A revision of the genus Leucobryum (Musci) in Asia

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Contents

I. Introduction

The genus Leucobryum is a group of whitish mosses as indicated by Latin epithet. Some species of Leucobryum form beautiful whitish green colonies and they are used for horticultural purposes in Japan (Inoue 1980, Ando & Matsuo 1984). Because of characteristic color of colonies, Leucobrya easily catch a collector's eye and numerous collections have been made in the world. According to Wijk et al. (1959-1969) and some additional literature, 189 species and 25 varieties have been described throughout the world.

The basic taxonomical characters of Leucobryum are the leaf structure with its peculiar combination of leucocysts (empty cells) and chlorocysts (chlorophyllose cells), and the dicranoid sporophyte. However, a large part of the leaf is occupied by a costa with multilayered cells, and the surface view of leaf cells is almost identical among all members of the genus. The characters of surface view of leaf cells (except for apical cells of the leaf) of Leucobryum are not useful for diagnostic characters, unlike most of the moss groups, and taxonomic distinction among the species of this genus have been unclear.

To date, 71 species and 7 varieties have been known

from Asia. The region of Asia in this study (Fig. I) corresponds with the locality abbreviations As 2-4 in Wijk et al. (1959-1969).

The purpose of this study is to revise all the known taxa of Asian Leucobryum, and secondly to find general taxonomic characters which reflect the phylogeny of the genus. In the course of this study, I examined ca. 3000 specimens deposited in various herbaria in addition to my own collections. The type specimens of 69 taxa deposited in 13 herbaria were also carefully examined. I also examined the specimens collected from Europe, America and Oceania to compare with Asian taxa. As a result, I recognized 19 taxa of Leucobryum in Asia.

II. Acknowledgements

I wish to express my sincere gratitude to Prof. Z. Iwatsuki of Hiroshima University for introducing me to this field of work, and for constant guidance and encouragement during my study. I also wish to express my thanks to Dr. N. Nishimura for his valuable advice and kind help for literature. I am indebted to Dr. K. Une of Okayama Hakuryo High School for his kind cooperation in carrying out a study of sexuality and geographical distribution of Japanese Leucobryum. Many thanks are also due to Assoc. Prof. T.

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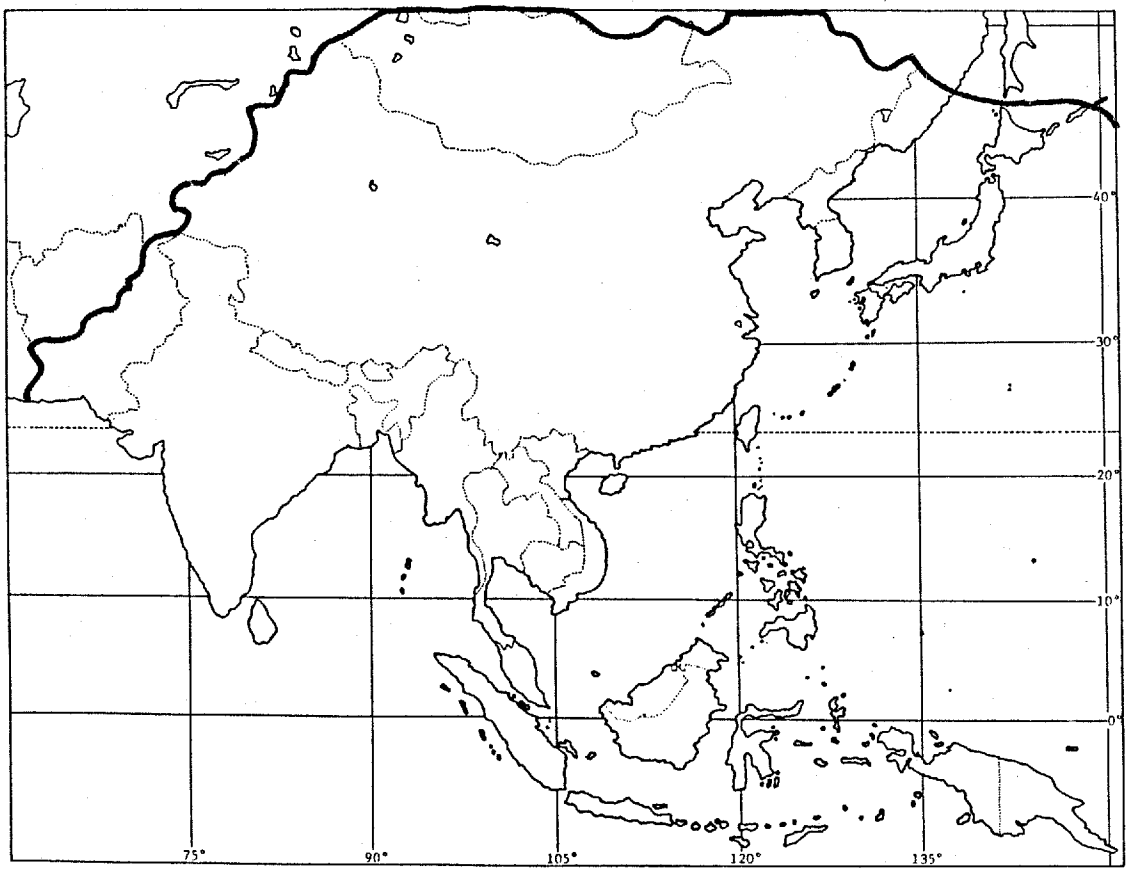

