade corresponding to the former 4 subfamilies of Brotherus (1925). They placed part of the Heterophylloideae in a new subfamily Wijkioideae, considered to be ancestor and containing the genera *Wijkia*, *Acanthorrhynchium* and *Trismegistia*. This supports Tan and Jia (1998), but did not include *Brotherella* in the subfamily Wijkioideae. All other genera were placed by them into the large subfamily Sematophylloideae. Their studies suggested that the family may be monophyletic although the taxonomic position of some probable members of the Hypnaceae has not been clearly determined. A clearer picture of relationships may appear once DNA studies have been completed although the reliability of results will depend on the range of species selected to present each genus. For some genera (e.g., *Sematophyllum*, *Taxithelium*), which appear polyphyletic, prior generic revisions may be necessary.

In addition, the relationships within the family and between the regions are still poorly understood. The similarity appearance between taxa from some regions have been reported, e.g., a synopsis review of Philippines Sematophyllaceae with emphasis on Clastobryoideae and Heterophylloideae (Tan and Buck 1989), the delimitation of familiar genera in the Malay-peninsula region, e.g., *Acroporium*, *Clastobryum*, *Rhaphidostichum*, *Sematophyllum*, *Taxithelium*, and *Trichosteleum* which are recognized in subfamily Sematophylloideae on basis of morphology also needs to be tested by using a numerical taxonomy by Tan (1994). The more studies of their relationships are important and useful for arrangement the good taxa and solve problems in Sematophyllaceae.

Furthermore, many complete works of some related genera have been published e.g., the Asiatic genera of Sematophyllaceae associated with *Trichosteleum* (Buck and Tan 1989), genetic distantness of *Brotherella* from *Pylaisiadelphina* Card. (Ando *et al.* 1989), a revision of the moss genus *Taxithelium* (Damanhuri and Longton (1996), taxonomic revision of the genus *Trismegistia* (Akiyama 2004), and a revision of the genus *Radulina* W.R.Buck & B.C.Tan (O'Shea 2006). Beside that, the revision of some genera in each area have been presented e.g., a review of *Taxithelium* in Brazil (Buck 1985), the genus of *Acroporium* in Borneo with notes on species of Java and the Philippines (Tan 1994), A revision of *Acanthorrhynchium* in Africa (O'Shea 1997), the genus *Taxithelium* in Australia (Ramsay *et al.* 2002a). However, the diversity of species in each region is necessary to revise for making a completed classification system of Sematophyllaceae and study their phylogenies in the future.

Although there are many publications of Sematophyllaceae from worldwide, but there had not any research presented from Thailand, except only checklist reports. For this, the systematic treatment of Sematophyllaceae from Thailand will made valuable results for Thai flora and necessary to complete works for moss flora of South East Asia.

## 1.2 BRYOLOGICAL HISTORY OF SEMATOPHYLLACEAE IN THAILAND

The study of Thai bryophytes began between 1899 and 1900 when Danish botanist Johs. Schmidt collected numerous mosses in Koh Chang Island (Brotherus 1901). Carl Hosseus, a German botanist, collected a handful of bryophytes in northern and northwestern Thailand between 1904 and 1905 (Brotherus 1911). A. F. G. Kerr, an Irish physician, collected bryophytes extensively throughout the country, during his 25 years stay in Thailand from the late 19<sup>th</sup> to early 20<sup>th</sup> (Larsen 1979). Based on Kerr's collections and all known literatures, Dixon (1932) published the first catalogue of Thai mosses, containing 220 species. Later, Dixon (1935) updated the list to 300 species.

Between the late 1950s and the early 1970s was the most active period of study of Thai mosses. Numerous joint botanical expeditions were undertaken by western and Japanese botanists 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 (Larsen 1979). Their unidentified moss collection (ca. 7,000 specimens) was recently studied at the Missouri Botanical Garden (MO) and distributed to many herbaria in Europe. These specimens provided a primary source for compiling the present checklist moss flora of Thailand (He 2005-2008).

During the same period (1950s-1970s) numerous botanical expeditions were also undertaken by Dutch, French, and Japanese botanists, such as E. Hennipman & A. Touw (Touw 1968), P. Tixier (Tixier and Smitinand 1966; Tixier 1971, 1971-72), K. Yoda, H. Ogawa, & T. Umesao (Horikawa and Ando 1964), and M. Tagawa & N. Kitagawa (Noguchi 1973). Since the late 1970s several Thai-Danish and Thai-Japanese botanical expeditions have occurred (Larsen 1992; Shimizu *et al.* 1980), but major collecting of bryophytes has not been reported. Throughout the history of Thai bryology, the collecting of bryophytes has been rather extensive, but very few bryologists have collected there besides A. Touw (1965-1966) and P. Tixier (1965-1968).

In reviewing the change of species number of mosses from the first checklist of 300 species (Dixon 1932, 1935) to the second updated specimen-based checklist of 516 species (Tixier 1971), and to the latest checklist of 563 species (Tan and Iwatsuki 1993), new records and new names, including several new species, have been added to the moss flora of Thailand as results of continuing exploration and regional studies of East Asiatic mosses. However, the later checklist was based on published literature without citing specimen data and locality information.

The last revision of mosses flora of Thailand was undertaken by He (1995-2008) in *A checklist of moss flora of Thailand*. It accepts 620 species and 31 subspecific taxa distributed in 190 genera and 52 families. All accepted taxa are provided with information on synonyms, illustrations, habitats, provincial localities as well as with the range of species distribution in Asia. This checklist presented Sematophyllaceae is the richest number of species in Thailand, 22 genera 91 species and 3 varieties are reported. However, the information that present in this checklist is not contained of species description and key for identification to species that are important and useful for Thai Flora.

### 1.3 GEOGRAPHICAL AND FLORISTIC DIVISIONS OF THAILAND

Thailand (Siam) is situated in the southeastern corner of Asia between the latitudes 6°-20° N and longitudes 98°-105° E, sharing borders on west and northwest by Myanmar (Burma), on northeast by Laos, on southeast by Kampuchea (Cambodia), and on south by Malaysia (Fig. 1.1). With an area of 514,000 square kilometers, Thailand exhibits a diverse landscape, ranging from sea level to 2,850 meters in elevation. The most conspicuous terrain features of Thailand include several high mountains, a lowland central plain dominated by the Chao Phraya River, and an undulating dry upland plateau bordered by the Mekong River.

#### Climate

The climate is characterized by tropical monsoon system which reverses its cycle seasonably. The temperatures normally range from an average annual high of 38 °C (100 °F) to a low of 19 °C (66 °F). The southwest monsoons that arrive between May and July (except in the South) signal the advent of the rainy season, which lasts into October. November and December mark the onset of the dry season. Temperatures begin to climb in January, and a hot sun parches the landscape. The dry season is shortest in the South because of the proximity of the sea to all parts of the Malay Peninsula. With only minor exceptions, every area of the country receives adequate rainfall, but the duration of the rainy season and the amount of rain vary substantially from region to region and with altitude. The Northeast experiences a long dry season, and its red, porous (laterite) soils retain water poorly, which limits their agricultural potential.

This variability in topography and climate has produced diverse vegetations that include a large number of mosses, representing one of the richest moss floras in the tropical Asia.

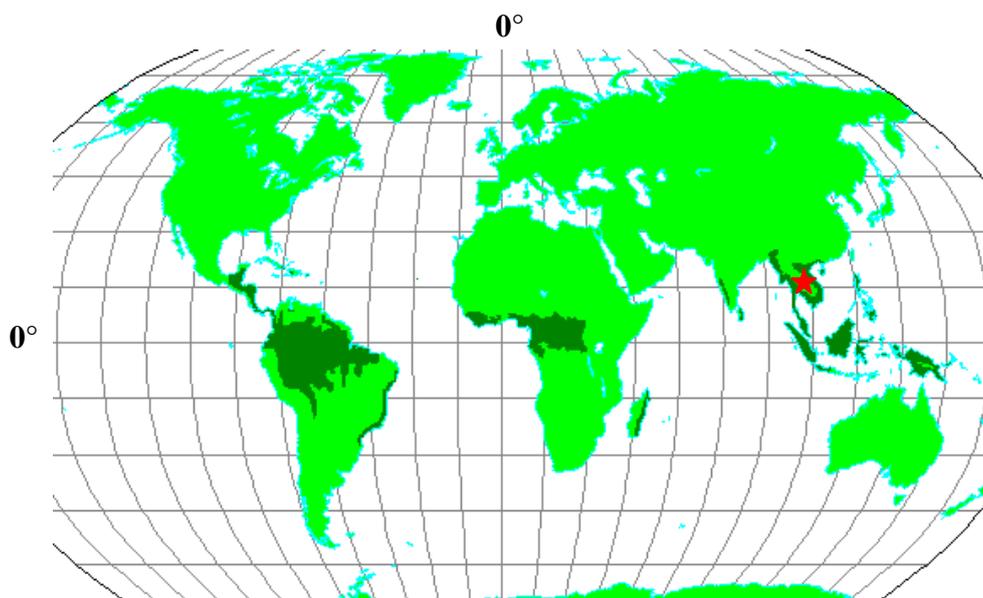


Figure 1.1 Map of tropical rainforest (dark green color) in the world, showing location of Thailand (red star) between the latitudes 6°-20° N and longitudes 98°-105° E.

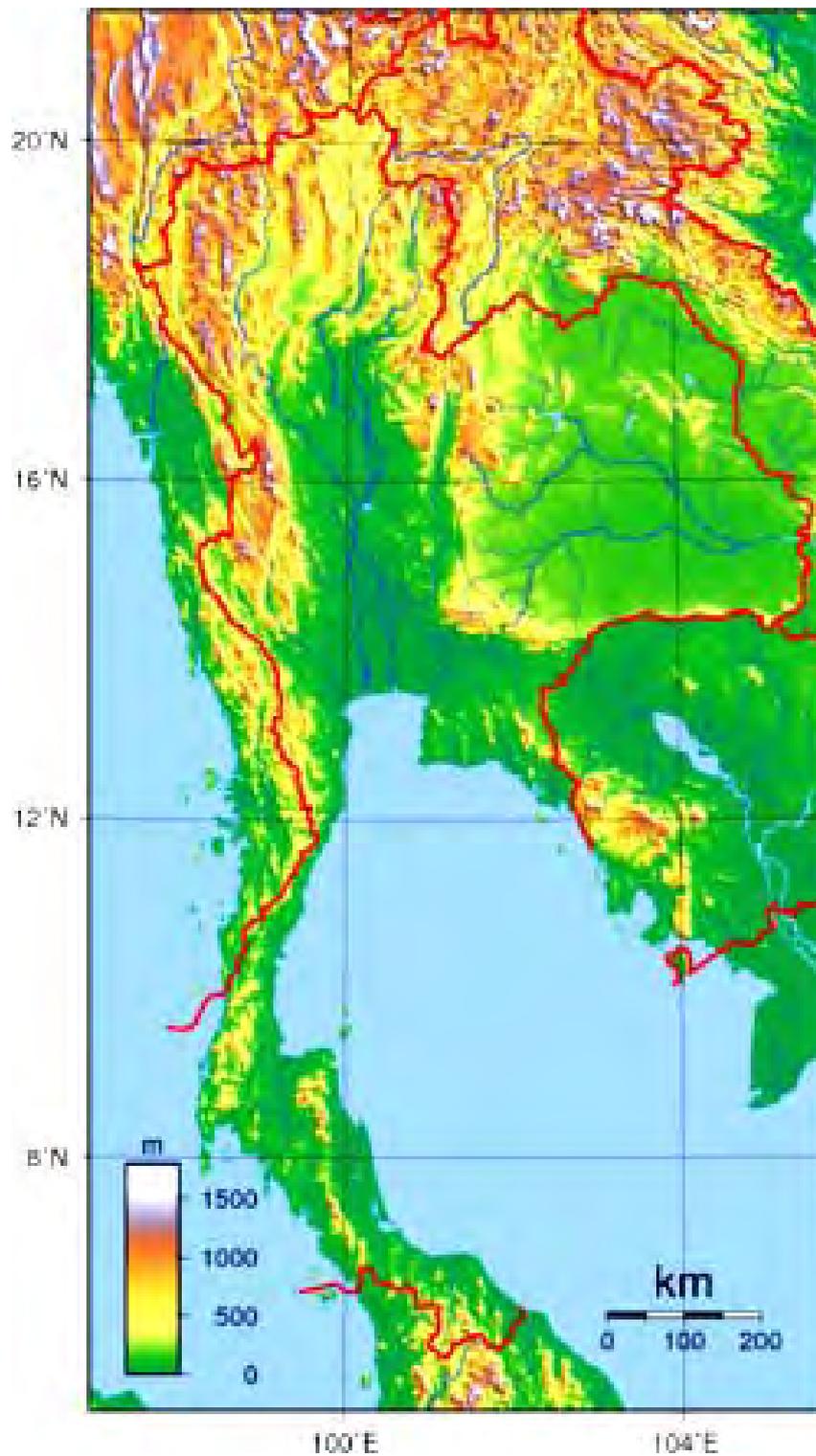


Figure 1.2 Topographic map shows ranges of elevation and geography of Thailand, [map available at [http://en.wikipedia.org/wiki/Geography\\_of\\_Thailand](http://en.wikipedia.org/wiki/Geography_of_Thailand)].

## Topography and drainage

The most conspicuous features of Thailand's terrain are high mountains, a central plain, and an upland plateau. Mountains cover much of northern Thailand and extend along the Myanmar border down through the Kra Isthmus and the Malay Peninsula. The central plain is a lowland area drained by the Chao Phraya River and its tributaries, the country's principal river system, which feeds into the delta at the head of the Bay of Bangkok. The Chao Phraya system drains about one-third of the nation's territory. In the northeastern part of the country the Khorat Plateau, a region of gently rolling low hills and shallow lakes, drains into the Mekong through the Mun River. The Mekong system empties into the South China Sea and includes a series of canals and dams. Together, the Chao Phraya and Mekong systems sustain Thailand's agricultural economy by supporting wet-rice cultivation and providing waterways for the transport of goods and people (Fig. 1.2). In contrast, the distinguishing natural features of peninsular Thailand are long coastlines, offshore islands, and diminishing mangrove swamps.

The topography and drainage of Thailand in part define the country as four widely recognized geographical regions: the North (N), Northeast (NE), Center (C), and South (S). The four regions have no administrative significance, but each differs from the others in population, basic resources, natural features, and level of social and economic development. Thailand is administratively divided into seventy-six districts (provinces). From bryological history, Thailand had been divided into 18 natural regions by grouping the central old province and its near by in each locality (Touw 1968; Noguchi 1972, 1973). Botanically, Thailand is included in the Indochinese subdivision of the continental southeast Asiatic region according to the recent floristic divisions of the earth (Good 1974). Thailand can be divided into seven floristic regions. They are: the Northern (N), Northeastern (NE), Eastern (E), Central (C), Southeastern (SE), Southwestern (SW), and the "Peninsula" (PEN). To illustrate the relationships among the geographical regions (4), natural regions (18), floristic divisions (7), and administrative provinces (76) of Thailand, the data into a classification as shown in table 1.1.

He (1998) presented the following descriptions of floristic features of each division, including natural regions and provinces (Note: roman numerals before natural regions and alphanumeric numbers before provinces are corresponding to those shown in the map (Fig.1.3).

**1) Northern division (N):** This division is under the Indo-Myanmaran floristic tendency. The region is rich in high mountains, having the highest peak (Doi Inthanon, alt. 2576 m) in Thailand. The geological formation is generally of sandstone or granite. Types of forests are ranging from dry dipterocarp forest below 500 m, dry evergreen forest between 500 to 1000 m, and to dry hill evergreen forests above 1000 m (Smitiand 1958). Both historically and in recent times, northern Thailand has received the most attention of botanists who collected bryophytes. The division includes four natural regions and 18 provinces.

**2) Northeastern division (NE):** This region corresponds to the Indochinese flora, but the Indo-Myanmaran elements can also be found here. Floristic affinities are close to southwestern China as well. The region is the high plateau of Thailand. Types of forests are from dry deciduous to mixed deciduous forests with large tracts of dry evergreen forests growing intermittently. Pine forests are present from above 1000 m. Dipterocarp

forests are the common feature of the region. A significant number of bryophytes have been collected from this region. This division includes two natural regions and 10 provinces.

**3) Eastern division (E):** This region is under the influence of the central and southern Indochinese flora. Dry dipterocarp forests are the main feature of the region. Savannas are also common. Pine forests can be seen side by side or mixed with dry dipterocarp forests. No significant bryophyte collections have been made from this region. This division includes two natural regions and 7 provinces.

**4) Central division (C):** This division corresponds with the southern half of Bangkok plain or central valley. The region is mostly under cultivation. Virgin forests have almost disappeared. The dipterocarps, once formed the evergreen forests in the region, are scattered here and there nowadays. Little bryological field work has been carried out in this area. The division includes three natural regions and 12 provinces.

**5) Southern division (SE):** This region is under the influence of both southern Vietnamese and Malayan floras. The dipterocarps together with *Solenospermum* and *Parkia* form the predominating species in the tropical rain forests (Smitinand 1958). Savannas are also widespread in the plains. The common low shrub species in the area is *Dillenia hookeri*, which grows in common, scattered clumps. Rich mangrove swamps and tidal forests are the dominant feature of the coastal line and along the estuaries of the main rivers. Field work involving bryophyte collecting has been relatively well undertaken in this region. The division includes two natural regions and 7 provinces.

**6) Southwestern division (SW):** This region is predominated by limestone formation and corresponds with the Lower Myanmaran flora. Evergreen forests are usually present in remote part of the region near the border between Myanmar and Thailand. Bamboo forests and savanna scrubs are the common features of the plains. The bamboo forests often gradually change into mixed deciduous and dry dipterocarp forests. Only a small number of bryophytes have been collected here mostly by collectors traveling from northern to peninsular Thailand. This division includes one natural region and 5 provinces.

**7) The peninsular division (PEN):** This region is mostly under the influence of the Malayan flora. The Malayan elements are fairly common in the region although in northern part of the region Myanmaran elements are notably joined together. The forests are mainly of the tropical rain forest type and are made up of many dipterocarp species. Mangrove swamps in the region are very rich and are the main mangrove-forests of the country. They almost cover the whole western coast. A large number of bryophyte collections have been made from this region. The division includes four natural regions and 14 provinces.

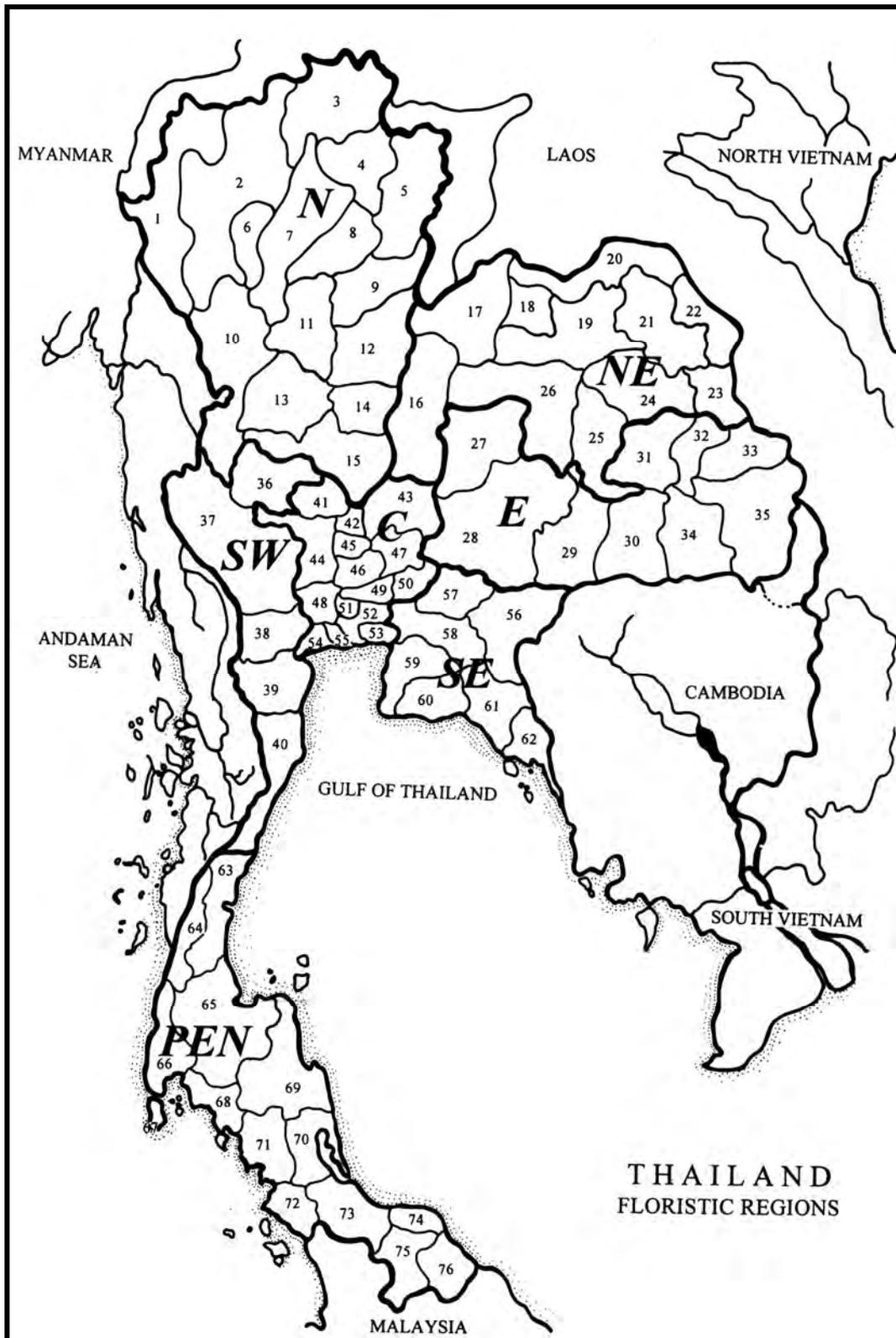


Figure 1.3 The Relationships between Geographic Regions (GE), Floristic Divisions, Natural Regions, and Provinces of Thailand (map available at Flora of Thailand Project).

Table 1.1 The relationships between Geographic Regions (GE), Floristic Divisions, Natural Regions, and Provinces of Thailand

GE	Floristic Divisions	Natural Regions	Provinces	
N	Northern (N)	PAYAP	1. Mae Hong Son; 2. Chiang Mai; 3. Chiang Rai	
		MAHARAT	4. Phayao; 5. Nan; 6. Lamphun; 7. Lampang; 8. Phrae	
		NAKHON SAWAN	10. Tak; 13. Kamphaeng Phet; 15. Nakhon Sawan	
		PHITSANULOK	9. Uttaradit; 11. Sukhothai; 12. Phitsanulok; 14. Phichit	
NE	Northeastern (NE)	UDAWN	16. Phetchabun; 17. Loei; 18. Nong Bua Lam Phu; 19. Udon Thani; 20. Nong Khai; 21. Sakon Nakon; 22. Nakhon Phanom; 23. Mukdahan; 26. Khon Kaen	
		ROI ET	24. Kalasin; 25. Maha Sarakham	
	Eastern (E)	UBON	30. Surin; 31 Roi Et; 32. Yasothon; 33. Amnat Charoen; 34. Sisaket; 35. Ubon Ratchathani	
		RACHASIMA	27. Chaiyaphum; 28. Nakhon Ratchasima; 29. Buriram	
C	Central (C)	AYUTHIA	41 Chai Nat; 42. Sing Buri; 43. Lop Buri; 45. Ang Thong; 46. Phra Nakhon Si Ayutthaya; 47. Sara Buri	
		KRUNGTEP	49. Pathum Thani; 50 Nakhon Nayok; 51. Nonthaburi; 52. Krung Thep Mahanakhon; 53. Samut Prakan	
		NAKAWN CHAISI	44. Suphan Buri; 48. Nakhon Pathom; 54 Samut Songkhram; 55. Samut Sakhon	
	Southeastern (SE)	CHANTHABURI	60. Rayong; 61. Chanthaburi; 62. Trat	
		PRACHINBURI	56 Sa Kaeo; 57. Prachin Buri; 59. Chon Buri; 58. Chachoengsao	
	Southwestern (SW)	RACHABURI	36 Uthai Thani; 37. Kanchanaburi; 38. Rat Buri; 40. Prachuap Khiri Khan	
	S	Peninsula (PEN)	SURAT	63. Chumphon; 65. Surat Thani
			PHUKET	64. Ranong; 66. Phangnga; 67. Phuket; 68. Krabi; 71. Trang; 72. Satun
NAKHON SI THAMMARAT			69. Nakhon Si Thammarat; 70. Phatthalung; 73. Songkhla	
PATTANI			74. Pattani; 75. Yala; 76. Narathiwat	

## 2 AIM MATERIALS AND METHODS

### 2.1 AIM OF STUDY

The aim is to provide a complete account of moss Family Sematophyllaceae for Thailand. The result of the study will provide a basis for the future completion of accounts moss for the Flora of Thailand.

### 2.2 MATERIALS AND METHODS

This revision was undertaken at the Jan-Peter Frahm Herbarium, Nees-Institut für Biodiversität der Pflanzen, Rheinische Friedrich-Wilhelms-Universität Bonn (BONN). Approximately 2000 voucher specimens were examined from the following herbaria: University of Aarhus, Denmark (AAU); The Forest Herbarium, Bangkok (BKF); The Natural History Museum, London (BM); Harvard University, Cambridge (FH); Brotherus Herbarium, Helsinki (H-BR); Nationaal Herbarium Nederland, Leiden University branch, Leiden (L); Herbarium, The New York Botanic Garden, New York (NY); Museum National d'Histoire Naturelle, Paris (PC) and some included additional collections from field study preserved at herbarium Chulalongkorn University, Bangkok (BCU).

#### 2.2.1 Herbarium collections and field study

##### 2.2.1.1 Herbarium collections

Study of the available herbarium collections was extremely important in this taxonomic study. The collaborating institutions of the Flora of Thailand project (AAU, BCU, BKF, BM, FH, H-BR, L, NY, PC) have good collections of the South East Asian flora. A large number of unidentified specimens filed under Sematophyllaceae were examined. Some are fined as new records to Thailand and some are identified to related families. Specimens that preserved in herbarium above were carried by many botanists under the coordination project between Thai and foreigner researchers. The collectors that recorded in specimen labels are presenting in year and report below.

- Johs. Schmidt, a Danish botanist, collected numerous mosses in Koh Chang, a big island in southeastern of Thailand. This first study report of Thai bryophytes began between 1899 and 1900 (Brotherus 1901).
- Carl Hosseus, a German botanist, collected a handful of bryophytes in northern and northwestern Thailand between 1904 and 1905 (Brotherus 1911).
- A. F. G. Kerr, an Irish physician, collected bryophytes extensively throughout the country during his 25 years stay in Thailand from the late 19th to early 20th. (Larsen 1979).
- Several Thai-Danish expeditions by the team consisting of Ch. Charoenphol, B. Hansen, K. Larsen, T. Santisuk, T. Smitinand, T. Sørensen, and E. Warncke were carried out between 1958 and 1970 (Larsen 1979).
- During the same period (1950s-1970s) numerous botanical expeditions were also undertaken by Dutch, French, and Japanese botanists, such as E. Hennipman & A. Touw (Touw 1968), P. P. Tixier (Tixier and Smitinand 1966; Tixier 1971, 1971-

- 72), K. Yoda, H. Ogawa & T. Umesao (Horikawa and Ando 1964), and M. Tagawa & N. Kitagawa (Noguchi 1973).
- Since the late 1970s several Thai-Danish and Thai-Japanese botanical expeditions have occurred (Larsen 1992; Shimizu *et al.* 1980), but the major collecting of bryophytes has not been reported.

### 2.2.1.2 Field study

Many field trips to collect more specimens were followed trails presented in study reported expeditions of Thai moss. Furthermore, specimens and literatures from the surrounding regions were also studied for comparison. In addition, field study within the region was extremely important in order to increase the understanding of some poorly known group. The field trips were made to Thailand in the years 2005, 2006 and 2007. Plants in their natural habitats and ecological information were gathered during the field work. The field works took place in reservation area of 8 national parks in several regions of the country.

1. Northern: Chiang Mai. Doi Inthanon National Park, Doi Suthep-Pui National Park; Phitsanulok. Phuhin Rongkla National Park.
2. Northeastern: Loei. Phu Kradang National Park.
3. Eastern: Nakhon Rat Chasima. Khao Yai National Park.
4. Southeastern: Prachinburi. Khao Soi Dao National Park.
5. Southwestern: Kanchanaburi. Thong Pah Phum National Park.
6. Southern: Nakhon Sri Thammarat. Khao Luang National Park.

In total, approximately 200 specimens were collected in all field trips. The voucher specimens are held in the Herbarium, Department of Botany, Chulalongkorn University, Bangkok, Thailand (BCU).

### 2.2.2 Morphological study and description

Dimensions given in the descriptions are based on herbarium specimens, spirit material and on living plants, supplemented by observations of plants made in the field. For dry specimens, gametophytes were softened in water before measurements were taken. Taxa are arranged taxonomically. Most of the major floras and publications in SE Asia, neighboring regions, and important floras, e.g., H.N. Dixon (1924), E.B. Bartram (1939), T. Seki (1968), H.C. Gangulee (1980), B.C. Tan (1994), B.C. Tan and Y. Jia (1999), H.P. Ramsay, W.B. Schofield and B.C. Tan (2002a, 2002b, 2004), Y. Jia, P.-c. Wu and B.C. Tan (2005) are cited where appropriate. Synonyms listed in the works mentioned above are included and verified. All specimens cited under each species have been seen and are arranged by country, floristic region and collector's name. Almost all types of correct names and synonyms have been seen and are indicated by (!) after the herbaria abbreviation. For the correct names, when there is no holotype or previous lectotypification, a lectotype or neotype has been chosen. In the case of synonyms, a lectotype has only been chosen in some instances; e.g., lectotype has been chosen when the types of the name belong to more than one taxon or some of the syntypes are of poor quality; otherwise they are left as syntypes. Neotype of synonym has been chosen only when there is no existing type material and a good representative specimen has been found. Ecological information was taken from specimens and from field observations. Illustrations and distribution in another publications list from references and specimens. The figure of species was taken from types or if not, from Thai specimens.

### 2.2.3 Photographs and illustrations

The photographs were taken in J.-P. Frahm Herbarium (BONN) by using a digital camera "NICON-COOLPIX 4500" under stereo microscope and light microscope "REIZE" of magnification from 25x to 400x. The illustrations were selected specimens from type or all species that found from Thailand. Many illustrations were draw from type specimens. They are very valuable evidence to identify the right species. Both photographs and illustrations were edited the good images by program "Adobe Photoshop version 7.0".

### 2.2.4 Scanning electron microscope study

#### 2.2.4.1 Plant materials

For the present study, the herbarium specimens of Sematophyllaceae were selected for SEM analysis. The samples were selected from gametophytes and sporophytes of plant for study interested characters. The specimens were prepared by using air drying method for study with SEM. The air drying technique prepared by cut small pieces to reduce the water evaporating surface (intersection) and fix the specimens with double adhesive tape (Tessa fix) on the SEM specimen holder (aluminum stubs). Use electron conducting liquid carbon (Plano, Germany) at the edges of the specimen for additional fixing. Store the specimens in an exsiccation. Sputtering as usually is followed directly by SEM.

#### 2.2.4.2 Scanning electron microscopy (SEM)

The dried specimens were coated with a 20-25 nm thick gold layer (Balzers SCD040, Balzers, Liechtenstein) before SEM. All samples were examined in a Stereoscan 200 (Leica, Brensheim, Germany) at KV 15.

## 2.3 EXPLANATIONS OF THE FORMAT

In the format of systematic treatments, description of Family and genera are providing included key to genera, key to species and key to varieties. Each "accepted" species entry includes the author citation, page citation of primary publications, synonyms and other combination names are proposed by alphabet of year, main references of taxonomically useful illustrations published from all revision works, plant ecology (habitats and elevations), localities information in Thailand, and species distribution in the world. The photos of each species showed as figure number before description of species. The information on voucher specimens cited in primary publications and from the field study is given in the distribution section in an order of collectors' names and collection numbers followed by herbarium acronyms indicating where the specimens are currently deposited. The appropriate, special notes and nomenclatural comments are included inside the species. The collectors' names from the specimens have studied are abbreviated as:

*CLW* = Ch. Charoenphol, K. Larsen & E. Warncke; *LSaW* = K. Larsen, T. Santisuk & E. Warncke; *LSmW* = K. Larsen, T. Smitinand & E. Warncke; *LNSa* = K. Larsen, I. Nielsen & T. Santisuk; *SLH* = Th. Sørensen, K. Larsen & B. Hansen; *HSeSm* = B. Hansen, G. Seidenfaden & T. Smitinand

### 3 HISTORICAL ACCOUNT

#### 3.1 HISTORY ACCOUNT OF SEMATOPHYLLACEAE

Tracing the Sematophyllaceae to its origin, it began as Tribus 16. Sematophylleae in Mitten's *Musci Austro Americani* (1869). The Sematophyllaceae was given family rank by Brotherus (1908) in Engler & Prantl, *Die Natürlichen Pflanzenfamilien* ed. 1. Afterwards Fleischer (1912) emended Brotherus' concept and divided this family into four subfamilies: Clastobryoideae, Heterophylloideae, Sematophylloideae and Macrohymenioidae. Later, Brotherus (1925) worked the revision of family presented in *Natürlichen Pflanzenfamilien*, he followed Fleischer's treatment.

Fleischer (1923) and Brotherus (1925) were emphasized the main characteristics of Sematophyllaceae are:

- 1) leaf costa absent or short and divided in two
- 2) alar cells enlarged
- 3) operculum long rostrate

It seems that both Brotherus and Fleischer gave slight significance to characters of the peristome, consequently, the Sematophyllaceae is heterogeneous with respect to peristomal characteristic. The relationships between the Sematophyllaceae and allied families were discussed in detail by Fleischer (1923) in his "Die Musci der Flora von Buitenzorg 4, p.1174", but he did not indicate the relationship of this family to the Hypnaceae. Loeske (1910) and Reimers (1931) have been pointed out the problem that the Sematophyllaceae and the Hypnaceae are actually very closely related. The hardest problem, therefore, is to separate clearly the Sematophyllaceae from Hypnaceae. Some authors, including Grout (1932) and Andrews (1954) united them under a single family. Later Reimers (1954) was reported the Sematophyllaceae contains 37 genera and 716 species in the world.

Despite its pantropical range and rich diversity, the family has not been understood and monophyletically defined. Since its inception (Brotherus 1909), the family has been circumscribed in many ways in this country by various workers (Fleischer 1915, 1922; Brotherus 1925; Seki 1968; Gangulee 1980; Crosby and Magill 1981; Tan and Buck 1989; Tan and Jia 1999; Tan 2000; Jia *et al.* 2005) and the inclusive genera are often weakly defined on the basis of small differences in the peristomial structure, leaf papillosity, and the degree of alar differentiation. Since the family was proposed, plants of this family often have been confused with those of the Entodontaceae, Hypnaceae or Pterobryaceae (Buck 1982). Recently, Robbert *et al.* (2001) had discussed that the Sematophyllaceae contain some 40-45 (50) genera and nearly 800-900 (1000) species, primarily of the tropics and in the Neotropics 20 genera and about 100 species. The two genera among those exhibiting smooth lamellar cells, *Sematophyllum* and *Acroporium*, are widespread in the Neotropics, the remaining genera are by and large rare, or locally common in distribution.

Although a basic concept of the Sematophyllaceae is well formed, the definite systematic positions of numerous genera are still somewhat uncertain. Among the pleurocarpous

mosses, the family is considered advanced from an evolutionary perspective and has been postulated to be related to members of Hookeriales and Garovaglioideae forming a separate clade (Hedenäs 1995, 1996). In the Present study the family is defined, gametophytically, by the presence of at least a basal row of much enlarged and often coloured alar cells and sporophytically, by collenchymatous exothecial cell walls, coupled with an obliquely long rostrate operculum and a hypnalean peristome. A critical analysis and establishment of monophyletic taxa is needed on a worldwide scale for subfamilies and genera; this has, in part, been initiated by Hedenäs (1996) and showed that the family *Hydropogonaceae* is closely related to the *Sematophyllaceae* that *Hydropogon* shares a number of features suggesting placement in the latter family.

The cladistic studies of Hedenäs and Buck (1999) were based on 80 species from 56 genera with 83 morphological characters and Tan and Jia (1998) based on 33 characters in 24 Chinese genera were warned that the value of analyses depend on the interpretation of characters and character states. For instance, their character interpretations differed in some taxa from that of Hedenäs (1996). Hedenäs and Buck (1999) used additional characters and considered that characters of sexual branches and sporophytes contributed most to an explanation of the pattern found within the family. However, some difficulties exist in determining the relationship to each other, of species with reduced peristomes.

Tan and Jia (1999) had been considered the various subfamilies of *Sematophyllaceae*, among them the *Heterophyllioideae* is distally related to the *Clatobryoideae*, *Macrohymenioideae* and *Sematophylloideae*. It is probably best to recognize the group as constituting its own family in order to define the *Sematophyllaceae* monophyletically. Within the family, the group *Heterophyllioideae* was to be more closely related to *Myuriaceae* and *Pterobryaceae* than to *Sematophyllaceae*. Nevertheless, for reasons of expediency, they are treating all three subfamilies together. From this result they have excluded *Callicladium*, *Foreauella*, *Giraldiella*, *Glossadelphus*, *Palisadula*, *Pylaisiopsis*, *Struckia* and *Taxithelium* from the family treatment.

The uncertain affinity of genera has been occurred in some genera related to this family. Tan and Buck (1989) had suggested the removal of *Taxithelium* and *Struckia* from *Sematophyllaceae*. Cladistically, both genera were shown to cluster outside the *Sematophyllaceous* clade (Hedenäs 1996). *Taxithelium* is currently undergoing a monographic revision by Mohamed and Longton (1996). Earlier, Tan *et al.* (1996) suggested a transfer of this genus to *Hypnaceae* after removing those included species that have a sematophylloid leaf alar differentiation. Similar to *Struckia* C. Muell., after examination the type of *Struckia argentata* (Mitt.) C. Müll., Tan and Buck (1989) considered *Struckia* C. Müll. to be better placed in *Hypnaceae* due to its loose and thin-walled alar cells. Later, Hydenäs (1996) showed that *Struckia* shares many character states with members of the *Plagiotheciaceae* based on the branched rhizoids with granulose papillae, thus suggesting that this genus belongs to the latter family rather than to the *Sematophyllaceae*.

The study of Hedenäs and Buck (1999) proposed an uncertain affinity of the genus *Glossadelphus* M. Fleisch., included in the family by Brotherus (1925), has been transferred to the family *Hypnaceae* (Seki 1968), placed it belongs to *Hypnaceae*. The other genera such as *Brotherella*, *Foreauella*, *Gammiella*, *Hageniella*, *Pylaisiadelpha* and

*Isocradiella* were suggested classification to Hypnaceae. Furthermore, the result was made certainly to place genus *Taxithelium* in subfamily Sematophylloideae.

As a recent new classification (Buck and Goffinet 2000) based on morphological and DNA analyses, has included the genera *Pseudohypnella*, *Isocradiella* and *Taxithelium* in the family. While, Ramsay *et al* (2002) had dealt with the excluded genera, *Taxithelium*, *Isocradiella* and *Pseudohypnella*, separately from the family until their status have been finalized. Goffinet *et al.* (2003) have obtained DNA for representatives of 37 genera by sequence four loci from three genomes: the trnL region and the rps4 gene (cpDNA), the 5' half of the 26S gene (nrDNA), and the 5' half of the nad5 gene (mtDNA). Analyses of cpDNA data (114 OTUS total) suggested that the genera *Foreauella*, *Pylaisiopsis*, and *Struckia* may belong to the Hypnaceae or Entodontaceae, whereas the hypnaceous genera *Isopterygium* and *Platygyrium* show affinities to the Sematophyllaceae. However, the newly revision of Moss flora of China (Jia *et al.* 2005) is presented *Isocradiella*, *Struckia* and *Taxithelium* in Sematophyllaceae.

### 3.2 HISTORY ACCOUNT OF SUBFAMILIES IN SEMATOPHYLLACEAE

The first system of classification to subfamily in the Sematophyllaceae was modified by Brotherus (1925). The system classified this family into 4 subfamilies (Table 3.1), they are Clastobryoideae, Sematophylloideae, Heterophylloideae, and Macrohymenioidae. The recognized characters of each subfamily presented follow Gangulee (1980) as:

**Subfamily Clastobryoideae:** Plants slender, branches frequently with filamentous propagules. All leaves similar. Alar cells acroporioid, colored, often thickwalled. Capsules mostly erect. Exothecial cells semicollenchymatous with uneven thickening of vertical and lateral walls. Operculum short rostrate. Exostome smooth, not hypnoid. Endostome usually reduced.

**Subfamily Heterophylloideae:** Plants large, branches provided with either filamentous propagules or flagellate branchlets serving as propagules. Stem and branch leaves different in size and shape. Alar cells heterophylloid, forming an excavate group of colored, often incrassate, rectangular or quadrate cells. Capsules erect or inclined, exothecial cells with much thickened vertical walls. Operculum conical or short rostrate. Exostome hypnoid, or nonhypnoid.

**Subfamily Sematophylloideae:** Plants small to robust, branches rarely bearing filamentous or specialized propagules. Stem and branch leaves rather similar. Alar cells acroporioid or brotherelloid, with at least a well differentiated basal row of much enlarged, hyaline and thinwalled cells. Capsules various, exothecial cells weakly to strongly collenchymatous. Operculum long rostrate. Exostome typically hypnoid or striatepapillose. Endostome reduced or well developed.

**Subfamily Macrohymenioidae** as a genus, *Macrohymenium* C. Muell. is easily identified by the endostomial segments much longer than the short exostomial teeth.

Tan and Buck (1989), Tan and But (1997), Tan and Jia (1998, 1999) supported the four subfamilies although they suggested some re-arrangement of genera within them (Table 3.1).

Table 3.1 Brotherus' (1925) and two more recent classifications of the Sematophyllaceae, or parts of the family related genera.

Brotherus (1925)	Seki (1968)	Tan and Buck (1989)
<b>SEMATOPHYLLACEAE</b>	<b>SEMATOPHYLLACEAE</b>	<b>SEMATOPHYLLACEAE</b>
<b>Clastobryoideae</b>	<i>Acanthorrhynchium</i> *	<b>Clastobryoideae</b>
<i>Aptychella</i> *	<i>Acroporium</i> *	<i>Clastobryophilum</i> *
<i>Clastobryella</i>	<i>Aptychopsis</i>	<i>Clastobryum</i> *
<i>Clastobryophilum</i> *	<i>Chionostomum</i> *	(Syn. <i>Clastobryella</i> )
<i>Clastobryopsis</i>	<i>Clastobryum</i> *	<i>Tristichella</i>
<i>Clastobryum</i> *	<i>Meiothecium</i> *	<b>Heterophylloideae</b>
<i>Hageniella</i> *	<i>Rhaphidorrhynchium</i>	<i>Aptychella</i> *
<i>Struckia</i>	<i>Rhaphidostichum</i> *	<i>Gammiella</i> *
<b>Heterophylloideae</b>	<i>Sematophyllum</i> *	<i>Heterophyllum</i>
<i>Aptychopsis</i>	<i>Trichosteleum</i> *	<i>Isocradiella</i> *
<i>Gammiella</i> *	<b>HYPNACEAE</b>	<i>Pylaisiopsis</i>
<i>Heterophyllum</i>	<i>Brotherella</i> *	<b>Sematophylloideae</b>
<i>Mastopoma</i> *	<i>Callicladium</i>	<b>“GROUP 1”</b>
<i>Pylaisiopsis</i>	<i>Clastobryella</i>	<i>Acanthorrhynchium</i> *
<i>Trismegistia</i> *	<i>Glossadelphus</i>	<i>Acroporium</i> *
<i>Wijkia</i> *	<i>Heterophyllum</i>	<i>Rhaphidostichum</i> *
<b>Sematophylloideae</b>	<i>Taxithelium</i> *	<i>Trichosteleum</i> *
<i>Acanthorrhynchium</i> *	<i>Wijkia</i> *	<b>“GROUP 2”</b>
<i>Acroporium</i> *	<b>PTEROBRYACEAE</b>	<i>Brotherella</i> *
<i>Allioniella</i>	<i>Aptychella</i> *	<i>Chionostomum</i> *
<i>Brotherella</i> *	<i>Palisadula</i>	<i>Donnellia</i> ( <i>Meiotheciopsis</i> )
<i>Chionostomum</i> *		<i>Hageniella</i> *
<i>Donnellia</i> ( <i>Meiotheciopsis</i> )		<i>Mastopoma</i> *
<i>Glossadelphus</i> *		<i>Meiothecium</i> *
<i>Maguireella</i>		<i>Taxithelium</i> *
<i>Meiothecium</i> *		<i>Trismegistia</i> *
<i>Papillidiopsis</i> *		<i>Warburgiella</i> *
<i>Phylloдон</i>		<i>Wijkia</i> *
<i>Potamium</i>		<b>Macrohymenioideae</b>
<i>Pterogoniopsis</i>		<i>Macrohymenium</i>
<i>Pterogonidium</i>		<b>HYPNACEAE</b>
<i>Pylaisiadelpha</i> *		<i>Clastobryopsis</i>
<i>Radulina</i> *		<i>Struckia</i>
<i>Rhaphidorrhynchium</i>		
<i>Rhaphidostichum</i> *		
<i>Schraderella</i>		
<i>Schraderobryum</i>		
<i>Schroeterella</i>		
<i>Sematophyllum</i> *		
<i>Syringothecium</i>		
<i>Taxithelium</i> *		
<i>Trichosteleum</i> *		
<i>Warburgiella</i> *		

Brotherus (1925)	Seki (1968)	Tan and Buck (1989)
<p><b>Macrohymenioideae</b>  <i>Macrohymenium</i>  <b>AMBLYSTEGIACEAE</b>  <i>Schofieldiella</i>  <b>FONTINALACEAE</b>  <i>Hydropogon</i>  <b>HOOKERIACEAE</b>  <i>Chaetomitriopsis</i>  <i>Chaetomitrium</i>  <b>HYPNACEAE</b>  <i>Palisadula Pylasiella</i>  <b>MYURIAACEAE</b>  <i>Piloecium</i>  <b>POSITION UNKNOWN</b>  <b>OR NOT TREATED</b>  <i>Foreauella</i>*  <i>Horridohypnum</i>  <i>Isoclediella</i>*  <i>Leptoischyrodon</i>  <i>Paranapiacabaea</i>  <i>Pseudopiloecium</i>  <i>Timotimius</i>  <i>Tristichella</i>  <i>Trolliella</i></p>		

\* The genera are occurring in Thailand.

Recently a cladistic and phylogenetic analysis by Hedenäs and Buck (1999) based on 83 characters of 56 genera and 80 species, including gametophytic and sporophytic, has produced a more extensive review of the family. They found no firm evidence for subdividing the Sematophylloideae into group corresponding to Clastobryoideae or Macrohymenioideae and no clade corresponding to the former 4 subfamilies of Brotherus (1925). They place part of the Heterophylloideae in a new subfamily Wijkioideae, considered to be ancestral and containing the genera *Wijkia*, *Acanthorrhynchium* and *Trismegistia* (Table 3.2). This supports result by Tan and Jia (1998), but did not include *Brotherella* in the subfamily Wijkioideae. All other genera were placed by them into the large subfamily Sematophylloideae. Whether this second large subfamily should be subdivided has still not been resolved although several possible groups are considered (Hedenäs and Buck, 1999). Their studies suggest that the family may be monophyletic although the taxonomic position of some probable members of the Hypnaceae has not been clearly determined. A clearer picture of relationships may appear once DNA studies have been completed although the reliability of results will depend on the range of species selected to present each genus. For some genera (e.g., *Sematophyllum*, *Taxithelium*), which appear polyphyletic, prior generic revisions may be necessary.

In the present analyses, *Wijkia*, *Trismegistia* and sometimes *Acanthorrhynchium* or more rarely, *Papillidiopsis* were found in the same clade. Thus, there seem to be reason to

recognize a subfamily Wijkioideae, including at least some of those genera (Table 3.2). The Wijkioideae correspond to a part of Brotherus' (1925) Heterophylloideae. The Heterophylloideae include those genera of Sematophyllaceae that have the least specialized perichaetia and sporophytes, and its members are likely to be the most primitive one of the family. The genera that were included in this subfamily by Brotherus, and which were not found among the Wijkioideae of the present study, appear to be members either of the Sematophylloideae or the Hypnaceae. Because the genus *Heterophyllum* is most likely a member of the Hypnaceae, the circumscription and name of Brotherus (1925) can not be retain. The name Heterophylloideae may be useful for a taxon in a sense of Tan and Buck (1989; excepted *Aptychella*), but should be placed in the Hypnaceae. Thus, the subfamily Wijkioideae is described by Hedenäs and Buck (1999) presents as below.

Nomenclatural novelty

Sematophyllaceae subfam. Wijkioideae Hedenäs and Buck, subfam. nov.

*Genera Sematophylloidearum similis, sed plantis saepe bipinnatim ramosis vel subdendroideis, paraphysibus vaginulae longis, seta longa, operculo plerumque conico, annulo discedenti, cellulis exothecii plerumque parenchymatosis aut si collenchymatosis non interne incrassates, margine exostomii ad zonam transitionis dilatato. Typus: Wijkia.*

Other genera included: *Trismegistia*, *Acanthorrhynchium*

The Wijkioideae are characterized by a number of character states that are plesiomorphous within the Sematophyllaceae, such as the presence of paraphyses on the vaginula, a long seta, exothecial cells that are mostly parenchymatous, or if collenchymatous never with internal thickenings, a usually conical lid, and separating annulus. Although some of these states resemble those in some members of Hypnaceae, they are convinced that the Wijkioideae should be in the Sematophyllaceae due to features such as the characteristic alar cells, the frequently strongly developed inside the upper exostome teeth, and the furrowed outside the exostome. The analyses with all or most ingroup species included also suggest that this subfamily belongs to a monophyletic Sematophyllaceae.

The Sematophyllaceae in Thailand found 24 genera, all of them excepted *Pseudotrismegistia* had been presented in Brotherus' (1925). Because of some re-arrangement of genera within family, it remained 18 genera in system by Tan and Buck (1989). In the classical system by Hedenäs and Buck (1999) all genera that occurred in Thailand are presented in system, but the samples for study were taken covered only 24 species that found in Thailand. This confirmed the classification system of subfamily by Hedenäs and Buck (1999) can be applied for Thai Sematophyllaceae by the reason of their morphological characters of genera. Nevertheless, it may be too early to apply any available classification as most useful for species since many of the taxa are intermediate in characters or the populations of species show different variations of morphology in the tropical zone. The clearing diagnostic characters and relationship of genera will useful to revise a complete classification system in the future.

Within this study all genera that occurred in Thailand are arranged by follow Brotherus' (1925). It is easy to classify by their alar organizations characters. However, this system can be comparative with another classifications system by study their nomenclatural history.

Table 3.2 Suggested classification of genera that at one time or another have been considered to be member of the Sematophyllaceae. Although the “Hypnaceae” is a polyphyletic entity (Hedenäs 1995, 1998a), it is here use in it traditional sence because no better familial classification is yet available. The studies members of the underlined genera have unspecialized sporophytes with well develop peristomes. Sporophytes were not seen in *Tristichella*. HO: Hookeriaceae. HY: Hypnaceae. HY? Possibly Hypnaceae. S?: Possibly Sematophyllaceae. SH: Sematophylloideae or Hypnaceae. SWH: Sematophylloideae, Wijkioideae, or Hypnaceae. W?: Possibly Wijkidioideae (Hedenäs and Buck 1999).

<b>Sematophyllaceae Sematophylloideae</b>	<b>Sematophyllaceae Wijkioideae</b>	<b>Uncertain affinity</b>	<b>“Hypnaceae” or Hookeriaceae</b>
<u>Acroporium*</u>	<u>Acanthorrhynchium*</u>	<u>Chaetomitriopsis</u>	<u>Brotherella (HY)*</u>
<i>Allioniella</i>	(S?)	(SWH)	<u>Crosbya (HO)</u>
<u>Aptychella*</u>	<u>Trismegistia*</u>	<u>Glossadelphus*</u>	<i>Daltonia (HO)</i>
<u>Aptychopsis</u>	<u>Wijkia*</u>	(SWH)	<u>Foreauella (HY)*</u>
<u>Chaetomitrium</u>		<i>Leptoischyrodon</i>	<u>Gammiella (HY)*</u>
<u>Chionostomum*</u>		(SH)	<u>Hageniella (HY)*</u>
<i>Clastobryella</i>		<u>Phyllodon (SWH)</u>	<u>Heterophyllum</u>
<u>Clastobryophilum*</u>		<i>Pterogonidium</i>	(HY)
<i>Clastobryopsis</i>		(SH)	<u>Horridohypnum</u>
<i>Clastobryum*</i>		<u>Schofieldiella</u>	(HY)
<i>Donnellia</i>		(SWH)	<u>Isocradiella (HY)*</u>
<i>Hydropogon (HY?)</i>		<i>Trolliella (SH)</i>	<i>Palisadula (HY)</i>
<i>Macrohymenium</i>			<u>Pylaisiadelpha*</u>
<i>Maguireella</i>			(HY)
<u>Mastopoma*</u>			<i>Pylaisiella (HY)</i>
<i>Meiothecium</i>			<i>Pylaisiopsis (HY)</i>
<u>Papillidiopsis (W?)*</u>			<i>Syringothecium</i>
<i>Paranapiacabaea</i>			(HY)
<u>Piloecium</u>			
<u>Potamium</u>			
<u>Pseudopiloecium</u>			
<i>Pterogoniopsis</i>			
(HY?)			
<u>Radulina*</u>			
<u>Rhaphidostichum*</u>			
<i>Schraderella</i>			
<i>Schroeterella</i>			
<u>Sematophyllum*</u>			
<u>Taxithelium*</u>			
<i>Timotimus</i>			
<u>Trichosteleum*</u>			
<i>Tristichella</i>			
<u>Warburgiella*</u>			

\* The genera are occurring in Thailand.

### 3.3 HISTORY ACCOUNT OF GENERA IN SEMATOPHYLLACEAE PRESENT IN THAILAND

Family Sematophyllaceae is the most richest species diversity of mosses in Thailand. They are always found in several habitats in tropical rain forest. Many specimens and reports of them were presented since 100 years ago. The specimens have been preserved in different herbaria around the world especially in Europe, America and Japan. Si He (1997) reported 22 species, 91 species and 3 varieties of Sematophyllaceae were collected from Thailand. The checklist of their genera were showed as: *Acanthorrhynchium*, *Acroporium*, *Aptychella*, *Brotherella*, *Chionostomum*, *Clastobryophilum*, *Clastobryum*, *Foreauella*, *Gammiella*, *Glossadelphus*, *Isocradiella*, *Mastopoma*, *Meiothecium*, *Papillidiopsis*, *Radulina*, *Rhaphidostichum*, *Sematophyllum*, *Taxithelium*, *Trichosteleum*, *Trismegistia*, *Warburgiella*, *Wijkia*.

Within this revision of moss family Sematophyllaceae in Thailand, the result is showed 24 genera with rearranged new genera of *Hageniella*, *Heterophyllum*, *Pseudotrismegistia* and *Pylaisiadelpha*, while *Glossadelphus* and *Foreauella* had accepted to place in Hypnaceae. The history of each genus that occurred in Thailand is presented below.

#### 1. *Acanthorrhynchium* M. Fleischer

The genus was described by Fleischer (1923) as a segregate of *Taxithelium* Mitten, to include subgenera *Monostigma* and *Oligostigma* Renaud & Cardot and as a replacement for the name *Acanthodium* Mitten, which was already in use outside the bryophytes. Generic boundaries and phylogeny in the Sematophyllaceae are poorly understood, but the genus is considered to be part of the subfamily Sematophylloideae, and to the subgroup with strongly collenchymatous exothecial cells, which includes *Acroporium*, *Rhaphidostichum*, *Sematophyllum* and *Trichosteleum* (Tan and Buck 1989). The other subgroup, distinguished by having only semi-collenchymatous exothecial cells, contains genera such as *Taxithelium* and *Wijkia*, with which *Acanthorrhynchium* might be confused. The subgroup containing *Acanthorrhynchium* also has what Tan and Buck (1989) described as “the most typical sematophyllaceous alar cells; a basal row of largely inflated, thin-walled, and only lightly colored cells”, and is also the Sematophyllaceae *sensu stricto* of Seki (1969). It is a genus with 11 described species, distributed from the East African islands through southern Asia and western Oceania.

#### 2. *Acroporium* Mitt.

The nomenclatural history of *Acroporium* was succinctly reviewed by Dixon (1924). The genus as originally defined by Mitten (1868) comprises a group of sematophyllaceous mosses characterized by shiny leaves, smooth leaf cells, large alar cells, and small, inclined capsules with rostrate opercular. Buck (1983) designated *Acroporium brevicuspidatum* Mitt. as the lectotype of the generic name. Tan (1994) have included in the genus species with or without papillose leaf cells and share primarily common leaf morphology, e.g., an ovate to lanceolate, concave lamina with incurved to convolute margins and a somewhat involute apex. The genus was related to other genera such as, *Rhaphidostichum*, *Sematophyllum* and *Trichosteleum*. As a genus *Acroporium* is characterized by having a single basal row of large, elongate, somewhat curved or kidney-shaped, colored and vesiculose alar cells, coupled with narrowly elongate, mainly smooth, incrassate, pitted leaf cells, and small, ovoid-oblong capsules. Buck (1989) suggested the genus is closest to *Rhaphidostichum* but differs from the latter in absence of the abruptly

constricted, toothed and slender leaf acumen. The emphasis on the ovate-lanceolate/concave/involute leaf outline serves to *Acroporium* from *Sematophyllum*. The latter genus consists of species having less concave leaves and generally a flat leaf apex. Unlike *Acroporium*, leaf cells of *Sematophyllum* are mostly linear, and often lack strongly incrassate-porose walls. Because of the variability observed in leaf cell papillae, it appears justified that Fleischer (1923) included as *Acroporium* sect. *Acroporiella* a group of *Acroporium*-like species which exhibit leaf cell papillae on some leaves. His emendation, however, created ambiguity in the generic delimitation between *Acroporium* and *Trichosteleum* Mitt. The latter is the “sister” genus of *Acroporium* defined by the presence of a strong papilla on most leaf cells. In spite of this overlap concerning the papillose leaf cell character, the two genera can still be delimited naturally by differences in their vegetative leaf morphology and in perichaetial leaf characters. *Trichosteleum*, on the other hand, differs from *Acroporium* in having non-involute and much less concave leaves with prominent leaf cell papillae. More importantly, it differs from both *Acroporium* and *Sematophyllum* in having scattered leaf cell papillae on perichaetial leaves. Bartram (1939) and Buck (1983) suggested that the furrowed exostome of *Acroporium* can be used to separate it from *Trichosteleum* which has a zigzag median line on the exostome teeth. However, Tan (1994) discussed the observations on the exostomial ornamentation of Malesian *Acroporium* does not support this claim. Both types are found in *Acroporium* and they show no correlation with any other taxonomic characters, such as leaf cell papilosity and leaf outline. There are more than 80 species validly published for the genus *Acroporium*, which is restricted to tropical and subtropical regions. The genus is common in the paleotropics including Indo-Malesia, in western Malesia (the Philippines, Borneo and Java), also in Indochina, China, Japan, Africa, tropical America, the Pacific and Australia. There are more than 80 species validly published for the genus *Acroporium*, which is restricted to tropical and subtropical regions.

### 3. *Aptychella* (Broth.) Herzog

Brotherus (1908) was established the genus *Aptychella* by segregate *Rhaphidostegium* Sect. *Aptychella* Broth. Later, Herzog (1916) had selected: *A. proligera* for lectotype specimen. The genus *Aptychella* was combined with *Clastobryopsis* by Fleischer (1915-1922), but Tixier (1977) suggested that the Asiatic species with perforate and densely papillose exostomial teeth be placed separately in *Clastobryopsis*. Gangulee (1980) was agreed with this reasonable to separate these two genera. Tan and Jia (1999) modify the concept of *Clastobryopsis* sensu Tixier (1977) to include a few morphologically related Asiatic species without perforate peristome teeth. The genus contains less than 10 species apparently with a pantropical distribution found in Mexico, Central America, Greater Antilles, tropical Andes, southeastern Brasil, Indomalesian, and east Asiatic.

### 4. *Brotherella* Loeske ex M. Fleisch.

The genus *Brotherella* was the first proposed by Loeske (1910) for two infrageneric groups of *Stereodon* in Brotherus (1908), namely, the C group (“Abteilung C”) of *Stereodon* subgenus *Heterophyllum* (Schimp.) Broth. and *Stereodon* subgenus *Pseudo-Rhaphidostegium* Broth., from which he considered *Stereodon nemorosus* (Brid.) Lindb. and *S. lorentzianus* (Mol. Ex Lor.) Lindb. as representative species belonging to his new genus. This publication, however, is regarded as invalid. Afterward, Fleischer (1914) validly published *Brotherella* with a statement of several diagnostic characters. At that time Fleischer changed the circumscription of the genus, excluding the C group of *Stereodon* subgenus *Heterophyllum* represented by *S. nemorosus*, and he placed seven

known species including *B. lorentziana* under *Brotherella*. Fleischer (1915-1923) later combined seven further species in this genus. Brotherus (1925), in the second edition of *Die Natürlichen Pflanzenfamilien*, enumerated 30 species of *Brotherella*, of which 11 were newly treated as members of the genus. Since then, the generic name *Brotherella* has been widely accepted and well known by bryologist worldwide.

Horikawa and Seki (1960) presented a review of the history of the genus and outlined the morphological characters and their broad range of variation. Emphasis was made concerning its generic relationship with *Wijkia* (Mitt.) Crum. Tan and Jia (1999) explained the three important features separating *Wijkia* from *Brotherella* as the strong differentiation of stem and branch leaves, the 2-3- pinnately branching system and the nearly entire leaf margins seen in many species of *Wijkia*. In *Wijkia*, the basal row of greatly enlarged and thin-walled cells are oblong in shape and slightly curved, with the marginal ones often divided into two subequal daughter cells, in addition to the enlarged supra-alar cells. In contrast, the basal row of enlarged, oval to round alar cells of *Brotherella* do not divide into two daughter cells.

*Brotherella* also is related to *Pylaisiadelphina* Card. The two genera have been regarded congeneric by some authors (Buck 1984) and *Pylaisiadelphina* is the senior name of the combined genus. However, Ando *et al.* (1989) demonstrated the taxonomic differences between the two genera. These include the poorly differentiated leaf alar cells and the presence of filiform propagules in the case of *Pylaisiadelphina*. Based on the Chinese specimens, species of *Brotherella* can be distinguished further from *Pylaisiadelphina* by the toothed margins towards the leaf apex. The leaves of *Pylaisiadelphina*, as in *Wijkia*, have nearly entire margins, except becoming toothed at the very distal tip.

The genus was suggested to move to Hypnaceae by Hedenäs and Buck (1999) in a result of phylogenetic analysis, but in this revision the genus *Brotherella* is remained in the Sematophyllaceae, while the systematic of Hypnaceae is not completed. It consists of some 50 species in the world. It seems to be primary a temperate genus with distribution in the east Asiatic mainland from eastern Himalaya to Japan.

### 5. *Chionostomum* Müll. Hal.

Genus *Chionostomum* was established in 1869 by selected the type specimen from *Neckera rostrata* Griff. [*Chionostomum rostratum* (Griff.) C. Müll.]. This genus is contained of Asiatic species. There were 11 species reported in this genus, at present only 4 species are recognized for the world. They are *C. baolocense* Tixier, *C. pinicola* Tixier, *C. rostratum* (Griff.) C. Müll., and *C. hainanense* B.C. Tan & Y. Jia., the forth species reported as endemic species to China (Tan and Jia, 1999).

### 6. *Clastobryophilum* M. Fleisch.

Fleischer (1914) created this genus to accommodate *C. ruficaule* (Thwaites & Mitt.) M. Fleisch. and *C. bogoricum* (Bosch. & Sande Lac.) M.Fleisch, but neglected to describe the genus. He remedied this (Fleischer, 1923), but included only *C. bogoricum* and *C. rufoviride* (Besch.) M.Fleisch. For *C. ruficaule*, he transferred it to *Clastobryella ruficaule* (Thwaites & Mitt.) M. Fleisch. [subsequently transferred (Tan, 1991) to *Trichosteleum ruficaule* (Thwaites & Mitt.) B.C. Tan]. Brotherus added to the genus, *C. balansaeum* (Besch.) Broth. (1925) and *C. serrulatum* Broth. (1928), and Thériot (1932) added *C. robustum* Thér. These are the five species list in *Index Muscorum*. Since that date, *C.*

*serrulatum* has been transferred to *Trichosteleum* (Tan, 1991), and *C. robustum* was made a synonym of *Myurium foxworthyi* (= *Oedocladium fragile*) (Tixier, 1962); both of these transfers are supported by O'Shea (2000). Two further species were added: *C. asperifolium* (Thwaites & Mitt.) B.C. Tan (Tan, 1993) and *C. bogoricum* var. *laevibogoricum* (Dixon) Seki (Noguchi, 1973), but the latter was subsequently synonymised with *C. bogoricum* (Tan, 1994), leaving four species recognised in the genus. In the revision by O'Shea (2000) suggested all but *C. balansaeae* of the four species mentioned above are found to be the same taxon, *C. bogoricum*, but *C. bogoricum* var. *laevibogoricum* is found not to belong to *Clastobryophilum*. From the result, there are three species of *Clastobryophilum* in the world. They are *C. bogoricum* (Bosch. & Sande Lac.) M.Fleisch, *C. rufo-viride* (Besch.) M.Fleisch, and *C. asperifolium* (Thwaites & Mitt.) B.C.Tan.

### 7. *Clastobryum* Dozy & Molk.

Genus *Clastobryum* was established by Dozy & Molkenboer in 1846, they were selected *Astrodonium indicum* Dozy & Molk. Earlier, Tan and Buck (1989) showed *Clastobryella*, which differs from *Clastobryum* principally by virtue of its toothed leaf margins, is considered a generic synonym of *Clastobryum*. The genus has been recently reviewed by Tan and Iwatsuki (1992) who lectotypified the generic type species, *C. indicum* (Dozy & Molk.) Dozy & Molk. In the same publication, *Tristichella* was combined with *Clastobryum*. There are about 23 species present the world. The genus is epiphytic on bark or epiphyllous. A genus of about ten species distributed in southeast Asia, Japan, the Philippines, Malesia and Australia.

### 8. *Gammiella* Broth.

The genus *Gammiella* was described the genus as monotypic by Brotherus in 1908, including its generic type, *G. pterogonioides* (Griffith) Brotherus [syn. *Pleuropus pterogonioides* Griffith], is identified by a profusion of slender branches forming extensive mat. Its heterophylloid type of leaf alar consisting of a group of quadrate or short rectangular cells is also diagnostic. Tixier (1977) reviewed this Himalayan-Indochinese genus and accepted four species. They are *G. pterogonioides*, *G. capillacea*, *G. merrillii* and *G. rugosa*. Tan and Buck (1989) suggested *Gemmiella capillacea* (Griff.) Tix. [syn. *Neckera capillacea* Griff.; *Clastobryum capillaceum* (Griff.) Broth. in Fleisch.] not belonging to *Clastobryum* nor *Gammiella*. Later, Tan and Jia (1999) proposed the transfer of *G. capillacea* to *Pylaisiadelphina* in revision of Chinese Sematophyllaceae. They reported four species are *G. pterogonioides*, *G. ceylonensis*, *G. tokinensis*, including a newly described species for *G. panchienii* B.C. Tan & Y. Jia ex B.C. Tan. Lastly, O'Shea (2003) suggested the genus *Gammiella* Broth. occurs only in the palaeotropics, and is wide spread particularly in tropical Asia. Seven species are currently accepted in the genus, which has been revised and extended particularly by recent reviews of Sematophyllaceae subfam. Heterophylloideae (Tan and Buck 1989; Tan 1990; Tan and Jia 1999).

### 9. *Hageniella* Broth.

Genus *Hageniella* was cited name by Brotherus in 1910. Tixier (1977) reviewed the genus and accepted five species, two of which have papillose leaf cells are *H. assamica* Dixon, and *H. nematosa* (Broth. & Paris) Tixier, and three species of smooth lamina cells are *H. sikkimensis* Broth., *H. pacifica* Broth. and *H. isopterygioides* Dixon. Recently, Tan (1990) added a new species, *H. hattoriana* Tan, from Mt. Kinabalu in North Borneo. The

last mentioned species is shown in this study to be a new synonym of *Wijkia hornschuchii*. Tan and Jia (1999) made a new combination of *H. micans* (Mitt.) B.C. Tan & Y. Jia and made it as the correctly name of *H. pacifica*, they suggest that the genus be defined around the type species, *H. sikkimensis* Broth., which is characterized by having broadly obovate and strongly concave leaves with a constricted apex and somewhat narrowed base, in addition to smooth lamina cells, and a brotherella-like alar organization. The capsules are also distinctly ovoid, with thickened vertical walls. Thus, they are accepting only two species for the genus, namely *H. sikkimensis* and *H. micans* (Mitt.) Tan & Jia. They suggested *H. isopterygioides* Dix. from Eastern Himalayas is possibly a member of *Brotherella* and for the remaining two species with papillose leaf cells can be transferred to either *Clastobryum*, *Trichosteleum* or *Wijkia*, depending on the leaf morphology and the nature of wall thickening of their exothecial cells, but careful study of the type is necessary.

#### **10. *Heterophyllum* (Schimp.) Kindb.**

The genus was named by Kindberg (1894) based on *Hypnum* subgen. *Heterophyllum* Schimp. Robinson and Reed (1966) have revised the genus and suspected that the genus is monotypic with the single species *Heterophyllum nemorosum* and the unexamined species are also likely to prove to be its synonyms. But, they did not examine as many as 15 species (according to Index Muscorum) which include all the Asiatic species. At this present, there are about 30 species known to this genus in the world. *Heterophyllum* have many characters closed to genus *Brotherella*, and *Pylaisiadelpha*, but can be separated by its stem and branch leaves differentiated, upper margin strongly serrate, while both former genera have not clearly differentiated leaves upper margin denticulate or nearly entire. At present, there are about 30 species known to this genus in the world.

#### **11. *Isocladiella* Dixon**

Dixon (1931) was described genus *Isocladiella* based on characters of *I. phyllogonioides* Dixon (holotype). Tan and Buck (1989) had placed this genus in a group of subfamily Heterophylloideae. The genus is best recognized by the presence of caducuous, flagellate branchlets serving as propagules. Tan and Mohamed (1990) reviewed the genus and discussed the morphological variability observed which led them to conclude that the genus is monotypic. There are many reports showed the genus is related to another familial such as H.-S. Lin (1986) suggested a pterobryaceous affinity for this genus, recently, Hadenäs and Buck (1999) showed its relationship to Hypnaceae. However, this study is following the taxonomic conclusion of Tan and Buck (1989) in accepting it as a sematophyllaceous genus allied to *Gammiella*.

#### **12. *Mastopoma* Cardot**

The genus *Mastopoma* was established by Cardot (1901), the species was described from *Mastopoma raphidostegioides* Card. (holotype). Brotherus (1925) separated *Mastopoma*, into a newly established category, subfamily Heterophylloideae, this genus is closed to *Trismegistia* and *Wijkia*. Dixon (1935) pointed out that *Mastopoma* differed from *Trismegistia* in 1) the smaller, less rigid habitat, 2) the leaf upper lamina cells that are all elongate and not incrassate, and never short and rhomboid, 3) absence of borders at the leaf margins, and 4) the conical capsule lid (rostrate in *Trismegistia*). Buck (1986) suggested this genus can be circumscribed and distinguished from each other as "Plant smaller, growing on branches of shrubs or small trees at river and stream sides. Leaves straight or strongly curled, often with geminate serration, alar cells arranged in a single

row (except *Mastopoma subfiliferum*)". Recently, Hedenäs and Buck (1999) proposed a new system of the Sematophyllaceae on the basis of cladistic analyses of morphological features. They transferred *Mastopoma* to the Sematophylloideae, while *Trismegistia* and *Wijkia* are in Wijkioideae. Later, Tsubota *et al.* (2001) confirmed a distant relationship of *Trismegistia* to both *Wijkia* and *Mastopoma*. There are 23 species of *Mastopoma* presented in TROPICOS database, but two species of them are invalid name.

### 13. *Meiothecium* Mitt.

Mitten (1868) was described the genus *Meiothecium* Mitt., the generic name refers to small capsules. The genus is characterized by usually more or less ovate leaves with shortest rhomboidal cells; large leaves tend to become somewhat plicate; the alar cells are differentiated, somewhat inflated and colored, but not pronounced as in most members of the Sematophyllaceae. The capsules are erect to suberect and the peristome is described as single, exostome teeth variously spaced and papillose, endostome absent (Buck, 1982). There are more than 50 species distributed worldwide in South America, Africa, Malesia, Pacific Islands and Australia.

### 14. *Papillidiopsis* (Broth.) W.R. Buck & B.C. Tan

The genus *Papillidiopsis* was established by Brotherus (1908) in diagnostic characters of *Trichosteleum* sect. *Papillidiopsis* Broth. The genus is characterized by strongly concave leaves with constricted or "throaty" leaf acumen and a markedly narrowed leaf base. Other diagnostic features include the unipapillose leaf cells and the reflexed upper leaf margins. Buck (1989) and Buck and Tan (1989) had discussed the relationship between *Papillidiopsis* and *Rhaphidostichum* by the alar cells of *Papillidiopsis* can be thick-walled and the perichaetial leaf cells are nearly smooth. The species consists of 13 species 1 variety in the world.

### 15. *Pseudotrismegistia* Akiyama & Tsubota

The monotypic genus was recently published by Akiyama and Tsubota (2001) based on *Trismegistia undulata* Broth. & Yasuda. is type of the genus. When Hirokawa and Ando (1964) transferred *Trismegistia perundurata* Dix. to the genus *Mastopoma* Card. on the basis of short conical lid observed from a confirmed specimen collected from Laos, they mentioned and considered *T. undulata* to be identical with it. Yet, they overlooked the fact that *T. undulata* (Brotherus 1926) which was published ten years before *T. perundulata* (Dixon 1936) should provided the epithet for the combined species. Traditionally, *Trismegistia* and *Mastopoma* are separated by characters such as the presence or absence of a well differentiated leaf border, and the rostrate versus conical opercular lid (Bartram 1939). Between these two generic characters, the nature of the opercular lid seems less reliable and satisfactory for a natural segregation. A better generic marker, in this observation, resides in the nature of alar organization. Species of Malesian *Mastopoma* have only a basal row of enlarged alar cells while species of Malesien *Trismegistia* frequently produce divided alar cells forming multiple or scalariform tiers. This multiple tiers of alar feature is most pronounced in the type of *T. undulata* and *T. perundulata*, and was nicely illustrated by Horikawa and Ando (1964) for what they called *M. perundulatum*. Furthermore, Tan (1991) was able to observe some, albeit weakly differentiated, borders on the leaves of the type of *T. undulata*. In addition, the upper leaf cells of *T. undulata* are short and broadly rhomboidal, much like those seen in many species of *Trismegistia* (but not *Mastopoma*) from the region. The species is disjunctive distribution in China, Kampuchea, Laos, and Vietnam.

### 16. *Pylaisiadelpha* Card.

*Pylaisiadelpha* was established by Cardot (1912), including two species, *P. raphidostegioides* (Card.) Card. and *P. drepanioides* Card. Gangulee (1980) reported the genera only two species recognized within the genus. the distribution of with 1 species (*P. raphidostegioides*) endemic in Mexico and the other species (*P. drepanioides*) endemic in the Himalaya. The genus was at one time combined with *Brotherella* by Buck (1984), he suggested *Pylaisiadelpha* has priority over *Brotherella*, therefore, it should replace to *Pylaisiadelpha*. However, Ando *et al.* (1989) demonstrated the taxonomic differences between the two genera by study of specimens of the related taxa, this reached the conclusion that genus *Brotherella* is generally distinct from *Pylaisiadelpha*. These include the poorly differentiated leaf alar cells and the presence of filiform propagules in the case of *Pylaisiadelpha*. As suggested by Ando *et al.* (1989) thus, it would be illogical to accommodate *Brotherella* in Sematophyllaceae and transfer *Pylaisidelpha* to Hypnaceae. Similarly, Hedenäs and Buck (1999) made a phylogenetic analysis and suggested to move the genus *Pylaisiadelpha* to Hypnaceae.

However, Tan and Jia (1999) considered *Pylaisidelpha* to be related to *Brotherella* in many details. The retention of *Pylaisiadelpha* in Sematophyllaceae can be justified further by its weakly collenchymatous exothecial cell wall thickenings. Equally important is the long opercular beak seen in species of *Pylaisidelpha*. Within this revision genus *Pylaisiadelpha* is remained in the Sematophyllaceae, while the systematic of Hypnaceae is not completed.

### 17. *Radulina* W.R. Buck & B.C. Tan

The genus *Radulina* was segregated recently from *Trichostomum* by Buck and Tan (1989) to accommodate member of section *Thelidium* (C. Muell.) Broth. The section is characterized by its autoicous with abruptly long acuminate, sharply toothed leaves and seriatly papillose laminal cells with a basal row of 3-4 alar cells of much inflated, haline, and strongly collenchymatous exothecial cells. Although *Radulina* may resemble *Acroporium* in the cuspidate branch apices and concave leaves with thick-walled leaf cells, it is separated by the pleuripapillose instead of smooth cells and alar cells that do not curve in towards the insertion. The genus is revised by O'Shea (2006), resulting in the genus being reduced to four species and one variety. They are *R. borbonica* (Bél.) W.R. Buck, *R. borbonica* var. *ferriei* (Cardot & Thér. in Thér.) O'Shea, *R. orthophylla* (Besch.) B.C.Tan, *R. pendens* (D.H.Norris & T.J.Kop.) B.C.Tan and *R. sematophylloides* (Dixon) O'Shea

### 18. *Rhaphidostichum* M. Fleisch.

The genus *Rhaphidostichum* was created by Fleicher (1923) to accommodate two Japan species with particularly long, loriform (parallel-sided) apices, each of which placed in a difference section of the genus, one with papillose laminal cells and one without. The former has now become *Papillidiopsis* (Buck & Tan, 1989), and the latter remains as *Rhaphidostichum*. Both genera are concentrated in Asia and Oceania. *Index Muscorum* (Wijk *et al.* 1959-1969) does of course not distinguish those taxa which would belong to *Papillidiopsis*, but list 32 species of *Rhaphidostichum* for Asia and 9 for Oceania. In addition, three species are noted as endemic to tropical Africa and 2 endemic to the neotropics (Buck 1989). An initial survey suggests that the majority of *Rhaphidostichum* s.l. species from Asia/Oceania will be transferred to *Papillidiopsis* (O'shea 1998).

### 19. *Sematophyllum* Mitt.

Mitten (1869) recognized no fewer than 52 species (excluding *Acroporium* and *Trichosteleum*). The history of *Sematophyllum* is nearly as complex as is present understanding of the species in *Acroporium*, *Rhaphidostichum* and *Trichosteleum*. *Rhaphidorrhynchium* M. Fleisch. is sometimes segregated from *Sematophyllum* based on the falcate-secund leaves, a feature that is not always obvious in several species in this genus. *Trichosteleum* as generally recognized is usually defined by the unipapillose laminal cells that suppose to separate this genus from the smooth cells of *Sematophyllum*. However, there are a few species in which the papillae are very difficult to detect. *Rhaphidostegium* (Schimp. in Bruch, Schimp. & W. Gümbel) De Not., nom. illeg. incl. gen. prior, is a name previously used for some of *Sematophyllum*'s. A careful study of *Sematophyllum* is very much needed, with particular attention given to the gametophytic variation within and between species. Not unexpected, the aquatic or semi-aquatic species appear to pose the greatest problems in expressed variation. Dixon (1920), possibly in a prolonged moment of despair, placed into synonymy many names of what appear to be distinct species under the name *S. caespitosum* (= *S. subpinnatum*), including a number of Andean (neotropical) taxa. Although a few species are listed as "status unknown", probably more than half of the species listed could be relegated to that list also. *Sematophyllum* is primarily a pantropical genus with more than 100 species; about 40-50 species in the Neotropics.

### 20. *Taxithelium* Spruce ex Mitt.

When the genus *Taxithelium* was first formally recognized by Mitten (1869), he credited the name to Spruce and cited (among others) Spruce's specimens of *T. planum* from Amazon to validate the name. The most recent revision of the genus *Taxithelium* was carried out by Damanhuri and Longton (1996), who suggested that about 40 taxa would remain after a critical generic revision. They retained the genus in the Sematophyllaceae. Furthermore, they suggested additional useful characters that can be used for species delimitation, including the type of branch development, such as the *Climacium* type in *T. planum* and *T. merrillii*, or the *Bryum* type in *T. kerianum*, as well as the papillosity of perichaetial leaves. Likewise, Tan *et al.* (1996) suggested that future purification of the genus should see the transfer of species of *Taxithelium* with Sematophylloid leaf alar differentiation to other sematophyllaceous genera. The following two sections were recognized by Renauld and Cardot (1901) and Fleischer (1923): section *Aptera* Renauld & Cardot and section *Vera* Renauld & Cardot, the latter changed to *Taxithelium* M. Fleischer. The former has leaves with acuminate apices and poorly defined alar cells. In the latter, the leaf is short-acuminate to obtuse, with inflated and sometimes colored alar cells. Section *Aptera* also has elongate leaf cells (>8 : 1), with the apical leaf cells, while the marginal leaf cells are usually papillose-serrate; and binate teeth are uncommon. In the section *Taxithelium*, the laminal cells are shorter. The apical leaf cells are also short and seldom coronate-papillose; binate teeth are almost always present, while the marginal leaf cells are not usually papillose-serrate (Norris and Koponen 1985). The genus is distributed mainly in the tropics with a small extension into the subtropics. Species occur in Africa, Asia, South Central and North America and Australia. It is well represented in the Indo-Malesian region, with a significant number of species extending into northern Australia. Species are generally corticolous, occurring on trunks and branches often on rotting logs, occasionally on rocks including limestone. One species, *T. merrillii*, occurs in coastal mangrove communities bathed in brackish waters.

### 21. *Trichosteleum* Mitt.

This pantropical genus was recently reviewed by Buck and Tan (1989) who subsequently divided it into two segregate genera, *Radulina* and *Trichosteleum*. Among the sematophyllaceous genera, *Acanthorrhynchium*, *Trichosteleum* and *Papillidiopsis* are similarly characterized by unipapillose leaf cells. However, in the case of *Trichosteleum*, the unipapillose cells are seen in the vegetative, and frequently also in perichaetial leaves, whereas in *Acanthorrhynchium* and *Papillidiopsis*, the papillae are found mostly on the vegetative leaves. In addition, exothecial cells of *Trichosteleum* are strongly mammillose. About 23 species in the Neotropics, possibly only 10-15 that are valid. A pantropical genus of over 100 species with the greatest diversity in tropical Asia. Plants distributed in the Tropical Andes found on logs, humus and soil in moist in wet lowland to mid montane forest, from near sea level to 1,800 m.

### 22. *Trismegistia* (Müll. Hal.) Müll. Hal.

The genus *Trismegistia* was first established as section *Trismegistia* in the genus *Hypnum* by Müller (1874). Later, the section was raised to a new genus by Müller (1896). Brotherus (1908), in the first edition of 'Die Natürlichen Pflanzenfamilien', adopted the Müller' concept (1896). Since then, around sixty taxa have been described in the genus. The genus was regarded to close relatives with *Brotherella*, *Heterophyllum*, *Mastopoma*, *Pseudotrismegistia* and *Wijkia*, by the reason of sharing some morphological features as long setae of sporophytes and more or less marked serration of the leaf margins. Dixon (1925) separated *Mastopoma*, *Trismegistia*, *Wijkia* and *Heterophyllum* into subfamily Heterophylloideae, Tan and Buck (1989) classified the former three genera in the Sematophylloideae ('Group 2'). Recently, Hedenäs and Buck (1999) established subfamily Wijkioideae to accommodate only three genera, *Acanthorrhynchium*, *Trismegistia* and *Wijkia* and they transferred *Mastopoma* to the Sematophylloideae. Later, Tsubota *et al.* (2001) suggested a distant relationship of *Trismegistia* to both *Wijkia* and *Mastopoma*. *Trismegistia* is a primary Indo-Malesian genus including New Guinea with about 20 species worldwide, several of which have been placed into synonymy (Tan 1991).

### 23. *Warburgiella* Müll. Hal. ex Broth.

The genus *Warburgiella* was established by Müller and Brotherus (1900) based on the type of *W. cupressinoides* Müll Hal. ex Broth. The character of a mitrate to campanulate calyptra traditionally used to define *Warburgiella* as a genus is barely consistent. In some cases the mitrate calyptra split up on one side and appears to be cucullate. Buck & Tan (1989) prefer to define the genus on the basis of its strongly circinate leaves with abruptly long tooth apices and somewhat thick-walled alar cells. The semi-collenchymatous exothecial cells and the sometimes prurulose to unipapillose laminal cells further separate it from many other Sematophyllaceae genera. Unipapillose species of *Warburgiella* can be separated from *Trichosteleum* by the calyptra and falcate-secund leaves with a serrate acumen, and semi-collenchymatous exothecial cells. From equally circinate-leaved members of *Rhaphidorrhynchium*, *Warburgiella* can be separated by the semi-collenchymatous exothecial cells, and the sheathing inner perichaetial leaves with a somewhat abruptly acuminate or contracted cuspidate apex. The perichaetial leaves of *Rhaphidorrhynchium* are non sheathing, granduallly long acuminate to filiform. The genus occurs on tree trunks in closed and subtropical or tropical forests.

#### 24. *Wijkia* H.A. Crum

*Wijkia* H.A. Crum, (1971) was long known as *Acanthocladium* Broth. (1925), but that name is untenable, both nomenclaturally as well as taxonomically. *Acanthocladium* Mitt., and the genus for which it was a replacement, *Acanthodium* Mitt., are illegitimate homonyms of flowering plant genera. Additionally, none of the species included in the original circumscriptions of the genera is now placed in *Wijkia*. Seki (1968) transferred *Wijkia* Crum from the Sematophyllaceae to Hypnaceae based on exothecial cells that are not collenchymatous. However, Buck (1986) noted the nature of collenchymatous exothecial cells was only a subordinate feature for Sematophyllaceae, and suggested that *Wijkia* should be remained in Sematophyllaceae. The genus is close to *Brotherella*. Indeed, several Asiatic species have been shifted back and forth between these two genera. Like *Brotherella*, the exothecial cell walls of *Wijkia* are not typically collenchymatous, but show only the vertical walls much thickened. Indeed, this is a good indication of a close relationship of this genus with *Brotherella* and *Pylaisiadelphina* in the subfamily Sematophylloideae (Buck 1986). The genus can be distinguished from *Brotherella* by the stem and branch leaves that are morphologically different and the stem and branching systems that are many times subdivided. Alar cells of *Wijkia* are brotherelloid consisting of a basal row of much enlarged, hyaline or colored, thin-walled cells with 2-3 rows of enlarged, albeit smaller, equally thin-walled supra cells. In *Wijkia*, the marginal cells of the basal row of inflated alar cells are often subdivided into two daughter cells, a feature not seen in *Brotherella*.

## 4 BIOLOGY OF SEMATOPHYLLACEAE

Sematophyllaceae is a family of pleurocarpous mosses that produce their archaegonia and sporophytes laterally on stems. This big group of mosses is very variable in morphology characters. To better understand the family, comments on certain morphological characters of various genera is necessary. The biology study of moss in this family is emphasis on a complete plant both in gametophyte and sporophyte. Furthermore the field study is necessary to observe in natural life survival. Their ontogenetic development, when fully understood, may suggest a certain phylogenetic relationship between subfamilies and among genera.

### 4.1 LIFE AND GROWTH FORM

In Sematophyllaceae, plants are commonly found in tropical rain forest and in some wet lowland to upper montane forests from near sea level to 3,500 m. Plants always slender, generally characterized by creeping with irregularly pinnate branches, usually green to golden and glossy with extensive lateral branching. Plants found monoicous or dioicous, when monoicous or autoicous rarely synoicous, polyoicous or phyllodioicous (Jia *et al.* 2005).

In Thailand, plants are generally trailing or prostrate, and may form mats, wefts, or dense tufts, in some species can be pendent (fig. 4.2). They usually found on terrestrial or epiphyte on tree trunks, branches, and bark. Many species can be had good distribution on logs and lichens. Some species grow as epiphyll on leaves in cloud forest.

### 4.2 GAMETOPHYTE

#### 4.2.1 Rhizoid

The rhizoids of mosses in family Sematophyllaceae are multicellular with oblique cross walls, their walls are smooth (Fig. 4.4, P.) They are often brown to red color, anchored to their substrates by filamentous. Rhizoids can be restricted to the base of the stem or arise all along the stem where it is in contact with the substrate e.g. *Acanthorrhynchium* and *Isocradiella*. In some Genera, e.g. *Gammiella*, *Taxithelium* densely packed rhizoids form the clusters on the stem. Rhizoids are not major sites of water and nutrient uptake, but can enhance capillary movement of water along the outer surface of the stem (Proctor 2000).

#### 4.2.2 Stem

Primary stems procumbent, creeping to ascending or erect, with rhizoids, usually irregularly branched, rarely pinnate branched, branches round or complanate. Shoots always funnel form short complanate or subcomplanate. In some genera stem short creeping with branches ascending less than 5 mm long e.g. *Acroporium convolutifolium*, *A. lamprophyllum*, *Foreauella orthothecia* and *Sematophyllum microcladiella*. In contrast, many species have long stem creeping and lateral branches usually more than 10 mm long are found as *Acroporium aciphyllum*, *A. hamulatum*, *A. secundum*, *A. stramineum*,

*Brotherella falcate*, *Mastopma robinsonii*, *M. subfiliferum* and *Pseudotrismegistia undulate*.

The internal structure of the stem in mosses may be homogenous or, more often, consist of an outer epidermis, a cortex, and a central strand. Often, the cortex is further differentiated into an outer cortex of cells with strongly thickened, darkish-pigmented walls surrounding an inner cortex of larger, thin-walled cells. The central strand is very small or absent in some species, in outer it is strong, up to one-third the diameter of the stem. It resembles a primitive vascular bundle and often contains a few large, thick-walled water-containing cells, the hydroids.

Stem cross section of almost species in Sematophyllaceae have usually round, central strand absent, without loose cells, thin or thick-walled cortex and towards the outside two to many layers of stereids to substereid peripheral cells (Fig. 4.4, M.-O.). Anyway, stem cross-section in many genera shows several layers of thick-walled epidermal and cortical cells enclosing a central mass of parenchyma cells. In other words, stem structure does not provide useful taxonomical characters (Tan and Jia 1999).

Paraphyllia and pseudoparaphyllia often absent. If pseudoparaphyllia present, they are of foliose the filamentous types. They do not seem to provide a meaningful correlation with other characters to define a genus.

#### 4.2.3 Branch

Branches in mosses are usually of a single morphological kind. These branches originate from cells of the stem epidermis, usually stand at an oblique angle with the stem and do not have a collar at the base. Branches usually irregularly short or long branched, rarely pinnate, radiculose, round or complanate branched. The group of long branches usually found in genus *Acroporium*, *Rhapidostichum*, *Pseudotrismegistia* and *Trismegistia*. The other kinds of branch such as julaceous branch (in *Gammiella*) and homomallous branch (in *Faureauella*) are found only in specific genera. The complanate branch is a dominant character found only in genus *Taxithelium*. The special branches that grew from terminal of lateral branch usually thin and long branched with many small imbricate leaves, they called “flagellate branchlet” are often found in *Isocradiella surcularis*, and *Wijkia surcularis*.

#### 4.2.4 Leaf

The generally diagnostic leaf of moss in Family Sematophyllaceae is usually dense and arranged in several ranks. Almost species are green to brownish green and glossy. Stem and branch leaves usually similar in shape, rarely differentiated, symmetric, not plicate, variable among genera in shape of leaf. The excepted genera that found stem and branch leaves differentiated both in shaped and size of leaf are *Acanthorrhynchium* and *Wijkia*. The leaf orientation is usually erect to erect-spreading. In some species have leaves secund or falcate-secund such as *Acroporium downii*, *A. secundum*, *Faureauella aothothecia*, *Radulina hamata* and *Warburgiella leptorrhynchoides*. While, the appressed leaves are found in many species of *Taxithelium*.

Leaf shapes are variable among and the same genera, they usually bilaterally symmetrical (to only slightly asymmetrical). The leaf shapes are typically ovate, ovate-lanceolate, lanceolate and rarely oblong-lanceolate (Fig. 4.3, A.-P.). Leaf apices usually acuminate, acute, cuspidate and long taper to filament (e.g., *Rhaphidostichum* and *Wijkia*). Leaf base are usually rounded to heart-shaped (cordate) without stalk of leaf, leaves are attached to the stem along broad transverse lines. Leaf margins may be plane, recurved, or revolute and are often toothed, with the teeth varying from pointed cellular, unistratose distally denticulate, or entire. Normally, leaf blades are not conspicuously bordered but can be found in genus *Trismegistia*. The leaves are nerveless or short double-nerved. The leaf nerves when present, not extending beyond the middle of the leaf.

The leaf cells presented both smooth (fig. 4.4, A.-H.) and papillose in the same genera (fig. 4.4, I.-L.). They various in shaped, generally longitudinal much elongated, often narrowly rhomboidal to linear, or some vermicular. The cell walls straight thin to thick walled or pit walled. Papillosity of leaf cells presents a serious problem in the genus. In species like *Acroporium diminutum* and *A. lamprophyllum* a few leaves have cells with a small, low papilla. At the other extreme, as in genus *Acanthorrhynchium*, *Papillidiopsis*, and *Trichosteleum*, leaf cells unipapillose are well developed, but not on all leaves. As in some genera found papillae are heterogeneous in form, size, and distribution. They may be over the cell lumen e.g. *Taxithelium* and *Radulina hamata*, or just at the distal end of the cell (prorose or prorulose) in *Hageniella assamica*. At the base of leaf, the basal angular cells clearly differentiated (these large, forming small auricles). There are three recognizable basic types of alar organization in the family.

The acroporioid alar organization (fig. 4.5, A.-D.) is made up of a conspicuous basal row of much enlarged or inflated, colored or hyaline, often thin walled cells. The supra-alar cells are much smaller in size and not so conspicuous in comparison (seen in *Acroporium*, *Acanthorrhynchium*, *Clastobryophilum*, *Clatobryum*, *Meiothecium*, *Papillidiopsis*, *Rhaphidostichum*, *Radulina*, *Trichosteleum* and *Warburgiella*).

Brotherelloid alar organization (fig. 4.5, E.-H.) represents a modified acroporioid alar type. Alar cells of the basal row are enlarged, at times much inflated, colored or hyaline, and mostly thin-walled. However, there are 2-3 rows of supra-alar cells that are equally inflated and thin walled, albeit slightly smaller in size. There is a gradual transition of morphology from the inflated supra-alar cells to the basal row of much enlarged alar cells (seen in *Brotherella*, *Chionostomum*, *Faureauella*, *Hageniella*, *Pylaisiadelpha* and *Wijkia*).

The heterophyllioid alar organization (fig. 4.5, I.-L.) consists of a group of colored or hyaline, quadrate to rectangular, often thick-walled cells arranged in a cluster of 2-4 tiers. The entire alar region is well defined and often excavate. The transition from the alar cells to regular laminal cells is rather abrupt (seen in *Aptychella*, *Gammiella*, and *Isocradiella*).

Some genera like *Isocradiella*, *Sematophyllum*, *Taxithelium* and *Trismegistia* may exhibit more than one type of alar organization among congeners.

#### 4.2.5 Perichaetial leaf

Perichaetial leaf is bearing on stem or lateral branches (fig. 4.3, Q.-S.). They arranged in a cluster of ovate to lanceolate leaves without alar differentiation, but with a much expanded,

colored base sheathing the vaginula. Lamina cells always smooth even if the vegetative leaf cells are markedly unipapillose. Leaf margin invariably toothed and their apices narrow into a biggest leaf is inner most. Inner perichaetial leaves, ovate, erect, gradually narrowed to a long, coarsely serrate point. Outer perichaetial leaves erect, ovate to lanceolate shaped wide, round base, acuminate apex, margin slightly serrate. Among the gametophytic characters, the potential of perichaetial leaves for generic and species delimitation has been overlooked.

#### 4.2.6 Perigonial leaf

In the same species perigonial leaves always smaller than perichaetial leaves. They are bearing on stem or lateral branch in a cluster of wide ovate to ovate-lanceolate usually acute apices (fig. 4.3, T). Leaf cells smooth without alar differentiation. Leaf margins are invariably dentate or entire.

### 4.3 SPOROPHYTE

As a definition of Sematophyllaceae is a family of pleurocarpous mosses, sporophytes always laterally on stems. The sporophyte generally produces a long seta, smooth or sometimes rough with the capsule horizontal to inclined resulting in bending of the apex of the seta. The calyptra always presented on young sporophyte, falling down when mature. It is symmetrical, splitting down one side, often cucullate, smooth.

#### 4.3.1 Seta

The sporophyte in the Sematophyllaceae produces a seta variably size, the generally long seta up to 3 cm long and may be up to 7 cm in *Mastopoma*, *Pseudotrismegistia* and *Trismegistia*. While, the short setae are less than 1 cm long found in *Meiothecium* and *Trichosteleum*. Seta usually slender or wiry, but sometimes twisted on the upper part when dry. Setae often smooth or sometimes rough on the upper portion below capsule.

#### 4.3.2 Capsule

Capsules exerted, inclined to horizontal, or pendulous, rounded ovoid or oblong-ovoid, often asymmetric; smooth or rarely mamilllose (fig. 4.6, A.-L.). Exothecia cells (fig. 4.7, Q.-T.) are typically collenchymatous, sometime subcollenchymatous (thickenings on lateral walls, but not confined to corners), stomata present; apophysis slightly developed. The operculum is conic, short or long rostrate or needle like at apex. A separating annulus is frequently lacking. Most members of the family have basically hynaceous peristomial organization (fig. 4.7, M.-P.). Peristome double, the exostome teeth 16 with a medial zigzag line or a furrow on the outer surface of the extostomial tooth, inner surface often trabeculate. The surface ornamentation of the exostome changes from striate at the basal part to papillose toward the apex. Other types of exostomial ornamentations exhibited are smooth or entirely papillose. While, non-striate exostome in some genera such as *Clastobryopsis*, *Gemmiella*, *Meiothecium* and *Chionostomum* have sparsely to densely papillose peristomes. The inner peristome well developed, rarely reduced in genus *Meiothecium*. Endostome teeth 16, segments usually narrowly lanceolate, keeled, rarely linear, with a basal membranous high with elongated “processes”. The processes of the

inner peristome alternated with the teeth of the outer peristome. Cilia usually present. Exostome often separated from endostome, except *Chionostomum*. The peristome provided some taxonomic and phylogenetic information.

#### 4.3.3 Spore

Most spores of moss in Sematophyllaceae are isosporous, meaning that spore sizes are unimodal, with variation ranging around one arithmetic mean (Mogensen 1983). Spores are typically single-celled, yellow, spherical shape, finely to distinctly papillose (fig.4.7, B.). Spore number per capsule is typically in the hundreds of thousands. The sized of spores variably in the same capsule, generally 12-25  $\mu\text{m}$  in diameter.

### 4.4 REPRODUCTION

#### 4.4.1 Sexual Reproduction

Gametangia are typically clustered with interspersed, sterile hairs, called paraphyses, at shoot or branch apices. Androecia, or male inflorescences, contain numerous, elongate, ovoid to cylindrical antheridia (over 100 in some taxa) and paraphyses, surrounded by perigonal leaves, and may be either budlike or disciform. Gynoecia, or female inflorescences, contain groups of long-necked, stalked archegonia, paraphyses, and surrounding perichaetia leaves, and are only budlike, never disciform.

The hypothesis that most species of Sematophyllaceae are probably monoicous or heteroicous is further supported by the abundant sporophytic specimens preserved in herbaria (Tan and Jia 1999). It would seem that the truly dioicous species are those with dwarf male plant. In addition to his morphological perplexity the emphasis placed traditionally on sexuality as a species character causes further problems. In a weft or mat-forming population it is difficult to isolate the long, entangled, and much branches stem of an individual plant to determine whether the species is monoicous or dioicous. In many observations, these two sexual conditions are not mutually exclusive and may represent only a temporary stage of development. Often, a tedious search among sporophytic materials of reportedly dioicous species will yield a few perigonia, thus proving that the plant is autoicous.

#### 4.4.2 Vegetative Reproduction

It has been estimated that up to 15% of moss taxa produce some type of asexual diaspore. These include caducous leaves, stems, and rhizoids, as well as morphologically specialized brood bodies (Crum 2001). Brood bodies of two major types; gemmae, which are small, unicellular or more commonly, multicellular structures comprised of undifferentiated cells and propagula, which are small, easily detached plantlets or bud. In Sematophyllaceae, gemmae can be filiform, discoid, or cylindrical, and often possess pigmented and thickened outer cell walls (Fig. 4.6 A.-E.). They can be produced gemmae in special branch or near the tip of elongate shoot apices (e.g., *Aptychella*, *Gammiella rugosa*), or in the axils of leaves (e.g., *Sematophyllum microcladiella*). Fragments of gametophytes, if dispersed to a suitable substrate, produce protonemata from which new shoots will develop as found in *Chionostomum rostratum* (fig. 4.6, F).

## 4.5 MORPHOLOGICAL ADAPTATIONS

### 4.5.1 Life and growth forms

The life forms of moss in family Sematophyllaceae always grow in group of individuals. They always have stem creeping with irregularly branches. They may found as small or big mass in each area, depend on their habitat. There are three growth forms occur in this family in Thailand (fig 4.2) such as below.

- Mat is a growth form in which stems are flattened prostrate on the substratum and densely interwoven. This growth form found in genus *Acanthorrhynchium*, *Brotherella*, *Gammiella*, *Mastopoma*, *Papillidiopsis*, *Pseudotrismegistia*, *Pylaisiadelpha*, *Rhaphidostichum*, *Trichosteleum*, and *Wijkia*.

- Tuft is a growth form of extensive patches of crowded erect shoots. This plant form found in genus *Acroporium*, *Aptychella*, *Clastobryum*, *Chionostomum*, *Isocradiella*, *Rdulina*, *Sematophyllum*, *Taxithelium*, *Trismegistia*, and *Warburgiella*.

- Pendant is a growth form in which long gametophore droop from the substratum, rarely found in Sematophyllaceae, but occurring in species *Acroporium diminutum*, and *Brotherella falcate*.

The growth form as mats and wefts are particularly effective in storing water and are characteristic for habitats with occasional desiccation. Pendants are highly characteristic of cloud belts, since this life form can effectively comb humidity from mist Frahm (2003b).

### 4.5.2 Water conducting and water storing structures

In the words of Proctor (2000), "Bryophytes... evolved desiccation tolerance and represent an alternative strategy of adaptation to life on land, photosynthesizing and growing when water is available, and suspending metabolism when it is not". For this reason, mosses always have adaptive structures for conducting water enable the plant to take up water rapidly (within seconds) and to start photosynthesis immediately (Frahm 2003b). The anatomical adaptations related to water conducting and water storing found in Sematophyllaceae are:

- Presence of a central strand. The central strands are present in many acrocarpous mosses. They consist of narrow, elongate cells with oblique end walls which can conduct water but not sufficiently. In contrasted, the pleurocarpous mosses are having a basic structure much like that of tracheophytes (lignified vascular plants) with an epidermis surrounding cortex that move internal substances mostly horizontally (Kawai 1991). The stem of moss in family Sematophyllaceae has not central strands but the outer cortex thick walled cells are useful for conducting water in stem (Fig. 4.4, M.-O.).

- Presence of external water conduction. External conduction is made possible by concave leaves in which the water is conducted by capillarity. They are typical of pleurocarpous mosses with a prostrate growth and erect branches, recognized in *Acroporium* and *Wijkia*.

- Presence papillae on the leaf surface that papillae enable the plant to soak water rapidly over the leaf surface. The papillosity of leaf cells can be found both unipapillose and pleuripapillose in many genera of Sematophyllaceae. *Rhaphidostichum*, *Taxithelium* and *Radulina* are common found their distributions in dried condition area.

- Presence alar cells that the typical character of moss in family Sematophyllaceae. They function in absorbing water into the leaf, which is externally conducted along the stem by rhizoids or concave leaves. Every species of this family has alar cells, but different in size and type of alar organizations.

## 4.6 ECOLOGY

### 4.6.1 Habitat preference

The Sematophyllaceae usually found in tropical rain forest. Within the forest, the soil is not much covered by bryophytes due to the large amount of litter and its fast composition. The amount of bryophytes on soil is slightly increasing in montane forest with increasing elevation. There are usually no rock habitats at lower altitudes in the humid tropics due to the deep lateritic soils and fast chemical decomposition. This confines the variety of habitats in rain forests areas mainly to trees and their leaves (Frahm 2003b). The majority habitats of Sematophyllaceae are epiphytic under tree canopies, on branches, and on decaying logs along trails inside forests (fig 4.1). There are many species often found on rotten wood in montane forests. A few are epiphyllous in humid lowland rain forests. However, many epiphyllous species can be found on other substrates as well.

### 4.6.2 Altitudinal zonation

Since the environmental conditions vary with the altitude, it found differently adapted bryophytes in different altitudes. There are several different attempts to determine the altitudinal zonation of rain forest. Frahm (2003b) described the altitudinal belts in tropical rain forest are as follow:

- alt. 0-400 m: tropical lowland forest
- alt. 1100-1300 m: submontane forest
- alt. 1800 m; lower montane forest
- alt. 2800 m; upper montane forest
- forest line: subalpine forest

In Thailand, Sematophyllaceae have distributions in tropical rain forest at altitude from sea level in beach forest up to 2500 meter above sea level in upper montane forest and also found in alpine forest (at Doi Chiang Dao, Chiang Mai Province). Species diversity appears to be highest in residual primary forests at mid-elevation between 900-2000 m from sea level.