Figure I. Map showing the study area.

III. History

1. Classification systems of leucobryoid genera

The genus Leucobryum was validly described by Hampe (1839). Before Hampe (1939), the taxa of Leucobryum were included in Dicranum, Bryum or Sphagnum because of their dicranoid sporophyte and whitish habits like Sphagnum. Leucobryum is characterized by its unique structure of leaves which are composed of leucocysts and chlorocysts. Schimper (1856) proposed Leucobryaceae which comprises Leucophanes, Octoblepharum and Arthrocormus together with Leucobryum, all of them have leucobryoid leaves.

Eleven genera are currently known as leucobryoid mosses which belong to Leucobryaceae in a wide sense. However, the classification systems of leucobryoid genera are very variable by each taxonomists (Table 1). Cardot (1899) classified Leucobryaceae into four tribus: Leucobryeae, Leucophaneae, Octoblephareae and Arthrocormeae. Brotherus (1901) adopted Cardot's sense of Leucobryaceae with four tribus. Brotherus (1924) promoted each tribus to subfamilies, namely, Leucobryoideae, Leucophanoideae, Octoblepharoideae and Arthrocomoideae, and he placed Leucobryaceae (sensu Cardot) in Dicranales. The classification systems of Leucobryaceae by Cardot and

Table 1. Summary of various classification of genera with leucobryoid leaves

Cardot (1899)	Fleischer (1904)	Herzog (1926)	Andrews (1947)	Vitt (1984)	Robinson (1985, 1990)	Eddy (1990)	Yamaguchi (1992)
LEUCOBRYACEAE	LEUCOBRYACEAE	LEUCOBRYACEAE	DICRANACEAE (syn. Leucobryaceae)	LEUCOBRYACEAE	LEUCOBRYACEAE	LEUCOBRYACEAE	LEUCOBRYACEAE
Leucobryeae	Eu-leucobryeae	Leucobryoideae					
Leucobryum	*Leucobryum*	*Leucobryum*	*Leucobryum* (Syn. *Cardotia*)	*Leucobryum*	*Leucobryum*	*Leucobryum*	*Leucobryum*
	Schistomitrieae					SCHISTOMITRIACEAE	
Ochrobryum		*Ochrobryum*	*Ochrobryum*	*Ochrobryum*	*Ochrobryum*	*Ochrobryum*	*Ochrobryum*
Cladopodanthus	*Cladopodanthus*	*Cladopodanthus*	*Cladopodanthus*	*Cladopodanthus*	*Cladopodanthus*	*Cladopodanthus*	*Cladopodanthus*
Schistomitrium	*Schistomitrium*	*Schistomitrium*	*Schistomitrium*	*Schistomitrium*	*Schistomitrium*	*Schistomitrium*	*Schistomitrium*
	LEUCOPHANACEAE		CALYMPERACEAE (syn. Leucophanaceae)	CALYMPERACEAE			CALYMPERACEAE
Octoblephareae	Octoblephareae	Octoblepharoideae				OCTOBLEPHARACEAE	
Octoblepharum	*Octoblepharum*	*Octoblepharum*	*Octoblepharum*	*Octoblepharum*	*Octoblepharum*	*Octoblepharum*	*Octoblepharum*
Cardotia							
Arthrocormeae	Arthrocormeae	Arthrocormoideae				CALYMPERACEAE	
Arthrocormus	*Arthrocormus*	*Arthrocormus*	*Arthrocormus*	*Arthrocormus*	*Arthrocormus*	*Arthrocormus*	*Arthrocormus*
					Holomitriopsis[2]		
					Steyermarkiella[2]		
Exodictyon	*Exodictyon*	*Exodictyon*	*Exodictyon*	*Exodictyon*	CALYMPERACEAE *Exodictyon*[3]	*Exodictyon* *Exostratum*	*Exodictyon*
		LEUCOPHANACEAE					
Leucophaneae	Leucophaneae						
Leucophanes	*Leucophanes*	*Leucophanes*	*Leucophanes*	*Leucophanes* *Carinafolium*[1]	*Leucophanes*	*Leucophanes*	*Leucophanes*

[1] *Carinaofolium* was described by Williams (1931) as monotypic genus including only *Carinafolium tatei* Williams. Bartram (1960) recombined *C. tatei* with *Octoblepharum* as *O. tatei* (Williams) Bartr.

[2] *Holomitriopsis* and *Steyermarkiella* were described by Robinson (1965b) as monotypic genera.

[3] Ellis (1985) devided *Exodictyon*(sensu lato) into *Exodictyon* (sensu strict) and *Exostratum*.

Brotherus were based on gametophytic characters, especially on cross-sectional features of leaves.

Fleischer (1904), considering peristome structure, divided Leucobryaceae (sensu Cardot) into two families, Leucobryaceae and Leucophanaceae. Fleischer (1904) placed Leucobryaceae (sensu Fleischer) with dicranoid peristome in Reihe Dicranoideae together with Dicranaceae and Fissidentaceae. At the same time, he placed Leucophanaceae with hyophiloid peristome in Reihe Hyophiloideae together with Syrrhopodontaceae and Calymperaceae.

Although Fleischer (1923) rearranged both Leucophanaceae and Leucobryaceae (sensu Fleischer) in Unterreich Leucobryineae (Reihe Dicranales), his principal consideration in which the Leucobryaceae (sensu Cardot) was divided into two groups was accepted by Andrews (1947), Vitt (1984) and others. Andrews (1947) included Leucobryaceae (sensu Fleischer) and Leucophanaceae in Dicranaceae and Calymperaceae respectively. Crosby and Magill (1981) compiled a list of genera including familial disposition based on the Andrew's system concerning leucobryoid genera. Vitt (1984) revived Leucobryaceae (sensu Fleischer) and disposed it in Dicranineae, and placed other leucobryoid genera in Calymperaceae (Pottineae). Ellis (1985) emended Leucophanoideae (Card.) Broth. and described Calymperaceae subfamily Leucophanoideae which includes Leucophanes,

Octoblepharum, Arthrocormus, Exostratum and Exodictyon. I agree with classification of Vitt (1984) and Ellis (1985). Yamaguchi and Iwatsuki (1991) used subfamily Leucophanoideae in the study of New Caledonian moss flora.