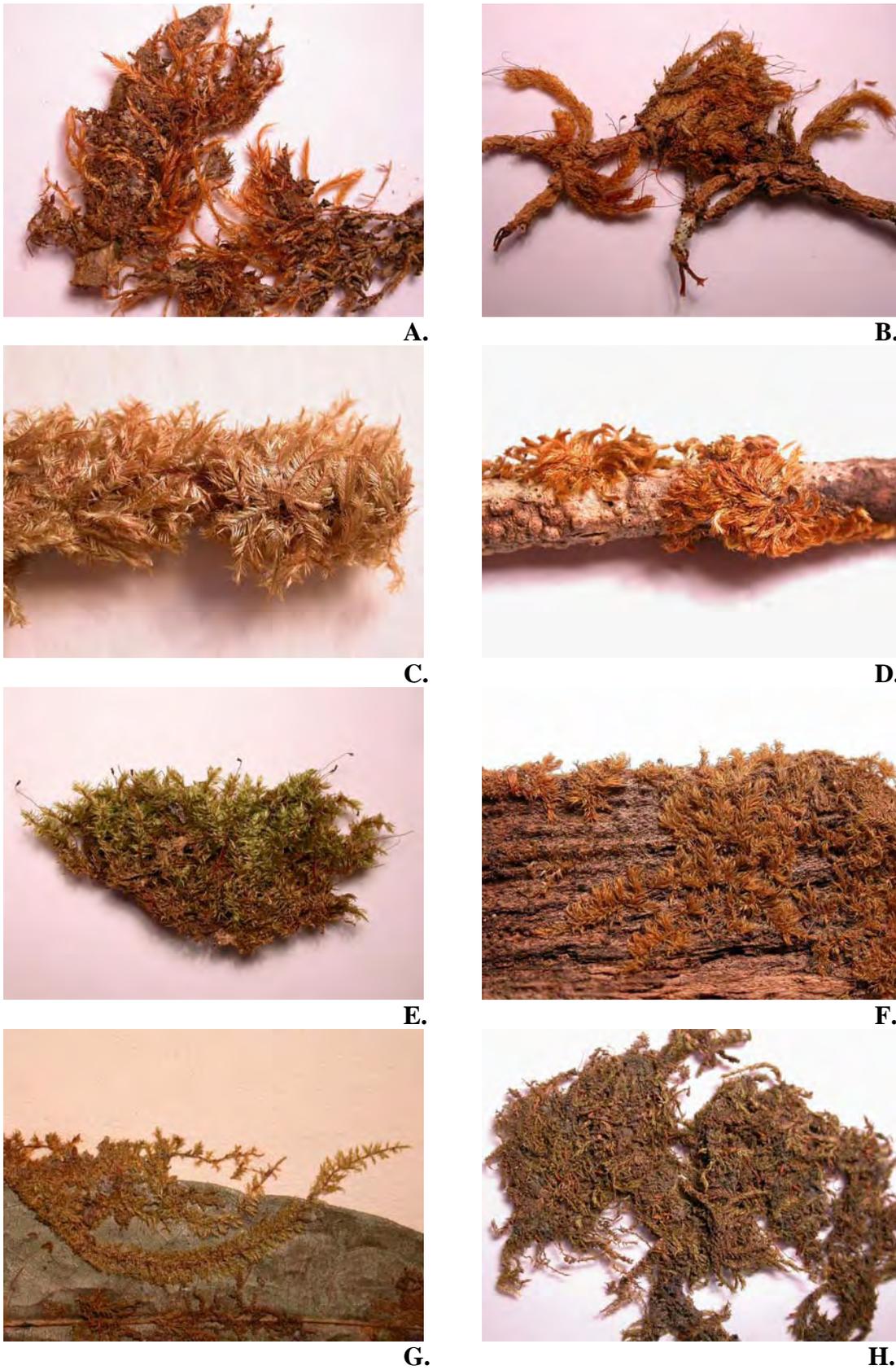


Figure 4.1 Habitats of the moss family Sematophyllaceae  
 A., B. epiphyte on lichens    C, D. epiphytes on branches    E. epiphyte on bark  
 F. epiphyte on log    G. epiphyll    H. terrestrial

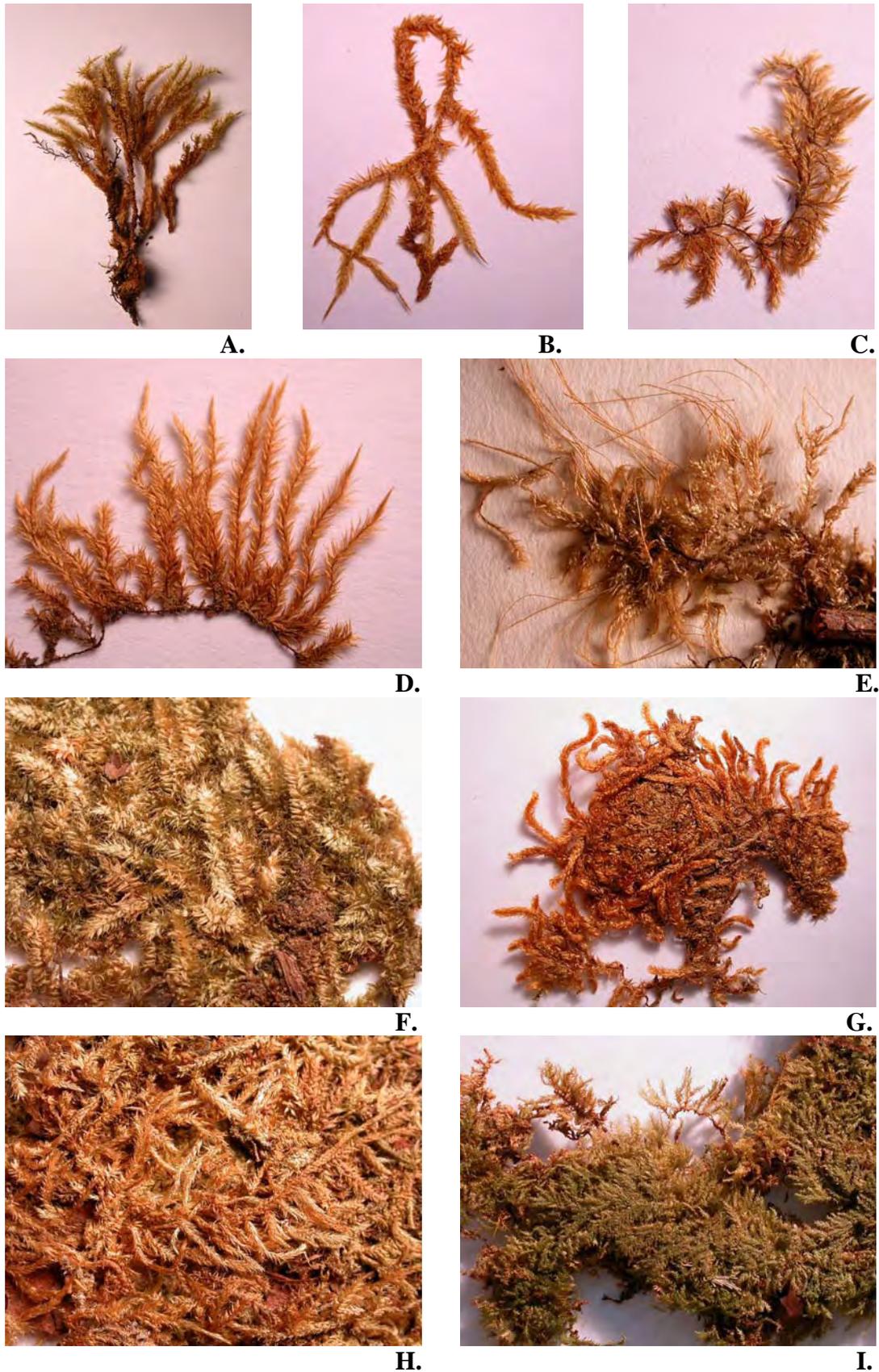


Figure 4.2 Growth forms of the moss family Sematophyllaceae

A. plant slightly dendroid, B. plant pendent, C.-E. stem long creeping with irregularly pinnate branches, F.-G. plant forming tuft, H.-I. plant forming mat

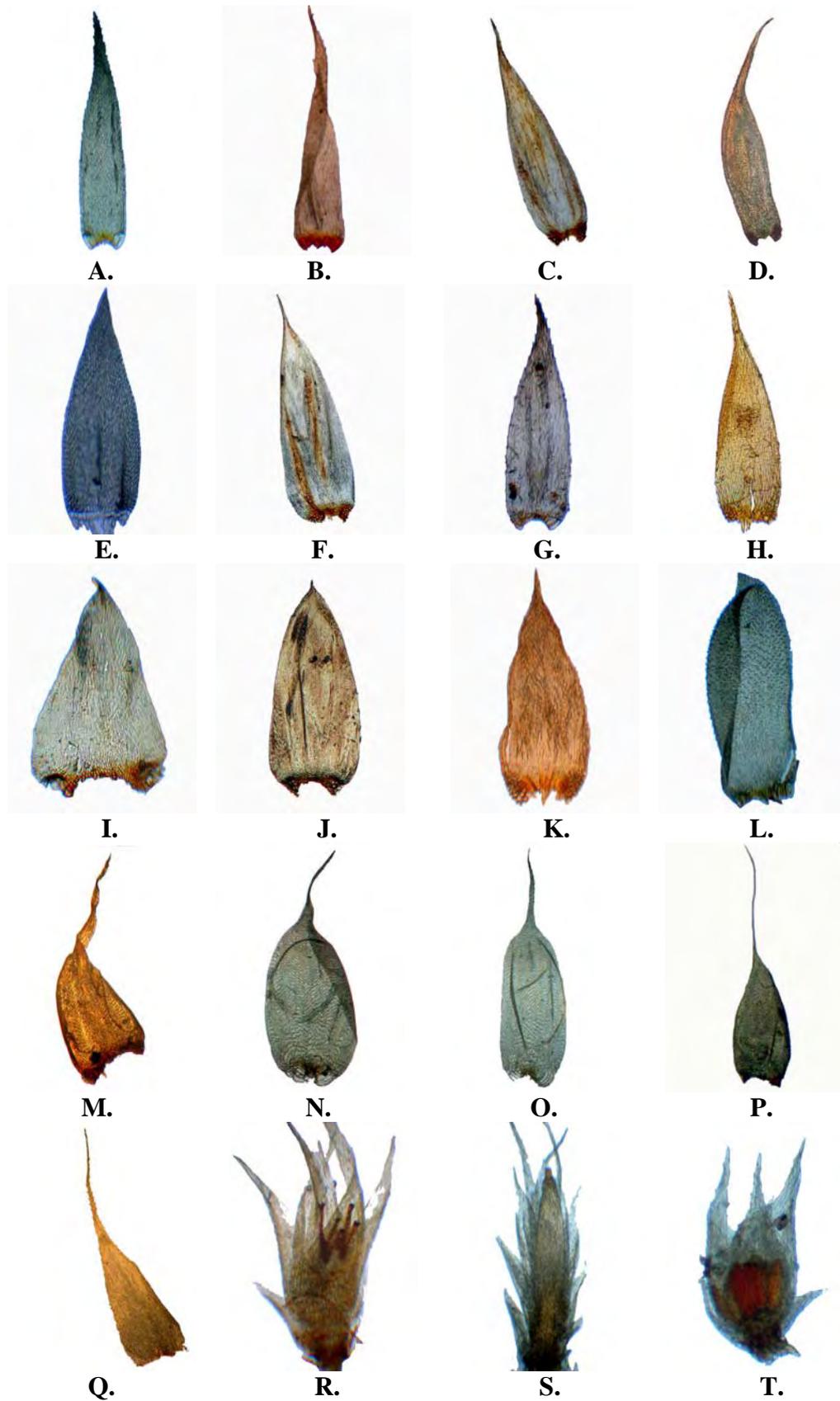


Figure 4.3 Gametophyte of the moss family Sematophyllaceae (1)  
 A.-P. diversity of leaves shape      Q. perichaetial      R. archaegonia branch  
 S. female branch with young sporophyte      T. anteridia branch

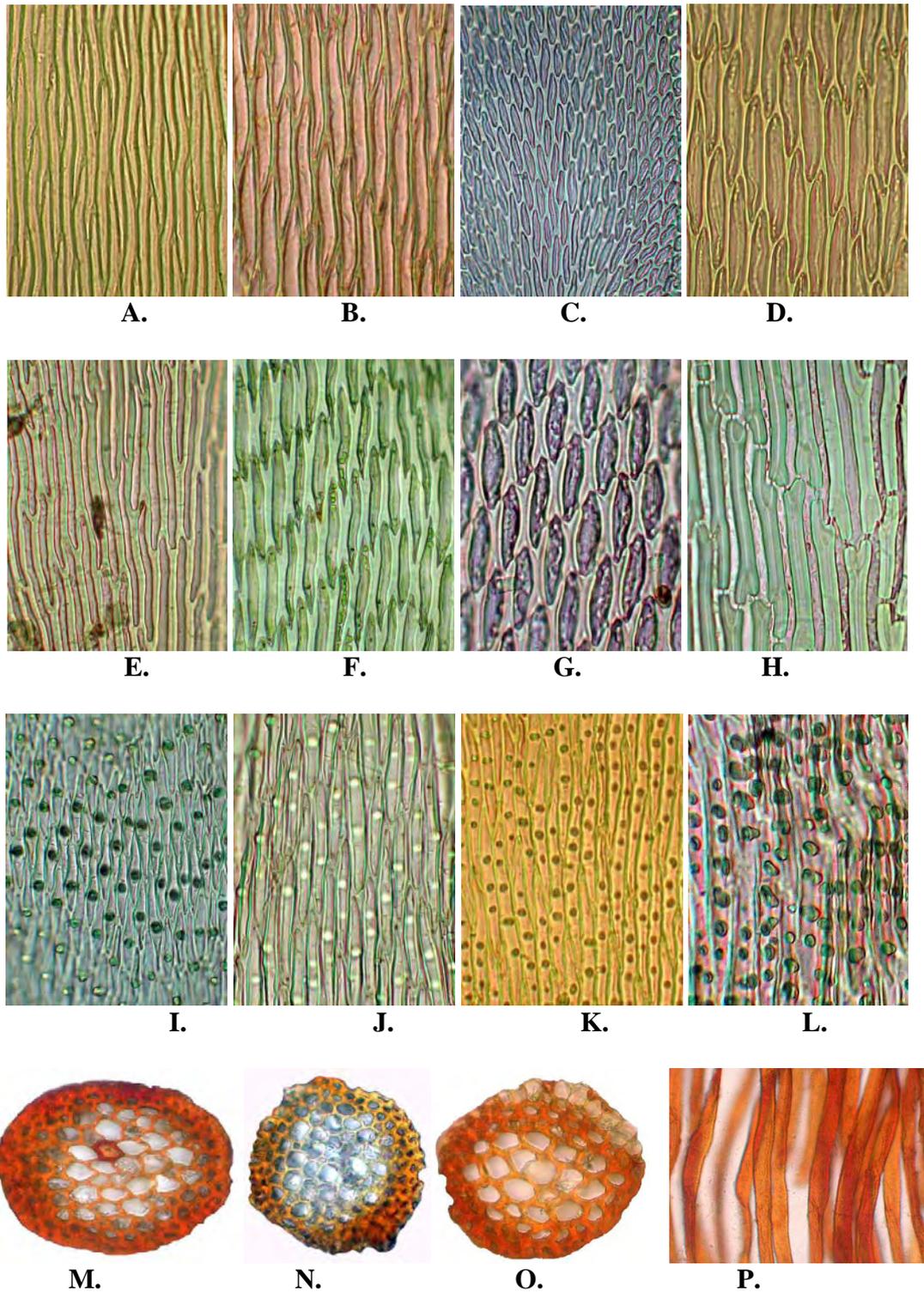


Figure 4.4 Gametophyte of the moss family Sematophyllaceae (2)  
 A.-C. leaf cells smooth thin walled,  
 E.-F. leaf cells smooth thick walled,  
 G.-H. leaf cells pitted,  
 I. unipapillose,  
 J.-L. leaf cells pleuripapillose,  
 M.-O. stems in cross-section,  
 P. rhizoids

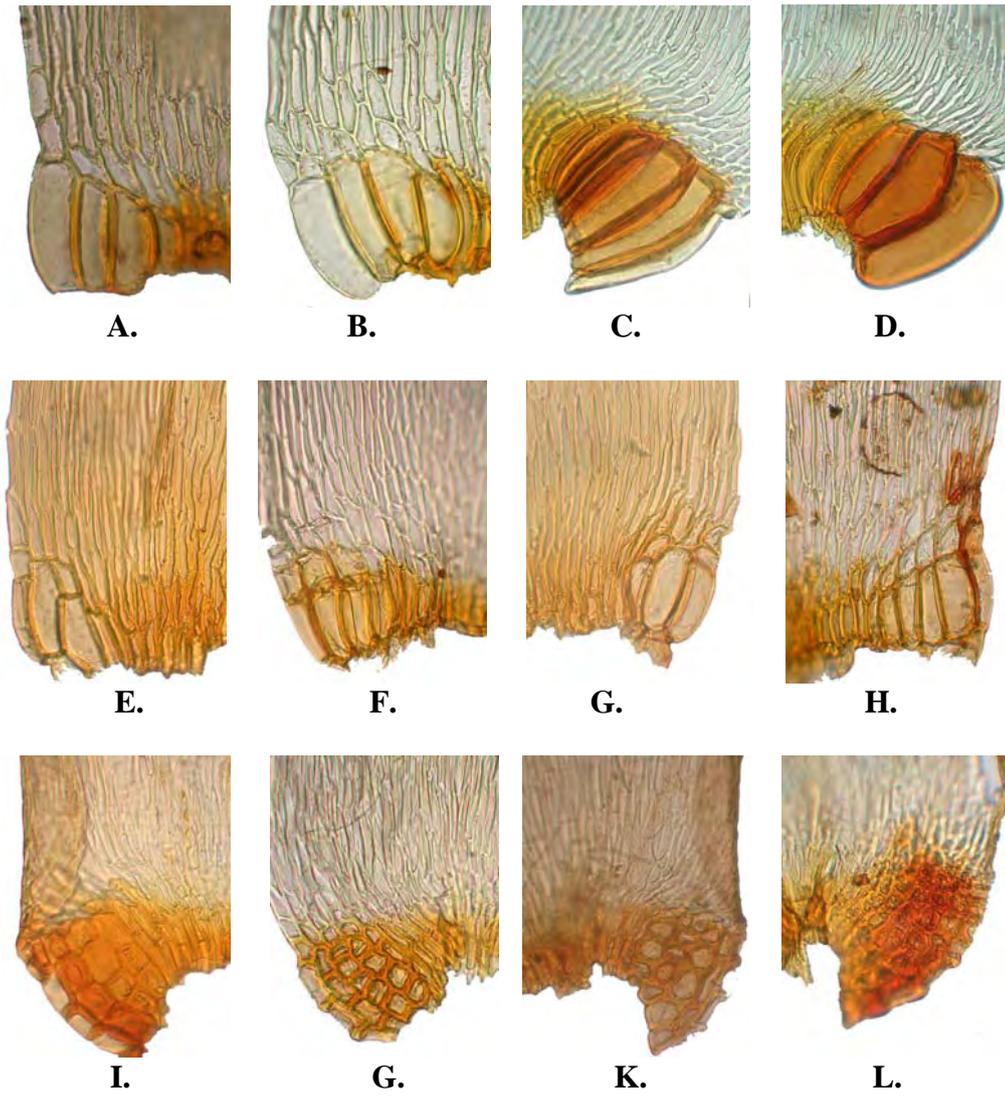


Figure 4.5 Types of alar organization  
 A.-D. alar acroporoid type, E.-H. alar brotheroid type, I.-L. alar heterophylloid type

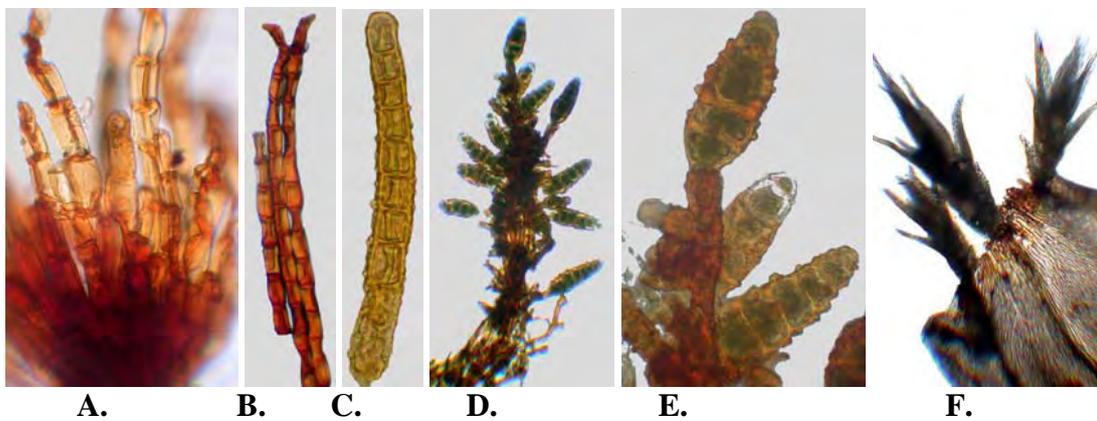


Figure 4.6 Types of vegetative reproduction  
 A.-B. propagule smooth filaments                      C. propagule rough filament  
 D.-E. propagule branch                      F. new shoots developed from basal leaf fragmentation.

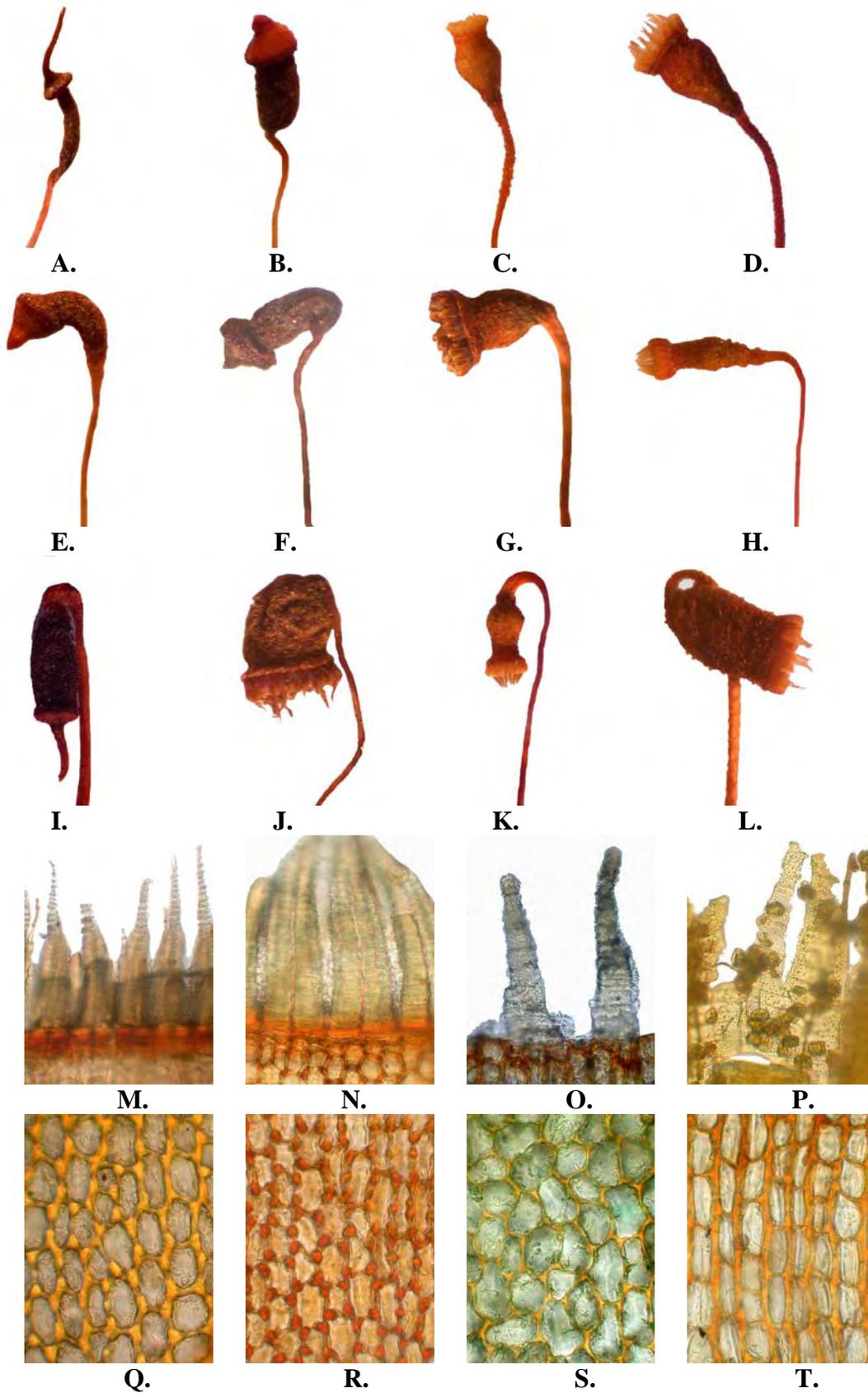


Figure 4.7 Sporophyte of the moss family Sematophyllaceae  
 A.-L. diversity of sporophytes showing different inclination of capsule  
 M.-N. exostome      O.-P. endostome      Q.- T. exothecia cells

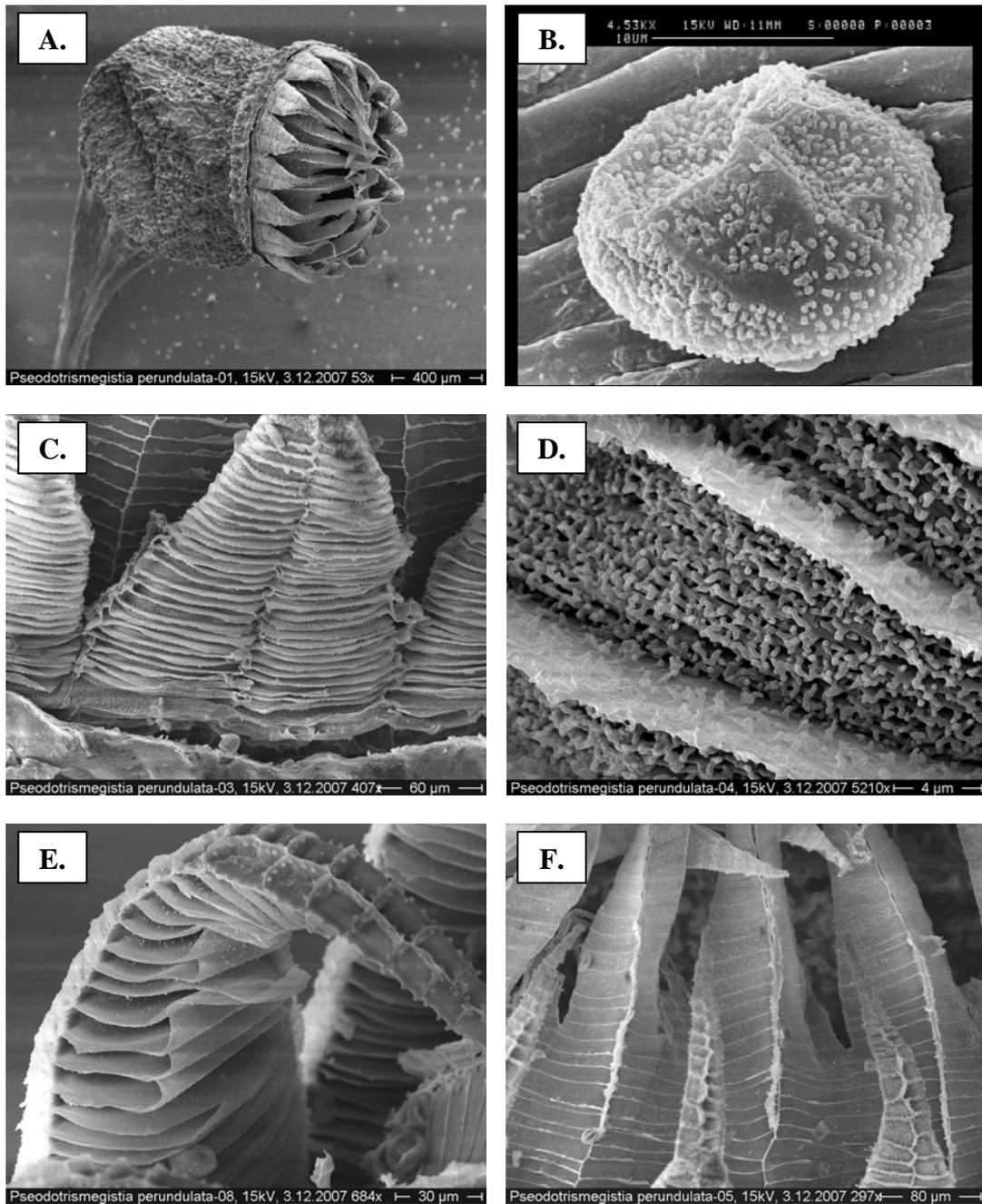


Figure 4.8 Morphology of sporangium (*Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota) from scanning electron microscope (SEM);

- A. capsule (hynaceous peristomial organization) shows 16 exostome teeth and 16 endostome teeth,
- B. spore spherical shaped, distinctly papillae ornamentation,
- C. exostome with a medial zigzag line or a furrow on the outer surface,
- D. papillae ornamentation on outer surface of exostome,
- E. inner surface of exostome often trabeculate,
- F. endostome usually narrowly lanceolate, keeled, rarely linear, with a high basal membrane.

## 5 SYSTEMATIC TREATMENT

### SEMATOPHYLLACEAE Broth. Nat. Pflanzenfam. 1(3): 1098. 1908.

*Plants* slender or robust, delicate or stiff, yellow, yellow, yellowish green, green or yellowish brown, somewhat glossy, often in dense mats or tufts. *Main stems* creeping to ascending or erect, with rhizoids, usually irregularly branched, rarely pinnately branched, branches round or complanate; stem cross section usually round, central strand absent, without loose cells, thin or thick-walled cortex and towards the outside two to many layers of stereids to substereid peripheral cells. *Leaves* in several ranks, stem and branch leaves usually similar in shape, rarely differentiated, symmetric, not plicate, variable among genera in shape of leaf; costae double, very short or rarely absent; leaf cells often narrowly rhomboidal, smooth or papillose, basal cells evidently differentiated.

*Autoicous* or dioicous, rarely synoicous. *Setae* elongate, straight or twisted when dry; capsules inclined or pendulous, rounded ovoid or oblong-ovoid, often asymmetric; exothecial cells thin-walled; apophysis slightly developed, stomata present; opercular conic, rostrate or needle like at apex; annuli often differentiated; peristome usually double, rarely endostome absent; exostome teeth splitting to base, very variable in shape, outer face usually cross-striate, rarely smooth, inner surface often trabeculate; exostome separating from endostome (except *Chionostomum*); segments usually narrowly lanceolate, keeled, rarely linear; basal membrane high; cilia usually present. *Calyptrae* often cucullate, smooth. *Spores* spherical, finely to distinctly papillose.

The Sematophyllaceae contain some 40-45 (50) genera and nearly 800-900 (1000) species in the world (Robbert *et al.* 2001). More than two-thirds of the genera are oligotypic, with four or fewer species. The distributions of Sematophyllaceae mainly grow in the tropical regions. Although a basic concept of the Sematophyllaceae is well formed, the definite systematic positions of numerous genera are still somewhat uncertain. Since the family was proposed the Sematophyllaceae were dealt with and discussed by various authors (Fleischer 1923; Brotherus 1925; Seki 1968; Crosby and Magill 1981; Tan and Buck 1989; Tan and Jia 1999; Tan 2000). Plants of this family often have been confused with those of the Entodontaceae, Hypnaceae or Pterobryaceae.

### Key to Genera

1. Alar cells numerous, forming cluster or grouping in tiers, mostly colored, quadrate or rectangular, not much inflated, usually thick-walled ..... 2
1. Alar cells oval to kidney-shaped, usually translucent, inflated, thin-walled, forming at least one distinctively defined basal row ..... 6
  2. Caducuous flagellate branchlets present on branch..... 11. *Isoclediella*
  2. Caducuous flagellate branchlets absent; asexual propagulate, if present, filiform ..... 3
3. Branches complanate with an enlarged and caudate terminus; leaf base decurrent; leaf axillary propagules abundant.....3. *Aptychella*
3. Branches not complanate, without an enlarged and caudate terminus; leaf base not decurrent; leaf axillary propagules rare or lacking ..... 4
  4. Plants small, slender, mat forming; leaves less than 1.5 mm long, margins entire or slightly denticulate ..... 8. *Gammiella*
  4. Plants large, stout, weft forming; leaves longer than 1.5 mm long, margin toothed .... 5

5. Leaves ovate-lanceolate, falcate, concave, apex narrow subulate, margin denticulate at tip, sometimes recurved to border..... 10. *Heterophyllum*
5. Leaves lingulate, margin bordered, irregularly and strongly toothed in the tongue-like portion..... 15. *Pseudotrismegistia*
6. Leaf cells smooth ..... 7
6. Leaf cells papillose or prorate ..... 20
7. Plants irregularly bi- to tripinnately branched; system and branch leaves different in size and shape ..... 24. *Wijkia*
7. Plants regularly branched, at most irregularly pinnate; stem and branch leaves similar, or different only in size..... 8
8. Leaves abruptly contracted to a narrow or filiform acumen ..... 9
8. Leaves acute or gradually long acuminate ..... 10
9. Leaves erect spreading, filiform acumen, margin smooth; calyptra small, cucullate ..... 18. *Rhaphidostichum*
9. Leaves strongly falcate, abruptly contracted to a narrow apex, margin serrate in upper margin; calyptra large, companuate..... 23. *Warburgiella*
10. Lamina cells often rhombic with elliptical lumen; peristome single... 13. *Meiothecium*
10. Lamina cells usually linear; peristome double ..... 11
11. Exostome teeth non-striate ..... 5. *Chionostomum*
11. Exostome teeth striate ..... 12
12. Leaves ovate-lingulate, irregularly and strongly toothed margin in the tongue-like portion ..... 13
12. Leaves ovate, oblong to lanceolate, margins not bordered, entire or serrulate ..... 14
13. Leaves lingulate to ovate-lingulate, margin bordered; outermost of alar cells divided to few small cells ..... 22. *Trismegistia*
13. Leaves ovate to lingulate, margin not bordered; almost alar cells kidney shaped, arranged in a single row (excepted *M. subfiliferum*) ..... 12. *Mastopoma*
14. Leaves often strongly tristichous ..... 7. *Clastobryum* in part
14. Leaves spiral or more than 3 rows ..... 15
15. Alar cells few, 4-5, not forming a continuous basal row reaching costa..... 16
15. Alar cells, including the well-developed supra-alar cells, more than 6, often forming a continuous basal row reaching costa ..... 17
16. Plants green or yellowish brown, with filiform propagules in leaf axials; leaves not concave ..... 16. *Pylaisiadelpha*
16. Plants reddish or purplish brown, without filiform propagules; leaves strongly concave ..... 9. *Hageniella*
17. Leaf apex toothed; exothecial cells not collenchymatous, thickened along vertical cell walls..... 4. *Brotherella*
17. Leaf apex entire to weakly toothed; exothecial cells strongly collenchymatous ..... 18
18. Lamina cells usually thin walled; margins plane or reflexed; alar cells small, oval to oblong ..... 19. *Sematophyllum*
18. Lamina cells often strongly porose or pitted; alar cells large, often curved, kidney shaped ..... 19
19. Leaf ovate to ovate-lanceolate, strongly concave, margins involute; alar cells large, often curved, kidney shaped ..... 2. *Acroporium* in part
19. Leaf long, narrow, erect, slightly flexulose and often twisted towards the apex, alar cells large, inflated and thick-walled ..... 6. *Clatobryophilum*
20. Leaves tristichous, leaf cells sparingly papillose or prorate.... 7. *Clastobryum* in part
20. Leaves not tristichous, leaf cells uniformy papillose or prorate ..... 21

21. Leaf cells pleuripapillose or uni- or bi-serriate papillose ..... 22
21. Leaf cells unipapillose or prorate ..... 23
22. Leaves falcate-secund; setae papillose above; opercula obliquely long-rostrate; exothecial cells strongly collenchymatous ..... 17. *Radulina*
22. Leaves not clearly falcate-secund; setae smooth throughout; opercula conic, short; exothecial cells not collenchymatous ..... 20. *Taxithelium*
23. Leaf cells short fusiform; operculum conic; exothecial cells not collenchymatous ..... 1. *Acanthorrhynchium*
23. Leaf cells elongate to linear; operculum long rostrate; exothecial cells collenchymatous ..... 24
24. Outermost alar cells long and curved; capsules erect to suberect ..... 2. *Acroporium* in part
24. Outermost alar cells not long and curved; capsules inclined or pendulous ..... 25
25. Leaves hooded in the upper half; apex somewhat constricted and narrowed into an acumen; alar cells often thick-walled ..... 14. *Papillidiopsis*
25. Leaves uniformly concave throughout; apex gradually attenuated; alar cells mostly thin-walled ..... 21. *Trichosteleum*

### 1. ACANTHORRHYNCHIUM M. Fleischer

- Acanthorrhynchium* M. Fleischer, Musci Fl. von Buitenzorg 4: 1331. 1923. *Acanthodium* Mitt., J. Linn. Soc. Bot. 10: 182, hom. illeg., non Delile, F. Egypte 97 1813. Lectotype: *A. papillatum* (Harv.) M. Fleisch. vide W.R. Buck & B.C. Tan 1989: 15.
- Taxithelium* subg. *Monostigma* Renaud & Cardot Rev. Bryol 28: 111. 1901. Lecto: *Taxithelium papillatum* (Harv.) Broth. vide W.R. Buck & B.C. Tan 1989: 15.
- Taxithelium* subg. *Oligostigma* Renaud & Cardot Rev. Bryol. 28: 111. 1901. Lectotype: *Taxithelium serratum* Renaud & Cardot, *Acanthorrhynchium serratum* (Renaud & Cardot) M. Fleisch.

*Plants* with elongate slender stems, closely pinnate or bipinnate forming extensive mats. *Branches* erect, short, complanately foliate. *Leaves* ovate to ovate-lanceolate, concave abruptly narrowed to a long filiform apex, margin serrulate to base, contracted to insertion; laminal cells short, firm-walled, unipapillose over lumen on abaxial surface; alar region with basal row of 3-4 inflated, large cells, ecostate.

*Autoicous*. *Perichaetial leaves* on main stem with erect leaves narrowed to a coarsely serrate apex. *Setae* long, red, smooth. *Capsules* horizontal, asymmetrical with short conical operculum; annulus present; exothecial cells weakly collenchymatous; peristome diplolepidous, double, alternate with 16 lanceolate exostome teeth, with a zig zag median groove on the outer surface, cross striolate below, striolate papillose above, coarsely papillose at apex. With projecting trabeculae on the inner surface; endostome with 16 keeled, very narrowly perforate, segments finely papillose, almost as long as the exostome teeth, arising from a high, finely papillose basal membrane; cilia, 1-2, well developed, nodulose, papillose. *Spores* medium sized.

The genus has distribution worldwide in East African Islands, Indo-Malesia, some Pacific Islands and Australia. This is a small genus of 11 described species. There are 2 species in Thailand.

## Key to Species

1. Plants medium sized creeping in tangled mats; branches pinnate or bipinnate, 3-5 mm long, erect to ascending; stem leaves concave at the base, contracted insertion, 1.3-1.6 x 0.3-0.4 mm, margin usually toothed throughout the length; laminal cells oval-rhomboidal, 30-45 x 7-8  $\mu\text{m}$ , alar 3-4 oblong, inflated, hyaline cells, yellowish or brownish; branch leaves usually smaller than stem leaves.....1. *A. papillatum*
1. Plants large with elongate slender stem, forming extensive mats; branches irregularly bipinnate, up to 5 mm long, complanately foliate; stem leaves concave abruptly narrowed to a long entire filiform apex, margin serrate at base of filiform portion, entire to base, 1.5-2 x 0.5-0.7 mm, laminal cells linear to oblong, 40-87.5 x 5  $\mu\text{m}$ , alar 4-5 oblong, inflated, coloured; branch leaves concave with acute apex..... 2. *A. scabrifolium*

1. *Acanthorrhynchium papillatum* (Harvey) Fleischer, Musci Fl. Buitenzorg 4: 1331. 1923. *Hypnum papillatum* Harvey in Hooker, Icon. Pl. Rar. 1:23 f. 8. 1836. London J. Bot. 2: 18, 1840. *Stereodon papillatus* (Harv.) Mitt., J. Linn. Soc. Suppl. Bot. 1: 113. 1859. *Acanthodium papillatum* (Harv.) Mitt., J. Linn. Soc. Bot. 10:182. 1868. *Sematophyllum papillatum* (Harv.) Mitt. In Seem., Fl. Vit. 398. 1873. *Trichosteleum papillatum* (Harv.) Laeg., Ber. S. Gall. Naturw. Ges. 1876-77: 417. 1878. (Ad. 2:483). *Taxithelium papillatum* (Harv.) Broth., Bot. Tidskr. 24: 123. 1901. — Type: Napal, Hooker 3168 (holo-, BM!).

*Acanthorrhynchium decolor* (Besch) Fleisch., Musci Fl. Buitenzorg 4: 1335. 1923., syn. nov. *Rhaphidostegium decolor* Bescherele, Ann, Sci, Nat. Bot. sér. 6, 10: 306. 1880. — Type: Seychelles: 1875, *G. de l'Isle* (holo-, BM).

*Acanthorrhynchium loucoubense* (Besch.) Fleisch., Musci Fl. Buitenzorg 4: 1335. 1923., syn. nov. *Rhaphidostegium loucoubense* Bescherele, Ann, Sci, Nat. Bot. sér. 6, 10: 306. 1880. *Taxithelium loucoubense* (Besch.) Ren. & Card., Rev. Bryol. 28:111. 1901. — Type: Forêt du Loucoubé, Nossi Bé, Madagascar, Mars 1851, Boivin, (lecto-, BM).

*Acanthorrhynchium serratum* (Ren. & Card.) Fleisch., Musci Fl. Buitenzorg 4: 1335. 1923. *Taxithelium serratum* Ren. & Card., Bull. Soc. R. Bot. Belg. 38(1): 40. 1900. — Type: In silvis circa Mahambo, Madagasca, *Perrot frères* (holo-, PC).

## Figure 5.1

*Plants* creeping in tangled mats, slender, soft greyish-green to pale-green, often brownish in herbarium specimens, not shiny. *Stems* flattened, elongate to 10 cm, 1-1.45 mm in diameter; branches closely pinnate or bipinnate, 3-5 mm long, 1-3 mm apart, widely spreading, erect to ascending. *Leaves* spiral arrangement, erect-spreading to complanate-foliate. Branch leaves erecto-patent to spreading when moist, appressed with out-turned long tips when dry, ovate to ovate-lanceolate, abruptly narrowed to a long piliform point usually 20-30 % of leaf length, slightly concave at the base, contracted insertion, 1.3-1.6 x 0.3-0.4 mm wide, usually toothed throughout the length, although teeth sometimes absent where the apiculus is particularly long, the teeth formed from projecting cell ends, ecostate, branch leaves usually smaller than stem leaves; laminal cells oval-rhomboidal near apex, firm-walled, pitted, narrower toward margins, mid-leaf cells oblong-rhomboidal, 30-75 x 4-5  $\mu\text{m}$ , with a single papilla over the centre of the cell lumen (many leaves having at least one cell with two papillae), 4-6  $\mu\text{m}$  in diameter, papillae on the dorsal side more prominent, the papillae often appearing to be distributed in oblique rows across the leaf;

alar region with basal row of 3 or 4 oblong, inflated, hyaline cells, yellowish or brownish, the outermost largest, 33-68 x 10-30  $\mu\text{m}$ , supra-alar cells few, irregular, reduced or absent at one side on asymmetric leaves.

*Autoicous*. *Perichaetial leaves* on main stem; inner perichaetial leaves, ovate, erect, up to 2.5 mm long, 0.6 mm wide, gradually narrowed to a long, coarsely serrate point; outer perichaetial leaves erect, ovate to lanceolate shaped, 0.8-1.0 mm long, 0.3 mm wide, round base, acuminate apex, margin slightly serrate. *Setae* red, smooth, throughout, 1.5-3.5 cm long. *Capsules* horizontal, asymmetrical, curved and gibbous on back, urn 1-1.5 mm long; opercula conical, brownish to reddish 0.4 mm long; annulus present but not dehiscent; exothecial cells weakly collenchymatous with few stomata spreading at base of urn; peristome diplolepidous, exostome 16 lanceolate teeth, with a zig zag median groove on the outer surface, cross striolate below, striolate papillose above, coarsely papillose at apex, with projecting trabeculae on the inner surface, endostome membranous with 16 keeled, very narrowly perforate, segments finely papillose, almost as long as the exostome teeth, arising from a high, finely papillose basal membrane; cilia 1-2, well developed, nodulose, papillose. *Spores* sized ca. 12-15  $\mu\text{m}$ .

Illustrations. — Fleischer 1922 (fig. 216, p. 1333); Bartram 1939 (fig. 441), Gangulee 1980 (fig. 982, p. 1918).

Thailand. — NORTHERN. Chiang Mai, Phitsanulok; CENTRAL. Phetchaburi; SOUTHEASTERN. Prachin Buri, Chanthaburi, Chon Buri, Trat; PENINSULA. Chumphon, Surat Thani, Trang, Phatthalung, Songkhla, Satun, Narathiwat.

Distribution. — East African Islands (Comoros, Madagasca, Seychelles), Indochina, China, Indonesia, Borneo, Philippines, New Guinea, Australia, Fiji, Samoa. Nepal, Burma and Penung.

Ecology. — A widespread of this species occurring as an epiphyte and on the ground in tropical rainforest up to 700 m from sea level. Many specimens show evidence of being corticolous and where details are given, these usually refer to tree stumps dead branches or fallen logs and occasionally leaf litter.

Specimens examined. — TYPE. Nepal [*Hooker 3168* (syn-BM)]. NORTHERN. Phitsanulok: [Thung Salaeng Luang, 20 Feb. 1964, *HseSm 11588* (AAU, BKF, L)]; SOUTHEASTERN. Prachin Buri: [Khao Yai National Park, 18 Feb. 1966, *Touw 12225* (AAU, BKF, BM,); *Touw 12324* (AAU, BKF, BM, L, NY); Khao Yai National Park, 20 May 1965, *Tixier 1280* (BKF), 3-5 Sept. 2006, *Pollawatn 350, 351, 357, 370* (BCU)]; Chanthaburi: [Nong Bon 25 km E of Makham, 31 Aug. 1972, *LNSa 32257* (AAU); Khao Sabab, 21 Aug. 1966, *LSmW 1650* (AAU, NY); Khao Sabab, 3 Aug. 1954, *Smitinand 1821* (BKF); Kao Sabab, 18 Jan. 1958, *SLH 6760* (NY)]; Trat: [Koh Chang Island, 18 Nov. 1970, *CLW 5014* (AAU); Koh Chang Island, 25 Aug. 1966, *LSmW 1793* (AAU), *LSmW 1797, 1818* (AAU, BM, L, NY); Huay Raeng, Dong Maduea, 19 Jun. 1952, *Smitinand 1320* (AAU, BKF); Huay Raeng, Pak Phreed, 22 Jun. 1952, *Smitinand 1420* (AAU, BKF), *Smitinand 1347* (BKF); Huay Raeng, Charng Klina, 27 Jun. 1952, *Smitinand 1453a*, Koh Chang Island, 17 Feb. 1955, *Smitinand 2203* (BKF, L)]; PENINSULA. Trang: [Khao Chong, 9 Oct. 1970, *CLW 3533* (AAU); Kao Kuab, 25 Dec. 1929, *Kerr 430* (BM)]; Chumphon: [Tahgaw, 21 Jan. 1927, *Kerr 173* (AAU, BM)]; Phatthalung: [Chawang, 25 Jan. 1958, *SLH 6738* (NY)]; Phuket: [Thalang, Khao Phara, 25 Jan. 1966, *Touw 11277* (BKF, BM); Kamala, 10 Mar. 1929, *Kerr 424* (AAU, BM)]; Ranaung: Kao Chang, 10 Jan. 1929, *Kerr 388* (AAU, BM); Kao Pauta Chongdong, Kraburi, 10 Jan. 1929, *Kerr 398* (AAU, BM)]; Surat Thani: [Bangbao, 7 Aug. 1955, *Smitinand 2862* (AAU, BKF, FH, L); Yanyao, 21 Feb. 1932, *Kerr 467* (AAU, BM); Ta Phet, 15 Apr. 1965, *Tixier 544, 546*, Wang Sai, 19 Apr. 1965, *Tixier 702* (PC)]; Satun: [Terutao, 27 Feb. 1966, *Hansen &*

*Smitinand 12462b, 12465*; Khuan Karong, 14 Oct. 1970, *CLW 3799* (AAU, NY)]; Narathiwat: [Chatvarin in Falls at Sungai Padi, 18 Oct. 1970, *CLW 4023* (AAU, NY)].

Discussion. — Many collections of this taxon from Thailand usually growing on tree trunks or rotting logs, soil or rock. Variable but distinguished by the flattened branches and small pointed leaves with strongly unipapillate cells. The long smooth setae bearing curved asymmetrical capsules with short conical opercula are quite characteristic.

2. *Acanthorrhynchium scabrifolium* (Broth.) B.C. Tan & C. Ying, *Crypt. Bryol.* 25: 307. 2004.

*Acanthocladium scabrifolium* Broth., *Hedwigia* 60: 326. 1919. *Wijkia scabrifolia* (Broth.) Touw, *J. Hattori Bot. Lab.* 44: 150. 1978. *Trichosteleum scabrifolium* (Broth.) W.R. Buck & B.C. Tan, *Acta Bryol. Lichenol.* 1: 8. 1989 [1990]. *Mastopoma scabrifolium* (Broth.) B.C. Tan & Ninh, *Acta Bot. Yunnan.* 20: 272. 1998.

### Figure 5.2

*Plants* large with elongate slender stems, closely pinnate or bipinnate forming extensive mats; branches spreading, erect, up to 5 mm long, densely complanate foliate. *Leaves* ovate to ovate-lanceolate; stem leaves concave abruptly narrowed to a long entire filiform apex, margin serrate at base of filiform portion, entire to base, 1.5-2 x 0.52-0.68 mm; laminal cells linear to oblong, to rhomboidal in upper part, 40-87.5 x 3-5  $\mu\text{m}$  firm-walled, unipapillose over lumen on abaxial surface; alar region with basal row of 4-5 inflated, coloured, 75-112.5 x 25-40  $\mu\text{m}$ ; branch leaves concave with acute apex, margin serrate from middle to apex, 1.2-1.6 x 0.4-0.52 mm, laminal cell linear to rhomboidal, 55-80 x 3-5  $\mu\text{m}$ , unipapillose; alar region with basal row of 4 or 5 oblong, inflated, hyaline cells, yellowish or brownish, the outermost largest, 50-92.5 x 17.5-32.5  $\mu\text{m}$ , supra-alar cells few, irregular, reduced or absent at one side on cylindrical leaves.

*Autoicous*. *Perichaetial leaves* on main stem; inner perichaetial leaves, ovate, erect, up to 2.5 x 0.6 mm, gradually narrowed to a long, coarsely serrate point; outer perichaetial leaves erect, ovate to lanceolate shaped, 0.8-1.0 x 0.3-0.5 mm, round base, acuminate apex, margin slightly serrate. *Setae* red, smooth, up to 5 cm long. *Capsules* horizontal, asymmetrical, curved and gibbous on back, 1-1.5 mm long; opercula conical, brownish to reddish 0.5 mm long; annulus present but not dehiscent; exothecial cells weakly collenchymatous with few stomata spreading at base of urn.; peristome diplolepidous, exostome 16 lanceolate teeth, with a zig zag median groove on the outer surface, cross striolate below, striolate papillose above, coarsely papillose at apex, with projecting trabeculae on the inner surface, endostome membraneous with 16 keeled, very narrowly perforate, segments finely papillose, almost as long as the exostome teeth, arising from a high, finely papillose basal membrane; cilia 1-2, well developed, nodulose, papillose. *Spores* sized ca. 15-18  $\mu\text{m}$ .

Illustration. — Tan & Ninh 1998 (p.273, figs. 1-6); Akiyama 2006 (p.7, Fig. 7).

Thailand.—NORTHERN. Chiang Mai; NORTHEASTERN. Loei; SOUTHEASTERN. Prachin Buri.

Distribution. — Indonesia (Java), Malaysia (Peninsular), Indochina.

Ecology. — Epiphytic plant in evergreen forest, alt. 1200-1300 m.

Specimens examined.— NORTHERN. Chiang Mai: [Doi Suthep (Doi Pui), 17 Jul. 1968, *LsaW 2585* (BM)]; NORTHEASTERN. Loei: [Phu Kradung, 7-9 Nov. 1970, *CLW 4765* (NY)]; SOUTHEASTERN. Prachin Buri: [Khao Yai National Park. Khao Khieo, 29 Oct. 1970, *CLW 424*; Khao Lom, 30, Oct. 1970, *CLW 4327* (BM, FH, NY)].

Discussion. — This species had reported by Tan & Ninh (1998) as *Mastopoma scabrifolium* (Broth.) B.C. Tan & Ninh for new species record to Thailand. Recently, Tan & Ying (2004) was replaced the position of species to *Acanthorrhynchium scabrifolium* (Broth.) B.C. Tan & C. Ying, by based on molecular study. Si He (1992) was identified all specimens from Thailand to *Rhaphidostichum luzonense* (Broth.) Broth. But with the comparable with type specimens of the later species, it differed in many characters such as long apical tapering, lamina cells long-linear and lacking of papillose cell. This species may make misunderstood to *Rhaphidostichum luxurians* (Dozy & Molk.) M. Fleisch. in their habitat and plant form, but the later species has leaf lanceolate shaped and alar region present brotheroid type.

## 2. ACROPORIUM Mitt.

*Acroporium* Mitt., J. Linn. Soc. Bot. 10: 182. 1868. Sematophyllaceae Sect. *Acroporium* (Mitt.) Mitt., J. Linn. Soc. Bot. 12: 474. 1869. Lectotype: *Acroporium brevicuspidatum* Mitt., J. Linn. Soc. Bot. 10: 183. 1868., vide Buck, Brittonia 35: 310. 1983.

*Plants* slender to robust, soft, rarely stiff, somewhat glossy in interwoven patches, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; pinnately branched. *Branches* suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, erect or erect-spreading, sometimes strongly second, narrowly to broadly ovate, oblong-ovate to oblong-lanceolate or lanceolate, 1.5 – 3 mm long, recurved or roughly concave, short to subulate pointed, apex long acuminate, sometimes subtubular, base usually auriculate; margin distally enrolled, entire to slightly serrulate near apex; ecostate; laminal cells upper and median cells narrowly rhomboidal to linear, basal cells shorter, smooth, often thickened and porose, or with single papilla on upper leaf cells; alar region consisting of one row of inflated, hyaline or yellowish cells, usually golden-yellow, rarely deeply brown, coloured cells recurving inwards at base; supra-alar cells 1 to 2 rows of quadrate coloured cells, present in a few species.

*Autoicous or dioecous or phylloidioicous*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* elongate, slender and wiry, red, tuberculate above, usually strongly papillose, rarely smooth. *Capsules* erect or inclined, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous, sometimes mammillose; stomata at urn base, superficial; operculum form a conic base, long-rostrate, oblique; peristome double, exostome of 16 lanceolate teeth, bordered, outer surface finely cross-striate with median zig zag line, weakly to strongly furrowed or not below, papillose above; inner surface clearly trabeculate; endostome segments 16, keeled and perforate, segments as high as the teeth, keeled, yellowish; basal membrane high; cilia simple, short, sometimes reduced. *Spores* large, sometimes varying in size, yellowish green, spherical, finely papillose. No chromosome number available.

The species are epiphytic and branches and tree crowns, or occur on decaying logs along trails within forests. A few are epiphyllous in humid lowland rainforests. *Acroporium* is abundant in semi-open to semi-dry habitats in tropical rainforest. The genus is common in the paleotropics including Indo-Malesia, in western Malesia (the Philippines, Borneo and Java), also in Indochina, China, Japan, Africa, tropical America, the Pacific and

Australia. There are more than 80 species validly published for the genus *Acroporium*, which is restricted to tropical and subtropical regions. There are 16 species 5 varieties are occurred in Thailand.

### Key to Species

1. Plants small, slender; lateral branch less than 10 mm long; leaves excluding the apices less than 1.5 mm long, narrowly lanceolate to linear, at times tubulose ..... 2
1. Plants medium to large; lateral branch more than 10 mm long; leaves more than 1.5 mm long, variously oriented; leaf lanceolate, ovate-lanceolate or broadly ovate ..... 4
  2. Plants with long terminal branches; leaves mostly divergent and wide-spreading throughout; leaf cells smooth, setae less than 10 mm long ..... 5. *A. diminutum*
  2. Plants slender with numerous short branches; leaves divergent on the penicillate branches; leaf cells papillose on upper part ..... 3
3. Branch up to 10 mm; Leaf lanceolate 1.2-1.5 mm long, margin slightly serrate at apical part; leaf cells usually unipapillose ..... 11. *A. lamprophyllum*
3. Branch up to 5 mm long; Leaves narrowly lanceolate up to 10 mm long, margin smooth throughout apex; leaf cells often 1-3 papillae in upper part ..... 3. *A. convolutifolium*
4. Stem and branch leaves narrowly ovate-lanceolate to lanceolate, long acuminate, without a broad cordate base, if broadly ovate, then apices subulate or cuspidate ..... 5
4. Stem and branch leaves broadly ovate, ovate-lanceolate, acute to short acuminate, usually with a broad cordate base ..... 12
5. Plants small, mat forming, with very few slender, pinnate branches up to 1 cm long; ..... leaves less than 2 mm long ..... 6
5. Plant medium to large, leaves more than 2 mm long ..... 7
  6. Branch ascending, irregularly pinnate; leaves ovate, erect spreading; leaf cells slightly pitted near base ..... 12. *A. laosianum*
  6. Branch patent, regularly pinnate; leaves lanceolate, often falcate, homomallous; leaf cells smooth ..... 13. *A. rufum*
7. Leaves appressed to erect-patent, bristly, a few falcate ..... 8
7. Leaves spreading, mostly falcate, most bristly ..... 9
  8. Lamina broadest above the base, mostly long acuminate, not gradually setaceous, margins incurved in the upper half ; leaf cells smooth ..... 4. *A. convolutum*
  8. Leaves less than 3 mm long ..... 10. *A. johannis-winkleri*
9. Leaves abruptly constricted to a piliferous tip ..... 1. *A. aciphyllum*
9. Leaves gradually narrowed into a long acuminate tip ..... 10
  10. Leaf slightly falcate, broadest at base, gradually becoming setaceous, margin incurved throughout ..... 6. *A. downii*
  10. Leaves erect, broadest above base, cells smooth; gradually becoming to long acuminate apex, margin incurved at apical part ..... 11
11. Plants synoecious; leaf ovate, 1.4-2.1 mm long, acuminate apex, perichaetial leaves short cuspidate, margins strongly toothed, especially near the shoulder; setae less than 15 mm long ..... 16. *A. sigmatodontium*
11. Plants autoecious or dioecious; leaves ovate-lanceolate, 2-2.8 mm long, apex long acuminate; perichaetial leaves long acuminate, margins weakly, denticulate; setae longer than 15 mm ..... 18. *A. strepsiphyllum*
12. Plant small; leaves less than 2 mm long; setae less than 15 mm long.. 2. *A. brevipes*
12. Plants medium to large; leaves more than 2 mm long; setae more than 15 mm long ..... 13

13. Plants medium size; branches up to 3 cm long ..... 14  
 13. Plant large size, forming tall tufts; branches more than 5 cm long ..... 16  
     14. Leaves horizontally spreading, broadly ovate, acuminate apex; at times falcate;  
        setae papillae, longer than 20 mm ..... 9. *A. hermaphroditum*  
     14. Leaves strongly cylind, acute apex or acuminate ..... 15  
 15. Leave ovate, with concave apex acute ..... 14. *A. secundum* var. *secundum*  
 15. Leaves broadly ovate, with long acuminate apex ..... 15. *A. secundum* var. *siamensis*  
     16. Branches erect, leaves spreading, broadly ovate, 2-2.2 mm long, less than 1 mm wide,  
        acuminate apex ..... 17. *A. stramineum*  
     16. Branches slender to cylindrical; leaves patent, ovate to widely ovate-lanceolate,  
        more than 2 cm long, strongly hamulous apex ..... 17  
 17. Branch slender, erect; leaves widely ovate..... 7. *A. hamulatum* var. *hamulatum*  
 17. Branch cylindrical; leaves ovate-lanceolate ..... 8. *A. hamulatum* var. *procumbens*

1. *Acroporium aciphyllum* Dixon, Bull. Torrey Bot. Club 51: 253. 1924. Fig. 1-6. — Type. Malay Peninsula. Pahang, G. Tahan, 7. 1911. *Ridley 1029* (lecto-, BM!); *ibid.*, *Ridley 1037* (syn-, BM!).

### Figure 5.3

*Plants* large, robust, soft, rarely woven patches, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches ascending up to 4 cm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, quiet straight on main stem, slightly falcate on branch, cylind, broadly ovate to ovate-lanceolate, 3.48-4.2 x 1.2-1.48 mm, recurved or roughly concave, strongly subulate pointed, abruptly piliform to subtubular, base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; laminal cells upper and median cells linear, 62.5-107.5 x 5-7.5  $\mu$ m, basal cells shorter, smooth, often strongly pitted; alar region consisting of one row of 5-6 inflated hyaline to yellowish brown cells, 137.5-187.5 x 32.5-45  $\mu$ m, coloured cells recurving inwards at base, outermost cell often hyaline; supra-alar cells 1 to 2 rows of small quadrate coloured cells.

*Autoicous*. *Perigonia* on branches. *Perichaetia* on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Setae* up to 2 cm long, slender and wiry, red, smooth. *Capsules* 1.0 x 0.6 mm, erect, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous; peristome double, hypnaceous.

Illustration. — Dixon 1924 (pl.4, fig. 9).

Thailand. — PENINSULA. Nakorn Sri Thamarat.

Distribution. — Malaysia (Peninsular), Philippines.

Ecology. — Epiphytic plant on tree trunks in evergreen forest, alt. 700-800 m.

Specimens examined.— TYPE. Gunong [Tahan, Pahang, July 1911, *Ridley 1029* (lacto-, BM); *Ridley 1018*, *1037* (syn-BM)]. PENINSULA. Nakorn Sri Thamarat: [Khao (Mt.) Luang, 7 Feb. 1966, *Touw 11977* (BM, L), 4 Aug. 2007, *Pollawatn 681*, *742* (BCU)].

Discussion. — Dixon (1924) selected specimens *Ridley 1017*, *1029* for holotype specimens of this species. Later, Tan (1944) has selected *Ridley 1029* as the lectotype and located the syntype by *Ridley 1039* including a non-cited specimen at BM (*Ridley 1018*) with the same locality and date information as *Ridley 1017*. The types of *A. aciphyllum* have mostly falcate leaves, but *Ridley 1037* represents the non-falcate leaf form. The study

of Thai specimens, leaves often smaller size than type specimen, but similar in all another characters.

2. *Acroporium brevipes* (Broth.) Broth., Nat. Pflanzenfam. (ed.2) 11: 437. 1925.

*Sematophyllum brevipes* Broth., Philipp. J. Sci. 8: 95. 1913.

**Figure 5.4**

*Plants* robust, golden, glossy, usually dense tufts. *Main stems* creeping or ascending branching regularly pinnately; branches erect, usually up to 1 cm long. *Leaves* dense, erectopatent (erect-squarrose cuspidate when dry), concave, ovate-lanceolate, 1.76-2 x 0.48-0.60 mm; apex acute, sharp cuspidate; margin faint denticulate at apical, sometime revolute on both margin near apex; ecostate; lamina cells linear to narrowly rhomboidal, 38-42 x 5  $\mu$ m at top, wall irregularly thickened, 62.5-87.5 x 5-8  $\mu$ m 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, 75-112.5 x 25-40  $\mu$ m.

*Autoecious*. *Sporophytes* on main stem. *Perichaetial leaves* narrow, erect, 0.92-1.52 mm. *Setae* slender, erect, up to 15 mm high. *Capsule* horizontal to nodding, ovate-cylindrical,  $\pm 1$  x 0.51 mm; peristome normal.

Illustration. — Gangulee 1980 (fig. 955).

Thailand. — NORTHERN. Phitsanulok; NORTHEASTERN. Loei; SOUTHEASTERN. Prachin Buri, Chanthaburi.

Distribution. — A Southeast Asiatic main land species.

Ecology. — Epiphytic plant on tree trunks and decaying wood or expose on humid rocks in evergreen forest, alt. 700-1300 m.

Specimens examined.— NORTHERN. Phitsanulok [Tung Salaeng Luang, 25 Jul. 1966, *LSmW* 907 (AAU, BM, L); Phu (Mt.) Miaeng, 28 Jul. 1966, *LSmW* 1039 (AAU)]; NORTHEASTERN. Loei [Phu (Mt.) Kradung, 7-9 Nov. 1970, *CLW* 5754 (NY), *CLW* 4756 (AAU); Thamsaw, 10 Mar. 1952, *Smitinand* 1114 (BKF)]; SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 7 Jul. 1966, *LSmW* 87 (AAU); Khao Yai National Park, 10 Jul. 1966, *LSmW* 226 (AAU); Khao Kaew, 4 Apr. 1965, *Tixier* 452, (P)]; Chanthaburi [Pong Namrawn, 18 Feb. 1959, *Smitinand* 5503 (BKF, L)].

Discussion. — Tan (1994) accepted this name for *Acroporium secundum* (Reinw. & Hornsch.) M. Fleisch. by the reason of its acute leaves. From this study, this name is still sited for this species because of the comparative characters between *Sematophyllum brevipes* Broth. (isotype, FH!) and *Leskea secundum* Reinw. & Hornsch. (type, FH!) showed differentiation of their leaf arrangement, leaf shape and sized (see in description of both species).

3. *Acroporium convolutifolium* Dixon, J. Siam Soc. Nat. Hist. Suppl.10: 21. 1935. —

Type: Puket. Takuapa, Kapong, 17 Feb., 1929, *Kerr* 417b (lecto-, BM!).

**Figure 5.5**

*Plants* small, glossy green, yellowish-green or golden, usually forming lax tufts. *Stems* reddish, long creeping with distally lateral branched; branches 5-10 mm long, suberect, densely foliate frequently cuspidate at tips; rhizoid few; central strand absent. *Leaves* in several ranks, patent when dry, narrowly ovate to ovate-lanceolate, 0.76-1 x 0.16-0.3 mm, apex long acuminate to subtubular; margin entire, minutely dentate at apex, usually enrolled from middle toward apical part; base auriculate, ecostate; lamina cells linear, 45-62.5 x 3-5  $\mu$ m, smooth, slightly thick walled at base, strongly papillose cells on upper

portion, usually 1-2 (-4) papillae per cell; alar region consist of one row, 3-4 cells, 50-75 x 25-30  $\mu\text{m}$ , inflated, hyaline, rarely colored, few supracellular with small rectangular cells.

*Sporophytes* not seen.

Illustration. — unknown.

Thailand. — PENINSULA. Phuket, Nakhon Si Thammarat, Songkla.

Distribution. — Endemic to Thailand.

Ecology. — On leaves of *Eugenia*, by stream in evergreen forest, alt. 100 m.

Specimens examined.— TYPE. Puket [Takuapa, Kapong, 17 Feb., 1929, *Kerr 417b* (lacto-, BM)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 26 Jun. 1953, *Ploenchit 585* (L)]; Songkla [Koa Keo, 27 Jul. 1928, *Kerr 319* (BM)].

4. *Acroporium convolutum* (Sande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4: 1276. 1923.

**Figure 5.6**

*Plants* medium, robust, soft, rarely woven patches, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; lateral branches up to 5 mm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. Leaves in several ranks, slightly falcate leaves, erect to cylind, ovate-lanceolate to lanceolate, 1.76-2.48 x 0.48-0.72 mm, broadest above the base, gradually narrow, apex long acuminate to subtubular, base usually auriculate; margin plane, entire slightly serrate and enrolled near apex; ecostate; laminal cells linear at median cells, 80-112.5 x 6-7.5  $\mu\text{m}$ , linear to rhomboidal near apex, basal cells shorter, thick walled, often pitted, unipapilla near apex; alar region consisting of one row of 4-5 inflated hyaline to yellowish brown cells or thick walled colored cells, 75-125 x 32.5-50  $\mu\text{m}$ , usually pellucid; supra-alar cells 1 row of small quadrate hyaline cells.

*Autoicous*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* red, smooth, up to 1.5 cm long, slender and wiry, recurve near apophyses. *Capsules* 1.0 x 0.6 mm, ovoid to elongate, slightly constricted under peristome base; exothecial cells collenchymatous; operculum form a conic base, long-rostrate, oblique; peristome double, normal.

Illustration. — Tan 1994 (figs. 10-13); Dozy & Molkenboer 1855-70 (tab. 315B, as *Hypnum convolutum*).

Thailand. — PENINSULA. Krabi.

Distribution. — Borneo, Java, Malay Peninsula, and Sumatra.

Ecology. — Epiphytic plant on branches, alt. 1.50 m.

Specimens examined.— TYPE: Borneo [Singawang, 10 April 1897, *J.B. Sedru s.n.* (lecto-, FH)]. PENINSULA. Krabi [24 Feb. 1928, *Kerr 371* (BM)].

Discussion. — The leaves of *A. convolutum* are mostly less than 2 mm long and broadest above the base, but not towards or at the base as in *A. downii* Tan (1994).

5. *Acroporium diminutum* (Brid.) M. Fleisch., Musci Fl. Buitenzorg 4: 1274, 1923. Fig. 22-25. *Dicranum diminutum* Brid., Bryol. Univ. 1: 814, 1826. — Type: Java, inter *Dicrani blunii* (not seen)

*Hypnum subulatum* Hampe, Icon. Musc. 9, 1844. *Acroporium subulatum* (Hampe) Dixon, J. Linn. Soc., Bot. 45: 508, 1922. — Type: Luzon, Manila, *Meyen* (holo-, BM; iso-, L!).

*Hypnum gracidicaule* Sande Lac., Bryol. Jav. 2: 214, 1869. — Type: Java, Mt. Salak, Kurz (Isolecto-, H-BR).

*Hypnum scabrellum* Sande Lac., Bryol. Jav. 2: 214, 1869. *Acroporium scabrellum* (Bosch & Sande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4: 1273, 1923. — Type: Sumatra, Korthals (lecto-L); Celebes (syn-, L).

### Figure 5.7

*Plants* very small, forming dense or loose mat, yellowish-green or golden. Stems densely branched; branches thin, linear to cylindrical, more than 5 mm long. *Leaves* often acicular and incurved when dry, oblong-lanceolate to lanceolate when moist, 1.08-1.20 x 0.16-0.20 mm; branch leaves smaller, erect-spreading, horizontally patent, occasionally incurved, rarely falcate; margins plane, weakly or slightly serrulate near apex; ecostate; laminal cells upper and median cells elongate, 20-75 x 5-7.5  $\mu\text{m}$ , basal cells shorter and wider, generally smooth, thick-walled, but a single row papilla may be developed on cells of some distal branch leaves; alar region consisting of one row of 2-4 inflated hyaline to yellowish brown cells, 50-62.5 x 25-32.5  $\mu\text{m}$ , thick walled; supra-alar cells 1 row of few small quadrate cells.

*Sporophytes* not seen.

Illustration. — Hampe 1844 (fig. 9 as *Hypnum subulatum*), Dozy & Molkenboer 1861-70 (t. 313 as *H. subulatum*, t. 314 as *H. gracilicaule*, t. 315 as *H. scabrellum*); Bartram 1939 (t. 25, fig. 422.), Tan 1944 (Fig. 22-25).

Thailand. — PENINSULA. Nakornsrihamarat, Chumporn.

Distribution. — China, Indonesia, Philippines and Moluccas Islands.

Ecology. — On decaying logs in evergreen forest, alt. 600-650 m.

Specimens examined.— TYPE. Indonesia [Manila, *Meyen s.n.*, (iso-, L)]. PENINSULA. Nakornsrihamarat [Khao Luang, 3 Feb. 1966, *Touw 11526* (AAU, BKF, BM, L)]; Chumporn [Khao Nom Sao, 24 Feb. 1927, *Kerr 199b* (BM).]

Discussion. — The detection of leaf cell papillae in *A. diminutum* is not easy. The small stature, finely branched habit, and the often acicular leaves when dry, are diagnostic. Under the microscope they are best observed along curved silhouettes of the tubulose branch leaves. Moreover, walls of the leaf cells are thick and slightly mamillate, creating what Dixon (1924) described as the “leaf rugulosity”. Bartram (1939) further distinguished the species by the production of setae from the main stem as opposed to other species where the sporophytes are often produced from the branches (Tan 1994). Tan (1994) discussed the polymorphism of this species and its morphological differences from the slightly larger *A. lamprophyllum*. While very common in Malesia, *A. diminutum* appears to be uncommon, in Thailand.

6. *Acroporium downii* (Dixon) Broth., Engler, Nat. Pflanzenfam., ed. 2, 11: 436. 1925.

Fig. 16-32. *Sematophyllum downii* Broth. ex Dixon, J. Linn. Soc., Bot. 43: 322. 1916.

*Trichosteleum downii* Broth. ex Dixon, J. Linn. Soc., Bot. 43: 322. 1916., nom. nud. in synon. — Type: Borneo, Sarawak, Matang, 1899, *St. V. Down* (iso-, H-BR!).

*Acroporium obscurum* Broth. ex Dixon, Bull. Torrey Bot. Club 51: 251, 1924.

*Sematophyllum obscurum* Broth. ex Dixon, Bull. Torrey Bot. Club 51: 251, 1924. nom. nud. in synon. — Type: Malay Peninsula, Johore, 1908, *Ridley s.n.* (Lecto-, BM; isolecto-H-BR); Borneo, Upper Sarawak, Oto Jungle, *Ridley*, ex herb. Mitten (syn-, BM).

*Acroporium albidissimum* Dixon, Bull. Torrey Bot. Club 51: 255, 1924. — Type: Malay Peninsula, Pahang, G. Tahan, *Ridley 1023b* (holo-, BM).

### Figure 5.8

*Plants* large, robust, usually forming tufts, glossy green, yellowish-green or golden. *Main Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches up to 2 cm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, mostly falcate, strongly second, narrowly triangular-lanceolate 1.5 – 3 x 0.3-0.4 mm wide, recurved or roughly concave, strongly subulate pointed, apex long acuminate to subtubular, base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; laminal cells upper and median cells linear-oblong, 75-125 x 5-7.5 µm, basal cells shorter, often strongly pitted, smooth or rarely unipapillose on upper part; alar region consisting of one row of 3-5 inflated yellowish-brown cells, 65-80 x 20-35 µm, coloured cells recurving inwards at base; supra-alar cells absent.

*Autoicous*. *Perigonia* on branches, perichaetia usually on stems, gradually taper into long flexuose and strongly toothed filiform points that are often as long as or considerably longer than the expanded laminal part, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* up to 2.5 cm long, slender and wiry, red, smooth. *Capsules* 1.0 x 0.6 mm, erect, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous; peristome double, normal.

Illustration. — Dixon 1916 (t.27, fig.17); Dixon 1924 (t.4, fig. 7 as *A. obscurum*, t.4, fig.13 as *A. albidissimum*); Tan 1994 (Figs. 26-32).

Thailand. PENINSULA. Nakornsrihamarat, Trang.

Distribution. — Malay Peninsula, Sumatra, Borneo.

Ecology. — On tree trunk near ground, in evergreen forest, alt. 700-1100 m.

Specimens examined.— TYPE. Borneo [Sarawak, Matang, 1899, *St. V. Down 14* (lacto-, BM)]. PENINSULA. Nakhon Si Thammarat, *Kerr 297b* (BM); Trang, *Kerr 536d* (BM);

Discussion. — Although the single leaf cell papilla in the present species is not as well developed as in *A. convolutum*, these two taxa are united by the similarity of their perichaetial leaf morphology. As noted and nicely illustrated by Dixon (1924), the perichaetial leaves of *A. obscurum* (= *A. downii*) gradually taper into long flexuose and strongly toothed filiform points that are often as long as or considerably longer than the expanded laminal part. In another critical species of *Acroporium downii*, its leaves are falcate-secund, but its papillose leaf cells would dissociate it from the *A. strepsiphyllosum/falcifolium* complex. In many ways, including the long tubulose leaf apices, *A. downii* looks like a papillose version of *A. johannis-winkleri*.

7. *Acroporium hamulatum* (M. Fleisch.) M. Fleisch. var. *hamulatum*, Musci Fl. Buitenzorg 4: 1294. 1923. *Sematophyllum hamulatum* M. Fleisch., Hedwigia 44: 316. 1905. — Type: West Java, am Gedeh bei Tjiburrum, Fleischer's Musci Frond. Archipel. Ind. 325 (lecto-, FH; isolecto-, H-BR!).

*Acroporium stramineum* var. *Hamulatum* (M. Fleisch.) B.C. Tan, Willdenowia 24: 285. 1994.

### Figure 5.9

*Plants* large, robust, rarely woven patches, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect;

irregularly pinnate branched; branches up to 8 cm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* densely in several ranks, erect or widely spreading, broadly ovate to ovate-lanceolate, 2.16-2.28 x 0.76-1 mm, usually minutely recurved at extreme apex or roughly concave, strongly hamulous apex, base usually auriculate; margin plane, entire slightly enrolled on upper part, slightly serrate to strongly spinose at apex; ecostate; laminal cells upper and median cells linear, 62.5-75 x 5-7  $\mu\text{m}$ , basal cells shorter, strongly pitted; alar region consisting of one row of 5-7 inflated hyaline to yellowish brown cells, 137.5-162.5 x 25-37.5  $\mu\text{m}$ , coloured cells recurving inwards at base; supra-alar cells 1 row of small elliptic cells.

*Dioicous*. *Perichaerial leaves* about 1.5 mm long, bluntly pointed, denticulate above. *Setae* 16 mm long, slightly pustulose above. *Capsules* inclined, urn barely 1 mm long (Bartram 1939).

Illustration. — Fleischer 1923 (fig.207); Bartram 1939 (t. 25, fig.430f); Tan 1994 (fig. 66-68).

Thailand. — PENINSULA. Nakorn Sri Thammarat.

Distribution. — Malaysia, Philippines.

Ecology. — On tree trunks in stunted mossy forest, along ridge of evergreen forest at alti. 1250-1740 m.

Specimens examined.— TYPE. Indonesia [West Java, 1650, 6 Jul. 1898, *Fleischer s.n.* (syn-, H-BR)]. PENINSULA. Nakorn Sri Thammarat: [Khao Luang, 5 Feb. 1966, *Touw 11639* (BKF, L), *Touw 11645* (AAU, NY), *Touw 11677*, *11736* (L), *Touw 11737* (AAU, BM, FH, L, NY), *Touw 11790* (BKF, BM, L), *Touw 11794* (AAU, BKF, BM, FH, L, NY), 6 Aug. 2007, *Pollawatn 645*, *672*, *684*, *695* (BCU)].

Discussion. — Other differences include the longer and more pendant habit of var. *hamulatum* with the stem reaching 5 cm length with relatively few short, lateral branches. Leaves of typical *A. hamulatum*, and even *A. hermaphroditum*, when closely examined, can also be seen to exhibit hamate leaf tips, albeit in various degrees of expression. The recurved leaf tip is rather a subtle character, but it can be demonstrated with careful examination. Although this species is similar in most respects to *A. hermaphroditum*, the dioicous inflorescence and the leaf tip seem to be good diagnostic characters.

8. *Acroporium hamulatum* var. *procumbens* (M. Fleisch.) Dixon, J. Siam Soc. Nat. Hist.

Supple.10: 22. 1935. *Acroporium hamulatum* fo. *procumbens* M. Fleisch. Musci Fl.

Buitenzorg 4: 1295. 1923.

**Figure 5.10**

*Plants* large, robust, soft, often woven patches, usually forming tufts, pendant, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches more than 12 cm long, suberect, slightly cylindrical, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, spreading, broadly ovate to ovate, 1.84-2.4 x 0.72-0.88 mm, recurved or roughly concave, often hamulous or subtubulate apex, base usually auriculate; margin plane, entire slightly spinose near apex; ecostate; laminal cells upper and median cells linear, 60-112.5 x 5-7.5  $\mu\text{m}$ , basal cells shorter, strongly pitted; alar region consisting of one row of 5-6 inflated yellowish brown cells, 100-150 x 30-37.5  $\mu\text{m}$  wide, thick walled cells recurving inwards at base; supra-alar cells 1 row of small elliptic hyaline cells.

*Sporophytes* not seen.

Illustration. — Unknown.

Thailand. — PENINSULA. Ranong, Surat Thani, Chumporn.

Distribution. — Java.

Ecology. — Epiphytic plant on tree trunks in evergreen forest, alt. 900-1600 m.

Specimens examined.— TYPE. Chumporn [Khao Nom Sao, 21 Feb. 1927, *Kerr 199a* (lacto-BM); 24 Feb. 1927, *Kerr 200* (syn-BM)]. PENINSULA. Ranong [Kerr 402 (BM); Surat Thani: *Kerr 199c*, 200, 223b (all in BM), 6 Aug. *Pollawatn 731*, 734 (BCU)].

Discussion. — This species is very similar to *A. stramineum* var. *hamulatum*. The diagnostic characters were differentiated in pendant and spreading habit with long thin flagellate branches.

9. *Acroporium hermaphroditum* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 4: 1292, 1923. *Hypnum hermaphroditum* Müll. Hal., Syn. Musc. Frond. 2: 388, 1851. — Type: Celebes, Mt. Klabat, *Reinwardt* (not seen).

#### Figure 5.11

*Plants* medium size, robust, in deep tufts, glossy, yellowish-green or golden. *Stems* short creeping then forming tall ascending to erect, up to 3 cm high; irregularly 1-2 pinnate branched; branches up to 1 cm long, suberect, rigid, densely foliate, sharply cuspidate tips; rhizoid few or absent; central strand absent. *Leaves* crowded, widely spreading in several ranks, broadly ovate to ovate-lanceolate, 1.92-2.12 x 0.6-0.96 mm, recurved or roughly concave, strongly subulate pointed, short acuminate to subtubular apex, base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; laminal cells upper and median cells linear, 62.5-95 x 5-7.5 µm wide, basal cells shorter, often strongly pitted; alar region consisting of one row of 5-6 inflated hyaline to yellowish brown cells, 112.5-150 x 12.5-42.5 µm wide, coloured cells recurving inwards at base; supra-alar cells 1 row of small quadrate coloured cells.

*Synocious*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* slender and wiry, red, pustulose above, up to 3 cm long. *Capsules* 1.0 x 0.6 mm, erect, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous; peristome double, normal.

Illustration. — Dozy & Molkenboer 1861-70 (t:305); Bartram 1939(t.25, fig. 428); Tan 1994 (fig. 18-21).

Thailand. — PENINSULA. Nakorn Sri Thammarat; SOUTHEASTERN. Prachin Buri.

Distribution. — Malaysia, Philippines, Borneo, Sumatra, Java, Celebes, Moluccas, New Caledonia, New Guinea.

Ecology. — On tree in evergreen forest, alt. 900-1600 m.

Specimens examined.— SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 04 Apr. 1965, *Tixier 419* (PC); 16 Feb. 1966, *Touw 12093* (BKF, L)]. PENINSULA. Nakorn Sri Thammarat [Khao Luang, 5 Feb. 1966, *Touw 1164* (AAU, BKF, L, NY); *Touw 11832* (AAU, BKF, L); *Touw 11698* (BKF, L), 6 Aug. 2007, *Pollawatn 641*, 652 (BCU)].

Discussion. — The synoecious inflorescence and the nearly horizontally spreading leaves render *A. hermaphroditum* most distinctive among the Malesian *Acroporium* species. To determine the synoecious sexual condition, only young perichaetia are useful mature perichaetia already with sporophytes often lost all anteridia. Perichaetial leaves of *A. hermaphroditum* have another unique feature: the lamina has only a short acumen or cusp, a condition uncommon in the genus. In general, the setae are long, measuring up to 3 cm.

10. *Acroporium johannis-winkleri* Broth., Inst. Allg. Bot. Hamburg 7: 133, 1928. Fig. 33-34. — Type: W Borneo, Bukit Mulu, *Hans Winkler 3054* (holo-, H-BR).  
*Acroporium longicuspis* Dixon, Bull. Tor. Bot. Club 51: 254. 4 f. 12. 1924.  
*Acroporium convolutum* var. *elatum* (Dixon) B.C. Tan, Willdenowia 24: 263. 1994.

**Figure 5.12**

*Plants* small, greenish brown, densely forming tuft, finely and highly branched. *Main stems* elongate, initially short creeping; branches erect, slightly curved, 5-7 mm long, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, densely, erectopate, often acicular when dry, slightly horizontal spreading, narrowly triangular to lanceolate, being broadest toward the base, 2.08-2.4 x 0.2-0.32 mm, margins plane, gradually tapered, tubulose and stiff, bristly apex; ecostate; laminal cells elongate, 50-87.5 x 5-7.5  $\mu\text{m}$ , smooth, thick-walled, without papilla, at base middle such cells are smooth and seem a radiate towards margins; alar cells consisting of one row of 3-4 inflated hyaline to yellowish brown cells hyaline, incrassate, lowest row large, rectangular, 75-87.5 x 25-42.5  $\mu\text{m}$ , supra-alar cells 1 to 2 rows of small and irregular hyaline cells above.

*Autoicous*. *Sporophytes* on main stem, smaller and irregular shaped above. *Perichaetial leaves* erect, lanceolate, abruptly narrowed, long, slightly entire acuminate. *Seta* erect, red, smooth below and pustulose distally above, 1.5 to 3 cm long; capsule inclined to horizontal, ovate, 1.2-1.4 x 0.6 mm; exothecial cells collenchymatous; operculum short-rostrate; peristome normal, double; exostome teeth 250-270 x 65-75  $\mu\text{m}$  at base, bordered, horizontally striped below; endostome basal membrane high, segments hyaline, as long as exostome, not split. *Spores* 18-24  $\mu\text{m}$  in diameter.

Illustration. — Tan 1994 (fig. 33-34).

Thailand. — PENINSULA. Nakornsrihammarat.

Distribution. — Borneo, Malaysia.

Ecology. — The species is widespread in evergreen forest along stream on branches with a broad altitudinal range from 700 to more than 2000 m.

Specimens examined.— PENINSULA. Nakornsrihammarat [Khao Luang, 7 Feb. 1966, *Touw 12001* (L)].

Discussion.— The species was unjustly reduced to a synonym of *A. longicuspis* by Dixon (1935). The latter has a different leaf outline and possesses papillose leaf cells. Leaves of *A. johannis-winkleri* are 1.5 to 3 mm long and pustulose distally. In many ways, *A. johannis-winkleri* looks like large individuals of *A. diminutum* forming a loose tuft. The only other species that may be confused with it is *A. rigens*, which is a much bigger plant.

Occasionally, atypical specimens of *A. sigmatodontium* with small and slightly falcate leaves may come close to *A. johannis-winkleri*. But the former is synoecious and has shorter setae, less than 1.5 cm long.

11. *Acroporium lamprophyllum* Mitt., J. Linn. Soc. Bot. 10: 183. 1868. *Trichosteleum lamprophyllum* (Mitt.) W.R. Buck, Brittonia 35: 310. 1983. — Type: Samoa, Upolu, *Powell 114* (holo-, NY).  
*Hypnum braunii* Müll. Hal. var. *oxyporum* Bosch & Sande Lac., Bryol. Jav. 2: 212. 1869.  
*Acroporium oxyporum* (Bosch & Sande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4: 1289. 1923. — Type: Java, Mt. Pangerango, *Junghuhn* (lecto-, L); Mt. Salak, *Kurz* (syn-, L).

*Sematophyllum punctuliferum* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 318. 1873.  
*Acroporium punctuliferum* (Thwaites & Mitt.) M. Fleisch., Musci Fl. Buitenzorg 4:  
 1274. 1923. — Type: Ceylon, *Thwaites s.n.* (holo-, NY).

**Figure 5.13**

*Plants* small, golden-green, slightly glossy, in dense mats. *Stems* creeping, prostrate, irregularly branched; branches up to 10 mm long, procumbent or suberect, with numerous perpendicular slender shoots. *Leaves* erect, often patent, narrowly lanceolate, 1.25-1.6 x 0.3-0.56 mm, more erect spreading below, slender, terminal shoot gradually long acuminate, concave, subtubulose, minutely denticulate near apex, margins entire, involute above; ecostate; laminal cells oblong-lanceolate, 32-55 x 5-7.5  $\mu\text{m}$ , thin- to thick-walled, not pitted, unipapillose at back; alar region consisting of one row of 3-4 inflated hyaline to yellowish brown cells, 60-75 x 20-25  $\mu\text{m}$ , slightly thick walled cells, recurved inwards at base; supra-alar cells 1 to 2 rows of small quadrate colorless cells.

*Dioicous*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* slender and wiry, red, smooth, up to 2 cm long. *Capsules* 0.8-1 x 0.3-0.5 mm, erect, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous; peristome double, nomal

Illustration. — Fleischer 1923 (fig. 206); Bartram 1939 (fig. 423); Touw 1999 (fig. 42-46).

Thailand. — NORTHERN. Tak; SOUTHEASTERN. Prachin Buri; PENINSULA. Phuket, Nakorn Sri Thammarat

Distribution. — China, Kampuchea, Laos, Vietnam, Malaysia, Sri Lanka, Philippines, and Australia.

Ecology. — On tree trunks along stream in moist evergreen forest, alt. 700-1700 m.

Specimens examined.— NORTHERN. Tak: [Doi Musae, 9 Nov. 1965, *Touw 8130* (AAU, BKF, L), *Touw 8377* (L)]; SOUTHEASTERN. Prachin Buri: [Khao Yai National Park, 18 Feb. 1966, *Touw 12291* (AAU, BKF, L), *Touw 12332* (BKF, FH, L, NY)]; PENINSULA. Phuket: [Thalang, Khao Phrara, 25 Jan. 1966, *Touw 11226* (BKF, L)]; Nakorn Sri Thammarat: [Khao Luang, 5 Feb. 1966, *Touw 11873*, *11875* (L), *Touw 11923* (AAU), 5 Aug. 2006, *Pollawatn 684*, *686*, *696*, *710* (BCU)].

Discussion. — This is a distinctive species characterised by slender habit. The oblong leaves with an acuminate apex are erect spreading or falcate, at times being homomallous on some branches. Only *A. dimidutum* and *A. lamprophyllum* produce perichaetia and saetae from primary stems; in other species, perichaetia and saetae are borne on secondary stems and branches.

12. *Acroporium laosianum* (Broth. & Paris) Broth., Nat. Pflanzenfam. (ed.2) (11): 437. 1925. *Sematophyllum laosianum* Broth. & Paris, Rev. Bryol. 35: 53. 1908.

*Stereodon planifrons* Broth. & Paris, Bulletin de l'Herbier Boissier, sér. 2, 2: 991. 1902.

*Hypnum planifrons* (Broth. & Paris) Cardot, 1905. *Glossadelphus planifrons* (Broth. & Paris) M. Fleisch., Musci Fl. Buitenzorg 4: 1357. 1923. *Isopterygium planifrons* (Broth. & Paris) Sakurai, 1940.

**Figure 5.14**

*Plants* medium, robust, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches up to 7 mm long, 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, 1.68-1.96 x 0.52-0.76 mm, recurved or roughly concave, strongly subulate pointed, apex acute to acuminate to subtubular, base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; laminal cells upper and median cells linear to oblong, 50-75 x 5-7.5  $\mu\text{m}$ , basal cells shorter, smooth, often strongly pitted near base; alar region consisting of one row of 3-4 inflated hyaline to yellowish brown cells, 62.5-100 x 32.5-50  $\mu\text{m}$ , coloured cells recurving inwards at base; supra-alar cells 1 row of small quadrate coloured cells.

*Autoicous*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Setae* up to 1.5 cm long, slender and wiry, red, smooth. *Capsules* 0.6-1.0 x 0.5 mm, erect, ovoid to elongate or elongate-cylindric, apophyses short; exothecial cells collenchymatous; operculum from a conic base, long-rostrate, up to 5 mm, oblique; peristome double; peristome double, normal. *Spores* 18-24  $\mu\text{m}$  in diameter, sometimes varying in size, yellowish green, spherical, finely papillose.

Illustration. — unknown.

Thailand. — NORTHERN. Phitsanulok; NORTHEASTERN. Loei; EASTERN. Chiyaphum; SOUTHEASTERN. Prachin Buri.

Distribution. — Laos, Vietnam, Indonesia.

Ecology. — On tree trunks or felled trees along revulet in hill evergreen forest, alt. 700-1400 m.

Specimens examined.— TYPE. Laos [Tranninh, 1500 m., Mar. 1909, *W. Miboliz s.n.* (lacto, FH)]. NORTHERN. Phitsanulok: [Thung Salang Luang, 5 Jul. 1965, *Tixier 1089* (BKF); Phu Mieng, 5 Nov. 1965, *Tixier 911* (PC)]; NORTHEASTERN. Loei: [Phu Luang, 8 Jan. 1966, *Touw 10525* (AAU, BKF, BM, FH, L, NY), *Touw 10559*, *10677* (AAU, BKF, BM, L), 9 Jan. 1966, *Touw 10677* (AAU, BKF, BM, L), 10 Jan. 1966, *Touw 10752* (L); Phu Krading, 14 Jan. 1966, *Touw 10884*, *10914* (L), *Touw 10960* (AAU, BKF, BM, L), *Touw 10963* (BKF, BM, L), 15 Jan. 1966, *Touw 11013* (L)]; EASTERN. Chiyaphum: [Phu Khieo, 22 Feb. 1931, *Kerr m583* (BM)]; SOUTHEASTERN. Prachin Buri: [Khao Yai National Park, 16 Feb. 1966, *Touw 12047* (BKF, L), *Touw 12094* (AAU, BKF, BM, L), *Touw 12115*, *12137* (BKF, L), *Touw 12436* (L), 18 Jan. 1966, *Touw 12238* (BKF, BM, L), *Touw 12282* (AAU, BKF, BM, L), *Touw 12376* (L), 2 Sept. 2007, *Pollawatn 329* (BCU)].

Discussion. — Plants similar to *A. breviense* in leaf shaped and sized, but plants is more smaller than the former. This species has narrower and leaves cells smooth, while the former leaves more wider and sometimes found cells papillose on upper part.

13. *Acroporium rufum* (Reinw. & Hornsch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1672 (1923). Fig. 53-59. *Leskea rufa* Reinw. & Hornsch., Nova Acta Phys.-Med. Acad. Caes. Leop. Carol. Nat. Cur. 14: 716. 1828. — Type: Java, Malabaria (not seen). *Hypnum braunii* Müll. Hal. Syn. Musc. Frond. 2: 687. 1851. *Acroporium braunii* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 4: 1278. 1923. — Type: Java, Blume [as *Leskea secunda* Herb. Al (expander) Br (aun)] (not seen). *Sematophyllum strepsiphyllum* var. *minus* Renauld & Cardot, Rev. Bryol. 23: 105. 1896. *Acroporium secundum* var. *minus* (Renauld & Cardot) M. Fleisch., Musci Fl. Buitenzorg 4: 1286. 1923. — Type: Java, Tjibodas, 1899, Massart 1415 ex parte (holo-, PC).

*Acroporium braunii* var. *falcatulum* M. Fleisch., Musci Fl. Buitenzorg 4: 1280. 1923.  
*Acroporium falcatulum* M. Fleisch., J. Linn. Soc., Bot. 43: 322. 1916, nom. nud. —  
 Type: W java, am Gedah bei Kadang-Baddak, Fleischer's Musci Frond. Archipel.  
*Indici* 492 (holo-, FH; iso-, H-BR).

*Acroporium braunii* var. *densum* M. Fleisch., Musci Fl. Buitenzorg 4: 1280. 1923. — Type:  
 W Java, am Gedeh bei Kadang-Badak, Fleischer's Musci Frond. Archipel. *Indici* 321  
 (holo-, FH; iso-, H-BR)

### Figure 5.15

*Plants* medium, robust, rarely woven patches, usually forming tufts or dense mats, glossy green, yellowish-green or golden. *Stems* short creeping, densely branched, elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches up to 1 cm long, suberect, with homomallous foliation at tips; rhizoid few or absent; central strand absent. *Leaves* erect-spreading in several ranks, strongly falcate-secund, oblong-lanceolate, 1.56–1.72 x 0.24–0.32 mm; acuminate apex, margins plane, entire, strongly incurved near apex, slightly broadest upper base; ecostate; laminal cells narrowly, elongate, thick walled, upper and median cells linear, 62.5–100 x 5–7.5  $\mu\text{m}$ , basal cells shorter, smooth, slightly pitted; alar region strongly inflated, thick walled, 3–4 cells in one row, 75–100 x 20–37.5  $\mu\text{m}$ , coloured cells recurving inwards at base; supra-alar cells few, 1 to 2 rows of small quadrate hyaline cells.

*Dioicous* and *pseudoautoicous*. *Sporophyte* borne on secondary stems and ultimate branches. *Perichaetial leaves* broadly ovate, abruptly narrowed to a short acuminate apex, strongly toothed above. *Setae* slender, 1.5–2 cm long, strongly papillose above. *Capsules* small, slightly inclined (Bartram 1939).

Illustration.— Dozy & Molkenboer 1861–70 (t. 312 as *Hypnum braunii*); Bartram 1939 (t. 25, fig. 424 as *A. braunii*).

Thailand. — PENINSULA. Nakorn Sri Thammarat.

Distribution.— China, Malaysia, Indonesia, Celebes, Borneo, and Philippines.

Ecology.— Epiphytic plant on tree in mossy forest at altitude 1740 m above sea level.

Specimens examined.— PENINSULA. Nakorn Sri Thammarat: [Khao Luang, 5 Feb. 1966, A. Touw 11795 (BKF, BM, L)].

Note. — This species is reported as new recorded to Thailand. Specimen from Thailand not found sporophyte, reported by follow Bartram (1939). The specimens from Thailand were identified as *Acroporium secundum*. The former has broadly ovate-lanceolate leaves with short acute apices. The setae of *A. secundum*, mostly less than 1.5 mm long, are shorter than those of *A. rufum*, and are only pustulose distally. In addition, leave of *A. secundum* are not strongly falcate-secund or homomallous as *A. rufum*.

As stated in Tan (1994), small individuals of *A. strepsiphyllum* may be confused with *A. rufum*. Both have a falcate-secund leaf orientation, but the leaves of the former have long acuminate apices in contrast with the short acuminate apices of *A. rufum*. The type of *A. secundum* var. *minus* is conspecific with *A. rufum*. Further more, some large specimens of *A. diminutum* (the 'scabrellum facies') may look like *A. rufum*. Give these circumstances, *A. rufum* is best identified by its non-bristly looking and non-papillose leaves. Leaves of *A. diminutum* are rarely falcate even when dry.

14. *Acroporium secundum* (Reinw. & Hornsch.) Fleisch. var. *secundum*, Musci Buitenzorg 4: 1283. 1923. *Leskea secunda* Reinw. & Hornsch., Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 14(2) (Suppl.): 717. 1829. — Type: Indonesia. Java, (FH!).

*Acroporium suzukii* Sak., Bot. Mag. (Tokyo) 46: 504. 1932.

**Figure 5.16**

*Plants* large, robust, usually forming dense tufts, glossy green, yellowish-green or golden. *Stems* creeping or ascending densely branched, irregularly pinnate; branches erect, usually up to 2.5 cm long, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* dense, erectopatent (erect-squarrose cuspidate when dry), strongly second, ovate-lanceolate, 1.76-2.88 x 0.48-0.8 mm, recurved or roughly concave, acute to shortly acuminate apex, base usually auriculate; margin faint denticulate on top, sometime revolute on both near apex; ecostate; laminal cells upper and median cells linear to rhomboid, 75-112.5 x 5-10  $\mu\text{m}$ , gradually shorter near extreme base, smooth, irregularly thickened wall at top, usually porose in lower leaf; alar region consisting of one row of 4-5 cells curved oblong, inflated hyaline to yellowish brown cells, 112.5-162.5 x 37.5-50  $\mu\text{m}$ .; supra-alar cells 1 rows of small quadrate hyaline cells.

*Dioicous*. *Perigonia* on branches, *Perichaetial leaves* erect, broadly ovate, 0.92-1.52 x 0.5-0.8 mm, abruptly constricted into a long acuminate apex, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, smooth and naked. *Sporophytes* on main stem. *Setae* erect, slender and wiry, red, smooth, up to 2 cm high. *Capsules* small, ovoid, horizontal to nodding, ovate-cylindrical, 0.8-1.2 x 0.5-0.6 mm, apophyses short; exothecial cells collenchymatous; operculum form a conic base, long-rostrate, oblique; peristome double. *Spores* large, sometimes varying in size, yellowish green, spherical, finely papillose.

Illustrations. — Bartram 1939 (Pl.25, fig. 425, 433 as *Acroporium brevipes*); Jia et al 2005 (Pl.592, fig.1-15).

Thailand. — PENINSULA: Chuporn, Patalung, Trang.

Distribution. — China, Japan, Kampuchae, Laos, Vietnam, Malay Peninsula, Indonesia, and the Philippines.

Ecology. — on tree trunks; 1200-1400 m.

Specimens examined.— TYPE. Java [*Fleischer* ! as *Leskea secunda* Reinw. & Hornsch. (lecto-, FH)]; Philippines [Luzon, May 1911, *Merrill* 7865 as *Sematophyllum brevipes* Broth. (Iso-FH)]; PENINSULA. Chumporn [Kao (Mt.) Nom Sao, Langsuan, 24 Feb. 1927, *Kerr* 199a (BM)]; Patalung [Kao (Mt.) Pauta Luang Keo, 01 Feb. 1919, *Kerr* m412 (BM)]; Trang [Kao (Mt.) Kuap, 16 Dec. 1929, *Kerr* m431 (BM)].

Discussion. — *A. secundum* is better known in the literature by its synonym, *A. brevipes*. The isotype of *A. brevipes* preserved at FH has more oblong leaves with more acuminate leaf apex than the average specimens of *A. secundum*. However, the presence of many intermediate specimens has prompted a concept their synonymy. In a regional monograph, Tan (1994) clarified further the past confusion that existed in the species concept of *A. secundum* which was for a long while misapplied by many workers to specimens that should be called *A. strepsiphyllum*.

15. *Acroporium secundum* var. *siamense* Dixon, J. Siam Soc., Nat. Hist. Suppl. 10(1): 22. 1935.

**Figure 5.17**

*Plants* large, robust, soft, usually forming tufts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched, branches up to 5 cm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, mostly falcate leaves, strongly second, broadly ovate to ovate-lanceolate, 2.0-2.4 mm long, 0.68-0.8 mm

wide, recurved or roughly concave, strongly subulate pointed, apex long acuminate to subtubular, base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; laminal cells upper and median cells linear, 75-100 x 37.5-50  $\mu\text{m}$ , basal cells shorter, smooth, often strongly pitted; alar region consisting of one row of 4-6 inflated hyaline to yellowish brown cells, 100-137.5 x 37.5-50  $\mu\text{m}$ , coloured cells recurving inwards at base; supra-alar cells none to 1 rows of small quadrate coloured cells.

*Autoicous*. *Perigonia* on branches, perichaetia on stems or branches, inner perichaetia leaves erect, sheathing at base, abruptly or gradually long pointed, apices serrulate, alar cells not strongly developed. *Calyptrae* cucullate, up to 2.5 mm long, smooth and naked. *Setae* 1.8- 2 cm long, slender and wiry, red, smooth below, slightly papillae above. *Capsules* 1.0 x 0.6 mm, erect, elongate or elongate-cylindric to funnel, apophyses short; exothecial cells collenchymatous; operculum form a conic base, long-rostrate, up to 1.5 mm long, oblique; peristome double, normal. *Spores* 18-24  $\mu\text{m}$ , sometimes varying in size, yellowish green, spherical, finely papillose,

Illustration. — unknown.

Thailand. — PENINSULA: Ranuang, Pangnga, Trang.

Distribution. — Endemic to Thailand.

Ecology. — Epiphytic plants on trees and shrubs in evergreen forest, alt. 700-1000 m.

Specimens examined.— TYPE. Ranuang [Khao (Mt.) Pauta Chong Dong, 20 Jan. 1929, *Kerr 400b* (Syn-, BM)]; Pangnga [Khao (Mt.) Kata Kwan, 8 Mar. 1930, *Kerr m490, m491* (Syn-, BM)]; Trang [Khao (Mt.) Soi Dao, 29 Apr. 1930, *Kerr 536b* (Syn-, BM)]

Discussion. — This diagnostic characters that separated this variety from *A. secundum* var. *secundum* by it has bigger sized of plant with more irregularly pinnate branches. Leaf has more widely base and apiecs slightly lanceolate secund.

16. *Acroporium sigmatodontium* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 4: 1281. 1923. Fig.88-90. *Hypnum sigmatodontium* Müll. Hal., Syn. Musc. Frond. 2:687. 1851. — Type: Java, *Blume*, Herb. Al [exander] Braum (not seen).  
*Acroporium balwinii* (Paris) Broth. in Engler, Nat. Pflanzenfam., ed. 2, 11: 436.1925. *Sematophyllum balwinii* Paris, Index Bryol. 1163. 1898.  
*Acroporium fusco-flavum* (Müll. Hal.) Broth. var. *baldwinii* (Paris) E. B. Bartram, Bernice P. Bishop Mus. Bull. 101: 235. 1933. *Pungentella balwinii* Müll. Hal., Flora 82: 471. 1896, nom. inval. — Type: Hawaii, western Maui, *Baldwin 1875* (syn-, FH).  
*Acroporium sigmatodontium* var. *robinsonii* (Broth.) E. B. Bartram, Philipp. J. Sci. 68: 334. 1939. *Sematophyllum robinsonii* Broth., Philipp. J. Sci., C, 8: 95. 1913. — Type: Philippines, Luzon, Mt. Banahao, *Robinson (Bur. Sci. 9800)* (holo-,H-BR).  
*Acroporium sigmatodontium* var. *brachypodum* Dixon ex Broth. in Phillip. J. Sci. 68: 35. 1939. *Acroporium brachypodum* Dixon ex Broth. in Philipp. J. Sci. 68: 335. 1939, nom. nud. in syn. — Type: Philippines, Luzon, Laguna Prov., Mt. Makiling, *Herklots 321* (holo-, FH).

### Figure 5.18

*Plants* medium-sized, rather slender in dense tufts, the synoicous buds are abundant, golden-green, glossy. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate and densely branched; branches ascending up to 4 cm long, suberect, rigid, densely foliate frequently cuspidate and more or less curved at tips; rhizoid few or absent; central strand absent. *Leaves* densely in several ranks, widely flexuose-spreading, slightly second, ovate-lanceolate, slender and sharply acuminate, 1.4- 2.1 x 0.56-0.72 mm, recurved or roughly concave, strongly subulate pointed, abruptly piliform to subtubular,

base usually auriculate; margin plane, entire slightly enrolled near apex; ecostate; lamina cells are linear, 75-112.5 x 5-7.5  $\mu\text{m}$ , basal cells shorter, smooth, often thick walled to strongly pitted, upper leaf cells rarely papillose; alar region consisting of one row of 4-5 inflated hyaline to yellowish brown cells, 80-162.5 x 25-40  $\mu\text{m}$ , cells are mostly colored except for the outermost one on each side of the leaf; supra-alar cells few to 1 row of small quadrate hyaline cells.

*Autoecious*. *Perigonia* on branches; perichaetia on stems or branches, perichaetial leaves broadly, base expanded which abruptly contract into a short to long cuspidate tip, margins toothed. *Calyptrae* cucullate, smooth and naked. *Setae* up to 15 mm long, slender and wiry, red, smooth. *Capsules* 1.0 x 0.6 mm, erect, ovoid to elongate, apophyses short; exothecial cells collenchymatous; operculum form a conic base, long-rostrate, oblique; peristome double.

Illustration. — Dozy & Molkenboer 1861-70 (t. 311); Bartram 1939 (t. 25, fig. 427).

Thailand.— PENINSULA: Nakorn Sri Thammarat.

Distribution. — Indochina, Malesia, Hawaii, Ceylon, Sumatra, Java, New Guinea, Tahiti and Philippine.

Ecology. — This species is widespread pantropical moss, occurring commonly on branches at 900-1300 m in rain forests.

Specimens examined.— PENINSULA. Nakorn Sri Thammarat: [Kaho Luang, 5 Feb. 1966, *Touw 11833* (BM, L), *Touw 11853* (BM), *Touw 11799B* (BKF, L), *Touw 11726*, *11797* (AAU, BKF, L), 5 Aug. 2007, *Pollawatn 704*, *709*, *726* (BCU).

Discussion.— Without inflorescences, *A. sigmatodontium* is difficult to separate from *A. strepsiphyllum*. Fortunately, the synoecious buds are abundant in most collections of *A. sigmatodontium*. As a secondary distinguishing character, the leaves of *A. sigmatodontium* are far more widely flexuose-spreading than the leaves of *A. strepsiphyllum*, which are mainly imbricate and falcate. Perichaetial leaves of *A. sigmatodontium* have a broadly expanded base which abruptly contract into a short to long cuspidate tip, margins are toothed. In the Malesian region *A. sigmatodontium* is a slender plant never reaching the stout sized of *A. strepsiphyllum*.

17. *Acroporium stramineum* (Reinw. & Hornsch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1301. 1923. *Leskea straminea* Reinw. & Hornsch., in Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. 14: 717. 1828. — Type: Java, Mt. Gedé; Celebes, Mt. Klabad (not seen).

*Hypnum hyalinum* Reinw. ex Schwägr., Spec. Musc. Frond. Suppl. 3(1): t. 227b, 1828.

*Hypnum hyalinum* Reinw., Nova Acta Phys.-Med. Acad. Leop.-Carol. 14: 730, 1829, nom. Illeg. *Acroporium hyalinum* (Reinw. ex Schwägr.) Mitt., J. Linn. Soc., Bot. 10: 183, 1868. — Type: Java, Mt. Gedé, *Reinwardt*; Celebes, Mt. Klabad, *Reinwardt* (not seen).

*Hypnum gedeanum* Müll. Hal., Syn. Musc. Frond. 2: 390, 1851. — Type: Java, Mt. Gedé, *Reinwardt*, ex Herb. Gottsche (not seen).

*Hypnum monoicum* Sande Lac., Bryol. Jav. 2: 207, 1869. *Acroporium monoicum* (Sande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4: 1287. 1923. — Type: Java, Mt. Pangerango, *Junghuhn* (lecto-, L; isolecto- BM); Mt. Salak, *Zollinger* (syn-, L; BM); Sumayra, *Korthals* (syn-, L); Java, *Korthals* (syn-, not seen).

*Sematophyllum lepinei* Besch., Ann. Sci. Nat., Bot., ser. 7, 20: 48, 1894. *Acroporium lepinei* (Besch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1303, 1923. — Type: Tahiti, Tairapu, *Lepine 15* (lecto-BM!); *ibid.*, *Vesco* (syn-, BM); *ibid.*, *Ribourt* (syn-, BM); *ibid.*, *Nadeaud 87* (syn-, BM).

*Sematophyllum macrotis* Paris, Index Bryol. 1167, 1898, nom. nud. Type: Philippines, Luzon, Sorsogon, Irosin, *Elmer 16298* (lecto-, H-BR).

*Sematophyllum pinnatum* M. Fleisch., Hedwigia 44: 320, 1905. *Acroporium pinnatum* (M. Fleisch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1298, 1923. — Type: W. Java, am Gedeh auf dem Pangerangogipfel, Fleischer's Musci Frond. Archipel. *Indici 327* (holo-, FH; iso-, H-BR).

*Acroporium hyalinoblastum* M. Fleisch., nom. Nud., Fleischer's Musci Frond. Archipel. *Indici 396*, 1905. — Original specimen: Borneo, Kenepei, Teysmann (FH, PC).

*Sematophyllum batanense* Broth., Philipp. J. Sci., C, 8: 96, 1913. — Type: Philippines, Batanes Is., 1907, *Fenix* (Bur. Sci. 3856) (holo-, H-BR!).

### Figure 5.19

*Plants* medium- sized, robust, forming interwoven mats or patches, glossy, yellowish to golden-green creeping. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched; branches complanate, prostrate or ascending, 1-3 cm long, densely arranged; rhizoid few or absent; central strand absent. *Leaves* erect-spreading, usually falcate near branch apices, 1.5-2.2 mm x 0.5-0.8 mm, often falcate towards apex, apical group imbricate-cuspidate, broadly ovate to ovate-lanceolate, concave, apex acute to very short acuminate, subtubulose above, margin entire above, at base strongly cordate-auriculate; ecostate; laminal cells linear, 55-87.5 x 5-7.5  $\mu\text{m}$ , thick-walled, strongly incrassate, pitted, gradually becoming shorter at apex and at base, some upper cells unipapillose; alar region well differentiated with 3-5 enlarged, 65-75 x 15-20  $\mu\text{m}$ , coloured, often thick-walled, except the outermost row, outer ones often curved inwards towards stem; basal cells across insertion orange; supra-alar cells reare or 1 to 2 rows of small quadrate coloured cells.

*Autoicous*. *Periginia* on branches; *perichaetia* usually on secondary stems, inner perichaetial leaves serrate, broadly shouldered, gradually constricted into a short or long acuminate apex. *Calyptrae* cucullate, smooth and naked. *Setae* slender and wiry, red, minutely papillae above, vary from 15 to 25 (-30) mm length. *Capsules* 0.8-1.0 x 0.5 mm, erect, ovoid to elongate or elongate-cylindric; exothecial cells strongly collenchymatous; operculum form a conic base, long rostrate, oblique; peristome well developed, exostome teeth striate below, papillose above; endostome segments finely papillose, segments as high as the teeth, keeled, yellowish; basal membrane high; cilia simple, short, sometimes reduced. *Spores* 10-15  $\mu\text{m}$ ., spherical, finely papillose.

Illustration. — Reinwardt & Hornschuch 1829 (t. 40, fig.a); Schwägrichen 1828 (t.227b as *Hypnum hyalinum*); Dozy & Molkenboer 1861-70 (t. 304 as *Hypnum hyalinum*, t. 306 as *Hypnum monoicum*, t. 307 as *Hypnum gedeanum*); Bartram 1939 (t. 25, fig. 431); Whittier 1976 (fig. 90).

Ecology. — On tree trunks; alt. 500-810 m.

Thailand. — SOUTHEASTERN. Chantaburi.

Distribution. — China, Kampuchae, Laos, Vietnam, Malaysia, Sri Lanka, and the Philippines.

Specimens examined.— TYPE. Philippines [Batanes Island, May-Jun. 1907, *Fenix* – Bur. Sci. 3856 (holo-, H-BR)]; SOUTHEASTERN. Chantaburi: [Pong Nam Rawn, Khao Nam Khieo, 18 Feb. 1959, *Smitinand 5505* (BKF)].

Discussion. — True to Bartram's observation (1939), "the short acuminate, erect-spreading leaves, not or very slightly second and not conspicuously cuspidate in the comal tufts" best establish the identity of *A. stramineum*. In many ways, *A. stramineum* appears like a slender version of *A. hermarphroditum* with longer leaf apices. It is also similar to large specimens of *A. secundum* with long, scabrous seta. Plant size, lengths of stem and branch leaf apices, as well as leaf orientation can vary greatly in *A. stramineum*. Perichaetial leaves of *A. stramineum* have a strongly toothed shoulder and an abruptly constricted short or long acumen.

18. *Acroporium strepsiphylum* (Mont.) B. C. Tan in Touw, J. Hattori Bot. Lab. 71: 353. 1992. *Hypnum strepsiphylum* Mont. var. *densum* Sande Lac., Bryol. Jav. 2 :210, 1869. *Acroporium secundum* (Reinw. & Hornsch.) M. Fleisch. var. *densum* (Lande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4 : 1285, 1923. — Type: Java, *Korthals* (syn-, H-BR!).  
*Hypnum alto-pungens* Müll. Hal., Linnaea 37: 179, 1872. *Acroporium alto-pungens* (Müll. Hal.) Broth. in Engler, Nat. Pflanzenfam., ed. 2, 11: 437, 1925. — Type: Philippines, ex Manila, 1870, *G. Wallis* (iso-, H-BR).  
*Sematophyllum falcifolium* Fleisch., Hedwigia 44: 318, 1905. *Acroporium falcifolium* (Fleisch.) Fleisch., Musci Fl. Buitenzorg 4: 1296. f. 208. 1923. — Type: W Java, Tjibodas, *Fleischer's Musci Frond. Archipel. Indici 327* (holo-, FH!; iso-, H-BR!).  
*Sematophyllum tubulosum* Broth., Philipp. J. Sci., C, 8: 94, 1913. — Type: Philippines, Negros, Mt. Canlaon, *Merrill 6819* (lecto-, H-BR); *ibid.*, *Merrill 6826* (syn-, FH; H-BR).  
*Acroporium secundum* (Reinw. & Hornsch.) M. Fleisch. var. *angustifolium* M. Fleisch., Musci Fl. Buitenzorg 4: 1285, 1923. — Type: W Java, am Gedeh bei Tjiburrun, *Fleischer's Frond. Archipel. Indici 323* (holo-, FH; iso-, H-BR).

#### Figure 5.20

*Plants* small to large, irregularly branched, forming loose mats or wefts, glossy green, yellowish-green or golden. *Stems* elongate, initially short creeping then ascending to erect; irregularly pinnate branched, branches ascending up to 4 cm long, suberect, rigid, densely foliate frequently cuspidate at tips; rhizoid few or absent; central strand absent. *Leaves* in several ranks, quiet straight on main stem, slightly falcate on branch, secund, broadly ovate to ovate-lanceolate, 2.0-2.8 x 0.28-0.52 mm, recurved or roughly concave, widest near base, strongly subulate pointed, usually auriculate; margin plane entire at base, slightly enrolled near apex. *ecostate*; laminal cells upper and median cells linear, 62.5-87.5 x 5-7.0  $\mu\text{m}$ , basal cells shorter, smooth, often strongly pitted; alar region consisting of one row of 3-4 inflated hyaline to yellowish brown cells, 100-130 x 30-32.5  $\mu\text{m}$ , cells oblong, kidney-shaped, recurving inwards at base, outermost cell often hyaline; supra-alar cells several, irregularly shaped, hyaline cells.

*Dioicous*. *Perigonia* on branches. *Perichaetia* on stems or branches, perichaetial leaves abruptly narrowed into a short or long acumen, with little denticulation on the leaf shoulder. *Calyptrae* cucullate, smooth and naked. *Setae* up to 3 cm long, smooth below, papillose above. *Capsules* inclined, 1.0 x 0.6 mm ovoid to elongate, apophyses short; exothecial cells collenchymatous; operculum form a conic base, long-rostrate, oblique; peristome double; peristome double.

Illustration. — Dozy & Mokenboer 1861-70 (t.310); Bartram 1939 (t. 25, fig. 425 as *A. secundum*, t.25, fig 426 as *A. alto-pungens*); Tan 1994 (fig. 78-87).

Thailand. — PENINSULA. Nakorn Sri Thammarat.

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

Ecology. — On dry branches in evergreen forest, at 1700 m.

Specimens examined.— TYPE. Java [*Korthals* (iso-, BM)]. PENINSULA. Nakorn Sri Thammarat: [Khao Luang, 25 Jun. 1953, *Phloenchit* 585 (BKF)].

Discussion. — For nearly a century this species was incorrectly identified as *Acroporium secundum* in publications until Tan (1994) clarified the confusion. Accordingly, *A. secundum* is a small plant with acute leaf apex (Tan 1994). Like *A. stramineum*, *A. strepsiphyllum* is a large and polymorphic species. However, the latter is best distinguished from the former by its long acuminate leaf apices. Typical leaves of *A. strepsiphyllum* are characteristically narrowly lanceolate to oblong-lanceolate, long acuminate, and without a well defined cordate base. Large individuals of *A. strepsiphyllum* are reaching 8 cm in stem or branch length and with strongly falcate-secund leaves are unmistakable, but small specimens with more spreading leaves may be confused with *A. sigmatodontium* or *A. johannis-winkleri*. From *A. sigmatodontium* the present species is differentiated by being dioicous, and from *A. johannis-winkleri* by its subpinnately branching habit. Unfortunately, perichaetial leaves of all three species narrow abruptly into a slender, short or long acumen, and possess little denticulation on the shoulder region.

### 3. APTYCHELLA (Broth.) Herzog

*Aptychella* (Broth.) Herz., *Biblioth. Bot.*, 87: 157. 1916. *Rhaphidostegium* Sect. *Aptychella* Broth., *Nat. Pfl.*, 1 (3): 1115. 1908. Lectotype: *A. prolifera* (Broth.) Herz.

*Plants* slender, yellow-green, glossy, usually forming turfts. *Main stems* creeping with prostrate irregularly pinnate branches, rise to erect. *Gemmae* filamentous often present. *Leaves* not dense, spreading or erectopate, more or less ovate-lanceolate, apex narrow acute to elongate, long acuminate, sometime flexuose, margin distantly dentate, crenulated at apex. *Costae* short, double, sometimes perceptible, or feeble or absent; laminal cells narrow, elongate to linear in upper leaf; alar distinguished, coloured or hyaline, somewhat decurrent, formed of lax, irregularly rectangular cells, lowermost cells largest.

*Dioicous*. *Sporophytes* on main stem. *Setae* slender, erect or flexuose, reddish, smooth up to 2 cm long. *Capsules* ovate, horizontal to suberect, or slightly bent. *Peristome* diplolepidous, exostome teeth not perforated, basal membrane low, endostome segments filamentous, long but often not well developed. *Cilia* absent. *Operculum* conical or very short rostrate

The genus contains less than 10 species apparently with a pantropical distribution found in Mexico, Central America, Greater Antilles, tropical Andes, southeastern Brasil, Indomalasian, and east Asiatic. Plant usually epiphytic, on branches of shrubs and small trees, occasionally in somewhat exposed sites; lower to upper montane forests, 1,600-3,800 m. There are two species in Thailand.

#### Key to Species

1. Leaves dense, concave, ovate to ovate-lanceolate, 1-1.24 x 0.20-0.36 mm, base rounded, concave; margin dentate from base to apex; leaf cells linear, 62.5-80 x 4-5  $\mu$ m; alar region heterogeous, 5-10 cells; filamentous propagules often present near leaves base or along branch..... 1. *A. speciosa*

1. Leaves not dense, plane, oblong-ovate to ovate-lanceolate, 1.4-1.64 x 0.36-0.5 mm, irregularly to cordate base; margin entire to slightly dentate at apex; leaf cells linear, 75-117.5 x 3-5  $\mu\text{m}$ ; alar region heterogeneous, 12-20 cells; filamentous often present on the tip of specialized branches ..... 2. *A. tenuiramea*

1. *Aptychella speciosa* (Mitt.) Tixier, Rev. Bryol. Lichénol. 43: 423. 1977. *Stereodon speciosa* Mitt., J. Linn. Soc. Bot. Suppl. 1: 95. 1859.

*Pylaisia speciosa* (Mitt.) Wilson ex Paris, Index Bryol. 1065. 1898. *Pylaisiopsis speciosa* (Mitt.) Broth., Nat. Pfl. I(3): 887. 1908.

*Clastobryum serrulatum* Cardot & P. de la Varde, Rev. Bryol. 50: 75. 1923. *Aptychella serrulata* (Cardot & P. de la Varde) Broth., Die Natürlichen Pfl., ed. 2, 11: 535. 1925.

### Figure 5. 21

*Plants* slender, glossy, brownish green, usually forming tufts. *Main stems* red, long creeping with irregularly pinnate branches, 2-2.5 cm long, 0.3-0.5 mm broad, lateral branches up to 5 mm long. *Filamentous propagules* often present near leaves base or along branch, dark brown, gemmae narrow linear shaped. *Leaves* erectopate, ovate to ovate-lanceolate, 1-1.24 x 0.20-0.36 mm, apex narrowed distally to long acuminate, base rounded, concave, margin slightly dentate from base to apex; leaf cells linear, 62.5-80 x 4-5  $\mu\text{m}$ ; alar region consist of heterogeneous group of tinted cells and distinguished though formed of only a few cells, 9-12 cells, mostly thick-walled cells, dark yellow to orange, always hyaline slightly rectangular shaped, irregularly, smaller to subquadrate shaped above; ecostate, rarely double short veinlets.

*Sporophytes* not seen.

Illustrations.— Tixier 1977 (Fig. 6).

Thailand. — NORTHERN. Phitsanulok.

Distribution.— Himalaya

Ecology.— Epiphyte in evergreen forest, altitude 1250-1,300 m.

Specimens examined.— NORTHERN. Phitsanulok [Phu Miang, 11 May 1965, Tixier 1113 (BKF); Phu Hin Rong Kla, 4 Sept. 2006, Pollawatn 364, 385 (BCU)].

Note.— Specimen from Thailand was identified by Tixier as *Clastobryum serrulatum* Cardot & P. de la Varde, plants have not sporophyte. Tixier (1977) described sporophytes characters as plant monoicous, setae red; capsule oval with mammillae cover at the top; peristome double; exostome with teeth having a ridge towards the top; endostome with processes cilia divided over all their length.

2. *Aptychella tenuiramea* (Mitt.) Tixier, Rev. Bryol. Lichenol., 43: 423. 1977.

*Pylaisia tenuiramea* (Mitt.) A. Jaeger ex Renauld & Cardot, Bull. Soc. R. Bot. Belg., 38(1): 38. 1899. *Stereodon tenuirameus* Mitt., Musci Ind. Or. 94. 1859. — Type: Sikkim Himalayan, 11,000 ft., *J. D. H.* 770 s.n. (iso-, BM!).

*Clastobryum tonkinense* Broth. & Paris, Rev. Bryol., 35: 47. 1908. *Aptychella tonkinensis* (Broth. & Paris) Broth., in Nat. Pfl., ed., 11: 406. 1925. *Gammiella tonkinensis* (Broth. & Paris) B.C. Tan, Bryol. 93: 433. 1990. — Type: Vietnam. *Eberhardt s.n.*, (H).

*Clastobryum oligonema* Cardot & P. de la Varde, Rev. Bryol. 50: 74. 1923.

*Clastobryum barbelloides* Dixon & P. de la Varde, Arch. Bot., 1 (8-9): 174. f. 3. 1927.

*Clastobryum assimile* Broth., Rev. Bryol. n. ser. 2: 13. 1929. *Myurium assimile* (Broth.) Seki, J. Sci. Hirochima Univ., er.B, Div.2, Bot.5. (12): 73. 1968. — Type: Japan. *Tutiga s.n.* (herb. Sasaoka).

- Clastobryum subplanulum* Broth. & Dixon, Ann. Bryol. 6: 33. 1933.  
*Clastobryum tenuirameum* (Mitt.) Dixon, Ann. Bryol., 6: 35. 1933.  
*Clastobryum caudiforme* Dixon, Ann. Bryol. 6: 36. 1933.  
*Clastobryum serratum* Dixon, Ann. Bryol. 6: 37. 1933.  
*Clastobryum pulchroalare* Dixon, Ann. Bryol. 9: 69. 1936.  
*Chionostomum angustifolium* Dixon, Ann. Bryol. 9: 70. 1937. — Type: Laos. Pu Muten, Chiang Kwang, *Kerr 514*, 20 Apr. 1932. (BM!)  
*Clastobryum carinatum* Dixon, J. Bot., 79: 74. 1941.  
*Aptychella subintegra* Tixier, Rev. Bryolo. Lichenol., 34: 160. f. 20: 1-8. 1966. — Type: Vietnam. *Demange s.n.*, 1926, (Herbarium not specified by author).  
*Aptychella tamdaoensis* Tixier, Rev. Bryolo. Lichenol. 34: 160. f. 20: 9-23. 1966. — Type: Vietnam. *Demange s.n.*, 1925, (Herbarium not specified by author).

### Figure 5.22

*Plants* slender, glossy, yellow-green, usually corticolous plants forming tufts. *Main stems* prostrate, red, 2.6-3.4 mm wide, more or less secondary pinnate branches, branch up to 5 mm long. *Filamentous propagules* often present on the tip of specialized branches, dark brown, gemmae narrow linear, spindle-shaped, up to 320  $\mu\text{m}$  long, bearing leaves bigger than normal leaves. *Leaves* erectopatent (appressed to stem when dry), not dense; leaves of stem plane, oblong-ovate to ovate-lanceolate, 1.4-1.64 x 0.36-0.5 mm; leaves of branch narrowly ovate-lanceolate, 0.8-1.4 x 0.2-0.3 mm, apex narrowed distally to long acuminate, irregularly to cordate base, concave, margin entire to slightly dentate at apex; ecostate, rarely double short veinlets; leaf cells linear, 75-117.5 x 3-5  $\mu\text{m}$ ; alar region consist of heterogeous group of tinted cells, 12-20 cells, 37.5-57.5 x 20-32.5  $\mu\text{m}$ , mostly thick-walled cells, yellow blade with dark orange red, the outer most of lower row always hyaline slightly rectangular shaped, irregularly and smaller subquadrate shaped above.

*Dioicous*. *Sporophytes* on main stem. *Setae* slender erect or flexuose, reddish, smooth, 1.5-2 cm long. *Capsules* small, more or less horizontal to suberect, ovate, 1-1.8 x 0.5 mm; *peristome* normal, double; exostome teeth up to 250  $\mu\text{m}$  high, 50  $\mu\text{m}$  wide, divided at the top; cilia presented the same size, sometimes split at the top; operculum conical with long rostrate (Tixier, 1977).

Illustrations. Gangulee (1969-80, Fig. 932); Tixier (1977, Fig. 11).

Thailand.— NORTHERN: Chiang Mai.

Distribution.— Borneo, India, Java, Laos, Nepal, and Vietnam.

Ecology.— Epiphyte on living or dead trees, or on rocks in moist forest, usually weft forming but can be pendulous, also occurs in dry places where there are some shades, altitude ranging from 45-1,725 m, frequently found from 400-1,000 m.

Specimens examined.— TYPE. Laos [Phu Muten, Chiang Kwang, *Kerr 514*, 20 Apr. 1932. (lecto-, BM); *J. D. H. 770* s.n. (Iso-, BM, as *Stereodon tenuirameus* Mitt.)]. NORTHERN: Chiang Mai. [Doi Suthep, 29 Nov. 1965, *Touw 8759*, 8581 (BKF, L), 7 Sept. 2006, *Pollawatn 412*, 428 (BCU); Doi Chiang Dao, 7 Dec. 1965, *Touw 9310* (BKF, L)].

Discussion. — All specimens have not sporophytes. Leaf veinlets could not be distinguished in normal leaves but were rarely showed in some older leaves.

## 4. BROTHERELLA Loeske ex M. Fleisch.

*Brotherella* Loeske ex M. Fleisch., Nova Guinea 12(2): 119. 1914. — Type: *Hypnum lorentzianum* Molendo, *B. lorentziana* (Molendo) Fleischer.

*Plants* slender or robust to moderate-sized, yellowish green or deeply green, rarely brownish green, glossy in tufts. *Stems* creeping, prostrate, densely irregular pinnate branched. *Leaves* spreading, erectopate, ovate-lanceolate or narrow oblong-lanceolate, often falcate, concave, usually long acuminate apex, margins slightly recurved, serrulate above; costae often absent; leaf cells rhomboid or narrowly rhomboidal to elongated linear; alar inflated, tinted along line of insertion, with a few, smaller and hyaline cells above.

*Autoicous*, rarely dioicous. *Sporophytes* on main stem. *Inner perichaetial leaves*, erect, long-plicate, slenderly acuminate, serrulate above. *Setae* elongate, smooth. *Capsules* often erect, oblong-ovoid, or cylindrical, slightly curved; opercula conic, shortly or long-rostrate; annuli differentiated, persistent; exothecial cells elongate, not collenchymatous; peristome double with high basal membrane; exostome teeth narrowly lanceolate, outer surface cross-striate, inner surface trabeculate; endostome segments yellowish; cilia often reduced. *Spores* smooth, medium-sized.

*Brotherella* seems to be primarily a temperate genus with distribution in the east Asiatic mainland from eastern Himalaya to Japan. From East Asia, the genus seems to have spilled a little to the Pacific, Europe and North America, but not to Africa, Australia or South America. It consists of some 50 species in the world. There are two species occurred in Thailand.

### Key to Species

1. Plants medium-sized to large, in tufts or compact mats; branches complanate, equally 0.5-1 cm long; leaves erectopate, ovate to ovate-lanceolate, concave, 0.9-1.20 x 0.2-0.32 mm, erect to slightly falcate, apex drawn out into a narrow subula; leaf cells narrowly oblong to linear, 60-90 x 5-7.5  $\mu\text{m}$ ; alar region, 2-3 cells, 30-42.5 x 17.5-30  $\mu\text{m}$ , often hyaline, with 2-3 irregularly cells above. .... 1. *B. erythrocaulis*
1. Plant large, trailing 10 to 20 cm long; branches erect or ascending; leaves spreading, often falcate, ovate-lanceolate, concave, 1.3-1.7 x 0.5-0.6, apex narrowly acute; leaf cells narrow elongate, 60-65 x 6  $\mu\text{m}$ ; alar region, 3-4 cells, 65-77 x 38-45  $\mu\text{m}$ , colored, with a few irregular cells above. .... 2. *B. falcata*

1. ***Brotherella erythrocaulis* (Mitt.) M. Fleisch.**, Musci Fl. Buitenzorg 4: 1245. 1923.  
*Stereodon erythrocaulis* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2:97. 1859.  
*Pylaisiadelpha erythrocaulis* (Mitt.) W. R. Buck, Yushania 1(2):12. 1984. — Type:  
 India, Sikkim, Yamtong, 3500 m, *JDH 1062* (BM).

### Figure 5.23

*Plants* medium-sized to large, brownish green, glossy in tufts or compact mats. *Main stem* creeping, prostrate, giving rise to regular pinnately or irregularly pinnately branched, often reddish, ca. 5 cm long, 2 mm wide with leaves; branches complanate, equally 0.5-1 cm long. *Stem Leaves* bigger than stem leaves, erectopate, appressed to stem with outspread tips when dry, concave, broadly rounded ovate, 0.9-1.20 x 0.5-0.75 mm, widest near or at the base, clearly with arcuate acumina, slightly falcate, apex drawn out into a narrow subula; margins entire near base, strongly serrulate at tip; ecostate; leaf cells narrowly oblong to linear, 60-90 x 5-7.5  $\mu\text{m}$  at middle leaf, 67.5-95 x 5  $\mu\text{m}$  at tip; alar cells few in one row, often 2-3 cells, 30-42.5 x 17.5-30  $\mu\text{m}$ , oblong, often hyaline, slightly inflated to enlarged, with 2-3 irregularly cells above.

*Dioicous*. *Sporophytes* on main stem. *Inner perichaetial leaves* erect, 2-3 mm long, lanceolate, long acuminate, weakly denticulate. *Setae* reddish, smooth, 1.0-1.5 cm long.

*Capsules* ellipsoidal to cylindrical, 1.5-2.0 x 0.8 mm, inclined or slightly curved; exothecial cells rectangular, vertical walls thinner or thicker; opercula conic, oblique-rostrate,  $\pm 0.9$  mm long; peristome normal double.

Illustration.— Gangulee 1980 (Fig. 969); Jia *et al.* 2005 (Pl.595, figs. 1-12).

Thailand. — NORTHERN. Chiang Mai

Distribution.— Myanmar, China, India and Himalayas.

Ecology.— Plant of temperate region, always find in humid hill evergreen forest along streamlet, on tree trunks and branches in undergrowth; altitude: 1800-2570 m.

Specimens examined.— NORTHERN. Chiang Mai: [Doi Inthanon, 18 Dec. 1965, *Touw 9762* (BKF); Doi Inthanon, 20, Dec. 1965, *Touw 10022* (BM, L), *Touw 10241* (AAU, L), 12 Sept. 2006, *Pollawatn 579* (BCU)].

Discussion.— Mitten (1859) mentions that the leaves has two short nerves but Gangulee not found in type specimen and similar to specimens from China and Thailand plants are ecostate. Regarding to Yu, Peng-cheng and Tan (2005) suggested the alar cells colored or alar cell walled slightly colored in the old leaves, but rarely to find out from Thai specimens.

2. *Brothera falcata* (Dozy & Molk.) M. Fleisch., Nov. Guinea 12, 2: 120. 1914. *Leskia falcata* Dozy & Molk, Ann. Sc. Nat. Bot. ser. 3, 2:310. 1844.

*Sematophylla molkenboerianum* (C. Müll.) Fleisch., Musci Archip. Ind. 7: n. 328.

1904.; *Rhaphidostegium molkenboerianum* (C. Müll.) Jaeg., Ber. S. Gall. Naturw. Ges., 1876-77: 401. 1878. *Hypnum molkenboerianum* C. Müll. In Syn., 2:317. 1851.

*Sematophyllum extensum* Card., Behi. Bot. Centralbl., 192 (1): 134, 25. 1905.

*Stereodon entodontella* (Broth.) Broth., Nat. Pfl. 1 (3): 1073. 1908. *Sematophyllum entodonella* Broth., Monsunia, 1: 177. 1900.

#### Figure 5.24

*Plants* large, in loose mats, yellow-green to reddish glossy, often pendent. *Main stems* elongate, creeping, 10 to 20 cm long, subpinnately branched; branches short or long, complanate to erect or ascending. *Leaves* spreading, appressed to stem when dry, stem leaves often falcate, ovate-lanceolate, 1.3-1.7 x 0.5-0.6 mm, strongly concave, plicate when dry, constricted into a long acuminate apex; margins entire or denticulate at apex; branch leaves narrower than stem leaves, 1.2-1.5 x 0.3-0.5 mm, with a long acuminate acumen, entire or denticulate from middle to apex; ecostate; leaf cells narrow elongate, 60-65 x 5-6  $\mu\text{m}$  at apex, 95-125 x 6  $\mu\text{m}$  at midleaf; alar cells differentiated in one row of 3- 4 cells, 65-77 x 38-45  $\mu\text{m}$ , oblong, inflated, hyaline to yellowish brown, with 3-5 irregular cells above.

*Dioicous*. *Sporophytes* on main stem. *Perichaetial leaves* smaller or slightly larger than vegetative leaves, 2-2.5 mm long, gradually constricted into a narrow and long piliform apex, margins denticulate above. *Setae* elongate, smooth, up to 2 cm long. *Capsules* ellipsoid to cylindrical, arcuate, 1.5-1.8 x 0.9-1 mm, inclined or slightly curved; exothecium cells rectangular, vertical walls thinner or thicker; peristome normal, double, cilia irregular; operculum conic, long rostrate.

Illustration.— Gangulee 1969-80 (Fig. 971).

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

Ecology.— Plant of temperate region, always find in humid hill evergreen forest along streamlet, on tree trunks and branches in undergrowth, Alt. 2300-2550 m.

Specimens examined.— TYPE. [*Faurie 1903* (lecto-, FH)]. Indonesia, Borneo, *Korthals s.n.*, (holo-, syn-, L); NORTHERN. Chiang Mai: [Doi Inthanon, 30 Oct. 1960, *Robbins 3638* (BKF, L); 17 Dec. 1965, *Touw 9589* (BKF, FH, NY); 18 Dec. 1965, *Touw 9698, 9811* (BKF); 19 Dec. 1965, *Touw 9875* (NY); 20 Dec. 1965, *Touw 10162* (BKF); Doi Suthep, 29 Nov. 1965, *Touw 8748* (BKF, NY); *Touw 8818* (NY)].

Discussion.— *B. falcata* can also be confused with *Papillidiopsis complanata*. The later has, however, laminal cells with thick and incrassate walls, often equally thick-walled alar cells, and more importantly, fusiform to oblong apical leaf cells. The leaves of *B. falcate* have thin to firm-walled alar cells, and elongate to linear apical cells.

## 5. CHIONOSTOMUM Müll. Hal.

*Chionostomum* Müll. Hal., *Linnaea* 36: 21. 1869. — Type: *Neckera rostrata* Griff., *C. rostratum* (Griff.) C. Mull.

*Plants* rather robust or soft, pale green, yellowish green or yellowish brown, glossy, in interwoven patches. *Stems* elongate, prostrate, with dense rhizoid at base; somewhat irregularly pinnately branched; branches erect, blunt at apex, short and unbranched, or elongate and remotely branched. *Leaves* dense, loosely appressed with 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; leaf 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*. *Inner perichaetial leaves* erect, lanceolate, margin recurved, smooth. *Setae* slender, elongate, reddish, smooth. *Capsules* erect or slightly suberect, elongated cylindrical; opercular conic at base, slender and long-rostrate; exostome teeth non-striate, evidently bordered at margins, densely trabeculate on inner surface; endostome sometimes adhering to exostome teeth, linear, as long as the teeth, papillose; basal membrane low; cilia absent. *Calyptrae* cuculate, smooth. *Spores* small.

This is the Asiatic genus that found distributions from India, Sri Lanka, China, Indo-China, Malaysia and Phillipines. There are 4 species reported in the world, the three of them are recognized for the Thai flora.

### Key to Species

1. Plants large, with several equally long branches forming tuft, lateral branch up to 15 mm long; leaves imbricate to erect, oblong-lanceolate, 1.4-1.6 x 0.3-0.4 mm; alar region with a row of 3-5 cells, lightly coloured, enlarged, often thick-walled, small quadrate-rectangular cells arranged in one row of several tiers (similar to acroporioid type); ..... 1. *C. baolocense*
1. Plant medium to large sized, robust; main stems creeping with irregularly pinnate branches, less than 10 mm long, densely foliate, tumid and blunt.....2
2. Leaves slightly secund, laxly erect when dry, more spreading when wet, oblong to lanceolate, strongly concave, 0.7-1.6 x 0.3-0.7 mm; alar region of a single basal row of vesiculose cells with 4-5 hyaline, colored, slightly enlarged, many quadrate to rectangular supra-alar cells (similar to heterophyllioid type) ..... 2. *C. pinicola*

2. Leaves loosely erect when dry, erect-spreading when moist, oblong to lanceolate, 1.6-2.2 x 0.4-0.6 mm; alar region of a single basal row of much inflated, colored, cells vesiculose with a few 3-5 cells hyaline, 50-80 x 25-38  $\mu\text{m}$ , few quadrate to rectangular supra-alar cells (similar to broterelloid type)..... 3. *C. rostratum*

1. *Chionostomum baolocense* P. Tixier, Rev. Bryol. Lichenol., 43: 430. f. 13: 3. 1977. —  
Type: Vietnam. Lam Dong, Bao Loc Tixier 310, (Holo-, PC).

### Figure 5.25

*Plants* large, with several equally long branches forming tuft, greenish-brown, glossy. *Stems* elongate, prostrate, with dense rhizoid at base; lateral branch up to 1 cm long and 2-3 mm wide included leaves. *Leaves* imbricate to erect, oblong-lanceolate, deeply concave, 1.2-2.1 x 0.5-0.7 mm, weakly plicate, gradually acuminate or abruptly acuminate; margin entire, slightly reflexed and weakly serrulate near apex; cells narrowly elongate to linear, 55-80 x 5-7.5  $\mu\text{m}$ , thicken walled, sometimes pitted near base, slightly shorter at apex; alar region with a row of 3-4 cells, lightly coloured, enlarged, often thick-walled, supra-alar cells consist of a row of small quadrate-rectangular cells arranged in several tiers.

*Autoicous*. *Perichaetial leaves* ovate to lanceolate, smaller, 2-2.5 mm long, acuminate, serrulate at apex, no alar differentiation. *Perigonial leaves* small, lateral in position; leaves ovate, 1 mm long. *Setae* smooth, reddish, to 2 cm long. *Capsules* long cylindrical, 3 x 0.6 mm; operculum long rostrate, 1.5 mm long; exothecial cells clearly collenchymatous; exostome with high of 450  $\mu\text{m}$  and broad teeth of 70  $\mu\text{m}$  at the base, end of the teeth finely granulous, peaks thin, papillose, alternating with striated parts; endostome finely papillose, with wall of 70  $\mu\text{m}$ , cilia present, 380  $\mu\text{m}$  long. *Spores* of 10-12  $\mu\text{m}$  of diameter (Tixier 1977).

Illustrations.— Tixier 1977 (Fig. 13.3).

Thailand. — SOUTHEASTERN. Trat.

Distribution.— Vietnam

Ecology.— Plant exposed, growing on soil humus, alt. 100 m.

Specimens examined.— SOUTHEASTERN. Trat: [Koh Chang, 2 Apr., 1959; SLH 7240 (AAU)].

Discussion. — There has not sporophyte in Thai specimen, but Tixier (1977) had clearly illustrated gametophytes and described sporophyte as present above.

2. *Chionostomum pinicola* P. Tixier, Rev. Bryol. Lichenol., 43 : 430. f. 13 : 2. 1977. —  
Type: Vietnam. Tuyen Duc, Dalat, cite Bellevue, 1400 m Tixier 306, (Holo-, PC).

### Figure 5.26

*Plants* robust, greenish brown, forming tufts. *Stems* closely, irregularly branched; branches densely foliate, up to 1 cm long, tumid and slightly succund. *Leaves* slightly secund, laxly erect when dry, more spreading when wet, oblong to lanceolate, strongly concave, with maximum width with the lower third, acuminate apex, 0.7-1.6 x 0.3-0.7 mm, smaller in branch leaves, margin entire, slightly toothed and curled near apex portion; ecostate; leaf cells narrowly elongate to linear, 40-75 x 5-7.5  $\mu\text{m}$ , becoming narrowly rhomboidal near apex, thin-walled, smooth; alar region of a single basal row of much inflated, colored, vesiculose cells with 4-5 hyaline, slightly enlarged, with a few quadrate to rectangular supra-alar cells.

*Monoicous*. *Perichaetial leaves* narrowly lanceolate, 0.3-0.4 mm long, *Perigonial leaves* ovate, less than 0.25 mm long. *Setae* red, smooth, 8-11 mm long. *Capsules* inclined,

cylindrical, 1.2-1.3 x 0.5-0.7 mm, slightly narrowed under the peristome; operculum long rostate up to 1.7 mm long; 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, 30µm height, overcome process ciliaires of 200 µm. *Spores* spherical of 20 µm of diameter.

Illustrations.— Tixier 1977 (Fig. 13:2).

Thailand. — NORTHERN: Chiang Mai.

Distribution.— Vietnam

Ecology.— Plant exposed, growing on soil humus in evergreen forest.

Specimens examined.— NORTHERN: Chiang Mai [Doi (Mt.) Chiang Dao, 30 Jul. 1968, *LSaW* 2881 (AAU, NY)].

Discussion. — This species is slightly similar to *C. rostratum*, it can be distinguished by its habit that have longer branches and sporophyte always constricted under the peristome teeth.

3. *Chionostomum rostratum* (Griff.) Müll. Hal., *Linnaea* 36:21. 1869. *Neckera rostrata* Griff., *Calcutta J. Nat. Hist.* 3: 70. 1843 [1842]. — Type: India. Assam.

*Chionostomum rostratum* var. *microcarpum* Broth., *Öfvers. Förh. Finska Vertensk.-Soc.* 62A(9): 50. 1921.

*Chionostomum latifolium* Thér. & R. Henry, *J. Siam Soc. Nat. Hist. Suppl.* 10(1): 20. 1935.

#### Figure 5.27

*Plants* medium to large sized, robust, yellow-green to golden (brown below), glossy, forming dense tufts. *Main stems* creeping with irregularly pinnate branched; branches short, less than 10 mm long, densely foliate, tumid and blunt. *Leaves* loosely erect when dry, erect-spreading when moist, oblong to lanceolate, 1.6-2.2 x 0.4-0.6 mm, acute to shortly acuminate, deeply concave, sometimes plicate; margin entire, reflexed in the upper 1/3, weakly denticulate near apex; ecostate; leaf cells narrowly elongate to linear, 100-150 x 5-7.5 µm, becoming narrowly rhomboidal near apex, thin-walled, smooth; alar region of a single basal row of much inflated, colored, vesiculose cells with a few hyaline, 3-5 cells, 50-80 x 25-38 µm, supra-alar cells consisted of a few quadrate to rectangular.

*Autoicous. Sporophyte* on main stem. *Perichaetial leaves* smaller, narrowly lanceolate. *Perigonial leaves* ovate, less than 0.25 mm long. *Setae* erect, slender, reddish, smooth, 20-25 mm long, smooth; capsule inclined, cylindrical, 1.8-2.2 x 0.5-0.7 mm; operculum conical, long rostrate, 1-1.4 mm long; peristome normal, double; exostome teeth up to 5 mm long, pale yellow, papillose toward tips and on inner face, or quiet smooth on outer face below; endostome with high basal membrane, segments filamentous, lid 1.6 mm long, slender beaked from a conical base. *Calyptrae* cucullate, extending nearly half way down capsule. *Spores* green when mature, round to short oblong, 15-22 µm long or diameter, slightly papillose.

Illustrations.— Bartram 1939 (Fig. 412).

Thailand.— NORTHERN. Chiang Mai, Phitsanulok; NORTHEASTERN. Loei; EASTERN. Chiyaphum; SOUTHEASTERN. Prachin Buri.

Distribution.— Sri Lanka, India, Indochina, China, Malesia, Coorg, Ceylon, Vietnam, Philippines, Taiwan.

Ecology.— Plant usually growing on barks.

Specimens examined.— TYPE. Tonkin [Chapa, Jul. 1927, A. Petelot *s.n.*, ((lecto-, BM, as *Chionostomum latifolium*)]. NORTHERN. Chiang Mai [ Doi Inthanon, 1 Dec. 1930, *Put* 3264e (BM), 12 Sept. 2006, *Pollawatn* 571 (BCU); Doi Suthep, 29 Nov. 1965,

*Touw 8709* (AAU, BM, L), 7 Sept. 2006, *Pollawatn 416* (BCU); Doi (Mt.) Chiang Dao, 30 Jul. 1968, *LSaW 2881* (AAU, NY), 5 Dec. 1965, *Touw 8996* (AAU, BM, L)]; Phitsanulok [Phumieng, 11 May 1965, *Tixier 908* (PC). NORTHEASTERN. Loei [Phu Luang, 8 Jan. 1966, *Touw 10564* (AAU, BM, L). EASTERN. Chiyaphum [Phu Khieo, 23 Feb. 1931, *Kerr 589* (BM)]. SOUTHEASTERN. Prachin Buri, 4 Apr. 1965, *Tixier 429* (BKF)].

Discussion. — These plants are richly fruited and show the peristome structure in excellent detail. The leaves are more slender than figured by Brotherus (1925), but this is probably a minor difference.

## 6. CLASTOBRYOPHILUM M. Fleisch.

*Clastobryophilum* M. Fleisch., Musci Fl. Buitenzorg, 4: 1200. 1923. — Type: *C. bogoricum* (Bosch. & Sande Lac.) M.Fleisch., Nov. Guinea 12(2): 121. 1914.

*Plants* medium size. *Leaves* long, narrow, erect, slightly flexuose and often twisted towards the apex; leaf cells thick-walled with a comparatively wide lumen; alar cells large, inflated and thick-walled.

*Dioicous*; *perichaetial leaves* very strongly toothed; *setae* quite short, roughened or papillose towards the capsule. *Capsules* oval and inclined, peristome complete.

*Clastobryophilum* predominantly a Southwest Asian genus with outlying occurrences in the East African islands (Madagascar as well as Seychelles) and New Caledonia. This is one of several such taxa at both genus and species level (O'Shea, 1997; O'Shea et al., 1996) that seem to have reached these ancient granite islands, but not the African mainland. There are three species in the world, only one species found in Thailand.

*Clastobryophilum bogoricum* (Bosch & Sande Lac.) M. Fleisch., Musci Fl. Buitenzorg 4: 1200. 198. 1923. *Hypnum bogoricum* Bosch & Sande Lac., Bryol. Jav. 2: 217. 318. 1870. *H. bogoricum* Bosch & Sande Lac. ex Hampe, Nuov. Giorn. Bot. Ital. 4: 285. 1872. *nom. inval. err. pro. H. bogoricum* Bosch & Sande Lac. *Sematophyllum bogoricum* (Bosch & Sande Lac.) A. Jaeger, Ber. S. Gall. Naturw. Ges. 1876-1877: 385. 1878 (Ad. 2: 451). — Types: Java: in m. Salak, altit. 5500', in trunks, 17 July 1860, *Kurz s.n.* (lecto-, L; iso-, L).

*Sematophyllum asperifolium* Thwaites & Mitt. in Mitt., J. Linn. Soc. Bot. 13: 319. 1873. *syn. nov. Acroporium asperifolium* (Thwaites & Mitt.) Dixon, Bull. Torrey Bot. Cl. 51: 250. 1924. *Clastobryophilum asperifolium* (Thwaites & Mitt.) B. C. Tan, J. Hattori Bot. Lab. 74: 227. 1993. — Types: Sri Lanka: *Dr. Thwaites 228*. (lecto-, NY; iso-, NY, BM).

*Rhaphidostegium rufo-viride* Besch., Ann. Sc. Nat. Bot. ser., 6, 10: 298. 1880. *syn. nov. Sematophyllum rufo-viride* (Besch.) Broth., Nat. Pfl. 1(3): 1121. 1908. *Clatobryophilum rufo-viride* (Besch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1203. 1923. — Types: (*lect. nov.*): Seychelles. Mahé, forêt-noire, *G. de l'Isle s.n.* (lect-, H-BR 1032006 !); Madagascar. Nossi-Comba, 8/1879, *Marie s.n.* (syn-, H-BR).

### Figure 5.28

*Plants* reddish- or yellowish-green, often glossy, tuft forming. *Stems* short creeping with irregularly pinnate branched; branches lax, usually more densely foliate, with very long, slightly flexuose leaves, twisted towards the apex, especially when dry. *Leaves*

lanceolate, widest at the base and tapering gradually, 1.15-2.8 x 0.15-0.36 mm, hollowed at the base, margins usually reflexed for most of the length, toothed or not with the projecting ends of cells, more strongly towards apex; ecostate; laminal cells regularly ranked often forming an oblique pattern, elongate, 60-110 x 6.5-10  $\mu\text{m}$  with the lumen occupying 70-90% of the cell width, strongly porose, variably papillose on the dorsal surface; alar cells large, consist of a row of 2-3 cells, 62.5-87.5 x 25-45  $\mu\text{m}$ , swollen and thick walled, straight or curved, sometime inclined towards the center lone of leaf, usually strongly coloured brown, orange or yellow, the colour often extending across the whole leaf base.

*Dioicous*. *Perichaetial leaves* lanceolate, wide at the base, very strongly toothed, usually with some teeth long and curved, alar cells larger than other cells, rectangular, not swollen or porose, cells above narrower and porose. *Setae* verrucose, usually for most of the upper half (Tixier 1977).

Illustration. — Tixier (1977, Fig. 1).

Thailand. — PENINSULA. Krabi.

Distribution. — Madagaca, Seychelles, Sri Lanka, Malaya, Java, Sumatra, Sarawak, Brunei, Kalimantan (Tengah), Cambodia, Thailand, Philippines.

Ecology. — On tree trunk in evergreen forest, alt. 400 m.

Specimens examined.— TYPE. Seychelles [Mahé, forêt-noire, *G. de l'Isle s.n.* (lect-, H-BR)]. PENINSULA. Krabi, *Kerr 524* (BM).

Discussion. — A specimen from Thailand is lacking of sporophytes, the description is follow Tixier (1977). Plants usually epiphyte on living and dead trees, humus and rock, uauslly weft forming but can be pendulous, mainly in coparatively moist forest, but in drier places where there is shade, altitude from 45-1,725 m, but most frequent from 400-1,000 m, probably reflecting availability of forest.

## 7. CLASTOBRYUM Dozy & Molk.

*Clastobryum* Dozy & Molk., Musci Archip. Indici 2: 41 (1845). — Lectotype: *C. indicum* (Dozy & Molk.) Dozy & Molk. fide Tan & Iwatsuki, Hikobia 11: 151, 1992.

*Clastobryella* M. Fleisch., Musci Fl. Buitenzorg 4: 1193, 1923. — Type: non designatus.

*Tristichella* Dixon, Ann. Bryol. 5: 44, 1932. — Type: *T. spiculifera* Dixon.

*Plants* slender forming glossy, golden-green sometimes reddish-brown turfs. *Main stems* long, creeping, pinnate with closely arranged erect to ascending branched; branches terete or complanate pinnate, sometimes long and flagellate; rhizoids short, in clusters, red, smooth to papillose. *Gemmae* filiform unbranched, papillose, on branch tips or in upper axils of upper leaves. *Stem leaves* concave, narrowly elongate with acute apex or ovate-lanceolate and long acuminate. *Branch leaves* sometimes ranked, sometimes tristichous, small, narrow ovate-lanceolate, acuminate, base more or less decurrent; costa absent or very short and double; laminal cells narrow elongate, rhomboid-linear, smooth or weakly papillose; alar region with 1 row of subquadrate basal alar cells, swollen, thick-walled and mostly coloured.

*Dioicous*. *Perigonia* and *perichaetia* on stems; inner perichaetial leaves lanceolate, contracted to a long denticulate point. *Setae* slender, long, purple, smooth or papillose above. *Capsules* erect, long-ovoid; operculum short, curved rostrate; annulus absent; persistome double, exostome and endostome alternate, exostome teeth 16, close together when dry, lanceolate, smooth, with low lamellae; endostome segments forming a stellate

pattern, extending over mouth, filamentous with a tendency to complete suppression; basal membrane low. *Spores* irregular, small and large.

A genus of about 23 species in the world, 10 species distributed in southeast Asia, Japan, the Philippines, Malesia. In Thailand, the genus consists of 4 species.

### Key to Species

1. Main stems long, creeping, pinnate with closely arranged erect to ascending, complanate pinnate branches up to 2 cm long; gemmae filiform unbranched, on branch tips or in upper axils of upper leaves. ....2
1. Main stems short creeping, pinnate with closely arranged erect to ascending, complanate pinnate branches up to 1 cm long; gemmae absent. .... 3
  2. Leaves ranked to various planes, sometimes tristichous, narrowly ovate-lanceolate with long acuminate, base more or less decurrent, 0.8-1.2 x 0.18-0.2 mm; margins smooth ..... 1. *C. caudatum*
  2. Leaves ranked into several planes, oblong-ovate to lanceolate with long acuminate apex, base more or less concave, 0.7-0.8 x 0.1-0.2 mm; margins slightly serrate from base of leaf and prominently dentate at apical portion. ....2. *C. cuculligerum*
3. Leaves ranked into one plane, narrowly ovate to lanceolate with abruptly long acuminate apex, base concave, 0.8-0.9 x 0.1-0.2 mm; margins smooth..... 3. *C. indicum*
3. Leaves tristichous, inflated, narrowly ovate to oblong-lanceolate with long acuminate apex, base concave, 0.6-0.7 x 0.1-0.2 mm; margins slightly serrate from base to prominently dentate at apex. .... 4. *C. spiculiferum*

1. ***Clastobryum caudatum* (Sande Lac.) M. Fleisch.**, Musci Fl. Buitenzorg 4: 1185. 1923. *Hypnum caudatum* Sande Lac., Bryol. Jav. 2: 219. 1870. *Sematophyllum caudatum* (Sande Lac.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 385. 1878.— Type: Indonesia, Java. Pangerango Gipfel, 3000 m, *M. Fleischer 14-06-1898* (Lecto-, FH Sheet-2240!).

*Sematophyllum glabrifolium* Broth. & Watts., J. Roy. Soc. New South Wales 49: 154. 1915. *Aptychella glabrifolia* (Broth. & Watts.) Broth., Nat. Pfl. 11: 406.1925.

### Figure 5.29

Plants golden-green sometimes reddish-brown turfs, glossy. *Main stems* long, creeping, pinnate with closely arranged erect to ascending, complanate pinnate branches up to 2 cm long, presented long cylindrical at terminal branches. *Stem leaves* concave, ovate-lanceolate and long acuminate, 0.8-1 x 0.2 mm. *Branch leaves* ranked to various planes, sometimes tristichous, narrowly ovate-lanceolate, acuminate, margin smooth, base more or less decurrent, 1.1-1.2 x 0.18 mm; ecostate; laminal cells narrow elongate, rhomboid-linear, smooth, 54 x 3 µm, smaller at apical part; alar region with 1 row of 3-4 subquadrate basal alar cells, swollen, thick-walled and mostly colored, 31.95 x 13.05 µm. *Gemmae* filiform unbranched, on branch tips or in upper axils of upper leaves.

*Dioicous*. *Perigonia* and *perichaetia* on stems; inner perichaetial leaves lanceolate, contracted to a long smooth pointx 0.5-0.7 x 0.18-0.2 mm. *Setae* slender, 2.0-2.5 cm long, reddish-brown, smooth and twist above; *capsules* erect, long-ovoid, 1 x 2 mm; operculum short, curved rostrate, 1 mm long; annulus absent; *peristome* double, close together when dry, lanceolate, smooth, with low lamellae; endostome segments forming a stellate pattern, extending over mouth, filamentous with a tendency to complete suppression; basal membrane low. *Spores* irregular, small and large.

Illustrations. — Tixier 1977 (Fig. 22).

Thailand. — SOUTHEASTERN. Chanthaburi.

Distribution. — Java, Malaysia, Philippines, and Vietnam.

Ecology. — Epiphyte on branches or log in moist evergreen forest. Altitude unknown.

Specimens examined.— TYPE. Indonesia [Java. Pangerango Gipfel, 3000 m, *M. Fleischer* 14-06-1898 (Lecto-, FH Sheet-2240)]. SOUTHEASTERN. Chanthaburi [*Kerr 451c* (BM)].

Discussion. — In Vietnam this species occurs at alt. 1,900 m, in Malaysia and Java it was found between 1,100-2,900 m above sea level.

2. *Clastobryum cuculligerum* (Sande Lac.) P. Tixier, J. Hattori Bot. Lab. 32: 28. 1969.-

*Hypnum cuculligerum* Sande Lac., Bryol. Jav. 2: 218. pl. 319. 1869.— Type: Ceylon, Neewara Eliza, Feb. 1913, *C.H. Biusiea* (H-BR!).

*Clastobryum papillosum* R. S. Williams, Bull. New York Bot. Gard. 8 (31): 360, 1914.

*Clastobryum epiphyllum* (Renauld & Cardot) B. C. Tan & Touw, J. Hattori Bot. Lab. 70: 93. 1991. *Trichosteleum epiphyllum* Renauld & Cardot, Rev. Bryol. 23: 106 1896.

**Figure 5.30**

*Plants* slender forming tuft, golden-brown to yellowish-brown, glossy. *Main stems* long, creeping, pinnate with closely arranged erect to ascending; branches slender, complanate pinnate up to 2 cm long. *Stem leaves* and *branch leaves* similar in shape, differed in sized; leaves ranked into several planes, oblong-ovate to lanceolate with long acuminate apex, base more or less concave, 0.7-0.8 x 0.1-0.2 mm, margin slightly serrate from base of leaf and prominently dentate at apical portion; ecostate; laminal cells elongate, narrow linear-rhomboidal, smooth, 45-50 x 3-5  $\mu\text{m}$ , smaller at apical part; alar region with 1 row of 3-4 subquadrate to rectangular basal alar cells, swollen, thick-walled and mostly colored, 34-36 x 12-15  $\mu\text{m}$ . *Gemmae* filiform unbranched, on branch tips or in upper axils of upper leaves.

*Dioicous*. *Perigonia* and *perichaetia* on stems; inner perichaetial leaves lanceolate, contracted to a long dentate point, 0.3-0.5 x 1.6-1.8 mm. *Setae* slender, up to 2 cm long, reddish-brown, smooth and twist above when dried. *Capsules* erect or slightly inclined, long ovoid, 2 x 0.6-0.8 mm; operculum short, curved rostrate, 1 mm long; annulus absent; *peristome* double, exostome lanceolate, smooth, with low lamellae, spreading outward when dried; endostome segments forming a stellate pattern, extending over mouth, filamentous with a tendency to complete suppression; basal membrane low.

Illustrations. — Bartram 1939 (Pl. 23, fig. 399, as *Clastobryella cuculligera*); Tixier 1977 (Fig. 21).

Thailand. — NORTHEASTERN: Nakhon Ratchasima; PENINSULA: Ranong

Distribution. — Mainland China, Japan, Cambodia, Vietnam, Philippines, Java, Malay Peninsula, and Sri Lanka.

Ecology. — Epiphyte on tree-branches in mossy forest, alt. 900-1300 m.

Specimens examined.— TYPE. Ceylon [Neewara Eliza, Feb. 1913, *C.H. Biusiea* (H-BR 1031006)]. NORTHEASTERN. Nakhon Ratchasima [*Tixier s.n.* (PC), *Tixier 326, 427, 446, 493, 505, 508, 512, 925, 1225* (all in PC)]; PENINSULA. Ranong [*Kerr 404b* (BM)].

Discussion. — The wide ranges of distribution are found in moist evergreen forest, alt. 1,400 m in Vietnam, alt. 1,000 m in Cambodia and alt. 2,450 m in Java.

3. *Clastobryum indicum* (Dozy & Molke.) Dozy & Molke., Musci Frond. Ined. Archip. Ind.

2: 43. 1846. *Astrodontium indicum* Dozy & Molk., Ann. Sc. Nat. Bot. ser. 32: 299. 1844. Type: Indonesia, Java. Pangerango Gipfel, 16 Juli 1898, *E. Nyman* (H-BR!).

*Clastobryum igorotum* Tixier, J. Hattori Bot. Lab. 32: 28. f. 5. 1969. — Type: Philippines, Luzon, Mt. Polis, *Tixier 1734* (PC).

*Neckera clastobryum* Müll.Hal., Syn. Musc. Frond. 2: 91. 1850.

### Figure 5.31

*Plants* yellowish-brown to golden-brown, glossy, forming tuft. *Main stems* long, creeping, pinnate with closely arranged erect to ascending, complanate pinnate branches up to 1 cm long, branches flattened at terminal. *Stem leaves* and *branch leaves* similar but stem leaves bigger in sized; leaves ranked into one plane, narrowly ovate to lanceolate with abruptly long acuminate apex, base concave, 0.8-0.9 x 0.1-0.2 mm, margin smooth; ecostate; laminal cells elongate, narrow linear-rhomboidal, smooth to pitted, 3-5 x 42-46 µm, smaller at apical part; alar region with 1 row of 3-4 subquadrate to rectangular basal alar cells, swollen, thick-walled and mostly colored, 36-40 x 13-14 µm. *Gemmae* absent.

*Dioicous*. *Perigonia* and *perichaetia* on stems; inner perichaetial leaves lanceolate, contracted to a long dentate point, 1.4-1.7 x 0.3-0.5 mm. *Setae* slender, up to 1 cm long, reddish-brown, smooth and twist above when dried. *Capsules* erect or slightly inclined, ovoid, 0.3-0.4 x 1.0 mm; operculum short, curved rostrate, 1 mm long; annulus absent; *peristome* double, exostome lanceolate, smooth, with low lamellae, easy lose when dried; endostome segments forming a stellate pattern, white, extending over mouth, basal membrane low.

Illustrations. — Seki 1968 (Fig. 7); Tan & Iwatsuki 1992 (Figs. 1-10); Tixier 1977 (Figs. 19, 20).

Thailand. — NORTHERN. Phitsanulok.

Distribution. — Mainland China, Japan, Taiwan, Vietnam, Philippines, Sumatra, Borneo, Celebes, Java, and Myanmar.

Ecology. — Epiphyte on tree-trunk at 1,300 m alt. (normally found in exposed area from 700–2,400 m).

Specimens examined.— TYPE. Philippines, *E. Nyman*, 18 Juli 1898 (H-BR 1033018); NORTHERN. Phitsanulok [Phu Miang, *Tixier 908* (PC)].

Discussion. — The features of leaf are variable according to condition of growing area. Laminal cells pitted when growing in exposed area and getting smooth when growing in shaded or moist forest.

4. *Clastobryum spiculiferum* (Dixon) B. C. Tan, Z. Iwats. & D. H. Norris, Hikobia 11: 151. 1992. *Tristichella spiculifera* Dixon, Ann. Bryol. 5: 44. 1932.

### Figure 5.32

*Plants* slender, greenish-brown to golden-brown, glossy, forming tuft. *Main stems* long, creeping, pinnate with closely arranged erect to ascending, complanate pinnate branches up to 1 cm long. *Stem leaves* and *branch leaves* similar but bigger in sized; leaves tristichous, inflated, narrowly ovate to oblong-lanceolate with long acuminate apex, base concave, 0.6-0.7 x 0.1-0.2 mm, margin slightly serrate from base to prominently dentate at apex; ecostate; laminal cells elongate, linear, smooth, 1.5-1.6 x 48-40 µm, smaller or linear-rhomboid at apical part; alar region with 1 row of 4-5 subquadrate to rectangular basal alar cells, swollen, thick-walled and mostly colored, 30-40 x 10-12 µm. *Gemmae* absent.

*Dioicous*. *Sporophytes* not found.

Illustrations. — Unknown.

Thailand. — PENINSULAR. Nakhon Si Thammarat.

Distribution. — Java and Sumatra.

Ecology. — Epiphyte on tree in moist or mossy forest at 1,530-1,740 m alt.

Specimens examined. — PENINSULAR. Nakhon Si Thammarat [Khao Luang, 4 Aug. 2007, *Pollawatn* 646, 658, 673 (BCU), *Touw* 11766, 11880 (L)].

Discussion. — Leaves arrange in three ranks. They are similar to *C. cuculligerum* in shape and size, but differed in more inflated.

## 8. GAMMIELLA Broth.

**Gammiella Broth.**, Nat. Pflanzenfam. I(3): 1067. 1908.

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

*Autoicous*. *Inner perichaetial leaves* erect, ovate-lanceolate, gradually becoming a long filiform acumen, nearly entire; costae none. *Setae* slender, reddish, smooth, often twisted when dry. *Capsules* erect cylindrical, apophyses short, thin-walled, the mouth not constricted when dry; opercula conic, bluntly tipped; annuli narrow, persistent; peristome double; exostome teeth broadly lanceolate, blunt at tips, yellowish, smooth below, inner surface densely trabeculate; endostome segments hyaline, broad and short, finely papillose, blunt at tips, keeled; basal membrane low, cilia absent.

The genus *Gammiella* Broth. occurs only in the palaeotropics, and is wide spread Particularly in tropical Asia such as Mainland China, India, Japan, Java, Kampuchea, Laos, Philippines, Sikkim, Sri Lanka, Taiwan, and Vietnam (O'Shea 2003). Seven species are currently accepted in the genus, four species found in Thailand.

### Key to species

1. Plants large, stem more than 1.25 mm wide including leaves; leaves ovate-oblong to oblong, more than 1.25 mm long, lightly to moderately plicate, margins recurved, serrulate, abruptly cuspidate ..... 2. *G. pterogonioides*
1. Plants small, stem less than 1 mm wide including leaves; leaves less than 1.25 mm long, plane to lightly concave..... 2
  2. Leaves lanceolate, more than 0.75 mm long; apex acuminate to long acuminate ..... 4. *G. tonkinensis*
  2. Leaves, less than 0.75 mm long; margin serrate from base to apex ..... 3
3. Branch slender, lacking propagule; leaves rigid, narrowly ovate to ovate-oblong, apex slightly bent, acute to acuminate ..... 1. *G. ceylonensis*
3. Branch short, propagule at terminal; leaves slightly secund, oblong to oblong-lanceolate, apex narrowly acute..... 3. *G. rugosa*

1. ***Gammiella ceylonensis* (Broth. in Herzog) B.C.Tan & W.R.Buck**, J. Hattori Bot. Lab.66: 318. 1989. *Clastobryum ceylonense* Broth., Herzog, Hedwigia 50: 137. 1911. *Clastobryella ceylonensis* (Broth.) Broth., Nat. Pfl. Ed. 2, 11: 407. 1925. — Type: Sri Lanka, an einem Baum in Urwald des Pidurutalagala, ca. 2200 m., 1906, *Th. Herzog*, (iso-, BM)
- Clastobryum merrillii* Broth., Philipp. J. Sci., C, 8: 81. 1913. *Clastobryella merrillii* (Broth.) Tixier, Rev. Bryol. Lichénol. 43:440. 1977. — Type: Philippines. Luzon, Subprovince of Benguet, Pauai, on tree trunks, May 1909, *Merrill 6677* (iso-, BM); Philippines. Luzon, 9 Sep. 1976, *R.M. del Rosaio* (holo-, H-BR!).
- Pterigynandrum pusillum* Thér., Recueil Publ. Soc. Havraise Etud. Div. 1925: 147. 1926. *Clastobryella pusilla* (Thér.) Wijk & Margad., Taxon 8: 73. 1959. *Pterigynandrum madagassum* Thér., Recueil Publ. Soc. Havraise Etud. Div. 89(2): 130. ic. 1922, hom. illeg. *Clastobryella madagassa* (Thér) Thér., Recueil Publ. Soc. Havraise Etud. Div. 1932: 144. 1932. *nom. Illeg. incl. spec. prior., syn.nov.* — Type: Madagascar. Massif d'Andrin-gitra, 1600-2500 m, *M. Perrier de la Bâthie, s.n.* (holo-, PC).

**Figure 5.33**

*Plants* small yellowish to brownish, in dense mats. *Stems* creeping; branches slender, often microphyllous and terete, up to 10 mm long. *Leaves* erect, ovate to ovate-oblong, 0.8-1.2 x 0.3-0.4 mm, concave, obtuse, acute to short acuminate (specially the stem leaves), margins serrulate to base; laminal cells narrowly fusiform to elongate, 40-65 x 3-5 µm; alar cells quadrate, 15-17 x 13-15 µm, thick-walled, in homogenous cluster. *Gammas* bearing distally clusters of filamentous propagules.

*Autoicous. Perigonial leaves* small, ovate. *Perichaetial leaves* oblong lanceolate, 1-1.25 mm long, acuminate, with strongly serrate margins. *Sporophytes* not seen.

*Illustrations.* — Thériot 1922 (fig. 130), Potier de la Varde 1932 (fig. 63), Tixier 1977 (fig. 441), Tan & Buck 1989 (fig. 313).

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

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

*Ecology.* — On tree trunk, alt. 1220-1650 m.

*Specimens examined.*— TYPE. Philippines [Luzon, 9 Sep. 1976, *R.M. del Rosaio* (holo-, H-BR)]. NORTHERN. Chiang Mai [Doi Suthep, 6 Dec. 1957, *Richards 5488, 5504* (BKF), 7 Sept., 2006, *Pollawatn 432, 427, 422* (BCU); *Kerr 22* (type of *Clastobryum brevifolium*, BM), *Rigby 583* (BM), *Put 3264f* (BM)]; Phitsanulok [Phu Miang, 11 May 1965, *Tixier 908* (PC); Phu Hin Rong Kla, 4 Sept. 2006, *Pollawatn 381, 394, 410* (BCU)]; EASTERN. Nakhon Ratchasima [*Tixier 316, 407, 434, 440, 451, 459, 465, 476, 482, 491, 514, 526, 529, 1216, 1222, 1228, 1237, 1267* (all in PC)].

*Discussion.* — *Gammiella ceylonensis* is a widespread, polymorphic species. Its small, ovate to ovate-oblong leaves with a well defined cluster of colored, quadrate alar cells are distinctive. A Philippine specimen shows thin-walled, hexagonal exothecial cells. The type specimen of *Clastobryella tenerrima* from Yunnan was shown to be conspecific with *G. ceylonensis* by Tan & Buck (1989).

2. ***Gammiella pterogonioides* (Griff.) Broth.**, Nat. Pfl. 1(3): 1067. 1908.

*Pleuropus pterogonioides* Griff., Cal. J. Nat. Hist., 3: 274. 1842.

*Stereodon pinetorum* Mitt., Musci Ind. Or.: 93. 1859.

*Hypnum pinetorum* (Mitt.) Jaeg., Ber. S. Gall. Naturw. Ges. 1877-78: 346. 1880.

**Figure 5.34**

*Plants* large, yellow-green (brown below), moderately robust, glossy plants in loose tufts. *Main stems* creeping, irregularly branched; branches to 10 mm long and 1.25-2 mm wide, sometimes curved, sometimes with leaves turned to one side or leaves on all sides (in younger branches). *Leaves* dense, imbricate to loosely erect, spreading leaves (appress to stem when dry), concave, sometimes falcate, ovate to oblong-lanceolate, 1.6-1.9 x 0.5-0.6 mm, lightly plicate, with abruptly narrowed acute to short acuminate apices; margins entire, narrowly recurved, weakly denticulate near apex, sometimes recurved on one side at base, shortly decurrent at base; ecostate (sometimes short, double costa); leaf cells narrow elongate rhomboid, 55-70 x 5-7  $\mu\text{m}$ ; alar region differentiated, consisting of colored or hyaline, quadrate to rectangular cells, 16-19 x 15-18  $\mu\text{m}$  at the lowest row, gradually smaller above, with often thickened walls, tinted in the lowest rows.

*Autoicous*. *Sporophytes* from the base of main branches. *Perichaetial leaves* larger, erect, narrowly lanceolate, acuminate. *Setae* slender, erect, about 1 cm long (known to be up to 2 cm). *Capsules* inclined or erect, cylindrical, 1.2-1.3 x 0.5-0.6 mm; peristome in this specimen show only exostome teeth, 180-200 x 50  $\mu\text{m}$  at base.

Illustration. — Gangulee 1980 (Fig. 940), Tixier 1977 (Fig. 16).

Thailand. — NORTHERN. Chiang Mai; EASTERN. Nakhon Ratchasima; SOUTHEASTERN. Prachin Buri.

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

Ecology. — Plants densely on tree trunks and branches, in evergreen forest, alt. 1300-1800 m.

Specimens examined.— NORTHERN. Chiang Mai [Doi Inthanon, 19 Dec. 1965, *Touw 9914* (BKF); Doi Suthep, 30 Nov. 1966, *Touw 8797* (BKF)]; EASTERN. Nakhon Ratchasima: *Tixier 409, 437, 468, 472, 474, 481, 484, 509, 513, 515, 531, 532* (all in PC); SOUTHEASTERN. Prachin Buri [Khao Khieo, 2 Apr. 1965, *Tixier 506* (BKF)].

Discussion. — Among its congeners, this species is unique by its large plant size, coupled with imbricate, concave, ovate to oblong-lanceolate leaves. The abruptly cuspidate leaf apices are also distinctive. Tixier (1977) observed exostome teeth 300 x 80  $\mu\text{m}$  and endostome represented only by a basal membrane. But, Brotherus shows endostome with clear but low segments. Griffith shows clear endostome segments as long as exostome. This seems to be a little problematic as Tixier has revised the genus on the basis of no endostome segments and this is true for this taxon specimens examined recently (but not the type). It is possible that the endostome is very fugacious. Gangulee (1980) reported that the peristome of this species has not been clearly observed, illustration of the peristome of the species is supported by the Chinese specimen studied. The Yunnan plants have good capsules which show a well developed endostome whose segments are papillose, broad and blunt, and as large as the exostome teeth. No cilia were seen.

3. *Gammiella rugosa* P. Tixier, Rev. Bryol. Lichenol., 43: 443. f. 19: 1. 1977. — Type:

Vietnam. Tuyen Duc, Mt. Lang Bian, 1900 m, *Tixier 211*, (Holo-, PC).

**Figure 5.35**

*Plants* rigid, small, yellowish to brownish, in dense mats. *Stems* creeping; branches slender, often microphyllous and terete, up to 10 mm long. *Gammae* bearing clusters of filamentous propagules near apical branch. *Leaves* erect, ovate-oblong to lanceolate, 0.8-1.2 x 0.3-0.4 mm long, concave, obtuse, acute to short acuminate (specially the stem leaves), margins serrulate to base; laminal cells narrowly fusiform to elongate, 20-45 x 3-5  $\mu\text{m}$  long; alar cells quadrate, thick-walled, 16-19 x 12-15  $\mu\text{m}$ , in homogenous cluster.

*Autoicous*. *Perigonial leaves* small, ovate. *Perichaetial leaves* oblong lanceolate, up to 1.25 mm long, acuminate, with strongly serrate margins. *Sporophytes* not seen.

Illustrations. — Tixier 1977 (Fig. 19).

Thailand. — NORTHERN. Chiang Mai, EASTERN. Nakhon Ratchasima.

Distribution. — Vietnam.

Ecology. — On tree trunks and branches, alt. 1300 m.

Specimens examined. — TYPE. Vietnam [Tuyen Duc, Mt. Lang Bian, 1900 m, *Tixier 211*, (Holo-, PC)]. NORTHERN. Chiang Mai [Doi Inthanon, 18 Dec. 1965, *Touw 9820* (AAU, BKF, L)]; EASTERN. Nakhon Ratchasima: *Tixier 513* (PC).

Discussion. — This is only one species of *Gemmiella* in Thailand that presented clusters of filamentous propagules near apical branches.

4. *Gammiella tonkinensis* (Broth. & Paris) B.C. Tan, *Bryologist* 93: 433. 1990. *Aptychella tokinensis* (Broth. & Paris) Broth., *Nat. Pflanzenfam.*(ed.2) 11: 406. 1925. *Clastobryum tokinensis* Broth. & Par., *Rev.Bryol.* 35:47. 1908. — Type: Vietnam. Tonkin, Vinh Yen province, Tam Dao, 950-1100m, *Eberhardt s.n.*, (H).

*Aptychella glomerat-propagulifera* (Toyama) Seki, *J. Sci. Hiroshima Univ.*, Ser. B, Div. 2, Bot. 12: 72. 1968. *Clastobryum glomeratopropaguliferum* Toyama, *Acta Phytotax. Geobot.* 4: 214. f.2 1935.

*Gammiella touwii* B. C. Tan, *Bryologist* 93(4): 432. 1990. [syn. nov.] — Type: Mindanao. Bukidnon Prov., Mt. Kitanglad, on log, ca. 1800 m, 25 May 1984, *Tan, Navarez & Amoroso 84-307* (Holo-, FH).— Isotypes: BM, H, L, NICH, NY.

*Plants* caespitose, mat forming. *Stems* profusely branched, in cross section without central differentiation; branches numerous, terete, filiform, fragile, to 4 cm long, forming thick felt over substrate. *Leaves* polymorphic, branch leaves complanate, lanceolate, 1.0-1.5 x 0.25-0.5 mm, ovate on stem and primary branches, becoming lanceolate on secondary branches, narrowly lanceolate to lanceolate-linear on microphyllous branchlets; ecostate acuminate apex; margins entire, weakly toothed only near apex; leaf cells elongated to linear, 60-85 x 5-7 $\mu$ m, shorter at extreme margin, short-oblong at apex, shortly rectangular to elongate at leaf base, often prorate; alar regions at times swollen or concave, consisting of groups of quadrate and short-rectangular, 15-18 x 16-21  $\mu$ m, thin to thick-walled, coloured, isodiametric cells. *Propagules* not seen.

*Sporophytes* not seen.

Illustrations. — Tan 1990 (figs. 13-17, as *gammiella touwii*); Noguchi 1987-94(Fig. 475A, as *Clastobryella glomerato-propagulifera*).

Thailand. — NORTHEASTERN. Phetchabun; EASTERN. Nakhon Ratchasima.

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

Ecology. — On soil or on rocks, alt. 900-1300 m.

Specimens examined. — NORTHEASTERN. Phetchabun: *Tixier s.n.* (PC); EASTERN. Nakhon Ratchasima: *Tixier s.n.* (PC), all reported by Tixier 1971: 146.

Discussion. — Tixier (1977: 423) treated *Aptychella tonkinensis* as a synonym of *A. tenuiramea*. However, the author did not transfer his Thai collections to the latter species by citing them in specimens examined section. Since the report of this species for Thailand was based on Tixier's (1971) study, it would be difficult to determine where Tixier's Thai collections under the name, *Aptychella tonkinensis* belong to. These specimens may belong to either one of the two species. According to Tan (1990: 423), the types of the two species concerned are different, representing two distinct species. Tan &

Iwatsuki (1993) reported *Gammiella tonkinensis* from Thailand by continuing citation of Tixier's (1971) paper. It appears that the record of this species from Thailand is questionable since Tixier (1977) considered both species identical or at least his Thai collections belonging to *Aptychella tenuiramea* (Tixier 1977). A final placement of these specimens cannot be determined until these specimens are examined. All descriptions above based on Tan (1990).

## 9. HAGENIELLA Broth.

***Hageniella* Broth.**, Oefv. Vet. Soc, Foerh., 52, Afd. A(7): 4, 1910. — Lectotype: *H. sikkimensis* Broth.

*Plants* slender, glossy, in dense tufts. *Main stems* prostrate; branches erect or spirally ascending. *Leaves* round ovate or elliptic from narrower base, apex acute to acuminate with dentate margin; leaf cells narrowly elongate, usually papillose or scabrous by extension of cell tips, alar cells differentiated and tinted; costa absent or indistinctly very short and double.

*Dioicous*. *Setae* erect, long, thin. *Capsules* small, ovoid; annuli not differentiated; peristome normal, double, hypnoid; endostome with high basal membrane and normal, hyaline segments as high as the exostome teeth; operculum conical, shortly rostrate.

The genus is always presents in Asia from Himalaya to Indo-China or Malesia. There are five species accepted by Tixier (1977). The only one species distributed in Thailand.

***Hageniella assamica* Dix.**, J. Bomb. Nat. Hist. Soc., 39: 790 (1937). — Type: Naga Hill, Japwo, 2750 m, *Bor* 305 (BM).

### Figure 5.36

*Plants* yellowish green, slightly glossy, densely caespitose. *Main stems* creeping, branches erect but curved, 5-7 mm long. *Leaves* dense, erectopatent (appressed, more cuspidate and imbricate when dry), concave, ovate with a narrow, acuminate, subpilose tip, 5-7  $\mu\text{m}$  in diameter, narrowed at base, 0.32-0.64 x 0.16-0.24 mm, margin faintly denticulate at tip; ecostate; leaf cells linear, slightly vermicular, 37.5-50 x 5  $\mu\text{m}$ , with cell tip forming a prominent papilla in the upper half of leaf; at base middle such cells are smooth and seem a radiate towards margins; alar cells differentiated, hyaline, incrassate, lowest row large, rectangular, 15-17.5 x 12.5-17.5  $\mu\text{m}$ , some smaller and irregular shaped cells above.

*Dioicous*. *Sporophytes* on main stem. *Perichaetial leaves* erect but with spreading tips. *Setae* long, thin, smooth, sinuose erect, 1.4-1.7 cm long. *Capsules* inclined to horizontal, ovate, 1.3-1.5 x 0.6 mm; operculum short-rostrate; peristome normal, double; exostome teeth 250-270 x 60-75  $\mu\text{m}$  at abse, bordered, horizontally striped below; endostome basal membrane high, segments hyaline, as long as exostome, not split. *Spores* 18-22  $\mu\text{m}$  in diameter.

Illustration.— Gangulee 1980 (fig.927); Tixier 1977 (Fig. 3.1).

Thailand.— NORTHERN. Chiang Mai.

Distribution.— India

Ecology.— Plant grows in expose ridge of brushwood field, epiphyte on tree trunks and branches. Usually, in hill evergreen forest on tree trunks and twigs, in undergrowth; altitude: 1,750-2,300 m

Specimens examined.— NORTHERN. Chiang Mai: [Doi Chiang Dao, 7 Dec. 1965, *Touw 9319* (BM, FH, L, NY); Doi Inthanon, 19 Dec. 1965, *Touw 9915, 9916, 10075* (BM, L), 20 Dec. 1965, *Touw 10120* (BM, NY), 12 Sept. 2006, *Pollawatn 640, 643* (BCU)].

### 10. HETEROPHYLLIUM (Schimp.) Kindb.

***Heterophyllum* (Schimp.) Kindb.**, *Canad. Rec. Sci.*, 6:72. 1894. *Hypnum* Subgen. *Heterophyllum* Schimp., *Syn. Musc. Eur.* 629. 1860. — Lectotype: *H. nemorosum* (Brid.) Kindb. fid. Robins. & Reed.

*Stereodon* Subgen. *Heterophyllum* (Schimp.) Broth., *Nat. Pfl.*, 1(3): 1072. 1908.

Plants robust, green, yellowish green or brownish green, glossy. Stems often extensively prostrate, usually not evidently branched; paraphyllia numerous. Leaves patent-spreading or falcate, ovate-lanceolate, slightly concave, long acuminate at apex; costae short, weak or absent; leaf cells narrowly linear; basal cells yellowish; alar cells loose, often quadrate or rectangular, yellow or yellowish brown, forming an excavate alar area. Autoicous or dioicous. Capsules erect or patent-spreading, symmetric or slightly curved; opercula conic, shortly rostrate; annuli slightly differentiated; peristome double; exostome teeth narrowly lanceolate, outer surface cross-striate at base; inner surface evidently trabeculate; endostome segments yellowish or hyaline; basal membrane high; cilia well developed.

There are about 30 species known to this genus in the world. Only one species found from Thailand.

***Heterophyllum amblystegum* (Mitt.) Y. Jia, S. He & Crosby**, *Novon* 17: 332-334, f. 1. 2007. *Stereodon amblyostegus* Mitt., *Musci Ind. Or.*: 97. 1859. *Brotherella amblystegia* (Mitt.) Broth., *Nat. Pfl.* ed. 2, 11: 425. 1925. *Pylaisiadelphina amblystega* (Mitt.) W. R. Buck, *Yushania* 1(2): 11. 1984. — TYPE: India. Sikkim, *J. D. Hooker* 973 (Lecto-, NY, BM).

#### Figure 5.37

*Plants* medium-sized to rather robust, brownish yellow or golden yellow, caespitose. *Main stems* creeping, regularly pinately branched; branches 0.1-0.2 mm diam. 2.4-4.2 x 0.2-0.3 mm with leaves; stem in transverse section round, ca. 0.4 mm diam., cortical cells in 3 layers, irregularly rounded, medullar cells thin-walled, irregularly rounded quadrate, central strand absent; pseudoparaphyllia few, foliose on stem and branches. *Leaves* dimorphic, imbricately appressed when dry, patent to squarrose when moist; stem leaves broadly lanceolate with long, slender, flexuose acumina, strongly serrate above, 1.8-2.1 x 0.3-0.5 mm; median leaf cells linear-rhomboidal, 45-80 x 3-5 µm; alar cells in an excavate group with 12 to 16 reddish brown, inflated, rectangular or subquadrate, thick-walled cells, 21-38 x 12-25 µm; branch leaves narrowly lanceolate with slender acumina, 1.2-1.4 x 0.2-0.3 mm; alar cells fewer, 6 to 12 in number.

*Dioicous*. *Sporophytes* on main stems. Inner perichaetal leaves narrowly lanceolate, long acuminate, serrate above, 2.5-3.0 x 0.3-0.4 mm, costae absent; outer perichaetal leaves smaller. *Setae* reddish, smooth, twisted when dry, 3.5-4.0 cm long. *Capsules* oblong-ovoid, 1.5-1.7 x 0.8 mm; operculum not seen; annuli not clearly developed; peristome double; exostome teeth yellowish brown, narrowly triangular, ca. 350 µm long, coarsely papillose above, cross-striolate below; endostome segments yellow, slenderly

lanceolate, keeled, nearly as long as the teeth; basal membrane high, 1/3-1/2 as high as the segments; cilia (1) 2 to 3. *Calyptrae* not seen. *Spores* spherical, large, 26-31  $\mu\text{m}$  diam., strongly papillose.

Illustrations. — Gangulee 1980 (Fig. 973); Jia 2007 (fig.1).

Thailand. — NORTHERN. Chiang Mai.

Distribution.— India, Himalaya.

Ecology.— Plants usually growing on rotting logs on forest floor in evergreen forest, alt. 2,530 m.

Specimens examined.— TYPE. [*Hooker 973* (Iso-, FH, as *Stereodon amblystegus* Mitt.). NORTHERN. Chiang Mai [Doi Inthanon, 18 Dec. 1965, *Touw 980, 9812* (AAU, BKF, BM, L), 12 Sept. 2006, *Pollawatn 572, 631, 638, 644* (BCU)].

Discussion. — The species has been reported from Thailand as *Brotherus amblystega* (Mitt.) Broth. Since then the species had revised to *Pylaisiadelpha amblystega* (Mitt.) W.R. Buck, and recently Jia (2007) replaced the species to *Heterophyllum*.

## 11. ISOCLAIELLA Dixon

*Isocradiella* Dixon, J. Bot., 69: 5. 1931. — Holotype: *I. phyllogonioides* Dixon.

*Neacroporium* Z. Iwats. & Nog., J. Hattori Bot. Lab. 34: 226. 1971. — Type: *Acroporium flagelliferum* Sakurai; — Holotype: *N. flagelliferum* (Sakurai) Iwatsuki & Noguchi, Willdenowia. 24: 255-294.

*Plants* small, long creeping, yellowish-green, *Main stems* long and prostrate, mostly densely pinnately branched, branches erect to ascending; central strands lacking; pseudoparaphyllia filamentous. *Branch leaves* imbricate, ovate, strongly concave; costae short or absent; median leaf cells elongated, smooth or occasionally slightly papillose; alar cells quadrate and rectangular, pitted.

*Dioecious*. *Sporophytes* on main stem, *Setae* long and slender, smooth. *Capsules* oblong-ovoid, slightly arcuate; exothecial cells collenchymatous, quadrate to rectangular, thin-walled; opercula long rostrate; exostome teeth linear-lanceolate, densely and finely papillose; endostome segments linear; basal membrane low; cilia none. *Calyptrae* campanulate, smooth.

The genus is monotypic, occur distributions from Asia to Australia.

*Isocradiella surcularis* (Dixon) B.C. Tan & Mohamed, Crypt. Bryol. Lichéno. 11: 357 (1990).

*Acroporium surculare* Dixon, Bull. Tor. Bot. Club 51: 258. pl. 4. f. 11. 1924.

*Rhaphidostichum surculare* (Dixon) Dixon, J. Lin. Soc., Bot. 50: 127. 1935.

*Warburgiella surcularis* (Dixon) Broth., Nat. Pflanzenfam. (ed.2) (11): 535. 1925.

*Acroporium flagelliferum* Sakurai, Bot. Mag. 48: 391. 1934. *Isocradiella flagellifera* (Sakurai) S.H. Lin, Yushania 3(2): 13. 1986. *Neacroporium flagelliferum* (Sakurai) Z.

Iwats. & Nog., J. Hattori Bot. Lab. 34: 226. 1971. *Pylaisiopsis nipponensis* Seki\*, J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 12: 77. 1968.

*Isocradiella phyllogonioides* Dixon, J. Bot., 69: 5. pl. 595: f. 4. 1931.

*Neacroporium flagelliferum* (Sakurai) Z. Iwats. & Nog., J. Hattori Bot. Lab. 34: 226. 1971.

**Figure 5.38**

*Plants* slender, yellow-green (with golden tinge) glossy, plants in dense tufts. *Main stems* thin, long creeping, densely or distally branched; branches erect, sometimes curved, 5-15 mm long and about 1.5 mm wide, subjulaceous to somewhat complanate, with many caducous, flagellate, branchlets. *Leaves* lax, patent to spreading, shrunk and somewhat erect in the lower leaves, broadly ovate to ovate-lanceolate, 0.8-1.2 x 0.25-3.0 mm, at times asymmetrically cymbiform with an abruptly constricted, short to long acumen and an equally constricted leaf base; apex narrow acuminate, sometimes twisted; margins entire below, weakly serrulate at leaf apex; ecostate; laminal cells linear, 55-60 x 5-7  $\mu\text{m}$  at top, slightly wider below, smooth, at times prurulose; alar cells irregularly rectangular, 12-15 x 9  $\mu\text{m}$ , to quadrate, moderately thick-to thin-walled, forming coloured cluster or tiers.

*Dioecious*. *Sporophytes* on main stem. *Perichaetial leaves* narrow, erect. *Setae* slender, erect or flexuose, 1.0-1.5 cm long. *Capsules* slightly bent, suburceolate, 0.8-1.2 x 0.5 mm; operculum conical, short rostrate; peristome not seen but exostome reported normal (not perforate) and endostome rudimentary.

Illustrations. — Gangulee 1980 (Fig. 937 as *Clastobryum surcularis*); Noguchi 1987-94 (Fig. 478A, as *Neacroporium flagelliferum*); Tan & Jia 1999 (Fig., III: F).

Thailand. — PENINSULAR. Nakorn Sri Thamarat; SOUTHEASTERN. Prachin Buri.

Distribution. — Sri Lanka, Indochina, China, Taiwan, Japan, Indonesia, Malaya Peninsula and Australia (Queensland).

Ecology. — Plant grows on small tree trunks and branches in semi-disturbed forest at Alt. 250-1200 m.

Specimens examined.— TYPE. Bidor Road, Tapah, Perak, 1908, *H. N. Ridley 153* (lecto-, BM); Penang Hill, Palau Penung, 1896, *H. N. Ridley 551* (syn-, BM). PENINSULAR. Nakorn Sri Thamarat [Khao Luang, 8 May 1951, *Smitinand 888* (L); *Smitinand 5774* (FH, NY); 2 Feb. 1966, *Touw 11385* (BM); 2 Jun. 1966, *Touw 11946* (BM), 3 Aug. 2007, *Pollawatn 646, 654, 671* (BCU)]; SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 18 Feb. 1966, *Touw 12327* (BM)].

Discussion. — There are two distinct forms of leaves observed in *I. surcularis*. Plants with strongly concave leaves are the same as the type of *Neacroporium flagelliferum* from Japan and Taiwan, while plants which complanate filiation or cymbiform leaves are called *I. surcularis* in Southeast Asia. Because of the presence of many intermediate specimens, the two extreme leaf forms are not accorded separate taxonomic recognition in this treatment. Iwatsuki and Noguchi (1971) prepared the best illustration for *I. surcularis*. Their drawings, however, show only the “flagelliferum” form of this species with concave leaves (Tan, B. C. & Jia Yu, 1999).

## 12. MASTOPOMA Cardot

***Mastopoma* Cardot**, Rev. Bryol. 28: 116. 1901. — Holotype: *Mastopoma raphidostegioides* Card.

*Plants* large, usually robust, glossy, in lax or dense mats. *Stems* creeping, pinnately branched. *Leaves* crowded, erect-spreading or second, ovate-lanceolate, concave, spinose-serrate in upper half; costa short and double or none; cells linear, smooth; alar group inflated and colored.

*Pseudoautoicous*. *Sporophytes* on main stem. *Setae* very long, curved at tip. *Capsules* horizontal, ovoid; operculum short, conical, apiculate, not beaked.

The genus consists of 23 species in world wide. There are 2 species found in Thailand.

## Key to Species

1. Leaves erect-spreading, lanceolate, 1.8-3.0 x 0.2-0.8 mm, concave base, long acuminate apex; margins serrate in upper half; laminal cells narrowly linear, smooth; alar cells forming a row of 3-5 large cells, inflated and colored.....1. *M. robinsonii*
1. Leaves slightly falcate, rigid, ovate to ovate-lanceolate, concave base; margins serrate in upper half, 2.0-2.5 x 0.6-0.8 mm; laminal cells fusiform to elongate, becoming smaller and narrower near margins at leaf apex; alar cells numerous, rectangular, inflated, hyaline or colored, thin-walled, forming several rows ..... 2. *M. subfiliferum*

1. ***Mastopoma robinsonii* (Broth.) E.B. Bartram**, Philip. Journ. Sci. 68: 316. f. 402. 1939. *Acanthocladium robinsonii* Broth., Philip. J. Sci. 5:159. 1910. — Type: Luzon, Laguna Province, Mount Banahao, *Robinson 6566* (FH!).

## Figure 5.39

*Plants* golden-green, robust in dense mats, glossy. *Stems* creeping, irregularly pinnate to bipinnate; lateral branches spreading, up to 1.5 cm long and 2 mm wide included leaves, ultimate branches up to 5 mm long, slightly complanate, slender, cuspidate at tips. *Leaves* erect-spreading, rigid, ovate-lanceolate, 1.8-3.0 x 0.2-0.8 mm, gradually narrowed from a broadly to linear acumen, concave base; margins strongly serrate in upper half; ecostate; laminal cells narrowly linear to elongate, 67-98 x 3-5  $\mu\text{m}$ , smooth, becoming smaller and broader near margins and leaf apex; alar cells large, arranged in a single row, oblong to kidney shaped, 55-70 x 18-25  $\mu\text{m}$ , inflated and colored; leaves of ultimate branches smaller.

*Dioecious*. *Perichaetial leaves* ovate-lanceolate, 4.5 mm long, gradually narrowed to a long, linear, spinose-serrate acumen. *Setae* up to 5.5 cm long, red, smooth, slightly curved at tip. *Capsules* inclined, asymmetrical, urn 2 mm long; peristome teeth densely striolate, with a fine zigzag median line, not furrowed, segments of endostome from a basal membrane about 1/3 height of teeth; operculum short, conic, apiculate, 0.6 mm long. *Calyptrae* large, cucullate, 5 mm long. *Spores* 15-22  $\mu\text{m}$ , minutely papillose.

Illustrations. — Bartram 1939 (Pl. 23, fig. 402).

Thailand. — PENINSULA. Surat Thani.

Distribution: Philippines.

Ecology. — Alt. 60 m.

Specimens examined.— Type: Luzon, Laguna Province, Mount Banahao, *Robinson 6566* (lecto-FH). PENINSULA. Surat Thani [*LNS 30807* (AAU)].

Discussion. — This species is showing a new locality distribution to Thailand, it was reported as endemic to Philippines.

2. ***Mastopoma subfiliferum* Horik. & Ando**, Nature and Life in Southeast Asia 3: 36. f. 8. 1964. — Type: Thailand. Doi Inthanon, *Yoda 67764* (Holo-, HIRO).

## Figure 5.40

*Plants* large, yellowish green to greenish brown, robust in dense mats, glossy. *Main stems* creeping, to 5 cm long, irregularly pinnate to bipinnate branched; branches spreading, short to long, up to 3 cm in length and 2 mm in width, slightly complanate, slender, cuspidate at tips; *Leaves* slightly falcate, rigid, gradually narrowed to linear acumen from an ovate-lanceolate, 2.0-2.5 x 0.6-0.8 mm, concave base; margins densely serrate in upper half; ecostate; laminal cells fusiform to elongate, 50-75 x 5-7  $\mu\text{m}$ ,

becoming smaller and broader near margins and leaf apex; alar cells numerous, quadrate to subrectangular, 18-25 x 15-18  $\mu\text{m}$ , inflated, thin-walled, hyaline or colored, forming several rows; leaves of ultimate branches smaller.

*Sporophytes* not seen.

Illustrations. — Horikawa & Ando (1964, Fig. 8).

Thailand. — NORTHERN. Chiang Mai

Distribution. — Endemic to Thailand.

Ecology. — Plants grow on tree trunks or trunk base, alt. 1300-2550 m.

Specimens examined.— TYPE. Chiang Mai, Doi Inthanon, 1 Sep. 1958, alt. 2550 m, *Yoda 67764* (iso-, HIRO); NORTHERN. [Chiang Mai, 12 Sept. 2007, Pollawatn 727, 732, 745 (BCU), *Yoda 67648*, 67770, 67918 (HIRO); 5 Dec. 2000, *Akiyama Th-2* (NY)].

Discussion. — Akiyama and Tsubota (2001) suggested *M. subfiliferum* should be transferred to *Heterophyllum* or place in a separate new monotypic genus by the reason of its alar organization that useful to separate most species of *Mastopoma* from *Trismegistia*, there exist an exception: *Mastopoma subfiliferum* Horik & Ando, which grows side by side with *Pseudotrismegistia undulata* at Doi Inthanon, and which has divided, scalariform quadrate to subrectangular alar cells that are all of nearly equal size. This alar feature is characteristic for the subfamily Heterophylloioideae of the Sematophyllaceae (Tan and Buck 1989).

### 13. MEIOTHECIUM Mitt.

*Meiothecium* Mitt., J. Linn. Soc. Bot. 10: 185. 1868. — Type: non designatus.

*Plants* slender to coarse, forming wide and compressed tufts, green to yellow to brownish-green, glossy. *Stems* creeping, irregularly-pinnately branched; branches arched, ascending, blunt, thick and terete to complanately leafed, short and unbranched to longer somewhat branched. *Leaves* imbricate when dry, second, sometimes weakly plicate, cucullate-concave, ovate to elongate, acute, margin entire, often recurved, branch leaves heteromorphic, the ventral leaves having longer points, ecostate; laminal cells usually smooth, upper cells rhombic with elliptical lumen, marginal cells longer, basal leaf cells longer and yellow at insertion; alar region with 2-3 swollen basal alar cells, hyaline or yellow, quadrate; supra alar cells forming a defined group of numerous row of sub-quadrate cells.

*Autoicous*. *Perigonia* and *Perichaetia* on branches; inner perichaetial leaves small, erect, acuminate, often somewhat curved, smooth or with very obscure mammillae. *Calyptrae* cucullate, small, smooth, or rough at apex. *Setae* 2-3 mm rarely to 5 mm with very flat mammillae. *Capsules* inclined, small ovoid to long elliptic or cylindrical, mouth often contracted when dry, neck short; exothecial cells semi-collenchymatous, thicken along longitudinal walls; operculum short, rostrate from a swollen conic base; peristome usually single, exostome 16, teeth lanceolate to linear-lanceolate, pallid, unistriate, densely papillose, rarely smooth, without trabeculae; endostome absent or distinct. *Spores* 25-30 (-40)  $\mu\text{m}$ , finely papillose. No chromosome number available.

There are more than 50 species worldwide in South America, Africa, Malesia, Pacific Islands and Australia. In Thailand found 3 species.

## Key to Species

1. Plants small, brownish green, low mats or tuft; leaves distally, ovate acute, plicate, 2.0-2.3 x 0.5-0.62 mm, nearly oval, thick-walled along near margin; leaf cells irregularly rhomboid, 23-25 x 7.5-10  $\mu\text{m}$ , at tip, more elongated and narrow at middle; alar region oblong, 3-4 cells, inflated and tinted ..... 1. *M. jagorii*
1. Plants large, yellow-green to greenish brown, more or less glossy, low tufts; leaves dense, erect to erectopate, concave, plicate, ovate to oblong-ovate, apex acute to acuminate; alar with a row of oval-rectangular more than 5 cells..... 2
  2. Plants slender, greenish brown; branches ascending; leaves plicate (2 to 3 plicae), .... ovate to oblong-ovate, 1.3-1.5 x 0.4-0.5 mm, apex short-acuminate; lamina cells short, rhomboidal, incrassate; setae less than 5 mm long ..... 2. *M. microcarpum*
  2. Plant robust, yellowish green; branches blunt; Leaves ovate to ovate-lanceolate, 2.2-2.5 x 0.6-0.8 mm, narrowly to acuminate apex, bent outward; margins involute on two side of the leaf; leaf cells oblong elliptically in middle leaf, 45-60 x 4-5  $\mu\text{m}$ , more shorter and narrower at apex; setae more than 5 mm long ..... 3. *M. turgidellum*

1. *Meiothecium jagorii* (Müll. Hal.) Broth., Nat. Pfl., 1(3): 1103. 1908. *Neckera jagorii* Müll. Hal., Bot. Zeit., 22: 373. 1864. *Sauloma jagorii* (Müll. Hal.) Sande Lac., Bryol. Jav., 2: 209. 1864. *Pterogonium jagorii* (Müll. Hal.) Müll. Hal., Linnaea 36: 8. 1869. *Pterogonium jagorii* (Müll. Hal.) Jaeg., Ber. S. Gall. Naturw. Ges., 1875-76: 207. 1877.

## Figure 5.41

*Plants* robust, glossy, yellow-green to brownish green, forming low mats. *Main stems* creeping, branching in irregular pinnate manner. *Leaves* dense, all bent to one side (erect on the flat stem), somewhat appressed to stem when dry, ovate acute, plicate, 2.0-2.3 x 0.5-0.62 mm, nearly oval, thick-walled along margin, involute on two side of the leaf; ecostate (Fleischer states that faint, short double costa is sometimes apparent); leaf cells irregularly rhomboid, 23-25 x 7.5-10  $\mu\text{m}$ , at tip, more elongated and narrow, 45-55 x 5-7  $\mu\text{m}$  at midleaf; alar region with a row of large, inflated and tinted cells, 45-50 x 18-22  $\mu\text{m}$ , forming a row across the leaf attachment region; on top of this the cells are smaller and irregularly rhomboid, 25-35 x 9-12  $\mu\text{m}$ , arranged in diagonal rows to the leaf margin; the axial row cells are a little narrower with highly porose walls.

*Autoicous*. *Perichaetial leaves* narrow, erect. *Setae* bent at top, 5-7 mm long. *Capsules* inclined to horizontal, ovate-cylindrical, 1.0-1.2 x 0.5- 0.6 mm; peristome of exostome teeth only, 180-200  $\mu\text{m}$  high and 55-60  $\mu\text{m}$  wide at base, distantly placed.

*Illustrations*. — Gangulee 1980 (Fig. 953).

*Distribution*. — Borneo, Celebes, India, Java, Myanmar, Philippines, and Sri Lanka.

*Ecology*. — Plants on tree trunks in *Areca* plantation along stream, Alt. 200-600 m.

*Specimens examined*.— TYPE. Singapore [*Faurie* 5889 as *Meiothecium viridissima* C. Müll (FH)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 2 Feb. 1966, *Touw 11376* (AAU, L); 3 Feb. 1966, *Touw 11490* (AAU, L); 7 Feb. 1966, *Touw 12013* (AAU, L, NY), 6 Aug. 2007, *Pollawatn 701, 712, 743, 749* (BCU)].

*Discussion*. — The Andaman specimen appears to be larger than Java specimens examined by Fleischer.

2. *Meiothecium microcarpum* (Hook.) Mitt., J. Linn. Soc. Bot., 10: 185. 1868. *Pterogonium microcarpum* Hook., Icon. Pl. Rar., 1: 24 f. 12. 1836. *Sauloma microcarpa* (Hook.) Mitt., Music Ind. Or.: 116. 1859. *Pterogoniella microcarpa* (Hook.) Jaeg., Ber. S. Gall. Naturw. Ges., 1874-75: 112. 1876. — Type: Indonesia, West Java, Wallich s.n. (BM).
- Pterogonium macrocarpum* Harv., Lond. J. Bot., 2: 12. 1840. nom. illeg.
- Pterigynadrum lineolatum* Duby, Moritzi: Syst. Verz. Zoll. Pfl.: 130. 1846.
- Neckera leucocytus* C. Müll., Syn., 2: 76. 1850. nom. illeg.
- Neckera macrocarpa* C. Müll., ibid.: 78. 1850. nom. illeg.
- Stereophyllum wattsii* Broth., Proc. Linn. Soc. New South Wales 24: 375. 1899, nom. nud. in synonym. — Original material: New South Wales, on fig trees, Tintenbar Road, Ballina, Richmond River, Apr 1897, W.W. Watts 1201 & 1202 (NSW).
- Pterogoniella wattsii* Broth., Oefv. Foerh. Finska Vetensk.-Soc. 42: 109. 1900.
- Meiothecium Wattsii* (Broth.) Broth., Nat. Pfl. 1(3): 1103. 1908, syn. nov. — Type: Australia, New South Wales, on bark, Alstonville Road, Ballina, 18 Aug 1899, W.W. Watts 3722 (holo-, H-BR; iso-, NSW).

#### Figure 5.42

Plants normal to quiet big, robust, yellow-green, glossy in low tufts. Main stems creeping, divaricating, pale red, glossy, subpinnate 1-1.5 cm; branches pinnate, often bushy. Leaves dense, erect to erectopate, concave, 1.3-1.5 x 0.4-0.5 mm, contorted or plicate when dry, otherwise suberect, narrowly ovate, apex short-acuminate, rounded or blunt, apical cell short, margin entire; ecostate; laminal cells short, rhomboidal, incrassate,  $\pm 36 \times 6 \mu\text{m}$  at top, margin entire, slightly recurved, single plica down centre, mid-laminal cells  $45 \mu\text{m} \times 6 \mu\text{m}$ , wider near margin; alar region with basal row of several tinted or swollen cells, large, ovate-rectangular, usually extending along leaf insertion, upper alar cells 2-4 rows, quadrate to rectangular.

*Autoicous*. Sporophytes on branches. Perigonia on branches, widely ovate, acute apex; perichaetial leaves erect, apex acuminate. Calyptrae smooth, truncate at base. Setae short, less than 5 mm, straight or occasionally twisted to right, smooth. Capsules nodding to suberect, inclined to horizontal, ovate-cylindrical, 1.2-1.5 x 0.3-0.5 mm; operculum conic, long rostrate; peristome single, exostome teeth 0.3 mm high, lanceolate, widely separated, papillose on both sides, up to 200  $\mu\text{m}$  long, zig-zag median line; endostome or annulus not developed. Spores 20-30  $\mu\text{m}$ , rough, papillose.

Illustrations. — Bartram 1939 (Pl. 24, fig. 411); Gangulee 1980 (Fig. 954, p.1875); Noguchi 1987-94 (Fig. 482A); Seki 1968 (Fig. 5).

Thailand. — NORTHERN. Chiang Mai; NORTHEASTERN. Loei; CENTRAL. Nakhon Nayok; SOUTHEASTERN. Chanthaburi; PENINSULA. Nakhon Si Thammarat, Phuket, Songkhla, Satun.

Distribution. — Ceylon, Singapore, Moluccas, Banka, Borneo, Celebes, Amboina, China, India, Japan, Java, Malaysia, Myanmar, Nepal, New Guinea, Philippines, New Guinea, New Caledonia, Samoa, Sri Lanka, Taiwan, and Vietnam.

Ecology. — Plant growth on trees and shrubs in open forest of sandstone and granitic massive, along stream in evergreen forest, alt. 50-1250 m.

Specimens examined.— TYPE. Indonesia, Bogor, as *Pterogoniella microcarpa* Hook (FH). NORTHERN. Chiang Mai [*LSaW 2881a* (AAU)]. NORTHEASTERN. Loei [8 Jan. 1966, *Touw 10514* (BKF, L)]. CENTRAL. Nakhon Nayok [*Touw 12178, 12384* (L)]. SOUTHEASTERN. Chanthaburi [Khao Yai National Park, 16 Feb. 1966, *Touw 12178* (AAU, L); 18 Feb. 1966, *Touw 12384* (L); *Kerr 446* (BM), 4 Oct. 2005, *Pollawatn 332, 339, 346* (BCU)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 2 Feb. 1966, *Touw*

11374 (AAU, L); 7 Feb. 1966, *Touw 12009* (L)]; Phuket [26 Jan. 1966, *Touw 11284* (L)]; Songkhla [*Kerr 321* (BM)]; Satun [*Kerr 264* (BM)].

Discussion. — *Meiothecium microcarpum* was a south & east Asiatic species spreading to Pacific. Ramsay et al (2004) proposed *Meiothecium watsii* is synonym of this taxon because of its differing from *M. microcarpum* in having shorter setae and smaller capsules. The numerous collections (over 60) of this specimens from Australia show that the distinctions between the two taxa are not clear cut, hence, they are proposing that they are synonymous.

3. *Meiothecium turgidellum* M. Fleisch., Musci Fl. Buitenzorg 4: 1238. 1923. — Type: Indonesia, West Java, Tjibodas, 1898, *M. Fleisch* (FH!).

#### Figure 5.43

*Plants* robust, glossy, yellow-green, glossy, forming mats (usually corticolous). *Main stems* creeping, branching in irregular pinnate manner; branches blunt, up to 1 cm long, 2 mm wide included leaves. *Leaves* dense, appressed to stem when dry, ovate to ovate-lanceolate, 2.2-2.5 x 0.6-0.8 mm, concave, gradually narrow to tapering acuminate apex, bent outward; margin involute on two side of the leaf, minutely serrate near apical; ecostate; leaf cells irregularly rhomboid, 25-35 x 5-7.5 µm, porose at tip, more elongated and narrow at midleaf, 45-60 x 4-6 µm; the axial cells near margin, arranged in oblique row of little narrower with highly porose walled cells; alar region with a row of large, inflated and colored cells, 45-50 x 18-22 µm, forming a row across the leaf attachment region; on top of this the cells are smaller and irregularly rhomboid, 13-15 x 7.5-10 µm, arranged in diagonal rows to the leaf margin.

*Autoicous*. *Perichaetial leaves* narrow, erect. *Setae* bent at top, up to 1 cm long. *Capsules* inclined to horizontal, ovate-cylindrical, 1.2-1.5 x 0.5-0.6 mm; peristome of exostome teeth only, 180-220 µm high, 50-60 µm wide at base, distantly placed.

Illustration. — Unknown.

Distribution. — Java and Myanmar.

Ecology. — On tree trunks in moist evergreen forest, along streamlet, alt. 725-800 m.

Specimens examined.— TYPE: Indonesia [West Java, Tjibodas, 1898, *M. Fleisch* (lecto-, FH)]. NORTHERN. Chiang Mai [Doi Inthanon, 28 Oct. 1962, *Robbins 3548* (L), 11 Sept. 2006, *Pollawatn 471, 477, 484* (bcu)]; Tak [Doi Musae, 20 Nov. 1965, *Touw 8269* (BKF, L)]. PENINSULA. Ranong [*Kerr 383, 386* (BM)].

Discussion. — In specimens from Thailand, sometime found short binerves present in old leaves.

### 14. PAPILLIDIOPSIS (Broth.) W.R. Buck & B.C. Tan

*Papillidiopsis* (Broth.) W.R. Buck & B.C. Tan, Acta Bryol. Asiat. 1:9. 1989. [1990]. *Trichosteleum* sect. *Papillidiopsis* Broth., Nat. Pflanzenfam. I(3): 1119. 1908.

*Plants* small to large, in loose mats. *Main stems* elongate, prostrate; secondary stems irregularly pinnately branched, complanate, often flagelliform; pseudoparaphyllia foliose; axillary hairs with a short, brownish basal cell and 2-3 elongate, hyaline apical cells; central strand absent. *Primary stem leaves* appressed, ovate-lanceolate, acuminate; branch leaves erect-spreading, often clearly five-ranked, ovate-lanceolate to oblong-lanceolate, strongly concave, narrowed at base, abruptly constricted toward apex, becoming shortly

acute, obtusely apiculate, or rarely long-acuminate at apex; margin serrulate, plane, or sometimes slightly recurved above; costae short, double or absent; leaf cells linear or vermiform, becoming shorter, thicker, thick-walled or pitted toward apex, upper cells unipapillose; alar cells inflated, oblong, thin-walled, colored, with smaller, thin walled cells above the inflated cells.

*Monoicous*. *Setae* elongate, sometimes slender, reddish, often coarse above, sometime smooth. *Capsules* small, ovoid, inclined to pendent; exothecial cells clearly collenchymatous; opercular obliquely long-rostrate; annuli none; peristome double; outer surface of the exostome teeth with a zigzag median line, coarsely papillose above, cross-striate below, inner surface trabeculate; endostome segments keel, perforate; basal membrane high; cilia 1-2. *Calyptrae* cucullate, naked, smooth. *Spores* medium-size, papillose.

The species consists of 13 species 1 variety in the world. Three species are recognized for the moss flora of Thailand.

### Key to Species

1. Plant medium-sized, in low mats; branches up to 7 mm long; leaves erect-spreading, broadly oblong to rounded ovate, concave, broadly shortly acuminate to acute apex; margins plane, plicate, entire below, weakly denticulate at apex; leaf cells fusiform to linear, 40-55  $\mu\text{m}$  long, oval to oblong near apex. ....2. *P. macrosticta*
1. Plant rather large, glossy, robust in extensive mats; branches up to 15 mm long; leaves ovate-lanceolate, or oblong to elliptico-lanceolate, acuminate to elongate acumen. .... 2
  2. Leaves more than 2 mm long, erect-spreading, oblong, abruptly tapering to an elongate, straight acumen, slightly concave; margin recurved at middle, serrulate above, elsewhere entire; middle laminal cells linear, 60-70 x 4.0-4.5  $\mu\text{m}$ , towards the leaf apex shorter and wider, with thicker walls, papillae in distinct... 1. *P. complanata*
  2. Leaves up to 2 mm long, erectopotent to spreading may be complanate, concave; lamina cells unipapillose ..... 3
3. Leaves narrow ovate-lanceolate, 1.7-1.9 x 0.4-0.5 mm, apex gradually acuminate, margin faintly denticulate down to midleaf; leaf cells narrow rhomboid with porose walls, 60-80 x 5-7  $\mu\text{m}$ , unipapillose. .... 3. *P. luxurians*
3. Leaves dense, oblong to elliptico-lanceolate, apex narrow acute 1.3-1.5 x 0.3-0.4 mm, concave, margin slightly denticulate; leaf cells elongate rhomboid, 35-38 x 5-7  $\mu\text{m}$ , with a central papilla on lumen except at base and at extrem tip. ....4. *P. stissophylla*

1. ***Papillidiopsis complanata* (Dixon) W.R. Buck & B.C. Tan**, Acta Bryol. Lichenol. 1: 12. 1989 [1990]. *Acroporium complanatum* Dixon, Bull. Tor. Bot. Club 51: 256. pl. 4: f. 15. 1924. *Warburgiella complanata* (Dixon) Broth., Nat. Pflanzenfam. (ed.2) 11: 535. 1925. *Rhaphidostichum complanatum* (Dixon) Dixon, J. Siam Soc. Nat. Hist. Suppl. 10: 24. 1935.