2. History of the taxonomic studies of Asian Leucobryum

The first species of Leucobryum was described by Bridel (1798) as Sphagnum javense. The name Sphagnum javense became nomenclaturally valid by the publication of Schwägrichen (1823), and S. javense was combined with Leucobryum by Mitten (1859), namely, L. javense (Brid. ex Schwägr.) Mitt.

After that, a large number of taxa were described from Asia mainly by European bryologists. Main authorities who contributed to the descriptions of new taxa from Asia (cf. Fig. I for area of Asia in this study) were Dozy and Molkenboer (1845, 1854, 1855), Fleischer (1899, 1904), Bescherelle (1898) and Renauld and Cardot (1905). Dozy, Molkenboer and Fleischer made great contributions to taxonomic study of Leucobryum and related genera of Java, Sumatra and Borneo. Bescherelle, Cardot and Renauld described many taxa from Japan, China, India and neighboring regions. Seventy one species with seven varieties are currently known from Asia as shown in Table 2.

Iwatsuki (1966, 1977) and Iwatsuki and Noguchi (1979) reduced many species to the synonymy, and proved the

Table 2. Historical review of Asian Leucobryum[1]

Leucobryum glaucum (Hedw.) Ångström in Fries (1846) [Europe, N. America and Jamaica. Basionym: Dicranum glaucum Hedwig (1801). Also reported from China and Japan]

L. javense (Brid. ex Schwägr.) Mitten (1859) [Java, Réunion. Basionym: Sphagnum javense Bridel ex Schwägrichen (1823)]

L. candidum (Bridel ex P. Beauv.) Wilson (1854) [Australia. Basionym: Dicranum candidum Bridel ex Palisot de Beauvois (1805). Also reported from S. E. Asia]

L. juniperoideum (Brid.) C. Müller (1845) [Tenerife and Réunion. Basionym: Dicranum juniperoideum Bridel (1826). Also reported from Japan, Taiwan, China and India]

L. sanctum (Brid.) Hampe (1839) [Java. Basionym: Dicranum glaucum var. sanctum Bridel (1827)]

L. piliferum (Dozy & Molk.) Jaeger (1873) [Java. Basionym: Cladopodanthus pilifer Dozy & Molkenboer (1845)]

L. chlorophyllosum C. Müller (1851) [Sumbawa]

L. mucronifolium Braun in C. Müller (1851) [Java]

L. neilgherrense C. Müller (1854) [India]

L. aduncum Dozy & Molkenboer (1854) [Java]

L. pentastichum Dozy & Molkenboer (1854) [Java]

L. holleanum Dozy & Molkenboer (1855) [Java]

L. teysmannianum Dozy & Molkenboer (1855) [Java]

L. boninense Sullivant & Lesquereux (1859) [Japan]

L. bowringii Mitten (1859) [India, Sri Lanka and China]

L. scabrum Sande Lacoste (1866) [Japan]

L. triviale C. Müller (1869) [India]

L. stenophyllum Bescherelle (1873) [New Caledonia. Also reported from New Guinea]

L. naumannii C. Müller (1884) [New Guinea]

L. auriculatum C. Müller in Geheeb (1889) [New Guinea]

L. retractum Bescherelle (1893) [Japan]

[1]Type locality is represented in square brackets.

Table 2. Continued

L. pachyphyllum C. Müller (1896) [Hawaii. Also reported from New Guinea]

L. papuense Paris (1896) [New Guinea]

L. ceylanicum (Besch.) Cardot (1901) [Sri Lanka. Basionym: Ochrobryum ceylanicum Bescherelle (1897)]

L. humillimum Cardot (1901) [India. Basionym: Ochrobryum wightii Bescherelle (1897)]

L. japonicum (Besch.) Cardot in Brotherus (1901) [Japan. Basionym: Ochrobryum japonicum Bescherelle (1897)]

L. arfakianum C. Müller ex Geheeb (1898) [New Guinea]

L. sericeum Brotherus ex Geheeb (1898) [New Guinea]

L. altiusculum Bescherelle (1898) [Japan]

L. brevicaule Bescherelle (1898) [Japan]

L. galeatum Bescherelle (1898) [China]

L. humile Brotherus ex Bescherelle (1898) [Japan]

L. lacteorum Bescherelle (1898) [Japan]

L. mittenii Bescherelle (1898) [India]

L. textorii Bescherelle (1898) [Japan]

L. wichurae Brotherus ex Bescherelle (1898) [Japan]

L. yamatense Bescherelle (1898) [Japan]

L. holleanum var. fragilifolium Fleischer (1899) [Java]

L. imbricatum Brotherus (1899a) [India]

L. nagasakense Brotherus (1899b) [Japan]

L. cuculliphyllum Fleischer (1904) [Sri Lanka]

L. scalare C. Müller ex Fleischer (1904) [Java, Sumbawa, Singapore and Philippines]

L. scalare var. marschmeyeri Fleischer (1904) [Java]

L. scalare var. tjibodense Fleischer (1904) [Java]

L. sumatranum Brotherus ex Fleischer (1904) [Sumatra]

L. uncinatum Fleischer (1904) [Borneo]

L. cucullifolium Cardot in Renauld & Cardot (1905) [India and Nepal]

L. deciduum Cardot in Renauld & Cardot (1905) [Vietnam]

Table 2. Continued

L. brotheri Cardot in Renauld & Cardot (1905) [Sumatra, Sulawesi, Sri Lanka and Japan]

L. ferriei Cardot in Renauld & Cardot (1905) [Japan]

L. flavulum Cardot in Renauld & Cardot (1905) [Sri Lanka]

L. salmonii Cardot in Renauld & Cardot (1905) [China]

L. scaberulum Cardot in Renauld & Cardot (1905) [China]

L. siamicum Bescherelle in Renauld & Cardot (1905) [Siam]

L. stenobasis Cardot in Renauld & Cardot (1905) [Himalaya, Sri Lanka]

L. neilgherrense var. minus Cardot (1905) [Taiwan]

L. confine Cardot (1905) [Taiwan]

L. subsanctum Brotherus (1907) [Philippines]

L. rhizophyllum Warnstorf (1915) [Japan]

L. subscalare Brotherus ex Potier de la Varde (1917) [Cambodia]

L. krempfii Thériot (1919) [Vietnam]

L. cyathifolium Dixon (1922) [New Guinea]

L. pulchrum Brotherus (1928) [Borneo]

L. angustissimum Brotherus (1929) [China]

L. armatum Brotherus (1929) [China]

L. poilanei Thériot (1929) [Cambodia]

L. perichaetiale Dixon (1932a) [Siam]

L. scaberulum var. divaricatum Dixon (1933) [China]

L. subsericeum Dixon (1933) [China]

L. nakaii Horikawa (1935) [Japan]

L. aduncum var. arnottii Thériot (1936) [Indes orientales]

L. propaguliferum (Dix.) Robinson (1965a) [Sri Lanka and India. Basionym: Ochrobryum propaguliferum Dixon (1938)]

L. novae-guineae Bartram (1953) [New Guinea]

L. brassii Bartram (1957) [New Guinea]

L. antarense Zanten (1964) [New Guinea]

L. papuense var. pendulum Zanten (1964) [New Guinea]

Table 2. Continued

L. byssaceum C. Müller ex Johnson (1964) [New Guinea]
L. microleucophanoides Dixon ex Johnson (1964) [Malay Penin.]

Table 3. Taxonomic treatments of Japanese Leucobryum by Iwatsuki (1966, 1977) and Iwatsuki and Noguchi (1979)

Leucobryum bowringii Mitt.
Syn. L. confine Card.
L. nagasakense Broth.
L. yamatense Besch.

L. glaucum (Hedw.) Ångstr. in Fries

L. javense (Brid. ex Schwägr.) Mitt.

L. neilgherrense C. Müll.
Syn. L. altiusculum Besch.
L. boninense Sull. & Lesq.
L. brevicaule Besch.
L. ferriei Card. in Ren. & Card.
L. humile Broth. ex Besch.
L. japonicum (Besch.) Card. in Broth.
L. lacteorum Besch.
L. nakaii Hor.
L. retractum Besch.
L. rhizophyllum Warnst.