*Rhaphidostichum longicuspdatum* Seki, J. Sci. Hiroshima Univ., Ser.B, Div.2, Bot.5. 12: 66. f. 8, 28. 1968. — Type. Japan. Amamioshima Island: Yuwan, Mt. Yuwandake, 670 m, *Seki TS-34217* (Holo-, HIRO).

*Plants* rather large, yellowish-green, glossy in extensive mats. *Stems* prostrate; branches up to 15 mm long, obtuse at the apex. *Stem leaves* appressed and slightly secund, oblong-lanceolate, slightly concave, abruptly tapering to an elongate, straight acumen, 2.4-

2.6 x 0.7 mm; margins plane, reflexed to incurved in the upper 1/3, entire below, weakly denticulate at apex; middle laminal cells linear, 90-110 x 5-7  $\mu\text{m}$ , thick-walled, towards the leaf apex shorter and wider, with thicker walls, papillae in distinct, toward the leaf base shorter, the extreme basal cells thick-walled, brown; alar cell much longer, 80-85 x 12-15  $\mu\text{m}$ , 4-5 in a transverse row oblong gradually long-attenuate.

*Monoicous*. Inner perichaetial leaves similar to the branch leaves, dentate to shoulders. *Perigonia* 0.45-0.50 mm, axillary. *Setae* 6-7 mm long, scabrous above. *Capsules* inclined, oblong, with an apophysis, 0.7-1.0 x 0.4-0.6 mm; operculum ca. 0.6 mm. long, with an erect beak; peristome double, exostome teeth to 0.3 mm long, irregularly in outline; basal membrane of endostome high.

Illustrations. — Noguchi 1994 (fig. 485, C. as *Rhaphidostichum longicuspdatum*), Dixon 1924 (Pl. 4, fig. 15).

Thailand. — NORTHEASTERN. Loei.

Distribution. — Africa, Malaysia, China, Japan, Kampuchea, Laos, Vietnam.

Ecology. — On tree trunks and branches in evergreen forest, alt. 1200 m.

Specimens examined.— NORTHEASTERN. Loei [*Kerr 571* (BM)].

Discussion. — This species was reported in a checklist moss flora of Thailand (He 1995), but the specimen is lacking from this revision. All description species based on Noguchi (1994) and Jia et al. (2005).

2. *Papillidiopsis luxurians* (Dozy & Molk.) W.R. Buck & B.C. Tan, Acta Bryol. Asiat. 1: 12. 1989. *Hypnum luxurians* Dozy & Molk., Ann. Sc. Nat. Bot. ser. 3, 2: 307. 1844. *Sematophyllum luxurians* (Dozy & Molk.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 380. 1878. *Trichosteleum luxurians* (Dozy & Molk.) Broth., Nat. Pfl., 1(3):1119. 1908. *Rhaphidostichum luxurians* (Dozy & Molk.) M. Fleisch., Musci Fl. Buitenzorg, 4:1310, 211. 1923.

#### Figure 5. 44

*Plants* yellow-green to brownish green, robust, glossy plants in densely tufts. *Main stems* long, creeping, pinnately branch, sometimes giving rise to slender flagelliform branches from tips; branches up to 1 cm long. *Leaves* erectopatent to spreading (appressed and sometimes falcate when dry), may be complanate, concave, narrow ovate-lanceolate, 1.7-1.9 x 0.4-0.5 mm, apex gradually acute, margin faintly denticulate down to midrib; ecostate; leaf cells narrow rhomboid with porose walls, 60-80 x 5-7  $\mu\text{m}$ , unipapillose; alar differentiated by a row of large, oblong, inflated, tinfated cells at extreme angle.

*Phylloidioicous* and *pseudoautoicous*. *Sporophytes* on main stem. *Perichaetial leaves* narrow lanceolate, erect, margin serrate. *Setae* erect, 1-1.5 cm. high, arcuate at top, slightly rough on top. *Capsules* horizontal to nodding, ovate, exothecial cells collenchymatous from a little below mouth; operculum long rostrate; peristome normal, double, with cilia in pairs, basal membrane high. *Calyptrae* cucullate. *Spores* smooth, 14- 18  $\mu\text{m}$  in diameter.

Illustration. — Gangulee 1980, (Fig 976, p.1910, as *Trichosteleum luxurians*).

Thailand. — PENINSULA. Nakhon Sri Thammarat, Songkhla.

Distribution. — Borneo, India, Java, Philippines, and Sumatra.

Ecology. — Plants growth on stone in light evergreen forest and epiphyte in stunted mossy forest, alt. 400-1700 m.

Specimens examined.— PENINSULA. Nakhon Sri Thammarat [Khao Luang, 2 May 1966, *Touw 11778* (BM)]; Songkhla [Khao Keo, 27. Jul. 1928, *Kerr 318* (BM)].

Discussion. — This species as the previous one (*glauco-virens*) were removed from *Trichosteleum* to *Rhaphidostichum*. But such change does not seem necessary so that they are brought back to *Trichosteleum* (Gangulee, 1980).

3. ***Papillidiopsis macrosticta* (Broth. & Par.) Buck & B. C. Tan**, Acta Bryol. Asiat. 1: 12. 1989 [1990]. *Trichosteleum macrostictum* Broth. & Par. Herb. Boissier, ser. 2, 2: 933. 1902. — Type: Japan.; *Rhaphidostichum macrostictum* (Broth. & Par.) Broth., Nat. Pflanzenfam. (ed.2), 11: 435. 1925.

*Rhaphidostichum chaetomitriopsis* (Dix.) Touw, Nat. Hist. Bull. Siam Soc. 22: 239. 1968.  
*Trichosteleum chaetomitriopsis* Dix., J. Siam Soc., Nat. Hist. Suppl. 10: 23. 1935.

#### Figure 5.45

*Plants* medium-sized, in low mats. *Main stems* prostrate; branches up to 5 mm long. *Leaves* erect-spreading, broadly oblong to rounded ovate, somewhat second to slightly twisted, concave, broadly shortly acuminate to acute apex, becoming narrower toward base; margins plane, plicate, entire below, weakly denticulate at apex; leaf cells fusiform to linear, 45-65 x 3-5  $\mu\text{m}$  at middle leaf, becoming thicker and pitted toward base, oval to elliptic near apex, unipapillose cells densely in upper 2/3 of leaf; alar cells forming one basal row, 4-5 cells, oblong enlarged, 40-45 x 13-15  $\mu\text{m}$ , inflated, hyaline or colored, thin- or thick-walled, supra-alar cells few, small, inconspicuous.

*Monoicous*. *Inner perichaetial leaves* large, twice as big as the vegetative leaves, long acuminate, sharply toothed in the upper half of the blade, no alar differentiation. *Perigonial leaves* smaller, ovate. *Setae* up to 13 mm long, smooth. *Capsules* small, ellipsoidal, less than 1 mm long, nodding.

Illustration.— Noguchi 1994 (fig. 487, B).

Thailand. — NORTHEASTERN. Loei; EASTERN. Nakhon Ratchasima;  
SOUTHEASTERN. Chanthaburi, Prachin Buri.

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

Ecology.— on tree trunks ; alt. 1,200-1,700 m.

Specimens examined.— TYPE. Laos [Chiang Wang, 20 Apr. 1932, *Kerr 511a*, (holo-, BM)]; Loei [Phu Krading, 2 Nov. 1931, *Kerr 569a* (as *Trichosteleum chaetomitriopsis*, (para-, BM)]. EASTERN. Nakhon Ratchasima [Khao Khieo, 4 Apr. 1965, *Tixier 503* (BKF, PC)]. SOUTHEASTERN. Chanthaburi [Pong Nam Rawn, 28 Jan. 1956, *Smitinand 3214* (BKF, FH)]; Prachin Buri [Khao Yai National Park, 4 Oct. 2005, *Pollawatn 330, 335, 338, 344* (BCU), *Touw 12091, 12100* (AAU, BKF)].

Discussion. — The specimens identified as *Trichosteleum chaetomitriopsis* Dix. has more shorter leaves and more prominent papilla leaf cells.

4. ***Papillidiopsis stissophylla* (Hampe) B.C. Tan & Y. Jia**, J. Hattori Bot. Lab. 86: 41. 1999.; *Trichosteleum stissophyllum* (Hampe & Müll. Hal.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 417. 1878.; *Hypnum stissophyllum* Hampe. In C. M. Muell., Syn., 2: 273. 1851. — Type: Ceylon, Java, Khasin Hills, 1200 m, *JDH & TT 1071b* (BM).

*Stereodon stissophyllum* Mitt., Musci Ind. Or.: 101. 1859.

#### Figure 5.46

*Plants* yellow-green, glossy, moderate-sized, usually tufts. *Main stems* creeping on twigs branching pinnately; branches 10-12 mm long and 1-1.25 mm wide, slightly curved distally. *Leaves* dense, erectopate (erect when dry), elliptic to lanceolate, apex narrow

acute, 1.3-1.5 x 0.3-0.4 mm, concave; margins faintly denticulate; ecostate; leaf cells elongate rhomboid to narrowly fusiform, 45-70 x 5-7 $\mu$ m, slightly incrassate and pitted, shorter and more incrassate at sharply acute leaf apex, with a central papilla on lumen except at base and at extreme tip; alar distinguished by about 2-3 large cells, colored, inflated, oblong cells, 35-40 x 20-25  $\mu$ m at extreme angle with some irregular, smaller cells on top; the row with large alar cells tinted along line of insertion.

*Monoicous*. *Sporophytes* on main stem. *Setae* slender, erect, arcuate at top, up to 1.2 cm long, smooth below and papillose above. *Capsules* small, horizontal to drooping, ovate 0.6-1.0 x 0.4-0.5 mm; exothecial cells strongly trigonous and mammillose; operculum long rostrate; peristome normal, double. *Spores* large, 20-22  $\mu$ m, slightly papillose.

Illustration. — unknown.

Thailand. — SOUTHEASTERN. Chantaburi; PENINSULA. Nakhon Sri Thammarat, Phuket.

Distribution. — India, China, Malaysia, Borneo and the Philippines.

Ecology. — On twigs and leaves, in stunted mossy forest, alt. 100-1300 m.

Specimens examined.— TYPE. [as *Hypnum stissophyllum* Hampe, (holo-, BM); as *Trichosteleum stissophyllum* (Hampe) Jaeg. (syn-, FH)]. SOUTHEASTERN. Chantaburi [Prieu Waterfall, Makham Forest Station, 26 Aug. 1966, *LSmW 1863* (AAU)]. PENINSULA. Nakhon Sri Thammarat [Khao Luang, 5 Feb. 1966, *Touw 11778, 11800* (BM)]; Phuket [Takuapa, Kapong, 17 Feb. 1929, *Kerr 417a*].

Discussion. — The species may in rivals *P. complanata* in morphological variation, but differs consistently from the latter in being smaller in plant sized and having a shorter and more acute leaf apex.

## 15. PSEUDOTRISMEGISTIA H. Akiy. & Tsubota

*Pseudotrismegistia* Akiyama & Tsubota, Acta Phytotax. Geobot. 52: 85. 2001.

*Plants* robust, stiff, often yellowish green, glossy, in interwoven patches. *Main stems* elongate and spreading, usually arcuate, erect or erect-spreading, with dense rhizoids; secondary stems erect, simple below, pinnately or densely branched above branches thick and short; paraphyllia rare. *Leaves* appressed or loosely appressed when dry, erect or erect-spreading when moist; stem leaves gradually becoming narrowly lanceolate to ligulate or forming a narrowly filiform acumen from an ovate base, often twisted at apex; margins slightly reflexed below, involute, serrate above; costae double, very short or none; leaf cells elongate, thick-walled, becoming shorter and wider upward, clearly prorate; leaf marginal cells in several rows, not prorate, forming a broad border, lower cells longer, smooth; basal cells yellowish brown; alar cells differentiated, large, golden yellowish or yellowish brown, with many small and short cells above alar cells; branch leaves small, acuminate, serrate.

*Dioicous*. *Inner perichaetial leaves* erect, narrowly lanceolate, margin serrate above. *Setae* thick, elongate, purple. *Capsules* large, horizontal, often arcuate; opercula conic, long rostrate; annuli differentiated; peristome double, the exostome teeth 16 with a medial zigzag line or a furrow on the outer surface of the exostomial tooth, inner surface often trabeculate. The surface ornamentation of the exostome changes from striate at the basal part to papillose toward the apex; Endostome teeth 16, segments usually narrowly lanceolate, keeled, rarely linear, with a basal membranous high with elongated

“processes”. The processes of the inner peristome alternated with the teeth of the outer peristome. Cilia usually present.

The monotypic genus. It is an Indochinese species with a disjunctive distribution in Taiwan. Its presence on Hainan Island can be predicted.

***Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota**, Acta Phytotax.

Geobot. 52: 86. 2002.; *Trismegistia undulata* Broth. & Yasuda, Rev. Bryol. 53: 4. 1926.— Type: Laos ? (holo-, H-BR) .

*Trismegistia perundulata* Dix., Ann. Bryol. 9: 69. 1936.; *Mastopoma perundulatum* (Dix.) Horik. & Ando, Nat. & Life Southe. Asia 3: 34. 1964.— Type: Laos, Chiengwang, Pu Bia, *Kerr 515* (holo-, BM).

#### Figure 5.47

*Plants* robust, stiff, often yellowish green, glossy, in interwoven patches. *Main stems* elongate and spreading, up to 5 cm long; usually arcuate, erect or erect-spreading, with dense rhizoids; secondary stems erect, simple below, pinnately or densely branched above branches thick and short; branches irregularly, short, up to 3 cm long, 2 mm wide; paraphyllia rare. *Leaves* appressed or loosely appressed when dry, erect or erect-spreading when moist; stem leaves gradually becoming narrowly lanceolate to ligulate or forming a narrowly filiform acumen from an ovate base, 1.8-2.4 x 0.5-0.8 mm, often twisted at apex; margins slightly reflexed below, involute, serrate above; costae double, very short or none; leaf cells elongate, thick-walled, 45-50(-80) x 4-7  $\mu\text{m}$ , becoming shorter and wider upward, clearly prorate; leaf marginal cells in several rows, not prorate, forming a broad border, lower cells longer, smooth; basal cells yellowish brown; alar cells differentiated, 5-8 large cells, 15-30 x 10-15  $\mu\text{m}$ , golden yellowish or yellowish brown, with, many small and short cells above alar cells; branch leaves small, acuminate, serrate.

*Dioicous*. *Sporophytes* on main stem. *Inner perichaetial leaves* erect, narrowly lanceolate, up to 3 mm long; margins serrate above. *Satae* thick, elongate, up to 5 cm long, reddish, smooth. *Capsules* large, ovate to oblong, 1.0-1.2 x 0.5-0.8 mm, inclined, groove at auricle when dry; annulus red permanent; exostome coil inside at apex, 350-380  $\mu\text{m}$  long, and 180-200  $\mu\text{m}$  wide at base; endostome with a basal membranous high, shorter erect; opercula conic, 1-2 mm long.

Illustration. — Jia *et al.* 2005. (Pl. 605, figs. 1-13).

Thailand. — NORTHERN. Chiang Mai.

Distribution. — China, Kampuchea, Laos, and Vietnam.

Ecology. — Epiphyte on trunks and branches along streamlets in hill evergreen forest, alt. 2,300-2,500 m.

Specimens examined.— TYPE. Japan [Mt. Daibu, Fomosa, 20 Nov. 1913, *E. Mitte 608* (holo-H-BR)]. NORTHERN. Chiang Mai [Doi Inthanon, 27 Mar. 1972, *Null 624* (L); 30 Oct. 1962, *Robbins 3628* (BKF, L); 12 Oct. 1969, *Beusekum B180, B234* (L, NY); 18 Dec. 1965, *Touw 9815* (BKF, L), *Touw 9747, 9729* (L); 20 Dec. 1965, *Touw 10038, 10232* (L), *10173* (L, NY), *Touw 10159*, (BKF, L, NY); 5 May 2000, H. Akiyama *Th-35* (NY)].

Discussion. — The monotypic genus was recently published by Akiyama (2002) based on *Trismegistia*. *Pseudotrismegistia undulata* is easily recognized by its leaves that are undulate, oblong or strap-shape from an expanded base. The several rows of much inflated, thin-walled and hyaline alar cells and the semi-collenchymatous exothecial cells ally this species in the subfamily Heteroophylloideae.

## 16. PYLAISIADELPHA Cardot

*Pylaiadiadelpa* Cardot, Rev. Bryol. 39: 57. 1912.

*Plants* slender, in densely interwoven patches. *Main stems* prostrate, extending, pinnately branched; branches short and erect. *Leaves* falcate curved, ovate-lanceolate, gradually becoming long acuminate toward apex; costae absent; leaf cells linear; alar cells differentiated.

*Dioicous*. *Setae* elongate; capsules erect or slightly curved; opercula long rostrate; peristome double, hypnoid; basal membrane low; cilia absent.

The genus *Pylaisiadelpha* at present consists of four species. The genus has distributed in India, Nepal, Sikkim, Sri Lanka, Myanmar, China, Japan, Korea, Japan, Kampuchea, Vietnam, Philippines, Eastern United States and Mexico. One species are known from Thailand.

*Pylaisiadelpha capillacea* (Griff.) B.C. Tan & Y. Jia, J. Hattori Bot. Lab. 86: 42. 1999.

*Neckera capillacea* Griff. in Cal. J. Nat. Hist., 3: 70. 1842. *Stereodon capillaceus* (Griff.) Mitt. in Musci Ind. Or.: 94. 1859. *Clastobryum capillaceum* (Griff.) Broth. ex Par. In Coll.:7. 1909.

*Hypnum prionotrichum* Hamp. In Dix.: Bull. Torr. Bot. Cl., 51: 236 (1924) *nom. nud. in synonym*.

### Figure 5.48

*Plants* slender to moderate-sized (not robust), yellow- to golden green, glossy in tufts. *Main stems* creeping with irregularly pinnate, somewhat julaceous branches; branches flattened up to 10 mm long, 2 mm wide. *Leaves* erectopatent (shrunk but not changed when dry), ovate lanceolate, varying according to specimen from 0.8-1.28 x 0.2-0.4 mm, tip acuminate, margin only faintly crenulate at tip (but Griffith shows a regular dentate tip and Mitten describes it as much); ecostate (Mitten suggests a faint, short, double veins); leaf cells narrow elongate, 38-45 x 5  $\mu$ m at tip, 55-75 x 7  $\mu$ m lower down; alar region differentiated by yellow tinted rectangular cells, 28-32 x 11-13  $\mu$ m, with a group of few quadrate to irregularly cells upward.

*Dioicous*. *Sporophytes* on main stem. *Perichaetial leaves* narrow, erect. *Setae* slender, erect, smooth, 1.1-1.3 cm long. *Capsules* erect or shortly inclined, ovate, 1.2-1.3 x 0.6-0.7 mm; operculum conic, short rostrate.

Illustration. — Gangulee 1969-80 (Fig. 939, as *Clastobryum capillaceum*); Tixier 1977 (Fig. 17).

Thailand. — SOUTHEASTERN. Prachin Buri.

Distribution. — India, Japan, Kampuchea, Myanmar, Nepal, Sikkim, Sri Lanka, Philippines, and Vietnam.

Ecology. — Alt. 1300 m.

Specimens examined.— TYPE. Burma [Moulurain, 7000 ft., Porish, H-BR1033010 as *Clastobryum capillaceum*]. SOUTHEASTERN. Prachin Buri [Khao khieo, 4 Apr. 1965, Tixier 418, 424, 425439, 452, 480, 486 (PC)].

Discussion. — Tixier (1977) considers the species as a *Gammiella* which he includes within the Clastobryoideae. This position, however, is not followed herein Gangulee (1980). The peristome in this specimen (*tenuiramenum*, JDH 770) clearly shows the broken base of exostome teeth but no trace of endostome. But Griffith shows clear narrow filamentous endostome processes slightly shorter than the exostome.

## 15. RADULINA W.R. Buck & B.C. Tan

**Radulina** W.R. Buck & B.C. Tan, Acta Bryol. Asiat. 1:9. 1989.

*Hypnum* sect. *Sigmatella* subsect. *Thelidium* Müll. Hal., Linnaea 39: 466. 1875.

*Trichosteleum* sect. *Thelidium* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gall. Naturwiss.

Ges. 1876-1877: 419. 1878., non *Thelidium* Massal. — Lectotype: *Hypnum pickeringii* Sull.

*Plants* medium to small in green to pale green patches, appearing somewhat opaque under the lens, often intermingled with other taxa, usually growing on the ground in forests, or on rotten logs. *Leaves* falcate-secund whether wet or dry, sometimes only at the tip of branches, lanceolate to ovate-lanceolate, long-acuminate, often serrulate, usually so distally; costa usually absent, short and double if present; laminal cells long, hexagonal to linear, quite thick-walled, usually porose, seriatly papillose, sometimes in more than one row; alar cells large and swollen, in a single row, with quadrate cells above, colored.

*Autoicous*, and often fertile. *Perichaetial leaves* oblong-lanceolate with irregular cell structure, cells longer, wider and laxer than normal leaf cells, strongly toothed above, often without papillae, alar cells not well-marked, but a row of large cells across the base. *Setae* orange-brown to red, tuberclose below the capsule but sometimes extending to near the base. *Capsules* walls strongly collenchymatous; peristome double.

The palaeotropic moss genus *Radulina* is revised, resulting in the genus being reduced to four species and one variety (O'Shea 2006). In Thailand found only one species.

**Radulina hamata** (Dozy & Molk) W.R. Buck & B.C. Tan, Acta Bryol. Asiat. 1: 10. 1989.

*Hypnum hamatum* Dozy & Molk., Ann. Sci. Nat. Bot. 3, 2: 307. 1844. *Trichosteleum hamata* (Dozy & Molk.) A. Jaeger, Ber. Thätigk. St. Gall. Naturwiss. Ges. 1876-1877: 420 (1878) (Ad 2: 486). — Type: Borneo, Sumatra, (syn-, L, NY!)

*Hypnum hamata* var. *semimamillosum* Müll. Hal. in Geheeb, Biblioth. Bot. 13:11. 1898.

*Trichosteleum hamatum* (Dozy & Molk.) A. Jaeger, var. *semimamillosum* (Dozy & Molk.) Paris, Ind. Bryol. 1: 1311. 1898. — Type: New Guinea, Astrolake Range, Rev. W.G. Law (L).

### Figure 5.49

*Plants* variable, in dense intricate tufts or mats, pale or lurid green, slightly glossy. *Stems* creeping, freely but irregularly pinnate; branches decumbent or ascending and falcate-cuspidate, 2-3(4) mm long, usually hooked at tips. *Pseudoparaphyllia* foliose. *Leaves* crowded, falcate-secund, narrowly lanceolate to ovate-lanceolate, gradually long-acuminate from a concave expanded ovate base, 1.5-2.2 x 0.4-0.5 mm, often smaller; margins plane, sharply serrulate in upper half; ecostate; laminal cells linear to narrowly elliptic 40-70 x 5 µm, firm to thick-walled, slightly porose, strongly seriatly pluripapillose with papillae uniseriate to biseriate over lumen; alar region differentiated with a basal row of 2-3 enlarged, 25-30 x 13-15 µm, inflated, hyaline thin-walleds, one row quadrate upper alar cells; across insertion cells yellow, thick-walled, in single row.

*Autoicous*. *Perichaetial leaves* abruptly long-acuminate, sharply toothed. *Calyptrae* cucullate, naked, roughened above. *Setae* elongate 1-1.75 cm, slender, reddish, smooth or papillose throughout, or papillose at base of capsule or in whole upper half. *Capsules* small, ovoid, 0.5-0.6 x 0.2-0.3 mm, inclined to horizontal, sometimes bending, arcuate, short-cylindric with obliquely, long slender rostrum exceeding the urn length; operculum

long rostrate, beak longer than urn; exothecial cells short-rectangular, strongly collenchymatous; annulus none; peristome double, exostome teeth 16, narrowly furrowed on outer surface, cross-striolate below, coarsely papillose above, trabeculate at back; endostome with high basal membrane, segments keeled, perforated, roughened, about as long as teeth, cilia single, stout, coarsely roughened. *Spores* medium sized, spherical, finely papillose.

Illustration. — Dozy and Molkenboer 1855-1861 (fig. 275, as *Hypnum hamatum*), Brothrus 1925 (fig. 741, p. 438 as *Trichosteleum hamatum*), Bartram 1939 (pl. 25, fig. 435 as *Trichosteleum hamatum*), Gangulee 1980 (fig. 979, p. 1913 as *Trichosteleum hamatum*), Tan and Jia 1999 (Fig. I: C; Fig. III: A.), Ramsey *et al.* 2004 (fig. 15-16).

Thailand. — NORTHEASTERN. Loei; EASTERN. Nakhon Ratchasima; SOUTHEASTERN. Trat, Prachin Buri; PENINSULA. Nakhon Si Thammarat, Ranuang.

Distribution. — Borneo, Celebes, Mainland China, India, Japan, Java, Kampuchea, Laos, Malaysia, New Guinea, Philippines, Sri Lanka, Sumatra, Vietnam and Australia.

Ecology. — This species occurs in dry coastal or upland monsoon rainforest, on trees and rotting logs on river bank and slope between 100-1,160 m alt.

Specimens examined.— TYPE. Indonesia [Padang-Bessie, Korthals s.n. (lecto-, L), Sumatra, Korthals s.n. (iso-, L)]. NORTHEASTERN. Loei [Phu Krading, 14 Jan. 1966, *Touw 10912* (AAU, L)]. EASTERN. Nakhon Ratchasima [Pak Thong Chai, 24 May 1965, *Tixier 1276* (BKF)]. SOUTHEASTERN. Trat [Koa Chang, 17. Nov. 1970, *CLaW 4976* (NY); Prachin Buri [Khao Yai National Park, 18 Feb. 1966, *Touw 12313* (AAU, L), 5 Oct. 2005, *Pollawatn 331, 342, 349* (BCU)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 6 Feb. 1966, *Touw 11923* (AAU, BKF), *Touw 11918* (AAU, BKF, NY); 3 Feb. 1966, *Touw 11448, 11513* (AAU, NY), *Touw 11519* (AAU); 2 Feb. 1966, *Touw 11425* (AAU, L)]; Ranuang [Khao Pujarn, 13 Jan. 1929, Kerr 392 (BM)].

Discussion. — This palaeotropic moss genus *Radulina* had revised by O'Shea (2006), the result had synonymized *Radulina hamata* (Dozy & Molk) W.R. Buck & B.C. Tan to *Radulina borbonica* (Bél.) W.R. Buck.

## 18. RHAPHIDOSTICHUM M. Fleisch.

*Rhaphidostichum* M. Fleisch., Musci Fl. Biutenzorg 4: 1307. 1923.

*Plants* rather robust, somewhat glossy, in dense patches. *Stems* prostrate, irregularly pinnately branched; branches erect-spreading or erect. *Leaves* arranged in numerous ranks, nearly complanate, erect or erect-spreading, ovate or oblong-ovate, spathulately concave, acute, shortly acuminate or slenderly acuminate to long piliform; margins weakly serrulate at apex; costae absent; leaf cells narrowly rhomboidal, thick-walled, sometimes pitted, smooth or papillose; basal cells slightly shorter; alar region consisting of one row of inflated cells, yellowish and hyaline, with few shorter and smaller cells above.

*Monoicous* or *dioicous*. *Setae* slender, elongate, smooth below, mamillate above. *Capsules* small, inclined or pendent, oblong-ovoid or cylindrical; opercular conic at base, obliquely and slenderly rostrate; peristome double; exostome teeth narrowly lanceolate, outer surface clearly with a median line, cross-striate below, hyaline, papillose above, inner surface clearly trabeculate; endostome segments as high as exostome teeth, keeled; basal membrane high; cilia 1-2, slightly shorter than segments. *Spores* small, smooth.

The genus consists of some 43 species in the world, mainly in the old world tropic regions, often growing on tree trunks and branches. There are 4 species occurred in Thailand.

### Key to Species

1. Plant large to medium sized; branches slender ascending; leaf ovate-lanceolate or oblong-ovate, concave; leaf cells linear, narrowly elongate or fusiform..... 2
1. Plant large; branches densely blunt, spirally arranged; leaf oblong-ovate, concave; leaf cells linear to rhomboidal. .... 3
  2. Leaves imbricate to erect-spreading, ovate-lanceolate, 3-3.4 x 0.8-0.96 mm, contracted to a long acuminate apex; margins entire, weakly serrulate at apex; leaf cells narrowly elongate or fusiform, 120-137.5 x 7.5-10  $\mu$ m, smooth, with firm walls; alar cells large, 4-6 cells..... 1. *R. bunodicarpum*
  2. Leaves crowded, oblong-ovate, 1.56-1.76 x 0.5 mm, long acuminate apex; margins entire or minutely denticulate near apex, broadly recurved; leaf cells linear, 87.5-107.5 x 5  $\mu$ m, smooth, with thin, pale walls; alar cells large, 3-4 cells .3. *R. luzonense*
3. Leaves loosely, imbricate, oblong-ovate, 1.6-2.2 x 0.5-0.8 mm, abruptly constricted into a tapering long acumen; margins plane, entire; leaf cells linear to rhomboidal, 60-75 x 5-10  $\mu$ m; alar cells large, 3-4 cells, rounded oval, inflated, brownish, 75-125 x 25-45  $\mu$ m..... 2. *R. leptocarpoides*
3. Leaves loosely arranged, oblong-ovate, 1.8-2.2(-4) x 0.5-0.7 mm, abruptly constricted into a falcate piliform acumen; margins plane, entire; leaf cells linear to rhomboidal, 62.5-75 x 4-7.5  $\mu$ m; alar cells large, 4-5 cells, rounded oval, inflated, brownish, 87.5-150 x 37.5-50  $\mu$ m.....4. *R. piliferum*

1. *Rhaphidostichum bunodicarpum* (C. Müll.) M. Fleisch., Musci Fl. Buitenzorg 4: 1309. 1923. *Hypnum bunodicarpum* C. Müll., Bot. Jahrb. Syst. 5: 85. 1883. — Type: Lavongai.

### Figure 5.50

*Plants* large, yellowish green, glossy. *Stems* elongate, prostrate, densely branched; branches ascending, up to 1.5 cm long, less than 3 mm wide with leaves. *Leaves* imbricate to erect-spreading, ovate-lanceolate, 3-3.4 x 0.8-0.96 mm, contracted to a long acuminate apex, concave; margins entire, weakly serrulate at apex; leaf cells narrowly elongate or fusiform, 120-137.5 x 7.5-10  $\mu$ m, smooth, with firm walls, becoming shorter and pitted near base; alar cells large, oval, 4-5 cells, 117.5-137.5 x 37.5-47.5  $\mu$ m, colored, inflated, thin-walled, a few small irregularly cells above.

*Sporophytes* on main stem. *Setae* erect, 2-3 cm long, curved above. *Capsules* oblong, cylindrical, 1.5 x 1 mm long, bended with nodding at base; exothecial cells collenchymatous with trigones; operculum long rostrate, 0.5 mm long.

Illustrations. — Brotherus 1924-25 (Fig. 739).

Thailand. — PENINSULA. Trang.

Distribution. — China, Indonesia, Malaysia, Philippines, Papua New Guinea, and Oceania.

Ecology. — On tree trunks or on limestone rocks in evergreen forest, alt. 400-600 m.

Specimens examined.— TYPE. [Arehipel Bismarok in Nova Mecklenburg merid, in mortibus Rossel, 400-600 m, Jan. 1905, *Parkinson* (holo-, FH)]; Fiji [On humus, dense

forest. Summit of Uluingalau, 1100-1200 m, 3 Jan. 1934, *Smith 902* (FH)]. PENINSULA. Trang [Na Tam Tai, 10 Nov. 1970, *CLaW 3670* (NY)].

Discussion. — *R. bunodiocarpum* differs from *R. piliferum* by its smaller plant and narrower leaves.

2. *Rhaphidostichum leptocarpoides* (Broth.) Broth., Nat. Pflanzenfam. (ed.2) (11): 434. 1925. *Sematophyllum leptocarpoides* (Broth.) Broth., Nat. Pfl., 1(3): 1123. 1908. *Trichosteleum leptocarpoides* Broth., Bot. Tidss. 24: 124. 1901.

#### Figure 5.51

*Plants* large, robust, golden green to yellow, glossy. *Main stems* elongate, creeping, prostrate, densely branched, branches irregularly pinnate up to 1.5 cm long. *Leaves* loosely, imbricate, upright from stems, oblong-ovate, 1.6-2.2 x 0.5-0.8 mm, concave, abruptly constricted into a piliform acumen; margins plane, entire; ecostate; leaf cells linear to rhomboidal, 60-75 x 5-10  $\mu\text{m}$ , smooth, with firm walls, colored across insertion, slightly pitted near base leaf; alar cells large, 3-4 cells, rounded oval, 75-125 x 25-45  $\mu\text{m}$ . inflated, brown.

*Sporophytes* not seen.

Illustrations. — Unknown.

Thailand. — SOUTHEASTERN. Trat.

Distribution. — Endemic to Thailand.

Ecology. — Altitude unknown.

Specimens examined.— TYPE. Trat [Koa Chang, *Schmidt 43*. (lecto-, H-BR; iso-, PC)].

Discussion. — Leaf cells and alar organization of this species are similar to plant in genus *Sematophyllum*, but it differentiated in leaves arrangement and leaf shaped. The large sized of plant and leaf ovate-lanceolate with abruptly constricted into a piliform apex are characters that made this species more closed to *Rhaphidostichum* than *Sematophyllum*.

3. *Rhaphidostichum luzonense* (Broth.) Broth., Nat. Pflanzenfam. (ed.2), (11): 434. 1925. *Sematophyllum luzonense* Broth., Philip. Journ. Sci. 13: 221. 1918. — Type: Luzon, Laguna Province, Mount Maquiling, *Robinson 17010* (BM!, FH!).

#### Figure 5.52

*Plants* relatively robust, yellowish green, glossy, dense tufts or mats. *Stems* elongate, radiculose, densely branched, branches curved, ascending, blunt. *Leaves* crowded, homomallous, oblong-ovate, concave, 2-2.5 x 0.5 mm, acuminate apex; margins entire or minutely denticulate near apex, broadly recurved; leaf cells linear with thin, 48-60 x 5-6  $\mu\text{m}$ , pale walls, smooth; alar cells large, oblong, 45-50 x 10-15  $\mu\text{m}$ , slightly inflated, golden brown, supra-alar cells subquadrate, rather numerous.

*Autoicous*. *Perichaetial leaves* subulate-acuminate, entire. *Setae* up to 20 mm long, slender, very indistinctly pustulose above. *Capsules* horizontal, 1 x 0.4-0.5 mm long; exothecial cells subcolenchymatous; peristome teeth with a narrow median furrow; operculum lid 1.5 mm long, with a slender, needle like beak.

Illustration. — Bartram 1939 (Pl. 24, fig. 417, as *Sematophyllum luzonense*).

Thailand. — NORTHERN. Chiang Mai; NORTHEASTERN. Loei; CENTRAL. Nakhon Nayok.

Distribution. — Philippines, Malaysia.

Ecology. — Alt. 1000-1100 m.

Specimens examined.— TYPE. Philippines [Luzon, Mt. Maguiling, Saguaa Province, 6-9 Dec. 1912, *C.B. Robinson 17010* (holo-, BM; syn-, FH)]. NORTHERN. Chiang Mai [Doi Suthep, 17 Jul. 1968, *LSaW 2585* (NY), 7 Sept. 2006, *Pollawatn 417, 425, 435* (BCU), *Touw 2184, 2577, 2585* (AAU, MO)]. NORTHEASTERN. Loei [*CLW 4765* (AAU, MO)]. CENTRAL. Nakhon Nayok [*CLW 4243, 4256, 4327* (AAU, MO)].

Discussion. — The species is differentiated from another *Rhaphidostichum* in Thailand by its leaf cells linear, and alar cells narrow throughout leaf, while the other species always rhomboidal cells and alar .

4. *Rhaphidostichum piliferum* (Broth.) Broth., Nat. Pflanzenfam. 2 (11): 434. 1925. *Wijkia piliferua* (Broth.) Crum, Bryologist 74: 173. 1971. *Sematophyllum piliferum* Broth., Öfvers. Förh. Finska Vertensk.-Soc. 47(14): 9. 1905. — Type: Borneo.

#### Figure 5.53

*Plants* robust, golden to yellowish green, glossy. *Main stems* elongate, creeping, prostrate, densely branched, branches spirally arranged and radically symmetric, 1.5-2.5 cm long. *Leaves* loosely arranged, upright from stems, oblong-ovate, 2-4 x 0.6-1.2 mm, concave, abruptly constricted into a piliform acumen; margins plane, entire; ecostate; leaf cells linear to rhomboidal, 60-100 x 4-7.5  $\mu\text{m}$ , smooth, with firm walls, colored across insertion, slightly pitted near base leaf; alar cells large, 3-4 cells, rounded oval, 117-150 x 37.5-50  $\mu\text{m}$ . inflated, brown.

*Sporophytes* not seen.

Illustration.— Bartram 1939 (fig. 420).

Thailand. — EASTERN. Nakhon Ratchasima.

Distribution.— Vietnam, Kampuchea, Borneo, China, Philippines.

Ecology.— On tree. A handsome moss easily recognized by the abruptly piliferous leaves from a broad, concave base.

Specimens examined.— EASTERN. Nakhon Ratchasima [Khao Yai National Park, 3 Nov. 1970, *CLW4501* (FH, NY), 4 Oct. 2005, *Pollawatn 333, 341, 349* (BCU)].

Discussion.— Sporophyte was not found from Thai specimen. Bartram (1939) had described specimens in Philippines that showed plants dioicous with sporophytes on main stem. Inner perichaetial leaves serrate at apex. Setae 2.5-3.0 cm long, reddish, mammillose above; capsules horizontal or pendulous, urn 1.5 mm long with neck short and pustulose; exostome teeth clearly with a median line, densely cross-striate below.

### 19. SEMATOPHYLLUM Mitt.

*Sematophyllum* Mitt., J. Linn. Soc. Bot. 8: 5. 1864.

*Hypnum demissum* A. Wilson, Engl. Bot. Suppl. 2740. 1832. Type: Europe, n.v.

*Sematophyllum demissum* (A. Wilson) Mitt., J. Linn. Soc. Bot. 8: 5. 1864.

*Rhynchostegium* Sect. *Rhaphidostegium* Bruch, Schimp. & Guembel, Bryol. Eur. 5:200. 1852.

*Plants* slender to forming dense dull or +/- glossy green to yellowish-green mats. *Main stems* creeping, red, branches crowded, irregularly subpinnately to pinnately branched, branches erect-ascending. Stem and branch leaves similar. *Leaves* appressed, erect or spreading, sometimes secund, never falcate when dry, +/- concave, never tubulose; ovate-lanceolate or oblong, blunt, short or broad pointed, acute or acuminate, entire or faintly

denticulate at upper margin; ecostate; laminal cells in upper 1/3 of leaf including acumen rhomboidal, oval-oblong, fusiform to shortly elongate l:w ratio <7:1, smooth; alar region well develop with distinct basal row of straight, slightly elongate, inflated, cells, walls coloured or hyaline; upper alar cells several, quadrate.

*Autoicous*, rarely dioicous. *Perichaetia* on main stems; *inner perichaetial leaves* elongate or broadly elongate, short or longer to subulate pointed. *Calyptrae* smooth, cucullate. *Setae* +/- elongate, red, smooth. Capsules small, nearly erect to horizontal, ovoid to elongate, exothecial cells collenchymatous; operculum slenderly rostrate from a swollen base; peristome diplolepidous, double, alternate, exostome teeth 16, lanceolate-subulate, cross-striate dorsally, lamellae well developed, teeth incurved between segments when dry; endostome 16 segments from a high basal membrane, same length as teeth, keeled, cilia 1-2, slender, sometimes rudimentary. Spores small to medium. Chromosome numbers: refer to earlier section on chromosomes.

*Sematophyllum* is primarily a pantropical genus with more than 100 species; about 40-50 species in the Neotropics. The habitat found on wet to semi-dry lowland to high montane forest, epiphytic, on branches, trunks, bases of trees and shrubs, also on rocks and logs, occasionally on soil. There are 8 species occurred in Thailand.

### Key to Species

1. Plants yellow-green, glossy, medium-sized in tufts; main stem long creeping, branches usually pinnate, erect, short, parallel, but may be fasciculated.....5
1. Plants green, glossy, robust forming low tufts; main stem short creeping, giving rise to erect, branches short or remotely branched.....2
  2. Main stems short creeping to prostrate, giving rise to erect branched. ....3
  2. Main stems prostrate, giving remotely branched; leaves appressed when dry, erect-spreading when moist. ....4
3. Branches with a cluster of imbricate leaves, slightly homomallous, less than 5 mm long; gemmae densely branches with many terminal differentiated cells; leaves dense, concave, ovate-lanceolate, 1.48-2.0 x 0.44-0.48 mm, narrowly acute apex; leaf cells narrow rhomboidal, 100-112.5 x 5-7.5 µm at middle leaf.....2. *S. microcladiellum*
3. Branches slender with spreading leaves, more than 5 mm long; gammae lacking; leaves erecto-patent to homomallous, narrowly ovate to lanceolate, 1.12-1.64 x 0.3-0.4 mm, concave, long acuminate to nearly filiform; leaf cells elongate to linear near apex, 55-87.5 x 2.5-5 µm at middle leaf..... 4. *S. phoeniceum*
4. Leaves spreading, narrowly ovate to lanceolate, acuminate at apex, concave on the upper, 1.0-1.25 x 0.2-0.3 mm long; margins entire, strongly crenulate from middle to apex; leaf cells elongate-rhomboidal, pitted; alar region consisting of one row of 3-4 irregularly oblong cells, inflated, cell walled thick, usually colored, with a rows of colored quadrate cells above..... 5. *S. subconnivens*
4. Leaves rise up on one side, ovate-lanceolate to lanceolate, acuminate at apex, concave, 1.1-1.3 x 0.25-0.4 mm; margins at times reflexed in middle, entire; leaf cells elongate-rhomboidal to linear, in a oblique row to the middle, rarely pitted; alar region consisting of one row of 3-4 irregularly oval cells, inflated, hyaline, with several rows of small irregularly hyaline cells above.....6. *S. subhumile*
5. Branches usually pinnate, erect, short, parallel, often fasciculated; leaves oblong-ovate to lanceolate, long acuminate apex. .... 6
5. Branches short ascending, curved; leaves widely ovate or ovate-lanceolate, narrowly acute to acute apex.....7

6. Leaves dense, imbricate, oblong-lanceolate, 1.6-1.8 x 0.32-0.4 mm., long tapering to acuminate apex, margin smooth below, dentate at apical portion; costate short double; leaf cells linear, 87.5-100 x 3-5  $\mu$  at middle, shorter and wider near base, alar ovate-oblong, 3-4 cells, thick walled cell, colored..... 3. *S. pavulum*
6. Leaves oblong ovate to lanceolate, 1.0-1.25 x 0.2-0.3 mm, acuminate at apex, slightly reflexed, concave at middle; margins entire, crenulate from upper part; ecostate; leaf cells elongate-rhomboidal, linear toward leaf apex, 25-55 x 3-5  $\mu$ m, moderately thick- to thick-walled; alar oval, 3-4 cells, inflated, colored..... 9. *S. subrevolutum*
7. Leaves dense, imbricate, almost erect, highly concave, ovate-lanceolate,  $\pm 1.28$  x 0.32 mm, apex narrow acute, margin smooth; leaf cells narrow rhomboid,  $\pm 46$  x 8  $\mu$ m at apex,  $\pm 65$  x 8  $\mu$ m at lower leaf; alar ovate-oblong, 3-4 cells, inflated; colored; *Setae* less than 15 mm long, usually spiral coil when dry..... 1. *S. humile*
7. Leaves crowded, slightly homomallous, widely ovate to ovate-lanceolate, concave, acute to long acuminate apex; costae short, double. .... 8
8. *Leaves* slightly homomallous, broadly ovate to ovate-lanceolate, 1.0-1.5 mm x 0.5-0.75 mm, acute to short acuminate; laminal cells oval, rhomboid, to narrowly rhomboidal near apex, 20-35 x 6-7  $\mu$ m, becoming longer and narrower at middle; alar oval 3-4 inflated cells with few small irregularly cell above. .... 7. *S. subpinnatum*
8. *Leaves* often homomallous, ovate-lanceolate, 1.0-1.2 mm x 0.4-0.5 mm, gradually narrow to acuminate apex; laminal cells rhomboidal, to linear-rhomboidal near apex, 20-35 x 6-8  $\mu$ m near tip, becoming longer and narrower at middle; alar oblong, 3-4 inflated cells, with few large of subquadrate cells above. .... 8. *S. subpinnatum* fo. *tristiculum*

1. *Sematophyllum humile* (Mitt.) Broth., Nat. Pfl. ed.2, 11: 431. 1925.

*Rhaphidostegium humile* (Mitt.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 397. 1878.

*Stereodon humilis* Mitt., Musci Ind. Or., 102. 1859. — Type: East Nepal, Wallich 802 (BM).

*Hypnum humile* Harv. in Hook.: Icon. Pl. Rar., 1: 23 f. 9. 1836. *hom. illeg.*

*Plants* medium-sized, yellow-green, glossy, in tufts. *Main stems* creeping; branches usually pinnate, erect, short, parallel, but may be fasciculate. *Leaves* dense, imbricate, almost erect, appressed when dry, highly concave, ovate-lanceolate,  $\pm 1.28$  x 0.32 mm., apex narrow acute, margin smooth; ecostate; leaf cells narrow rhomboid,  $\pm 46$  x 8  $\mu$ m at apex,  $\pm 65$  x 8  $\mu$ m at lower leaf, lower cells showing papillose development of cell tips; alar differentiated by about three large,  $\pm 63$  x 34  $\mu$ m, ovate-oblong, inflated cells at extreme angle and a few small irregular cells on top of them.

*Sporophytes* on main stem. *Setae* slender, erect,  $\pm 1.2$  cm. long, almost smooth.

*Capsules* horizontal, oblong-ovate,  $\pm 1.6$  x 0.65 mm; peristome disintegrated.

Illustrations. — Gangulee 1980 (Fig. 960).

Thailand. — NORTHERNEASTERN. Phetchabun.

Distribution. — Mainland China, Nepal, and Sri Lanka.

Ecology. — On tree trunk, alt. 1300 m.

Specimens examined.— not found.

Discussion. — The species reported new to Thailand by He (1995), by specimens *LSmW 1042* (AAU, MO) that could not found specimens within this study. All species description above base on Gangulee (1980).

2. *Sematophyllum microcladiellum* M. Fleisch., Musci Fl. Buitenzorg 4: 1266. 1923.

**Figure 5.54**

*Plants* medium-sized, yellow-green, glossy, in tufts. *Main stems* creeping; branches usually pinnate, erect, 3-5 mm, with a cluster of dense imbricate leaves, slightly second. *Gemmae* branches with many terminal differentiated cells. *Leaves* dense, imbricate, almost erect, appressed when dry, highly concave, ovate-lanceolate, 1.48-2.0 x 0.44-0.48 mm, apex narrow acute, margin smooth, sometimes curved to border margin; ecostate; leaf cells in obliques row of narrowly rhomboidal, 100-112.5 x 5-7.5  $\mu\text{m}$  at middle, smaller at upper part; alar differentiated by about 3-4 large, 50-70 x 28-32  $\mu\text{m}$ , ovate-oblong, colored, inflated cells at extreme angle and a few small irregular cells on top of them.

*Sporophytes* on main stem. *Setae* slender, erect, 1.5-2 cm. long, almost smooth. *Capsules* horizontal, oblong-ovate,  $\pm 1.6 \times 0.65$  mm; peristome disintegrated.

Illustrations. — Dozy and Molkenboer 1855-70 (Tab. 242, as *Hypnum microcladon*).

Thailand. — NORTHERN. Chiang Mai, Tak; PENINSULA. Ranong, Surat Thani; SOUTHEASTERN. Prachin Buri.

Distribution. — Borneo, Celebes, Malay Peninsula, Myanmar, New Guinea, and Singapore.

Ecology. — On tree trunks in open hill forest or along road side or sea shore, alt. 10-1600 m.

Specimens examined.— NORTHERN. Chiang Mai [Doi Suthep, 21 Mar. 1951, *Smitinand 6162* (BKF, L, PC); *Smitinand 6194* (FH)]; Tak [Doi Musae, 20 Nov. 1965, *Touw 8204* (L)]. PENINSULA. Ranong: *Kerr 382, 407* (BM); Surat Thani: *Kerr 216* (BM). SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 18 Feb. 1966, *Touw 12241* (BKF, L)]. Papua. [Peria Creek, 25 Aug. 1953, *Brass 24187* (AAU)].

Discussion. — The species is easy to recognized by its long creeping with short branches, always presented gemmae branches.

3. *Sematophyllum parvulum* (Broth.) Dixon, J. Siam Soc. Nat. Hist. Suppl. 9: 42. 1932.

*Rhaphidorrhynchium parvulum* (Broth.) Broth. Nat. Pflanzenfam. (ed.2) (11): 426.

1925. *Rhaphidostegium parvulum* Broth., Bot. Tidss. 24: 124. 1901. — Type: as *R.*

*parvulum*, J. Schmidt s.n. (lecto-, H-BR).

**Figure 5.55**

*Plants* medium-sized, yellow-green, glossy, in tufts. *Main stems* creeping; branches irregularly pinnate, erect, up to 1 cm long, often fasciculate. *Leaves* dense, imbricate, almost erect, appressed when dry, slightly concave, oblong-lanceolate, 1.6-1.8 x 0.32-0.4 mm, long tapering to acuminate apex, margin smooth below, dentate at apical portion; costate short double; leaf cells narrow rhomboid to linear, 87.5-100 x 3-5  $\mu\text{m}$  at middle, shorter and wider at lower leaf, cells tip shorter; alar differentiated, 3-4 cells, ovate-oblong, 35-50 x 18-25  $\mu\text{m}$ , thick walled cell, colored across basal part.

*Sporophytes* on main stem. *Setae* slender, erect, bended at terminal, 1-1.2 cm. long, almost smooth. *Capsules* oblong-ovate, 1.3-1.6 x 0.5-0.6 mm, few knobs at basal; exothecial cells collenchymatous, trigones; peristome double, normal.

Illustration. — Unknown.

Thailand. — EASTERN. Trat.

Distribution. — Endemic to Thailand.

Ecology. — On tree trunk in evergreen forest.

Specimens examined.— TYPE. Trat [Koh Chang, 1900, *Schmidt s.n.* (lecto-, H-BR)].

Discussion. — Leaf shaped and leaf cells of this species are quiet similar to *Trichosteleum boschii*, but the latter has riches of cells papillose.

4. *Sematophyllum phoeniceum* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 3: 1266. 1923. *Hypnum phoeniceum* Müll. Hal. Flora 61: 85. 1878.

**Figure 5.56**

*Plants* forming low tufts, glossy. *Main stems* creeping, branches short, slender, up to 10 mm long, giving rise to erect. *Leaves* erecto-patent to homomallous, lanceolate, mostly narrowly lanceolate, 1-1.25 mm long, concave, long acuminate to near filiform, margins entire, plane to slightly recurved on both sides, crenulate at tip; leaf cells elongate to linear near apex, 65-80 x 2.5-5  $\mu\text{m}$  at tip, becoming longer and narrower at middle of the leaf; alar cells, large, 3-4 oblong inflated, 35-40 x 12-15  $\mu\text{m}$ , cell wall thick, more or less colored, with several rows of quadrate cells above.

*Monoicous*. *Perigonal leaves* small, narrowly lanceolate. *Perichaetial leaves* ovate lanceolate, gradually long acuminate, nearly entire; paraphysis abundant, stiff. *Setae* short, less than 7 mm long. Capsules ovoid, inclined; opercular lid long needle-like; exostome regular, as in other species; endostome reduced, segments filamentous.

Illustration. — Gangulee 1980, (Fig. 958).

Thailand. — NORTHERN. Chiang Mai, Mae Hong Son, Phitsanulok; NORTHEASTERN. Loei; SOUTHEASTERN. Chanthaburi, Trat, Prachin Buri.

Distribution. — Africa, Andaman, India, Indochina, China, Bangladesh, Mainland China, Kampuchea, and Vietnam.

Ecology. — On tree trunks near base and ground floor, alt. 40-1100 m.

Specimens examined.— NORTHERN. Chiang Mai [*Tixier s.n.* (PC)]; Mae Hong Son [Mae Sariang, 7 Aug. 1968, *LSaW* 2266 (AAU)]; Phitsanulok [*Tixier s.n.* (PC)]. NORTHEASTERN. Loei [Phu Krading, 7-9 Nov. 1966, *CLW* 4668 (AAU, NY)]. SOUTHEASTERN. Chanthaburi [Pru Waterfall, 22 Aug. 1966, *LSmW* 1709, 1720, 1723, 1727, (AAU), *LSmW* 1716 (AAU, NY); 25 Aug. 1966, *LSmW* 1867 (AAU), *Tixier s.n.* (PC)]; Trat [Koh Chang Island, 25 Aug. 1919, *LSmW* 1819 (AAU, L)]; Prachin Buri [Khao Yai National Park, 7-9 Nov. 1970, *CLW* 4402, (AAU)].

Discussion. — The species is similar to *Sematophyllum microcladiella*, but can be distinguished them by their habits. *S. microcladiella*, branches short with a cluster of dense imbricate leaves usually secund and abundant gemmae branches, while *S. phoeniceum* has a slender branches more than 5 mm long and lacking of gemmae.

5. *Sematophyllum subconnivens* (Broth.) Dixon, J. Siam Soc. Nat. Hist. Suppl. 9: 42. 1932. *Rhaphidostegium subconnivens* Broth., Bot. Tidss. 24: 124. 1901.

**Figure 5.57**

*Plants* creeping, robust, pale yellowish to brownish, in compact tufts. *Main stems* prostrate, branches densely to remote, irregularly pinnate, up to 5 mm long. *Leaves* appressed when dry, erect-spreading when moist, narrowly ovate to lanceolate, acuminate at apex, concave on the upper, 1.0-1.25 x 0.2-0.3 mm; strongly crenulate margin from middle to apex, entire, minutely serrulate at apex; costae absent; leaf cells elongate-rhomboidal, linear toward leaf apex, 25-55 x 3-5  $\mu\text{m}$ , moderately thick- to thick-walled, pitted through out leaf; alar region consisting of one row of 2-3 irregularly oblong cells, inflated, cell walled thick, colored, with a rows of 2-3 small colored quadrate cells above.

*Sporophytes* not seen.

Illustration. — Unknown.

Thailand. — SOUTHEASTERN. Trat.

Distribution. — Myanmar.

Ecology. — On soil near base of tree trunk in open forest.

Specimens examined.— TYPE. Trat [Koh Chang, Klong Munsé, as *Rhaphidostegium subconnivens*, Schmidt s.n. (lecto-, H-BR)].

Discussion. — The leaves pitted and almost colored of alar cells and supra alar quadrate cells are the most easy recognized for this species.

6. *Sematophyllum subhumile* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 4: 1264. 1923. *Rhaphidostegium subhumile* (Müll. Hal.) Jaeg., Ber.Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 397. 1878. *Hypnum subhumile* Müll. Hal., Syn. Musc. Frond. 2: 330. 1851. — Type: India. Nilgiri Hill, *Perrottet s.n.* (FH!).  
*Meiothecium angustirete* Broth., Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1, 131: 220. 1923. — Type: China. Human, Tschangscha, Yolu-schan (Mt.), *Handel-Mazzetti 12684*.  
*Sematophyllum henryi* (Paris & Both.) Broth., Nat. Pflanzenfam. (ed. 2) 11: 431. 1925. *Rhaphidostegium henryi* Paris & Broth., Rev. Bryol. 36: 12. 1909.  
*Sematophyllum pulchellum* (Cardot) Broth., Nat. Pflanzenfam. (ed. 2) 11: 431. 1925. *Rhaphidostegium pulchellum* Card., Bull. Soc. Bot. Genève, ser. 2, 4: 383. 1912.  
*Sematophyllum subhumile* subsp. *japonicum* (Broth.) Seki, J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 12: 38. 1968. ; *Sematophyllum japonicum* (Broth.) Broth., Nat. Pflanzenfam. (ed. 2) 11: 431. 1925. *Rhaphidostegium japonicum* Broth., Hedwigia 38: 230. 1899.

#### Figure 5. 58

*Plants* slender, pale yellowish to brownish, in compact tufts. *Main stems* prostrate, remotely irregularly branched, more than 5 mm long. *Leaves* appressed when dry, erect-spreading when moist, oblong ovate-lanceolate to narrowly lanceolate, concave, acuminate at apex, 1.1-1.3 x 0.25-0.4 mm; margins at times reflexed in middle, entire, sometimes serrulate at apex; costae absent; leaf cells in obliques rows of elongate-rhomboidal, linear toward leaf apex, 35-55 x 3-5 µm, moderately thick- to thick-walled, rarely pitted; alar region consisting of one row of irregularly 3-4 oval cells, 20-22 x 10-12 µm, hyaline, somewhat inflated, with several rows of quadrate cells above.

*Monoicous*. *Perigonal leaves* small. *Inner perichaetial leaves* broadly lanceolate to ovate-lanceolate, up to 2 mm long, shortly or long acuminate, nearly entire or denticulate at apex. *Setae* red, smooth, less than 15 mm long, usually spiral coil when dry. *Capsules* horizontal to pendent, ovoid to ellipsoidal, 0.8-1.2 x 0.4-0.5 mm, constricted at mouth when dry; opercula long rostrate.

Illustration. — Fleischer 1904-22 (Fig. 205); Gangulee 1980 (Fig. 959); Seki 1968 (Fig. 15); Jia *et al* 2005 (Pl. 609, figs. 1-14).

Thailand. — NORTHERN. Tak.

Distribution. — Mainland China, India, Japan, Java, Kampuchea, Laos, Myanmar, Nepal, Sri Lanka, Sumatra, Taiwan, Indonesia and Vietnam.

Ecology. — Mostly on stones or tree trunks; alt. 400-1300 m.

Specimens examined.— Type. India [Nilgiri Hill, *Perrottet s.n.* (lecto-, FH)]. NORTHERN. Tak [Doi Musae, 19 Nov. 1965, Touw 8102 (L)].

Discussion. —

7. *Sematophyllum subpinnatum* (Brid.) Britt., Bryologist 21: 28. 1918. *Leskea sunpinnata* Brid., Muscol. Recent. Suppl. 2: 54. 1812.— Type: Europe.  
*Rhaphidostichum caespitosum* (Hedw.) Besch., Ann. Sci. Nat., Bot., ser. 6, 3: 247. 1876.  
*Sematophyllum caespitosum* (Hedw.) Mitt., J. Linn. Soc., Bot. 12: 479. 1869. *Leskea caespitosum* Hedw., Spec. Musc. 233. 49, f.1-5. 1801.  
*Sematophyllum demissum* auct. Non (Wils) Mitt., J. Proc. Linn. Soc., Bot. 8: 5. 1864.  
*Sematophyllum robustulum* (Card.) Broth., Nat. Pflanzenfam. (ed. 2) 11: 437. 1925.  
*Rhaphidostegium robustulum* Card., Beih. Bot. Centralbl. 19(2): 135. f.26. 1905.  
*Sematophyllum sinense* Thér. in Broth., Nat. Pflanzenfam. (ed. 2) 11: 437. 1925, *nom. nud.*  
*Sematophyllum striatifolium* Dix., J. Siam Soc., Nat. Hist. Suppl. 9(1): 41. 1932.  
*Sematophyllum subpinnatum* fo. *tristiculum* (Mitt.) B. C. Tan & Y. Jia, J. Hattori Bot. Lab. 86: 51. 1999. *Sematophyllum tristiculum* (Mitt.) Fleisch., Musci Fl. Buitenzorg 4: 1262. 1923. *Stereodon tristiculus* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 102. 1859.

**Figure 5.59**

*Plants* variable in sized, caespitose, slender or robust, yellowish brown, slightly glossy, mats forming. *Main Stems* long creeping, densely branched, variable in sized, slender to stout, at most 1.25 mm wide including the leaves, distally curved upward (scorpioid) or attenuate. *Leaves* erect-patent, or appressed to branch when dry, slightly homomalous, broadly ovate to ovate-lanceolate, 1.0-1.5 mm x 0.5-0.75 mm, concave, acute to short acuminate; costae short, double; laminal cells oval, rhomboid, to narrowly rhomboidal near apex, 20-35 x 6-7  $\mu\text{m}$ , becoming longer and narrower at middle, 50-65 x 5-7.5  $\mu\text{m}$ , smooth, thin to thick-walled, not pitted; alar cells oval, 3-4 inflated cells, often colored, vesiculose, at times thick-walled, supra-alar cells may be well developed and large.

*Perichaetia* on stems. *Perichaetial leaves* erect, narrower, ecostate, entire. *Setae* smooth, reddish purple, 10-15 mm. *Capsules* suberect to inclined oblong-cylindric, symmetrical scarcely arcuate, 1.3 x 0.7 mm, constricted below mouth; operculum conic, rostrate; peristome double; exostome teeth 16 incurved, lanceolate; endostome segment yellow, densely papillose, not perforated; cilia absent or single. *Spores* 23-35  $\mu\text{m}$ , papillose.

Illustration. — Gangulee 1980 (Fig. 957); Jia *et al.* 2005 (Pl. 610, Figs. 1-12).

Thailand. — NORTHERN. Phitsanulok ; SOUTHEASTERN. Chanthaburi, Prachin Buri.

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

Ecology. — Grows on a variety of habitats such as tree trunks, branches, boulders, cement walls, wet rocks and even on calcareous rock. Populations with upwardly curved branches are often epiphytic on tree trunks; alt. 500-2000 m.

Specimens examined.— NORTHERN. Phitsanulok [Tung Salaeng Luang, 23 Jul. 1966, LSmW 763 (AAU)]. SOUTHEASTERN. Chanthaburi [Pong Nam Rawn, 21 Jan. 1956, Smitinand 3195 (AAU, BKF, L, FH, PC)]; Prachin Buri [Khao Yai Nationalpark, 4 mar. 1956, Tixier 239 (BKF)].

Discussion. — The type of *S. striatifolium* Dix. preserved at BM have acuminate leaves with oval to shortly fusiform apical cells. The holotype is from Thailand and paratypes are from Peninsula Philippines (Dixon 1932). It is also a member of this species complex. Buck (1983) reduced the well known Old World species, *S. caespitosum*, to a synonym of the New World species, *S. subpinnatum*.

8. *Sematophyllum subpinnatum* fo. *tristiculum* (Mitt.) B.C. Tan & Y. Jia, J. Hattori Bot. Lab. 86: 51. 1999. *Stereodon tristiculus* Mitt., J. Linn. Soc. Bot. Suppl. 1: 102. 1859. *Sematophyllum tristiculum* (Mitt.) M. Fleisch., Musci Fl. Buitenzorg 4: 1262. 1923.

**Figure 5.60**

*Plants* slender or robust, yellowish brown, slightly glossy, in dense mats. *Main Stems* long creeping, densely branched, at most 1 mm wide including the leaves; branches distally curved upward (scorpioid) or attenuate. *Leaves* erect-patent, or appressed to branch when dry, often homomallous, ovate-lanceolate, 1.0-1.2 mm x 0.4-0.5 mm, concave, gradually narrow to acuminate apex; costae short, double; laminal cells linear-rhomboidal, to narrowly rhomboidal near apex, 20-35 x 6-8  $\mu$ m near tip, becoming longer and narrower at middle, ca. 50-65 x 5-7  $\mu$ m, and linear at the middle of leaf base, smooth, thin to thick-walled, not pitted; alar cells oval, 3-5 inflated cells, often colored, vesiculous, at times thick-walled, supra-alar cells well developed and large of subquadrate cells.

*Autoicous*. *Perichaetia* on stems. *Perichaetial leaves* erect, gradually and rather broadly acuminate, ecostate, entire. *Setae* erect, reddish, 7-10 mm, smooth. *Capsules* suberect to inclined oblong-ovoid, 1.0-1.4 x 0.4-0.5 mm, constricted below mouth when dry; operculum conic, long rostrate; peristome double; exostome teeth 16 incurved, lanceolate; endostome segment yellow, densely papillose, not perforated; cilia absent or single. *Spores* 23-35  $\mu$ m, papillose.

Illustration. — Bartram 1939 (Pl. 24, fig. 416).

Thailand. — NORTHERN. Tak; NORTHEASTERN. Loei; SOUTHEASTERN. Nakhon Nayok.

Distribution. — Mainland China, India, Java, Myanmar, Philippines, Sri Lanka, Taiwan, and Vietnam.

Ecology. — Alt. 700-900 m.

Specimens examined. — TYPE. Indonesia [Toagoe, 21 Feb. 1861, Kurz (FH60376); Ceylon, Gardmes (FH60375)]. NORTHERN. Tak [Doi Musae, 17 Nov. 1965, Touw 8007 (AAU, L)]. NORTHEASTERN. Loei [Touw 10854 (L)]. SOUTHEASTERN. Nakhon Nayok [Touw 12372 (L)].

Discussion. — The species is smaller sized than *S. subpinnatum*, branches slightly curved and leaves are not conspicuously homomallous. This characters are similarity to *S. luzonense* Broth. that have strongly homomallous leaves. The latter species was a combination name of *Rhaphidostichum luzonense* (Broth.) Broth., but lectotype (H-BR) of *S. luzonense* showed characters more closed to *Sematophyllum* than *Rhaphidostichum*.

9. *Sematophyllum subrevolutum* Broth., Botanisk Tidsskrift 24: 123. 1901.

**Figure 5.61**

*Plants* slender, pale yellowish to brownish, in compact tufts. *Main stems* long creeping prostrate, remotely irregularly branched, up to 5 mm long. *Leaves* appressed when dry, erect-spreading when moist, oblong ovate to lanceolate, acuminate at apex, slightly reflexed, concave at middle, 1.0-1.25 x 0.2-0.3 mm; margins entire, crenulate from upper part, slightly serrulate at apex; costae absent; leaf cells elongate-rhomboidal, linear toward leaf apex, 35-55 x 3-5  $\mu$ m, in a oblique row to the middle, moderately thick- to thick-walled, rarely pitted at basal; alar region consisting of one row of 3-4 irregular, inflated cells, with several rows of small irregularly subquadrate cells above.

*Sporophytes* not seen.

Illustration. — Unknown.

Thailand. — SOUTHEASTERN. Trat.

Distribution. — Endemic to Thailand.

Ecology. — On soil near base of tree trunk, alt. 126 m.

Specimens examined.—: TYPE. Thailand [Trat, Koh Chang, *Schmidt 33*. (lecto-, H-BR type of *Sematophyllum subrevolutum*)].

Discussion. — The species found growing on ground floor and have abundant rhizoid along stem on substrate.

## 20. TAXITHELIUM Spruce ex Mitt.

*Taxithelium* Spruce ex Mitt., J. Linn. Soc., Bot. 12: 21, 496. 1869.

*Plants* rather small, forming thin to rather dense mats, pale olive green. *Stems* and branches spreading, regular to irregular pinnately branched. *Leaves* weakly to strongly complanate, lateral leaves somewhat larger and slightly asymmetric, broadly oblong-ovate to ovate-lanceolate, 0.7-1.2 mm long, to 0.6 mm wide, concave, apex broadly to narrowly acute; margins plane, serrulate throughout by projecting papillae; costa none; median cells linear, pluripapillose, papillae ca. 3-7 in a row over cell lumen; alar region usually differentiated, cells quadrate to short rectangular or oval.

*Autoicous*. *Perichaetial* leaves sheathing seta, lanceolate, ca. 2 mm long, acuminate, cells papillose. *Setae* 8-22 mm long, slender, smooth. *Capsules* inclined to suberect, urn broadly short-ovoid to ovoid-cylindrical, ca. 0.5-1.2 mm long, asymmetric, contracted below mouth when deoperculate; exothecial cells thick-walled, weakly collenchymatous or not; stomata at urn base, superficial; opercula conic-short rostrate; peristome double, exostome teeth cross-striate below, papillose distally, with a median zig-zag line, bordered, trabeculate on back; endostome basal membrane high, segments keeled, papillose, cilia 1. *Calyptrae* cucullate, smooth and naked. *Spores* spherical, appearing smooth to lightly papillose.

Plants found on logs and tree trunks; frequent in humid lowland and submontane forests, from near sea level to 1,200 m. A pantropical genus stated to contain over 100 species, (many likely synonyms), 16 species are reported from Thailand.

### Key to Species

1. Plants slender, usually depressed tufts, glossy, yellowish-green; stems creeping, closely pinnate; leaves lanceolate, ovate-lanceolate ..... 2
1. Plants slender, robust, usually tufts to loose mat, glossy, green to brownish-green; stems creeping, irregularly pinnate; leaves widely ovate to oblong-ovate ..... 11
  2. Branches slightly regularly, up to 1 cm long, 1.5 to 2 mm wide with leaves; leaves ovate-lanceolate erect to twist spreading, concave base, acuminate apex, margins plane, smooth below, strongly serrulate above, laminal cells narrowly linear ..... 3
  2. Branches usually irregularly, up to 1 cm long, 1.5-2 mm wide; leaves distally to complanate, ovate-lanceolate, apex broadly to narrowly acute ..... 4
3. Leaves narrowly ovate-lanceolate, gradually filiform-acuminate, 1.28-2 x 0.28-0.4 mm; laminal cells 80-105 x 3-5  $\mu$ m, papillae 5-7 per cell; alar cells, oval, 1 row of 3-5 cells. ..  
..... 1. *T. alare*
3. Leaves ovate-lanceolate, acuminate apex, 1.7-2 x 0.5-0.6 mm; laminal cells; 60-100 x 4-5  $\mu$ m, papillae 4-6 per cell; alar cells, oval. 2-3 cells..... 12. *T. magnum*

4. Leaves distally or complanate, ovate-lanceolate or narrowly ovate, apex acuminate or acute, constricted base; lamina cells linear or rhomboidal ..... 5
4. Leaves erect to twist, spreading, non-complanate foliate, erect to twist, spreading, narrowly ovate-lanceolate ..... 6
5. Leaves distally, ovate-lanceolate, apex acuminate, often constricted base 0.6-0.72 x 0.2-0.28 mm; margins entire or nearly so; lamina cells rhomboidal, 37.5-50 x 2.5-5  $\mu\text{m}$ , strongly seriate-papillose, 3-5 cells, marginal row frequently shorter, alar cells quadrate to short rectangular, 2-3 cells, distinctly small group of 2-3 irregular cells just above; seta 4 to 5 mm long.....3. *T. bakeri*
5. Leaves complanate, narrowly ovate, apex acute, gradually concave near base, 1.28-2 x 0.28-0.4 mm; margins plane, smooth below, minutely serrulate above; laminal cells vermiform to rhomboidal, 80-105 x 3-5  $\mu\text{m}$  long, smooth. rarely papillae, alar cells rectangular, 2-3 cells, inflated hyaline, distinct group of 6-9 subquadrate cells just above; seta slender, 1.5-1.75 cm long. ....6. *T. epapillosum*
6. Lamina cells very long linear, with irregular cell walls and cell tips rise to form papillae, 4-6 cells fine papillae which may sometimes be made out to form a row on the lumen ..... 7
6. Lamina cells linear, seriate-papillose, papillae 3-7 in a row over cell lumen..... 8
7. Leaves narrowly ovate-lanceolate, 1.28-2 x 0.28-0.4 mm wide, margins plane, smooth to minutely serrulate below, slightly serrulate above; laminal cells linear; 80-105 x 3-5  $\mu\text{m}$  long, alar cells small, 1-3 cells, hyaline, oval, inflated, few small irregular cells above.....5. *T. clastobryoides*
7. Leaves concave, ovate-lanceolate, 0.83-1.2 x 0.4-0.5 mm, apex acute; margins dentate in two-thirds of leaf, may be revolute on one side at base; laminal cells narrowly linear, 80-110 x 2.5-4  $\mu\text{m}$ ; alar 2-3 cells, quadrate hyaline. .... 18. *T. vernieri*
8. Leaf ovate-lanceolate, acuminate apex, concave, margin serrate, minutely seriate-papillose, papillae 3-6 cells, some twin baggies cell papillae..... 9
8. Leaf ovate-lanceolate to oblong-lanceolate, margin serrate, seriate-papillose, papillae 3-7 cells, some twin baggies cell papillae..... 10
9. Leaves narrowly ovate from a constricted base or oblong-lanceolate, concave, 1.2-1.5 x 0.4-0.48 mm, gradually acuminate; margins erect, sharply biserrulate all around; laminal cells long linear, vermicular, about 48-80 x 4  $\mu\text{m}$ , minutely seriate-papillose, papillae 3-5 cells, some twin baggies cell papillae, alar cells rectangular, 3-5 cells, distinct group of 6-12 irregular to subquadrate cells above.....15. *T. oblongifolium*
9. Leaves arranged in one plan, erect to twist spreading, narrowly ovate-lanceolate, gradually acuminate apex, concave, 1.28-2 x 0.28-0.4 mm wide, margins plane, minutely serrulate below, slightly smooth above; laminal cells narrowly linear; 80-105 x 3-5  $\mu\text{m}$ , seriate-papillose, 4-6 cells, alar cells oval, 2-3 cells, distinct a small group of 2-3 irregular cells just above. ....10. *T. isocladum*
10. Leaves strongly complanate, lateral leaves slightly asymmetric, oblong-ovate to lanceolate, 1.2-1.4 x 0.3-0.4 mm, concave, apex broadly to narrowly acute, slightly falcate; often constricted base; margins plane, serrulate throughout by projecting papillae; lamina cells linear, 55-100 x 5  $\mu\text{m}$ , seriate-papillose, papillae 3-7 in a row over cell lumen the whole leaf. .... 2. *T. arnottii*
10. Leaves erect, appressed, ovate-lanceolate to oblong-lanceolate, concave near base, gradually acute apex, 1.0-1.2 x 0.24-0.4 mm; margins plane, smooth to minutely serrulate below, strongly serrulate from middle to apex; laminal cells rhomboidal near base and apex, middle cells linear; 50-75 x 3-5  $\mu\text{m}$  wide, dominant seriate-papillose at middle leaf, papillae 3-5 baggy cells.. .... 4. *T. binsteadii*

11. Leaves ovate, cells few papillae, papillae bumpy shaped ..... 12
11. Leaves widely ovate, cells dominant papillae, papillae baggy shaped..... 13
12. Leaves erect-spreading, ovate, concave, obtuse or broadly acute 1.5 x 0.5 mm; margin plane, minutely denticulate near apex; lamina cells at leaf apex short rhomboid, papillose, mid-laminal cells linear, 24-40 x 3-4  $\mu\text{m}$ , 3-5 minutely papillae per cell; alar cells with single basal row of inflated 2-3 cells and a triangular group of a few upper alar cells..... 13. *T. merrillii*
12. Leaves crowded, erect, ovate to ovate-oblong, gradually short acuminate to acute apex, middle leaf inflated, base concave, 0.9-1.0 x 0.4-0.5 mm, margins plane, smooth to minutely dentate below, shortly dentate above; laminal cells linear rhomboidal, 80-105 x 3-5  $\mu\text{m}$ , cells minutely papillae at middle leaf, 2-3 small cells papillae, upper and lower cells slightly smooth; alar cells oval, 2-3 cells, inflated and hyaline, with the small group of quadrate cells just above.... 17. *T. sumatranum*
13. Plants relatively robust, pale yellowish green, glossy plant in lax tufts. Stems creeping, irregularly pinnate, branches complanate-foliolate; leaves ovate, obtuse, apex second; alar cells 2 or 3, small, oval, more or less inflated, pellucid or hyaline, with a small group of 9-12 irregularly quadrate cells just above ..... 14
13. Plants slender, dull, yellowish-green, not glossy or slightly glossy, forming dense, flat mats; main stems prostrate, elongate, irregularly branched with short and long branches; leaves widely ovate, concave, apex erect; lamina cells at leaf apex short, rhomboid; mid-laminal cells narrowly rhomboid, thin-walled, 40-80 x 4  $\mu\text{m}$ ; strongly seriate-papillose ..... 15
14. Leaves broadly ovate from a constricted base, abruptly acute, deeply concave, 1-1.2 x 0.7 mm; margins erect, sharply erose-denticulate above; leaf cells linear to narrowly rhomboidal, very distinctly seriate-papillose ..... 7. *T. gottscheanum*
14. Leaves ovate, gradually constricted into a shortly piliform apex, 1.1-1.3 x 0.2-0.4 mm, concave; leaf cells linear; margins serrulate; upper cells each with 3-5 indistinct papillae; median cells 50-70 x 4-5  $\mu\text{m}$ , thin-walled ..... 16. *T. pavulum*
15. Branches short, 1-3 mm long, widely spreading, complanately foliate; leaves imbricate, ovate from a contracted clasping base, concave, acute to short-acuminate, 1 x 0.4 mm; margins erect, sharply serrate above and serrulate to base; alar region 2-3 cells, oval, slightly inflated, often yellowish, upper alar cells irregularly quadrate in a small triangular group..... 9. *T. instratum*
15. Branches almost terete to slightly complanate, 2-4 mm long; leaves closely imbricate, densely arranged, broadly ovate, 0.8-1.1 x 0.4-0.5 mm, deeply concave, apex obtuse or bluntly acute; margins entire below, serrulate near apex; alar region 3-4 small cells, rectangular to oval, scarcely inflated, upper alar cells irregularly quadrate, numerous, extending obliquely a few cells up margin ..... 14. *T. nepalense*

1. *Taxithelium alare* Broth., Philip. Jour. Sci. C.3, 28. 1908.

#### Figure 5.62

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, closely pinnate, branches to 1 cm long, 1.5 to 2 mm wide with leaves, complanate-foliolate; rhizoid few in cluster, red. *Leaves* crowded, erect to twist spreading, narrowly ovate-lanceolate, gradually filiform-acuminate, concave, 1.28-2 x 0.28-0.4 mm; margins plane, smooth to minutely serrulate below, strongly serrulate above; ecostate; laminal cells narrowly linear, 80-105 x 3-5  $\mu\text{m}$ , minutely seriate-papillose, 5-7 bumpy cells papillae;

alar cells consist of 1 row of 3-5 cells, oval, inflated and yellowish, sharply distinct from the small group of irregular cells just above.

*Autoicous.* *Inner perichaetial leaves* long-acuminate, sharply serrate. *Calyptrae* cucullate, smooth and naked. *Setae* slender, 2-3 cm long, reddish, smooth. *Capsules* small, 0.8 x 0.4 mm, slightly inclined, ovoid to elongate or elongate-cylindric, urn 1 mm long; lid conical, 0.5 mm long.

Illustration. — Bartram 1939 (Pl. 26, fig. 448).

Thailand. —NORTHERN. Chiang Mai; NORTHEASTERN. Loei; PENINSULA. Nakorn Sri Thamarat, Phatthalung, Pattani, Krabi, Chumporn.

Distribution. — Borneo and Philippines.

Ecology. — On twigs of trees. Alt. 100-1740 m.

Specimens examined.— TYPE. Mindor [Mt. Haleyon, June 1906, *M.S. Merrid* (Syn-, BM)]. NORTHERN. Chiang Mai [Doi Inthanon, 17 Dec. 1965, *Touw 5973* (AAU, BKF), 11 Sept. 2007, *Pollawatn 419, 424, 431* (BCU)]. NORTHEASTERN. Loei [Phu Luang, 10 Jan. 1966, *Touw 10762, 10769* (AAU, BKF)]; PENINSULA. Nakorn Sri Thamarat [Khao Luang, 5 Feb. 1966, *Touw 11800* (BKF, BM, FH); *Touw 11680* (BKF, BM); *Touw 11780* (AAU), 6 Aug. 2007, *Pollawatn 653, 662, 673* (BCU)]; Phatthalung [Khao Soi Dao, 29 Apr. 1930, *Kerr 540* (BM)]; Pattani [Khao Kalakiri, *Kerr 277, 283c* (BM)]; Krabi [Khao Panom, 31 Mar. 1930, *Kerr 520* (BM)]; Chumporn [Khao Nom Sao, 21 Feb. 1927, *Kerr 190* (BM)].

Discussion. — The species is closed to *T. magnum*, but the later species can be separated from *T. alare* by its leaves have more wider ovate leaves and acuminate apex.

## 2. *Taxithelium arnottii* Thér. ex Tixier, Rev. Bryol. Lichenol., 38: 157. f. 7. 1971-72.

### Figure 5.63

*Plants* rather small, forming dense mats, pale olive green. *Stems* creeping, slightly regularly pinnate branched; branches up to 5 mm long, flattened, complanate-foliolate; rhizoid distantly cluster, red. *Leaves* strongly complanate, lateral leaves slightly asymmetric, oblong-ovate to lanceolate, 1.2-1.4 x 0.3-0.4 mm, concave, apex broadly to narrowly acute, slightly falcate; often constricted base; margins plane, serrulate throughout by projecting papillae; ecostate; lamina cells linear, 55-100 x 5  $\mu$ m, pluripapillose, papillae 3-7 in a row over cell lumen; alar region usually differentiated, 2-3 cells quadrate to short rectangular or oval, 25-37.5 x 12.5-20  $\mu$ m, sharply distinct from the small group of 3-6 irregular cells just above.

*Autoicous.* *Perichaetial leaves* sheathing base, lanceolate, 1.5-1.8 mm x 0.4-0.5 mm, acuminate, cells papillose. *Setae* up to 1.5 cm long, red, slender, smooth. *Capsules* inclined to suberect, urn broadly short-ovoid to ovoid-cylindrical, 0.8-1.2 x 0.5-0.6 mm, asymmetric, contracted below mouth when deoperculate; exothecial cells thick-walled, weakly collenchymatous or not; stomata at urn base, superficial; opercula conic-short rostrate; peristome double, exostome teeth cross-striate below, papillose distally, with a median zig-zag line, bordered, trabeculate on back; endostome basal membrane high, segments keeled, papillose, cilia 1. *Calyptrae* cucullate, smooth and naked. *Spores* spherical, appearing smooth to lightly papillose.

Illustration. — Tixier 1971-72 (Pl. 7, figs. 1-8).

Thailand. — NORTHERN. Chiang Mai; SOUTHEASTERN. Prachin Buri; PENINSULA. Nakhon Sri Thammarat, Phangnga, Phuket.

Distribution. — Vietnam.

Ecology. — On tree trunks or on twigs of trees, alt. 100-1740 m.

Specimens examined.— TYPE. [Indes Orientales, *Arnott 87, 189* (specimens for original illustrations, PC). NORTHERN. Chiang Mai [Hauy Koon, alt. 300 m, 3 May 1965, *Tixier 900* (PC)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 18 Feb. 1966, *Touw 12296* (AAU, BKF), 5 Oct. 2005, *Pollawatn 345, 347, 348* (BCU)]. PENINSULA. Nakhon Sri Thammarat [Kaho Luang, 2 Feb. 1966, *Touw 11426* (BKF), 6 Aug. 2007, *Pollawatn 647, 661, 666* (BCU)]; Phangnga [Khao Nang Hong, 28 Jan. 1966, *Touw 11299* (AAU, BKF)]; Phuket [Khao Phara, 25 Jan. 1966, *Touw 11272* (BKF)].

Discussion. — Brotherus (1925) classified this species as *Polystigma vera*, with well differentiated wing. The species remains nearest *T. instratum*. The other species which approach to *T. arnottii* are *T. sumatranum*, *T. capillipes*, *T. gottscheanum* and probably *T. bataanense* Broth. In more of the quite distinct and coloured auricle the species is remarkable by the shape of the slightly dissymmetrical sheet which brings closer this taxon the *Glossadelphus* kind. Chiang May, Fang, edges of Mae Tchai, on trunk, 600 m, 1/V/65, No. 1026; idem, Huay Koon, on trunk, 400 m, 3/V/65. No. 500.

### 3. *Taxithelium bakeri* Broth., Philipp. J. Sci. 13: 218. 1918.

#### Figure 5.64

*Plants* rather small, forming loose mats, green to yellowish green. *Stems* long creeping, slightly regularly pinnate branched; branches distance, flattened, up to 5 mm long, 1 mm wide with leaves; rhizoid small cluster, red. *Leaves* distally complanate, ovate-lanceolate, acuminate, 0.6-0.72 x 0.2-0.28 mm, apex broadly to narrowly acute, slightly falcate; often constricted base; margins entire or nearly so; ecostate; lamina cells rhomboidal, 37.5-50 x 2.5-5  $\mu$ m, distinctly seriate-papillose, 3-5 papillae per cell, marginal row frequently shorter, rhomboidal and smooth; alar cells few, 2-3 cells quadrate to short rectangular or oval, 10-20  $\mu$ m long and 5-7.5  $\mu$ m wide, not at all inflated, distinctly small group of 2-3 irregular cells just above.

*Sporophyes* not seen.

Illustration. — Bartram 1939 (Pl. 26, fig. 453).

Thailand. — PENINSULA. Trang.

Distribution. — Philippines.

Ecology. — On bark of trees.

Specimens examined.— TYPE. Philippines [Luzon, Los Boros, January 1914, *C. F. Baker* (syn-, BM). PENINSULA. Trang [*CLW 3743* (MO)].

Discussion. — This species was reported specimen *CLW 3743* (MO) as new record to Thailand by He (1995), but could not find specimen in this study. The description above follow Bartram (1939).

### 4. *Taxithelium binsteadii* Broth. & Dixon, J. Bot., 53: 294. Pl.540, f. 297. 1915.

#### Figure 5.65

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, slightly regular pinnate branch; branches spreading, 5-7 mm long, 1.5-2 mm wide with leaves, complanate-foliate; rhizoid few in cluster, red. *Leaves* erect, appressed, ovate-lanceolate to oblong-lanceolate, concave near base, gradually acute apex, 1.0-1.2 mm long, 0.24-0.4 mm wide, margins plane, smooth to minutely serrulate below, strongly serrulate from middle to apex; ecostate; laminal cells rhomboidal near base and apex, middle cells linear; 50-75  $\mu$ m long, 3-5  $\mu$ m wide, dominant seriate-papillose at middle leaf, 3-5 baggy cells papillae; alar cells consist of 1 row of 2-4 cells, 30-42.5  $\mu$ m long, 15-20  $\mu$ m wide,

oval, thick walled, yellowish, inflated, sharply distinct from the small group of 9-12 irregular cells just above.

*Autoicous.* Inner perichaetial leaves long-acuminate, sharply serrate. Calyptrae cucullate, smooth and naked. Setae slender, 1.5-2 cm long, reddish, smooth. Capsules small, 0.8-1.0 x 0.4-0.5 mm, slightly inclined, ovoid to elongate or elongate-cylindric; exothecial cells collenchymatous; operculum form a conic base, urn 1 mm long; lid conical, 0.5 mm long; peristome double.

Illustration. — Dixon 1915 (Pl. 540, fig. 297).

Thailand. — CENTRAL. Bangkok; SOUTHEASTERN. Prachin Buri; PENINSULA. Songkhla.

Distribution. — India.

Ecology. — On twigs or tree trunks by stream, alt. 100 m.

Specimens examined.— TYPE. Ceylon [Kirklees, 4 Mar. 1913, *C. H. Binstead* 413, (BM, PC)]. CENTRAL. Bangkok [On old brick wall, *Kerr* 316 (BM)]. PENINSULA. Songkhla [Khao Chang Lon, *Kerr* 317 (BM)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 3 Oct. 2005, *Pollawatn* 336, 348 (BCU)].

Discussion. — The species may be misunderstood with *T. arnottii* by its complanate-foliate, but can be differentiated by their alar organizations.

5. *Taxithelium clastobryoides* Dixon, J. Siam Soc. Nat. Hist. Suppl. 10(1): 26. 1935.

**Figure 5.66**

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, closely pinnate, branches to 5 mm long, non-complanate foliate; rhizoid few in clusters, red. *Leaves* erect to twist, spreading, narrowly ovate-lanceolate, 0.8-1.2 x 0.28-0.3 mm; margins plane, smooth to slightly serrulate from below to strongly serrulate above; ecostate; laminal cells narrowly linear; 70-95 x 3-5  $\mu\text{m}$ , minutely seriate-papillose, 3-5 bumpy cells papillae; alar cells consist of 1 row of 2-3 cells, hyaline, oval, inflated, few small irregular cells above.

*Autoicous.* Inner perichaetial leaves long-acuminate, sharply serrate. Calyptrae cucullate, smooth and naked. Setae slender, up to 2 cm long, reddish, smooth. Capsule not found.

Illustration. — Unknown.

Thailand. — PENINSULA. Nakhon Si Thammarat, Krabi.

Distribution. — Endemic to Thailand.

Ecology. — On tree trunks in evergreen forest, alt. 600-1100 m.

Specimens examined.— TYPE. Krabi [Panom Bencha, alt. 1100 m, 28 Mar. 1930, *Kerr* 512b (lecto-, BM)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 21 Nov. 1951, *Phloenchit* 149 (AAU, BKF, PC), 4 Aug. 2007, *Pollawatn* 646, 659, 663, 679 (BCU)].

Discussion. — Fairly distinct in the dense habit, pale straw colour, non-complanate leaves, acuminate, acuminate or acute, with distinct papillae. *T. robinsonii* Broth. from the Philippines is a little like it in habit, but more flexuose, with much narrower, finely acuminate leaves, and very faint papillae.

6. *Taxithelium epapillosum* Dixon, J. Siam Soc. Nat. Hist. Suppl. 10(1): 24. 1935.

**Figure 5.67**

*Plants* slender, usually dense tufts, glossy, yellowish-green. *Stems* creeping, closely pinnate, branches to 1 cm long, 0.5 to 1 mm wide with leaves, complanate-foliolate, abundance funnel shoots; rhizoid few in cluster, red; central strand absent. *Leaves* crowded, complanate, ovate-oblong to ovate-lanceolate, acute apex, gradually concave near base, 1.5-1.8 x 0.4-0.5 mm; margins plane, smooth below, minutely serrulate above; ecostate; laminal cells vermiform to rhomboidal; 50-75 x 3-5  $\mu\text{m}$ , rarely papillae or smooth, alar cells consist of 1 row of 2-3 cells, rectangular, inflated hyaline, sharply distinct from the group of 6-9 subquadrate cells just above.

*Autoicous*. *Perichaetial leaves* erect, long-acuminate, sharply serrate. *Calyptrae* cucullate, smooth and naked. *Setae* slender, 1.5-1.75 cm long, reddish, smooth. *Capsules* medium, 0.8-1.2 x 0.4-0.5 mm, slightly inclined, ovoid to elongate, urn 1 mm long; lid conical, 0.5 mm long; peristome double, normal.

Illustration. — Unknown.

Thailand. — PENINSULA. Chumphon.

Distribution. — Endemic to Thailand.

Ecology. — On stems of shrub in river. Alt. 50 m.

Specimens examined.— TYPE. Chumphon [Tasan, 22 December 1928, *Kerr* 368 (lecto-, BM)]

Discussion. — This has the alar cells of *T. alare* Broth., but broadly and shortly pointed leaves, and quite smooth cells are differentiated.

7. *Taxithelium gottscheanum* (Hampe ex Müll. Hal.) Broth., Nat. Pflanzenfam. 1(3): 1091. 1908. *Trichosteleum gottscheanum* (Hampe ex Müll. Hal.) A. Jaeger., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877-78: 412. 1878. *Hypnum gottscheanum* Hampe ex Müll. Hal., Linnaea 38: 568. 1874.

*Taxithelium percapillipes* Broth., Philipp. J. Sci. 8: 89. 1913.

*Taxithelium subtrachaelophyllum* Dixon, Bull. Tor. Bot. Club 51: 243. f.3: 18. 1924.

*Plants* Relatively robust, pale yellowish green, glossy plant in lax tufts. *Stems* creeping, irregularly pinnate, branches spreading, blunt, about 1 cm long, complanate-foliolate. *Leaves* broadly ovate from a constricted base, abruptly acute, deeply concave, ecostate, 1 to 1.2 mm long, 0.7 mm wide; margins erect, sharply erose-denticulate above; ecostate; lamina cells about 3  $\mu\text{m}$  wide, 12 to 15 times as long, minutely but very distinctly seriate-papillose, alar cells 2 or 3, small, oval, more or less inflated, pellucid or hyaline, with a small group of 9-12 irregularly quadrate cells just above.

*Autoicous*. *Inner perichaetial leaves* long-acuminate, sharply serrate. *Calyptra* cucullate, smooth and naked. *Setae* 1 to 2 cm long, very slender, smooth. *Capsules* ovoid, suberect, wide-mouthed when dry, urn about 0.6 mm long; lid short, conical, apiculate; peristome double, normal.

Illustration. — Bartram 1939 (Pl. 26, fig. 446).

Thailand. — SOUTHEASTERN. Chonburi.

Distribution. — Borneo and Philippines.

Ecology. — On branches of trees. Alt. 100-1740 m.

Specimens examined.— SOUTHEASTERN. Chonburi [Eastern part of Khao Yai National Park, 10 Aug. 1968, *LSaW* 3285 (AAU)].

Discussion. — Probably allied to *T. nepalense* but thoroughly distinct in the larger, glossy, more sharply toothed leaves showing 2 or 3 distinctly inflated alar cells and the suberect capsules.

8. *Taxithelium inerme* P. Tixier, Rev. Bryol. Lichenol., 38: 159. f. 8. 1971-72 [1972].

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, irregularly pinnate, branches draw up, flattened, up to 1 cm long; rhizoid few in cluster, red; central strand absent. *Leaves* ovate to ovate-lanceolate, acuminate apex, concave, 1 mm long, 0.4 mm wide; margins smooth to crenulate above; ecostate; laminal cells linear to oblong with thin walled, 30 x 7  $\mu\text{m}$  near base, 50 x 6-7  $\mu\text{m}$  in middle part, nonpapillose; alar cells consist of 1 row of 5 cells, quadrangular to oblong-rectangular, 15 x 15  $\mu\text{m}$ . hyaline, distinct the group of numerous small quadrangular cells above.

*Sporophytes* not seen.

Illustration. — Tixier 1971-72 (Pl. 8, figs. 1-6).

Thailand. — SOUTHEASTERN. Chanthaburi.

Distribution. — Endemic to Thailand.

Ecology. — On tree trunks or twigs.

Specimens examined.— TYPE. Chanthaburi [Plew Waterfalls, 3 Jun, 1965, Tixier 965 (holo-, PC).

Discussion. — The species was first described from Thai specimen by Tixier (1971-72), but could not found specimen from herbarium at this study, the description above follow original description.

9. *Taxithelium instratum* (Brid.) Broth., Rev. Bryol. 28: 110. 1901. *Hypnum instratum* Brid., Bryologia Universa 2: 394-5 (1827). — Type: 'Patria ignota'. [not seen].

**Figure 5.68**

*Plants* slender, dull, yellowish-green, forming dense, flat mats. *Stems* elongate, creeping, regularly and sparsely pinnate; branches short, 1-3 mm long, widely spreading, complanately foliate. *Leaves* imbricate, ovate from a contracted clasping base, concave, acute to short-acuminate, 1 x 0.4 mm; margins erect, sharply serrate above and serrulate to base; lamina cells at leaf apex short, rhomboid, papillose; mid-laminal cells narrowly rhomboid, thin-walled, 40-80 x 4  $\mu\text{m}$ , strongly seriate-papillose; alar region small, basal alar cells few (usually 2 or 3), oval, slightly inflated, often yellowish, upper alar cells irregularly quadrate in a small triangular group.

*Autoicous*. *Perichaetial leaves* narrow-lanceolate, acuminate, upper margin serrulate, laminal cells shorter, less papillose than in vegetative leaves. *Setae* slender, 12-18 mm long, smooth, curved at tip. *Capsules* small, horizontal  $\pm$  gibbose; exothecial cells rectangular with irregular thickening; operculum with rostrum up to 0.4 mm long; peristome with exostome teeth narrowing to apex, strongly papillose, short trabeculae projecting on abaxial surface; endostome segments perforated, papillose, basal membrane low (1/4 length of segment), cilium 1, same length as segment. *Spores* 10-15  $\mu\text{m}$ .

Illustration. — Bartram 1939 (Pl. 26, fig. 443).

Thailand. — NORTHEASTERN. Khon Kaen; EASTERN. Nakhon Ratchasima; CENTRAL. Nakhon Nayok; SOUTHEASTERN. Trat, Chanthaburi, Prachin Buri; SOUTHWESTERN. Kanchanaburi; PENINSULA. Nakhon Si Thammarat, Satun, Trang.

Distribution. — Borneo, Mainland China, Java, Kampuchea, Malay Peninsula, Myanmar, New Guinea, Philippines, Taiwan, and Vietnam.

Ecology. — On bark of trees and on decayed wood. Alt. 50-1300 m.

Specimens examined.— NORTHEASTERN. Khon Kaen [Chumpae, 27 Mar. 1952, Smitinand 1234 (AAU, BKF, PC). EASTERN. Nakhon Ratchasima [Pak Thong Chai, 8 Aug. 1968, LSaW 3150, 3166 (AAU). CENTRAL. Nakhon Nayok [LSaW 3390 (AAU)].

SOUTHEASTERN. Trat [Khao Mai Si, 21 Jun. 1952, *Smitinand* 1417, 1418 (AAU, BKF); Dong Maduea, 19 Jun. 1952, *Smitinand* 1316, 1319 (BKF); Koh Chang Island, 25 Aug. 1966, *LSmW* 1804, 1825 (AAU); Ta Sen Fall, 9 Feb. 1972, *LNSa* 32392 (AAU); Koh Kut, 20 Nov. 1970, *CLW* 5085 (AAU, FH, NY)]; Chanthaburi [Makam rubber plantation, 22 Aug. 1966, *LSmW*, 1714, 1726 (AAU), *LSmW* 1734 (AAU, BM, NY)]; Prachin Buri [Ban Bung Hills, 22 Aug. 1966, *LSmW* 1160 (AAU)]. SOUTHWESTERN. Kanchanaburi [Sai Yok, 12 Apr. 1961, *Larsen* 8505, 8670, 9122, 9182, 9282 (AAU)]. PENINSULA. Nakhon Si Thammarat [*Touw* 11954 (L)], Satun [Kuan Karong, 14 Oct. 1970, *CLW* 3801 (AAU, BM, NY)], Trang [Khao Chong, 9 Oct. 1970, *CLW* 3527, 3543, 3547, 3619 (AAU)].

Discussion. — *Taxithelium instratum* was first recorded by Brotherus (1901) from Koh Chang, Trat. This species is recognized by the regularly complanate appearance with short, dull, almost grey-green branches, leaves ovate with acute to acuminate apex, strongly papillose leaf cells, sharply toothed apices and the leaf margins serrulate to the base. The small but  $\pm$  inflated basal alar cells (usually two) are conspicuous.

10. *Taxithelium isocladum* (Bosch & Sande Lac.) Renaud & Cardot, Rev. Bryol. 28: 111. 1901. *Hypnum isocladum* (Bosch & Sande Lac.), Bryol. Jav. 2: 173. 272. 1867. *Trichosteleum isocladum* (Bosch & Sande Lac.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 412 (Gen. Sp. Musc. 2: 478). 1878. *Sigmatella isoclada* (Bosch & Sande Lac.) Müll. Hal., Index Bryol. Supple. Primum 309. 1900.

#### Figure 5.70

*Plants* slender, usually tufts, glossy, yellowish-green. *Stems* creeping, closely pinnate, branches distant, up to 1 cm long, 1.5, complanate-foliate; rhizoid few in cluster, red; central strand absent. *Leaves* arranged in one plan, erect to twist spreading, narrowly ovate-lanceolate, gradually acuminate apex, concave, 1.28-2 x 0.28-0.4 mm; margins plane, minutely serrulate below, slightly smooth above; ecostate; laminal cells narrowly linear; 3-5  $\mu$ m wide 80-105  $\mu$ m long, minutely seriate-papillose, 4-6 bumpy cells papillae, alar cells consist of 1 row of 2-3 cells, oval, inflated and hyaline, sharply distinct from the small group of irregular cells just above.

*Autoicous*. *Inner perichaetial leaves* long-acuminate, sharply serrate. Calyptrae cucullate, smooth and naked. Setae slender, up to 1.2 cm long, reddish, smooth. Capsules small, slightly incline, ovoid to elongate or elongate-cylindric 1.0-0.8 x 0.4-0.5 mm, exothecial cells collenchymatous; operculum form a conic base, urn 0.5 mm long; lid conical, 0.5 mm long, oblique; peristome double.

Illustration. — Dozy & Molkenboer (1855-70, Tab. 272, as *Hypnum isocladum*).

Thailand. — SOUTHEASTERN. Chanthaburi, Trat; PENINSULA. Ranong.

Distribution. — Borneo, Laos, Malaysia, New Guinea, and Vietnam.

Ecology. — On twigs of trees. Alt. 50-200 m.

Specimens examined.— TYPE. Indonesia [Borneo, *Kurz s.n.* (lecto-BM); 7 Apr. 1897, *J. B. Sedru s.n.* (syn-, BM)]. SOUTHEASTERN. Chanthaburi [*Smitinand* 1822 (BKF, PC)]; Trat [*Schmidt s.n.* (H)]. PENINSULA. Ranong [Khao Talu, 4 Feb. 1927, *Kerr* 179 (BM)].

Discussion. — With the habit and fruiting characters of *T. isocladum*. This differs quiet markedly in the much narrower and more narrowly acuminate leaves, the sharply denticulate margin,

11. *Taxithelium kerianum* (Broth.) Broth., Nat. Pflanzenfam. 1(3): 1901 (1908).  
*Trichosteleum kerianum* Broth., Oefv. Finsk. Vet. Soc. Foerh., 33: 108 (1891). — Type:  
Australia: Queensland: Haevey's Creek, Russell River ubi ad ramulos, anno 1889, *F. M. Bailey N598* (holo-, H-BR; iso-, BRI).

*Plants* small, usually dull, pale golden-green in dense, feathery mats. *Main stems* elongate, to 2-3 cm, creeping, densely pinnate, branches 1-4 mm, not spreading, laxly complanately foliate. *Stem and branch leaves* erecto-patent to spreading horizontally, more appressed when dry, ovate-lanceolate, gradually narrowing to acumen, concave, 0.8-1.0 x 0.2-0.3 mm; margins usually involute, entire; cell at leaf apex usually coronate-papillose with 1-3 papillae, rarely smooth; ecostate or costa short and double; mid-laminal cells narrowly rhomboid, 48-90 x 3-6  $\mu\text{m}$ , distinctly papillose, 3-5 papillae along lumen (except at extreme leaf tip and lower margins); alar region differentiated, basal alar cells few and small, occasionally slightly enlarged at extreme angles, hyaline; upper alar region with 2 or 3 rows of quadrate cells.

*Perichaetial leaves* filiform-acuminate, subentire, apical cells long, 4:1 (L:W), coronate papillose; margins smooth. *Setae* slender, erect 5-10 mm long, very slightly rugulose toward tip. *Capsules* minute, 0.8 mm, suberect to inclined, cernuate-ovate; exothecial cells quadrate to rectangular and somewhat thickened; peristome with exostome teeth narrow-lanceolate, papillose above, tabeculae projecting on abaxial surface, adaxial surface strongly papillose with median groove; endostome segments strongly attenuate above, basal membrane of medium height, smooth on outer surface, quadrate and papillose on inner surface; cilia not seen. *Spores* 15-20  $\mu\text{m}$ .

Illustration. — Bartram 1939 (Pl. 26, fig. 452), Fleischer 1904-22 (Fig. 218), Gangulee 1980 (Fig. 984), Noguchi 1987-94 (Fig. 479C), Ramsay *et al* 2002 (Fig.3-4).

Thailand. — PENINSULA. Surat Thani.

Distribution. — This species is distributed in Borneo, India, Japan, Java, Kampuchea Malesia, particularly the Philippines and Papua New Guinea, as well as Australia.

Ecology. — occurs mostly on twiggy branches on small logs rarely on soil over rocks in riverine closed forests.

Specimens examined.— PENINSULA. Surat Thani: *Tixier s.n.* (PC).

Discussion. — This species was reported found in Thailand by Tixier (1971). Specimen was preserved in Paris herbarium could not found for this study. The description above is following Ramsay *et al* (2000).

12. *Taxithelium magnum* M. Fleisch., Musci Fl. Buitenzorg 4: 1348. 1923.

#### Figure 5.71

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, 10-15 cm, closely pinnate, branches slightly regular, spreading with bent terminal, up to 1 cm long, 1.5 - 2 mm wide with leaves, erect to complanate-foliate; rhizoid red, few, attach to substrate; central strand absent. *Leaves* crowded, erect to twist spreading, narrowly ovate to ovate-lanceolate, gradually filiform-acuminate, concave near base, 1.7-2 x 0.5-0.6 mm wide, margins plane, smooth to minutely serrulate below, strongly serrulate above; ecostate; laminal cells narrowly linear, 60-100 x 4-5  $\mu\text{m}$ , minutely seriate-papillose in middle part, 4-6 small bumpy cells; alar cells consist of 1 row of 2-3 cells, oval, inflated, hyaline to yellowish, sharply distinct from the small group of irregular cells just above.

*Autoicous*. *Perichaetial leaves* oblong, long-acuminate apex, upper margin sharply serrate. *Calyptrae* cucullate, smooth and naked. *Seta* slender, 2-3 cm long, reddish brown,

smooth. *Capsules* small, 0.8 x 0.4 mm, slightly inclined, ovoid to elongate or elongate-cylindric, urn 1 mm long; lid conical, 0.5 mm long; peristome double, normal. *Spores* small, 13-15  $\mu\text{m}$ , yellowish green, spherical, finely papillose.

Illustration. — Unknown.

Thailand. — PENINSULA. Nakhon Si Thammarat, Krabi, Phangnga.

Distribution. — Borneo, Java, Malay Peninsula, and Sumatra.

Ecology. — On twigs of trees in evergreen forest, alt. 800-1100 m.

Specimens examined.— PENINSULA. Nakhon Si Thammarat [Khao Luang, 20 Apr. 1925, *Smitinand 1293* (AAU, BKF, PC)]; Krabi [Panom Bencha, 28 Mar. 1930, *Kerr 513* (BM)]; Phangnga [Khao Kata Kwam *Kerr 492* (BM); Khao Bangto, *Kerr 419, 422* (BM)]. Indonesia. Borneo [W. Koetai, Kemoel, Oct. 1925, *Endert 3676a* (BM)]; Java [G. Halimoen, Dec. 1913, *Bacher 2082* (BM)].

Discussion. — This species is similar to *T. alare*, but the former different in plant bigger sized, leaves more ovate and strongly serrate margin near apex.

13. *Taxithelium merrillii* Broth., Philipp. J. Sci. 13:219 (1918).— Type: Philippines: Tatay, Palawan iv.1913, *E.D. Merrill 8992* (H-BR!).

#### Figure 5.72

*Plants* robust, in dense, dull, brownish-green mats. *Stems* creeping, closely pinnate, branches 1-3-5 mm, complanately foliate. *Stem and branch leaves* erect-spreading, ovate, concave, obtuse or broadly acute 1.5-1.7 x 0.5-0.6 mm, margin plane, minutely denticulate near apex. Lamina cells at leaf apex short rhomboid, papillose, mid-laminal cells linear, 24-40 x 3-4  $\mu\text{m}$ , 3-5 minutely papillae per cell; alar region somewhat differentiated, alar group small with single basal row of inflated 2-3 cells and a triangular group of a few upper alar cells.

*Perichaetial leaves* smaller than vegetative leaves, lanceolate, short acuminate, margin entire. *Setae* up to 1.7 cm long, smooth, curved at tip. *Capsules* curved, slightly asymmetrical, exothecial cells not or slightly thickened at corners; operculum with curved rostrum; peristome with exostome teeth papillose and trabeculae well developed, apices of teeth hyaline; endostome with a basal membranemedium height (1/3 height of exostome tooth, only slightly papillose, cilia not seen. *Spores* 10-20  $\mu\text{m}$  in diameter, green.

Illustration. — Bartram 1939 (Pl. 26, fig. 442), Ramsay *et al.* 2002 (Fig.5).

Thailand. — SOUTHEASTERN. Trat; PENINSULA. Satun.

Distribution. — Philippines, South-east Asia, Australia.

Ecology. — The plants form extensive mats on silky sediments and small exposed mangrove roots.

Specimens examined.— TYPE. Philippines [Taytay Palawan, Apr. 1913, E.D. Merrill 8992 (lecto-, FH; iso-, BM)]. SOUTHEASTERN. Trat [Koh Kut, 21 Nov. 1970, *CLW 5130* (AAU, NY)]. PENINSULA. Satun [Terutao Island, 28 Feb. 1966, *Hansen & Smitinand 12493* (AAU, L)].

Discussion. — Original recorded as endemic to the Philippines (Bartram 1939), this species is now recorded for South-east Asia (Tan and Iwatsuki 1993) and also for Australia (Stone 1982).

14. *Taxithelium nepalense* (Schwaegr.) Broth., Monsunia 1: 51. 1899.; *Trichosteium nepalense* (Schwaegr.) Jaeg., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 142. 1878.; *Stereodon nepalense* (Schwaegr.) Mitt., J. Proc. Linn. Soc. Bot., Suppl. 2:

100. 1859.; *Hypnum nepalense* Swaegr., Sp. Musc. Frond., Suppl. 3(1): 226. 1828.—  
Type: Nepal. Wallich *s.n.*

*Hypnum punctulatum* Harv., Hook., Icon. Pl. 1: 13. f. 10. 1836., hom. Illeg.

*Taxithelium turgidellum* (C. Müll.) Par., Index Bryol. Ed. 2, 4: 358. 1905. *Trichosteleum turgidellum* (C. Müll.) Kindb., Enum. Bryin. Exot., Suppl. 2, 104. 1891. *Hypnum turgidellum* C. Müll. Bot. Jahrb. Syst. 5: 87. 1883.

*Trichosteleum trochalophyllum* Hampe, Jaeg., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 414. 1878.

### Figure 5.73

*Plants* robust, dull yellowish green, not glossy or slightly glossy, in dense mats. *Main stems* prostrate, elongate, irregularly branched with short and long branches up to 2.0 cm long; branches almost terete to slightly complanate, 2-4 mm long. *Stem and branch leaves* closely imbricate, densely arranged, broadly ovate, 0.8-1.1 x 0.4-0.5 mm, deeply concave, apex obtuse or bluntly acute; margins entire below, serrulate near apex; costae absent; leaf cells near apex short rhomboidal; mid-laminal narrowly rhomboidal, thin-walled, 40-80  $\mu\text{m}$  x 4-6  $\mu\text{m}$ , strongly serriate papillose in one row though out apex; basal cells similar to upper cells, but with larger papillae; alar cells differentiated, basal alar cells several, 3-4 small cells, rectangular to oval, scarcely inflated, upper alar cells irregularly quadrate, numerous, extending obliquely a few cells up margin.

*Inner perichaetial leaves* lanceolate, acuminate, laminal cells, strongly papillose, margin smooth above, serrulate at base. *Setae* erect, 1.7-2.0 cm long, smooth. *Capsules* ovoid, 1.2-1.3 x 0.5 mm, inclined to horizontal, slightly curved, strongly constricted under mouth when dry; exothecial cells somewhat collenchymatous; opercula conic, urn 1-1.4 mm long; peristome double; exostome teeth lanceolate, papillose, short trabeculae on inner surface, ca. 330  $\mu\text{m}$  high; endostome segments narrow, papillose, basal membrane low (1/4 length of exostome tooth); cilia not seen. *Calyptrae* campanulate. *Spores* 15-20  $\mu\text{m}$  in diameter.

Illustrations. — Bartram 1939 (Pl. 26, fig. 445), Fleischer 1904-22 (Fig. 217), Gangulee 1980 (Fig. 983), Ramsay *et al.* 2002 (fig. 8).

Thailand. — NORTHERN. Chiang Mai, Phitsanulok, Nakhon Sawan, Tak; EASTERN. Nakhon Ratchasima; CENTRAL. Bangkok; SOUTHEASTERN. Chanthaburi, Trat; PENINSULA. Phuket, Ranong, Trang, Chumphon, Surat Thani, Satun, Pattani.

Distribution. — Bangladesh, Borneo, Mainland China, India, Java, Kampuchea, Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Sumatra, and Vietnam and Auetria.

Ecology. — *T. nepalense* is found on decaying logs, bases and roots of large trees or on rock faces, including limestone, in low monsoon rainforest, or re-growth forest on river flats, alt 30-600 m.

Specimens examined.— NORTHERN. Nakhon Sawan [Langsang National Park, 23 Nov. 1965, Touw 8346 (AAU, BKF, BM)]; Tak [Touw 8346 (MO)]; Chiang Mai [Mae La Noi, 27 Dec. 1965, Touw 10304 (BKF)]; Phitsanulok [Tixier *s.n.* (PC)]. EASTERN. Nakhon Ratchasima [Khao Lotung, 9 Aug. 1968, LsaW 3228 (AAU, NY)]. CENTRAL. Bangkok [on old brick wall, 25 Nov. 1923, Kerr 68 (BM); 31 Dec. 1923, Kerr 53, 54 (BM); 23 Oct. 1927, Kerr 238, 239 (BM); 10 Jun. 1928, Kerr 316 (BM)]. SOUTHEASTERN. Chanthaburi [Khao Sabap, 7 Jan. 1930, Kerr 450 (BM); Makhm Rubber Plantation, 22 Aug. 1966, LSmW 1698, 1715 (AAU)]; Trat [Hauy Raeng, 21 Jun. 1952, Smitinand 1376 (AAU, BKF, PC)]. PENINSULA. Phuket [Thalang, Khao Kluay, 24 Jan. 1966, Touw 11179 (AAU, BKF), Touw 11141, 11164 (BKF, BM)]; Ranong [Tixier 3961 (PC)]; Trang [Khao Chong, 11 Jan. 1929, Kerr 389 (BM); 9 Oct. 1970, CLW 3532

(AAU); Chumphon [Kaw Tao, 21 Sep. 1928, *Kerr* 333, 335, 343, 344, 345, 346 (BM), Jul. 1927, *Kerr* 208 (BM), 31 Dec. 1924, *Kerr* 156 (BM)]; Surat Thani [Khao Haung, 11 Aug. 1927, *Kerr* 231 (BM); Kiensa, 19 Feb. 1930, *Kerr* 458 (BM); Yanyao, 22 Feb. 1930, *Kerr* 468 (BM); Bangbao, 8 Aug. 1955, *Smitinand* 2903 (AAU); 9 Aug. 1955, *Smitinand* 2924 (AAU, BKF); 9 Aug. 1955, *Tixier* 2235 (PC); Tan Phet, 15 Apr. 1965, *Tixier* 557 (PC)]; Satun [Tarutao Island, 5 Mar. 1966, *Hansen & Smitinand* 12532, 12536 (AAU)]; Pattani [Ban Sai Kao, 30 Mar. 1918, *Kerr* 270 (BM)].

Discussion. — *Taxithelium nepalense* has often been confused with *T. planum*, but Buck (1985) points out that the more ovate leaf with smooth cells near the apex, long mid-laminal cells and the margin serrulate almost to the base differentiate *T. planum* from the former. In *T. nepalense*, the laminal cells are much shorter and the margin is serrulate only near the apex and entire below. Damanhuri and Longton (1996) recognized them as separate species. *Taxithelium nepalense* is similar in colour to *T. instratum* but is more robust and is distinguished by the densely foliate and terete branches with broader, more abruptly pointed, concave leaves, the lack of inflated alar cells and the almost entire leaf margin.

15. *Taxithelium oblongifolium* (Sull. & Lesq.) Iwats., J. Hattori Bot. Lab. 29:60 1966.

*Hypnum oblongifolium* Sull. & Lesq., Proceedings of the American Academy of Arts and Sciences 4: 279. 1859. — **Type:** China. Hong Kong *Wright s.n.*

*Taxithelium batanense* Bartr., Philipp. J. Sci. 68: 345. 1939. Syn. nov.

**Figure 5.74**

*Plants* slender, usually depressed tufts, glossy, yellowish-green. *Stems* creeping, irregularly pinnate, branches strongly complanate-foliate, up to 0.5 mm long, 2 mm wide with leaves, terminal branch with narrowly crowded shoot; rhizoid, red, distally along main stem; central strand absent. *Leaves* narrowly ovate from a constricted base or oblong-lanceolate, concave, 1.2-1.5 mm long and about 0.4-0.48 mm wide, gradually acuminate; margins erect, sharply serrulate all around; ecostate; laminal cells very long and narrow, vermicular, about 4 µm wide and 12 to 20 times as long, minutely seriate-papillose, 3-5 papillae per cell, some twin baggies cell papillae, alar cells few, consist of 1 row of 3-5 cells, rectangular, slightly inflated at basal angles, distinct the small group of 6-12 irregular to subquadrate cells above.

*Autoicous*. *Inner perichaetial leaves* long-acuminate, sharply serrate. *Calyptrae* cucullate, smooth and naked. *Setae* slender, smooth, up to 2 cm long, reddish to orange-brown. *Capsules* small, 1.0 x 0.4 mm, slightly inclined, ovoid to elongate or elongate-cylindric; exothecial cells collenchymatous; operculum form a conic, 0.5 mm long; peristome double.

Illustration. — Bartram (1939, Pl. 26, fig. 444).

Thailand. — NORTHERN. Phitsanulok; CENTRAL. Nakhon Nayok; SOUTHEASTERN. Trat; PENINSULA. Nakhon Si Thammarat.

Distribution. — Mainland China and Philippines.

Ecology. — On twigs of trees, alt. 50-800 m.

Specimens examined.— **TYPE.** Philippines [Lower slopes of Mt. Iraya, Batan Island, Batanes Province, 20 July 1935, *H. H. Bartlett* 15464 (syn-, FH)]. NORTHERN. Phitsanulok [Phu Hin Rong Kla, 11 Sept. 2007, Pollawatn 382, 390 (BCU), *LSmW* 764 (AAU)]. CENTRAL. Nakhon Nayok [Salika fall, 14 Dec. 1968, *LSaW* 3416 (AAU, NY)]. SOUTHEASTERN. Trat [*Smitinand* 1422 (BKF)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 2 Mar. 1966, *Touw* 1523, 11489 (AAU, BKF) *Smitinand* 1293 (BKF)].

Discussion. — Similar to *T. instratum* but slightly larger and with a decided cluster. Distinguished from *T. instratum* by the longer, relatively narrower leaves, less strongly toothed margins, and uniformly narrower cells with very minute, scarcely visible papillose.

16. *Taxithelium parvulum* (Broth. & Par.) Broth., Nat. Pflanzenfam. I(3): 1092. 1908. *Trichosteleum parvulum* Broth. & Par., Bull. Herb. Boissier, ser.2, 2: 988. 1902. — Type: Japan.

**Figure 5.75**

*Plants* small, slender, yellowish-green, glossy, usually formed tufts. *Stems* short, branches 2-3 mm long, ca. 1.3 mm wide with leaves. *Stem leaves* lanceolate, gradually narrowed into an obtuse apex, concave; margins serrulate above, involute below; branch leaves ovate, gradually constricted into a shortly piliform apex, 1.1-1.3 mm x 0.2-0.4 mm, concave; margins serrulate; leaf cells linear, upper leaf cells each with 3-5 indistinct papillae; median cells 50-70 x 4-5  $\mu\text{m}$ , thin-walled; alar region not clearly differentiated, but with hyaline, small, quadrate to rectangular, smooth, thin-walled cells, 9-13  $\mu\text{m}$  long.

*Perichaetial leaves* triangular-lanceolate, ca. 1.24 mm x 0.28 mm. *Setae* elongate, up to 15 mm long; capsules cylindrical, ca. 0.88 x 0.6 mm; peristome double; exostome teeth and endostome segments nearly equal in length, ca. 250  $\mu\text{m}$  long. *Spores* small, 11-16  $\mu\text{m}$  in diameter, smooth.

Illustration. — Jia *et al.* 2005 (Pl. 614, figs. 1-16).

Thailand. — PENINSULA. Nakhon Si Thammarat.

Distribution. — China and Japan.

Ecology. — On rocks, tree trunks or rotten logs; alt. 500-675 m.

Specimens examined.— PENINSULA. Nakhon Si Thammarat [Khao Luang, 2 Mar. 1966, Touw 11484 (BKF)].

Discussion. — The diagnostic characters of this species are leaf ovate with long acuminate apex, leaf cells linear, pleuripapillose.

17. *Taxithelium sumatranum* (Bosch & Sande Lac.) Broth., Nat. Pflanzenfam. I(3): 1092. 1908. *Hypnum sumatranum* Bosch & Sande Lac., Bryol. Jav. 2: 149. 247. 1866.

**Figure 5.76**

*Plants* slender, yellowish-green, usually formed tufts. *Stems* creeping with irregularly pinnate branches; branches 3-7 mm long, 0.5-1 mm wide with leaves, complanate-foliate, slightly ascending at young terminal branch; rhizoid few in cluster, red; central strand absent. *Leaves* crowded, erect, ovate to ovate-oblong, gradually short acuminate to acute apex, middle leaf inflated, base concave, 0.9-1.0 mm long, 0.4-0.5 mm wide, margins plane, smooth to minutely dentate below, shortly dentate above; ecostate; laminal cells linear rhomboidal, 3-5 x 80-105  $\mu\text{m}$ , cells minutely papillae at middle leaf, 2-3 small cells papillae, upper and lower cells slightly smooth; alar cells consist of 1 row of 2-3 cells, oval, inflated and hyaline, sharply distinct from the small group of quadrate cells just above.

*Sporophytes* not seen.

Illustration. — Dozy & Molkenboer 1855-70 (Tab. 247, as *Hypnum sumatranum*).

Thailand. — PENINSULA. Ranong.

Distribution. — Borneo and Sumatra.

Ecology. — Altitude unknown.

Specimens examined.— PENINSULA. Ranong [Kapong, 15 Jan. 1929, Kerr 393 (BM)].

Discussion. — The species has dominant leaf shaped characters that widely ovate, this made it different from another *Taxithelium*.

18. *Taxithelium vernieri* (Duby) Besch., Bull. Soc. Bot. France, 45: 123. 1898.  
*Trichosteleum vernieri* (Duby) Jaeg., *ibid.*: 414. 1878. *Hypnum vernieri* Duby, Flora, 58: 285. 1875.

*Hypnum lepineanum* Schimp. ex Jard., Bull. Soc. Linn. Normandie, ser.2, 9: 264. 1875.  
nom. nud.

*Isopterygium lindbergii* A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 433. 1878

*Sigmatella sublaevifolia* Par., Index Bryol. Suppl. 318. 1900.

*Taxithelium lindbergii* (A. Jaeger) Renaud & Cardot, Rev. Bryol. 28: 111. 1901.;  
*Trichosteleum lindbergii* A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 412. 1878.; *Hypnum lindbergii* Sande Lac., Bryol. Jav. 2: 172. pl. 271. 1867. hom. Illeg.

### Figure 5.77

*Plants* light green, glossy, delicate, forming tufts, usually on bark. *Main stems* creeping up to 6 cm long, giving rise to short, erect to ascending pinnate branches which are mostly simple and complanate. *Leaves* spreading, erect at branch tip, appressed to stem (mostly with outspread tips) when dry, concave, ovate-lanceolate, 0.83-1.2 x 0.4-0.5 mm, apex acute; margins dentate in two-thirds of leaf, may be revolute on one side at base; ecostate; leaf cells linear, 80-110 x 2.5-4  $\mu\text{m}$  with irregular cell walls and cell tips risen to form papillae. There are very few fine papillae which may sometimes be made out to form a row on the lumen; alar cells small, hyaline, quadrate.

*Monoicous*. This specimen not fruiting but fruiting plants known in the East Indies. *Sporophytes* on main stem. *Setae* slender, erect, 1-2 cm high. *Capsules* inclined to horizontal, ovoid small; operculum conical with very short beak; peristome normal double. *Spores* smooth, 13-18  $\mu\text{m}$

Illustration. — Bartram 1939 (Pl. 26, fig. 450, as *Taxithelium lindbergii*), Gangulee 1980 (Fig. 985).

Thailand. — PENINSULA. Nakhon Si Thammarat, Trang.

Distribution. — Bangladesh, Borneo, Java, Kampuchea

Ecology. — Alt. 600-1300 m.

Specimens examined.— PENINSULA. Nakhon Si Thammarat [Khao Luang, 4 Feb. 1966, *Touw 11589* (BKF, BM), *11587*, ( L); *Phloenchit 149* (BKF)]; Trang [*CLW 3673* (AAU)].

Discussion. — Leaf cells long narrowly linear of this species is very differentiated from another species in the genus.

## 21. TRICHOSTELEUM Mitt.

*Trichosteleum* Mitt., J. Linn. Soc., Bot. 10: 181. 1868.

*Plants* somewhat small to medium sized, forming loose to dense mats, light green to yellowish-green or golden. *Stems* and branches spreading to short ascending; in cross-section outer 2-3 rows of cells small, thick-walled, inner cells large, thin- to rather thick-walled, central strand absent; radiculose. *Leaves* erect to erect-spreading, often homomallous, 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; ecostate; 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. *Gemmae* absent.

*Autoicous*. *Perichaetia* lateral; leaves differentiated. *Setae* elongate, slender and wiry, often twisted, smooth or weakly papillose distally. *Capsules* inclined to horizontal, urn ovoid, constricted below urn mouth; exothecial cells collenchymatous; stomata at urn base, superficial; 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.

Plants distributed in the Tropical Andes found on logs, humus and soil in moist in wet lowland to mid montane forest, from near sea level to 1,800 m. A pantropical genus of over 100 species with the greatest diversity in tropical Asia. There are 8 species 1 variety occurred in Thailand.

### Key to Species

1. Plant medium to large sized, yellowish brown, glossy, in low mats; stems elongate, irregularly branched; branches erect-spreading, more than 5 mm long ..... 2
1. Plant small to medium sized, yellowish green, glossy, in dense mats; stems elongate, regularly or irregularly branched; branches slightly complanate, up to 5 mm long ..... 5
  2. Branches up to 10 mm long; leaf cells thin-to occasionally thick-walled, slightly pitted, with small or large papillae ..... 3
  2. Branches more or less 5 mm long; leaf cells thin-to occasionally thick-walled, smooth, with small papillae. .... 4
3. Leaves slightly concave, acuminate or acute at apex; 1.0-1.5 x 0.25-0.50 mm; leaf cells elongate-rhomboidal to linear, 87.5-100 x 7.5  $\mu$ m; alar cells ovoid to oblong, 3-4 inflated, often colored; setae less than 1 cm long. . .... 1. *T. boschii*
3. Leaves concave, abruptly long acuminate apex; 1.52-2.0 x 0.40-0.56 mm.; leaf cells elongate-rhomboidal to linear, 50-75 x 4-5  $\mu$ m; alar cells rectangular, 2-3 cells, inflated, thick walled, often colored. Setae more than 1 cm long. .... 2. *T. mammosum*
  4. Leaves ovate-lanceolate, acuminate apex, often falcate, 1-1.20 x 0.32-0.40 mm; leaf cells elongate-rhomboidal to linear, 50-62.5 x 5-7.5  $\mu$ m, papillae dominantly with 5-7.5  $\mu$ m in diameter; alar cells ovoid, 2-3 cells, inflated, thick walled, often colored. Setae more than 1 cm long, smooth. .... 5. *T. pseudo-mammosum*
  4. Leaves lanceolate, acuminate or narrow tapering apex, 0.88-1.2 x 0.28-0.32 mm; leaf cells elongate-rhomboidal to linear, 62.5-82.5 x 7.5  $\mu$ m, papillae found at upper part, small; alar cells rectangular, 3-4 inflated, thick-walled, often colored; setae 1-1.3 cm long, minutely papillose above, smooth below. . 3. *T. monostictum* var. *laevius*
5. Stems long creeping, regularly pinnate branched; branches 3-5 mm long, loosely foliate, spreading; leaves erect-spreading, rigid, ovate to oblong-lanceolate, 0.96-1.12 x 0.20-0.24 mm, slightly concave, narrowly acute to acuminate apex; margins plane, slightly serrulate from base to apex; leaf cells linear, pellucid, with small papillae; alar cells oblong, 2-3 cells inflated, thin-walled, often colored. .... 4. *T. pinnatum*
5. Stems elongate, irregularly pinnate branched; branches more or less than 5 mm long, densely foliate; leaves erect-spreading ..... 6
  6. Branches slender, complanate, more than 5 mm long; leaves greenish brown, narrowly ovate-oblong to lanceolate, 1.2-1.6 x 0.28-0.36 mm, slightly concave, long acuminate apex; margins plane, slightly serrulate from base to apex; leaf cells linear

- to elongate, with rarely unipapillose on upper part; alar cells enlarged oblong, 2-4 cells inflated, thin-walled, often colored; seta red, 5-6 mm long, smooth. 8. *T. trachycystis*
6. Branch robust, erect to spreading, more or less than 5 mm long; leaves densely spreading, oblong-lanceolate to lanceolate ..... 7
7. Branches closed densely; leaves erect to spreading, oblong-lanceolate, slightly concave, bluntly acute apex; margins plane, strongly serrulate from base to apex, 0.72-0.96 x 0.16-0.20 mm; leaf cells equally elongate, 45-62.5 x 2.5-3  $\mu$ m, thin to moderately thick-walled, with small papillae; alar cells enlarged oblong, 2-3 hyaline cells. .... 6. *T. ruficaule*
7. Branches distally slender; leaves spreading, narrowly oblong-lanceolate, acuminate apex; margins plane, weakly serrulate, 1.5- 1.8 x 0.2-0.4 mm; leaf cells linear, 60-95 x 2.5-3  $\mu$ m, thin to moderately thick-walled, usually smooth, occasionally pitted, low papillose. alar cells ovoid to rectangular, 2-3 colored cells..... 7. *T. saproxylophilum*

1. *Trichosteleum boschii* (Dozy & Molk.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-1877: 421. *Rhaphidostichum boschii* (Dozy & Molk.) Seki, J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 12: 58. 1968. *Hypnum boschii* Dozy & Molk., Ann. Sci. Nat., Bot., sér. 3, 2: 306. 1844. — Type: Indonesia.
- Trichosteleum brachypelma* (Müll. Hal.) Par., Index Bryol. 656. 1897. *Hypnum brachypelma* Müll. Hal., Syn. Musc. Frond. 2: 404. 1851.
- Trichosteleum thelidictyon* (Sull. & Lesq.) Jaeg., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-1877: 417. 1878. *Hypnum thelidictyon* Sull. & Lesq., Proc. Amer. Acad. Arts 4: 280. 1859.

### Figure 5.78

*Plants* variable in sized, brownish, somewhat glossy, in dense, low-caespitose mats. *Stems* elongate, irregularly branched; branches up to 10 mm long, loosely foliate, sometime complanate. *Leaves* and branch leaves similar, erect-spreading, ovate to oblong-lanceolate, 1.0-1.5 x 0.25-0.50 mm, concave, acuminate or acute at apex; margins plane below, reflexed above, crenulate to serrulate at apex; leaf cells elongate-rhomboidal to linear, 50-70  $\mu$ m long, thin-to occasionally thick-walled, slightly pitted, with small or large papillae; alar cells inflated, often colored.

Inner perchaetial leaves oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. Setae less than 10 mm long, papillose above, smooth below; capsules small, usually pendent; exothecial cells smooth to mammillose.

Illustration. — Bartram 1939 (Pl. 26, fig. 44), Gangulee 1980 (Fig. 977), all as *Trichosteleum boschii*.

Thailand. — NORTHEASTERN. Khon Kaen, Loei; CENTRAL. Nakhon Nayok; SOUTHEASTERN. Prachin Buri, Chanthaburi, Trat; PENINSULA. Nakhon Si Thammarat, Surat Thani, Phuket, Satun.

Distribution. — Mainland China, India, Japan, Java, Kampuchea, Laos, Malaysia, Myanmar, Nepal, Philippines, Sumatra, Taiwan, and Vietnam.

Ecology. — on tree trunks or rocks; alt. 420-1700 m.

Specimens examined.— TYPE. Malaysia [Java, *Korthals in Herb. Hampe-1881* (lecto-BM)]; Indonesia [Borneo, *Herb. Korthals in Emill Besscherelle-1990* (syn-, BM); *Korthals s.n.* (holo-, L)]. NORTHEASTERN. Khon Kaen [Phu Wieng, 5 Feb. 1931, *Kerr 561* (BM)]; Loei [Phu Luang, 9 Jan. 1966, *Touw 10684* (AAU, NY)]. CENTRAL. Nakhon Nayok [Nang Rong Falls, 13 Aug. 1968, *LSaW 3388* (NY)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 3 Apr. 1965, *Tixier 275* (BKF); 18 Feb. 1966, *Touw 12311* (AAU); 8 Mar. 1954, *Smitinand 1822* (AAU, BKF), 5 Oct. 2005, *Pollawatn 334, 337, 340*

(BCU)]; Chanthaburi [*Kerr* 439, 445, 450 (BM)]; Trat [*Schmidt s.n.* (H-BR)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 26 Jun. 1953, *Phloenchit* 614 (FH)]; Surat Thani [Ta Phet, 15 Apr. 1965, *Tixier* 13024 (PC)]; Phuket [Thalang, 24 Jan. 1966, *Touw* 11138, 11190 (AAU); 25 Jan. 1966, *Touw* 11278 (AAU); *Touw* 11259 (AAU, BKF, NY)]. Satun [*Hansen & Smitinand* 12511 (L), *CLW* 3811 (AAU)].

Discussion. — Plants in synonym of *Trichosteleum brachypelma* has more wider leaf than *T. boschii*, leaf cells shorter, rhomboidal with more prominent papillose, alar large consist of 2-3 cells colored.

2. *Trichosteleum mammosum* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 421. *Hypnum mammosum* Müll. Hal. Syn. Musc. Frond. 2: 684. 1851.

*Rhaphidostichum leeuwenii* Dixon, Ann. Bryol. 9: 140. 1937.— Type: "On Ficus stem in jungle, Krakatau, circa 800 m alt." May 30, 1928, *van Leeuwen* 11824 (Herb. Hort. Bot. Bog.).

### Figure 5. 79

*Plants* medium sized, yellowish brown, glossy, in dense, low-caespitose mats. *Stems* elongate, irregularly branched; branches up to 10 mm long, loosely foliate, complanate when dry. *Stem leaves* and branch leaves similar, erect-spreading, ovate to oblong-lanceolate, 1.52-2.0 x 0.40-0.56 mm, concave, abruptly long acuminate apex; margins plane below, reflexed above, crenulate to serrulate at apex; leaf cells elongate-rhomboidal to linear, 50-75 x 4-5 µm, thin-to occasionally thick-walled, slightly pitted, with papillae, 3-4 µm in diameter; alar cells 2-3 cells, inflated, thick walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. *Setae* red, erect, up to 15 mm long, papillose above, smooth below. *Capsules* ovoid, 1.1-1.5 x 0.3-0.5 mm long, basal densely papillose, usually horizontal or pendent; exothecial cells smooth to mammillose; operculum long rostrate.

Illustration. — Dozy & Molkenboer 1855-70 (Tab. 273, as *Hypnum mammosum*).

Thailand. — SOUTHEASTERN. Prachin Buri; PENINSULA. Ranong.

Distribution. — Mainland China, Java, Kampuchea, Malay Peninsula, and Sumatra.

Ecology. — On tree trunks in evergreen forest, alt. 50-700 m.

Specimens examined.— TYPE. Indonesia [Sumatra, (lecto-, FH)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 18 Feb. 1966, *Touw* 12285 (AAU, BM), 5 Oct. 2005, Pollawatn 342, 343, 347 (BCU)]. PENINSULA. Ranong [Klang Kampuan, 30 Jan. 1929, *Kerr* 410b (BM)].

Discussion. — Plants always produced abundant sporophytes.

3. *Trichosteleum monostictum* var. *laevius* Dixon, Records of the Botanical Survey of India 6(3): 86. 1914.

### Figure 5. 80

*Plants* slender, yellowish brown, glossy, in dense, low-caespitose mats. *Stems* elongate, irregularly branched; branches up to 5 mm long, loosely foliate, complanate. *Stem leaves* and branch leaves similar, erect-spreading, ovate to oblong-lanceolate, 0.88-1.2 x 0.28-0.32 mm, concave, quietly narrow to acuminate apex; margins plane below, reflexed above, slightly crenulate to serrulate at apex; leaf cells elongate-rhomboidal to linear, 62.5-82.5 x 7.5 µm, thin-to occasionally thick-walled at base, smooth, with small papillae; alar cells ovoid to oblong, 3-4 inflated, thick-walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. *Setae* 1-1.3 cm long, minutely papillose above, smooth below. *Capsules* usually horizontal to pendent, ovoid-oblong, 0.5-0.6 x 0.3-0.4 mm, rarely papillose at base, constricted in upper part; exostome coil inward, endostome straight; exothecial cells collenchymatous.

Illustration. — Unknown.

Thailand. — CHANTHABURI. Chanthaburi.

Distribution. — Borneo, India, Malaysia, and Sri Lanka.

Ecology. — Altitude unknown.

Specimens examined.— TYPE. India [Mahableshtar, Jan. 1918, S.J. Sedgwick 21 (lecto-, BM; holo-, PC). CHANTHABURI. Chanthaburi [Khao Sabap, 7 Jun. 1930, *Kerr 448b* (BM)].

Discussion. — Plants always with numerous young shoots and many sporophytes, erect to patent.

#### 4. *Trichosteleum pinnatum* Dixon, J. Siam Soc., Nat. Hist. Suppl. 9: 43. 1932.

##### Figure 5.81

*Plants* medium sized, yellowish green to greenish brown, glossy, in dense mats. *Stems* elongate, regularly pinnate branched; branches 3-5 mm long, loosely foliate, spreading. *Stem leaves* and branch leaves similar, erect-spreading, rigid, oblong-lanceolate, 0.96-1.12 x 0.20-0.24 mm, slightly concave, narrowly acute to acuminate apex; margins plane, strongly serrulate at apex; leaf cells linear, pellucid, 55-75 x 2.5-3  $\mu$ m, pellucid, with small papillae; alar cells oblong, 2-3 cells inflated, thick walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. *Sporophytes* not seen.

Illustrations. — Unknown.

Thailand. — Peninsula. Ranong.

Distribution. — Malay Peninsula.

Ecology. — On branches or leaves in evergreen forest, alt. 50 m.

Specimens examined.— TYPE. Malasia [Palau Penang, 24 Feb. 1929, R.E. Holttum s.n. (holo-, BM); Ranong [Lam Lieng, 2 Feb. 1927, *Kerr 196c* (syn-, BM)].

Discussion. — The diagnostic characters of this species are long creeping and regularly branches, prostrate.

#### 5. *Trichosteleum pseudo-mammosum* M. Fleisch., Musci Fl. Buitenzorg 4: 1319. 213. 1923.

##### Figure 5.82

*Plants* medium sized, yellowish brown, glossy, in dense mats. *Stems* elongate, irregularly branched; branches up to 5 mm long, loosely foliate, spreading. *Stem leaves* and branch leaves similar, erect-spreading, ovate to oblong-lanceolate, 1-1.20 x 0.32-0.40 mm, concave, abruptly acuminate apex, often falcate; margins plane below, reflexed above, crenulate to serrulate at apex; leaf cells elongate-rhomboidal to linear, 50-62.5 x 5-7.5  $\mu$ m, thin-to occasionally thick-walled, smooth, with large papillae, 5-7.5  $\mu$ m in diameter; alar cells ovoid to oblong, 2-3 cells, inflated, thick walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. *Setae* more or less 1 cm long, smooth, usually hooked.

*Capsules* oval 0.8-1.2 x 0.4-0.5 mm, few papillose at base, horizontal to pendent; exothecial cells mammillose.

Illustration. — Fleischer 1904-22 (Fig. 213).

Thailand. — EASTERN. Nakhon Ratchasima.

Distribution. — Borneo, Mainland China, Java, Kampuchea, Laos, and Vietnam.

Ecology. — On tree trunks in Dipterocarp forest, alt. 760 m.

Specimens examined.— TYPE. Indonesia [Sumatra, 7 Jan. 1913, *M. Fleischer s.n.* (lecto-, FH). EASTERN. Nakhon Ratchasima [Khao Yai National Park, 18 Nov. 1962. *Robbins 3683* (AAU, L), 3 Sept. 2006, *Pollawatn 352, 360, 366* (BCU)].

Discussion. — The species is similar to *T. mammosum*, it can be distinguished by this species has more spreading leaves and more prominently big papilllose in each cells.

6. *Trichosteleum ruficaule* (Thwaites & Mitt.) B.C. Tan, J. Hattori Bot. Lab. 70: 101. 1991.

**Figure 5.83**

*Plants* medium sized, yellowish green to golden brown, glossy, in dense mats. *Stems* elongate, irregularly pinnate branched; branches 3-5 mm long, densely foliate, complanate when dry. *Stem leaves* and branch leaves similar, erect-spreading, rigid, oblong-lanceolate, 0.72-0.96 x 0.16-0.20 mm, slightly concave, bluntly acute apex; margins plane, strongly serrulate from base to apex; leaf cells equally elongate, 45-62.5 x 2.5-3  $\mu$ m, thin to moderately thick-walled, with small papillae; *alar cells* enlarged oblong, 2-3 cells inflated, thin-walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells clearly papillose. *Sporophytes* on main stem. *Setae* red, 6-8 mm long, smooth; capsules ovoid, 0.5 mm long, inclined, exothecial cells strongly collenchymatous.

Illustrations. — Tan 1991 (Figs. 19-23).

Thailand. — PENINSULA. Phatthalung, Phuket.

Distribution. — Borneo, Java, Kampuchea, Malay Peninsula, Philippines, Sri Lanka, and Vietnam.

Ecology. — Alt. 100-600 m.

Specimens examined.— TYPE. Malaysia [Penang hill, 1898, *H.N. Ridley 750* (lecto-, BM); 1896, *H.N. Ridley 547* (syn-, BM)]; Phuket [Takuapa, 17 Feb. 1929, *Kerr 417a* (holo-, BM, type of *Trichosteleum superserrulatum*)]. PENINSULA. Phatthalung [Khao Soi Dao, 29 Apr. 1930, *Kerr 540c* (BM)].

Discussion. — Leaf of this species is similar to *Trichosteleum pinnatum*, but it differentiated in papillose cell that rarely present in *T. ruficaule*. Further more, habit of *T. pinnata* is complete regularly pinnate branches.

7. *Trichosteleum saproxylophilum* (Müll. Hal.) B.C. Tan, W.B. Schofield & H.P. Ramsay, Nova Hedwigia 67: 220. 1998. *Sematophyllum saproxylophilum* (Müll. Hal.) M. Fleisch., Musci Fl. Buitenzorg 4: 1266. 1923. *Rhaphidostegium saproxylophilum* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 397 (Gen. Sp. Musc. 2: 463). 1878. *Hypnum saproxylophilum* Müll. Hal., Syn. Musc. Frond. 2: 334. 1851. — Type: Indonesia. Java, *Zollinger 243*. (?)

*Clastobryophilum serrulatum* Broth., Mitt. Inst.Allg. Bot. in Hamburg 7(2): 129. 1928.

*Sematophyllum decipiens* Dixon, J. Bot. 57: 77. 1919.

**Figure 5.84**

*Plants* small pale green, glossy, in dense caespituous mats. *Stems* prostrate, ca. 15 mm long, irregularly branched. *Leaves* somewhat complanate, erect-spreading, 1.8-2.1 x 0.3-0.4 mm, narrowly oblong-lanceolate, acuminate apex; margins plane, weakly serrulate at tip; leaf cells linear, (60-)65-95 x 2.5-3  $\mu\text{m}$ , thin to moderately thick-walled, usually smooth, occasionally pitted, low papillose; alar oblong, 2-4 inflated cells, 50-60 x 20-25  $\mu\text{m}$ , colored, sometimes with few small irregularly cells above.

*Inner perichaetial leaves* larger than the vegetative leaves, abruptly constricted into a long acuminate apex, irregularly serrulate, cells linear. *Setae* smooth, up to 15 mm long, usually hooked. *Capsules* oval, 0.6-0.8 x 0.2-0.3 mm, inclined; peristome double, spreading teeth when dry; operculum long rostrate up to 1 mm long.

Illustration. — Bartram 1939 (Pl. 24, fig. 418).

Thailand. — Distribution. — Borneo, Celebes, Mainland China, Indonesia, Java, Malay Peninsula, and Philippines.

Ecology. — On rotten logs; alt. 50-1400 m.

Specimens examined.— NORTHERN. Chiang Mai [Doi Chiang Dao, 4 Dec. 1965, Touw 8961 (L), 11 Sept. 2006, Pollawatn 472, 479, 483 (BCU)]. SOUTHEASTERN. Trat [Huai Raeng, Dong Maduae, 19 Jun. 1952, Smitinand 1321 (AAU), Smitinand 6660 (FH); Koh Chang, 25 Aug. 1966, LSmW 1813, 1815 (AAU), 17 Nov. 1970, CLW 4978 (AAU); Koh Rang Yai, 19 Nov. 1970, CLW 5054, 5059 (AAU)]. PENINSULA. Phangnga [Kerr 416 (BM)]; Phuket [Kerr 425 (BM)]; Ranong [Kerr 404f (BM)].

Discussion. — Leaves of this species is similar to *Trichosteleum monostictum* var. *laevius*, but leaf cells of *T. saproxylophilum* is rarely papillose and more complanate branches.

#### 8. *Trichosteleum trachycystis* Broth., Bot. Tidss.24: 115. 1901.

#### Figure 5.85

*Plants* medium sized, green to greenish yellow, glossy, in low tuft. *Stems* elongate, irregularly pinnate branched; branches more than 5 mm long, densely foliate, complanate when dry. *Stem leaves* and branch leaves similar, erect-spreading, narrowly ovate-oblong to lanceolate, 0.28-0.36 x 1.2-1.6 mm, slightly concave, long cylindrical acuminate apex; margins plane, slightly serrulate from base to apex; leaf cells linear to elongate, 45-62.5 x 2.5-3  $\mu\text{m}$ , thin to moderately thick-walled near base, with small papillae; alar cells enlarged oblong, 2-4 cells inflated, 55-75 x 25-42.5  $\mu\text{m}$ , thin-walled, often colored.

*Inner perchaetial leaves* oblong-lanceolate, long acuminate or cuspidate, serrate above; cells almost papillose at middle leaf. *Sporophytes* on main stem. *Setae* red, 5-6 mm long, smooth. *Capsules* ovoid to oblong, 0.5-0.6 x 0.2-0.3 mm, inclined to horizontal; exothelial cells strongly collenchymatous.

Illustration. — Unknown.

Thailand. — SOUTHEASTERN. Trat; PENINSULA. Krabi.

Distribution. — Endemic to Thailand.

Ecology. — Altitude unknown.

Specimens examined.— SOUTHEASTERN. Trat [Koh Chang, Lem Dan, Schmidt s.n. (H-BR)]. PENINSULA. Krabi [Khao Phanom Bencha National Park, 25 Jun. 1994, Schafer-Verwimp 16254A (PC)].

Discussion. — The species is easy to recognize by it complanate branches, leaves narrowly ovate-lanceolate to lanceolate with long cylindrical acuminate apex.

## 22. TRISMEGISTIA (Müll. Hal.) Müll. Hal.

*Trismegistia* (Müll. Hal.) Müll. Hal., Flora 82: 474. 1896. *Hypnum* Section *Trismegistia* Müll. Hal., J. Mus. Goddefroy 3(6): 39 (1874). — Type: *T. subauriculata* Müll. Hal.

*Plants* robust, glossy plants in stiff dense tufts. Primary *stems* very long creeping, arched or ascending, thickly coated with rhizoids; secondary stems short, thick, erect, usually much branched above; *branches* erect, densely foliate, subdendroid. *Stem leaves* concave from an oval, ovate to ovate-elongate base, lanceolate-ligulate or lanceolate-subulate pointed, point often twisted; *laminal cells* thinwalled, thickened above with narrow to oval lumen, smooth; *alar region* multitiered with row of basal alar cells, coloured, swollen, long, supra alar cells several, small, thin-walled. *Branch leaves* erect spreading, narrower, smaller, lanceolate from an ovate base, broadly acuminate, usually broadly bordered above and margin sharply serrate in upper half; costa short-double or none; *laminal cells* oval or oval-rhomboidal, smooth, alar region well developed, basal alar cells inflated and coloured at angles, thick-walled, porose, curved towards stem; supra alar cells rectangular.

Dioicous. *Perichaetia* on stems; inner perichaetial leaves erect, weakly long-plicate, elongate, lanceolate long pointed, sharply toothed above. Seta very long, thick, twisted, purple to red, smooth; *capsule* large 2-2.5 mm, horizontal; *operculum* from conic base, long rostrate; *annulus* differentiated, broad, persistent; *peristome* diplolepidous, double, alternate; *exostome* teeth 16, lanceolate, incurved, dorsally finely cross striate, ventral lamellae radially developed; *endostome* segments 16 with broad, sharply keeled segments, cilia 3-4, high basal membrane, segments and teeth similar in length. *Spores* medium sized, papillose. No chromosome number available.

*Trismegistia* is a primary Indo-Malesian genus including New Guinea with about 20 species worldwide. There is one species found in Thailand.

*Trismegistia rigida* (Mitt.) Broth., Nat. Pfl., ed. 1, 3: 1078. 1908.

*Acanthodium rigidum* Mitt., J. Linn. Soc. Bot. 10: 182 1868;

*Hypnum rigidum* Reinw. & Hornsch., Nov. Act. Ac. Leop. Car. 14 (suppl.): 731 1829.

*hom. illeg.*

*Trismegistia lancifolia* (Harv.) Broth., Nat. Pfl. 1, 3: 1078 (1908).; *Neckera lancifolia*

Harv. in Hook., Icon. Pl. Rar. 1:21. 1836. T: *n.v.*

### Figure 5.86

*Plants* in extensive, wiry, glossy, golden-green dense turfts. *Primary stem* very long, often stoloniferous, creeping, arched; secondary stems erect, often subdendroid and copiously branched above, slightly complanate, blunt at tips. *Stem leaves* patent to spreading, appressed when dry, concave from an oval, ovate to ovate-elongate base, lanceolate-ligulate or lanceolate-subulate pointed, point often twisted; 1.8-2.4 x 0.4-0.6 mm, larger and acute pointed on main stem; branch leaves smaller, narrower, patent to spreading, narrowly lanceolate, 1.5-2.0 x 0.3-0.4 mm, concave, slightly narrowed to a ligulate tip with short acuminate apex; margins sharply serrate to dentate above and distinctly bordered with 2-3 rows of narrow, thick-walled, porose cells in upper half; laminal cells linear-rhomboidal 40-50 x 5-7.5 µm, shorter and broader near apex 25-30 x 10 µm; alar region strongly differentiated, basal alar cells large, golden brown 110-130 x 25-35 µm, inflated, thick-walled, some porose and outermost cells transversely divided to 2-3 small cells; supra alar cells 1-2 rows, rectangular.

*Dioicous*. *Perichaetia* on main stem. *Perichaetial leaves* narrow, erect with acuminate, serrate apex. *Setae* long, smooth 6-7.5 cm long. *Capsules* long exserted, horizontal, large arcuate, cylindrical, 3.8 x 1.2 mm; operculum long, rostrate; peristome double; exostome teeth 16, lanceolate, 700-800  $\mu\text{m}$  long, subulate, papillose, dorsal trabeculae short; endostome segments similar length to exostome teeth, papillose, basal membrane high, cilia in bundles of 3-4. *Spores* 16-20  $\mu\text{m}$ .

Illustration. — Bartram 1939 (Pl. 24, fig. 406-407), Gangulee 1980 (Fig. 951).

Thailand. — NORTHEASTERN. Loei; PENINSULA. Nakhon Si Thammarat, Narathiwat, Phangnga.

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

Ecology. — Alt. 400-1740 m.

Specimens examined.— TYPE. Nepal [Wallich, lecto-, FH]. NORTHEASTERN. Loei [Phu Luang, 9 Oct. 1966, *Touw 10688* (FH)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 7 Feb. 1966, *Touw 11978* (AAU), 4 Aug. 2007, *Pollawatn 648, 649* (BCU)]; Narathiwat [Chhatvarin Falls, 18-19 Oct. 1970, *CLW 4055, 4018* (AAU)]; Phangnga [Khao Ohra Mi, 9 Jul. 1972, *LNSa 30807* (AAU)]. Indonesia [Sumatra, Dec. 1899, *M. Fleischer 531*; Sumatra, *M. Fleischer 532* (L)].

Discussion. — *Trismegistia* is not recorded in Streimann & Curnow (1989) but was reported for Australia by Stone (1982) as *T. lancifolia* (*T. rigida*). *Trismegistia rigida* is corticolous occurring on trees and log in rainforest. Although large, the species has been rarely collected in Australia. It is a robust and extremely polymorphic taxon, with a secondary bipinnate branching system, sometime dendroid. The strongly bordered, serrate leaves distinguish *T. rigida* from all other Australian Sematophyllaceae. Pre-germination of spores was noted in capsules of collections from Papua New Guinea. Australian collections are sterile, hence details of peristome are based on the New Guinea collection, *H. Streimann 19860*.

### 23. **WARBURGIELLA Müll. Hal. ex Broth.**

***Warburgiella* Müll. Hal. ex Broth.**, *Monsunia* 1: 176 (1900).— Type. *W. cupressinoides* Müll Hal. ex Broth., *Monsunia* 1: 176. 1900.

*Plants* small, in dense, glossy yellow-green mats. *Stems* creeping, elongate, irregularly pinnate to bipinnate branched. Branches to 2 cm, with short, erect-divergent cuspidate branch tips. *Pseudoparaphyllia* foliose. *Stem and branch leaves* similar, strongly falcate-secund to circinate, lanceolate to ovate-lanceolate, with expanded, sheathing leaf base, often abruptly long acuminate, acumen sometimes twisted; margin sharply serrate to nearly entire above, entire below, plane but sometimes appearing involute from the strong concavity, ecostate; laminal cells elongate to narrow-linear, prorulose to smooth, sometime unipapillose; alar region often coloured, single basal row of 3 large, swollen, thick-walled, elongate alar cells; one row of 3 subquadrate small supra-alar cells. Perigonia and perichaetial leaves large, with expanded base clasping the branch nad vaginula, often abruptly cuspidate, without differentiated alar cells.

*Autoicous*. *Calyptra* large, campanulate (mitrate) sheathing the whole capsule or cucullate, smooth, base deeply lacinate to entire. *Setae* slender, elongate, curved at apex, smooth or papillose above. *Capsules* horizontal to inclined, cylindrical, neck with stomata, contracted under mouth when dry, smooth, exothecial cells rectangular with thickened

longitudinal walls, at times semi-collenchymatous; operculum obliquely long rostrate; peristome double, exostome of 16 lanceolate teeth, subulate, densely cross-striolate below, coarsely papillose above with a deep median furrow, well developed trabeculae on inner surface; endostome segments same length as exostome teeth, keeled, slit and perforated, hyaline, smooth, from a high basal membrane, cilia usually 2, well developed, nodose. *Spores* finely papillose.

About ten species are distributed in tropical Africa, Malesia, Oceania and New Caledonia. Only one species is accepted for Thailand.

***Warburgiella leptorrhynchoides* (Mitt.) M. Fleisch.**, Musci Fl. Buitenzorg 4: 1253. 1923. *Stereodon leptorrhynchoides* Mitt., J. Linn. Soc. Bot. Suppl. 1: 103. 1859. *Hypnum leptorrhynchoides* Mont., Mitt., J. Linn. Soc. Bot. Suppl. 1: 103. 1859. *nom. nud.* — Type: India, Nilghiri, Perrotet (NY). *Rhaphidostegium leptorrhynchoides* (Mitt.) A. Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 404. 1878. *Rhaphidorrhynchium leptorrhynchoides* (Mitt.) Broth., Nat. Pflanzenfam. (ed.2) (11): 427. 1925. *Rhaphidostegium subleptorrhynchoides* M. Fleisch., Hedwigia 44: 321. 1905. *Warburgiella subleptorrhynchoides* (M. Fleisch.) M. Fleisch., Musci Fl. Buitenzorg 4: 1250. 1923. — Type: West Java, July 1898, M. Fleisch. (L).

#### Figure 5.87

*Plants* creeping, irregularly pinnate to bipinnate, greenish to yellow-green, forming mats. *Main stems* creeping, up to 2 cm.; branches upright to spreading, 4-5 mm long. *Leaves* falcate to falcate-secund, narrow to lanceolate, 0.5-1.1 x 0.2-0.3 mm, abruptly narrowed to a long serrulate acumen; laminal cells rhomboidal 55-75 x 5-6  $\mu$ m, often unipapillose over lumen, apical cells long; alar region with basal row of 2-3 large alar cells, orange, elliptical, thick-walled, 85-110 x 15-20  $\mu$ m; supra-alar cells few, thick-walled.

*Polyoicous*. *Perigonia* on branches. *Perichaetia* on stems, perichaetial leaves long narrow, acuminate, apex serrulate. *Setae* orange, 1.5-2 cm, smooth, often curled upward; capsules 1.1-1.3 x 0.3-0.4 mm; exothecial cells semi-collenchymatous; peristome double; exostome teeth 16, papillose above, cross-striolate below, medial groove, trabeculate on inner face, papillose on outer and inner surface; endostome segments 16, surface with scattered papillae, basal membrane high, cilium single, shorter than teeth or segments. *Spores* 11-15  $\mu$ m, papillose.

Illustration. — Fleischer 1923 (fig. 203, as *W. subleptorrhynchoides*); Ramsey *et al* 2004 (fig. 26, 27).

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

Distribution. — India, Sri Lanka, Sumatra, Malesia, New Guinea, and Australia.

Ecology. — Alt. 2,300-2,550 m.

Specimens examined.— TYPE. Ceylon [Jul. 1883, T.W.N. Beckett-c215, (lecto-, FH)]. NORTHERN. Chiang Mai [Doi Inthanon, 20 Dec. 1965, Touw 10121 (L), 10118 (AAU)]. PENINSULA. Nakhon Si Thammarat [Khao Luang, 5 Feb. 1966, Touw 11780 (AAU)].

Discussion. — Previously Fleischer (1923) suggested *W. subleptorrhynchoides* and *W. leptorrhynchoides* are close relatives together, although he retained them as two separated species. Touw (1992) accepted *W. subleptorrhynchoides* into synonym with *W. leptorrhynchoides*. and represent a single taxon. *W. leptorrhynchoides* has often been confused with *W. cupressinoides* Müll. Hal. ex Broth. The latter has mitrate or companate calyptra and strongly toothed, falcate leaf acumens.

## 24. WIJKIA H.A. Crum

*Wijkia* H.A. Crum, Bryologist 74: 170. 1971.

*Acanthocladium* sensu Broth. Nat. Pfl., ed. 2, 11: 412. 1925., non *Acanthocladium* Mitt. Proc. Linn. Soc. New South Wales 7: 102. 1882. [= *Trismegistia*], hom. illeg., non F. Muell., Fragm. Phyt. Austr. 2: 155. 1861. (Asteraceae); nec *Acanthodium* Mitt., J. Linn. Soc. Bot. 10: 182 (1868). – Lectotype: *Wijkia extenuata* (Brid.) H.A. Crum

*Dioicous*. Plants creeping, irregularly subpinnately to irregularly bipinnately branched with stem and branch leaves differing. *Stem leaves* appressed to erect widespreading when dry, abruptly tapered from an ovate to ovate-lanceolate, strongly concave base, sometimes with a piliferous, serrulate apex. *Branch leaves* smaller and gradually acuminate. Laminal cells long, hexagonal to linear, smooth to seriatly papillose over lumina and cell walls; alar region clearly differentiated with basal row of large, inflated and coloured or hyaline cells, and several rows of small quadrate supra-alar cells. Gemmae as groups of flegelliform brood branches with microphyllous leaves sometimes occur at ends of branches. Stem long, capsule horizontal; peristome double, diplolepidous, alternate with exostome and endostome well developed trabeculae at back; endostome with high, pleated basal membrane, cilia 1-2. Spores small.

Plants distributed in mainly and old world genus in Africa, Asia and Australasia but also present in Mexico and PENINSULA Brazil and very locally in western Canada (Buck 1986). About 25 species in the world. There are 8 species occurred in Thailand.

### Key to Species

1. Plants slightly monomorphic; stem and branch leaves similar shaped, but different in sized ..... 2
1. Plants strongly dimorphic; stem and branch leaves different both shaped and sized..... 6
  2. Plants in lax tufts; main stem creeping, giving rise to erect, pinnately branched shoots; leaves dense, imbricate, almost erect to patent, concave, oblong-acute, 0.83-0.9 x 0.35-0.54 mm, apex acute, margin faintly crenulate at tip; leaf cells elongate rhomboid; alar differentiated and deep tinted ..... 1 *W. baculifera*
  2. Plants robust in dense tuft or mats; leaves concave, often abruptly constricted into a short filiform acumen, constricted at base ..... 3
3. Plants green to yellowish brown, glossy, in mats; main stems 2-3 pinnately branched; leaves erect, oblong-ovate, 1.1-1.2 x 0.3-0.4 mm; leaf margins plane or involute, slightly toothed above; lamina cells linear to fusiform, 75-135 x 5-7.5 µm; alar cells few, 3-4 cells, with a large and thin-walled decurrent cell..... 4. *W. hornschurchii*
3. Plants reddish bronze-green, glossy, in dense tufts; main stem creeping, giving rise to erect, 1-pinnate branched; leaves erectopate ..... 4
  4. Leaves, ovate-lanceolate, 1.2-1.4 x 0.28-0.4 mm, deflexed tips, narrow acuminate apex, margin smooth; leaf cells linear, 75-100 x 5-7.5 µm; alar differentiated, 3-4 large cells, with some irregular cells on top. .... 2. *W. deflexifolia*
  4. Leaves dense imbricate, oblong-lanceolate or ovate to oblong-lanceolate, slightly narrow to acute apex to long acuminate apex ..... 5
5. Lateral branches pinnate with slender long branched shoots; leaves oblong-lanceolate, 1.52-1.7 x 0.44-0.56 mm, slightly narrow to acute apex; margins almost smooth; leaf cells elongated narrow rhomboid to linear, 35-55 x 3-5 µm at middle; alar tinted, 2-4 cells, inflated, with a few smaller cells above ..... 7. *W. surcularis*

5. Lateral branches distally with long filamentous, up to 5 mm long; leaves ovate to oblong-lanceolate, 0.92-1.28 x 0.24-0.44 mm, narrowed into a long acuminate apex, margin slightly serrate from base; leaf cells pellucid, narrow linear, 95-125 x 3-5  $\mu$ m at middle, elongated narrow rhomboid at tip; alar rectangular, 3-5 cells, hyaline, inflated, with a few small rectangular to quadrate cells above ..... 3. *W. filipendula*
6. Plants spreading, yellowish green to brown, glossy, forming tufts; main stem creeping, 1-2 pinnate branched; stem leaves lax, larger, wide oblong-ovate, plicate, narrowed into a long filiform subula, lamina 1.4 x 0.9 mm; subula 0.77 mm long, usually twisted; branch leaves dense imbricate, erectopatent, concave, ovate-lanceolate with the tip narrowed into a long, narrow subula; margin dentate at shoulder but smooth at subula; leaf cells narrow linear..... 8. *W. tanytricha*
6. Plants rigid, reddish bronze-green, glossy, in dense tufts; main stem creeping, giving rise to dendroid pinnate to fasciculate penicillate branches, more than 5 mm long; stem leaves patent (appressed to stem with outspread points when dry), concave ..... 7
7. Stem leaves widely oblong-ovate, suddenly narrowed into a long, filiform apiculus, 1.76-2.40 x 0.48-0.56 mm; margin smooth; branch leaves curved, widely ovate, 1.2-1.8 x 0.44-0.56 mm., acute apex, margin slightly serrulate below apex; costae short; leaf cells narrowly oblong to linear; alar irregularly rectangular, 3-6 cells..... 5. *W. laxa*
7. Stem Leaves widely ovate, suddenly narrowed into a long, filiform apiculus, 0.75-1.08 x 0.44-0.6 mm; margin dentate on top; branch leaves curved, narrowly ovate, 0.8-1.04 x 0.4-0.52 mm., acute apex, margin slightly serrulate below apex; ecostate; leaf cells narrow elongate; alar rectangular, 2-3 cells..... 6. *W. penicillata*

1. *Wijkia baculifera* (Dixon) H.A. Crum, Bryologist, 74: 171. 1971. *Acanthocladium baculiferum* Dix., J. Bomb. Nat. Hist. Soc., 39: 791. 1937.

*Plants* in lax tufts, yellow-green to brownish or reddish, glossy. *Main stem* creeping, giving rise to erect, pinnately branched shoots. *Leaves* dense, imbricate, almost erect to patent (more appressed when dry but not otherwise changed), concave, oblong-acute, varying from 0.83 x 0.54 mm. to 0.9 x 0.35 mm., apex acute, margin faintly crenulate at tip; ecostate; leaf cells elongate rhomboid,  $\pm 30 \times 6 \mu$  at tip,  $30 \times 5 \mu$  lower down; alar differentiated and deep tinted, extreme cells  $\pm 57 \times 19 \mu$ .

*Sporophytes* on main branches. *Perichaetial leaves* narrow, erect. *Setae* slender, erect,  $\pm 3$  cm long. *Capsules* inclined, arcuate cylindrical,  $\pm 1.92 \times 0.83$  mm; *peristome* normal but exostome teeth short and blunt ( $\pm 200 \times 75 \mu$  at base). Dixon's Type was sterile but Dickason's Burmese specimen (det. Bartram) is fertile.

Illustration. — Gangulee 1980 (Fig. 948).

Thailand. — NORTHERN. Chiang Mai.

Distribution. — India, Laos, Myanmar, and Vietnam.

Ecology. — at. 1300 m.

Specimens examined.— NORTHERN. Chiang Mai: *Tixier s.n.* (PC).

Discussion. — This species was reported from Thailand by Tixier (1971). Specimens could not be found from herbarium for this study. The description above follows Gangulee (1980).

2. *Wijkia deflexifolia* (Ren. & Card.) H.A. Crum, Bryologist 74: 171. 1971. *Acanthocladium deflexifolium* Mitt. ex Ren. & Card., Bull. Soc. Roy. Bot. Belgique 41(1): 92. 1902-03 [1905]. — Type: Bhutan.
- Pylaisiadelphina subintegra* (Broth.) W. R. Buck, Yushania 1(2): 13. 1984. *Brotherella subintegra* Broth., Ann. Bryol. 1:24. 1928. — Type: Taiwan, Taityn, Onae, Suzuki s.n.
- Wijkia benguetense* (Broth.) Crum, Bryologist 74: 171. 1971. *Acanthocladium benguetense* Broth., Philipp. J. Sci. 31(3): 294. 1926.

**Figure 5. 88**

*Plants* robust, brownish green, glossy in dense tufts. *Main stem* creeping, giving rise to erect, irregularly and bi- to tripinnately branched, ultimate branchlets attenuate, subulate at the apex, brownish green. *Stem leaves* erect spreading, broadly ovate to oblong-ovate, gradually subulate-acuminate, concave, 1.5-2 x 0.5-0.8 mm, deflexed tips narrow acuminate; margins plane, entire to weakly dentate below, serrulate at apex; branch leaves smaller, ovate-lanceolate, concave, abruptly acuminate to shortly acuminate; ecostate; leaf cells linear, 60-80 x 5-7  $\mu$ m, firm to thick-walled, slightly prorulose, more lax across the insertion; alar differentiated by 3 - 4 large cells, 45-60 x 20-25  $\mu$ m, in one row with some irregular cells on top and becoming narrower along the line of insertion.

*Sporophytes* on main branches. *Perichaetial leaves* large, long acuminate, toothed above; cells linear, more lax and colored at base, but without alar differentiation, serrulate above. *Setae* slender, erect to flexuose, purplish, up to 3 cm long. *Capsules* horizontal, oblong-ovoid, cylindrical, 2-2.5 x 0.5-0.7 mm.; operculum conic at base, long rostrate, ca. 0.96 mm long; peristome normal, double with 2 to 3 cilia. *Spores* 15-20  $\mu$  in diameter.

Illustration. — Gangulee 1980 (Fig. 945); Jia *et al.* 2005 (Pl. 619, figs. 1-14).

Thailand. — NORTHERN. Chiang Mai.

Distribution. — China, Himalayas, Bhutan, Sikkim, India, Kamphuchea, Laos, Vietnam, Taiwan, and Philippines.

Ecology. — On rotten logs, tree trunks, or branches; alt. 600-2570 m.

Specimens examined.— TYPE. India [British Boolang, 14 Apr. 1898, *Renauld S. Durel* (H-BR)]. NORTHERN. Chiang Mai [Fang, 30 Apr. 1965, Tixier 868 (PC); Doi Inthanon, 20 Dec. 1965, *Touw 10233* (BM, L, NY), *Touw 10160* (BM, L), *Touw 10113* (BM, FH, L, NY), *Touw 10037* (L), 12 Sept. 2007, *Pollawatn 702, 709* (BCU)].

Discussion. — This is the most common species of *Wijkia* in China and is frequently misidentified either as a species of *Brotherella*, *Meiothecium* or *Sematophyllum*. It is reported here new to Guangdong, Guangxi, Hainan, Sichuan, Yunnan and Zhejiang provinces. Large populations of *W. deflexifolia* can be seen covering forest floor, boulders, cliffs, decaying logs and tree trunks in primary or little disturbed forests. Plant size and degree of branching can vary greatly among collections. The gradually long acuminate and deflexed leaf acumen is a good diagnostic character. *Wijkia deflexifolia* is the only species of the genus in China that does not have a cuspidate leaf apex. It can be determined further by the presence of a few subdivided enlarged basal alar cells forming two tiers of equally inflated cells. A widely distributed Guangdong specimen of *W. deflexifolia* needs special mention. The duplicate of the same collection preserved at FH contains only material of *Brotherella falcata*.

3. *Wijkia filipendula* (Dixon) H.A. Crum, Bryologist 74: 171. 1971., *Acanthocladium filipendulum* Dixon, J. Siam Soc. Nat. Hist. Suppl. 10: 18. 1935.

**Figure 5. 89**

*Plants* moderately robust, yellowish-green to brown, glossy, in tufts. *Main stems* creeping, giving rise to erect, distally short pinnately branched, young branches usually long filamentous. *Stem leaves* dense imbricate, erectopate (appressed to stem with outspread tips when dry), concave, ovate to oblong-lanceolate, tip narrowed into a long acuminate, 0.92-1.28 x 0.24-0.44 mm, margin slightly serrate from base; filamentous; branch leaves narrowly lanceolate, smaller; ecostate; leaf cells pellucid, narrow linear, 125 x 3  $\mu$  at middle, elongated narrow rhomboid, 70 x 5  $\mu$  at tip; alar differentiated, with a row of rectangular, 3-5 cells, hyaline, outermost largest, 42.5 x 17.5  $\mu$ , inflated, with 6-8 rectangular to quadrate smaller cells above.

*Sporophytes* not seen.

Illustrations. — Unknown.

Thailand. — NORTHEASTERN. Loei; CENTRAL. Nakhon Nayok; PENINSULA.

Krabi, Ranuang.

Distribution. — Endemic to Thailand.

Ecology. — On tree trunks in evergreen forest, alt. 900-1100 m.

Specimens examined.— TYPE. Krabi [Panom Bencha, 20 Mar. 1930, *Kerr 515* (lecto-, L, BM)]; Ranong [Khao Pauta, 21 Jan. 1929, *Kerr 404e* (BM)]. CENTRAL. Nakhon Nayok: *Touw 12327* (L). NORTHEASTERN. Loei: *Touw 11076, 11087* (both in L).

4. *Wijkia hornschurchii* (M. Fleisch.) H.A. Crum, *Bryologist* 74: 172. 1971.

*Acanthocladium hornschurchii* Fleisch., *Musci Fl. Buitenzorg* 4: 1206. 1923.

*Hypnum hornschurchii* Dozy & Molk., *Ann. Sci. Nat., Bot., ser.3, 2*: 307. 1844, *hom. illeg.*  
— Type: Indonesia.

*Acanthocladium pseudotanytrichum* Broth. (Dozy & Molk.) Broth., *Index Bryol. ed. 2, 1*: 2. 1903. *Sematophyllum pseudotanytrichum* (Dozy & Molk.) Par., *Index Bryol. Suppl.* 307. 1900. *Hypnum pseudotanytrichum* Dozy & Molk., *Bryol. Jav. 2*: 150. f. 248. 1866.

*Hageniella hattoriana* B. C. Tan, *Bryologist* 93: 433. f.18-22. 1990.

*Pylaisiadelphina piliformis* (Broth.) W. R. Buck, *Yushania* 1(2): 13. 1984. *Brotherella piliformis* Broth., *Acad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1*, 131: 219. 1923. — Type: China. Hunan, Wu-kang Co., *Handel-Mazzettii 12193* (iso-, BM, FH, PE).

*Wijkia juliformis* (Herz. & Dix.) Crum, *Bryologist* 74: 172. 1971. *Acanthocladium juliforme* Herz. & Dix. in Dix., *Hong Kong Naturalist, Suppl. 2*: 25. f.15. 1933.

*Wijkia sublepidum* (Broth.) Crum, *Bryologist*, 74: 173. 1971. *Acanthocladium sublepidum* Broth., *Symb. Sin.* 4: 119. 1929. — Type: China. Yunnan, *Handel-Mazzetti 8274* (syn-, H); Hunan, *Handel-Mazzetti 12100* (syn-, H)

#### Figure 5. 90

*Plants* green to yellowish brown, glossy, in mats. *Main stems* 2-3 pinnately branched, branches long and slender, slightly plane, distally attenuate. *Stem leaves* erect, oblong-ovate, 0.3-0.4 x 1.1-1.2 mm long, concave, often abruptly constricted into a short filiform acumen, 170-225  $\mu$ m long, weakly toothed, constricted at base; leaf margins plane or involute, slightly toothed above; branch leaves small narrower than stem leaves at base, concave, 0.2-0.3 x 0.7-1.0 mm, acumen shorter, 100-160  $\mu$ m long; ecostate; lamina cells linear to fusiform, 5-7.5 x 75-135  $\mu$ m, uniformly, thin-walled, gradually becoming shorter towards apex, oblong and thick-walled near base; alar cells few, 3-4 cells, 25-32.5 x 55-75  $\mu$ m, inflated, hyaline or slightly yellowish, with a large and thin-walled decurrent cell.

*Dioicous*. *Sporophytes* on main stem. *Inner perichaetial leaves* lanceolate, up to 2 mm long, acuminate, serrate to serrulate apex. *Setae* smooth, 1.75-2 cm long. *Capsules*

inclined, oblong-ovoid or subcylindrical, 1.1-1.5 x 0.4-0.5 mm, slightly arcuate; exothelial cells with longitudinally thickened walls.

Illustrations. — Jia *et al.* 2005 (Pl.620 figs. 1-12).

Thailand. — NORTHERN. Chiang Mai.

Distribution.— China and Japan.

Ecology.— On stones or rotten logs; alt. 2000-2150 m.

Specimens examined.— NORTHERN. Chiang Mai [Doi Inthanon, 20 Dec. 1965, *Touw 10046* (BM), 12 Sept. 2007, *Pollawatn 705, 711* (BCU)].

Discussion. — This species is reported as new record to Thailand from this study.

5. *Wijkia laxa* (Dixon) H.A. Crum, *Bryologist* 74: 172. 1971. *Acanthocladium laxum* Dixon, *J. Siam Soc. Nat. Hist. Suppl.* 9(1): 39. 1932. — Type: Thailand. "Payap. Doi Sutep, Siam, on rotting log in evergreen forest, circa 1300 m. alt." *A. F. G. Kerr* 52, 20 Nov. 1922, (BM).

#### Figure 5. 91

*Plants* sturdy, reddish bronze-green, glossy, in dense tufts. *Main stems* creeping, giving rise to dendroid pinnate to fasciculate penicillate branches, more than 5 mm long, ultimate branches smaller, curved. *Stem Leaves* patent (appressed to stem with outspread points when dry), concave, widely oblong-ovate, suddenly narrowed into a long, filiform apiculus, 1.76-2.40 x 0.48-0.56 mm; margins smooth; branch leaves curved, widely ovate, 1.2-1.8 x 0.44-0.56 mm., acute apex, margin slightly serrulate below apex; costae slightly short; leaf cells narrowly oblong to linear, 50-87.5 x 5-7.5  $\mu$ m at middle, 37.5-50 x 5-7.5  $\mu$ m lower down; alar differentiated by irregularly rectangular, 3-6 cells, 75-100 x 25-30  $\mu$ m, inflated, yellow to red, with few small quadrate cells above.

*Dioicous*. *Sporophytes* on main stem. *Perichaetial leaves* narrow, erect. *Setae* slender, erect, up to 3 cm long. *Capsules* curve, inclined, ovate-cylindrical, 1.3-1.5 x 0.5-0.6 mm.; apophysis thick, nodding when dry; operculum conical, short rostrate,  $\pm 0.57$  mm high; peristome normal, double; exostome teeth  $\pm 360$   $\mu$  high and 0.75  $\mu$  wide at base, with the fine horizontal stripes, papillose at top; endostome segments keeled, split, basal membrane high, cilia in pairs.

Illustrations. — Unknown.

Thailand.—NORTHERN. Chiang Mai; NORTHEASTERN. Loei; SOUTHEASTERN. Chanthaburi

Distribution. — Vietnam.

Ecology. — On tree trunks and branches in evergreen forest, alt. 1150-1800 m.

Specimens examined.— TYPE. Chiang Mai [Doi Sutep, 20 Nov. 1922, *Kerr 52* (iso-, BM)]; Chanthaburi [Kao Soi Dao, 13 Dec. 1924, *Kerr 115b* (syn-, BM). NORTHERN. Chiang Mai [Doi Inthanon, 19 Dec. 1965, *Touw 8969* (BM, FH, L, NY); Doi Sutep, 30 Nov. 1965, *Touw 8812* (BM, L, NY), 7 Sept. 2007, *Pollawatn 420, 430* (BCU)]. NORTHEASTERN. Loei [Phu Luang, 8 Jan. 1966, *Touw 10461* (BM, L, NY)]. SOUTHEASTERN. Chanthaburi [*Kerr 1914* (PC)].

Discussion. — The very handsome moss with leaves differentiated, leaf cells linear to oblong and alar cells tinted.

6. *Wijkia penicillata* (Mitt.) H.A. Crum, *Bryologist*, 74: 173. 1971. *Stereodon penicillatus* Mitt., *Musci Ind. Or.*: 112. 1859. *Eurhynchium penicillatum* (Mitt.) A.

Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 346. 1878. *Acanthocladium penicillatum* (Mitt.) Broth., Nat. Pfl., 1(3): 1076. 1908.

**Figure 5. 92**

*Plants* sturdy, reddish bronze-green, glossy in dense tufts. *Main stems* creeping, giving rise to dendroid pinnate to fasciculate penicillate branches, ultimate branches curved. *Leaves* patent (appressed to stem with outspread points when dry), concave, oblong-ovate, suddenly narrowed into a long, filiform apiculus,  $\pm 0.75 \times 0.144$  mm (including the 0.144 mm long apiculus), margin dentate on top; ecostate; leaf cells narrow elongate,  $\pm 57 \times 8 \mu$  at top,  $\pm 75 \times 7 \mu$  lower down. Alar differentiated by irregularly rectangular cells, the extreme cells are  $\pm 47 \times 19 \mu$ . all leaf cells (including alar) yellow.

*Sporophytes* on main stem. *Perichaetial leaves* narrow, erect. *Setae* slender, erect,  $\pm 2.5$  cm long. *Capsules* inclined, ovate-cylindrical,  $\pm 1.92 \times 0.64$  mm; operculum conical, short rostrate,  $\pm 0.57$  mm high; peristome normal, double; exostome teeth  $\pm 360 \mu$  high and  $0.75 \mu$  wide at base, with the fine horizontal stripes, papillose at top; endostome segments keeled, split, basal membrane high, cilia in pairs.

Illustrations. — Gangulee 1980 (Fig. 944).

Thailand. — NORTHERN. Chiang Mai.

Distribution. — Nepal, Sikkim, Darjeeling, Bhutan, Himalaya

Ecology. — On tree trunks in mossy forest, alt. 2500-2570 m.

Specimens examined.— NORTHERN. Chiang Mai [Doi Inthanon, 18 Dec. 1965, Touw 9723 (BM, FH, L, NY), Touw 9778, 9818 (L, BM)].

Discussion. — Plant is easy to recognize by its strongly pinnate branches, robust to rigid and wide spreading. Stem leaves wide oval or round shaped with long filiform apex.

7. *Wijkia surcularis* (Mitt.) H.A. Crum, Bryologist 74. 173. 1971. *Stereodon surcularis* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1:112. 1859. — Type: India. *Acanthocladium surculare* (Mitt.) Broth., Index Bryol. (ed.2), 1:3. 1903. *Hypnum surculare* (Mitt.) Jaeg., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877-78: 344. 1880.

**Figure 5. 93**

*Plants* medium-sized when well developed, dull green, in dense mats, with several upright erect shoots. *Main stems* prostrate, pinnately branched; secondary stems arcuate, up to 5 mm long, with many erect, flagellate branchlets with appressed leaves, ending in a conical tip. *Stem leaves* imbricate to erect, broadly ovate to ovate-lanceolate, constricted into a slender and long acumen, ca.  $\frac{1}{2}$  the leaf length; leaf cells oblong to elongated, 22-45  $\mu$ m long, thick-walled, slightly pitted; branch leaves patent, oblong to oblong-lanceolate, strongly concave, acuminate to shortly acuminate; margins slightly involute, entire below, serrulate at apex; elongate-oblong to narrowly linear, (30-)40-55  $\mu$ m long, thick-walled, not pitted, sometimes lowly papillose.

*Sporophytes* on main shoot. *Perichaetial leaves* narrowly elongated, erectopatent cuspidate as on stem. *Setae* slender, erect sinuose, smooth, reddish,  $\pm 3.6$  cm long. *Capsules* horizontal, ovate,  $\pm 1.73 \times 0.9$  mm.; peristome not seen but reported normal.

Illustrations. — Gangulee (1969-80, Fig. 947); Jia *et al.* (2005, Pl.621, Figs. 1-12).

Thailand. — NORTHERN. Chiang Mai; NORTHEASTERN. Loei; SOUTHEASTERN. Prachin Buri; SOUTHEASTERN. Prachin Buri.

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

Ecology. — On rotten logs, tree trunks, and rocks, alt. 700-2550 m.

Specimens examined.— TYPE. Chiang Mai [Doi Suthep, 6 Sep. 1914, Kerr 12 (lecto-, BM, as *Acanthocladium amblyphyllum* Dixon)]. NORTHERN. Chiang Mai [Doi Suthep,

20 Mar. 1951, *Smitinand* 6147, 6184 (L), 6 Dec. 1957, *Smitinand* 3912 (L), Apr. 1965, Tixier 737 (PC), 15 Jul. 1968, *LSmW* 2498 (AAU, BM, FH, NY), 14 Jul. 1968, *LSmW* 2452 (AAU), 6 Jul. 1914, *Kerr* 12 (BM), 28 Nov. 1965, *Touw* 8523, 8634 (L), *TOUW* 8505 (BM, L, NY), 29 Nov. 1965, *Touw* 8745 (BM, L), 2 Jan. 1966, *Touw* 10333; Doi Chaing Dao, 11 Nov. 1962, *Robbins* 3679 (L), 6 Dec. 1965, *Touw* 9085 (L); Doi Inthanon, 29 Oct. 1962, *Robbins* 3589, 3597 (L), 30 Oct. 1962, *Robbins* 3609 (L), 9 Jan. 1958, *Yoda-HIRO* 67697 (NY), 17 Dec. 1965, *Touw* 9652 (BM, L), 19 Dec. 1965, *Touw* 9949 (L), 21 Dec. 1965, *Touw* 10288 (BM, L, NY); Pong Pho, 30 Jul. 1968, *LSmW* 2889, 2887 (AAU), *LSmW* 2883 (AAU, BM, FH, NY)]. NORTHEASTERN. Loei [Phu Luang, 30 Jan. 1964, *HSeSm* 11455a (AAU, BKF), 8 Jan. 1966, *Touw* 10464 (L)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 16 Feb. 1966, *Touw* 12134 (L)];

Discussion. — The species found abundant in Northern of Thailand, it is one of Sino-Himalaya elements.

8. *Wijkia tanytricha* (Mont.) H.A. Crum, *The Bryologist* 74: 174. 1971. *Hypnum tanytrichum mont.*, *Ann. Sc. Nat. Bot. ser. 3, 4*: 88. 1845. *Stereodon tanytrichus* (Mont.) Mitt., *Journal of the Proceedings of the Linnean Society, Botany, Supplement 2*: 112, 157. 1859. *Hylocomium tanytrichum* (Mont.) A. Jaeger, *Bericht über die Thätigkeit der St. Gallischen Naturwissenschaftlichen Gesellschaft 1877-78*: 352 (Gen. Sp. Musc. 2: 616). 1880. *Sematophyllum tanytrichum* (Mont.) Paris, *Index Bryologicus Supplementum Primum* 308. 1900. *Acanthocladium tanytrichum* (Mont.) Broth., *Index Bryologicus, editio secunda* 1: 3. 1903.

*Acanthocladium longipilum* Broth., *Beihefte zum Botanischen Centralblatt. Abb. 2, Systematik*. 28(2): 361. 1911. — Type: Siam, Doi Sutäp, 1660-1675 m, *C. C. Hosseus s.n.*, (H-BR)

*Acanthocladium semitortipilum* M. Fleisch., *Musci Fl. Buitenzorg* 4: 1210. 1923.

#### Figure 5. 94

*Plants* robust, yellow-green (brownish in older part), glossy, large and spreading, forming turfts. *Main stems* creeping, without central strand, much branched, branches pinnate and bipinnate, ultimate branches often curved. *Stem leaves* lax, larger, wider, oblong-ovate, plicate, narrowed into a long filiform subula, lamina 1.4 x 0.9 mm; subula 0.77 mm long, usually twisted. *Branch leaves* dense imbricate, erectopate (appress with outspread tips when dry), concave, ovate-lanceolate with the tip narrowed into a long, narrow subula, lamina 0.9 x 0.42 mm, subula 0.45 mm long, margin dentate at shoulder but smooth at subula; ecostate; leaf cells narrow linear, 76 x 6 µm; alar differentiated, extreme cells 69 x 31 µm, tinted or hyaline, inflated, yellowish along point of attachment.

*Sporophytes* on main branches. *Setae* slender erect or curved, 3 cm long. *Capsules* inclined, ovate-cylindrical, 2.88 x 0.9 mm. Operculum conic, long rostrate, 1.47 mm long. *Annulus* present. *Peristome* perfect normal, with 1 to 2 cilia.

Illustrations. — Gangulee (1969-80, Fig. 946).

Thailand. — NORTHERN. Chiang Mai, Phitsanulok; NORTHEASTERN. Loei; SOUTHEASTERN. Prachin Buri

Distribution. — Sikkim, Bhutan, Borneo, Sumatra, Java, Philippines, and Vietnam.

Ecology. — Alt. 1000-1800 m.

Specimens examined. — TYPE. Chiang Mai [Doi Suthep, Jan. 1905, *Hosseus* (iso-, PC, type of *Acanthocladium longipilum*)]. NORTHERN. Chiang Mai [Doi Inthanon, 19 Dec. 1965, *Touw* 9938 (L, NY), *Touw* 9867 (FH)]; Doi Suthep, 27 Nov. 1965, *Touw* 8420 (BM, FH, L, NY)]; Phitsanulok [Phu Miang, 28 Jul. 1966, *LSmW* 1029 (AAU, BM, NY)].

NORTHEASTERN. Loei [Phu Krading, 14 Jan. 1966, Touw 10993 (BM, L, NY), *Touw 10964* (BM, L), 15 Jan. 1966, *Touw 11011* (BM, FH, L, NY), 16 Jan. 1966, *Touw 11100* (BM, L); Phu Luang, 10 Jan. 1966, *Touw 10738* (BM, L)]. SOUTHEASTERN. Prachin Buri [Khao Yai National Park, 16 Feb. 1966, *Touw 12129* (BM, L), *Touw 12127* (BM, L, NY), *Touw 12034* (BM, L)].

Discussion. — The species was reported from Thailand under *Wijkia longipilum* (Broth.) H.A. Crum. This is the first name cited of *Wijkia tanytricha* (Mont.) H.A. Crum for Flora of Thailand.

## 6 DISCUSSION

### 6.1 DIVERSITY OF SEMATOPHYLLACEAE IN THAILAND

The nomenclature system of Sematophyllaceae in Thailand is based on Brotherus (1925). Although Hedenäs and Buck (1999) has a new updated classification system of moss in this family, but the system was related to family Hypnaceae or Hookeraceae and uncertainly relationship of some genera within the family. Since the first report of Sematophyllaceae from Thailand, all taxon were reported follow system of Brotherus (1925). Recently, the moss flora of Thailand has presented on bryological research in TROPICOS. He (1995-2008) was classified Sematophyllaceae of Thailand into 22 genera 91 species and 3 varieties. The genera presented in database moss of Thailand are *Acanthorrhynchium*, *Acroporium*, *Aptychella*, *Chionostomum*, *Clastobryophilum*, *Clastobryum*, *Foreauella*\*, *Gammiella*, *Glossadelphus*\*, *Hageniella*, *Isocradiella*\*, *Mastopoma*, *Meiothecium*, *Papillidiopsis*, *Radulina*, *Rhaphidostichum*, *Sematophyllum*, *Taxithelium*, *Trichosteleum*, *Trismegistia*, *Warburgiella*, and *Wijkia*.

Within this study three genera (\*) that had been placed in Sematophyllaceae by Brotherus (1925) are still in doubt with affinity in the family. Genus *Glossadelphus* is transferred from Sematophyllaceae to place it belongs to Hypnaceae (Seki 1968), but Hedenäs and Buck (1999) uncertainly affinity of this genera to be Sematophyllaceae or Hypnaceae. The genus *Isocradiella* was belong to Sematophyllaceae in accepting it as a sematophyllaceous genus allies to *Gammiella* (Tan and Buck 1989, Tan and Mohamed 1990), but Hedenäs and Buck (1999) studied cladistic methods based on morphological and anatomical characters transferred *Isocradiella* and *Foreauella* belong to Hypnaceae. Later Buck and Goffinet (2000) included the genera *Isocradiella* and *Foreauella* in the family Sematophyllaceae based on morphological and DNA analyses. Recently, Goffinet *et al.* (2003) have presented analyses of cpDNA data (114 OTUS total) suggested that the genera *Foreauella* may belong to the Hypnaceae or Entodontaceae.

From Thai specimens found two species of genus *Glossadelphus* e.g. *G. borneensis* (Broth. & Geh.) Broth. and *G. spathulifolius* (Dixon) R.S. Chopra, their characters are clarify more similar to Hypnaceae than Sematophyllaceae. As same as *Foreauella orthothecia* (Schwaegr.) Dixon & P. Varde, its habit and leaf character showed to be out group of Sematophyllaceae and seem to be related to Hypnaceae. These two genera are rejected from this systematic treatment. For *Isocradiella surcularis* (Dixon) Tan & Mohamed, there are some characters similar to species in genus *Gemmiella* and *Wijkia*, from this reason this species still place in the Sematophyllaceae. Furthermore, the results of many complete revisions added three new genera, *Heterophyllum*, *Pylaisiadelpha*, and *Pseudotrismegistia* for Thailand. The diversity of each genus has discussed below.

#### 1. *Acanthorrhynchium* M. Fleischer

This is a small genus of 11 described species. There are 2 species found in Thailand. They are *A. papillatum* (Harv.) M. Fleisch. and *A. scabrifolium* (Broth.) B.C. Tan & C. Ying. The later species was made a new combination based on a reason of molecular study by Tan and Ying (2004) replaced species from *Mastopoma scabrifolium* (Broth.) B.C. Tan & Ninh. Plants in this genus always found on forest floor, on roots, fallen logs and tree trunks. The unipapillose cells might cause confusion of the genus with *Trichosteleum* but it

differs from this and other papillose leaf cells genera by having short leaf cells, filamentous pseudoparaphyllia, a weekly differentiated leaf border, presence of an annulus and the weakly collenchymatous exothecial cells. The exostome teeth are incurved between the endostome segments when dry but the narrow apices are recurved.

## 2. *Acroporium* Mitt., J. Linn.

This is a big genus of moss in Sematophyllaceae in Thailand. There are 16 species 5 varieties, among them, *A. hamulatum* (M. Fleisch.) M. Fleisch. var. *procumbens* (M. Fleisch.) Dixon and *A. secundum* (Reinw. & Hornsch.) M. Fleisch. var. *siamense* Dixon reported as endemic species to Thailand. The three new species records are presented, *A. johannis-winkleri* Broth., *A. rufum* (Reinw. & Hornsch.) M. Fleisch., and *A. sigmatodontium* (Müll & Hal.) M. Fleisch. All of them showed distributions in peninsular of Thailand. The diagnostic characters of *Acroporium* in Thailand showed both two types of leaf that described by Tan (1994). The “stramineum-type” which is broadly ovate to ovate-lanceolate with an acute to short acuminate or cuspidate tip; the slender apical portion is at most 1/3 of the entire leaf length, the basal part is expanded, cordate, with strongly curved marginal alar cells: e.g., *A. convolutifolium* Dixon, *A. convolutum* (Sande Lac.) M. Fleisch., and *A. diminutum* (Brid.) M. Fleisch. The “strepsiphylum-type”, with a more narrowly lanceolate leaf which tapers gradually from base to leaf tip, the laminal is more or less incurved throughout, and becomes tubular or subulate apically; the tapering upper portion of the leaf comprises more than 1/3 of whole leaf length with the basal portion not clearly cordate and the alar cells are nearly straight throughout: e.g., *A. aciphyllum* Dixon, *A. baviense* (Besch.) Broth., *A. hermaphroditum* (C. Müll.) M. Fleisch., *A. lamprophyllum* Mitt., *A. secundum* (Reinw. & Hornsch.) M. Fleisch., *A. stramineum* (Hornsch. & Reinw.) M. Fleisch., and *A. strepsiphylum* (Mont.) Tan. The leaf cells nearly almost smooth and pitted, the papillosity of cells can be found in *A. convolutifolium* Dixon, *A. convolutum* (Sande Lac.) M. Fleisch., and *A. lamprophyllum* Mitt. The genus usually epiphytic and branches and tree crowns, or occur on decaying logs along trails within forests. A few are epiphyllous in humid lowland rainforests. *Acrporium* is abundant in semi-open to semi-dry habitats in tropical rainforest.

## 3. *Aptychella* (Broth.) Herz.

The genus contains less than 10 species apparently with a pantropical distribution. There are two species in Thailand, *Aptychella speciosa* (Mitt.) Tixier treated to be new recorded to Thailand and *A. tenuiramea* (Mitt.) Tixier. *Aptychella* is characterized by the short tufts (commonly 2-3 cm) or occasional mats that often become long pendent, when erect stems terminating in a subspherical-cluster of gemmae, distant, oblong-to linear-lanceolate leaves, recurved margins, variable costae, mostly single, sometimes double or absent, and well differentiated, non-inflated, subquadrate alar cells. Reproduction is asexual faciliate by both and production of gemmae and propagula in the form of fragile, flagellate branches. Given the amount of gametophytic variation in the Neotropics, a more critical study may be warranted than that presented by Tixier (1977).

## 4. *Brotherella* Loeske ex M. Fleisch.

Genus *Brotherella* consists of some 50 species in the world. In Thailand, occurred two species of *B. erythrocaulis* (Mitt.) M. Fleisch. and *B. falcata* (Dozy & Molk.) M. Fleisch., the former reported as new record to Thailand. Both species are found only in northern of Thailand, they confirmed the distribution of Sino-Himalayan elements to Thailand. After, Ando *et al.* (1989) demonstrated the taxonomic differences between *Brotherella* and

*Pylaisiadelpha*, the genus *Brotherella* was easy to separated from *Pylaisiadelpha* by diagnostic characters as 1) plants large (leaf stems usually more than 1.5 mm wide); 2) plants often somewhat complanate; 3) leaves usually almost straight, infrequently falcate; 4) lowermost alar cells well differentiated, conspicuously enlarged and inflated, subquadrate cells above few (0-3, rarely 4) along the margin; 5) propagula absent; 6) sporangia inclined to almost horizontal, more or less asymmetric; 7) peristome perfect; basal membrane  $2/5 - 1/3$  as high as the teeth, with 1-2 cilia (rarely rudimentary); 8) spores smooth or faintly roughened. Further more, based on the Thai specimens, species of *Brotherella* can be distinguished further from *Pylaisiadelpha* by the toothed margins towards the leaf apex. The leaves of *Pylaisiadelpha* have nearly entire margins, except becoming toothed at the very distal tip.

### 5. *Chionostomum* C. Müll.

The genus consists of four species in the world. Three of them are occurred in Thailand. *C. baolocense* Tixier, and *C. pinicola* Tixier had been reported only one locality in Vietnam (Tixier 1977). The first specimens collected from Koh Chang the island in southeastern of Thailand. The second species had collected specimen from Doi Inthanon the mountain in northern of Thailand. Both species reported as new records to Thailand. The third species is *C. rostratum* (Mitt.) C. Müll., this species has widely distributions in Asia boundary from India, Sri Lanka, China, Indo-China, Malaysia and Phillipines. This genus is unique in having a slightly papillose, non-strait exostome. Its alar cells can be either heterophyllioid or brotherelloid, and its quadrate to rectangular exothecial cells are strongly thickened at corners and also along lateral walls.

### 6. *Clastobryophilum* M. Fleisch.

After O'Shea (2000) finished a revision of *Clastobryophilum*, this made the genus consists of three species in the world. It is predominantly a Southwest Asian genus with outlying occurrences in the East African islands (Madagascar as well as Seychelles) and New Caledonia. *Clastobryum bogoricum* (Bosch. & Sande Lac.) M.Fleisch is only one species that found in Thailand. This species have reached the ancient granite islands in Krabi Province, southern of Thailand. The remaining collections are consistently similar, and appear to form a coherent and readily identified genus, distinguished by its often reddish-brown colouration and shiny appearance, with very long, slightly flexuose leaves, usually twisted towards the apex, short, thick-walled alar cells, and laminal cells with a wide lumen and prominent walls (In most Sematophyllaceae with thick laminal cells walls between the cell lumina). This is not the case with this plant, where they are usually quiet clearly visible, and the lumina are particularly wide. This sometimes gives an obliques, stippled pattern to the leaf, caused by the cell walls and lumina being so prominent, and emphasised by the pores between the ends of adjacent cell lumina. Species of *Acroporium*, which can also have long needle-like leaves, can be distinguished by the more rigid leaves and narrower cell lumina, with thinner cell walls. *Clastobryophilum* is distinguished from other genera in the subfamily principally by the position of a perfect peristome and long narrow, erect leaves, without propagules.

### 7. *Clastobryum* Dozy & Molk.

The genus has been combined with *Tristichella* by Tan & Iwatsuki (1992) and had a generic synonym with *Clastobryella* (Tan and Buck 1989). Many nomenclatural species in this genus were replaced to combination in many genera. There are 23 species presented in Index Muscarum. There are four species found in Thailand, *C. caudatum* M. Fleisch., *C.*

*cuculligerum* (Dozy & Molk.) P. Tixier, *C. indicum* (Dozy & Molk.) Dozy & Molk. and *C. spiculiferum* (Dixon) Tan & Iwats. All of them are found distributions only in Asia from mainland China to Japan, the Philippines, Malesia and Indo-China.

### **8. *Gammiella* Broth.**

The genus *Gammiella* is easy to identify by a profusion of slender branches forming extensive mat. Its heterophylloid type of leaf alar consisting of a group of quadrate or short rectangular cells is also diagnostic. There are four species occur in Thailand; *G. ceylonensis* (Broth.) Tan & Buck, *G. pterogonioides* (Griff.) Broth., *G. rugosa* P. Tixier and *G. tonkinensis* (Broth. & Par.) Tan. O'Shea B. J. (2003) suggested the genus *Gammiella* Broth. occurs only in the palaeotropics, and is wide spread Particularly in tropical Asia. *G. pterogonioides* (Griff.) Broth. is found most abundant in Thailand while, the other species were rare in each area.

### **9. *Hageniella* Broth.**

The species *Hageniella assamica* Dixon is reported as new record to Thailand. This is one of two species in *Hageniella* sensu Tixier (1977) that have papillose leaf cells. Although, Tan and Jia (1999) suggested transfer the species to either *Clastobryum*, *Trichosteleum* or *Wijkia*, but within this study it still place in *Hageniella* by following the generic described by Brotherus (1910). *H. assamica* was reported as endemic to Assam, In Thailand found at more than 2000 m from sea level in Doi Inthanon, northern of Thailand, the species showed the distribution of Sino-Himalayan elements to Thailand.

### **10. *Heterophyllum* (Schimp.) Kindb.**

This genus is new added to Thailand under species *Heterophyllum amblystegum* (Mitt.) Y. Jia, S. He & Crosby. This species was reported from Thailand as *Brotherella amblystega* (Mitt.) Broth. Recently, Jia (2007) presented an evaluation of Asian *Brotherella* Loeske ex M. Fleischer, reveals that a new combination in the genus *Heterophyllum* is necessary to replace *B. amblystega* for it noticeably dimorphic stem and branch leaves, strongly serrate leaf apice, differentiated alar cells in an excavate group, erect and symmetric capsules, and strongly papillose spores.

### **11. *Isocradiella* Dixon**

This is the monotypic genus that occur only species, *Isocradiella surcularis* (Dixon) Tan & Mohamed. The species is best recognized by the presence the flagellate branchlets serving as propagules and the often colored basal part of the lamina, including the alar region consisting of a mixture of quadrate and rectangular, thin- to thick-walled cells. This species is found though out Thailand. The genus has affinity to transfer to Hypnaceae based on the taxonomic conclusion of Hadenäs and Buck (1999). But it has some characters of alar organization closed to *Gammiella* and differentiated leaf closed to *Wijkia* in Sematopyllaceae, that the reason to place this genus in this family.

### **12. *Mastopoma* Cardot**

The genus *Mastopoma* Cardot is one of genera that have big size found in Thailand. It usually misunderstood with *Trismegistia*, *Wijkia* and *Heterophyllum* in the same subfamily Heterophylliidae. The diagnostic characters to separate this genus from another genera are 1) the smaller, less rigid habitat, 2) leaves straight or strongly curled, often with geminate serration, 3) the leaf upper lamina cells that are all elongate and not incrassate, and never short and rhomboid, 4) alar cells arranged in a single row (except

*Mastopoma subfiliferum*), 5) absence of borders at the leaf margins, 6) the conical capsule lid, and 7) plant growing on branches of shrubs or small trees at river and stream sides. There are two species occur in Thailand. *M. robinsonii* (Broth.) E.B. Bartram the species reported as endemic to Philippines, distributed in Surat Thani province, Southern of Thailand. *M. subfiliferum* Horik. & Ando reported as endemic to Thailand found abundant in Doi Inthanon, Northern Thailand.

The species *M. subfiliferum* has some doubts in taxonomic classification by the reason of its alar organization, which has divided, scalariform quadrate to subrectangular alar cells that are all of nearly equal size. This alar feature is characteristic for the subfamily Heterophyllioideae of the Sematophyllaceae. Akiyama and Tsubota (2001) suggested *M. subfiliferum* should be transferred to *Heterophyllum* or place in a separate new monotypic genus by the reason of its alar organization.

### 13. *Meiothecium* Mitt.:

The species in genus *Meiothecium* have distributions worldwide in South America, Africa, Malesia, Pacific Islands and Australia. There are more than 50 species in the world. In Thailand found 3 species: *M. jagorii* (Müll. Hal.) Broth, it is distributed in southern of Thainad that showed Malay-Penninsular elements; *M. microcarpum* (Hook.) Mitt. this species distributed in every regions of Thailand and *M. turgidellum* M. Fleisch., the species distributed along western border of Thailand, it was reported distributed in Burma.

### 14. *Papillidiopsis* (Broth.) W.R. Buck & B.C. Tan

Buck & Tan (1989) had described the different characters of genus *Papillidiopsis* from *Tichosteleum*, *Rhaphidostichum* and *Isocradiella*. The oblong leaves, strongly concave, often strongly ranked, not constricted at the base, with apex obtuse, acute to shortly acuminate, cells smooth or papillose only in the upper half of leaves are the diagnostic characters. The species consists of 13 species 1 variety in the world. Three species *Papillidiopsis* of are recognized for the moss flora of Thailand. *P. luxurians* (Dozy & Molk.) W.R. Buck & B.C. Tan and *P. macrosticta* (Broth. & Par.) Buck & B. C. Tan, the species as the previous one were removed from *Trichosteleum* to *Rhaphidostichum*. *P. stissophylla* (Hampe & Müll. Hal.) B.C. Tan & Y. Jia, a species combination from *Trichosteleum*. All species are wide distribution in southeast Asia. One species reported by Dixon (1935) as *P. complanata* (Dixon) W.R. Buck & B.C. Tan was excluded from this study because of the specimens in herbarium including type specimen were loosing.

### 15. *Pseudotrismegistia* Akiyama & Tsubota

The monotypic genus with a species *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota. This species was reported as *Mastopoma perundulatum* (Dix) Horik. & Ando. for checklist of Thai moss. It is easily recognized by its leaves that are undulate, oblong or strap-shape from an expanded base. It is an Indochinese species with a disjunctive distribution in Taiwan and China. In Thailand found only one area at elevation more than 2300 m above sea level in Doi Inthanon, Chiang Mai province.

### 16. *Pylaisiadelpha* Card.

Genus *Pylaisiadelpha* at present consists of four species. Two species are known from Thailand, they are *Pylaisiadelpha amblystega* (Mitt.) W. R. Buck and *Pylaisiadelpha capillacea* (Griff.) B. C. Tan & Y. Jia. The latter species was a new combination from *Neckera capillacea* Griff. by Tan and Jia (1999). Ando *et al.* (1989) has described a

completed diagnostic characters of this genus that separated from *Brotherella* such as 1) plants small (leaf stems usually less than 1.5 mm wide), sometimes filiform; 2) plants weakly or not complanate; 3) leaves weakly to strongly falcate, rarely straight; 4) inferior alar cells not conspicuously enlarged or inflated; subquadrate cells above numerous (2-7, rarely 8) along the margin; 5) propagula scabrous, septate, filiform, rarely branched, sometimes in axillary clusters; 6) sporangia erect to somewhat inclined, symmetric; 7) peristome rather imperfect; basal membrane 1/3-1/4 as high as the teeth, cilia rudimentary or absent; 8) spores minutely papillose.

#### **17. *Radulina* W.R. Buck & B.C. Tan**

The genus *Radulina* was found only one species species in Thailand, it is *Radulina hamata* (Dozy & Molk) W.R. Buck & B.C. Tan. O'Shea (2006) had revised the genus *Radulina*, resulting had placed this name to synonym of *Radulina borbonica* (Bél.) W.R. Buck, that 33 synonyms were accepted. However *R. hamata* is used in this study because all descriptions were described from the species namely *R. hamata*, and it should be easy to follow information of the former publications by using this name. The genus is confined to the palaeotropics. It is disturbed in Indochina, Malesia, Australia, Pacific Islands and occurs in every regions of Thailand at elevation 100-1600 m above sea level.

#### **18. *Rhaphidostichum* M. Fleisch.**

The handsome moss genus *Rhaphidostichum* is easy to recognize by its big sized mosses, leaf ovate with long filamentous apical, leaf cells narrowly rhomboidal, thick-walled and alar organization big oval colored cells. There are four species occur in Thailand: *R. bunodicarpum* (C. Müll.) M. Fleisch. and *R. luzonense* (Broth.) Broth., the species found throughout Southeast Asia; *R. leptocarpoides* (Broth.) Broth., this species reported as endemic to Thailand, *R. piliferum* (Broth.) Broth. the species reported as new record to Thailand, reported in Philippines and Borneo.

#### **19. *Sematophyllum* Mitt.**

The genus *Sematophyllum* was reported 11 species from many publications, but within this study the specimens of *S. humile* (Mitt.) Broth. and *S. latifolium* Broth. were disappeared from herbarium. Both two species reported from only one locality of each species. *S. microcladiellum* M. Fleisch. and *S. phoeniceum* (C. Müll.) M. Fleisch. are found abundant in every regions, while *S. subconnivens* (Broth.) Dixon and *S. subhumile* (C. Müll.) M. Fleisch. had to be rare species in the area. The endemic species were reported for *S. latifolium* Broth., *S. parvulum* (Broth.) Dixon and *S. subrevolutum* Broth. The synonyms of species were accepted for *S. caespitosum* (Hedw.) Mitt. (Buck 1998) and *S. striatifolium* Dixon (Tan & Jia 1999) to place them as *S. subpinnatum* (Brid.) E. Britton. Furthermore *S. tristiculum* (Mitt.) M. Fleisch. had renamed to *S. subpinnatum* fo. *tristiculum* (Mitt.) B.C. Tan & Y. Jia (Tan & Jia 1999). All species are found in tropical rain forest at elevation from sea level to 1600 m. Plants are epiphytic, on branches, trunks, bases of trees and shrubs.

#### **20. *Taxithelium* Spruce ex Mitt.**

The genus is rich in number of species, contains over 100 species, (many likely synonyms). The diagnostic characterized principally by the pluripapillose laminal cells with the papillae arranged in a single row over the cell lumen; the alar cells are not as strongly differentiated as in, for example, *Sematophyllum* or *Trichosteleum*. The 16 species occurred in Thailand can separate into two sections following by Renauld and

Cardot (1901) and Fleischer (1923). Section *Aptera* also has elongate leaf cells (>8 : 1), with the apical leaf cells, while the marginal leaf cells are usually papillose-serrate; and binate teeth are uncommon. e.g., *T. alare* Broth., *T. magnum* M. Fleisch., *T. bakeri* Broth., *T. vernieri* (Duby) Besch., *T. batanense* Battr., *T. arnottii* Tixier, *T. binsteadii* Broth. and Dixon, *T. epapillosum* Dixon, and *T. clastobryoides* Dixon, the last two species reported as endemic to Thailand. Section *Taxithelium*, the laminal cells are shorter. The apical leaf cells are also short and seldom coronate-papillose; binate teeth are almost always present, while the marginal leaf cells are not usually papillose-serrate e.g., *T. isocladum* (Bosch & Sande Lac.) Ren. & Card., *T. merrillii* Broth., *T. sumatranum* (Bosch & Sande Lac.) Broth., *T. gottscheanum* (Hampe) Broth., *T. instratum* (Brid.) Broth., *T. nepalense* (Schwaegr.) Broth. and *T. pavulum* (Broth. & Paris) Broth., the lastest species is a new record to Thailand. Furthermore, there are 3 species excluded from this study because the lacking of their specimens e.g., *T. kerianum* (Broth.) Broth., *T. inerme* P. Tixier, and *T. schmidtii* Broth. the last two species was reported as endemic to Thailand, they reported only one locality from Koh Chang, southeastern of Thailand.

### 21. *Trichosteleum* Mitt.

In generally, *Trichosteleum* is very similar to *Sematophyllum* except for the unipapillose lamina cells, although in that genus there is considerable more variation. The papillae are occasionally so faint in some *Trichosteleum* species that such species are readily misidentified as *Sematophyllum*. The genus is a greatest diversity in tropical Asia. There are 8 speices 1 variety found in Thailand. The species reported as *Rhaphidostichum boschii* (Dozy & Molk.) Seki, and *T. brachypelma* (Müll. Hal.) Paris were accepted by Tan & Jia (1999) to place in *T. boschii* (Dozy & Molk.) A. Jaeger., the other one species of *Sematophyllum saproxylophilum* (Müll. Hal.) M. Fleisch. was placed to *T. saproxylophilum* (C. Müll.) B.C. Tan, Schofield & Ramsay (1998). Both two species were found abundant in Thailand. The other species e.g., *T. pseudomammosum* M. Fleisch., *T. pinnatum* Dixon, *T. mammosum* (C. Müll.) Jaeg., *T. monostictum* (Thwait. & Mitt.) Broth. var. *laevius* Dixon and *T. ruficaule* (Thwait. & Mitt.) B. C. Tan are presented only one locality and rare to each area. *T. trachycystis* Broth. is an endemic species found from Trat province, southeastern Thailand. Plants distributed in the Tropical Andes found on logs, humus and soil in moist in wet lowland to mid montane forest, from near sea level to 1,800 m.

### 22. *Trismegistia* (Müll. Hal.) Müll. Hal.:

Traditionally, *Trismegistia* and *Mastopoma* are separated by characters such as the presence or absence of a well differentiated leaf border, and the rostrate versus conical opercular lid (Bartram 1939). A better generic marker, in this observation, resides in the nature of alar organization. Species of *Mastopoma* have only a basal row of enlarged alar cells while species of *Trismegistia* frequently produce divided alar cells forming multiple or scalariform tiers. *Trismegistia* was reported from Thailand 2 species as *T. lancifolia* (Harv.) Broth. and *T. rigida* (Hornsch. & Reinw.) Broth. Ramsay *et al.* (2002) placed *Neckera lancifolia* Harv. to be a synonym of *T. rigida*, for this reason there is only one species of *T. rigida* in Thailand. The species is wide distribution in Thailand.

### 23. *Warburgiella* Müll. Hal. ex Broth.

The only one species of *Warburgiella* in Thailand is *W. leptorhynchoides* (Mitt.) M. Fleisch. It is a moss that have strongly circinate leaves with abruptly long tooth apices and thick-walled alar cells. The seta usually curled below capsule, semi-collenchymatous exothecial cells, operculum long rostrate. The species has wide distributions from India to Malesia

and Australia. Thai specimens found in high montane forest at summit of Doi Inthanon, Chiang Mai province.

#### 24. *Wijkia* H. A. Crum

*Wijkia* is distinguished by differentiated branch and stem leaves. The stem leaves are very concave and abruptly tapered to a long, serrulate acumen. The plants often produce flagellate branches. The capsules sometimes have remarkably thickened exothecial cells. In Thailand the genus was reported 8 species, *W. baculifera* (Dixon) H. A. Crum is excluded from this study because lacking of its specimen. *W. filipendula* (Dixon) H. A. Crum presented as endemic species and *W. hornschurchii* (M. Fleisch.) H. A. Crum reported for new record to Thailand. *W. deflexifolia* (Mitt. ex Renault & Cardot) H. A. Crum, *W. laxa* (Dixon) H. A. Crum and *W. penicillata* (Mitt.) H.A. Crum, the species that found only in northern of Thailand, while *W. surcularis* (Mitt.) H. A. Crum is found abundant in every region. *W. longipila* (Broth.) H.A. Crum had been reported from many locality is accepted to a synonym with *Wijkia tanytricha* (Mont.) H. A. Crum.

### 6.2 PHYTOGEOGRAPHY OF SEMATOPHYLLACEAE

The diverse distributional patterns of Thai mosses are primarily due to the country's diverse climates and landscapes (appendix 1). In the northern part of Thailand, plants in the dry lowlands are very poor but grow vigorously in moist evergreen forests that are developing at altitude above 1,000 meters (Iwatsuli 1972). The climates in the large central plain and the Korat Plateau in the east are dry and are intermediate between the monsoon regions and tropical regions. A broad zonation belt is formed centrally, which separates the country into two climatic zones. It is practical in biogeographical standpoint to divide Thailand into two floristic regions, the "Sino-Himalayan region" in the north and northeast and the "Malayan region" in the southeast and the peninsula (He 1998).

The mosses of high elevations in the north exhibit affinities to those of eastern Himalayas, Myanmar, and southwestern China (Yunnan, Sichuan, and Guizhou). The abundant species of Sematophyllaceae found in northern 37 species and 23 species from northeastern, they are almost of species in genus *Aptychella*, *Brotherella*, *Gammiella*, *Hageniella*, *Heterophyllum*, *Mastopoma*, and *Pseudotrismegistia*. The genus *Sematophyllum* and *Wjki*a have conjunction distribution from northern to southeast region.

In the southern part of Thailand most species are occurring there belong to the Malayan elements known from Malay Peninsula, Java, Sumatra, and its archipelago as well as the Philippines. These include many species found in southeastern 38 species and 50 species in Peninsula, They are nearly most of species in genus *Acroporium*, *Taxithelium*, *Trichostelem*, and *Trismegistia*.

It appears that the Sino-Himalayan elements have rarely extended southwards beyond the central plain in Thailand. The Malayan-Philippine elements clearly predominate in the "Peninsula" and southeastern Thailand. There are a significant number of species that were reported from both northern and peninsular Thailand. These elements usually have much wider distributional patterns throughout East and South Asia and often have pantropic and paleotropic distribution.