L. scaberulum Card. in Ren. & Card.

L. scabrum Lac.

Table 4. Taxonomic treatment of Leucobryum juniperoideum of Japan by Yamaguchi and Iwatsuki (1988)

Leucobryum juniperoideum (Brid.) C. Müll.
Syn. L. altiusculum Besch.
L. brevicaule Besch.
L. ferriei Card. in Ren. & Card.
L. humile Broth. ex Besch.
L. japonicum (Besch.) Card. in Broth.
L. lacteorum Besch.
L. neilgherrense C. Müll. (specimens reported from Japan)
L. rhizophyllum Warnst.
L. textorii Besch.

Table 5. Taxonomic treatment of Malesian Leucobryum by Enroth (1989, 1990)

Leucobryum aduncum Dozy & Molk.

Syn. L. scalare C. Müll. ex Fl.

L. scalare var. marschmeyeri Fl.

L. scalare var. tjibodense Fl.

L. subscalare Broth. ex Vard.

L. bowringii Mitt.

Syn. L. brotheri Card. in Ren. & Card.

L. confine Card.

L. sericeum Broth. ex Geh. — L. bowringii var. sericeum (Broth. ex Geh.) Dix.

L. chlorophyllosum C. Müll.

L. javense (Brid. ex Schwägr.) Mitt.

Syn. L. brassii Bartr.

L. candidum (Brid. ex P. Beauv.) Wils.

L. cyathifolium Dix.

L. novae-guineae Bartr.

L. pentastichum Dozy & Molk. — L. candidum var. pentastichum (Dozy & Molk.) Dix.

L. teysmannianum Dozy & Molk.

L. uncinatum Fl.

L. neilgherrense C. Müll.

Syn. L. holleanum Dozy & Molk.

L. triviale C. Müll.

L. pulchrum Broth.

L. sanctum (Brid.) Hampe

Syn. L. arfakianum C. Müll. ex Geh.

L. papuense Par.

L. subsanctum Broth.

L. stenophyllum Besch.

Syn. L. byssaceum C. Müll. ex Johnson

Table 6. Taxonomic treatment of Malesian Leucobryum by Eddy (1990)

Leucobryum aduncum Dozy & Molk. var. aduncum

L. aduncum var. scalare (Dozy & Molk.) A. Eddy

Basionym L. scalare C. Müll. ex Fl.

Syn. L. scalare var. marschmeyeri Fl.

L. scalare var. tjibodense Fl.

L. bowringii Mitt.

Syn. L. brotheri Card. in Ren. & Card.

L. sericeum Broth. ex Geh. — L. bowringii var. sericeum (Broth. ex Geh.) Dix.

L. candidum (Brid. ex P. Beauv.) Wils.

Syn. L. pentastichum Dozy & Molk. — L. candidum var. pentastichum (Dozy & Molk.) Dix.

L. teysmannianum Dozy & Molk.

L. javense (Brid. ex Schwägr.) Mitt.

Syn. L. antarense Zant.

L. brassii Bartr.

L. candidum (P. Beauv.) Wils.

L. cyathifolium Dix.

L. novae-guineae Bartr.

L. uncinatum Fl.

L. juniperoideum (Brid.) C. Müll.

Syn. L. holleanum Dozy & Molk.

L. neilgherrense C. Müll.

L. microleucophanoides Dix. ex Johnson

L. papuense Par.

Table 6. Continued

L. sanctum (Brid.) Hampe var. sanctum
Syn. L. auriculatum C. Müll. in Geh.
L. sanctum var. arfakianum (C. Müll. ex Geh.) A. Eddy
Basionym L. arfakianum C. Müll. ex Geh.
Syn. L. papuense Par.
L. subsanctum Broth.
L. scabrum Lac.
L. sumatranum Broth. ex Fl.
Syn. L. pulchrum Broth.

occurrence of six species of Leucobryum in Japan (Table 3). Yamaguchi and Iwatsuki (1988) proposed that Leucobryum neilgherrense C. Müll. reported from Japan was identical with L. juniperoideum (Brid.) C. Müll. described from Canary Islands and Réunion Island (Table 4).