## 7 CONCLUSION

### 7.1 THE CLASSIFICATION SYSTEM OF SEMATOPHYLLACEAE IN THAILAND

As a result that Sematophyllaceae is the biggest family found from Thailand. The study of this family for Thailand has been revised from 2004 to 2007 based on nearly 2,000 specimens. The taxonomical system within this revision is accepted to follow Brotherus (1925). An enumeration of this moss family included 24 genera, 97 species, 5 varieties and 1 form (appendix 1). It is approximately 15 % of mosses that reported from Thailand. The classification system follow Brotherus (1925) and Tan and Buck (1989) based on variation of alar organizations can be divided moss in Sematophyllaceae that occur in Thailand in to 3 subfamilies.

1) **Subfamily Clastobryoideae**, consists of 4 genera: *Aptychella* (Broth.) Herz., *Clastobryophilum* M. Fleisch., *Clastobryum* Dozy & Molk., and *Hageniella* Broth.

2) **Subfamily Heterophylloideae**, consists of 7 genera: *Gammiella* Broth., *Heterophyllum* (Schimp.) Kindb., *Isocradiella* Dixon., *Mastopoma* Cardot, *Trismegistia* (Müll. Hal.) Müll. Hal., *Pseudotrismegistia* Akiyama & Tsubota and *Wijkia* H. A. Crum.

3) **Subfamily Sematophylloideae**, consists of 13 genera: *Acanthorrhynchium* M. Fleisch., *Acroporium* Mitt., *Brotherella* Loeske ex M. Fleisch., *Chionostomum* C. Müll., *Meiothecium* Mitt., *Papillidiopsis* (Broth.) W.R. Buck & B.C. Tan, *Pylaiadiadelpha* Card., *Radulina* W.R. Buck & B.C. Tan, *Rhaphidostichum* M. Fleisch., *Sematophyllum* Mitt., *Taxithelium* Spruce ex Mitt., *Trichosteleum* Mitt. and *Warburgiella* Müll. Hal. ex Broth.

This result is not included *Foreauella* and *Glossadelphus* because they have uncertainly their affinities in this family and they may belong to family Hypnaceae. The study of molecular phylogeny should be revised for the affinity in the future.

The new nomenclatures for flora of Thailand are presented both in genera and species. Genus *Heterophyllum* (Schimp.) Kindb., *Pseudotrismegistia* Akiyama & Tsubota and *Pylaiadiadelpha* Cardot, are new genera added to flora of Thailand. In addition to, many new provincial records are reported, six species are new records to Thailand e.g., *Acroporium rufum* (Reinw. & Hornsch.) M. Fleisch., *A. sigmatodontium* (Müll. & Hal.) M. Fleisch., *Brotherella erythrocaulis* (Mitt.) M. Fleisch., *Chionostomum baolocense* Tixier, *C. inicola* Tixier, *Rhaphidostichum piliferum* (Broth.) Broth., and five species new report for Indochina e.g., *Acroporium johannis-winkleri* Broth., *Aptychella speciosa* (Mitt.) P. Tixier, *Hageniella assamica* Dixon, *Taxithelium parvulum* (Broth. & Paris) Broth. and *Wijkia hornschurchii* (M. Fleisch.) H. A. Crum.

The endemic species to Thailand presented 11 species 2 varieties e.g., *Acroporium convolutifolium* Dixon, *A. hamulatum* (M. Fleisch.) M. Fleisch. var. *procumbens* (M. Fleisch.) Dixon, *A. secundum* (Reinw. & Hornsch.) M. Fleisch. var. *siamense* Dixon, *Mastopoma subfiliferum* Horikawa & Ando, *Rhaphidostichum leptocarpoides* (Broth.) Broth., *Sematophyllum subrevolutum* Broth., *Taxithelium clastobryoides* Dixon, *T. epapillosum* Dixon, *Taxithelium inerme* P. Tixier, *Trichosteleum trachycystis* Broth. and *Wijkia filipendula* (Dixon) H. A. Crum.

## 7.2 THE SPECIES REVISED NAMES FOR FLORA OF THAILAND

Since the first publication of checklist moss of Thailand had presented more than 652 taxa were accepted for Thai Flora. Up to now there are many revisions had published for Sematophyllaceae, they revised many nomenclatures by their combinations and synonyms for taxa in each family. In Sematophyllaceae, there are 14 species and 1 form reported as updated name for moss family Sematophyllaceae in Thailand (table 7.1).

Table 7.1 The new revised names of moss family Sematophyllaceae in Thailand.

No.	Names in Checklist	New revised Names
1.	<i>Mastopoma scabrifolium</i> (Broth.) B.C. Tan & Ninh	<i>Acanthorrhynchium scabrifolium</i> (Broth.) B. C. Tan & C. Ying
2.	<i>Brotherella amblystega</i> (Mitt.) Broth.	<i>Heterophyllum amblystegum</i> (Mitt.) Y. Jia, S. He & Crosby
3.	<i>Rhaphidostichum chaetomitriopsis</i> (Dixon) Touw	<i>Papillidiopsis macrosticta</i> (Broth. & Paris) W.R. Buck & B.C. Tan
4.	<i>Trichosteleum stissophyllum</i> (Hampe & Müll. Hal.) A. Jaeger	<i>Papillidiopsis stissophylla</i> (Hampe & Müll. Hal.) B.C. Tan & Y. Jia
5.	<i>Trismegistia undulate</i> Broth. & Yasuda	<i>Pseudotrismegistia undulata</i> (Broth. & Yasuda) H. Akiy. & Tsubota
6.	<i>Gammiella capillacea</i> (Griff.) P. Tixer	<i>Pylaisidelpha capillacea</i> (Griff.) B. C. Tan & Y. Jia
7.	<i>Sematophyllum caespitosum</i> (Hedw.) Mitt., <i>Sematophyllum striatifolium</i> Dixon	<i>Sematophyllum subpinnatum</i> (Brid.) E. Britton
8.	<i>Sematophyllum tristiculum</i> (Mitt.) M. Fleisch	<i>Sematophyllum subpinnatum</i> fo. <i>tristiculum</i> (Mitt.) B.C. Tan & Y. Jia
9.	<i>Rhaphidostichum subrevolutum</i> (Broth.) Broth.	<i>Sematophyllum subrevolutum</i> Broth.
10.	<i>Rhaphidostichum boschii</i> (Dozy & Molk.) Seki	<i>Trichosteleum boschii</i> (Dozy & Molk.) A. Jaeger
11.	<i>Sematophyllum saproxylophilum</i> (C. Müll.) M. Fleisch.	<i>Trichosteleum saproxylophilum</i> (C. Müll.) B.C. Tan, Schofield & Ramsay
12.	<i>Taxithelium batanense</i> E.B. Bartram	<i>Taxithelium oblongifolium</i> (Sull. & Lesq.) Iwats.
13.	<i>Trismegistia rigida</i> (Hornsch. & Reinw.) Broth.	<i>Trismegistia lancifolia</i> (Harv.) Broth.
14.	<i>Wijkia longipila</i> (Broth.) H.A. Crum	<i>Wijkia tanytricha</i> (Mont.) H. A. Crum

## 7.3 THE EXCLUDED SPECIES

Many species of Sematophyllaceae that had been presented in checklist moss flora of Thailand (He 2005-2008) could not find out specimens from herbarium and field trips, e.g. *Gammiella tonkinensis* (Broth. & Par.) Tan, *Papillidiopsis complanata* (Dixon) Buck & Tan, *Sematophyllum humile* (Mitt.) Broth., *Taxithelium inerme* P. Tixier, *T. kerianum* (Broth.) Broth., and *Wijkia baculifera* (Dixon) H. A. Crum. However, they had included in

this revision, the species description are described following publications of each species. For the two endemic species of Thailand that specimens are disappearing from herbarium treated to exclude from this revision, *Sematophyllum latifolium* Broth. and *Taxithelium schmidtii* Broth., some information of them sited out as below.

*Sematophyllum latifolium* Broth., Beihefte zum Botanischen Centralblatt. Abb. 2, Systematik 28: 362. 1911. — Type: Thailand. Chiang Mai: Doi Sutäp, 1660-1675 m, *C. Hosseus s.n.* (Herbarium not specified by author.)

*Taxithelium schmidtii* Broth., Botanisk Tidsskrift 24: 122. 1901. — TYPE: Thailand. Trät: Klong Munsé, *Schmidt s.n.* (H).

#### 7.4 DISTRIBUTION OF SEMATOPHYLLACEAE IN THAILAND

The distribution of Sematophyllaceae in Thailand is found abundant in tropical rain forest at middle altitude from 600- 2000 m above sea level. It is clarify that moss in this family always found in moist area, under cloud trees near stream, on wet surface of stems or branches or ground floor. These habitats usually found in the forests from southern to northern of Thailand, this is the reason to explain that Thailand is one of the plenty places for moss family Sematophyllaceae.

The Sematophyllaceae flora of Thailand is comparable to that of neighboring countries or regions, such as Borneo, Java, Malay Peninsula, Myanmar, the Philippines, and Vietnam. Its phytogeography showed that Thailand is a transitional region forming a bridge between Sino-Himalayan and the Malayan-Philippine floras. The species of Sino-Himalayan elements that occur in Thailand are *Aptychella speciosa* (Mitt.) P. Tixier, *A. tenuiramea* (Mitt.) P. Tixier, *Brotherella erythrocaulis* (Mitt.) M. Fleisch., *B. falcata* (Dozy & Molke.) M. Fleisch., *Hageniella assamica* Dixon, *Heterophyllum amblystegum* (Mitten) Y. Jia, S. He & Crosby, *Mastopoma robinsonii* (Broth.) E. B. Bartram, *Mastopoma subfiliferum* Horikawa & Ando, and *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota. Some species extended southwards beyond the central plain are showed the affinity in genus *Sematophyllum* and *Wjxia*. For the Malayan-Philippine elements, the species clearly predominate in the "Peninsula" or southeastern Thailand. These included many species of the genus *Acroporium*, *Taxithelium*, *Trichostelem* and *Trismegistia*. Furthermore, There is a significant number of species that have their distributions throughout from northern to peninsular of Thailand. They occur in genus *Acanthorrhynchium*, *Clastobryum*, *Meiothecium*, *Papillidiopsis*, *Radulina*, and *Warburgiella*. These elements usually have much wider distributional patterns throughout East and South Asia and often have pantropic and paleotropical distribution.

#### 7.5 FUTURE PROSPECTS

- To complete work of Sematophyllaceae in Thailand, its related families in Hypnales should be made continuous study for evaluation their relationship and affinities of genera in each family and should have researches cover Indo-China Region.
- The results of this study will published as a part of "Moss Flora of Thailand Project".

## 8 SUMMARY

The Sematophyllaceae is one of pleurocarpous moss families that primarily tropical and subtropical assemblage of genera with few representatives in North America and even fewer in Europe. As a consequence, family recognition awaited a global overview of the mosses, or at least a tropical perspective. There are about 53 genera and over 600 species worldwide at present. The Sematophyllaceae are frequently considered a troublesome family, and the circumscription of it and its subfamilies have not been dealt with in its entirety in later time. In Thailand, the species accounts of Sematophyllaceae were reported as a biggest data checklist by various bryologists. But there were no information of characters and classical system within the family for flora of Thailand. It is thus of interest to begin this study with a history of the family up to present. The main focus of the present study is an inventory of Thai Sematophyllaceae and for publication as one part of “Moss Flora of Thailand” project.

Within this study the taxonomic treatment of the Sematophyllaceae from Thailand was carried out based on about 2000 specimens. These specimens were on loan from herbaria: University of Aarhus, Denmark (AAU); Royal Forest Herbarium, Bangkok (BKF); The Natural History Museum, London (BM); Harvard University, Cambridge (FH); Brothier Herbarium, Helsinki (H-BR); Nationaal Herbarium Nederland, Leiden University branch, Leiden (L); Herbarium, The New York Botanic Garden, New York (NY); Museum National d'Histoire Naturelle, Paris (PC) and also included additional collections by the author preserved at herbarium Chulalongkorn University (BCU). Intensive morphological studies were carried out in all organs of each specimen; description, illustrations and photographs were taken under microscope studies. An artificial key, description, distribution, ecology, illustrations and photos of each species are provided. An enumeration of this moss family included 24 genera, 97 species, 5 varieties and 1 form. Three genera, *Pseudotrismegistia*, *Heterophyllum*, and *Pylaisiadelpha* are added to the flora of Thailand. In addition to many new provincial records, six species are reported new to Thailand, they are *Acroporium rufum* (Reinw. & Hornsch.) M. Fleisch., *A. sigmatodontium* (Müll & Hal.) M. Fleisch., *Brotherella erythrocaulis* (Mitt.) M. Fleisch., *Chionostomum baolocense* Tixier, *C. inicola* Tixier, *Rhaphidostichum piliferum* (Broth.) Broth., and five species new reported for Indochina are *Acroporium johannis-winkleri* Broth., *Aptychella speciosa* (Mitt.) P. Tixier, *Hageniella assamica* Dixon, *Taxithelium parvulum* (Broth. & Paris) Broth. and *Wijkia hornschuchii* (M. Fleisch.) H. A. Crum. The endemic to Thailand presented 11 species 2 varieties e.g., *Acroporium convolutifolium* Dixon, *A. hamulatum* (M. Fleisch.) M. Fleisch. var. *procumbens* (M. Fleisch.) Dixon, *A. secundum* (Reinw. & Hornsch.) M. Fleisch. var. *siamense* Dixon, *Mastopoma subfiliferum* Horikawa & Ando, *Rhaphidostichum leptocarpoides* (Broth.) Broth., *Sematophyllum subrevolutum* Broth., *Taxithelium clastobryoides* Dixon, *T. epapillosum* Dixon, *T. inerme* P. Tixier, *Trichosteleum trachycystis* Broth. and *Wijkia filipendula* (Dixon) H. A. Crum. The other two endemic species had been reported from Thailand e.g., *Sematophyllum latifolium* Broth. and *Taxithelium schmidtii* Broth. are excluded from this revision because of their specimens disappeared from herbarium. The phytogeography of this family is confirmed that Thailand is a traditional region forming a bridge between the Malayan-Philippine and Sino-Himalayan floras.

## Publication:

**Pollawatn R.**, Frahm J.-P., and Boonkerd T. 2008. New species records of Sematophyllaceae (Musci) from Thailand. In: Haji Mohamed, Baki Bakar, Amru N Boyce, Patrick KY Lee (eds.), "Bryology in Asia in the New Millennium", *Proceedings of the World Conference of Bryology, 23 – 27 July 2007*, Crystal Crown Hotel, Petaling Jaya, Malaysia. University of Malaya, International Association of Bryologists and Malaysian Ministry of Natural Resources. (In press).

## Oral Presentation:

**Pollawatn R.**, Frahm J.-P. and Boonkerd T. 2007. A synopsis of Sematophyllaceae (Musci) in Thailand. *The world conference of bryology 2007: bryology in Asia in the New Millennium, 23–27 July 2007*, Crystal Crown Hotel, Petaling Jaya, Malaysia.

## Poster Presentation:

**Pollawatn R.**, Frahm J.-P. and Boonkerd T. 2006. Taxonomic Revision of Sematophyllaceae (Musci) in Thailand. *Biodiversity Research and Training Program (BRT) Annual Meeting, 8-11 October 2006*, Maritime Park and Spa Resort, Krabi, Thailand.

## 9 ACKNOWLEDGEMENTS

My greatest appreciation and thanks go to my supervisor, Prof. Dr. Jan-Peter Frahm. He had given me a great opportunity to pursue a Doctoral degree. He gave excellent guidance and always being open for a helpful discussion. His supervisions during my work making sure that I become successful in it. Moreover, I would like to thank him very much for his providing many field trips of bryophytes in Europe that gave the great experiences to me.

I am very grateful to Prof. Dr. Wilhelm Barthlott, the director of Nees-Institut for Biodiversity of Plants, University of Bonn, whom kindly agreed to take the second referent and always pleasure to advise everything to me.

My sincere thanks to Prof. Dr. Wolfgang Böhme, Institut für Zoologie der Universität Bonn and Prof. Dr. Thomus Litt, Institut für Paläontologie der Universität Bonn, whom kindly accepted to be committee of my defense dissertation.

A very special thank-you goes to Prof. Dr. Ming-Ju Lai (University of Taiwan), who sadly recently passed away. Many thanks for his shared experiences, and supported many literatures. He always cheer on my working and study in Bryophytes, that was very good impress in many motivating discussion and talk we had during the past four years.

I am much grateful to Dr. A. Touw at the Rijksherbarium, Leiden, he gave excellent advices and provided useful references in systematic classification. A very special thank-you goes to Prof. Dr. Benito C. Tan and Dr. Lars Hadenäs for their help with clarify all characters and classification is much appreciated.

At Nees-Institute for Biodiversity of Plants, I am very grateful to the colleagues for providing a nice atmosphere and for always being helpful when I came along with various problems. I am particularly grateful to Dr. Kerstin Koch and Hans-Jürgen Ensikat, who kindly to teach SEM techniques and always friendly to me. I would like to thank Dr. Kai Müller, my teacher in systematic and biodiversity of flowering plants who please to lecture in English and showed many wonderful lives of plant to me. A very warm thank-you is expressed to Rosemarie Pretscher for her very helpful to me in literatures and all materials equipments for support my research.

A very grateful thank-you to the colleagues of the AG Bryologie, especially to Dr. Isabelle Franzen-Reuter, she gave a very goodwill to me and suggested new chance for me to start my living in Bonn. My sincere thank goes to Dr. Rolf Blöcher, Dr. Marko Sabolvjevic, Boon-Chuan Ho, and Sahut Chanthanaorrapint for their very helpful comments and the interesting discussions we had on field trips and working together.

I am indebted to the curators of the herbaria at Herbarium Jutlandicum, Aarhus (AAU), The Natural History Museum, London (BM), Rijksherbarium, Leiden (L), Museum National d'Histoire Naturelle, Paris (PC), Brotherus-Herbarium, Helsinki (H-BR), Farlow Herbarium, Harvard University (FH), Herbarium of The New York Botanic Garden (NY) and Forest Herbarium, Bangkok (BKF), for the loan of specimens.

Additionally, I must express my thanks to Alfons Schäfer-Verwimp from Herdwangen-Schönach, for providing many specimens in his herbarium, and give a special thank to his wife for her kindly take care to me along field trips. They always gave a very good discussion and warm wishes to me.

In Thailand, I am deeply indebted to the staff of Department of Botany and would like to express my sincere thanks to Assoc. Prof. Nantana Angkinand, Assoc. Prof. Dr. Preeda Boon-long and Assoc. Prof. Dr. Supachitra chadchawan for their kindness. Without their support through this study would not have been possible.

I would like to express my deeply thanks to Assoc. Prof. Dr. Obchant Thaithong and Prof. Dr. Thaweesakdi Boonkerd at Plant of Thailand research Unit, Chulalongkorn University, both who introduced me to the bryophyte researches and has been passing on knowledge of fieldtrip, nomenclature and classification. Moreover, they have been very supportive and have helped me through several difficult times.

I am grateful to staff and students of the Herbarium, Department of Botany, Chulalongkorn University who have given me help in various ways. Assoc. Prof. Busban Na Songkhla, Assoc. Prof. Wiyada Thephuttee, Dr. Chumpol Khunwasi, Dr. Tosak Seelanan, Dr. Manit Kidyu, Ruangwit Bunjongrat, Suchada Wongpakam and most special thanks to Parinyanoot Klinratana, who help for everything at home during my time in Nees-Institute for Biodiversity of Plants, thank you so much.

For my good friends, you never let me feel lonely while living oversea, Dr. Kamhaeng Wattanasen, Siripong Songsiri, Somrak Luxanachan, Pizamai Kittipoom, Dr. Anchalee Jaidee, Montarop Sudhadham, Ungkana Khanikul, and Kanyada Kasetsinsombat, all deserve to be thanked. I also wish to thank the Thai student Köln-Bonn group for the good time we had together.

My grateful to thank the staff of the Thai Government Students' Office, the Royal Thai Embassy in London and Thai student consulting in Berlin, for their help several times with all businesses to government office in Thailand during my study.

I would like to acknowledge the commission on higher education, Ministry of education, Thailand for scholarship of my doctoral study. The thesis project was supported by Biodiversity Research and Training Program, Thailand (BRT). I am most indebted and most grateful.

Above all, for my family, no words can satisfactorily express my deep feeling of gratitude. My deep grateful goes to my parents, my aunt and my sister their encouragement and inspiration in my entire studies since I was young. Moreover, I would like to express my gratitude to my great maternal-grandmother who always encouraged and taught me everything which is useful for my life. I hope she is still looking forwards to my success from the paradise.

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**APPENDIX 1: Diversity of Species in floristic regions of Thailand**

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
15.	Sematophylloideae	<i>Acanthorrhynchium papillatum</i> (Harv.) M. Fleisch.	/	-	-	-	/	-	/
16.	Sematophylloideae	<i>Acanthorrhynchium scabrifolium</i> (Broth.) B. C. Tan & C. Ying	/	/	-	-	/	-	-
17.	Sematophylloideae	<i>Acroporium aciphyllum</i> Dixon	-	-	-	-	-	-	/
18.	Sematophylloideae	<i>Acroporium brevipes</i> (Broth.) Broth.	/	/	-	-	/	-	-
19.	Sematophylloideae	<i>Acroporium convolutifolium</i> Dixon	-	/	-	-	-	-	/
20.	Sematophylloideae	<i>Acroporium convolutum</i> (Sande Lac.) M. Fleisch.	-	-	-	-	-	-	/
21.	Sematophylloideae	<i>Acroporium diminutum</i> (Brid.) M. Fleisch.	-	-	-	-	/	-	/
22.	Sematophylloideae	<i>Acroporium downii</i> (Dixon) Broth.	-	-	-	-	-	-	/
23.	Sematophylloideae	<i>Acroporium hamulatum</i> (M. Fleisch.) M. Fleisch. var. <b>hamulatum</b>	-	-	-	-	-	-	/
24.	Sematophylloideae	<i>Acroporium hamulatum</i> (M. Fleisch.) M. Fleisch. var. <b>procumbens</b> (M. Fleisch.) Dixon	-	-	-	-	-	-	/
25.	Sematophylloideae	<i>Acroporium hermaphroditum</i> (C. Müll.) M. Fleisch.	-	-	-	-	/	-	/
26.	Sematophylloideae	<i>Acroporium johannis-winkleri</i> Broth.	-	-	-	-	-	-	/
27.	Sematophylloideae	<i>Acroporium lamprophyllum</i> Mitt.	/	-	-	-	/	-	/
28.	Sematophylloideae	<i>Acroporium laosianum</i> (Broth. & Par.) Broth.	/	/	/	-	/	-	-
29.	Sematophylloideae	<i>Acroporium rufum</i> (Reinw. & Hornsch.) M. Fleisch.,	-	-	-	-	-	-	/

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
30.	Sematophylloideae	<b>Acroporium secundum</b> (Reinw. & Hornsch.) M. Fleisch. var. <b>secundum</b>	-	-	-	-	-	-	/
31.	Sematophylloideae	<b>Acroporium secundum</b> (Reinw. & Hornsch.) M. Fleisch. var. <b>siamense</b> Dixon	-	-	-	-	-	-	/
32.	Sematophylloideae	<b>Acroporium sigmatodontium</b> (Müll & Hal.) M. Fleisch.	-	-	-	-	-	-	/
33.	Sematophylloideae	<b>Acroporium stramineum</b> (Hornsch. & Reinw.) M. Fleisch.	-	-	-	-	/	-	-
34.	Sematophylloideae	<b>Acroporium strepsiphylum</b> (Mont.) Tan	-	-	-	-	-	-	/
35.	Heterophylloideae	<b>Aptychella speciosa</b> (Mitt.) P. Tixier	/	/	-	-	-	-	-
36.	Heterophylloideae	<b>Aptychella tenuiramea</b> (Mitt.) P. Tixier	/	-	-	-	-	-	-
37.	Sematophylloideae	<b>Brotherella erythrocaulis</b> (Mitt.) M. Fleisch.	/	-	-	-	-	-	-
38.	Sematophylloideae	<b>Brotherella falcata</b> (Dozy & Molk.) M. Fleisch.	/	-	-	-	-	-	-
39.	Sematophylloideae	<b>Chionostomum baolocense</b> P. Tixier	-	-	-	-	/	-	-
40.	Sematophylloideae	<b>Chionostomum pinicola</b> P. Tixier	/	-	-	-	-	-	-
41.	Sematophylloideae	<b>Chionostomum rostratum</b> (Mitt.) C. Müll.	/	/	/	-	-	-	/
42.	Clastobryoideae	<b>Clastobryophilum bogoricum</b> (Bosch & Sande Lac.) M. Fleisch.	-	-	-	-	-	-	/
43.	Clastobryoideae	<b>Clastobryum caudatum</b> M. Fleisch.	-	-	-	-	/	-	-
44.	Clastobryoideae	<b>Clastobryum cuculligerum</b> (Dozy & Molk.) P. Tixier	-	-	/	-	-	-	-
45.	Clastobryoideae	<b>Clastobryum indicum</b> (Dozy & Molk.) Dozy & Molk.	-	/	-	-	-	-	-
46.	Clastobryoideae	<b>Clastobryum spiculiferum</b> (Dixon) Tan & Iwats.	-	-	-	-	-	-	/

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
47.	Heterophylloideae	<i>Gammiella ceylonensis</i> (Broth.) Tan & Buck	/	-	-	-	-	-	-
48.	Heterophylloideae	<i>Gammiella pterogonioides</i> (Griff.) Broth.	/	/	-	-	/	-	-
49.	Heterophylloideae	<i>Gammiella rugosa</i> P. Tixier	/	-	-	-	-	-	-
50.	Heterophylloideae	<i>Gammiella tonkinensis</i> (Broth. & Par.) Tan	-	/	-	-	-	-	-
51.	Sematophylloideae	<i>Hageniella assamica</i> Dixon	/	-	-	-	-	-	-
52.	Heterophylloideae	<i>Heterophyllum amblystegum</i> (Mitten) Y. Jia, S. He & Crosby	/	-	-	-	-	-	-
53.	Heterophylloideae	<i>Isoclatiella surcularis</i> (Dixon) Tan & Mohamed	-	-	-	-	-	-	/
54.	Sematophylloideae	<i>Mastopoma robinsonii</i> (Broth.) E. B. Bartram	/	-	-	-	-	-	-
55.	Sematophylloideae	<i>Mastopoma subfiliferum</i> Horikawa & Ando	/	-	-	-	-	-	-
56.	Sematophylloideae	<i>Meiothecium jagorii</i> (Müll. Hal.) Broth.	-	-	-	-	-	-	/
57.	Sematophylloideae	<i>Meiothecium microcarpum</i> (Hook.f.) Mitt.	-	/	-	-	/	-	/
58.	Sematophylloideae	<i>Meiothecium turgidellum</i> M. Fleisch.	/	-	-	-	-	-	-
59.	Sematophylloideae	<i>Papillidiopsis complanata</i> (Dixon) Buck & Tan	-	/	-	-	-	-	-
60.	Sematophylloideae	<i>Papillidiopsis luxurians</i> (Dozy & Molk.) Buck & Tan	-	-	-	-	-	-	/
61.	Sematophylloideae	<i>Papillidiopsis macrosticta</i> (Broth. & Paris) W.R. Buck & B.C. Tan	-	/	/	-	/	-	/
62.	Sematophylloideae	<i>Papillidiopsis stissophylla</i> (Hampe & Müll. Hal.) B.C. Tan & Y. Jia	-	-	-	-	/	-	/
63.	Heterophylloideae	<i>Pseudotrismegistia undulata</i> (Broth. & Yasuda) H. Akiy. & Tsubota	/	-	-	-	-	-	-
64.	Heterophylloideae	<i>Pylaisiadelpha capillacea</i> (Griff.) B. C. Tan & Y. Jia	-	-	-	-	/	-	-

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
65.	Sematophylloideae	<b>Radulina hamata</b> (Dozy & Molk) W.R. Buck & B.C. Tan	-	/	/	-	/	-	/
66.	Sematophylloideae	<b>Rhaphidostichum bunodiocarpum</b> (Müll. Hal.) M. Fleisch.	-	-	-	-	-	-	/
67.	Sematophylloideae	<b>Rhaphidostichum leptocarpoides</b> (Broth.) Broth.	-	-	-	-	/	-	-
68.	Sematophylloideae	<b>Rhaphidostichum luzonense</b> (Broth.) Broth.	/	-	-	-	-	-	-
69.	Sematophylloideae	<b>Rhaphidostichum piliferum</b> (Broth.) Broth.	-	-	/	-	-	-	-
70.	Sematophylloideae	<b>Sematophyllum humile</b> (Mitt.) Broth.	-	/	-	-	-	-	-
71.	Sematophylloideae	<b>Sematophyllum latifolium</b> Broth. ***	/	-	-	-	-	-	-
72.	Sematophylloideae	<b>Sematophyllum microcladiellum</b> M. Fleisch.	/	-	-	-	/	/	-
73.	Sematophylloideae	<b>Sematophyllum parvulum</b> (Broth.) Dixon	-	-	-	-	/	-	-
74.	Sematophylloideae	<b>Sematophyllum phoeniceum</b> (C. Müll.) M. Fleisch.	/	/	-	-	/	-	-
75.	Sematophylloideae	<b>Sematophyllum subconnivens</b> (Broth.) Dixon	-	-	-	-	/	-	-
76.	Sematophylloideae	<b>Sematophyllum subhumile</b> (C. Müll.) M. Fleisch.	/	-	-	-	-	-	-
77.	Sematophylloideae	<b>Sematophyllum subpinnatum</b> (Brid.) E. Britton	/	-	-	-	/	-	-
78.	Sematophylloideae	<b>Sematophyllum subpinnatum</b> fo. <b>tristiculum</b> (Mitt.) B.C. Tan & Y. Jia	/	-	-	-	-	-	-
79.	Sematophylloideae	<b>Sematophyllum subrevolutum</b> Broth.	-	-	-	-	/	-	-
80.	Sematophylloideae	<b>Taxithelium alare</b> Broth.	/	/	-	-	-	-	/
81.	Sematophylloideae	<b>Taxithelium arnottii</b> Thér. & P. Tixier	/	-	-	-	/	-	/
82.	Sematophylloideae	<b>Taxithelium bakeri</b> Broth.	-	-	-	-	-	-	/

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
83.	Sematophylloideae	<i>Taxithelium binsteadii</i> Broth. & Dixon	-	-	-	-	-	/	/
84.	Sematophylloideae	<i>Taxithelium clastobryoides</i> Dixon	-	-	-	-	-	-	/
85.	Sematophylloideae	<i>Taxithelium epapillosum</i> Dixon	-	-	-	-	-	-	/
86.	Sematophylloideae	<i>Taxithelium gottscheanum</i> (Hampe) Broth.	-	-	-	-	/	-	-
87.	Sematophylloideae	<i>Taxithelium inerme</i> P. Tixier	-	-	-	-	/	-	-
88.	Sematophylloideae	<i>Taxithelium instratum</i> (Brid.) Broth.	-	/	/	/	/	-	/
89.	Sematophylloideae	<i>Taxithelium isocladum</i> (Bosch & Sande Lac.) Ren. & Card.	-	-	-	-	/	-	/
90.	Sematophylloideae	<i>Taxithelium kerianum</i> (Broth.) Broth.	-	-	-	-	-	-	/
91.	Sematophylloideae	<i>Taxithelium magnum</i> M. Fleisch.	-	-	-	-	-	-	/
92.	Sematophylloideae	<i>Taxithelium merrillii</i> Broth.	-	-	-	-	/	-	/
93.	Sematophylloideae	<i>Taxithelium nepalense</i> (Schwaegr.) Broth.	/	-	/	-	/	/	/
94.	Sematophylloideae	<i>Taxithelium oblongifolium</i> (Sull. & Lesq.) Iwats	-	-	-	-	-	/	/
95.	Sematophylloideae	<i>Taxithelium parvulum</i> (Broth. & Paris) Broth.	-	-	-	-	-	-	/
96.	Sematophylloideae	<i>Taxithelium schmidtii</i> Broth. ***	-	-	-	-	/	-	-
97.	Sematophylloideae	<i>Taxithelium sumatranum</i> (Bosch & Sande Lac.) Broth.	-	-	-	-	-	-	/
98.	Sematophylloideae	<i>Taxithelium vernieri</i> (Duby) Besch.	-	-	-	-	-	-	/
99.	Sematophylloideae	<i>Trichosteleum boschii</i> (Dozy & Molk.) A. Jaeger	-	/	-	-	/	/	/
100.	Sematophylloideae	<i>Trichosteleum mammosum</i> (C. Müll.) Jaeg.	-	-	-	-	/	-	/
101.	Sematophylloideae	<i>Trichosteleum monostictum</i> (Thwait. & Mitt.) Broth. var. <i>laevius</i> Dixon	-	-	-	-	/	-	-
102.	Sematophylloideae	<i>Trichosteleum pinnatum</i> Dixon	-	-	-	-	-	-	/

No.	Subfamily	Total Species	Floristic Regions						
			N	NE	E	C	SE	SW	PEN
103.	Sematophylloideae	<i>Trichosteleum pseudo-mammosum</i> M. Fleisch.	-	-	/	-	-	-	-
104.	Sematophylloideae	<i>Trichosteleum ruficaule</i> (Thwait. & Mitt.) B.C. Tan	-	-	-	-	-	-	/
105.	Sematophylloideae	<i>Trichosteleum saproxylophilum</i> (C. Müll.) B.C. Tan, Schofield & Ramsay	-	-	-	-	/	-	-
106.	Sematophylloideae	<i>Trichosteleum trachycystis</i> Broth.	-	-	-	-	/	-	/
107.	Sematophylloideae	<i>Trismegistia lancifolia</i> (Harv.) Broth.	-	/	-	-	-	-	/
108.	Sematophylloideae	<i>Warburgiella leptorhynchoides</i> (Mitt.) M. Fleisch.	/	-	-	-	-	-	/
109.	Sematophylloideae	<i>Wijkia baculifera</i> (Dixon) H.A. Crum	/	-	-	-	-	-	-
110.	Sematophylloideae	<i>Wijkia deflexifolia</i> (Mitt. ex Renault & Cardot) H.A. Crum	/	-	-	-	-	-	-
111.	Sematophylloideae	<i>Wijkia filipendula</i> (Dixon) H.A. Crum	-	-	-	-	-	-	/
112.	Sematophylloideae	<i>Wijkia hornschuchii</i> (M. Fleisch.) H.A. Crum	/	-	-	-	-	-	-
113.	Sematophylloideae	<i>Wijkia laxa</i> (Dixon) H.A. Crum	/	/	-	-	/	-	-
114.	Sematophylloideae	<i>Wijkia penicillata</i> (Mitt.) H.A. Crum	/	-	-	-	-	-	-
115.	Sematophylloideae	<i>Wijkia surcularis</i> (Mitt.) H.A. Crum	/	/	-	-	/	-	-
116.	Sematophylloideae	<i>Wijkia tanytricha</i> (Mont.) H.A. Crum	/	/	-	-	/	-	-

Note: Floristic regions; N=northern, NE= northeastern, E=eastern, C=central, SE=southeast, SW=southwest, PEN=peninsular  
 \*\*\* Excluded species within this study (they reported as endemic to Thailand.).



**Research Interests:** Diversity of Bryophytes and Pteridophytes in Thailand and adjacent region

**Publications:**

1. Boonkerd, T. and **Pollawatn, R.** 2002. The first record of *Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A. Heller (Dennstaedtiaceae) in Thailand. *The Natural History Bulletin of The Siam Society* 30: 72-74.
2. Boonkerd, T. and **Pollawatn, R.** 2002. *Leptochilus minor* Fée (Polypodiaceae), a new record for Thailand. *The Natural History Journal of Chulalongkorn University* 2(1): 1-3.
3. Boonkerd, T. and **Pollawatn, R.** 2004. A revised taxonomic account of the fern genus *Woodwardia* (Blechnaceae) in Thailand. *Thai Forest Bulletin (Botany)* 32: 1-5.
4. Boonkerd, T. and **Pollawatn, R.** 2006. Pteridophyte Flora of Thong Pha Phum National Park, Kanchanaburi Province, Thailand. *The Natural History Journal of Chulalongkorn University* 6(1): 17-30.
5. Boonkerd, T., **Pollawatn, R.**, Chantanaorrapint, S. and M.-J. Lai. 2007. A Note on *Asterella khasyana* (Griff.) Pandé, K.P. Srivast and Sultan Khan (Marchantiales, Aytoniaceae) in Thailand. *The Natural History Journal of Chulalongkorn University* 7(2): 175-179.
6. Koch, K., Frahm J.-P. and **R. Pollawatn.** 2007. The cuticle of the *Buxbaumia viridis* sporophyte. *Flora*. In press.
7. **Pollawatn, R.**, Lai, M.-J. and J.-P. Frahm. 2008. Taxonomic Review of *Atrichum* P. Beauv. (Musci, Polytrichaceae) in Thailand. *The Natural History Journal of Chulalongkorn University*, In press.
8. **Pollawatn, R.**, Frahm, J.-P. and T. Boonkerd. 2008. New species records of Sematophyllaceae (Musci) from Thailand. World Conference of Bryology 2007: Bryology in Asia in the New Millennium, 23–27 July 2007, Kuala Lumpur, Malaysia. In press.
9. **Pollawatn, R.**, Frahm, J.-P. and T. Boonkerd. The genus *Taxithelium* Spruce ex Mitt. (Sematophyllaceae) in Thailand. In preparation.

**Book:**

Boonkerd, T. and **Pollawatn, R.** 2000. Pteridophytes in Thailand. Office of Environmental. Policy and Planning, Bangkok.

**Oral Presentation:**

**Pollawatn, R.**, Frahm, J.-P. and T. Boonkerd. A synopsis of Sematophyllaceae (Musci) in Thailand. World Conference of Bryology 2007: Bryology in Asia in the New Millennium, 23–27 July 2007, Kuala Lumpur, Malaysia.

**Poster:**

**Pollawatn, R.**, Frahm, J.-P. and T. Boonkerd. Taxonomic Revision of Sematophyllaceae (Musci) in Thailand. 8-11 October 2006: Biodiversity Research and Training Program (BRT) Annual Meeting, Maritime Park and Spa Resort, Krabi, Thailand.



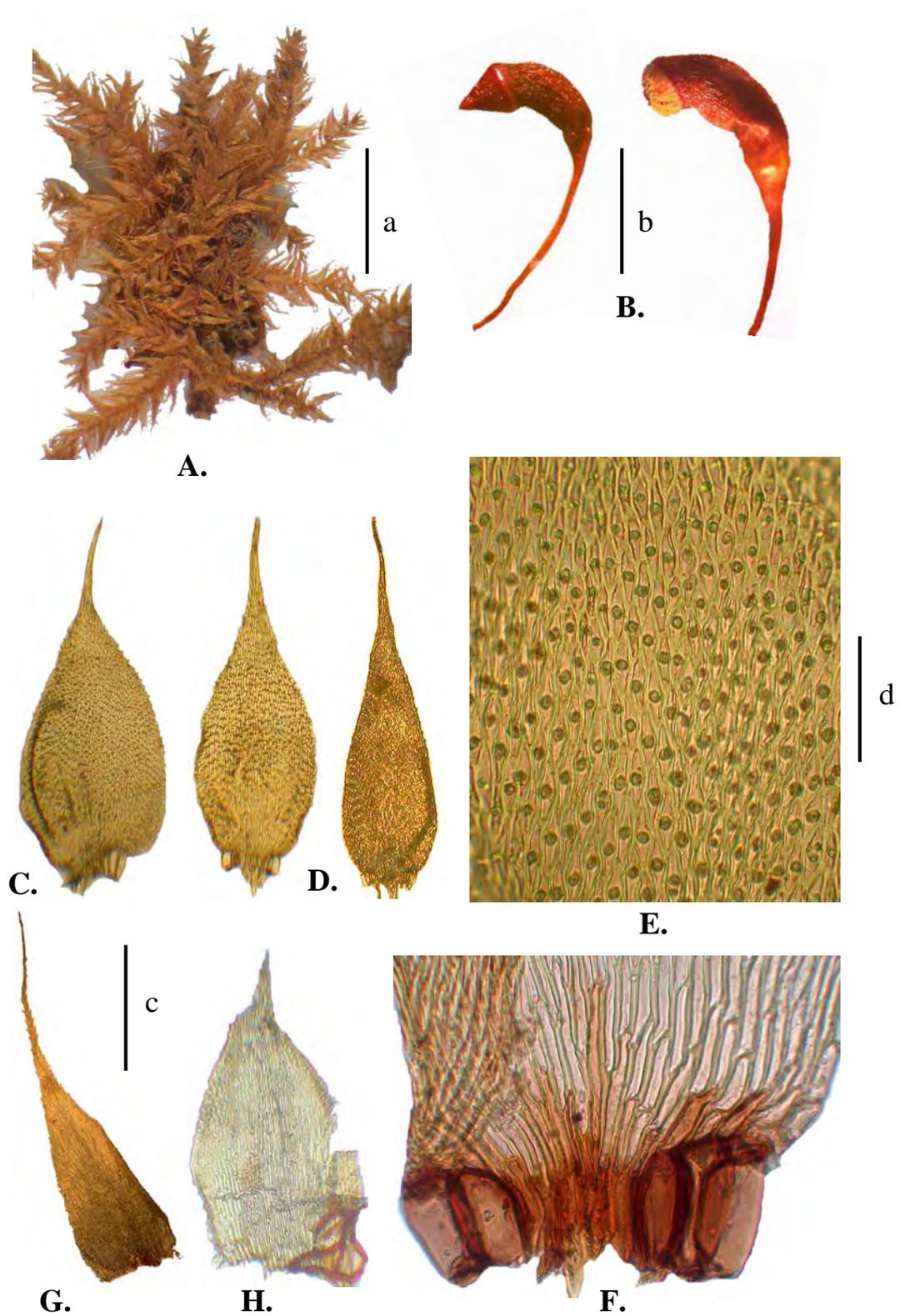


Figure 5.1 *Acanthorrhynchium papillatum* (Harv.) M. Fleisch.; photos based on *Hooker 3168*, type, BM; A. habit, B. sporophyte, C. stem leaf, D. branch leaf, E. leaf cells unipapillose F. acroporium alar organization, G, perichaetia leaf, H. perigonia leaf; scale bars: A.= a = 1 cm, B. = b = 1 mm, C., D., G., H.= c = 1mm, E., F.= c = 50 µm,

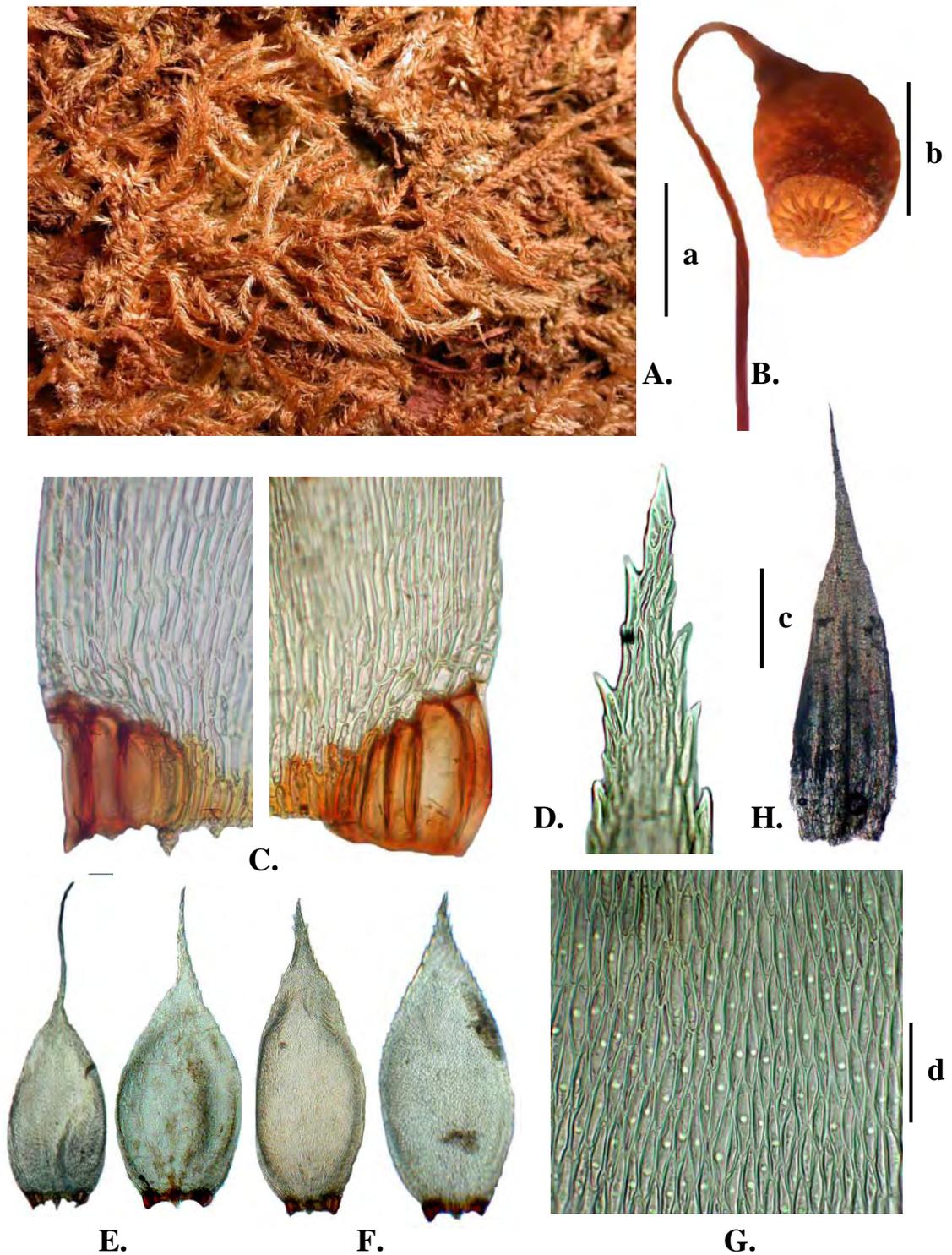


Figure 5.2 *Acanthorrhynchium scabrifolium* (Broth.) B. C. Tan & C. Ying; photos based on *CLaW* 4327, BM; A. habit, B. sporophytes, C. acroporoid alar organization, D. leaf apex, E. stem leaves, F. branch leaves, G. leaf cells unipapillose, H. perichaetia leaf; scale bars: A. = a = 5 mm, B. = b = 1 mm, E., F., H. = c = 5 mm; C., D., G. = d = 30  $\mu$ m.

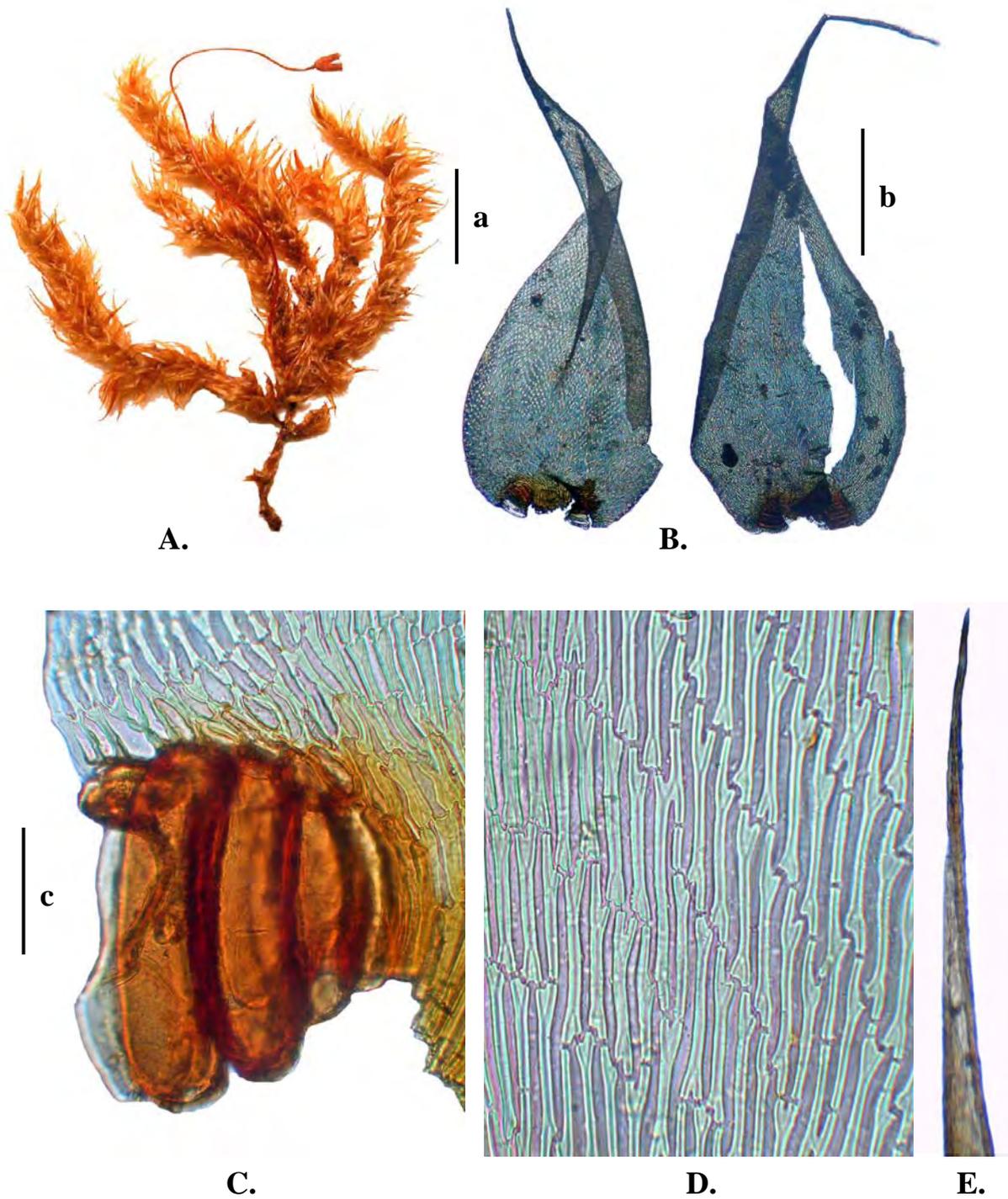


Figure 5.3 *Acroporium aciphyllum* Dixon; photos based on *Ridley 1037*, syntype, BM; A. habit, B. leaves, C. acroporoid alar organization, D., pitted leaf cells, E. leaf apex; scale bars: A. = a = 1 cm; B. = b = 1 mm; C., D., E. = c = 50  $\mu$ m.

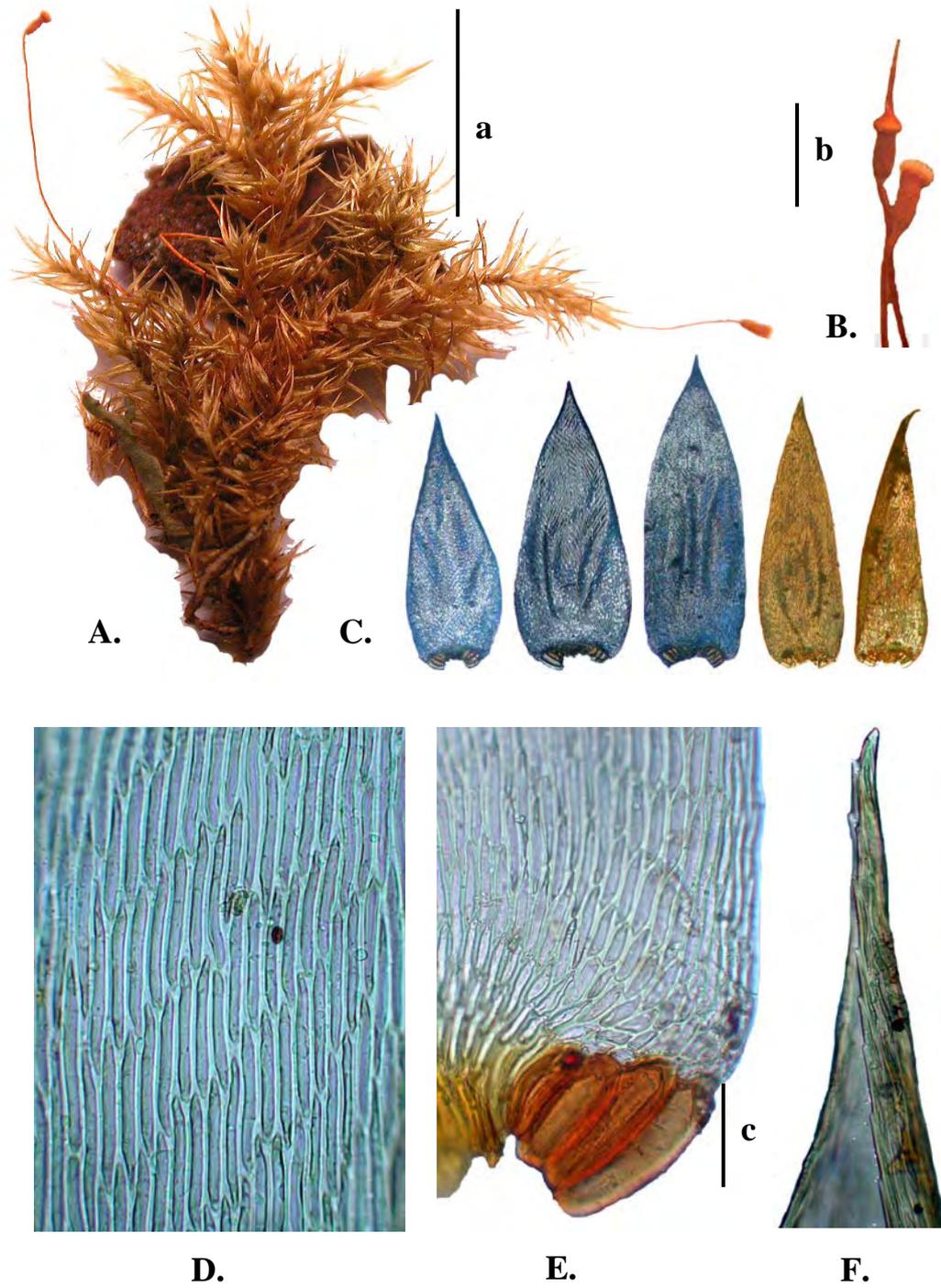


Figure 5.4 *Acroporium brevipes* (Broth.) Broth.; photos based on *Merrill 7865*, isotype, FH) A. habit, B. sporophytes, C. leaves, D. leaf cells, E. acroporoid alar organization, F. leaf apex; scale bars: A. = a = 1 cm; B., C. = b = 1 mm; D., E., F. = c = 50  $\mu$ m.

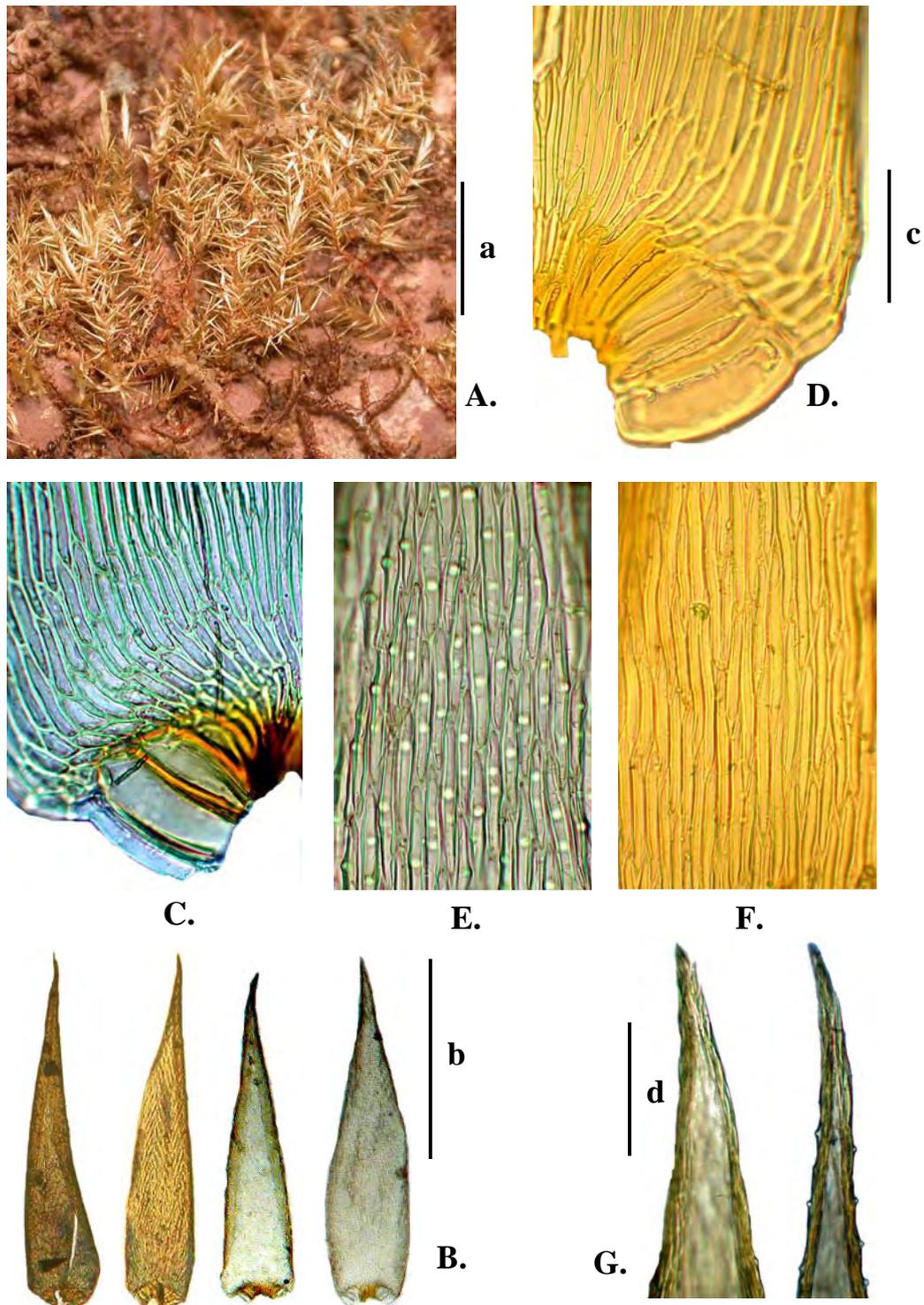


Figure 5.5 *Acroporium convolutifolium* Dixon; photos based on *Kerr 417b*, type, BM; A. habit, B. leaves, C., D. acroporoid alar cells organization, E. leaf cell 1-2 papillae near apex, F. leaf cells smooth at middle lamina, G. leaf apices; (scale: A. = a = 5 mm; B. = b = 0.5 mm; C.,D.,E.,F. = c = 50  $\mu$ m, G = d = 10  $\mu$ m).

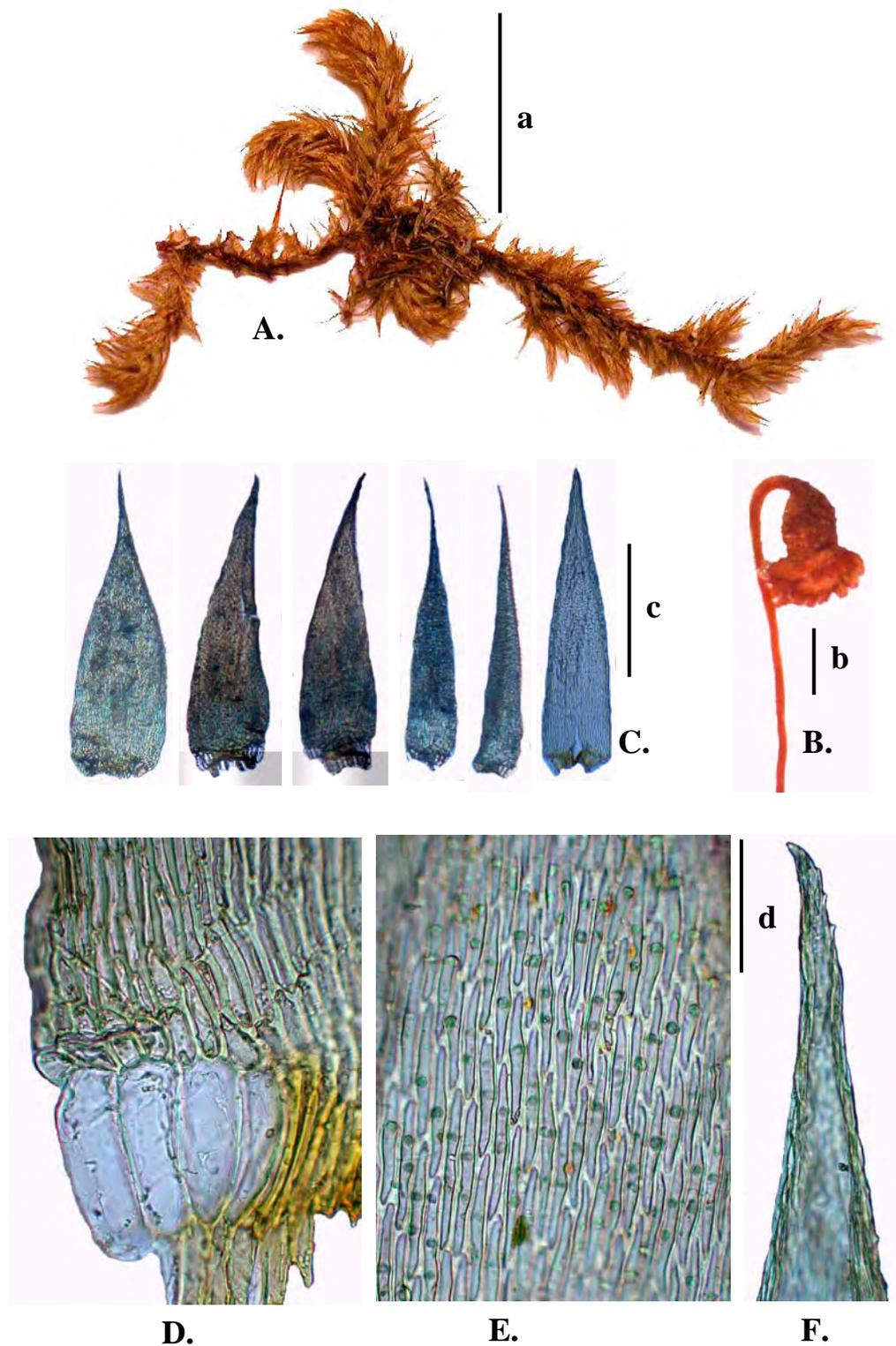


Figure 5.6 *Acroporium convolutum* (Sande Lac.) M. Fleisch.; photos based on *Sedree 10 April 1897*, type, FH; A. habit, B. sporophyte, C. leaves, D. acroporoid alar organization, E. leaf cells 2-3 papillae, A. leaf apex; scale bars: A. = a = 5 mm; B. = b = 1 mm; C. = c = 1 mm; D., E., F. = d = 100  $\mu$ m.

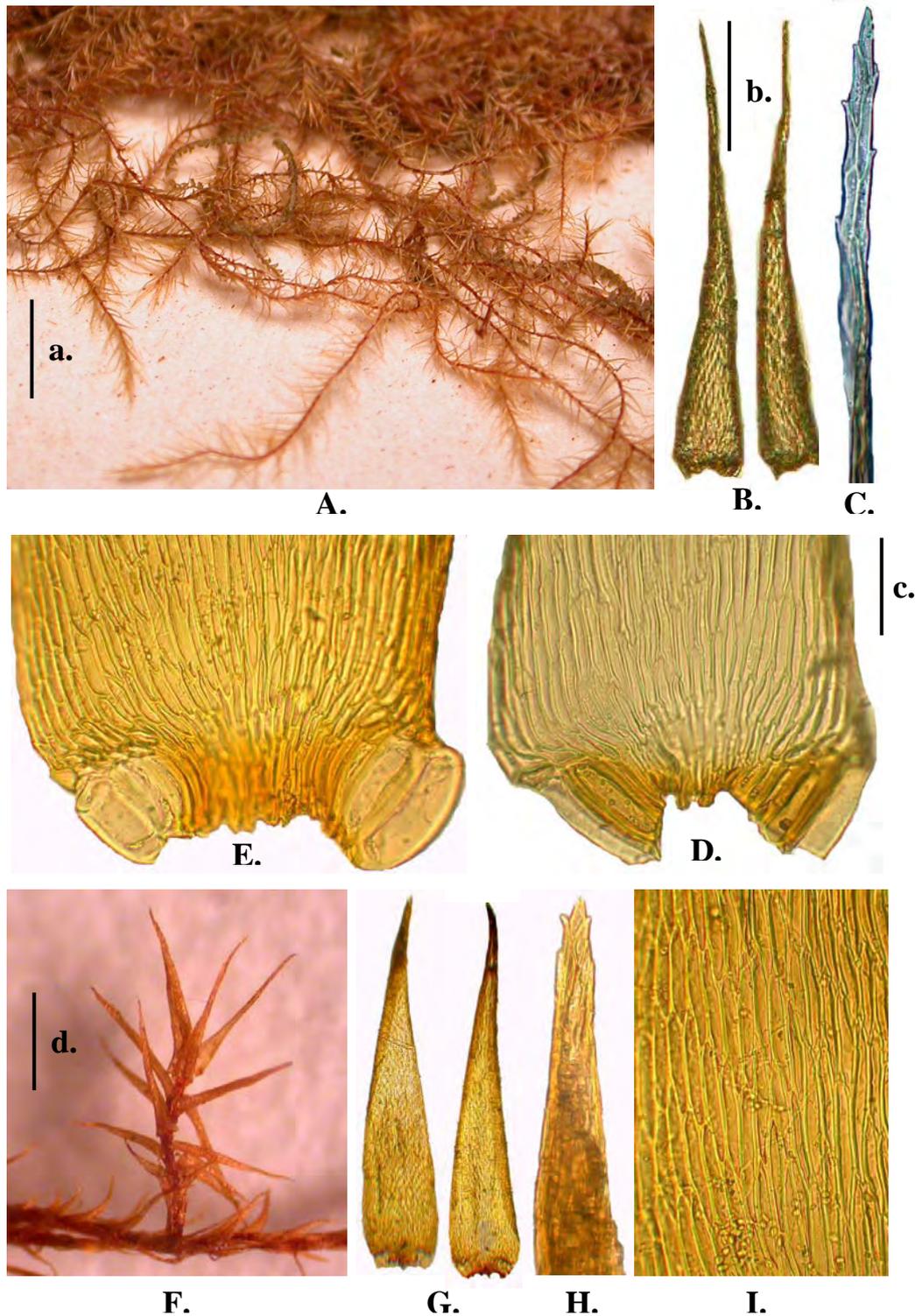


Figure 5.7 *Acroporium diminutum* (Brid.) M. Fleisch.; photos based on isotype, L0057092; A.-D. (as *Hypnum gracidicaule* Sande Lac.): A. habit, B. leaves, C. leaf apex, D. acroporoid alar cells organization; E.-I. (as *Hypnum subulatum* Hampe): E. Acroporoid alar cell organization, F. lateral branch, G. leaf, H. leaf apex, I. leaf cells; scale bars: A. = a = 1 cm; B.,G. = b = 0.3 mm; C.,E.,D.H., I. = c = 50  $\mu$ ; F. = d = 1 mm)

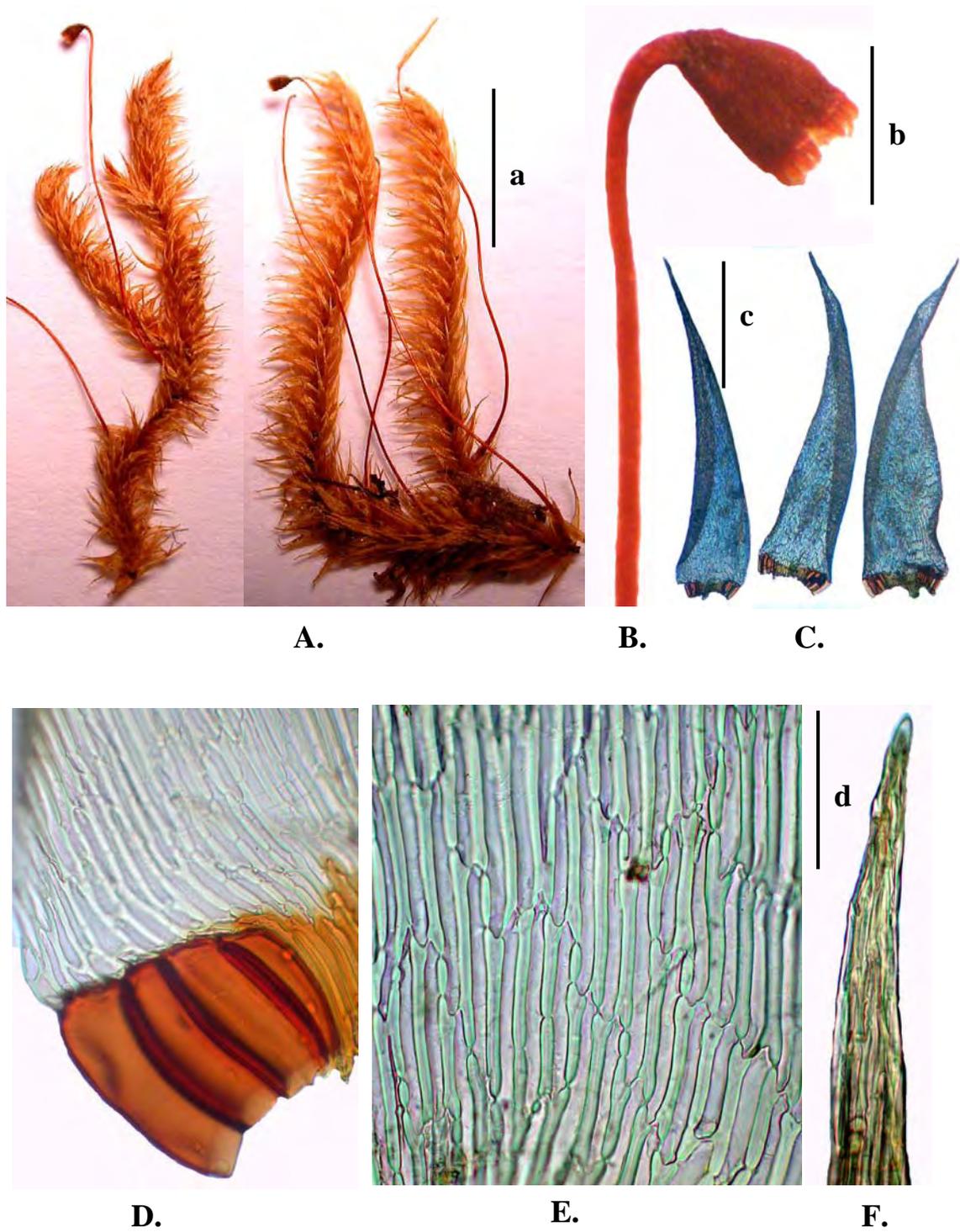


Figure 5.8 *Acroporium downii* (Dixon) Broth.; photos based on *Down 14*, type, BM; A. habit, B. sporophyte, C. leaves, D., acroporoid alar cells organization, E. leaf cells pitted, F. leaf apex; scale bars: A. = a = 1cm; B. = b = 1 mm; C. = c = 1mm; D., E., F. = d = 100  $\mu$ m.

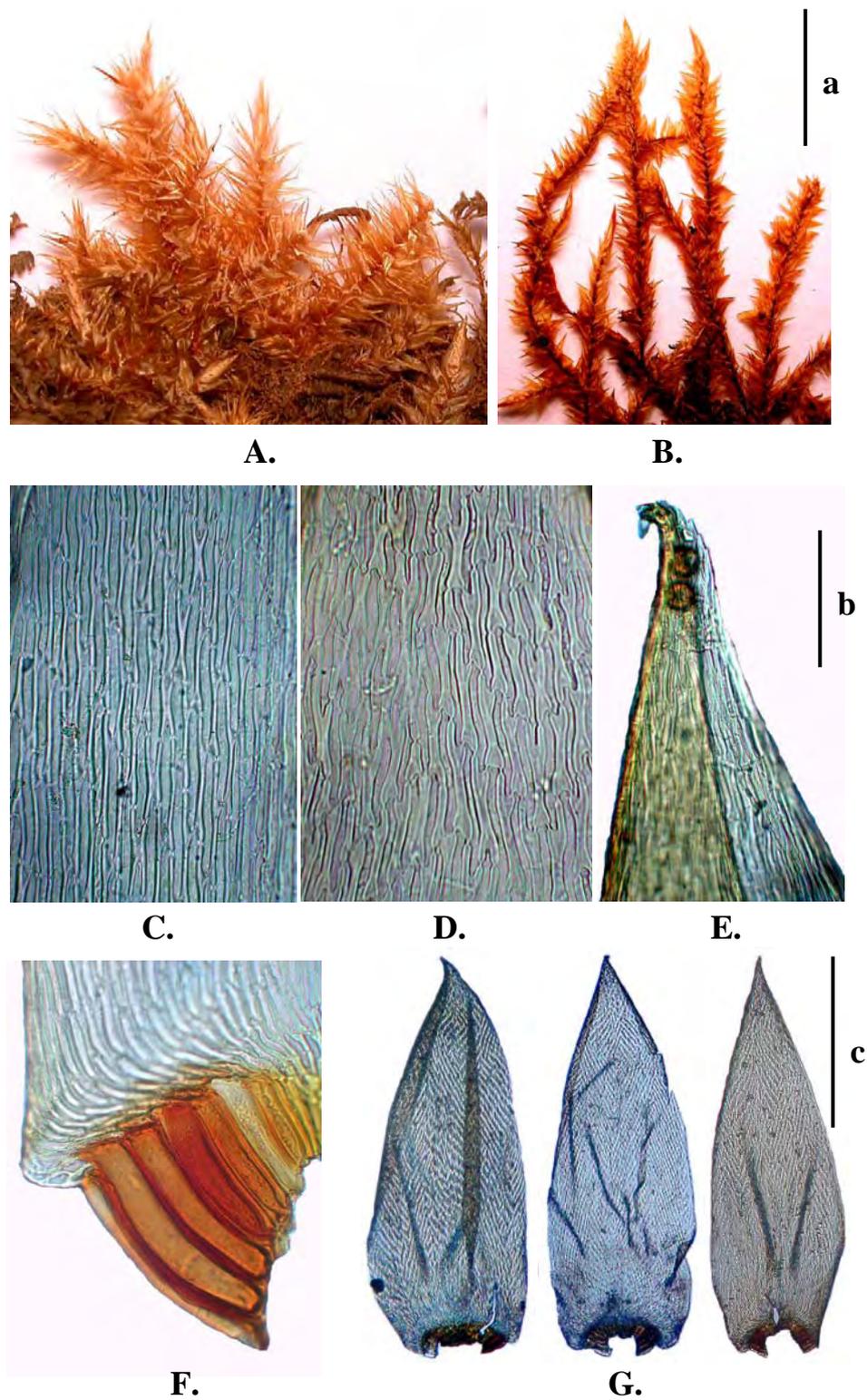


Figure 5.9. *Acroporium hamulatum* (M. Fleisch.) M. Fleisch. var. *hamulatum*; photos based on *Fleischer 6 July 1898*, syntype, H-BR; A. habit, B. stem elongate, C. leaf cells thickened wall near apex, D. leaf cells pitted near base, E. leaf apex like hook, F. acropoid alar cells organization, G, leaves; scale bars: A.,B. = a = 2 cm; C.,D.,E, F = b = 50  $\mu$ m ; G = c = 1 mm.

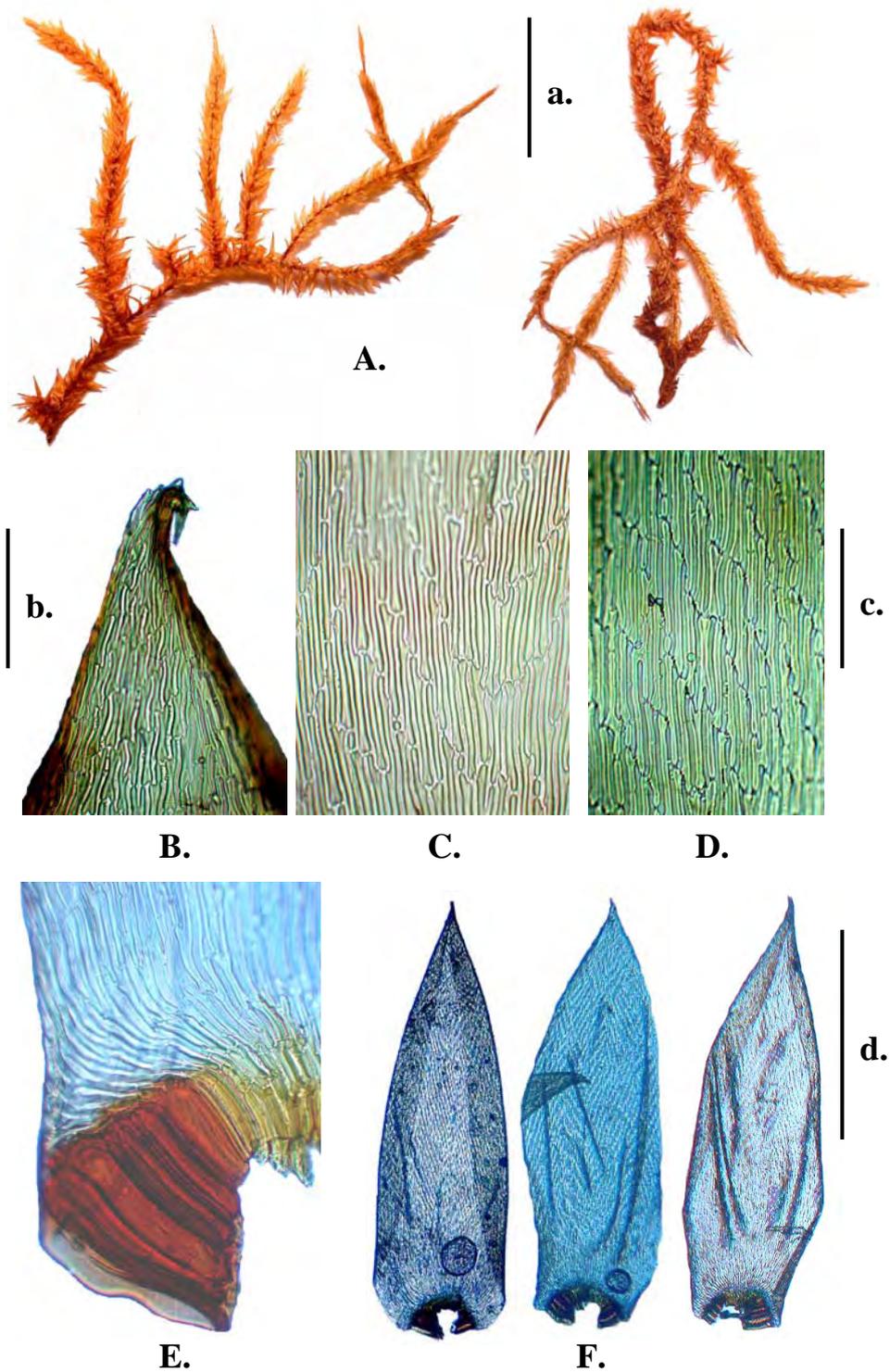


Figure 5.10 *Acroporium hamulatum* (M. Fleisch.) M. Fleisch. var. *procumbens* (M. Fleisch.) Dixon; photos based on Kerr 199c, BM; A. habit, B. leaf hamulous apex, C. leaf cells pitted at apical, D. leaf cells pitted, middle, E. alar cells acroporoid type, F. leaves; scale bars: A.= a = 2 cm; B. = b = 1 mm; C., D., E. = c = 80  $\mu$ m; F. = d = 1 mm.

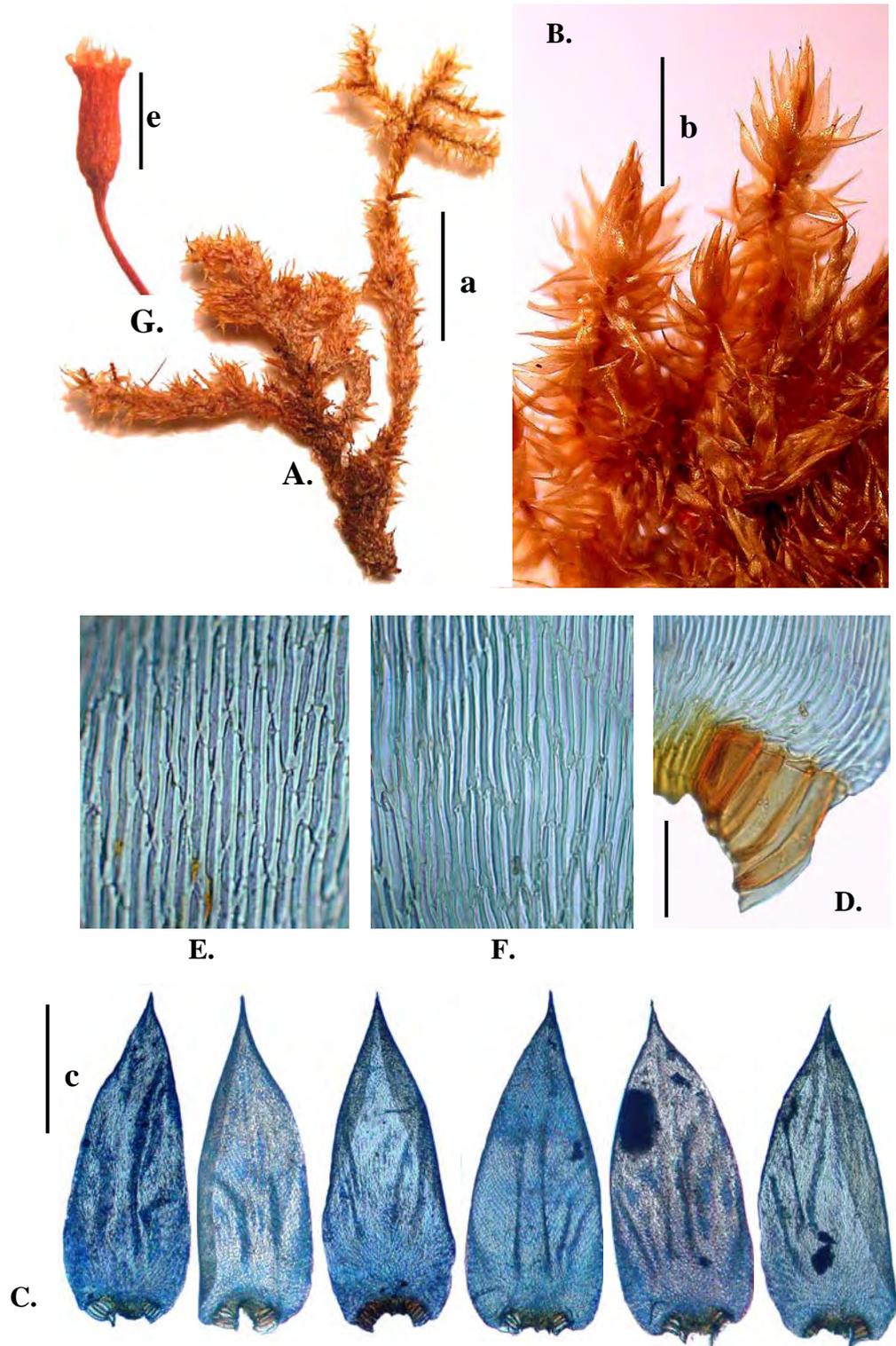


Figure 5.11 *Acroporium hermaphroditum* (C. Müll.) M. Fleisch.; photos based on *Touw 11799A*, BKF; A. habit, B. lateral branch, C. leaves, D. alar cells acroporoid type, E. middle leaf cells, F. leaf cells near base, G. sporophyte; scale bars: A.= a = 1 cm, B.= b = 5 mm, C. = c = 1 mm, D., E., F. = d = 50  $\mu$ m, G.= e = 1 mm.

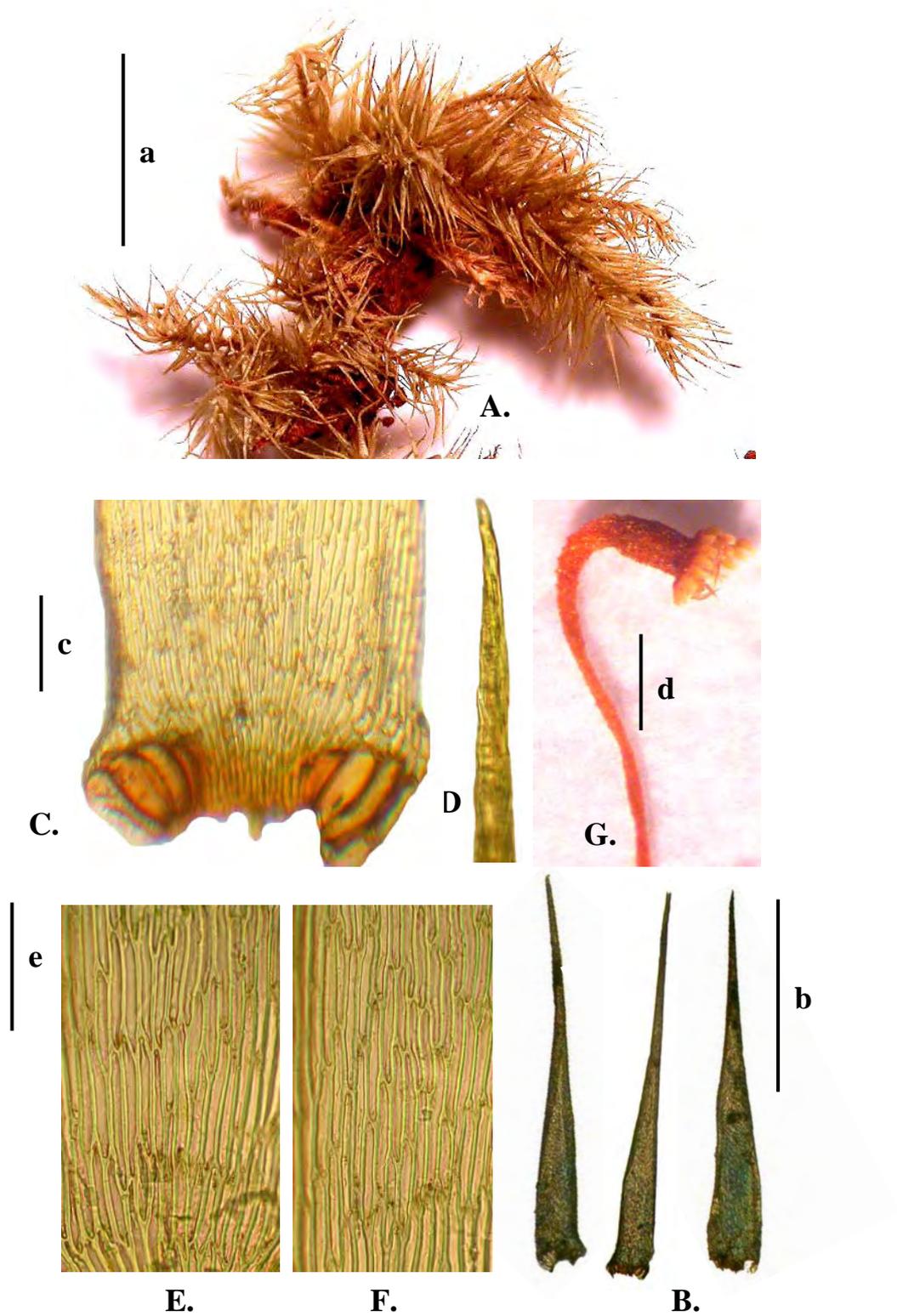


Figure 5.12 *Acroporium johannis-winkleri* Broth.; photos based on *Touw 12001*, L; A. habit, B. leaves, C. base leaf with acroporoid alar cells, D. leaf apex, E. lamina cells near base, F. mid-leaf cells, G. sporophyte; scale bars: A. = a = 5 mm, B. = b 1 mm, C., D. = c = 50  $\mu$ m, E., F. = 50  $\mu$ m, G. = d = 5 cm.

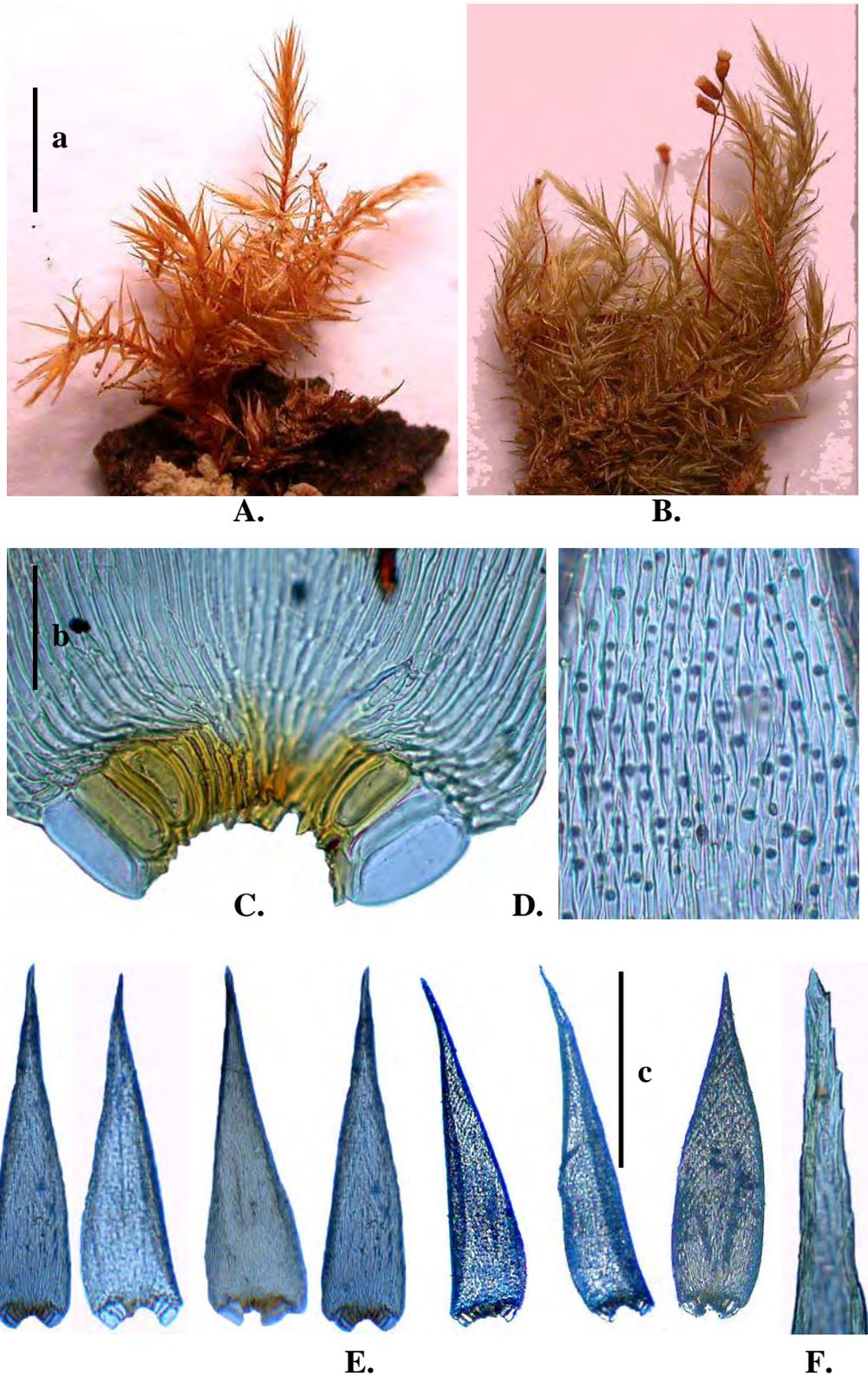


Figure 5.13 *Acroporium lamprophyllum* Mitt.; photos based on *Touw 8130*, AAU; A. habit, B. plant with sporophytes, C. leaf base with acroporoid type, D. lamina cells with 2-3 papillae, E. leaves, F. leaf apex; scale bars: A., B = a = 5 mm, C., D., F. = b = 50  $\mu$ m, E. = 0.5 mm.

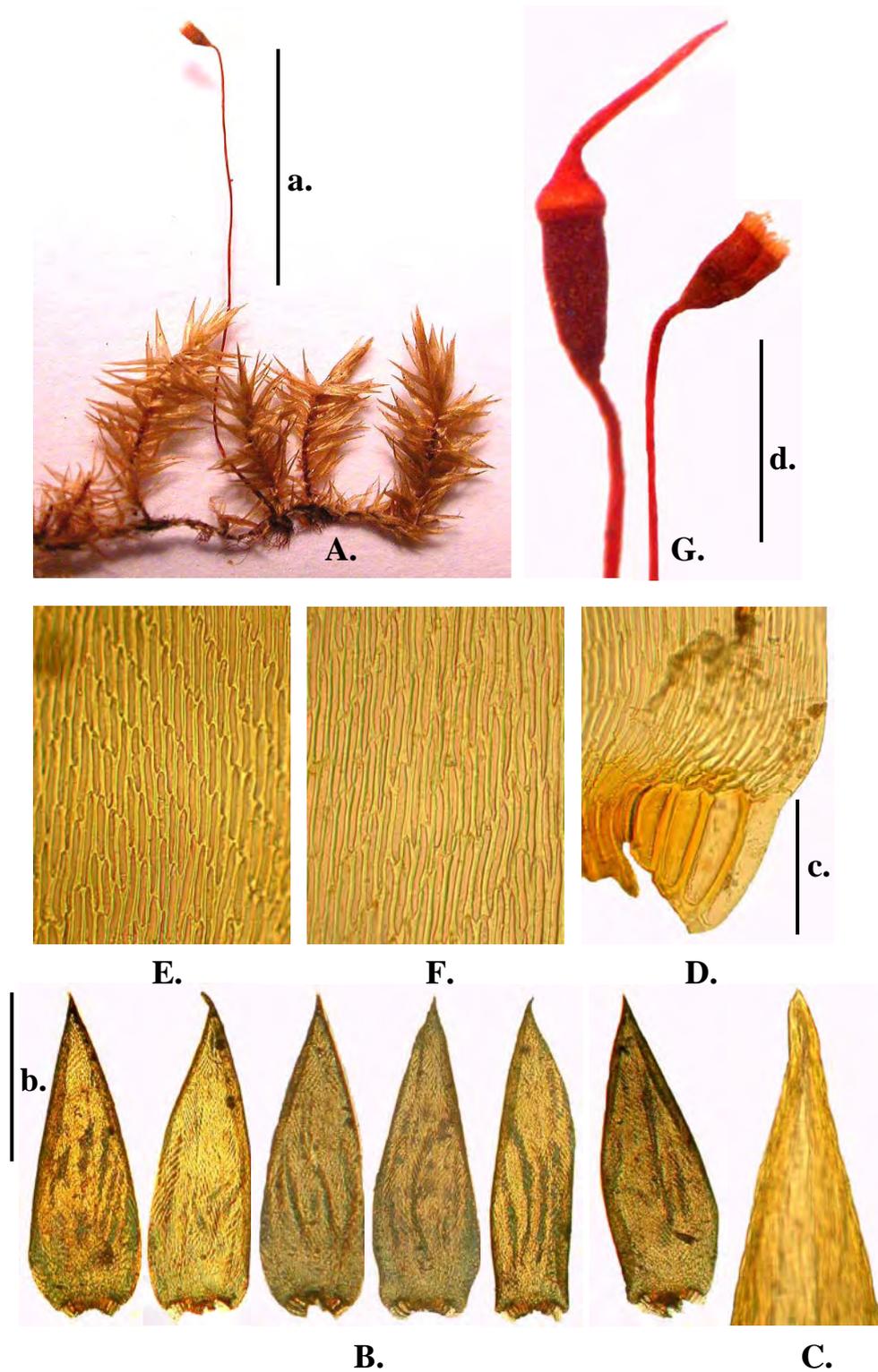


Figure 5.14 *Acroporium laosianum* (Broth. & Par.) Broth.; photos based on *Miboliz* 03/1909, type, H; A. habit, B. leaves, C. leaf apex, D. base leaf with acroporoid alar organization, E. mid-leaf cells, F. leaf cells pitted near base leaf, G. sporophytes; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E., F. = c = 100 µm, G. = d = 5 mm.

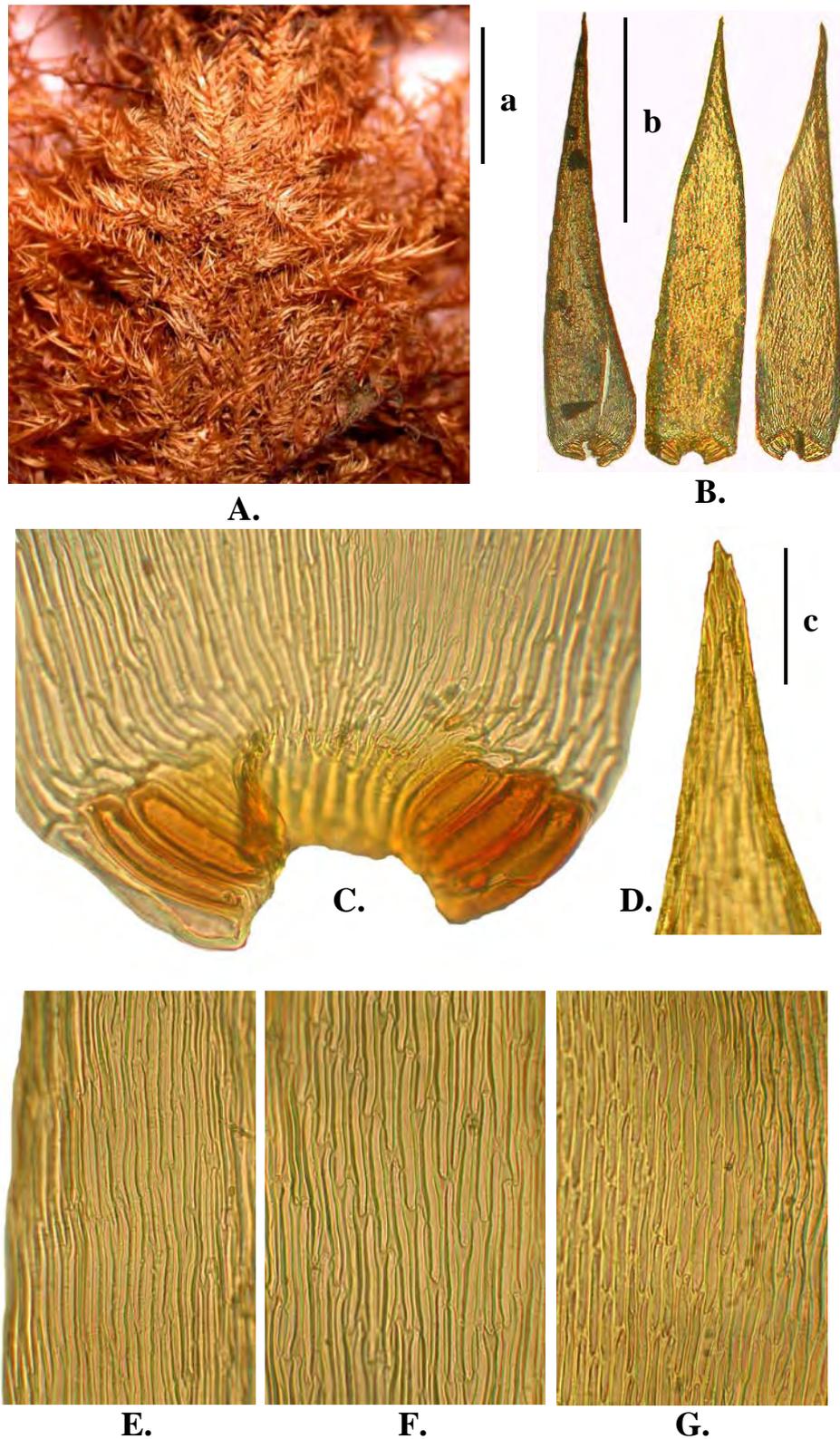


Figure 5.15 *Acroporium rufum* (Reinw. & Hornsch.) M. Fleisch.: photos based on Touw 11795; BM; A. habit, B. Leaves, C. base leaf with acroporoid alar organization, D. leaf apex, E. leaf cells near margin, F. leaf cells pitted near base, G. mid-leaf cells; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E., F., G. = c = 70  $\mu$ m.

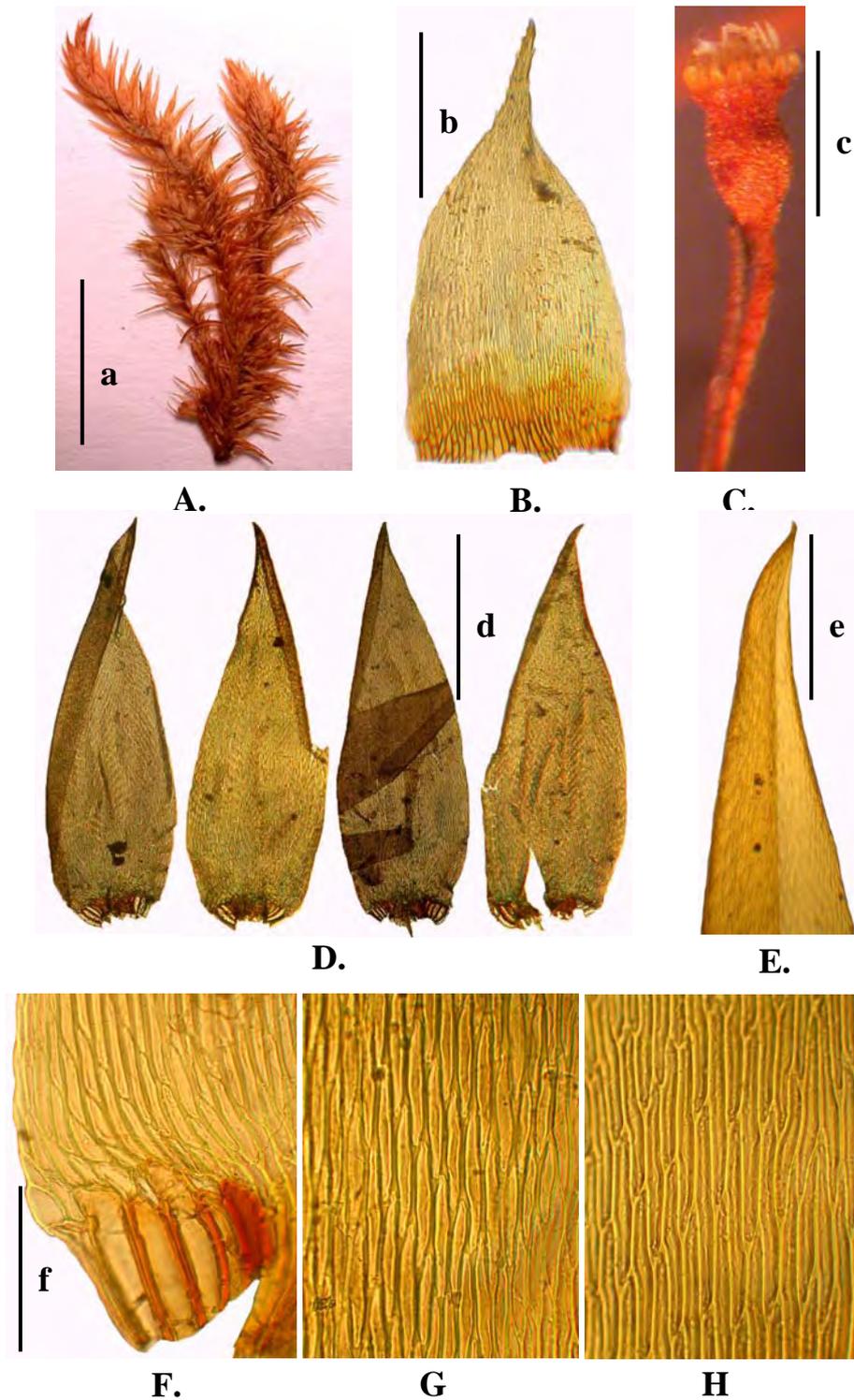


Figure 5.16 *Acroporium secundum* (Reinw. & Hornsch.) M. Fleisch. var. *secundum*; photos based on Java, type, (FH); A. branch, B. outer perichaetial leaf, C. sporangium, D. leaves, E. leaf apex, F. base leaf with acroporoid organization, G. mid-leaf cells, H. leaf cells near apex; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C. = c = 5 mm, D. = d = 1 mm, E. = e = 0.1 mm, F. G., H. = f = 100  $\mu$ m.

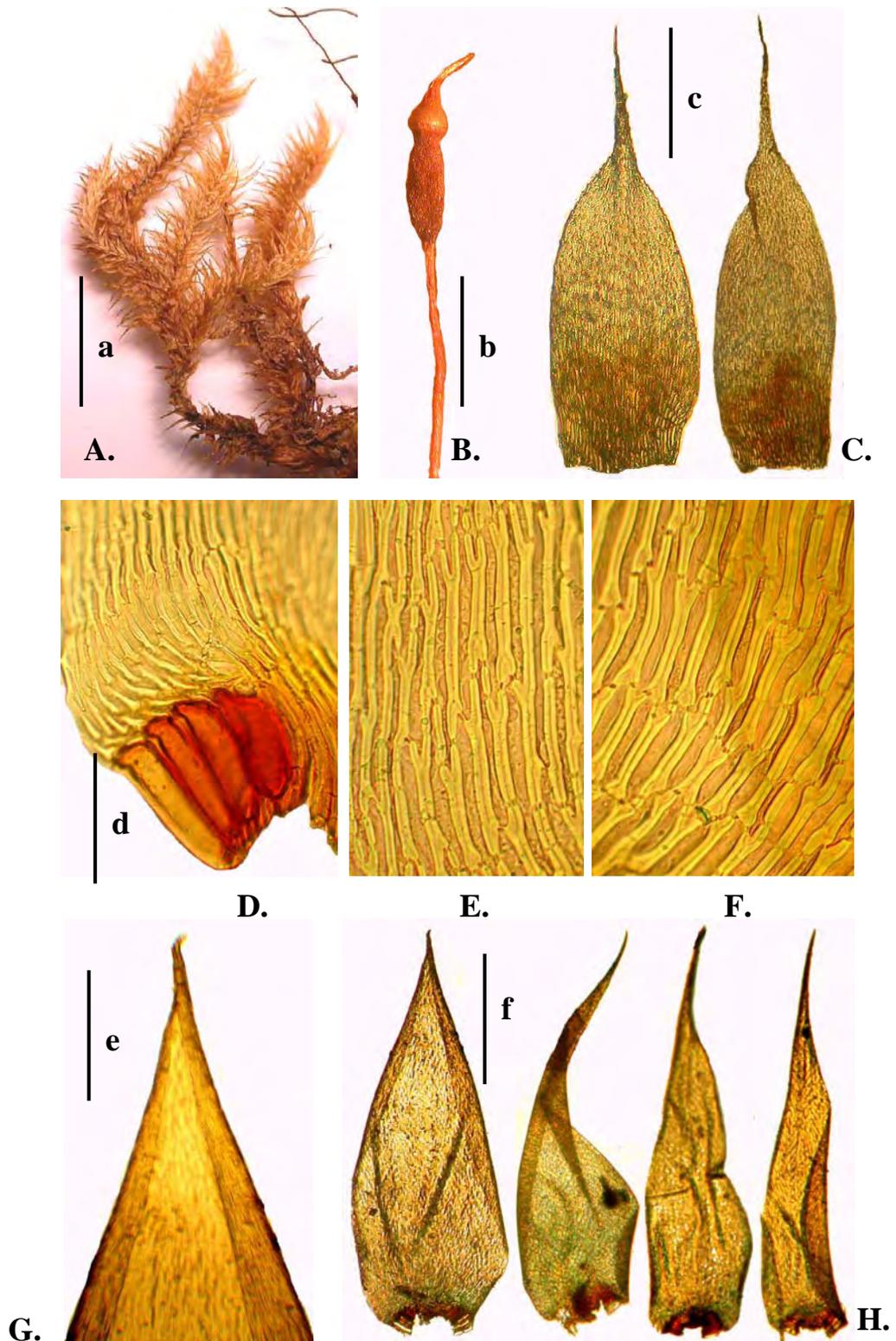


Figure 5.17 *Acroporium secundum* (Reinw. & Hornsch.) M. Fleisch. var. *siamense* Dixon; photos base on Kerr 490, type, BM; A. habit, B. sporophyte, C. perichaetia, D. base leaf with acroporoid alar organization, E. mid-leaf cells pitted, F. leaf cells pitted near base. G. leaf apex, H. leaves; scale bars: A.= a = 1 cm., B.= b = 5 mm. C. = c = 0.5 mm, D., E., F. = d = 100 μm, G.= e = 0.1 mm, H.= f = 1 mm.