Enroth (1989, 1990) and Eddy (1990) re-examined Malesian taxa of Leucobryum. However, there are some difference of taxonomic treatments between them (Table 5, 6). As mentioned by Eddy (1990), taxonomic status of Asian Leucobrya is not settled. It is necessary to critically re-examine the type specimens and to clarify the taxonomic status of Leucobryum in Asia where the genus is one of the main constituents of bryoflora.

IV. Morphology

General morphology of Leucobryum species is described below and each character is discussed in view of its taxonomic value in the genus.

1. Habit

Color of plants is yellowish- or whitish-green when moist and whitish when dry. Some taxa, such as L. bowringii and L. sumatranum, have more or less glossy appearances.

Most taxa of Leucobryum grow on soil and humus, and form colonies like cushions. Some taxa also grow on tree

trunks (e. g. Leucobryum arfakianum C. Müll. ex Geh.) or wet rocks (e. g. Leucobryum scabrum Lac.). The habitats and the growth habits are important characters for taxonomy of Leucobryum.

Figs. II-IV show plants of 19 taxa of Leucobryum in Asia. Each taxon differs in plant size, leaf arrangement.

Most species of perennial acrocarpous mosses continuously grow by innovations. However, the maximum size of plant is limited and variable among taxa. The variation of plant size seems to be depending on the branching pattern, amount of annual growth and habitat. Taxa with perichaetia terminal on lateral short branches, which continuously grow by elongation of main stems and without subfloral innovations, tend to be robust. They are L. javense and its varieties, L. scabrum and L. sumatranum. The plants growing in wet habitats tend to elongate. They are plants of L. scabrum growing on vertical rock faces splashed with water in streams, and plants of L. glaucum growing on wet humus in damp sites.

Leaf arrangement and posture are classified by manner of spreading, secundness and shape when dry. Leaves of some taxa, such as L. aduncum var. aduncum, L. aduncum var. teysmannianum and L. boninense, are arranged in five rows on stem. However, sometimes the pentastichous leaf arrangement