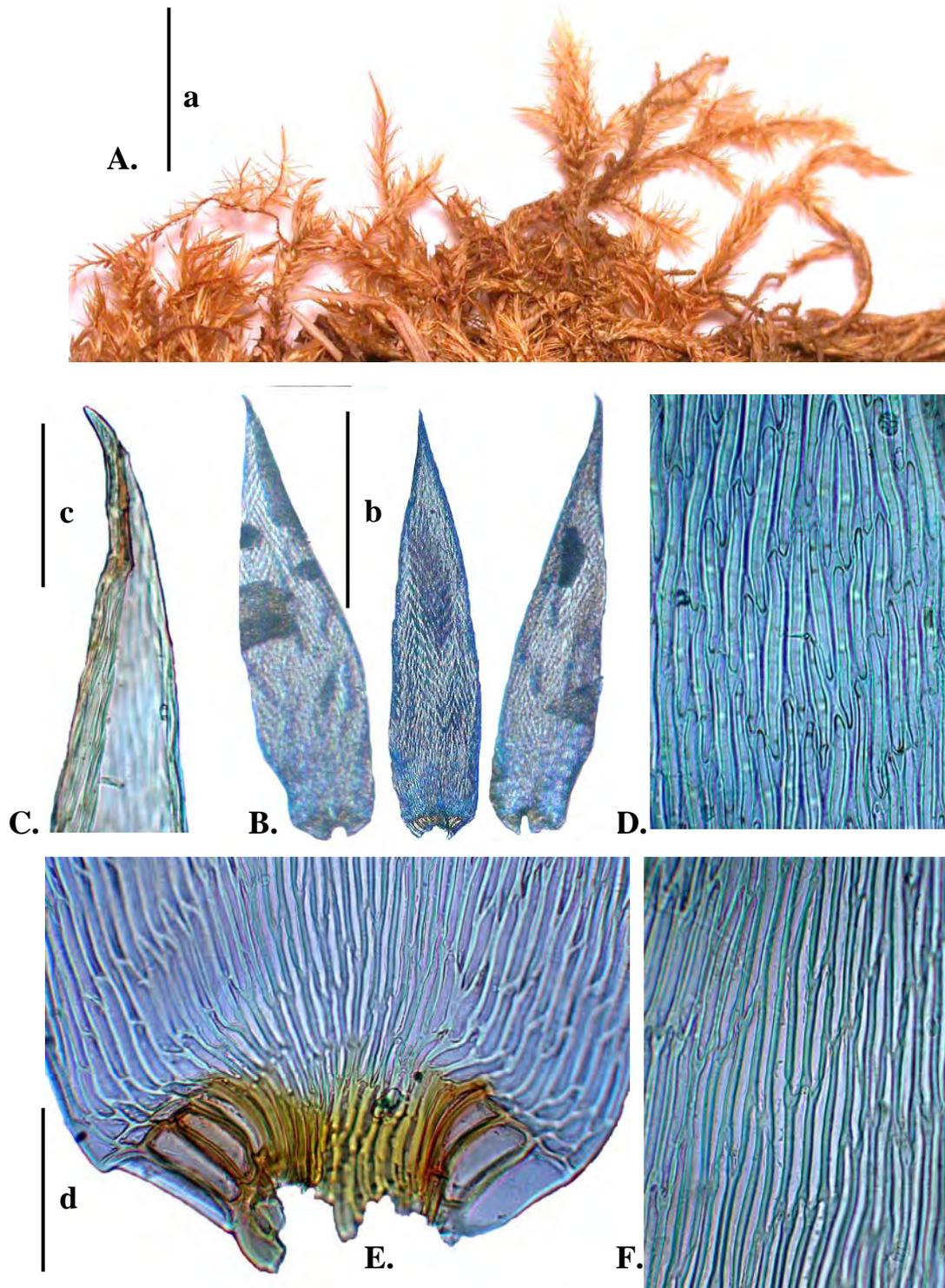


Figure 5.18 *Acroporium sigmatodontium* (Müll & Hal.) M. Fleisch.; photos based on *Touw 11726*, AAU; A. Habit, B. Leaves, C. Leaf apex, D. Leaf cells unipapillose near apex, E. base leaf with alar organization, F. Leaf cells pitted near base; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 0.1 mm, D., E., F. = d = 100  $\mu$ m.

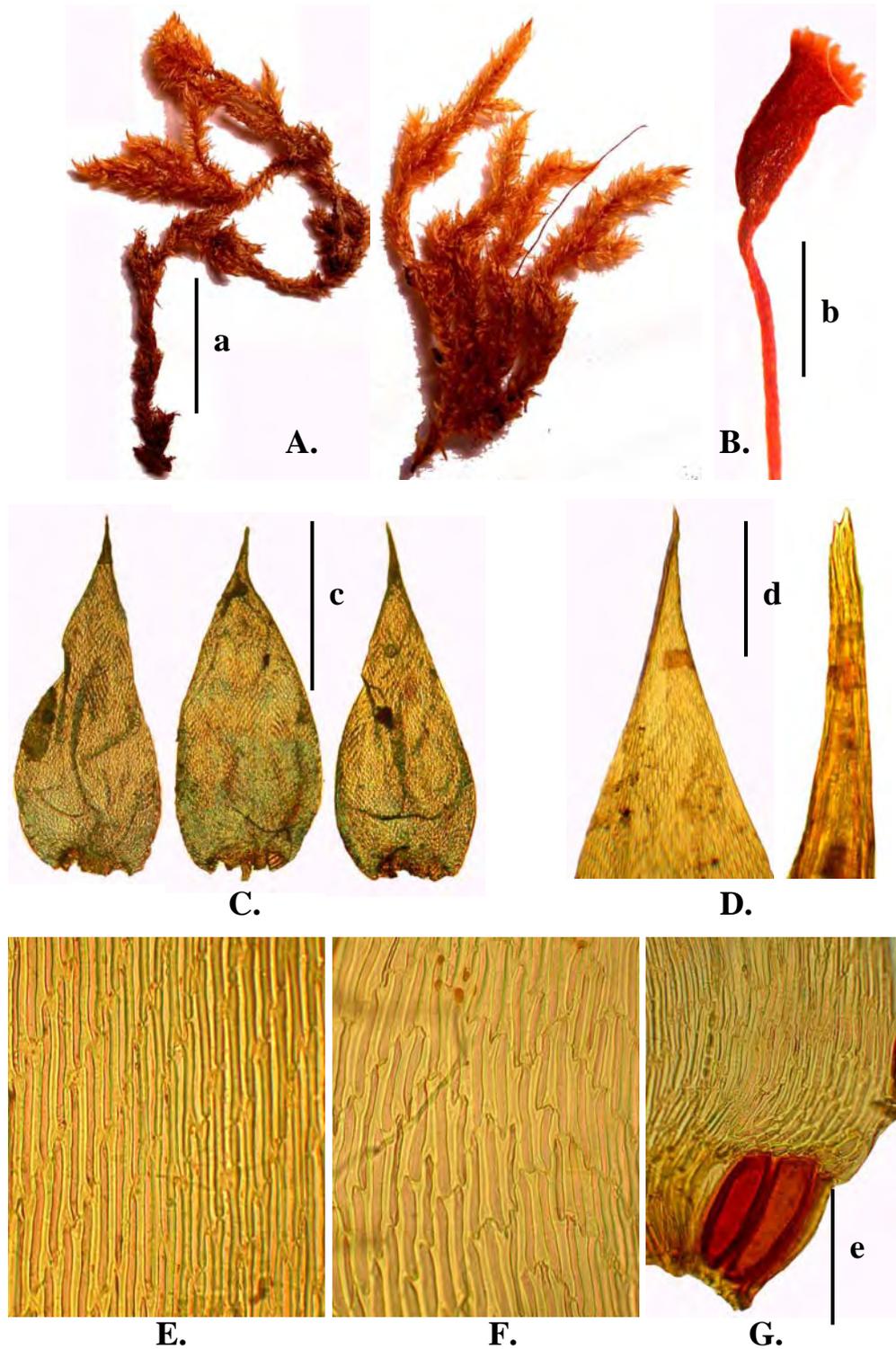


Figure 5.19 *Acroporium stramineum* (Hornsch. & Reinw.) M. Fleisch.; photos based on *Fenix 39771*, holotype, H-BR; A. habit, B. sporophyte, C. leaves, D. leaf apex, E. leaf cells near apex, F. leaf cells pitted near base, G. base leaf with alar organization; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 1 mm, D. = d = 0.1 mm, E., F., G. = 70  $\mu$ m.

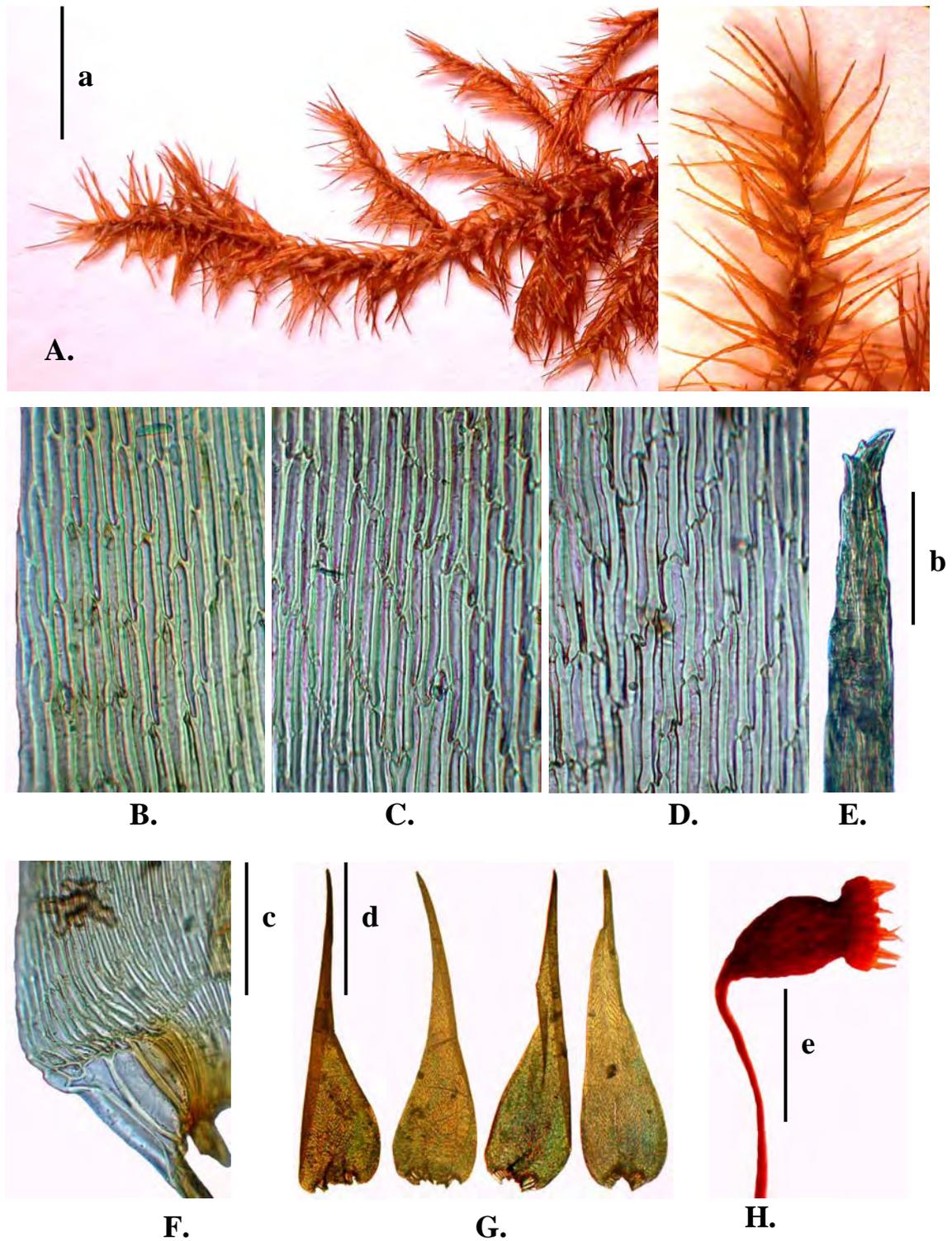


Figure 5.20 *Acroporium strepsiphyllum* (Mont.) Tan; photos based on *Maguel*, Java, 1843, type, BM; A. habit, B. leaf cells pitted near apex, C. mid-leaf cells pitted, D. leaf cells pitted near base, E. leaf apex, F. leaf base with acroporoid organization, G. leaf, H. sporophyte; scale bars: A. = a = 1 cm, B., C., D., E. = b = 50 µm, F. = c = 100 µm, G. = d = 1 mm, H. = e = 1 mm).

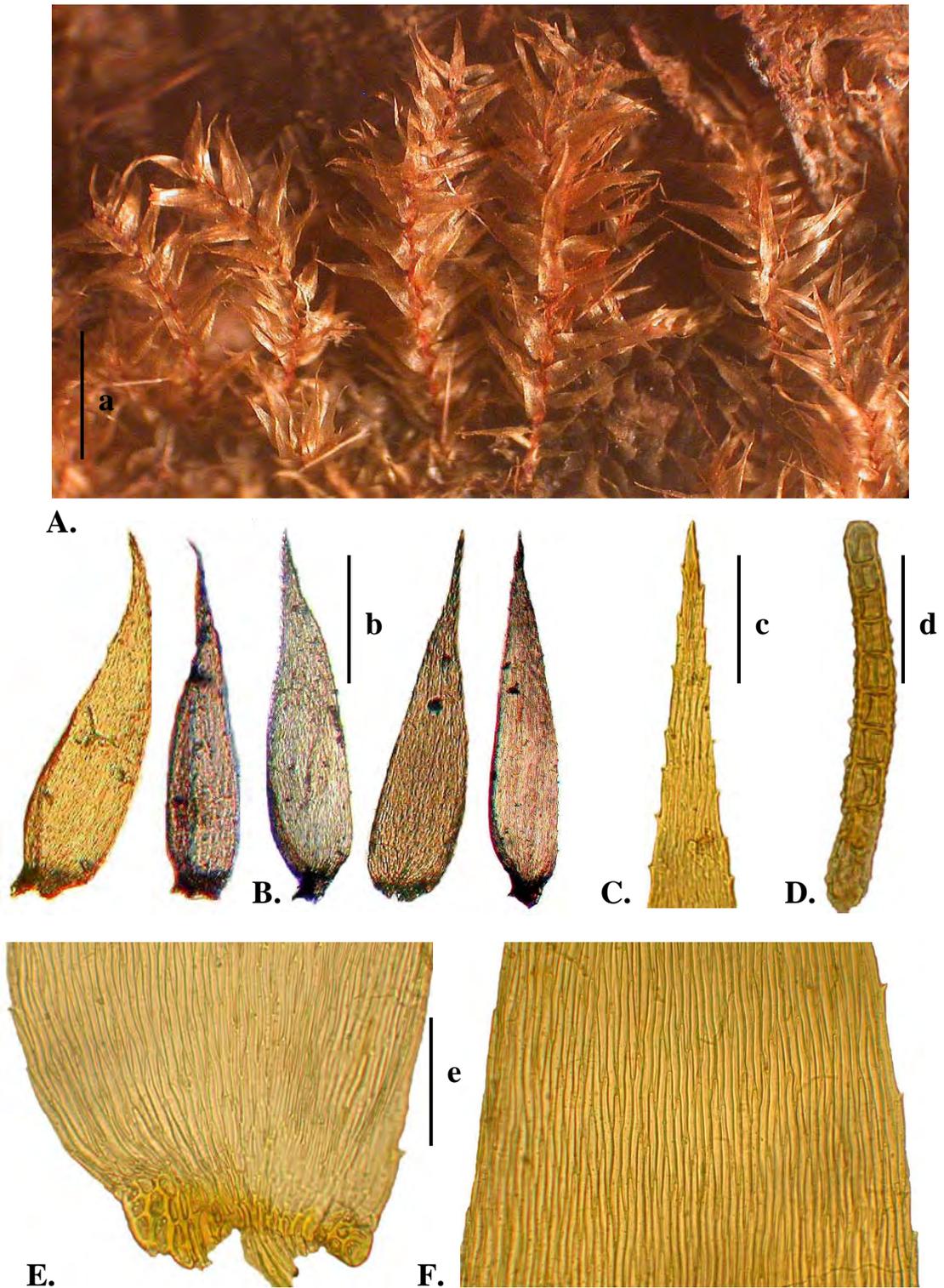


Figure 5.21 *Aptychella speciosa* (Mitt.) P. Tixier; photos based on *Touw 10525*, BKF; A. habit, B. leaves, C. Leaf apex, D. filamentous gammae, E. base leaf with alar heterophylloid organization, F. mid-leaf cells; scale bars: A. = a = 1 mm, B. = b = 0.5 mm, C. = c = 0.1 mm, D. = d = 0.5 mm, E., F. = e = 50  $\mu$ m.

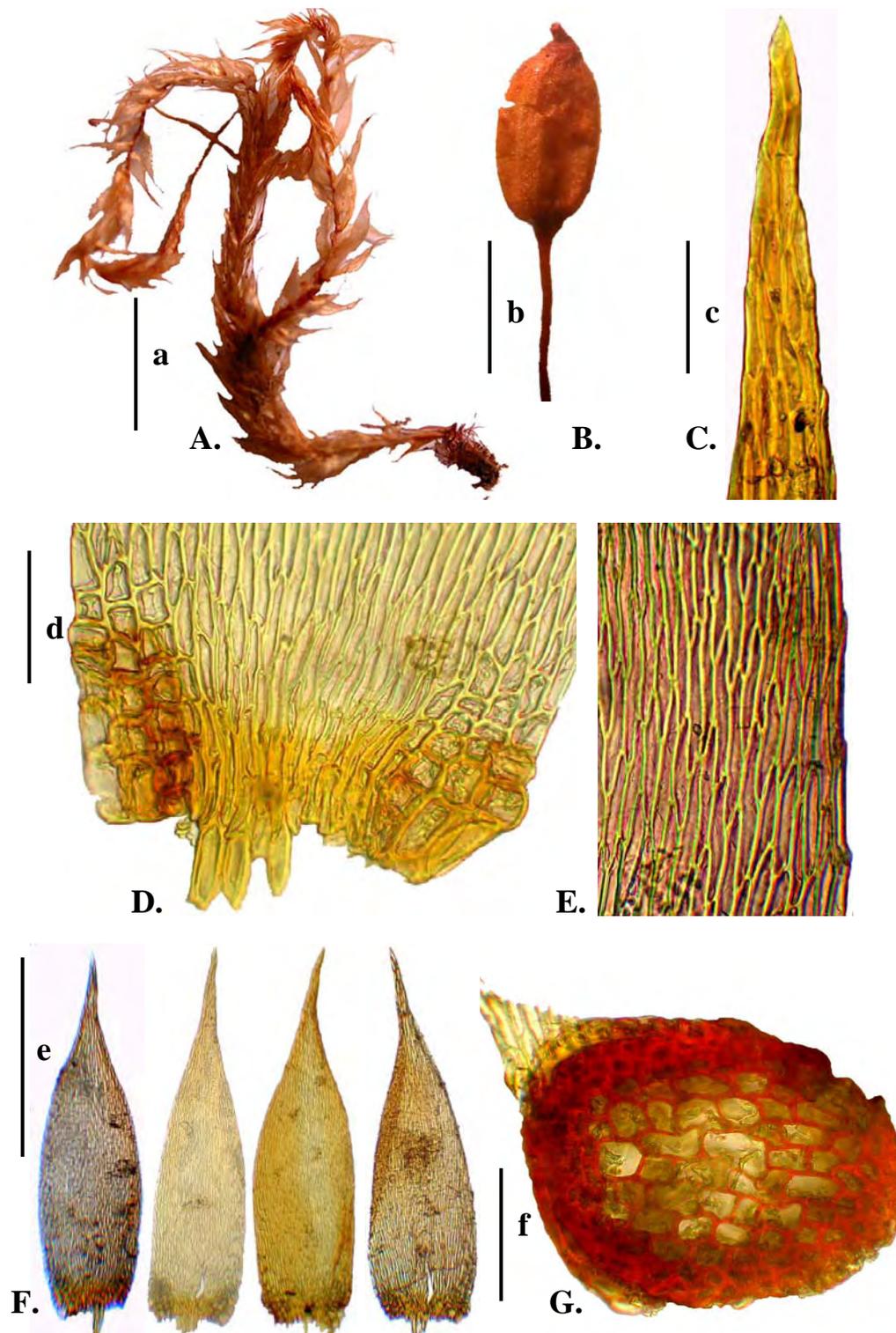


Figure 5.22 *Aptychella tenuiramea* (Mitt.) P. Tixier; photos based on *J.D.H.* 770, type, BM; A. habit, B. sporophyte, C. leaf apex, D. leaf base with heterophylloid organization, E. mid-leaf cells near margin, F. leaves, G. x-s stem; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 0.5 mm, D., E. = d = 100  $\mu$ m, F. = e = 0.5 mm, G. = f = 1 mm.

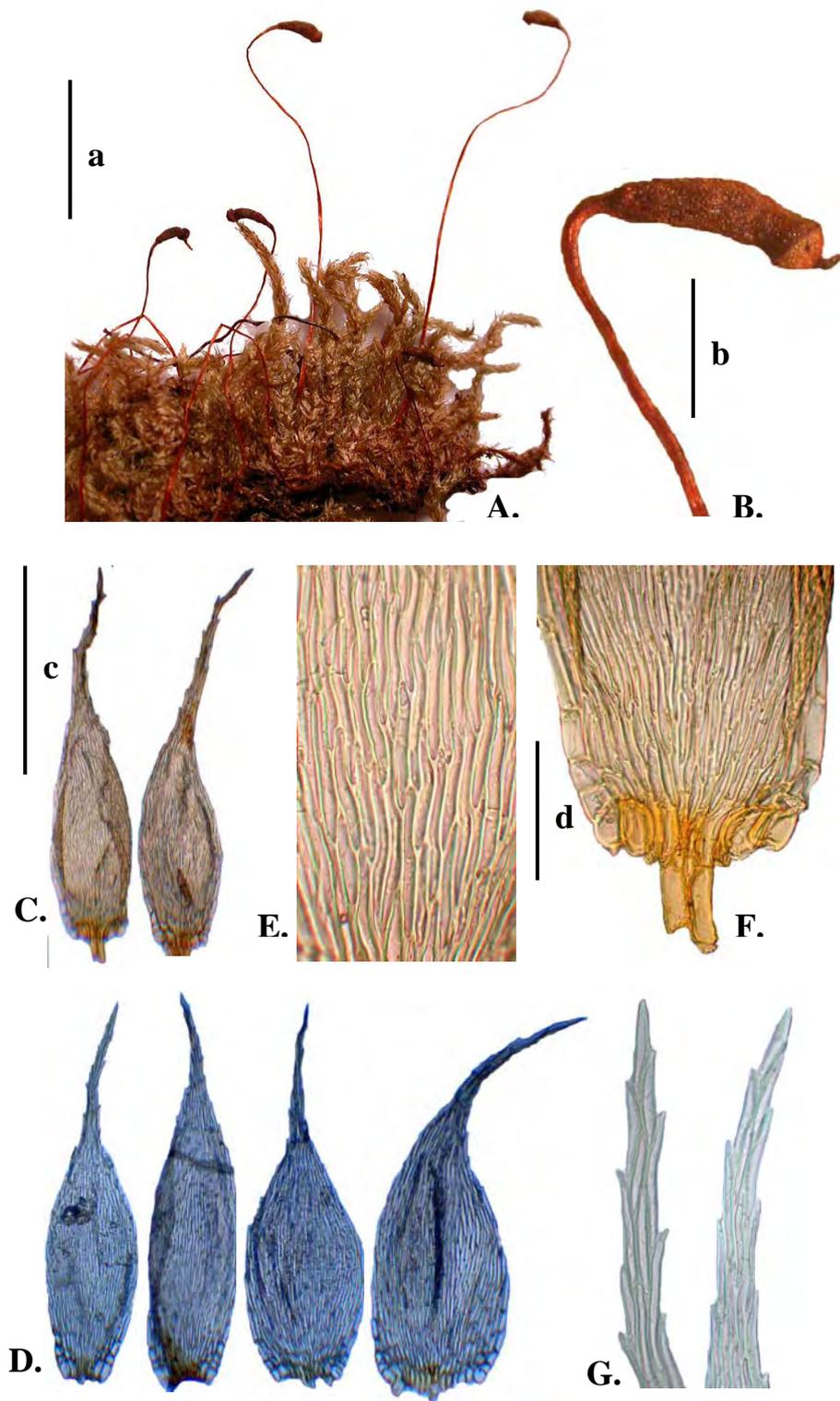


Figure 5.23 *Brotherella erythrocaulis* (Mitt.) M. Fleisch.; photos based on *Touw 10241*, AAU; A. habit, B. sporophyte, C. branch leaves, D. stem leaves, E. leaf cells, F. basal leaf with brotheroid alar organization, G. leaf apex; scale bars: A. = 5 mm, B. = b = 1 mm, C., D. = c = 1 mm, E., F., G. = d = 70  $\mu$ m.

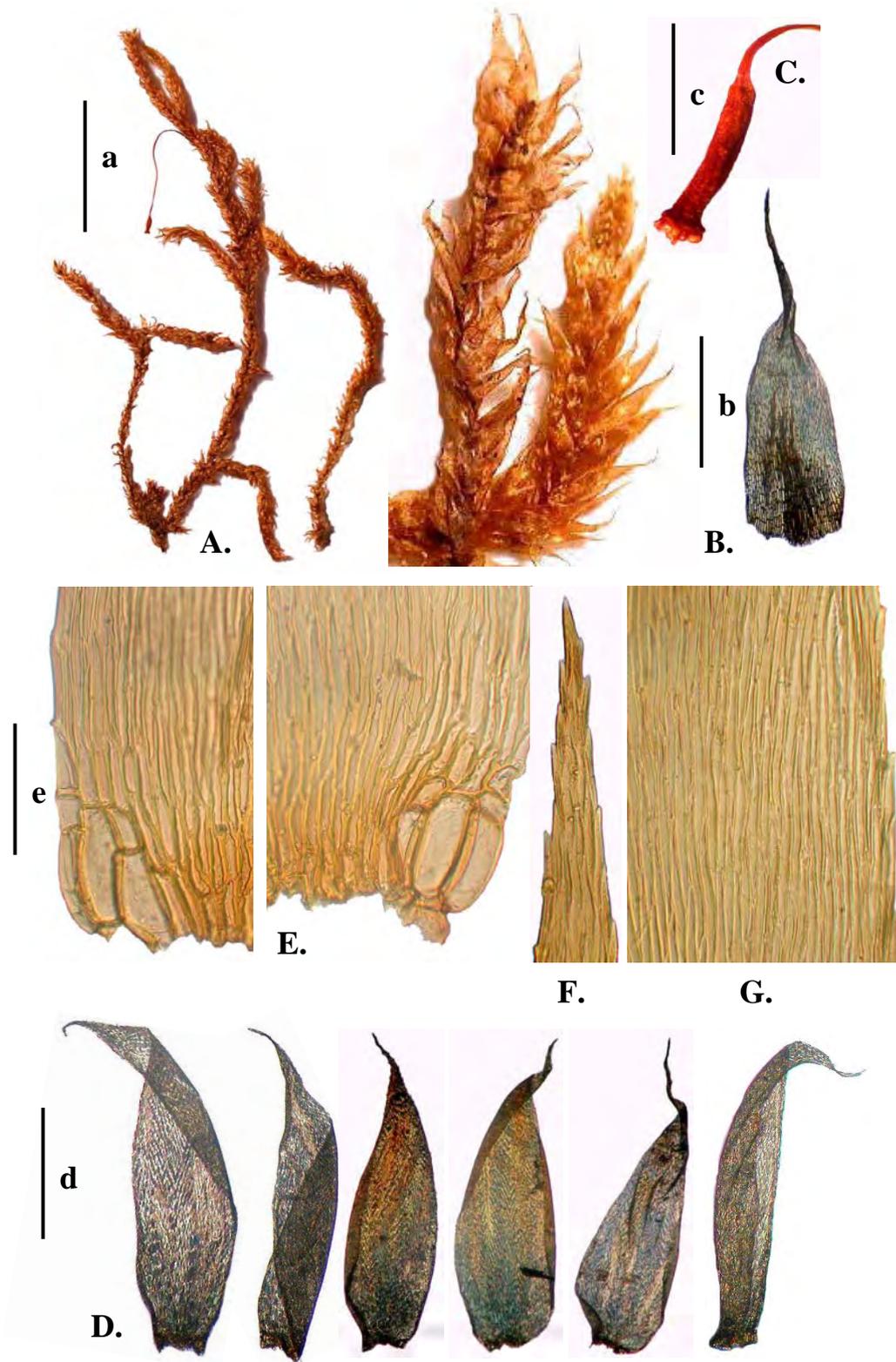


Figure 5.24 *Brotherella falcata* (Dozy & Molke.) M. Fleisch.; photos based on *Faurie s.n.*, 1903, type, FH) A. habit, B. perichaetia, C. sporophytes, D. leaves, E. leaf base with alar brotheroid organization, F. leaf apex, G. mid-leaf cells; scale bars: A. = a = 2 cm, B. = b = 1 mm, C. = c = 1 mm, D. = d = 0.5 mm, E., F., G. = e = 50 µm.

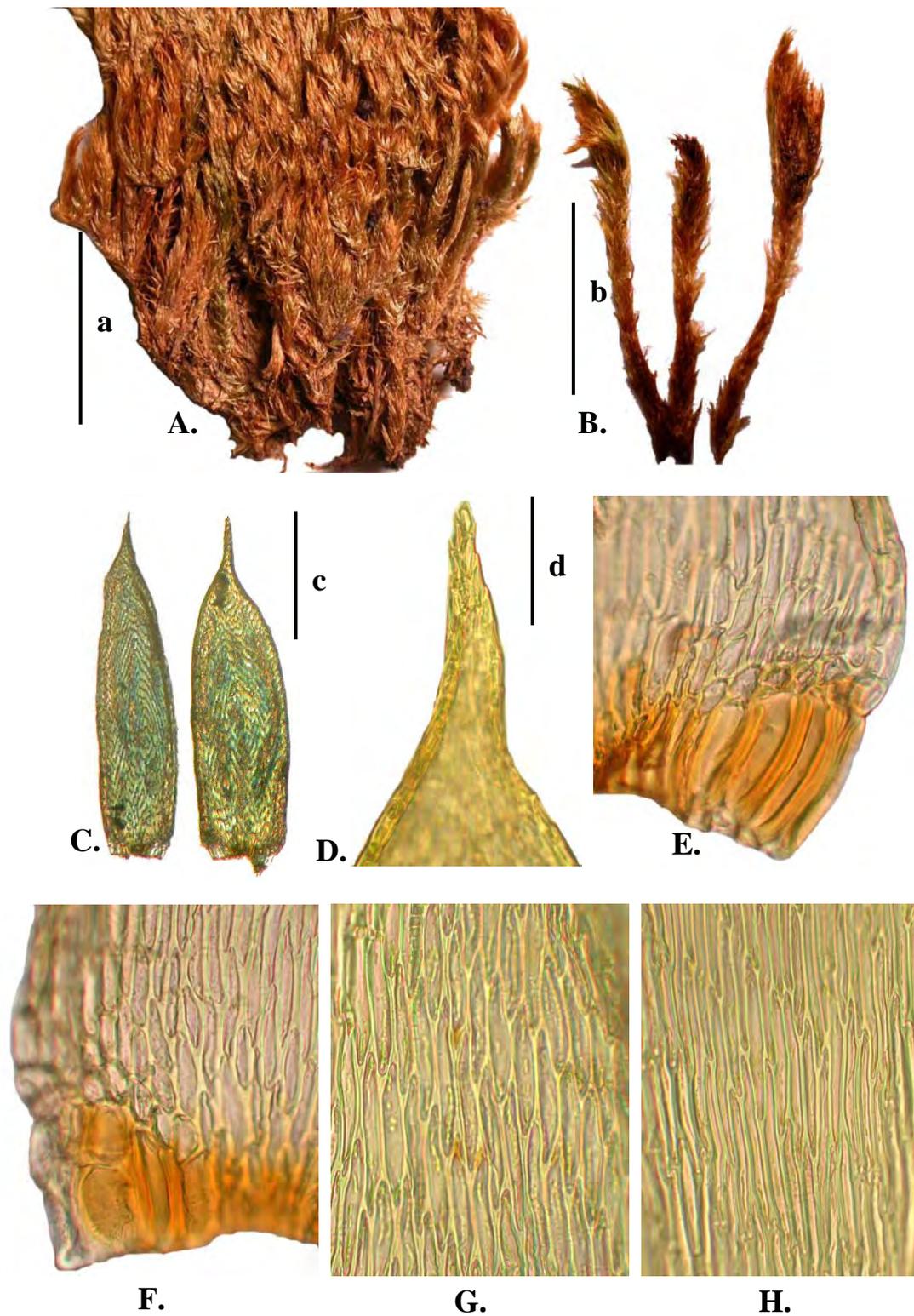


Figure 5.25 *Chionostomum baolocense* Tixier; photos base on *Sorensen et al.* 7240, AAU; A., B. habit, C. leaves, D. leaf apex, E., F. base leaf with acroporioid organization, G. mid-leaf cells, H. leaf cells at apical part; scale bars: A. = a = 1 cm, B. = b = 5 mm, C. = c = 0.5 mm, D. = d = 50  $\mu$ m.

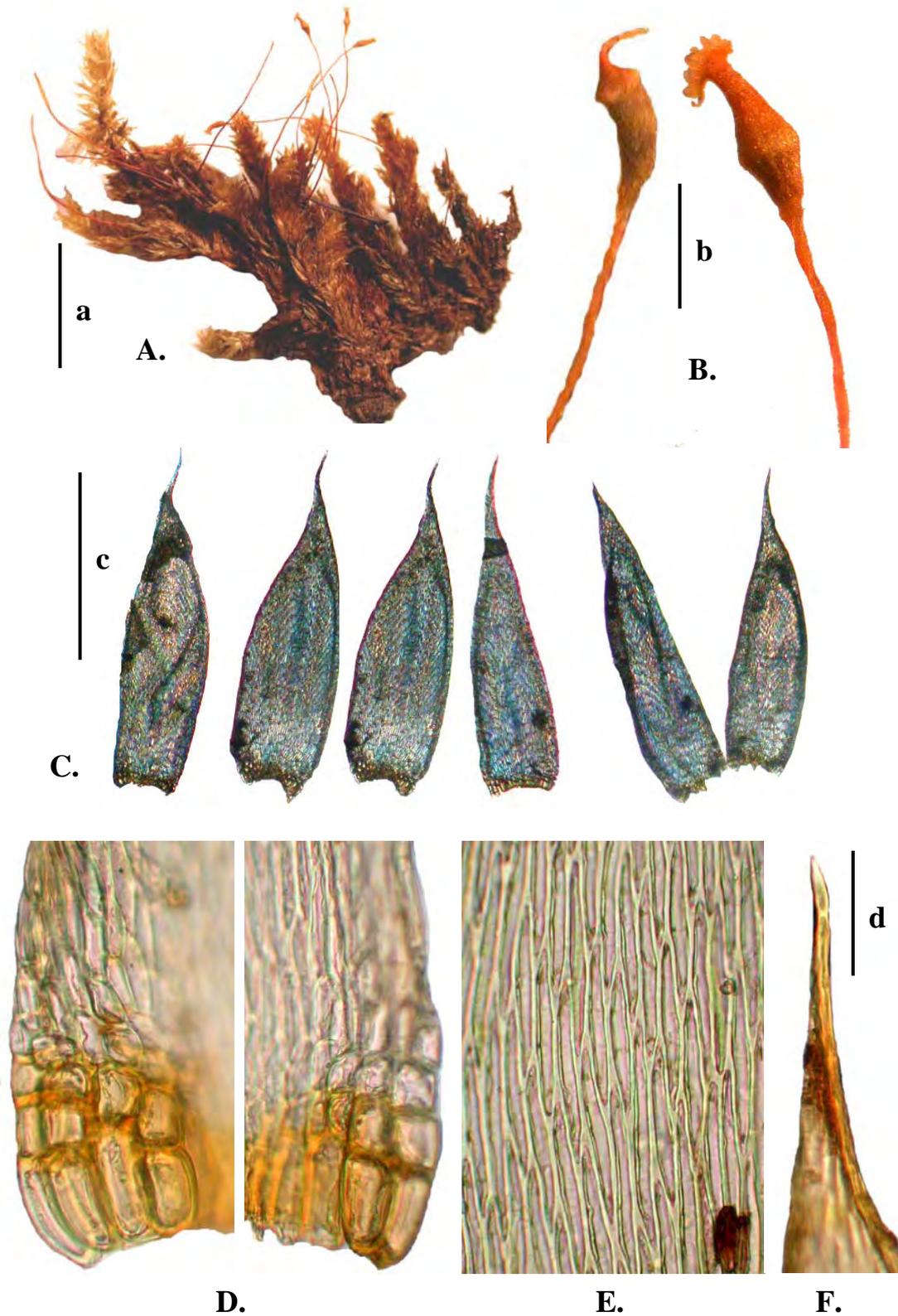


Figure 5.26 *Chionostomum pinicola* Tixier; photos base on LSW 2881, AAU; A. habit, B. sporophytes, C. leaves, D. base leaf with alar acroporioid organization, E. mid-leaf cells, F. leaf apex; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 1 mm, D., E., F. = d = 50  $\mu$ m.

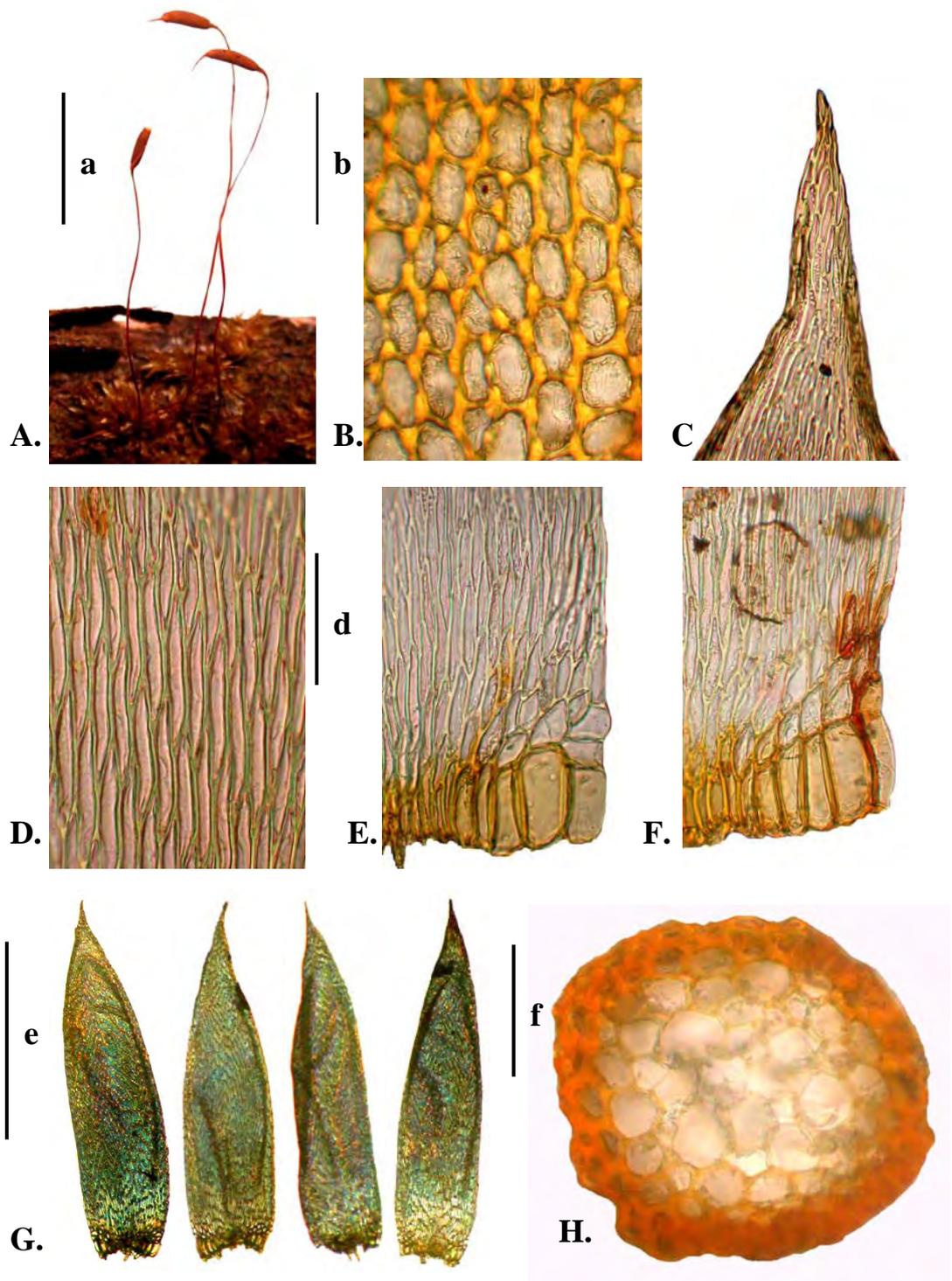


Figure 5.27 *Chionostomum rostratum* (Mitt.) C. Müll.; photos base on Tixier 429, BKF; A. plant with sporophytes, B. collenchymatous exothelial cells, C. leaf apex, D. leaf cells, E., F. base leaf with alar brotherelloid organization, G. leaves, H. x-s stem; scale bars: A. = a = 1 cm, B. = b = 80  $\mu$ m, C. = c = 0.5 mm, D., E., F. = d = 100  $\mu$ m, G. = e = 1 mm, H. = f = 0.5 mm.

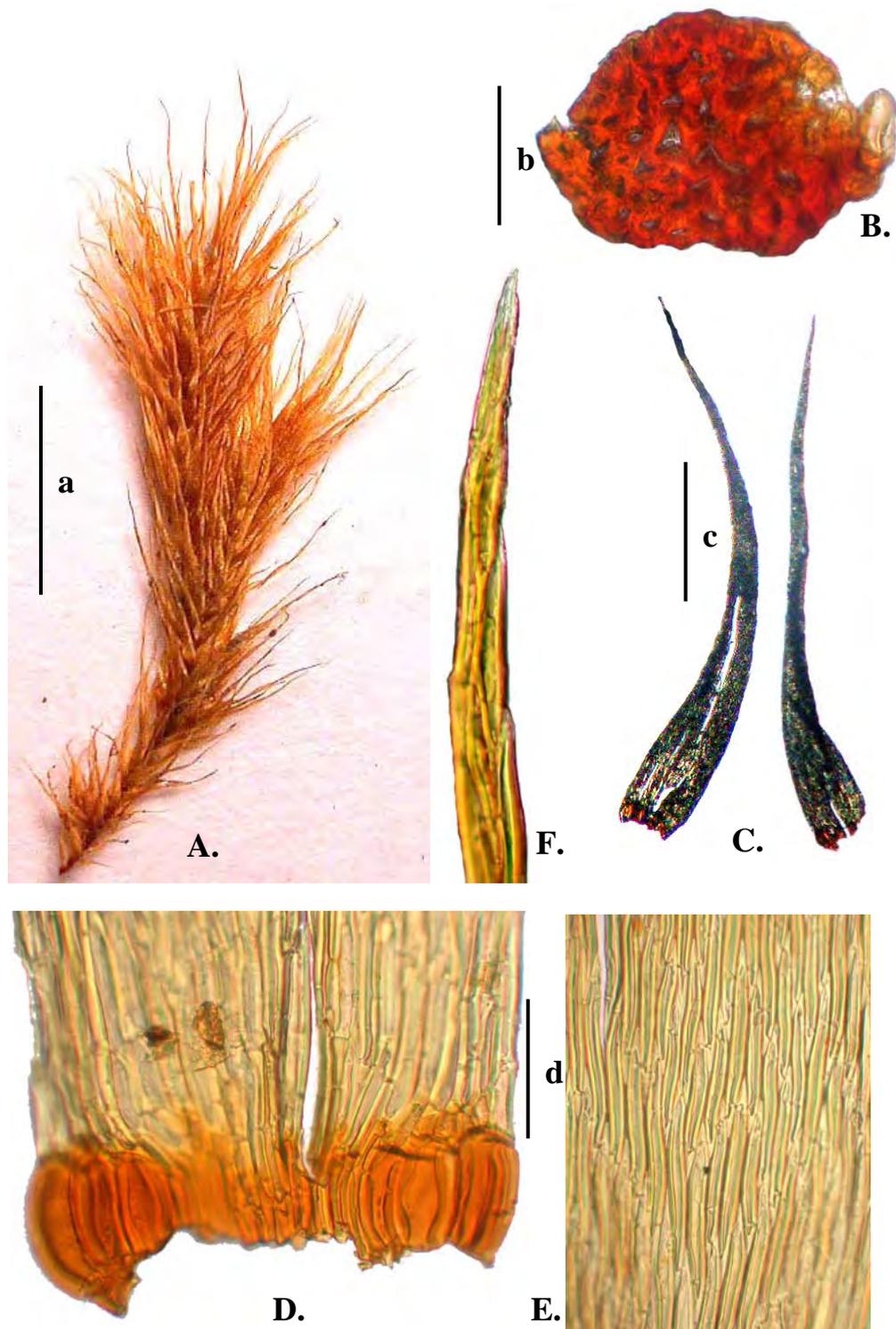


Figure 5.28 *Clastobryophilum bogoricum* (Bosch & Sande Lac.) M. Fleisch.; photos based on lectotype, H-BR 1032006; A. branch, B. x-s stem, C. leaves, D. base leaf with acroporioid organization, E. leaf cells, F. leaf apex; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 0.5 mm, C., E., F. = d = 50  $\mu$ m.

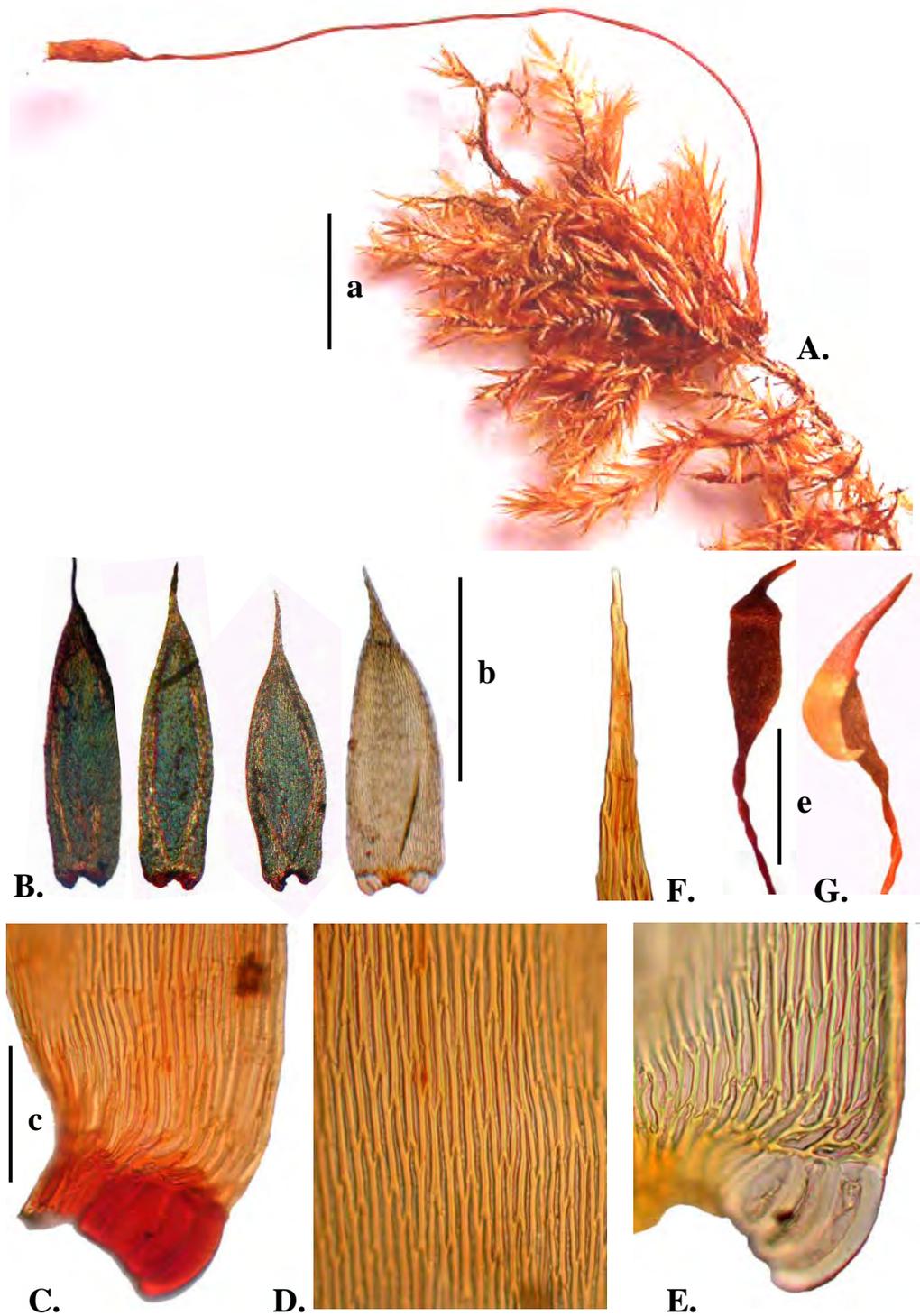


Figure 5.29 *Clastobryum caudatum* M. Fleisch.; photos based on *Fleischer 19/06/1898*, FH; A. habit, B. leaves, C. base of stem leaf with acroporioid alar organization, D. mis-leaf alar cells, E. base of branch leaf, F. leaf apex, G. sporophytes; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E., F. = c = 50  $\mu$ m, G. = e = 0.5 mm.

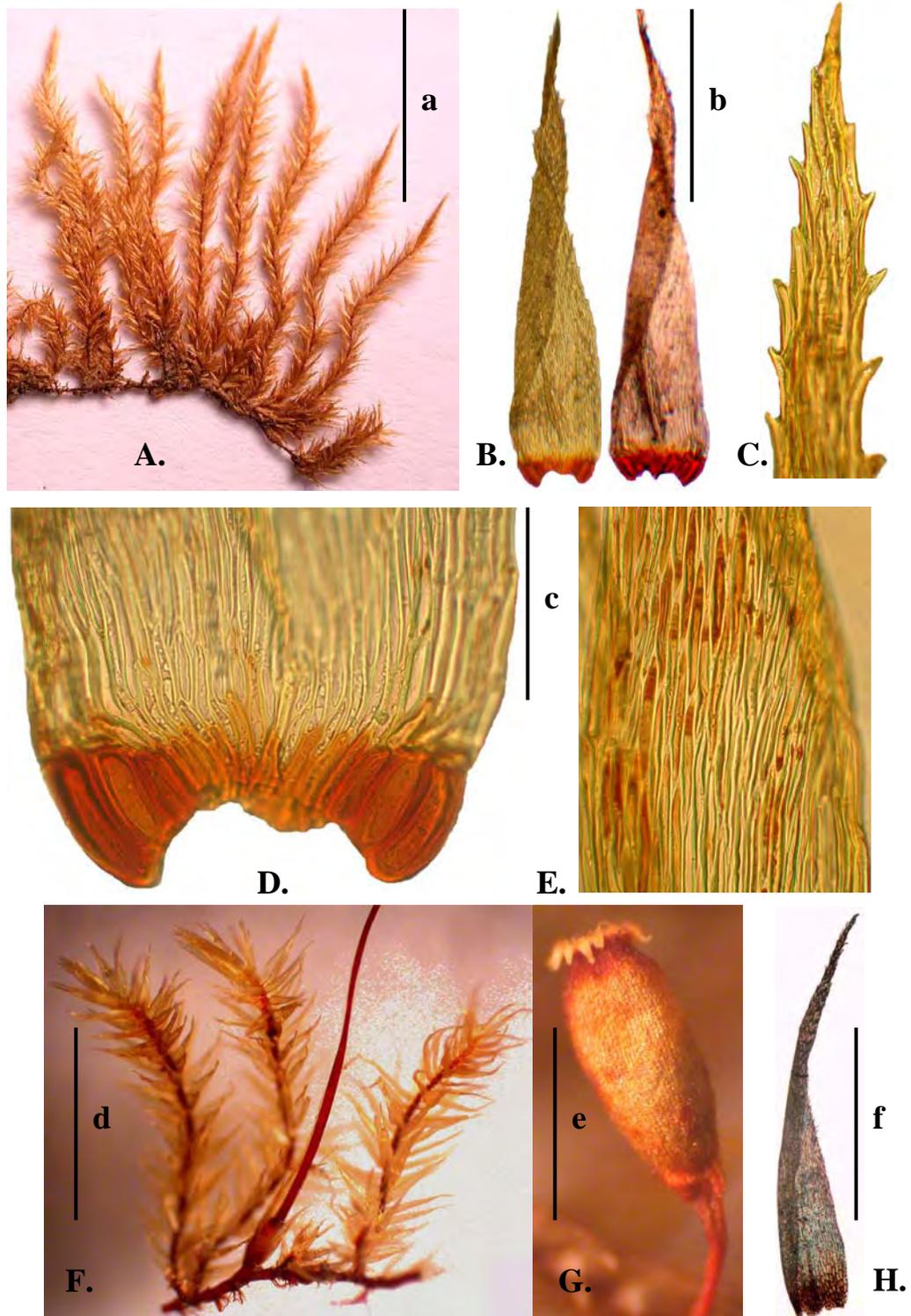


Figure 5.30 *Clastobryum cuculligerum* (Dozy & Molke.) P. Tixier; photos based on *Fleischer 18/06/1898*, type, FH; A. habit, B. leaves, C. leaf apex, D. base leaf with acroporioid organization, E. mid-leaf cells, F. lateral branches and sporophyte, G. sporangium, H. perichaetium leaf; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E. = c = 40  $\mu$ m, F. = d = 3 mm, G. = e = 0.5 mm, H. = f = 1 mm.

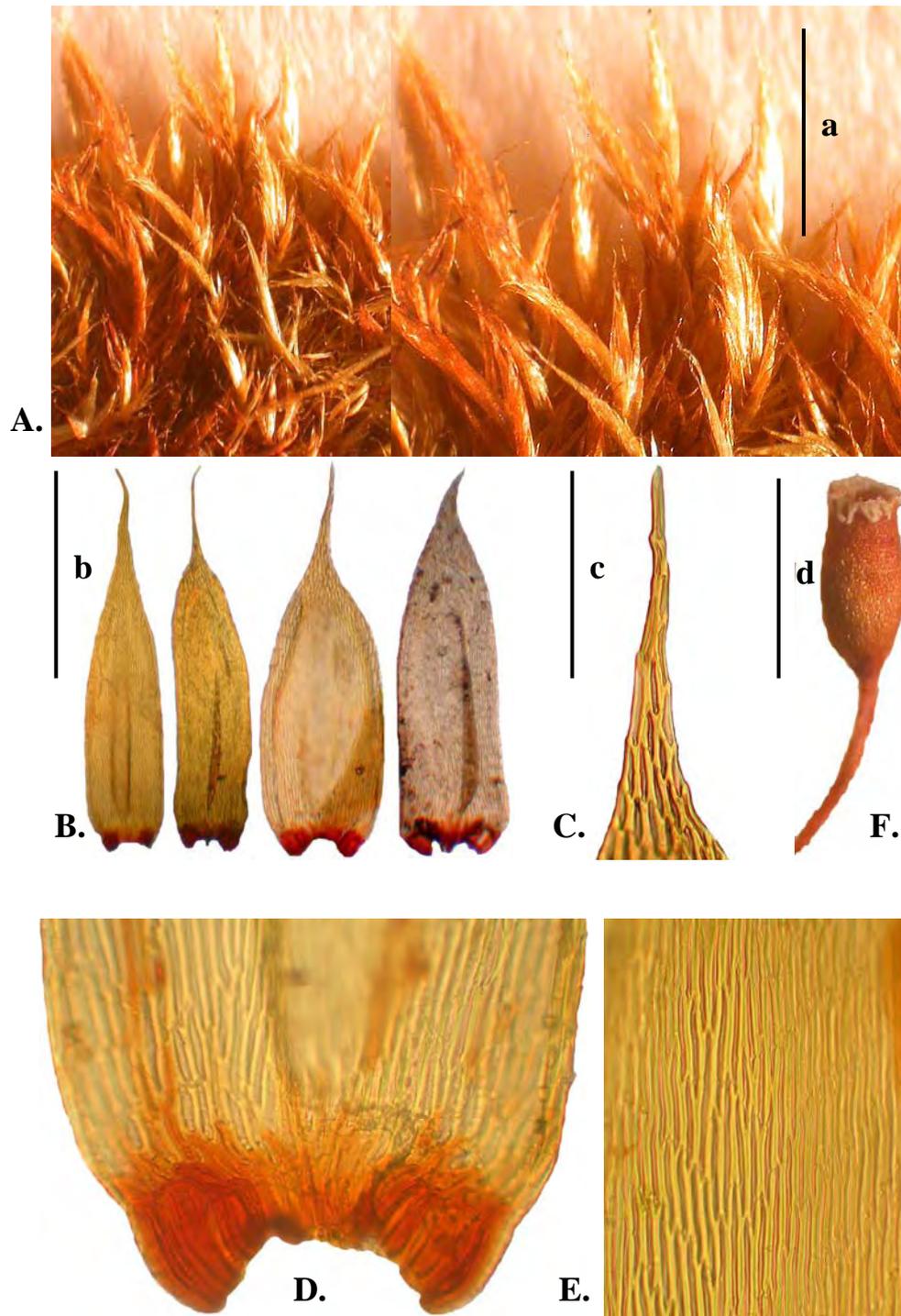


Figure 5.31 *Clastobryum indicum* (Dozy & Molk.) Dozy & Molk.; photos based on *Nyman 16/07/1898*, type, H-BR; A. habit, B. leaves, C. leaf apex, D. base leaf with acroporioid organization, E. mid-leaf cells, F. sporangium; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E. = c = 100  $\mu$ m, F. = d = 1 mm.

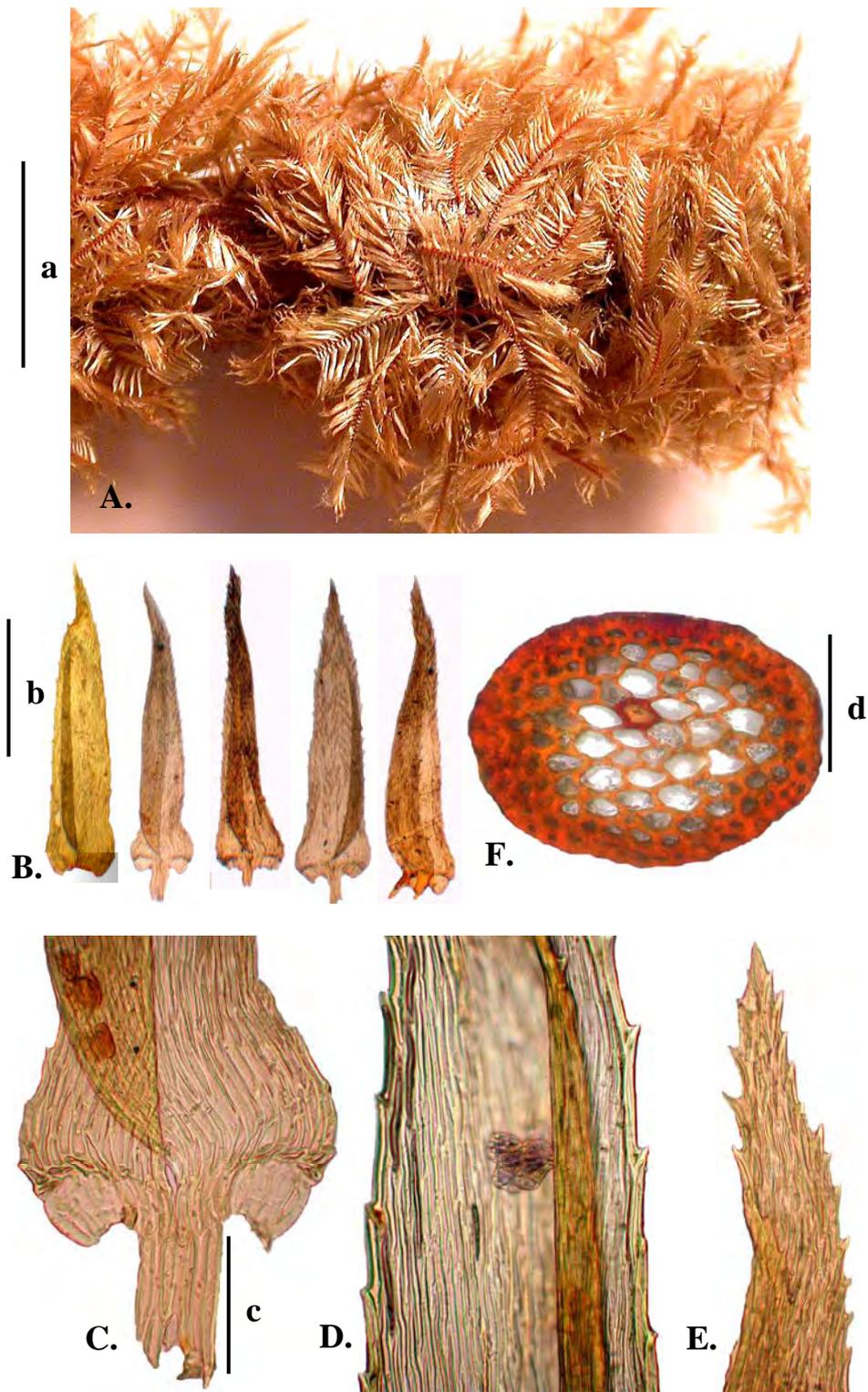


Figure 5.32 *Clastobryum spiculiferum* (Dixon) Tan & Iwats.; photos based on *Touw 11766*, NY; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf cells, E. leaf apex, F. x-s stem; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E. = c = 50  $\mu$ m, F. = d = 0.5 mm.

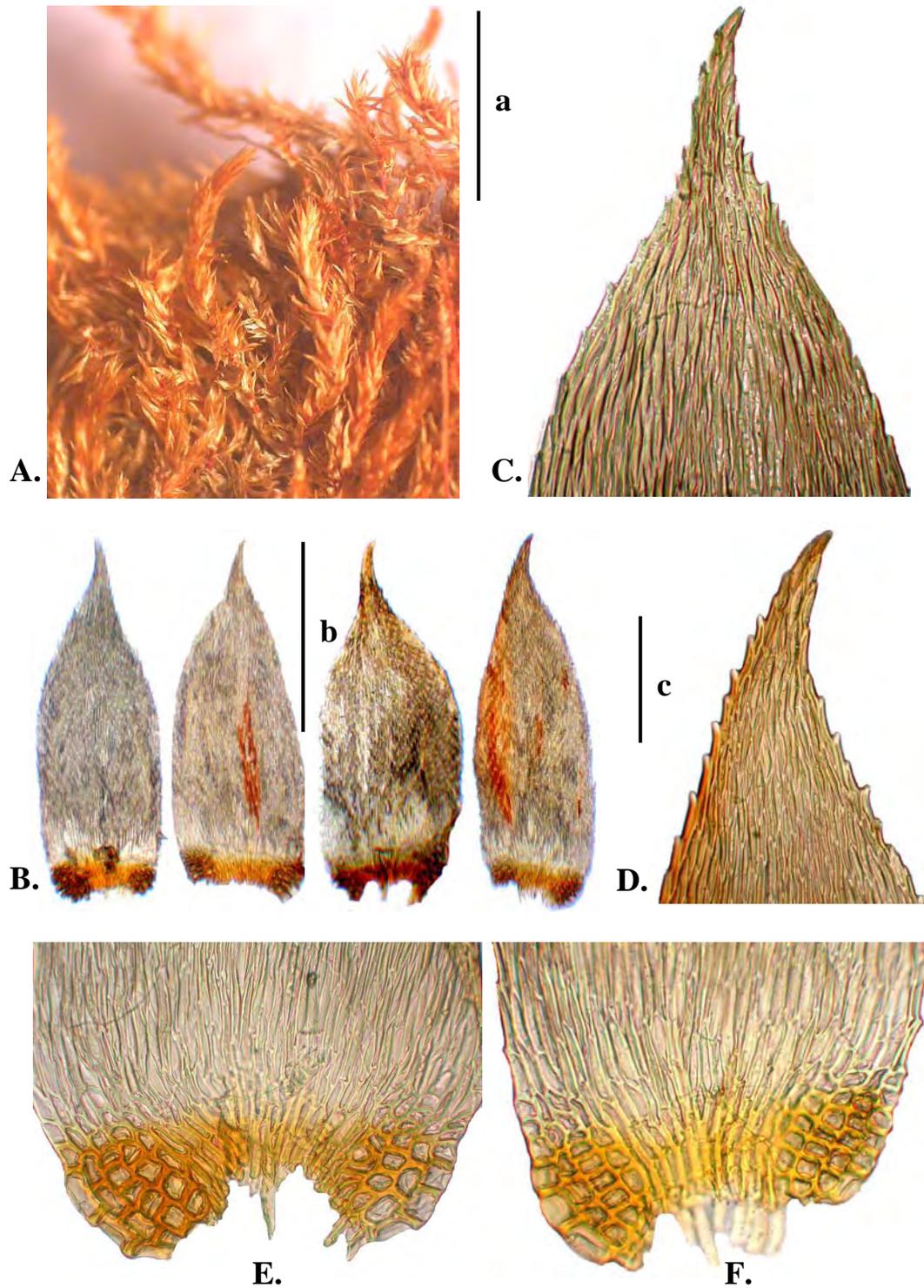


Figure 5.33 *Gammiella ceylonensis* (Broth.) Tan & Buck; photos based on *R.M. del Rosaio* 9/9/1976, Holotype; A. habit, B. leaves, C., D. apical leaf, E. base leaf symmetry with alar heterophylloid organization, F. base leaf asymmetry with alar heterophylloid organization; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E., F. = c = 40 μm.

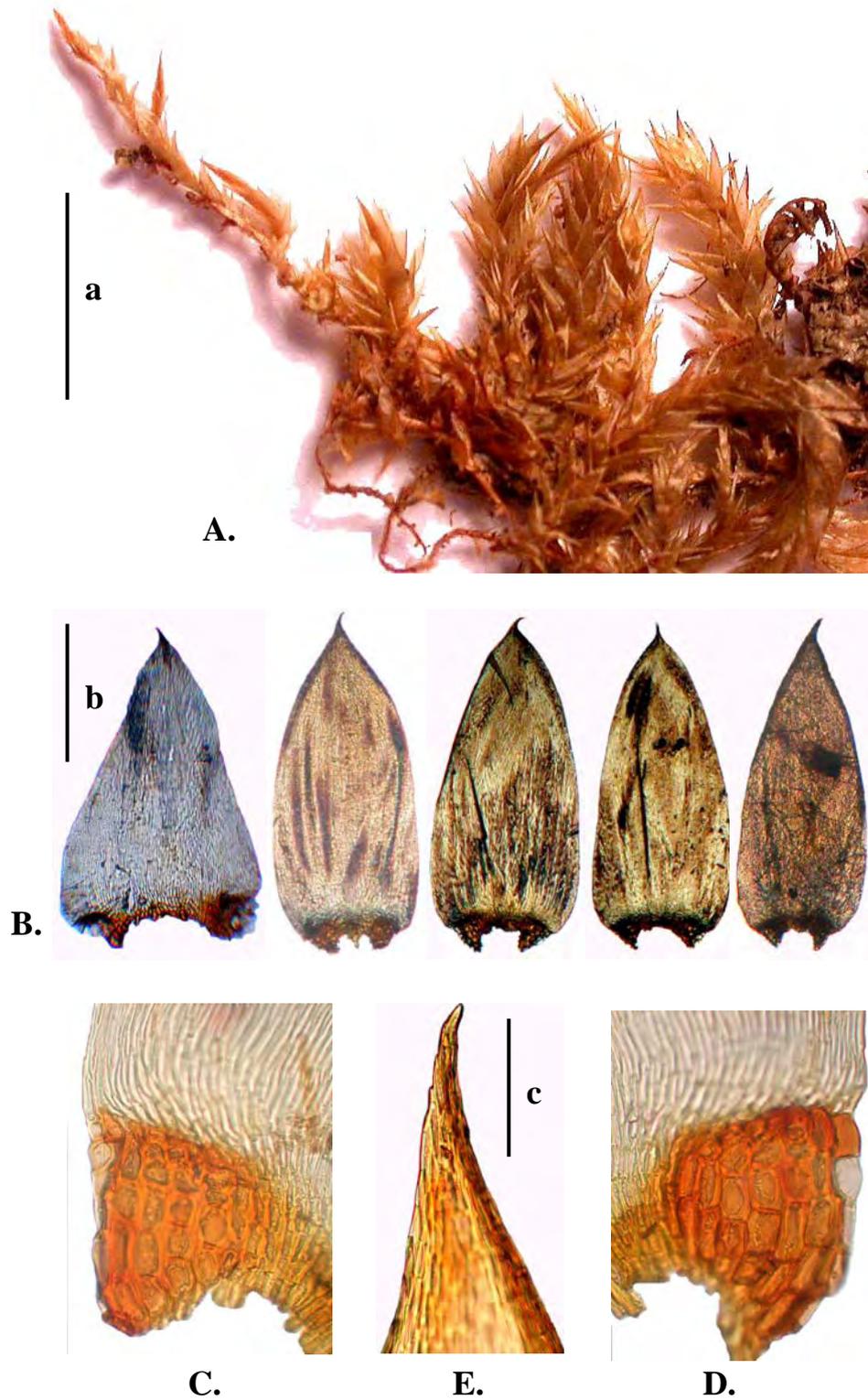


Figure 5.34 *Gammiella pterogonioides* (Griff.) Broth.; photos based on *Touw 10666*, BKF; A. habit, B. leaves, C., D. base leaf with alar heterophyllioid organization, E. leaf apex; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E. = c = 40  $\mu$ m.

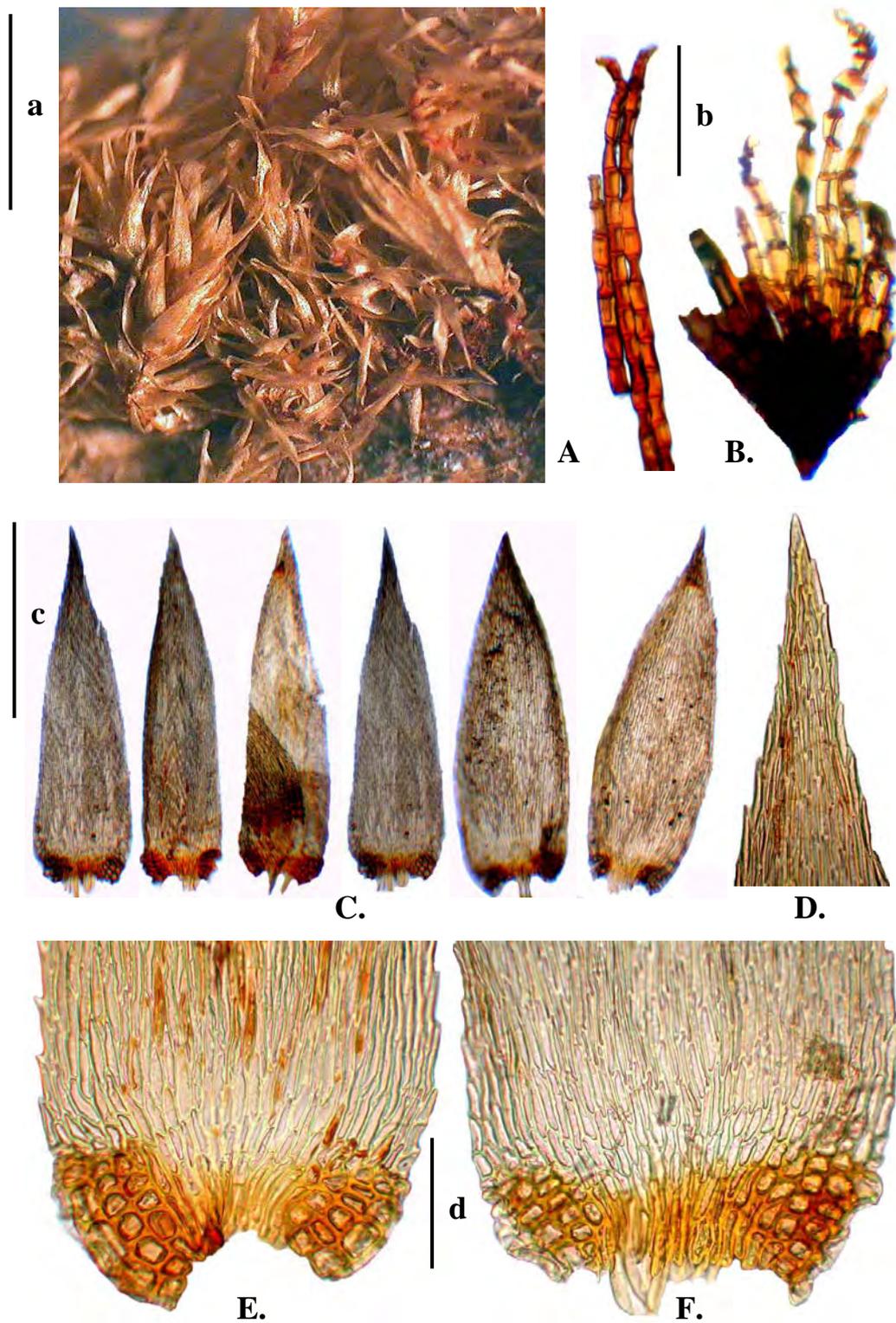


Figure 5.35 *Gammiella rugosa* P. Tixier; photos based on *Tixier 211*, type, P; A. habit, B. gemmae filaments, C. Leaves, D. leaf apex, E., F. asymmetry base leaf with alar heterophylloids organization; scale bars: A. = a = 1 cm, B. = b = 0.1 mm, C. = c = 0.5 mm, D., E., F. = d = 40  $\mu$ m.

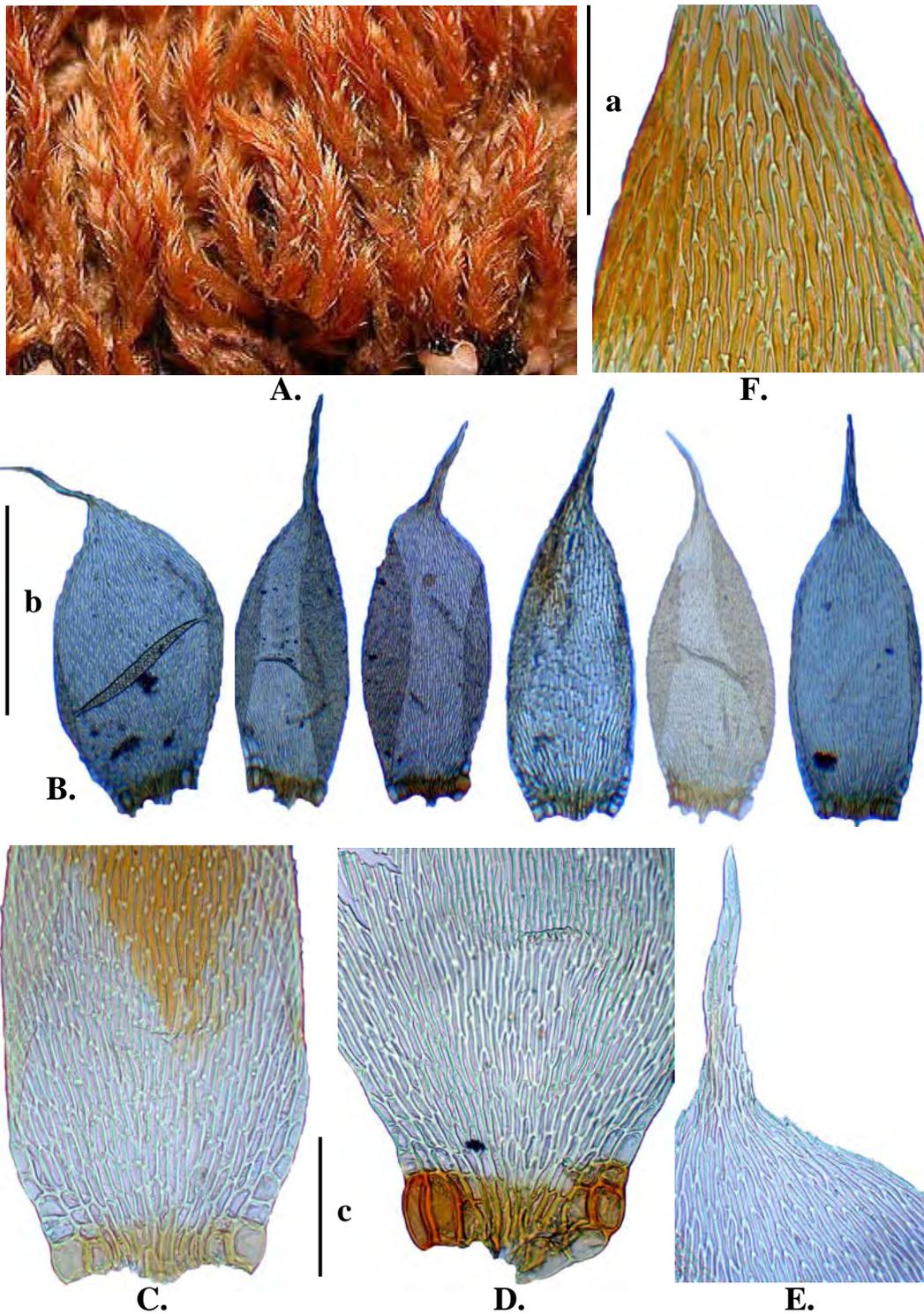


Figure 5.36 *Hageniella assamica* Dixon; photos based on *Touw 10075*, BM; A. habit, B. leaves, C., D. base leaf with alar acroporoid organization, E. leaf apex, F. leaf cells tip forming papilla in the upper half of leaf; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E., F. = c = 40  $\mu$ m.

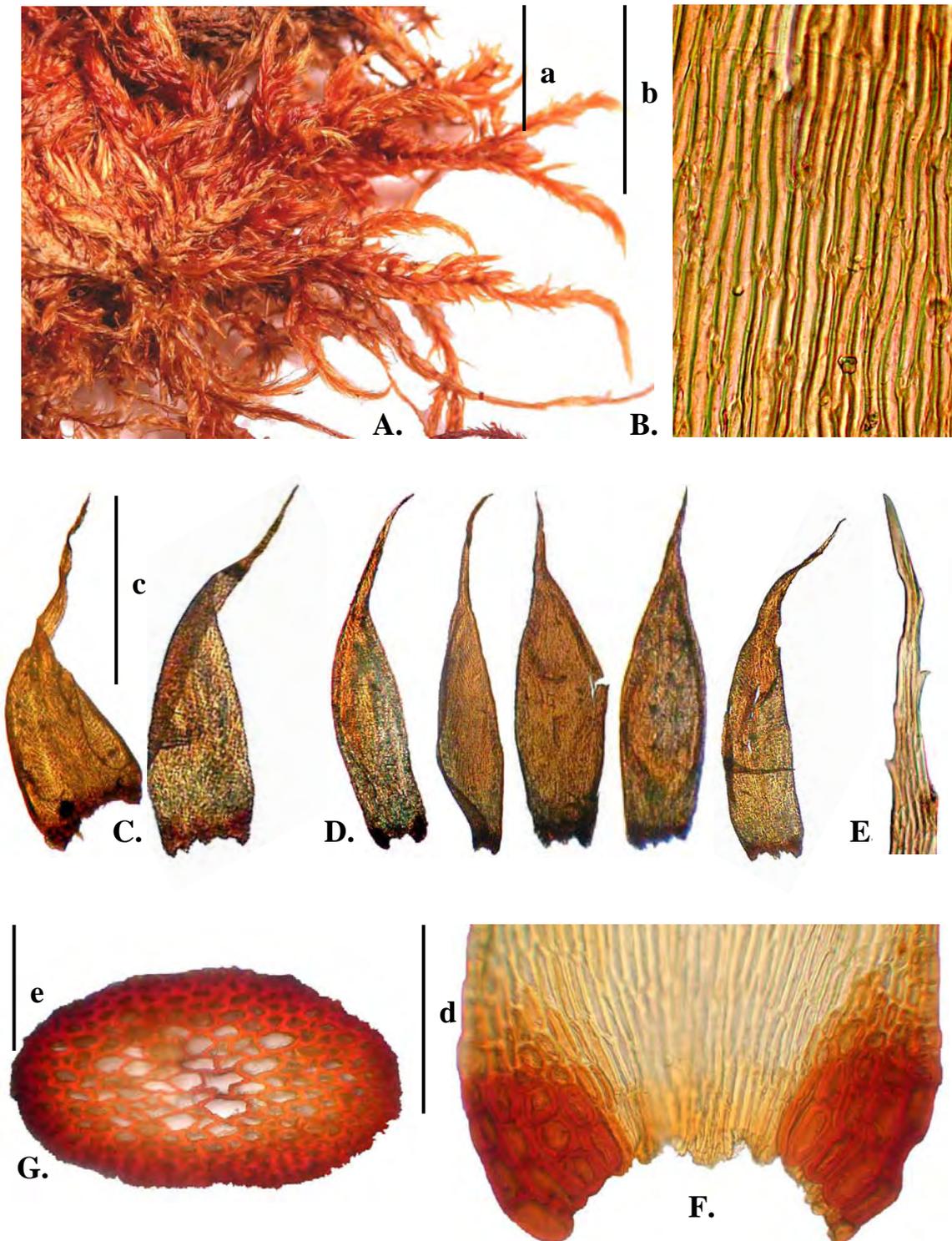


Figure 5.37 *Heterophyllum amblystegum* (Mitt.) Y. Jia, S. He & Crosby; photos based on *Hooker 973*, isotype, FH; A. habit, B. leaf cells, C. stem leaves, D. branch leaves, E. leaf apex, F. base leaf with alar heterophyllioid organization, G. x-s stem; scale bars: A. = a = 1 cm, B. = b = 40  $\mu$ m, C., D. = c = 1 mm, E., F. = d = 80  $\mu$ m, G. = e = 50  $\mu$ m.

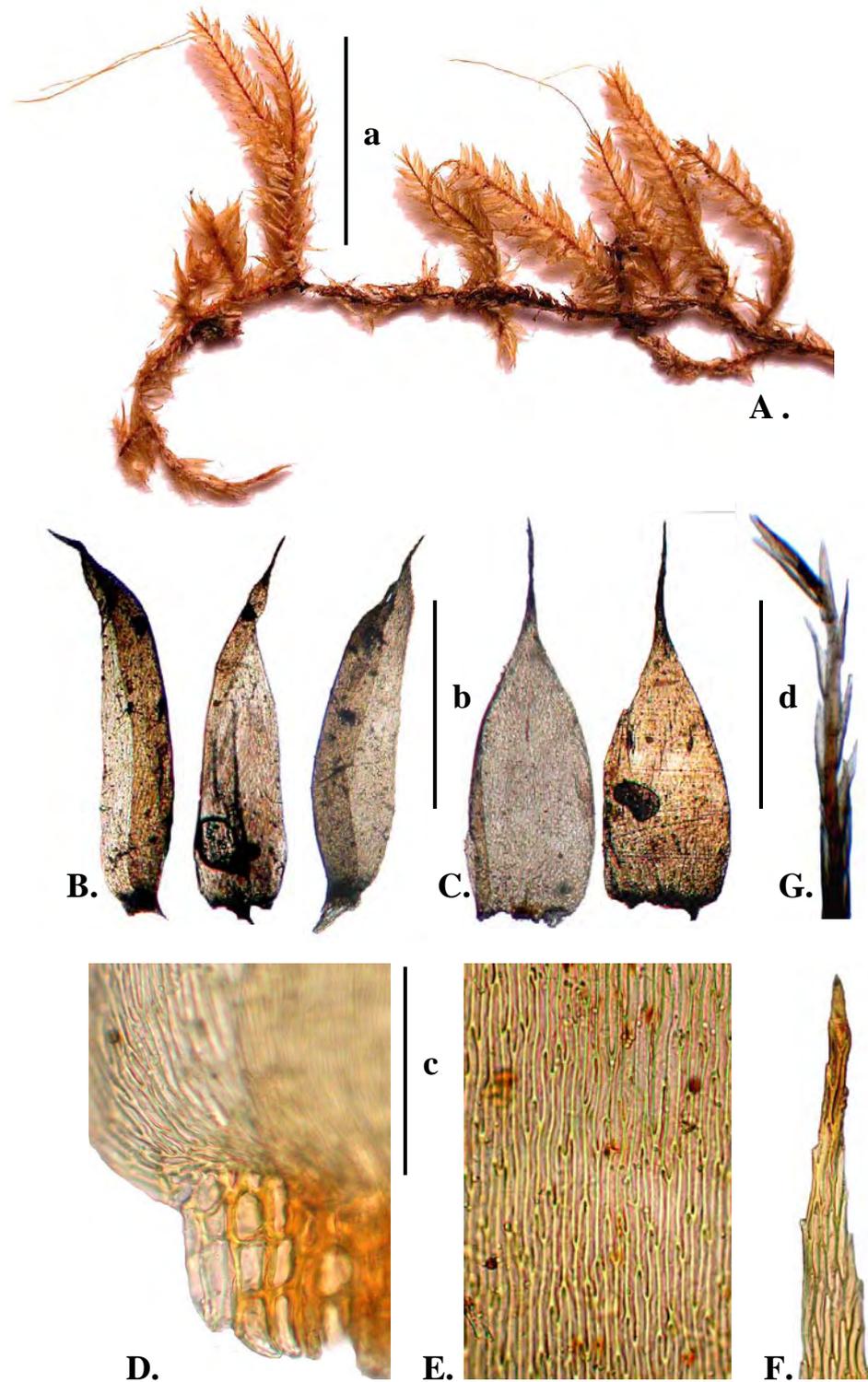


Figure 5.38 *Isocladiella surcularis* (Dixon) Tan & Mohamed; photos based on *Thwaites* 243, type, BM; A. habit, B. branch leaves, C. stem leaves, D. base leaf with alar heterophylloid organization, E. mid-leaf cells, F. leaf apex; scale bars: A. = a = 1 cm, B., C. = b = 0.5 mm, D., E., F. = c = 50  $\mu$ m, G. = d = 1 mm.

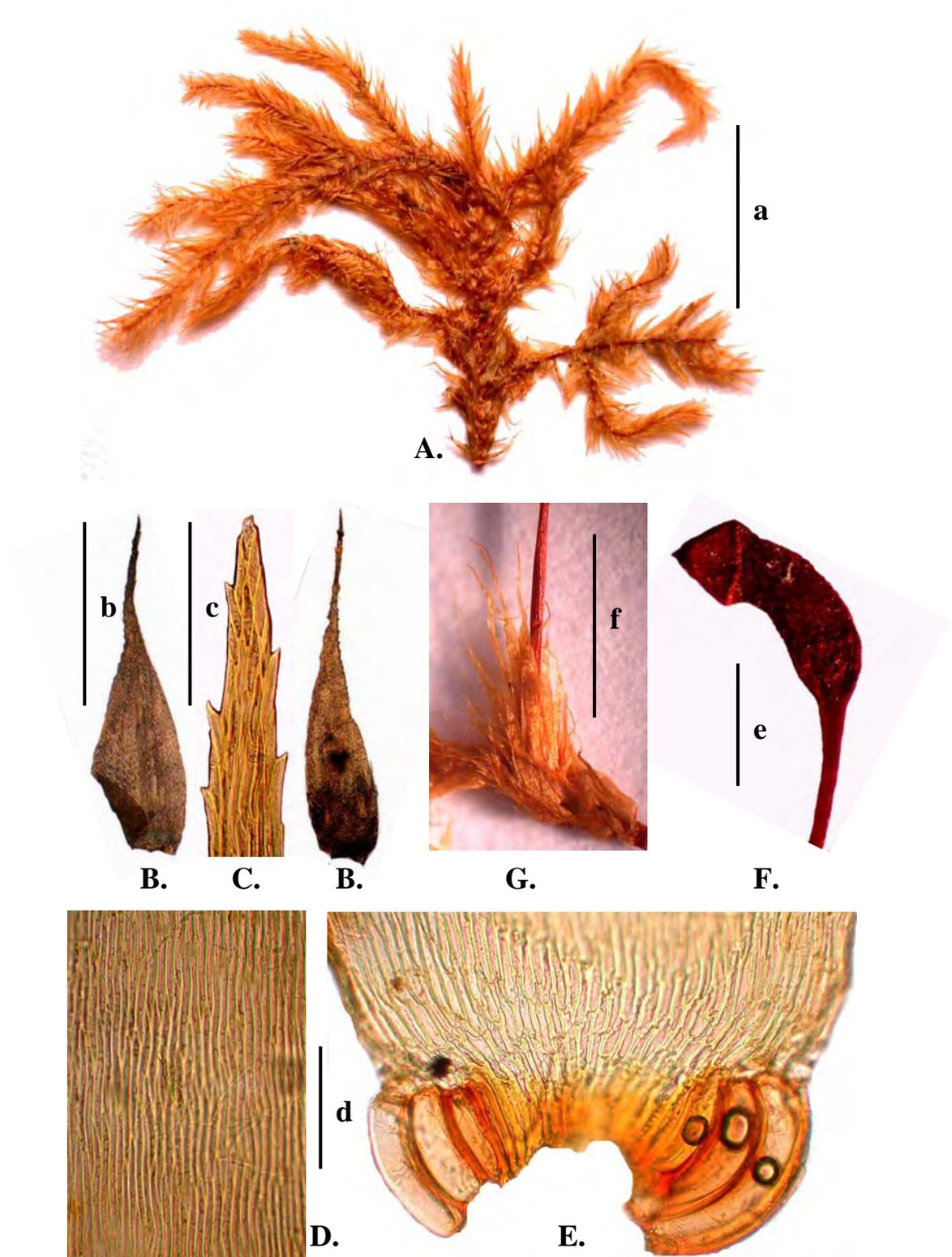


Figure 5.39 *Mastopoma robinsonii* (Broth.) E. B. Bartram; photos based on *Robinson 6566*, type, FH; A. habit, B. leaves, C. leaf apex, D. leaf cells, E. base leaf with acroporioid alar organization, F. sporangium, G., perichaetia; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 0.1 mm, D., E. = d = 50  $\mu$ m, F. = e = 2 mm, G. = f = 4 mm.

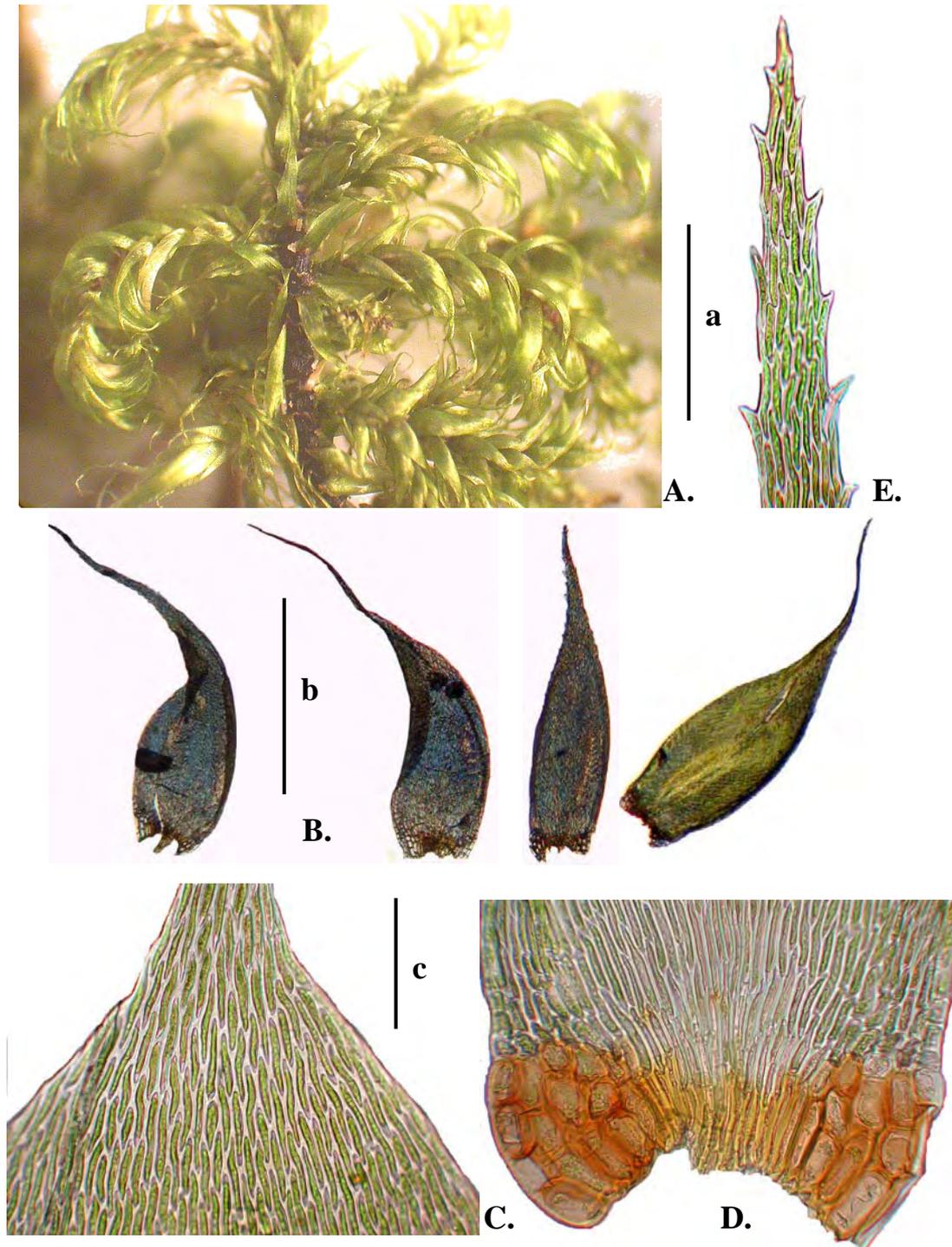


Figure 5.40 *Mastopoma subfiliferum* Horikawa & Ando; photos based on *Hiro 67764*, isotype, L; A. habit, B. leaves, C. Leaf cells, D. Base cells with alar heterophylloid organization, E. leaf apex; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E. = c = 50  $\mu$ m.

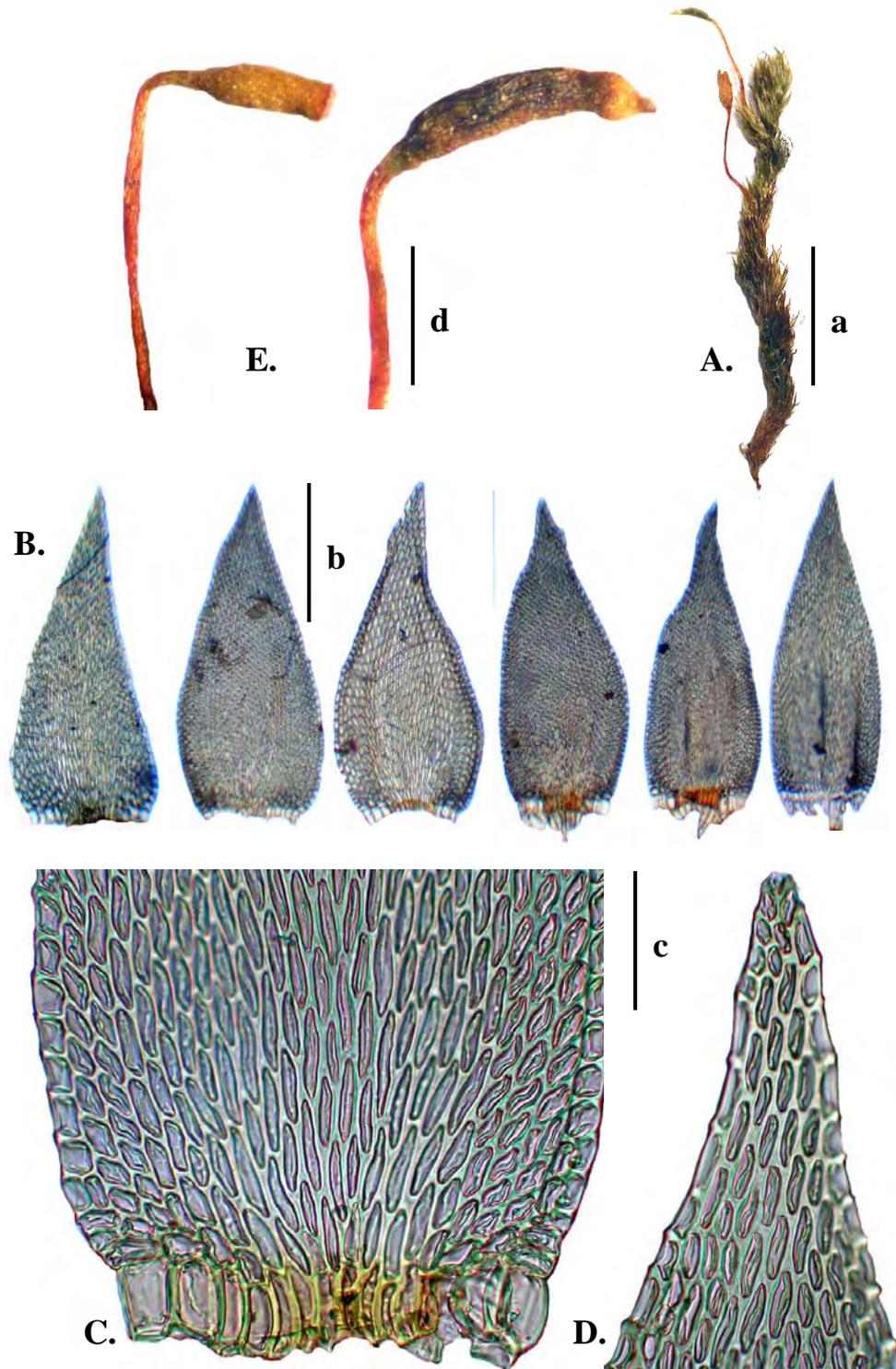


Figure 5.41 *Meiothecium jagorii* (Müll. Hal.) Broth.; photos based on type, HF 60372; A. habit, B. Leaves, C. base leaf with alar acroporioid organization, D. leaf apex; E. sporophytes; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D. = c = 50  $\mu$ m, E. = d = 1 mm.

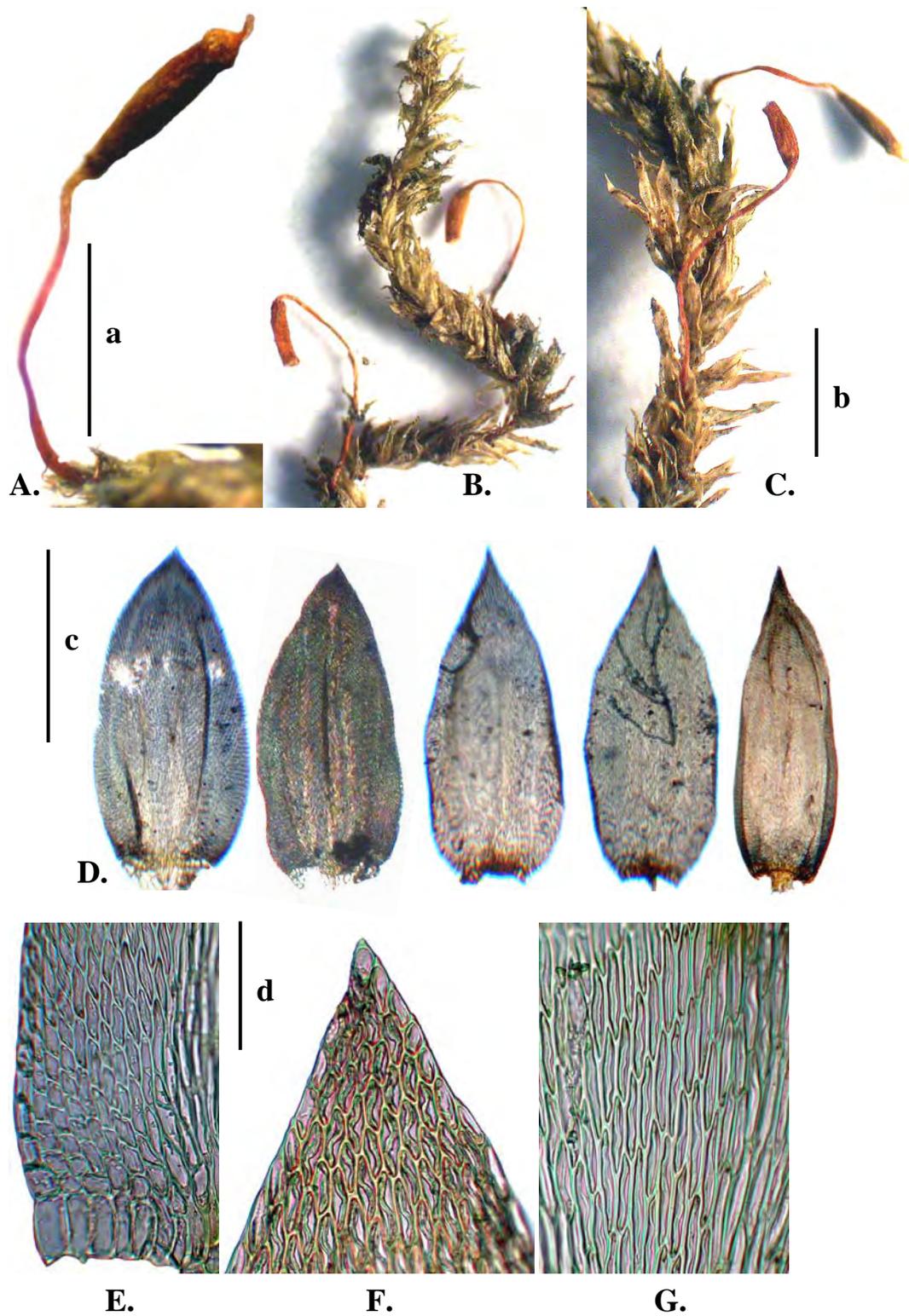


Figure 5.42 *Meiothecium microcarpum* (Hook.f.) Mitt.; photos based on type, FH60374; A. sporophyte, B., C. Habit, D. Leaves, E. Base leaf with alar acroploid organization, F. leaf apex, G. leaf cells; scale bars: A. = a = 1.5 mm, B., C. = b = 2 mm, D. = c = 1 mm, E., F., G. = d = 50  $\mu$ m.

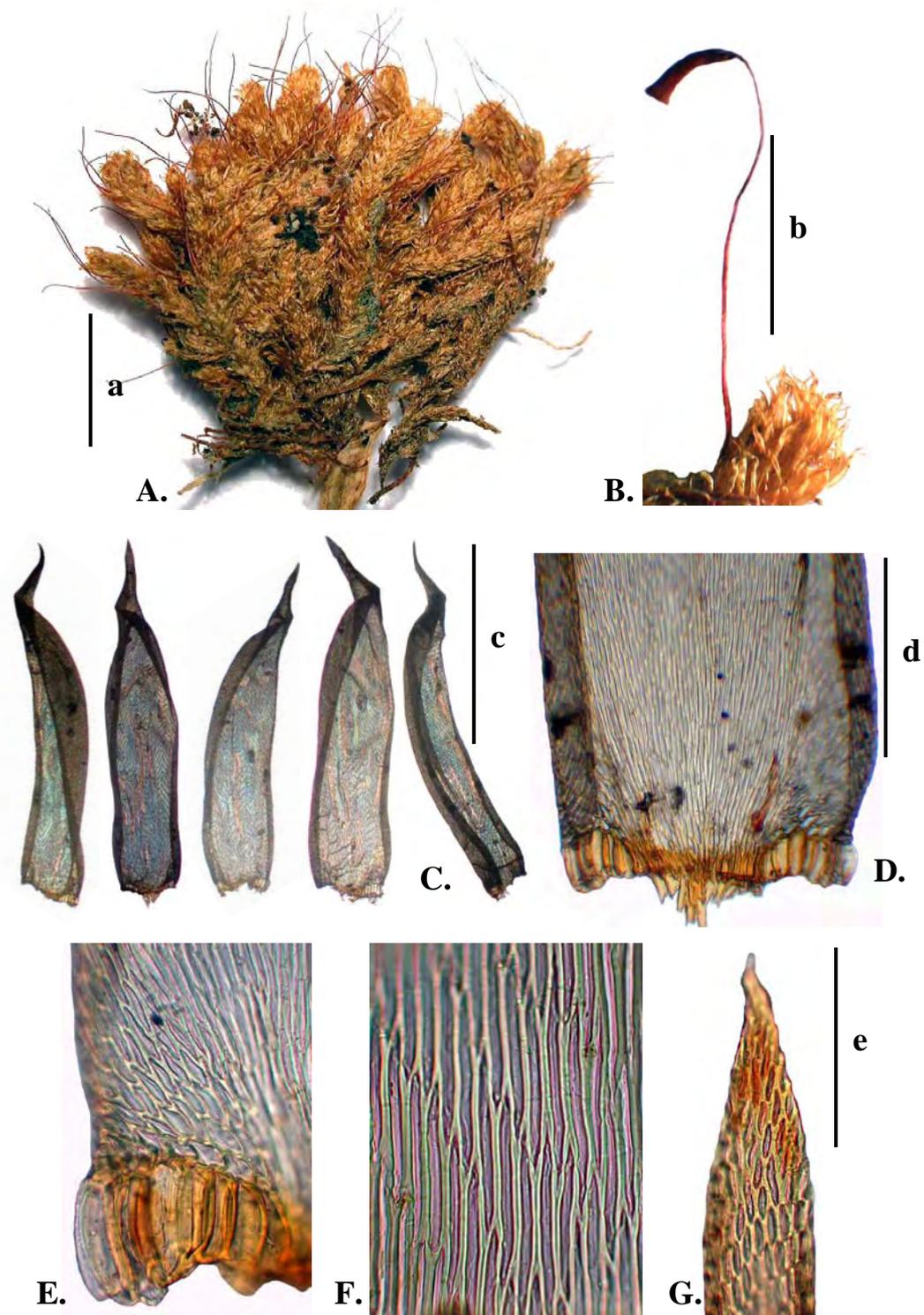


Figure 5.43 *Meiothecium turgidellum* M. Fleisch.; photos based on *Fleischer s.n. 1898*, type, FH; A. habit, B. sporophyte, C. leaves, D. lower part of leaf, E. base leaf with alar organization, F. mid-leaf cells, G. leaf apex; scale bars: A. = a = 1 cm, B. = b = 3 mm, C. = c = 1 mm, D. = d = 0.2 mm, E., F., G. = e = 50  $\mu$ m.

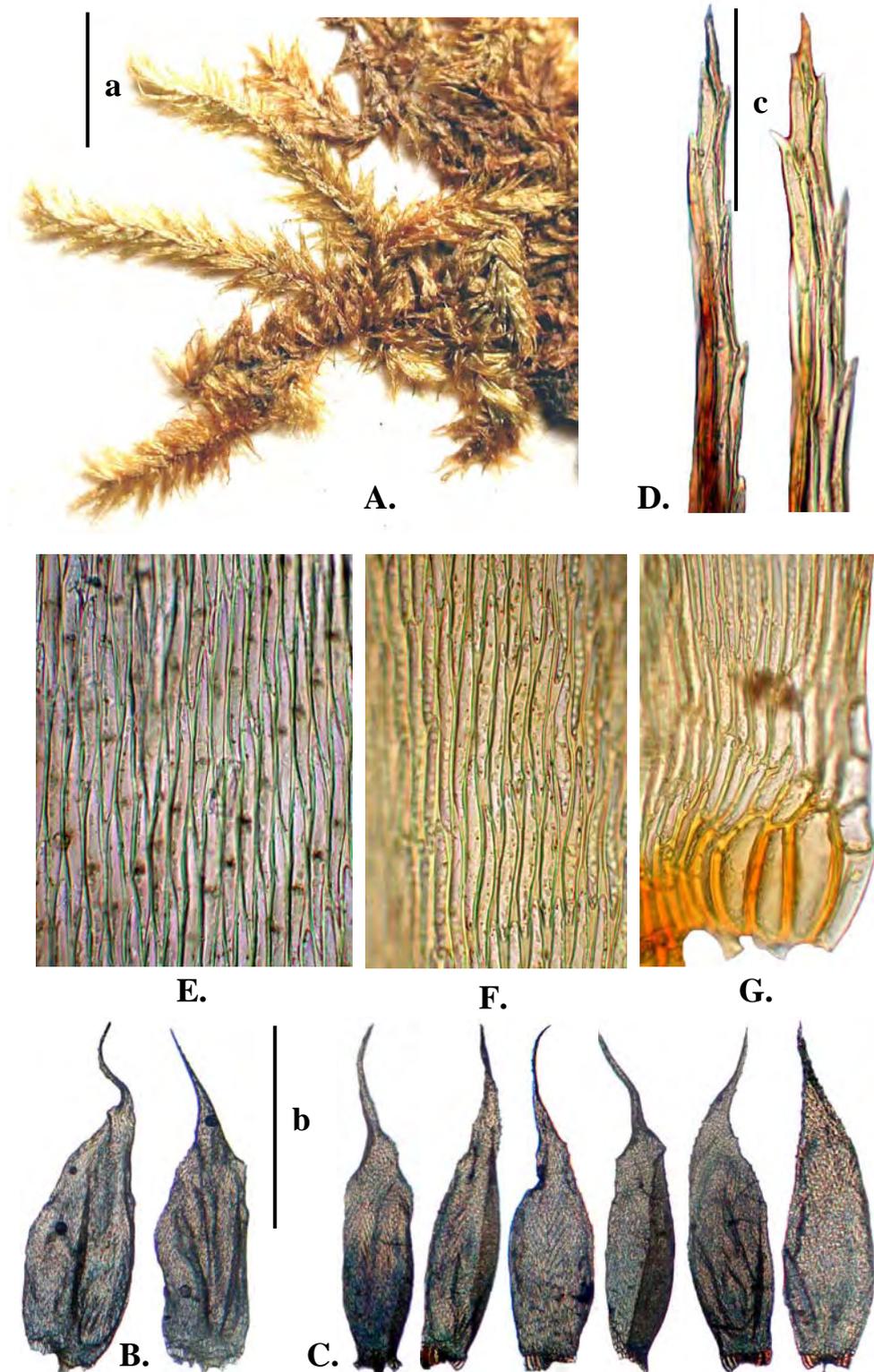


Figure 5.44 *Papillidiopsis luxurians* (Dozy & Molke.) Buck & Tan; photos based on *Kerr 318*, BM; A. habit, B. stem leaves, C. branch leaves, D. leaf apex, E. leaf cells near apex with unipapillose, F. mid-leaf cells, G. base leaf with alar acroporioid organization; scale bars: A. = a = 1 cm, B., C. = b = 1 mm, D., E., F., G. = c = 100  $\mu$ m.

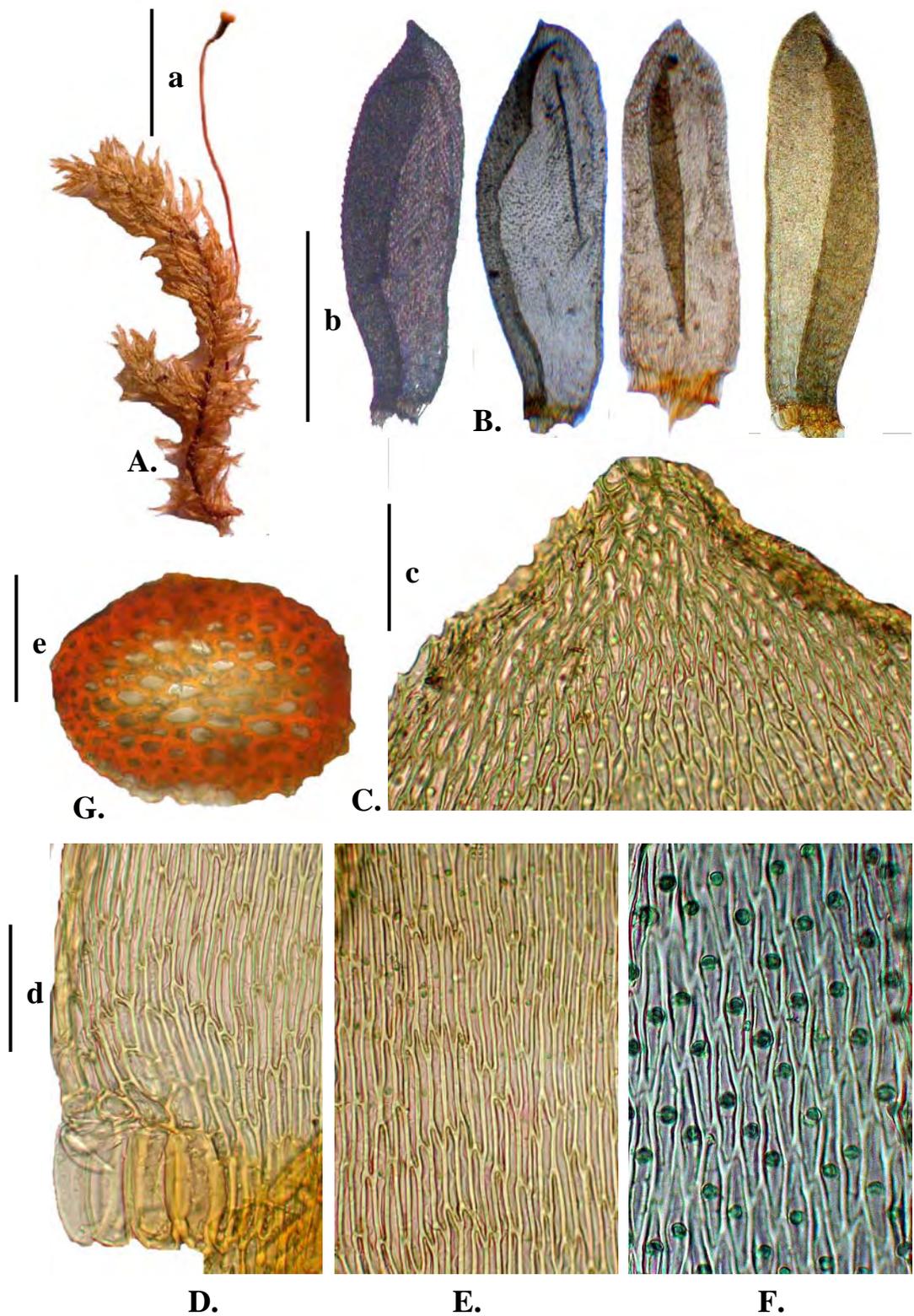


Figure 5.45 *Papillidiopsis macrosticta* (Broth. & Paris) W.R. Buck & B.C. Tan; photos based on *Kerr 511a*, type, P; A. habit, B. leaves, C. leaf apex, D. base leaf with alar acroporioid organization, E. mid-leaf cells, F. leaf cells near apex with cell unipapillose, G. x-s stem; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C. = c = 30  $\mu$ m, D., E., F. = d = 50  $\mu$ m, G. = e = 0.5 mm.

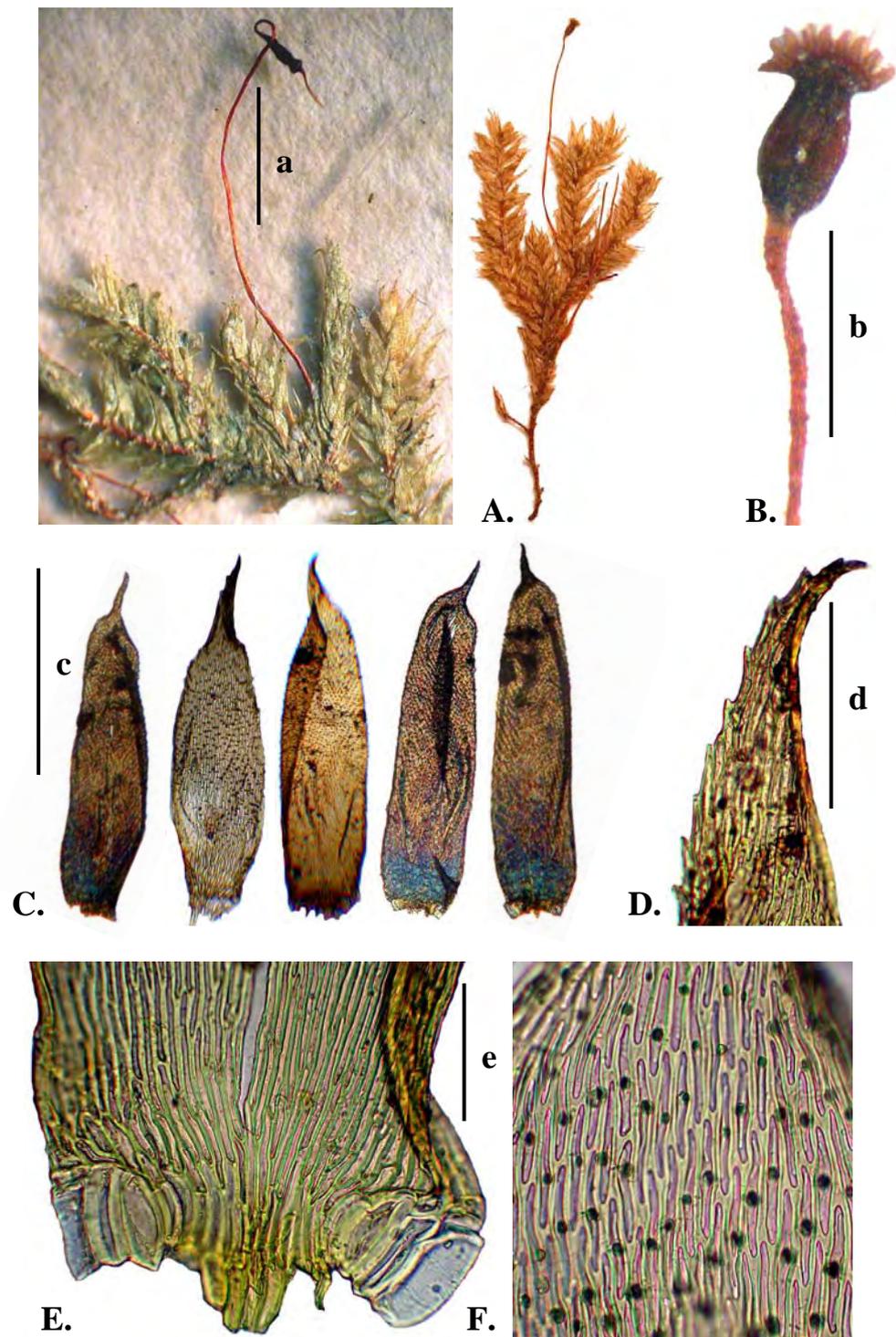


Figure 5.46 *Papillidiopsis stissophylla* (Hampe & Müll. Hal.) B.C. Tan & Y. Jia; photos based on type, FH60338; A. habit, B. sporophyte, C. leaves, D. leaf apex, E. base leaf with alar acroporioid organization, F. leaf near apex with cells unipapillose; scale bars: A.= a = 5 mm, B. = b = 1 mm, C. = c = 1 mm, D. = d = 50  $\mu$ m, E., F., = e = 50  $\mu$ m.

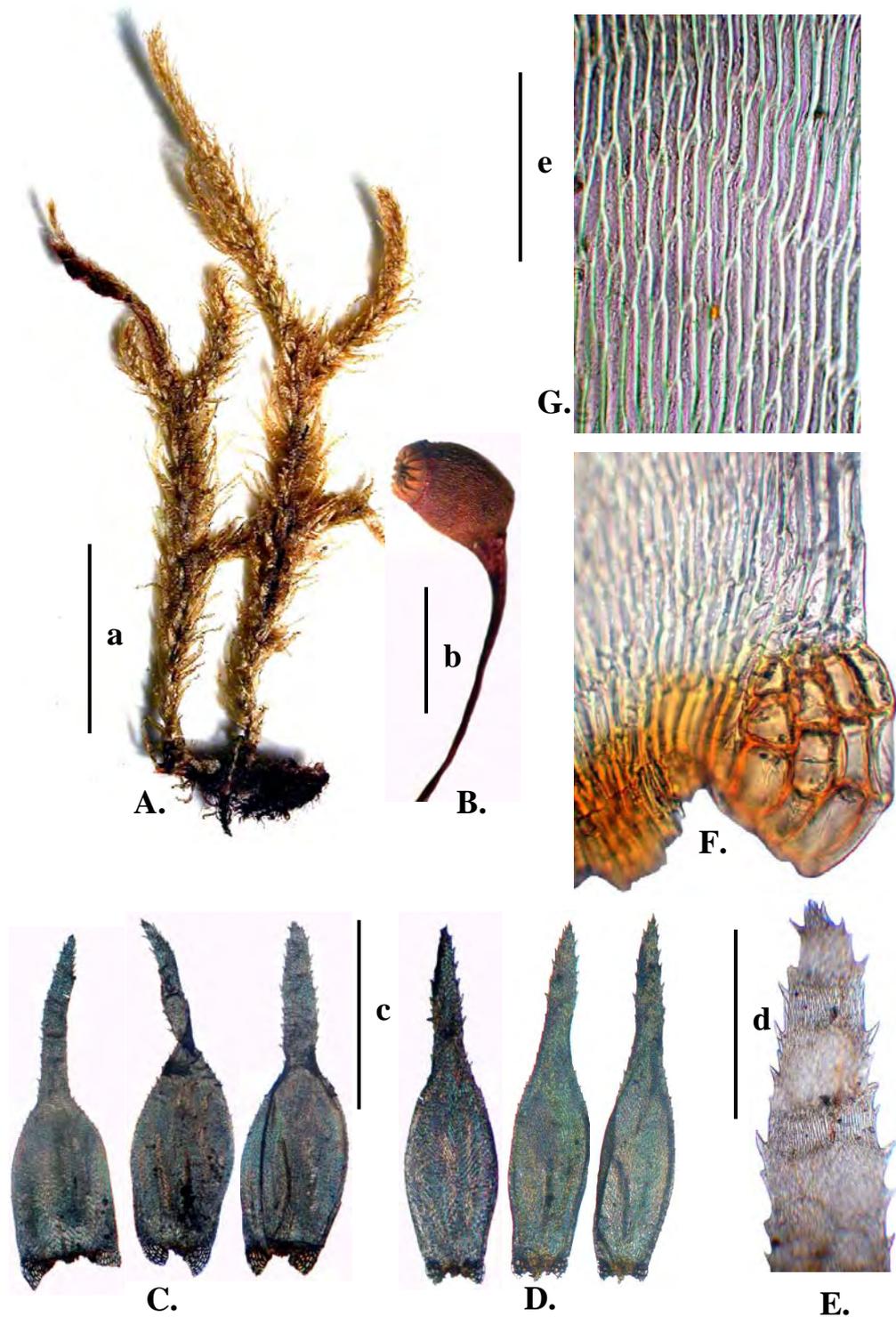


Figure 5.47 *Pseudotrismegistia undulata* (Broth. & Yasuda) H. Akiy. & Tsubota; photos based on holotype, H-BR 4321009; A. habit, B. sporophyte, C. stem leaves, D. branch leaves, E. leaf apex, F. base leaf with alar heterophylly organization, G. mid-leaf cells; scale bars: A. = a = 1 cm, B. = b = 5 mm, C., D. = c = 1 mm, E. = d = 1 mm, F., G. = e = 60  $\mu$ m.

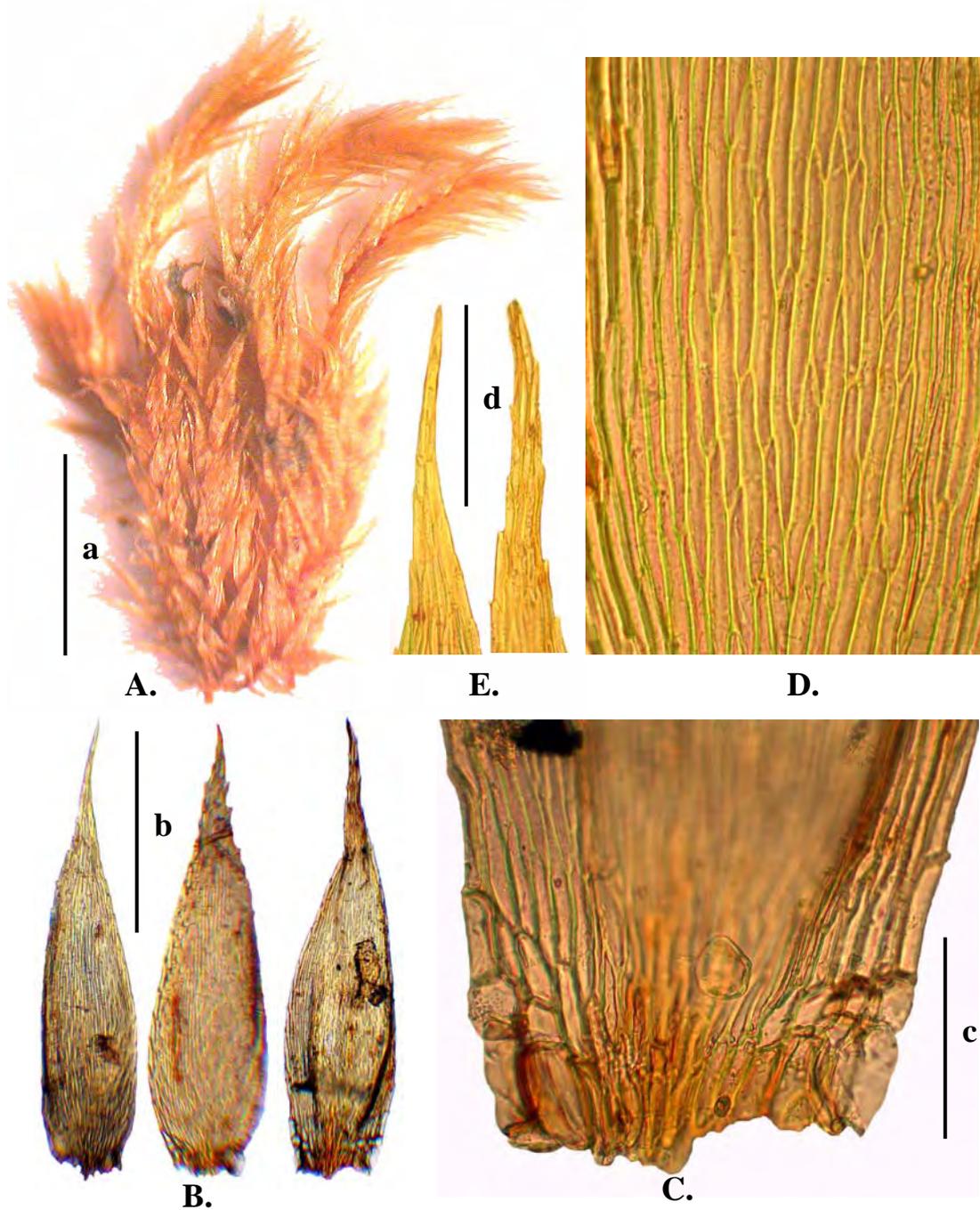


Figure 5.48 *Pylaisiadelpha capillacea* (Griff.) B. C. Tan & Y. Jia; photos based on type, H-BR 1033010; A. habit, B. leaves, C. base leaf with alar brotherelloid organization, D. mid-leaf cells, E. leaf apex; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D. = c = 50  $\mu$ m, E. = d = 100  $\mu$ m.

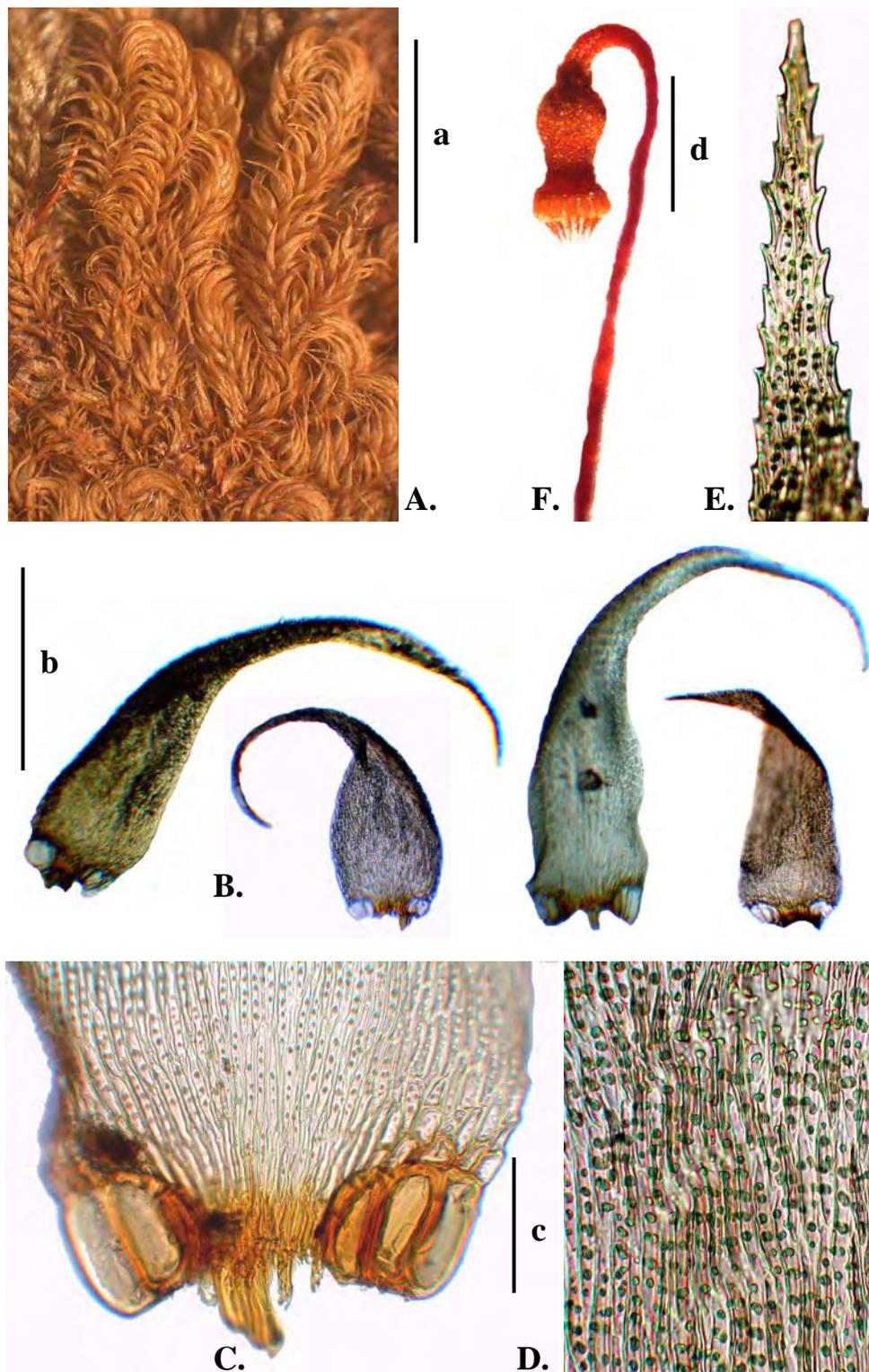


Figure 5.49 *Radulina hamata* (Dozy & Molk) W.R. Buck & B.C. Tan; photos based on *Touw 10912*, AAU; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf with cells pleuripapillae, E. leaf apex, F. sporophyte; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E. = c = 50  $\mu$ m, F. = d = 5 mm.

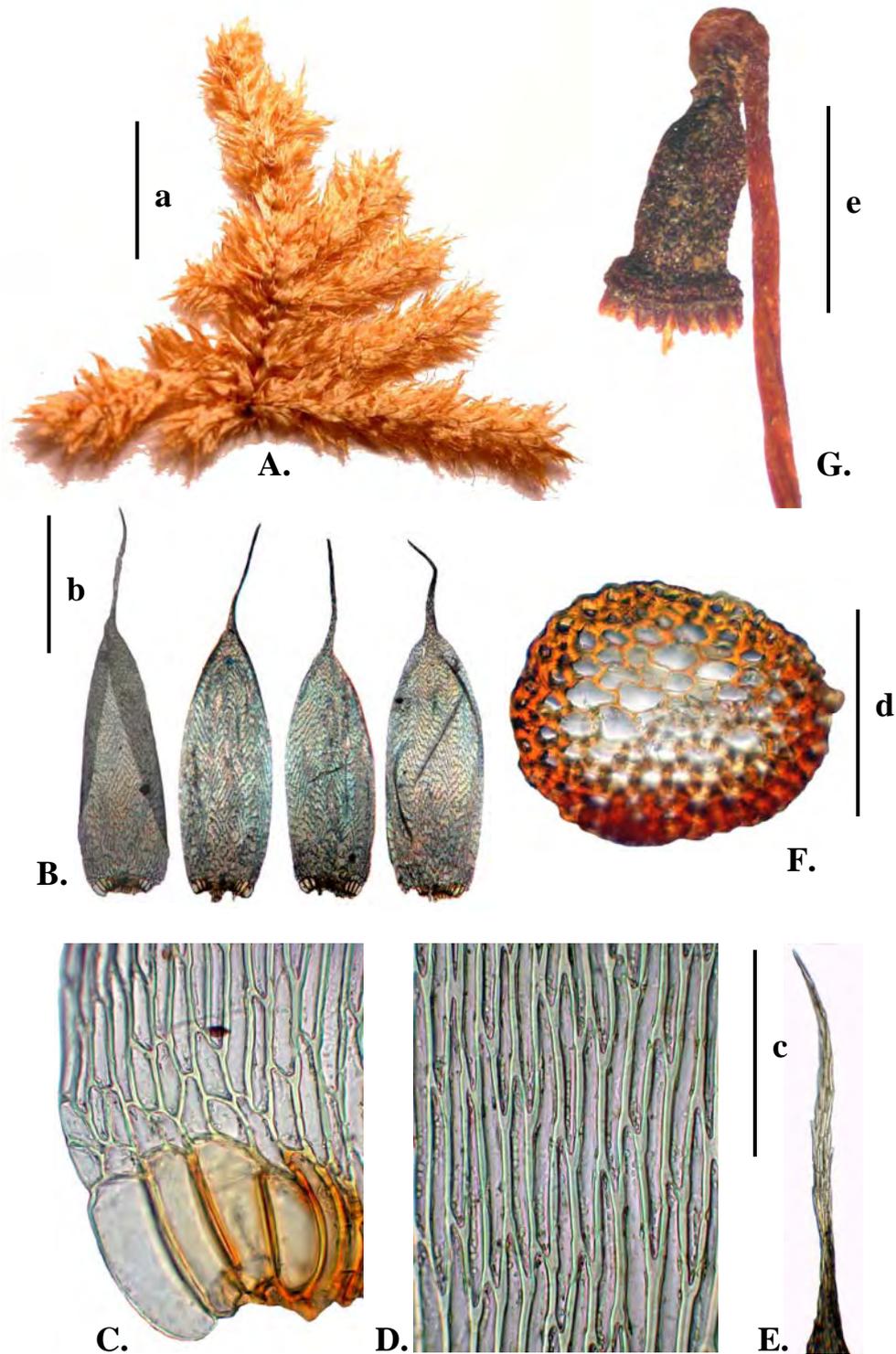


Figure 5.50 *Rhaphidostichum bunodiocarpum* (Müll. Hal.) M. Fleisch.; photos based on type, BM000824194; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf cells, E. leaf apex, F. x-s stem, G. sporophyte; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E. = c = 100  $\mu$ m, F. = d = 2 mm, G. = e = 1 mm.

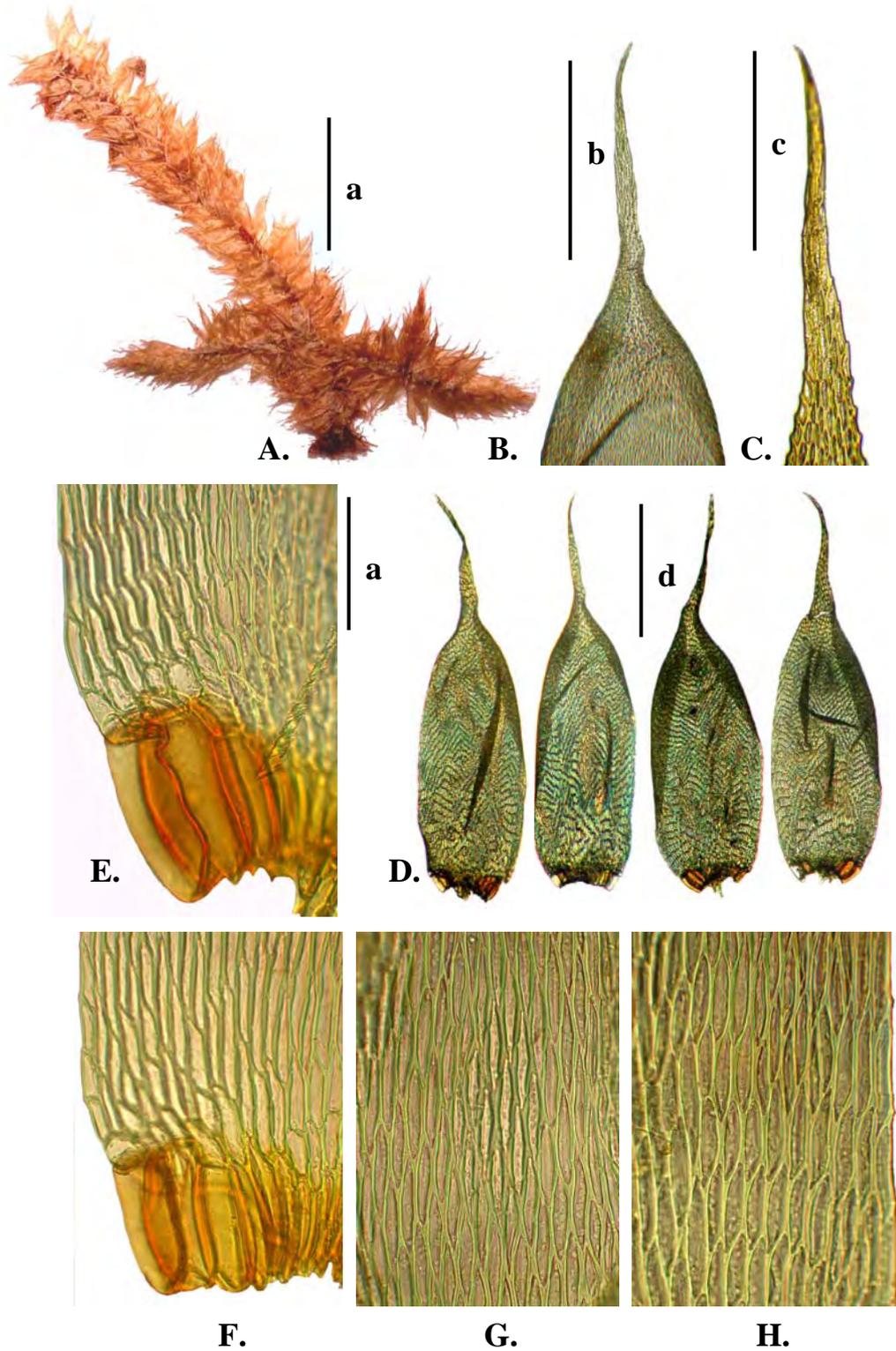


Figure 5.51 *Rhaphidostichum leptocarpoides* (Broth.) Broth.; photos based on Schmidt 43, H-BR; A. habit, B. upper part of leaf, C. leaf apex with minutely serrulate margin, D. leaves, E., F. base leaf with alar acroporioid organization, G. mid-leaf cells, H. leaf cells near margin; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = c = 0.1 mm, D. = d = 1 mm, E., F., G., H. = e = 100  $\mu$ m.

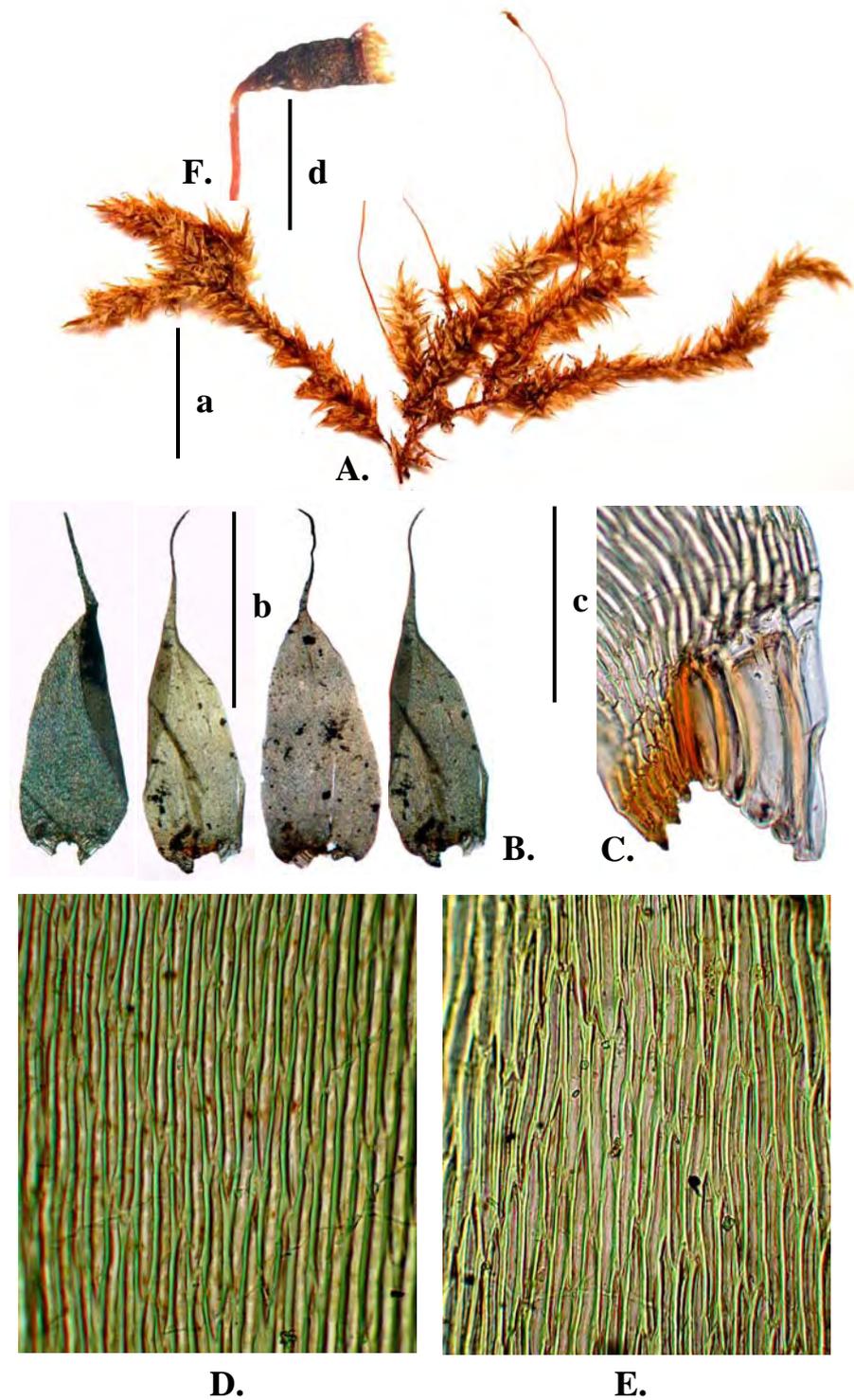


Figure 5.52 *Rhabdostichum luzonense* (Broth.) Broth.; photos based on *Robinson 6-9/12/1912*, type, BM; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D., E. mid-leaf cells, F. sporophyte; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E. = c = 50  $\mu$ m, F. = d = 1 mm.

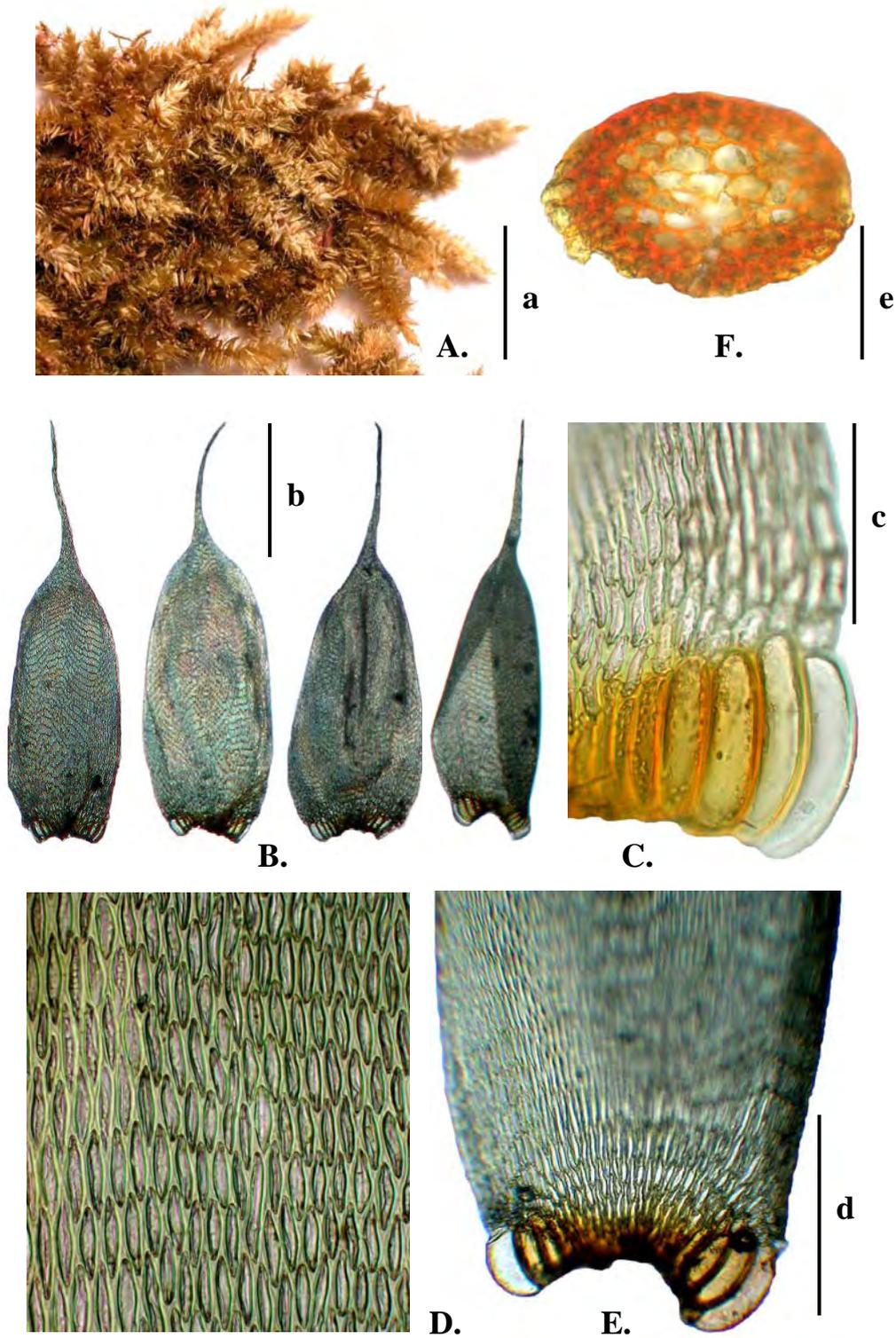


Figure 5.53 *Rhabdostichum piliferum* (Broth.) Broth.; photos based on CLW 4501, NY; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf cells, E. base leaf, F. x-s stem; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D. = c = 100  $\mu$ m, E. = d = 0.2 mm, F. = e = 1 mm.

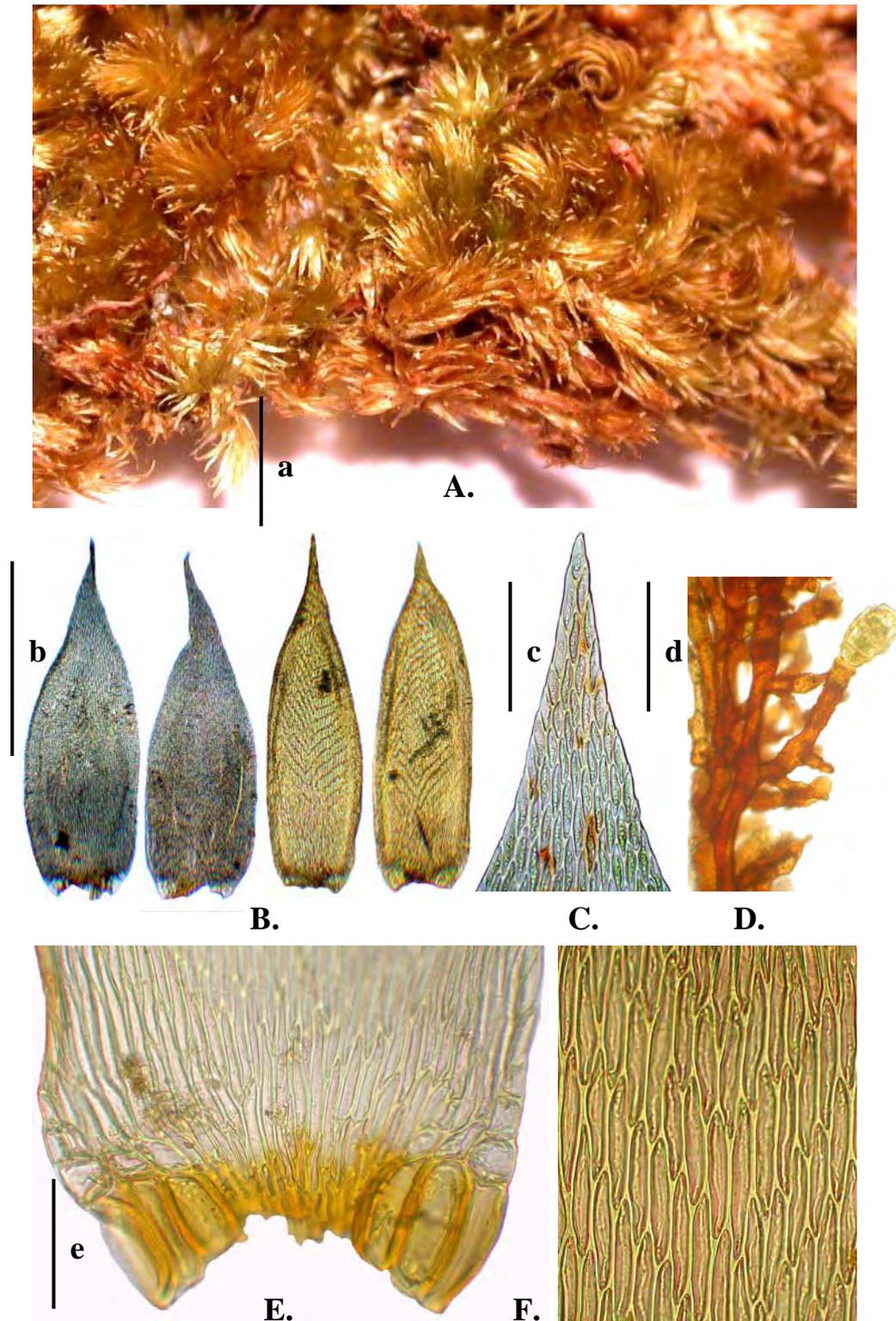


Figure 5.54 *Sematophyllum microcladiellum* M. Fleisch.; photos based on *Robbins 3548*, BKF; A. habit, B. leaves, C. leaf apex, D. gemmae branch, E. base leaf with alar acroporioid organization, F. leaf cells; scale bars: A. = a = 5 mm, B. = b = 1 mm, C. = c = 0.1 mm, D. = d = 1 mm, E., F. = e = 80  $\mu$ m.

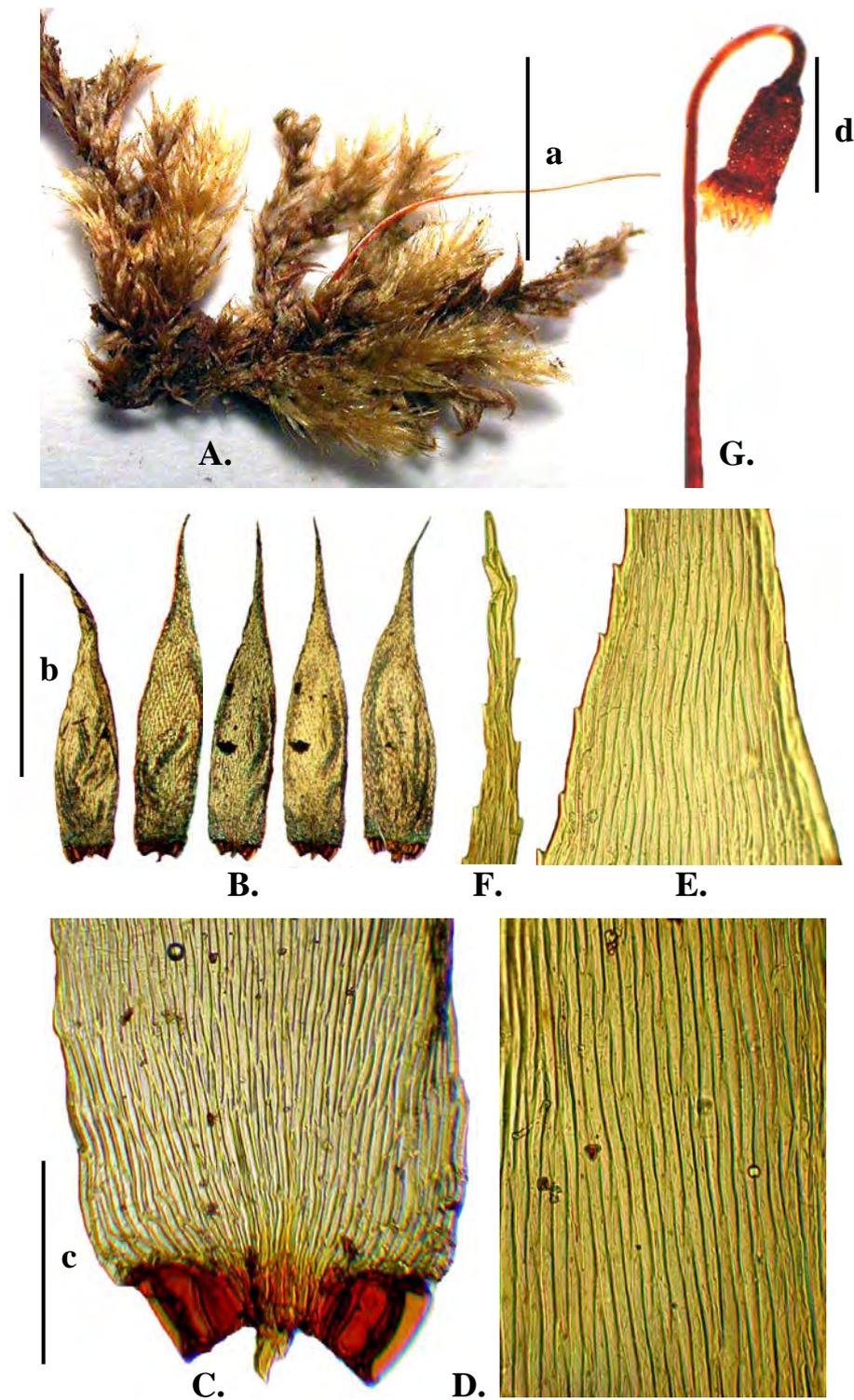


Figure 5.55 *Sematophyllum parvulum* (Broth.) Dixon; photos based on *Schmidt. s.n.*, type, H-BR3610044; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf cells, E. margin serrate near apex, F. leaf apex, G. sporophyte; scale bars: A. = a = 1 cm, B. = b = 1 mm, C., D., E., F. = c = 100  $\mu$ m, G. = d = 1 mm.

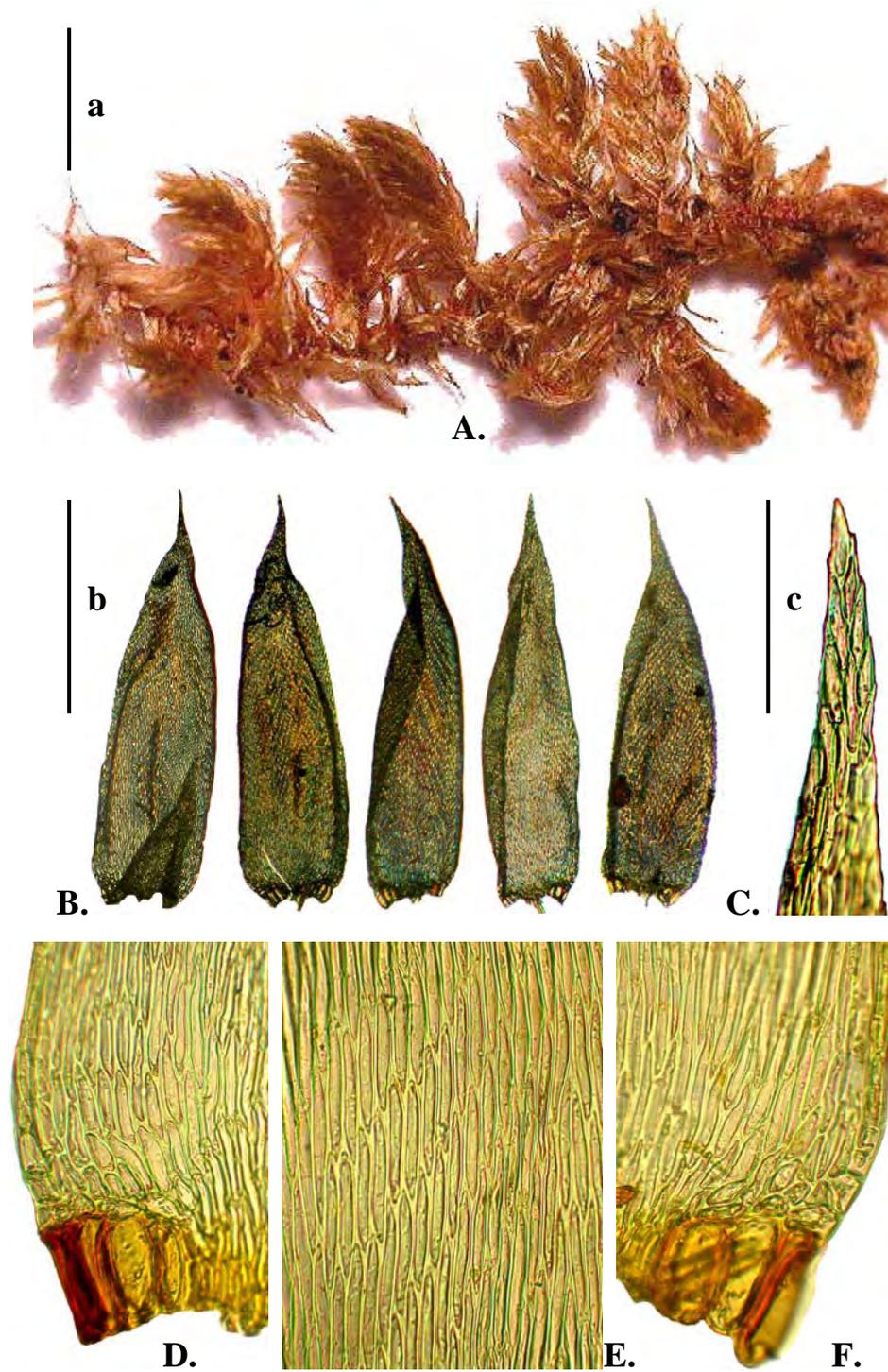


Figure 5.56 *Sematophyllum phoeniceum* (C. Müll.) M. Fleisch.; photos base on Tixier 572, BKF; A.habit, B. leaves, C. leaf apex, D., F., base leaf with alar acroporioid organization, E. mid-leaf cells; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E., F. = c = 70  $\mu$ m.

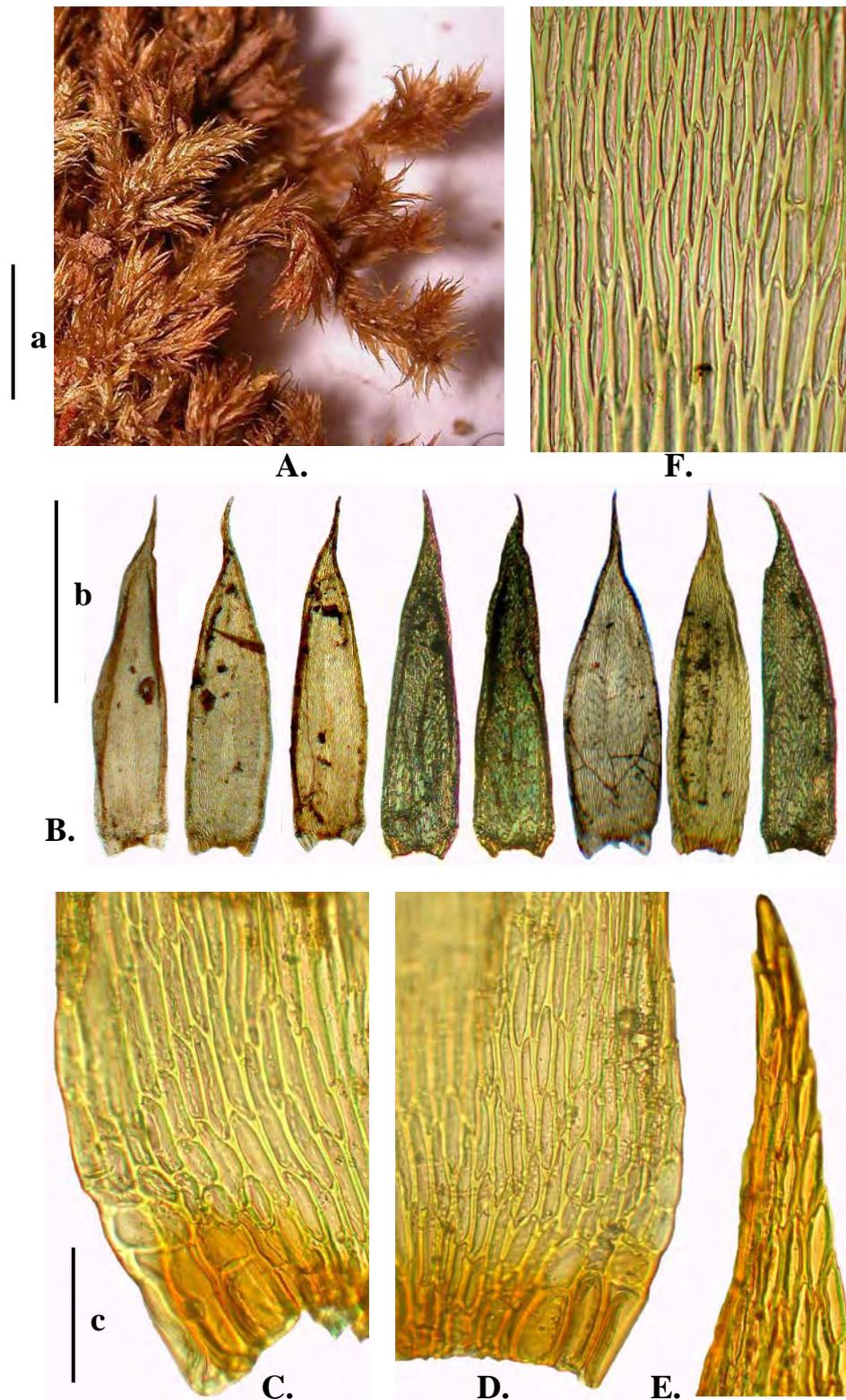


Figure 5.57 *Sematophyllum subconnivens* (Broth.) Dixon; photos based on *Schmidt. s. n.*, type, H-BR3822024; A. habit, B. leaves, C., D. base leaves with acroporioid organization, F. mid-leaf cells; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E., F. = c = 50  $\mu$ m.

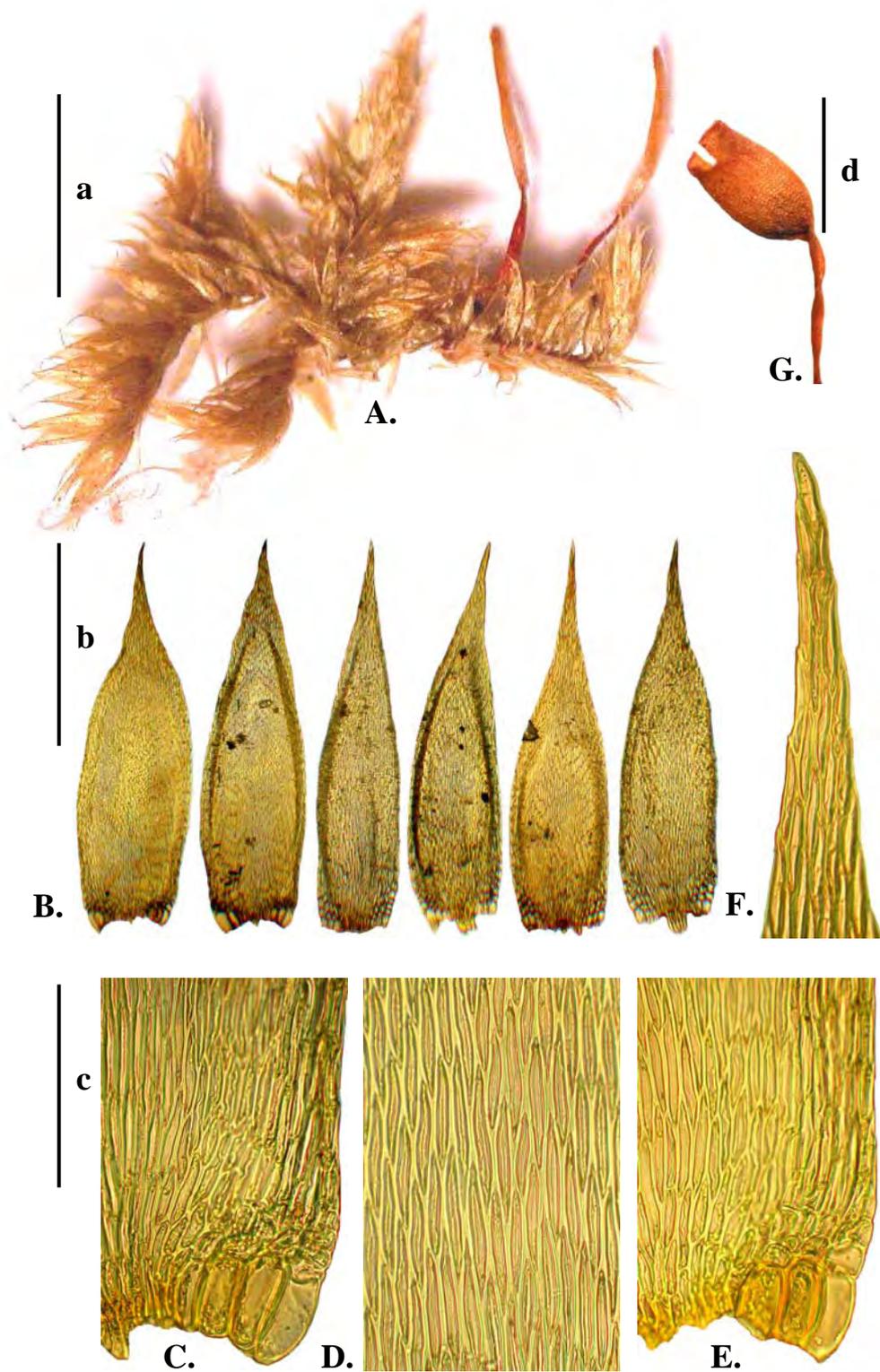


Figure 5.58 *Sematophyllum subhumile* (C. Müll.) M. Fleisch.; photos based on *Perrottet s.n.*, isotype, FH60377; A. habit, B. leaves, C., E. base leaf with alar brotherelloid organization, D. mid-leaf cells, F. leaf apex, G. sporophyte; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E., F. = c = 50  $\mu$ m, G. = d = 1 mm.

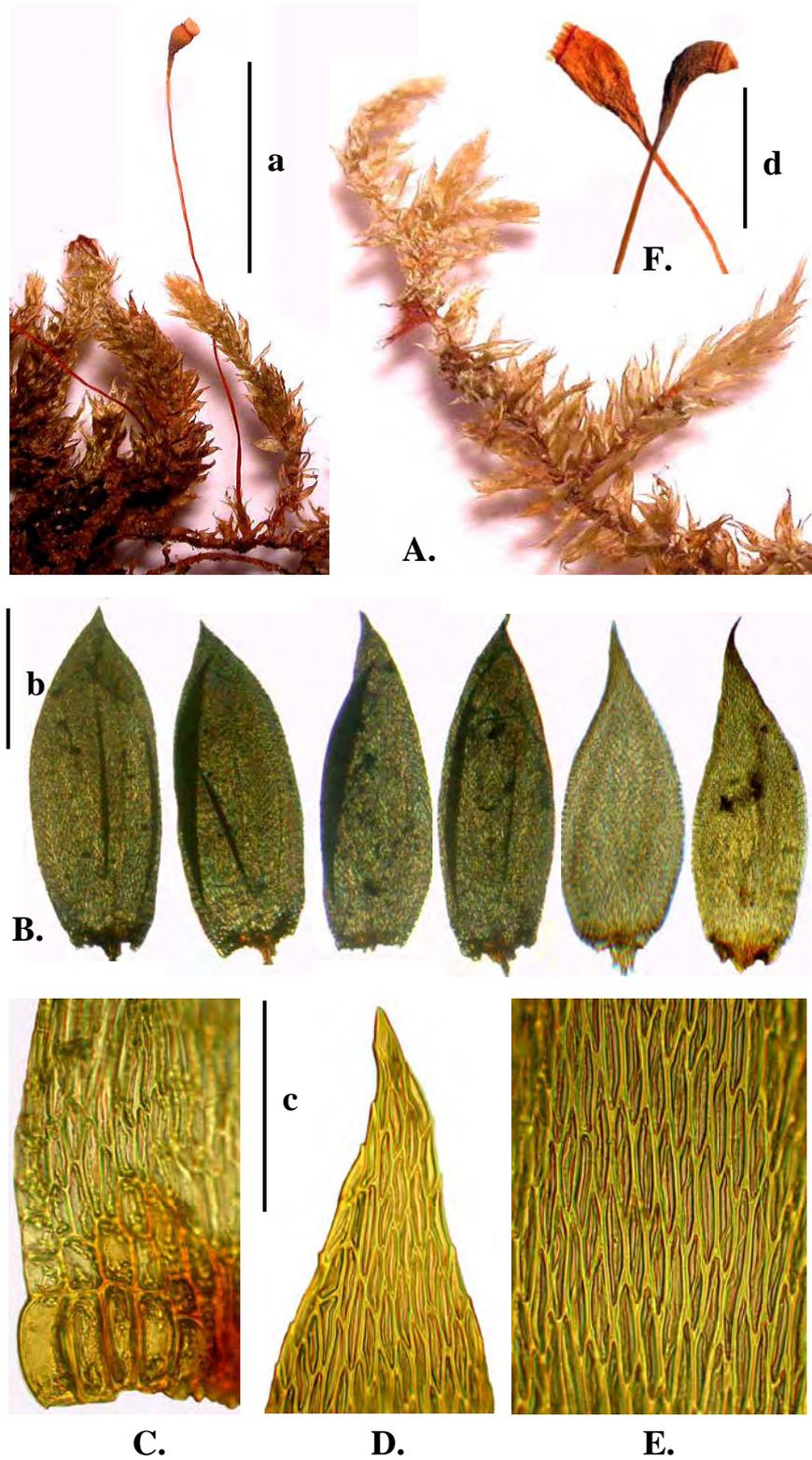


Figure 5.59 *Sematophyllum subpinnatum* (Brid.) E. Britton; photos based on *Smitinand 3195*, FH; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. leaf apex, E. mid-leaf cells, F. sporophytes; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E. = c = 80  $\mu$ m, F. = d = 5 mm.

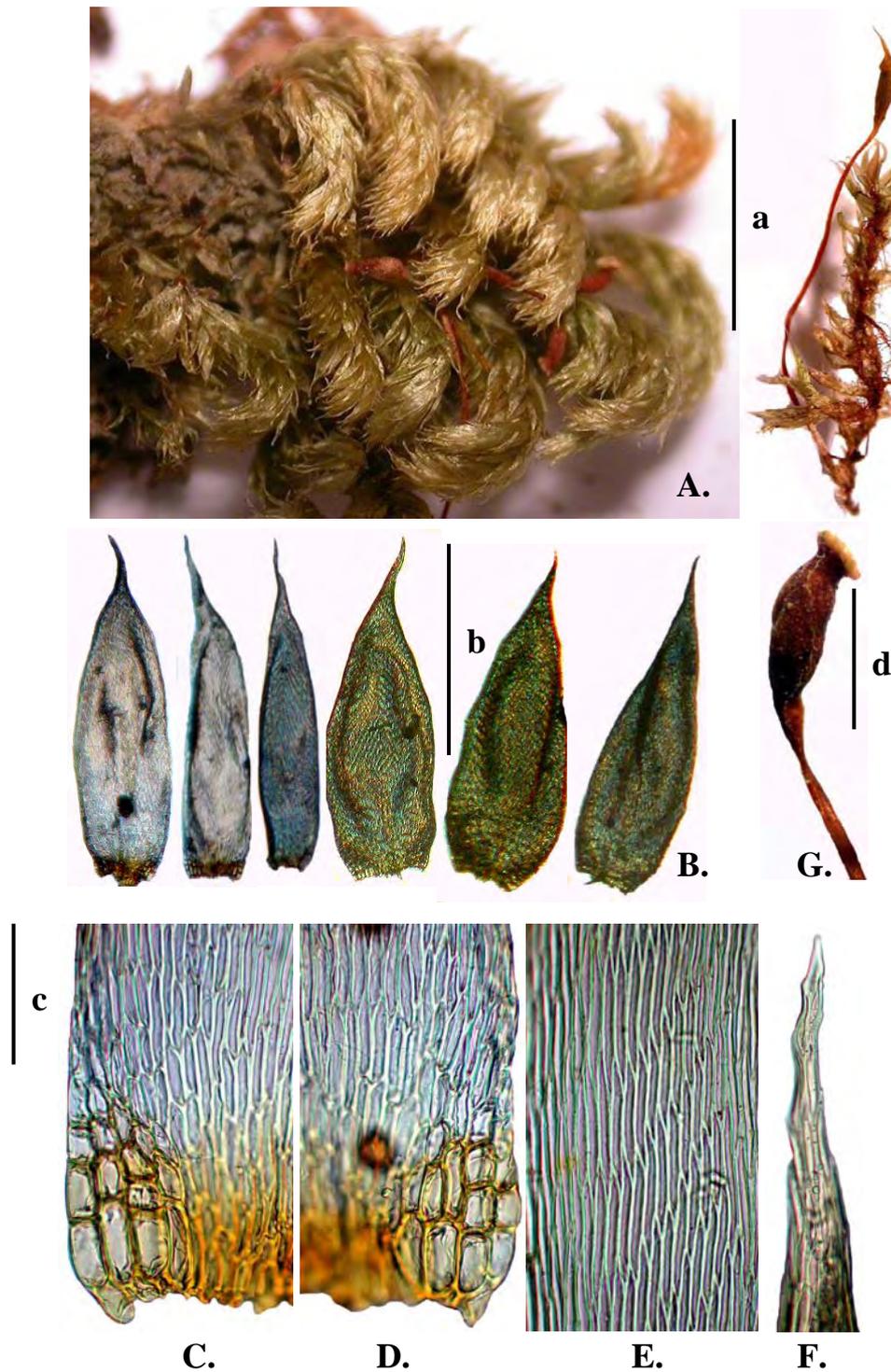


Figure 5.60 *Sematophyllum subpinnatum* fo. *tristiculum* (Mitt.) B.C. Tan & Y. Jia; photos based on *Sanchez 05/1910*, lectotype, H-BR; A. habit, B. leaves, C., D. base leaves with alar brotherelloid organization, E. mid-leaf cells, F. leaf apex, G. sporophyte; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E., F. = c = 50  $\mu$ m, G. = d = 1 mm.

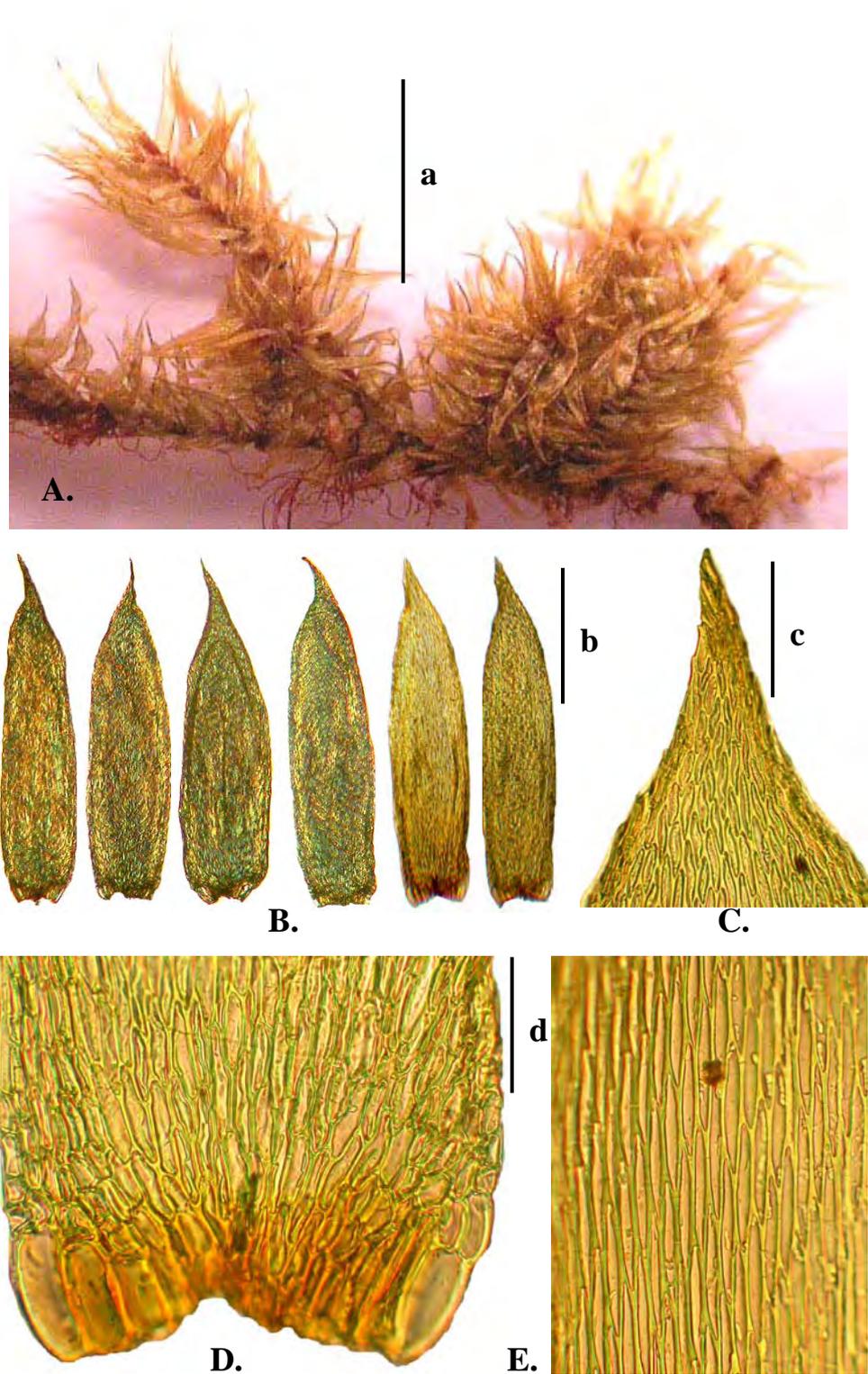


Figure 5.61 *Sematophyllum subrevolutum* Broth.; photos based on *Schmidt. s.n.*, type, H-BR3627003; A. habit, B. leaves, C. leaf apex, D. base leaf with alar acroporioid organization, E. mid-leaf cells; scale bars: A. = a = 3 mm, B. = b = 0.5 mm, C. = c = 0.1 mm, D., E. = d = 50  $\mu$ m.

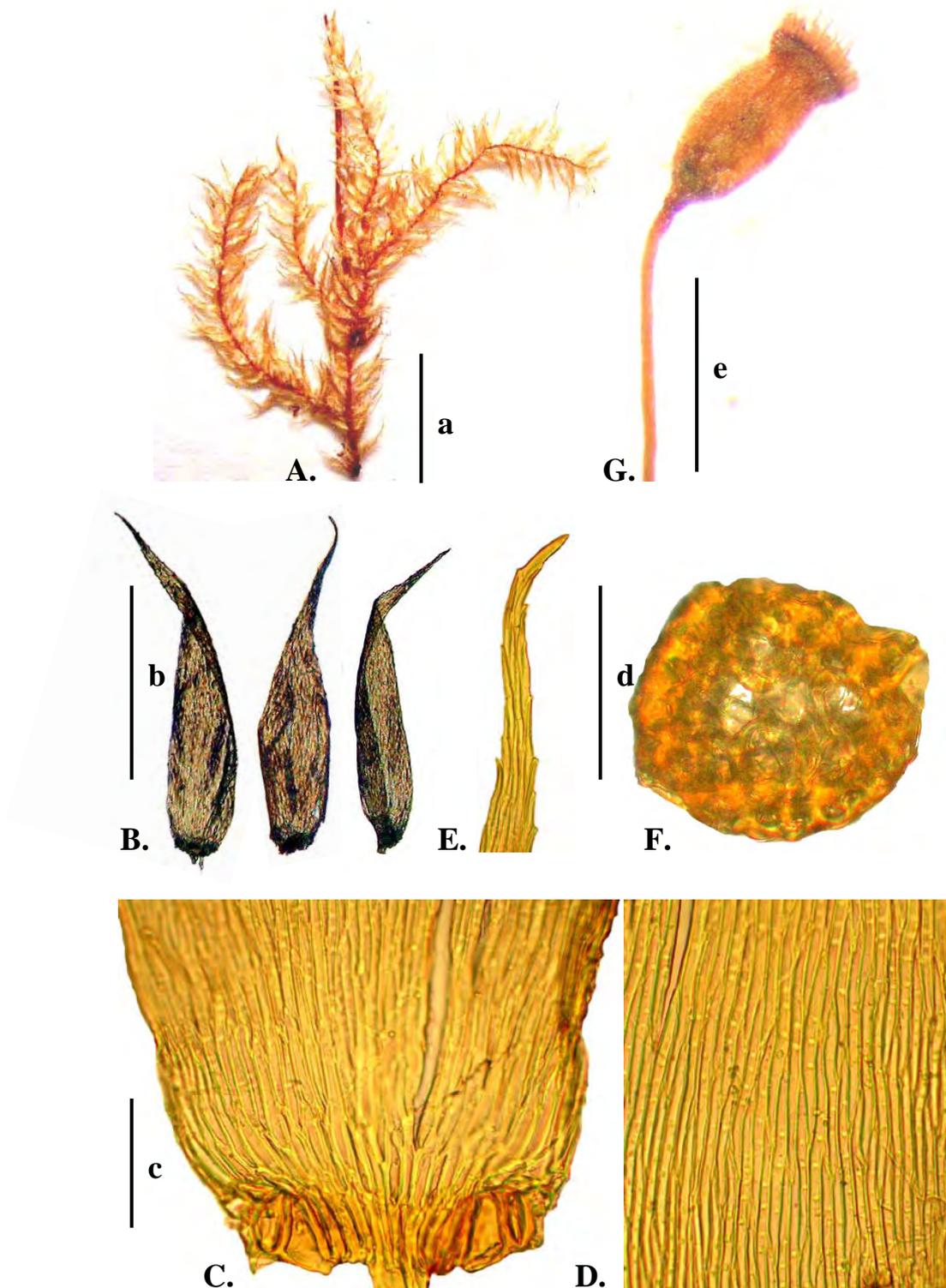


Figure 5.62 *Taxithelium alare* Broth.; photos based on *M.L. Merrid 6/1906*, syntype, BM; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. mid-leaf cells, E. leaf apex, F. x-s stem, G. sporophyte; scale bars: A. = a = 5 mm, B. = b = 1 mm, C., D., E. = c = 50  $\mu$ m, F. = d = 1 mm, G. = e = 1 mm.

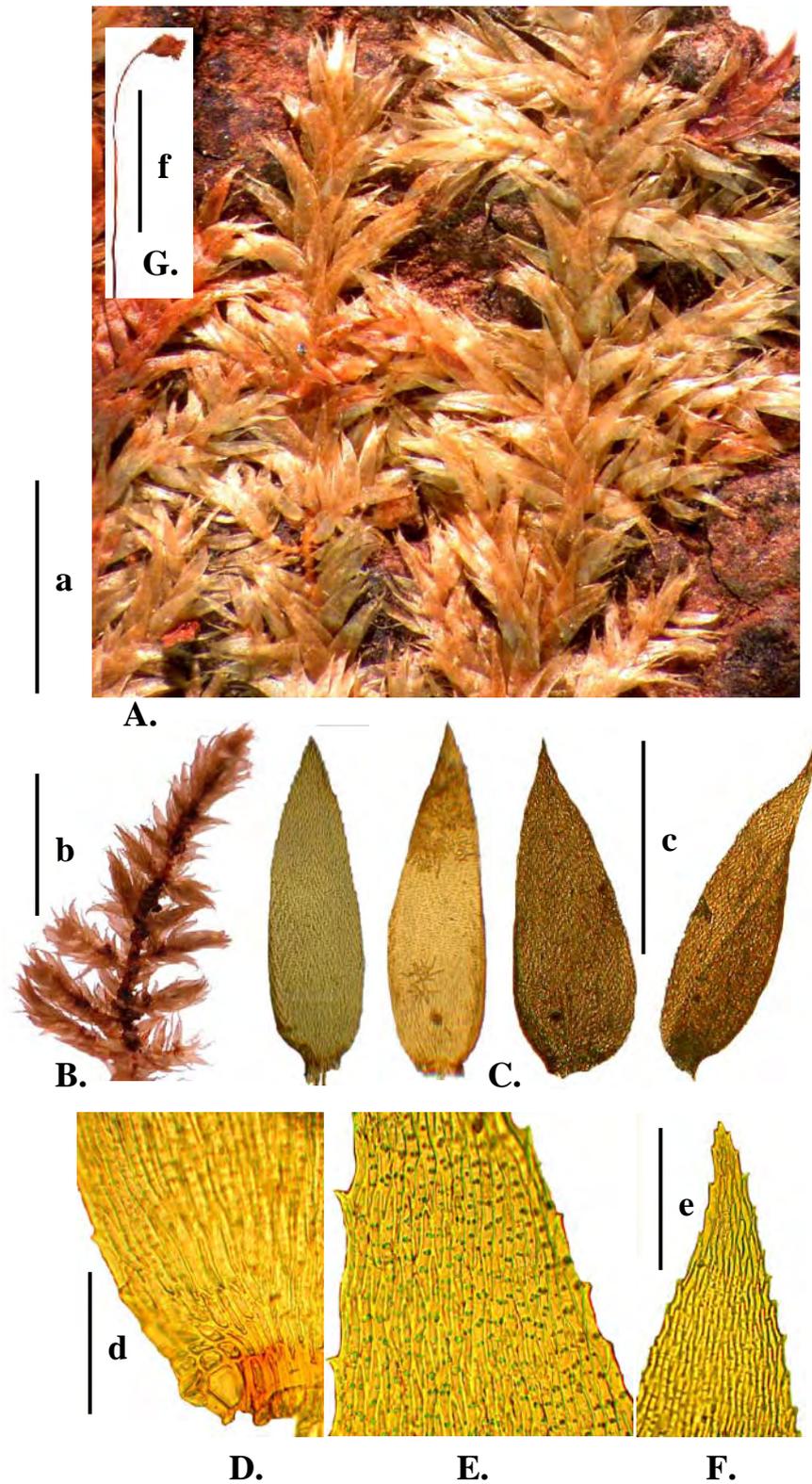


Figure 5.63 *Taxithelium arnottii* Thér. & P. Tixier; photos base on Anott 87,189, laectotype, P; A. habit show dorsal flatten plant. B. habit show ventral view, C. leaves, D. basal leaf with alar acroporioid organization, E. leaf cells with pleuripapillose, F. leaf apex, G. sporophyte; scale bars: A.= a = 5 mm, B. = b = 1 cm, C. = c = 1mm, D., E. = d = 100  $\mu$ m, F. = e = 50  $\mu$ m, G. = f = 5 mm.

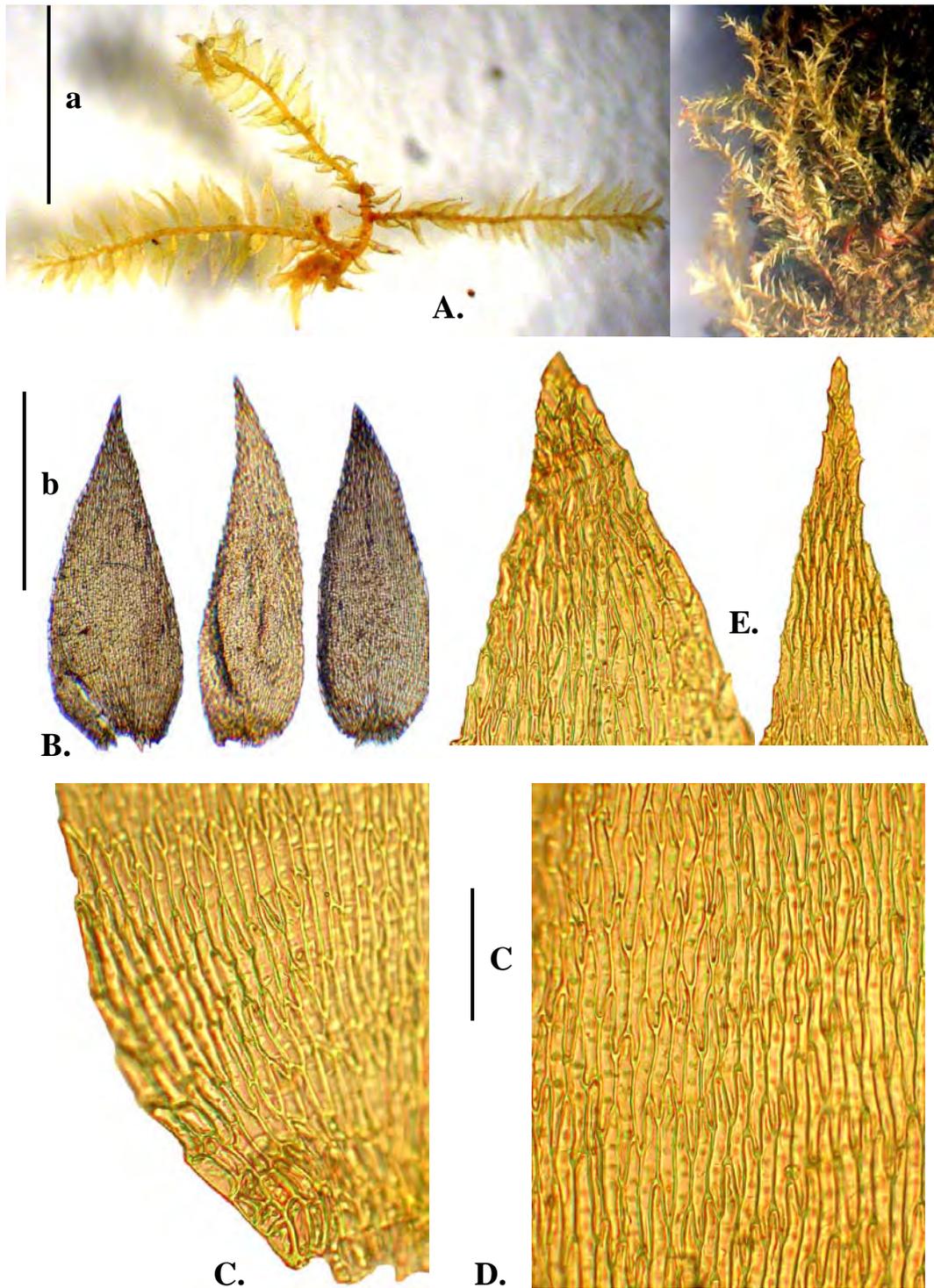


Figure 5.64 *Taxithelium bakeri* Broth.; photos based on *C.F. Baker 1/1914*, Type, BM; A. habit, B. leaves, C. base leaf with small alar brotherelloid organization, D. mid-leaf cells rhomboidal with pleuripapillose, E. leaves apex; scale bars: A. = a = 3 mm, B. = b = 0.5 mm, C., D., E. = c = 40  $\mu$ m.

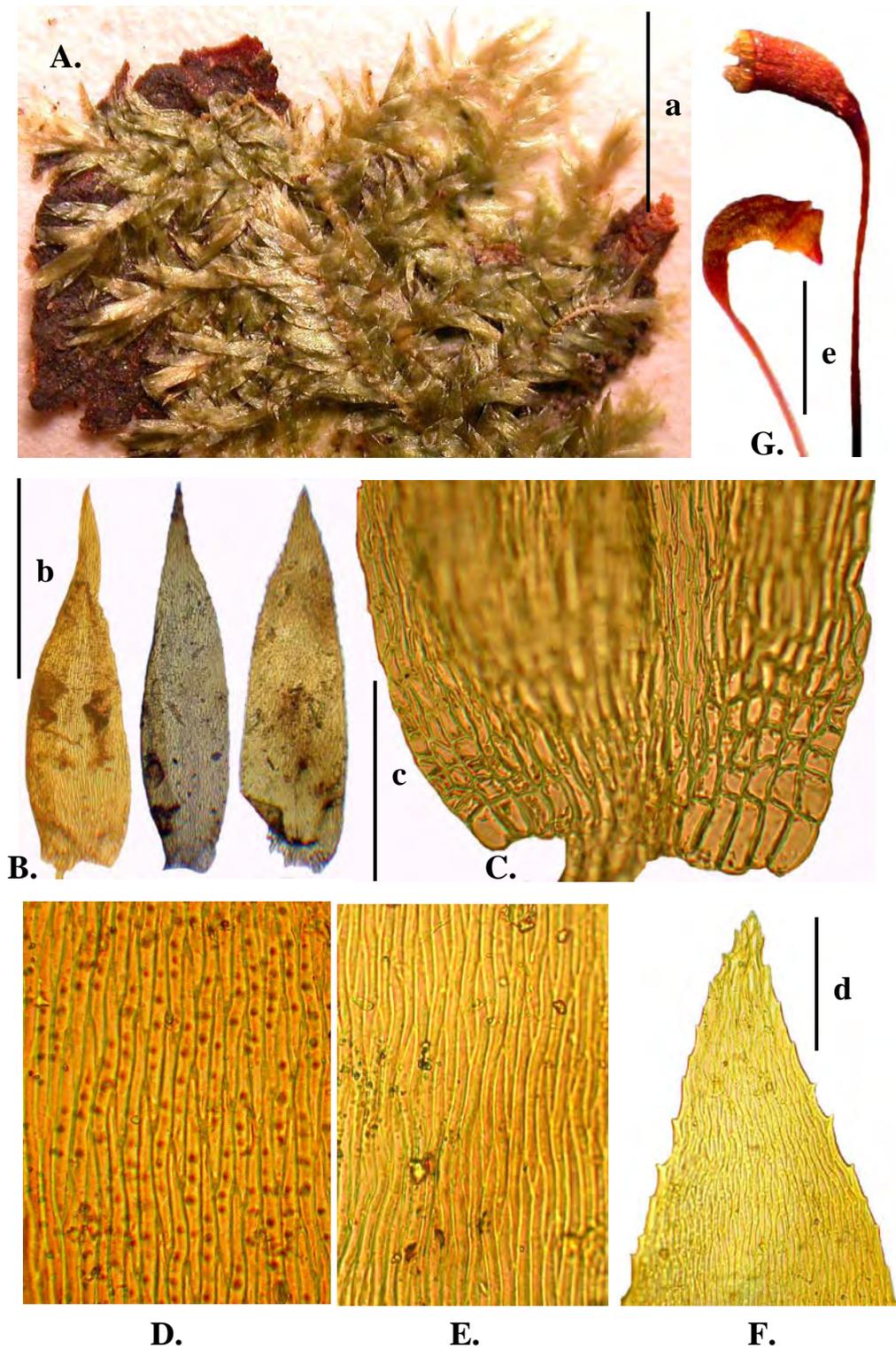


Figure 5.65 *Taxithelium binsteadii* Broth. & Dixon; photos based on *Binstead 413*, type, BM; A. plant with regularly branches, B. leaves, C. base leaf with alar brotherelloid organization, D. mid-leaf cells pleuripapillose, E. leaf cells near apex, F. leaf apex, G. sporangium with conic operculum; scale bars: A. = a = 1 cm, B. = b = 0.5 mm, C., D., E. = c = 80  $\mu$ m, F = d = 100  $\mu$ m, G. = e = 1 mm.

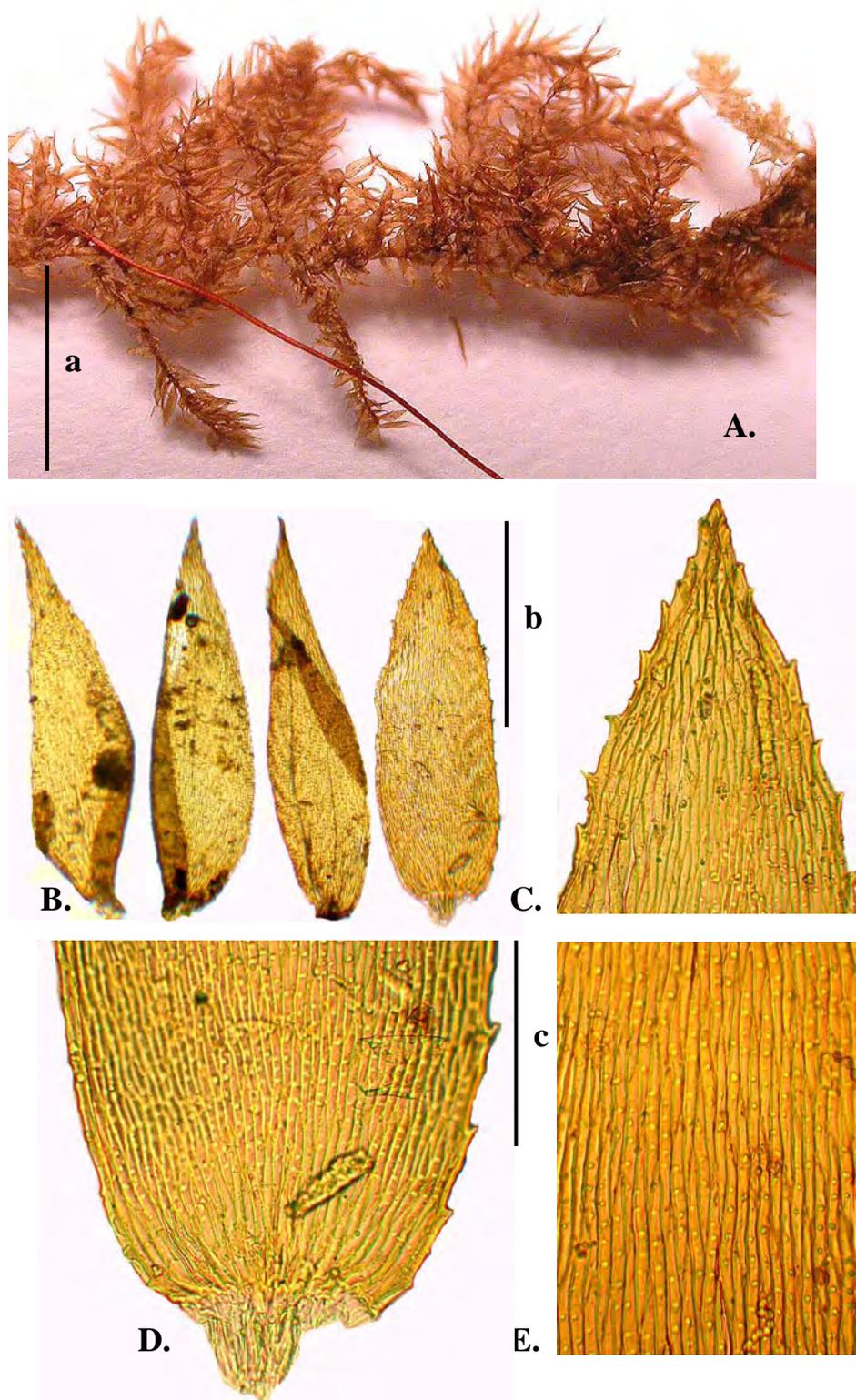


Figure 5.66 *Taxithelium clastobryoides* Dixon; photos based on *Phloenchit* 149, AAU; A. habit, B. leaves, C. leaf apex, D. leaf base with alar acroporioid organization, E. mid-leaf cells pleuripapillose; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E. = c = 80  $\mu$ m.

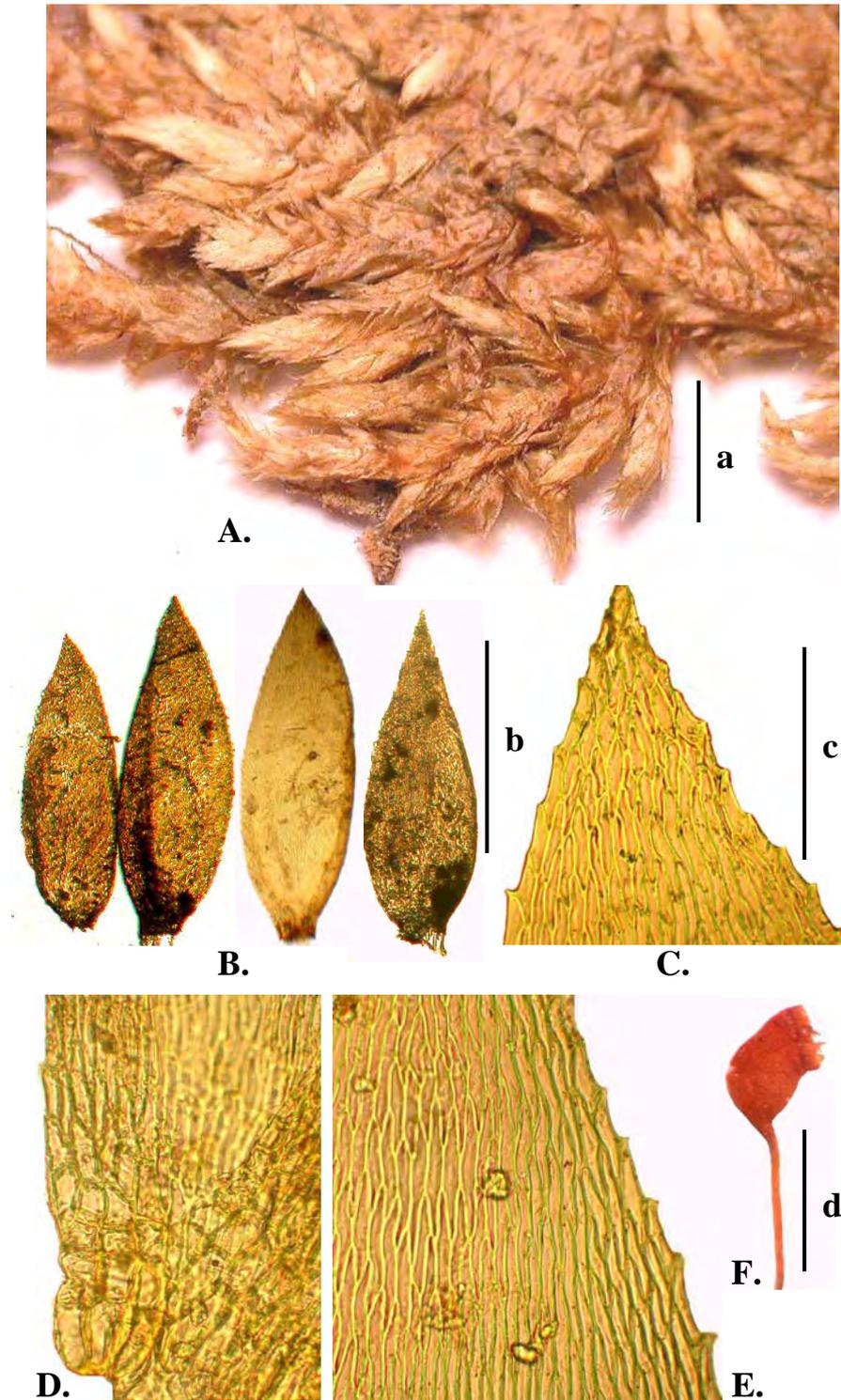


Figure 5.67 *Taxithelium epapillosum* Dixon; photos based on *Kerr 368*, type, BM; A. habit, B. leaves, C. leaf apex, D. leaf base with alar brotherelloid organization, E. leaf cells vermiform rarely papillae, F. sporophyte; scale bars: A. = a = 5 mm, B. = b = 0.5 mm, C., D., E. = c = 100  $\mu$ m, F. = d = 1 mm.

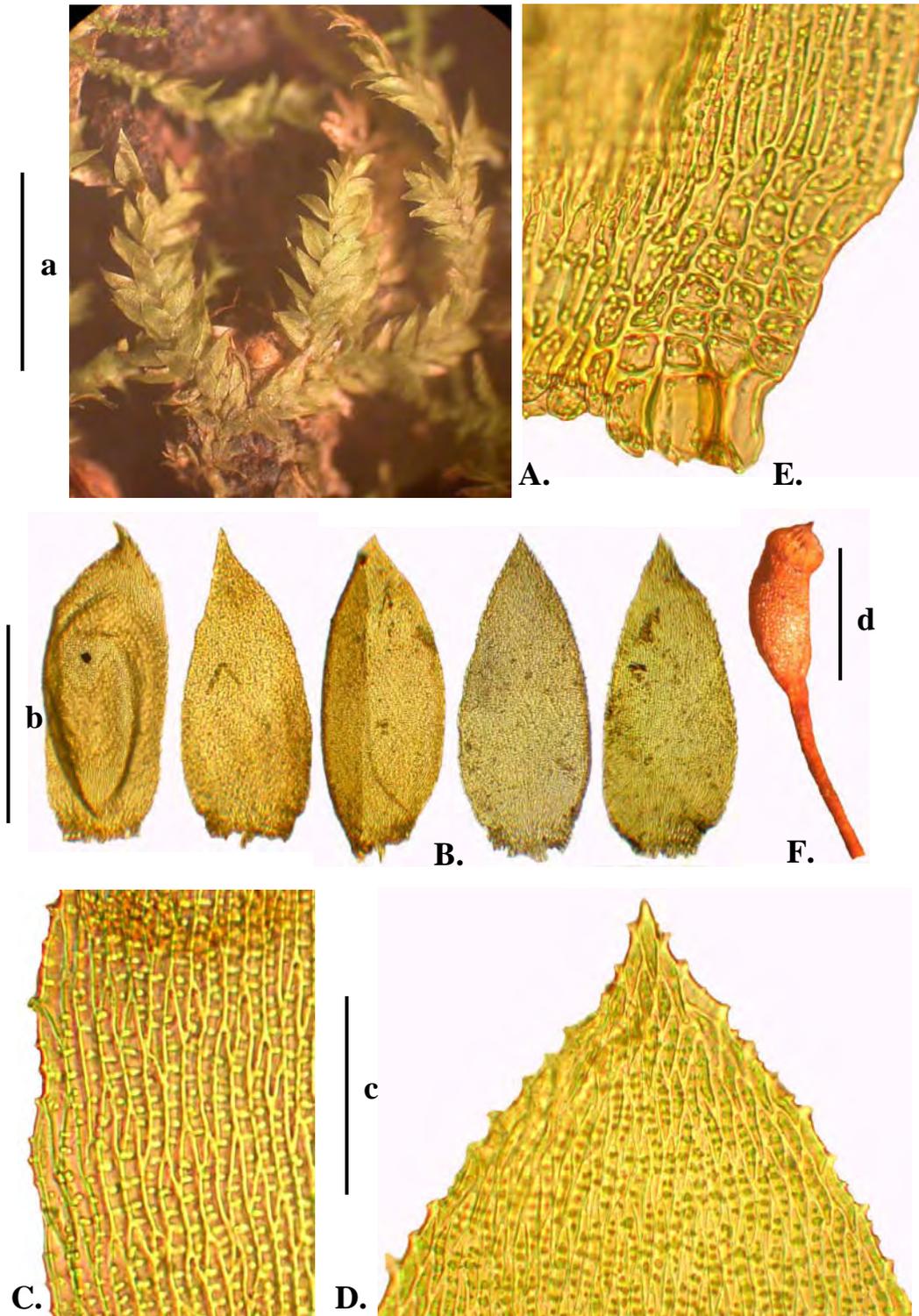


Figure 5.68 *Taxithelium gottscheanum* (Hampe) Broth.; photos base on *Sloover* 42497, NY; A. habit, B. leaves, C. leaf cells rhomboidal showing pleuripapillae, D. leaf apex, E. base leaf with alar acroporioid organization and group of quadrate cells above, F. sporophyte; scale bars: A. = a = 1 cm, B. = b = 1 mm, C. = D. = E. = c = 50  $\mu$ m, F. = d = 1 mm.

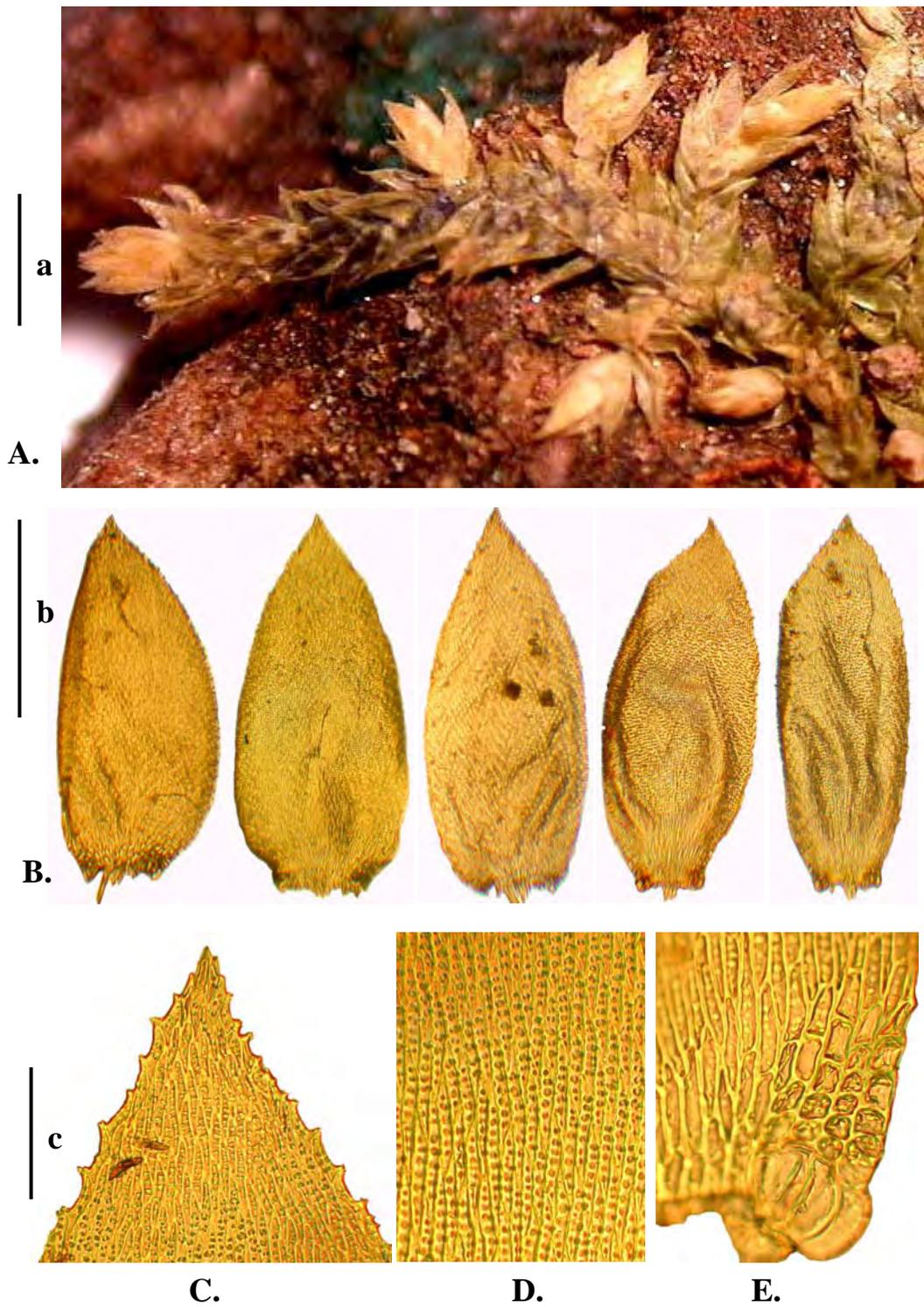


Figure 5.69 *Taxithelium instratum* (Brid.) Broth.; photos base on CLW 3547, AAU; A. habit, B. leaves, C. leaf apex, D. leaf cells pleuripapillae, E. base leaf with alar acroporioid organization; scale bars: A. = a = 1 mm, B. = b = 0.5 mm, C., D., E. = c = 50  $\mu$ m.

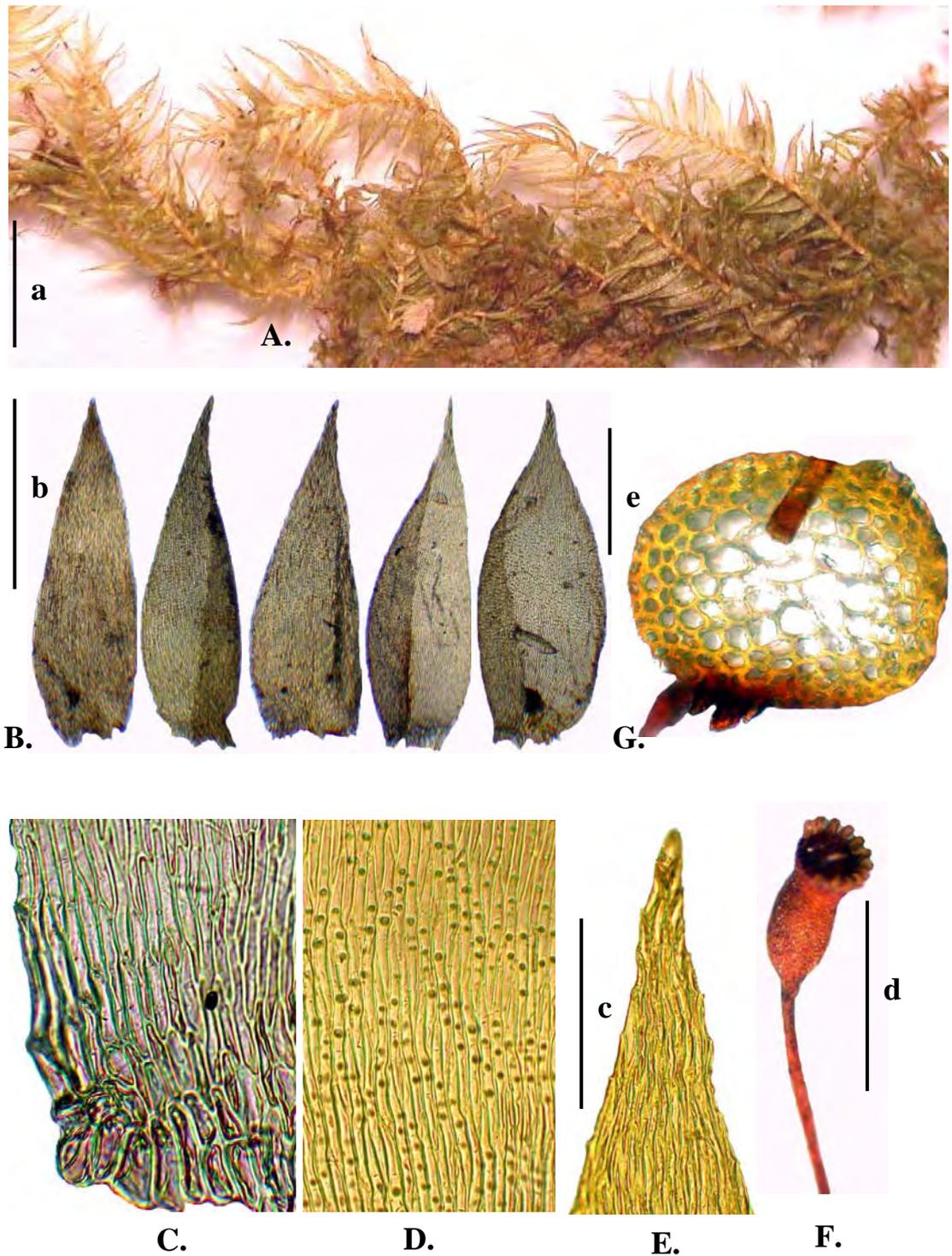


Figure 5.70 *Taxithelium isocladum* (Bosch & Sande Lac.) Ren. & Card.; photos base on Müller 2332, BM; A. habit, B. leaves, C. base leaf with alar acroporioid organization, D. leaf cells with pleuripapillae, E. leaf apex, F. sporophyte, G. x-s stem; scale bars: A. = a = 1 mm, B. = b = 0.5 mm, C., D., E. = c = 100  $\mu$ m, F. = d = 1 mm, G. = e = 0.5 mm.