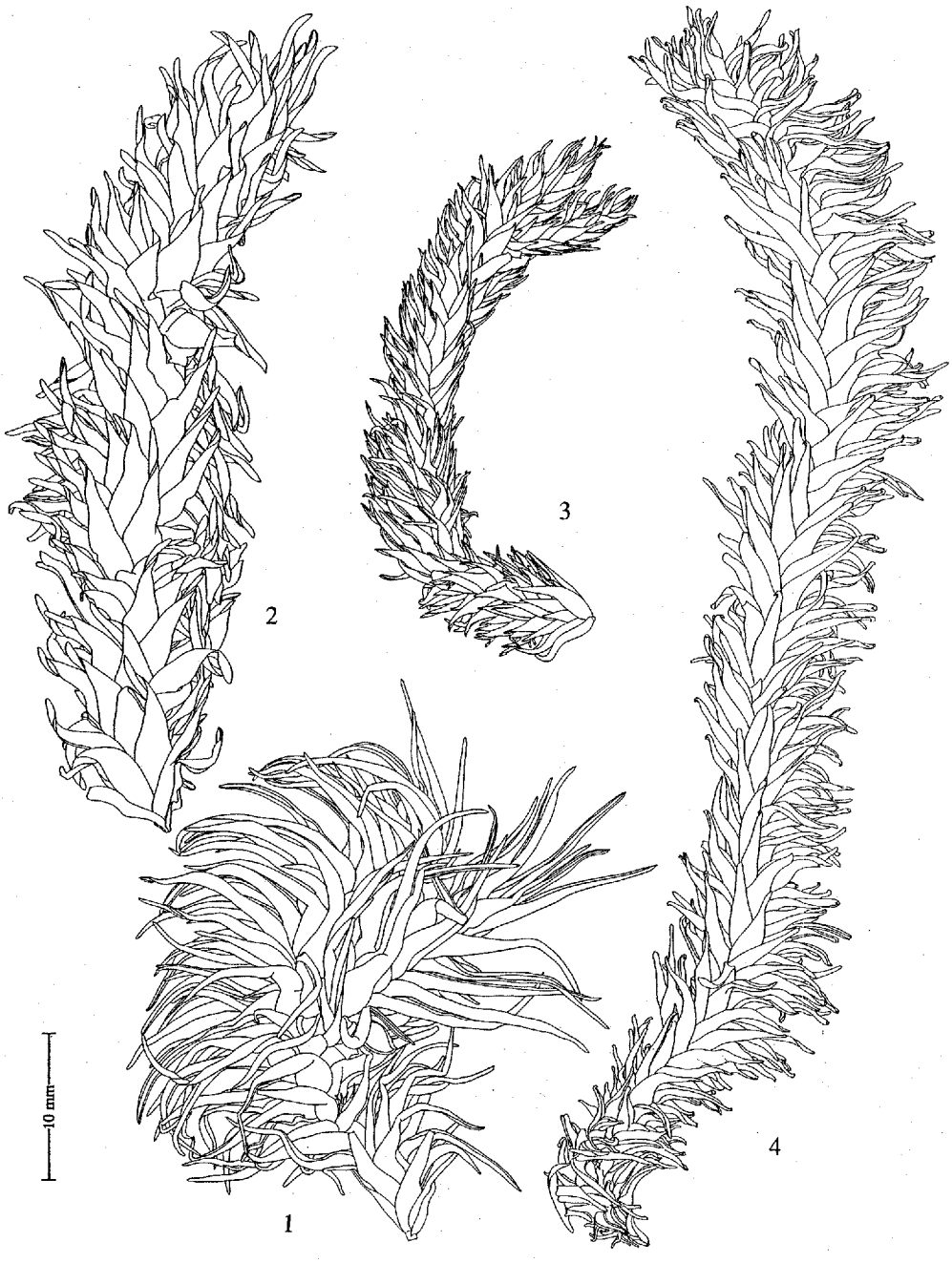

Figure II. Habits of 4 taxa of Leucobryum. 1. L. javense (Brid. ex Schwägr.) Mitt. 2. L. javense var. cyathifolium (Dix.) T. Yamaguchi. 3. L. javense var. novae-guineae (Bartr.) T. Yamaguchi. 4. L. javense var. uncinatum (Fl.) T. Yamaguchi. Fig. 1 was drawn from Joncheere 1621 (L); 2, from holotype of L. cyathifolium (BM); 3, from holotype of L. novae-guineae (FH); 4, from holotype of L. uncinatum (FH).

Figure III. Habits of 10 taxa of Leucobryum. 1. L. scabrum Lac. 2. L. aduncum Dozy & Molk. var. aduncum. 3. L. aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. 4. L. aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 5. L. chlorophyllosum C. Müll. 6. L. boninense Sull. & Lesq. 7. L. juniperoideum (Brid.) C. Müll. 8. L. humillimum Card. 9. L. imbricatum Broth. 10. L. glaucum (Hedw.) Ångstr. in Fries. Fig. 1 was drawn from holotype of L. scabrum (L); 2, from lectotype of L. aduncum (L); 3, from holotype of L. teysmannianum (L); 4, from lectotype of L. scalare var. marschmeyeri (FH); 5, from isotype of L. chlorophyllosum (L); 6, from holotype of L. boninense (FH); 7, from syntype (Teneriffa) of Dicranum juniperoideum (B); 8, from isotype of L. galeatum (BM); 9, from lectotype of L. imbricatum (H); 10, from Europe, Sept. 1797, s. n. (B).

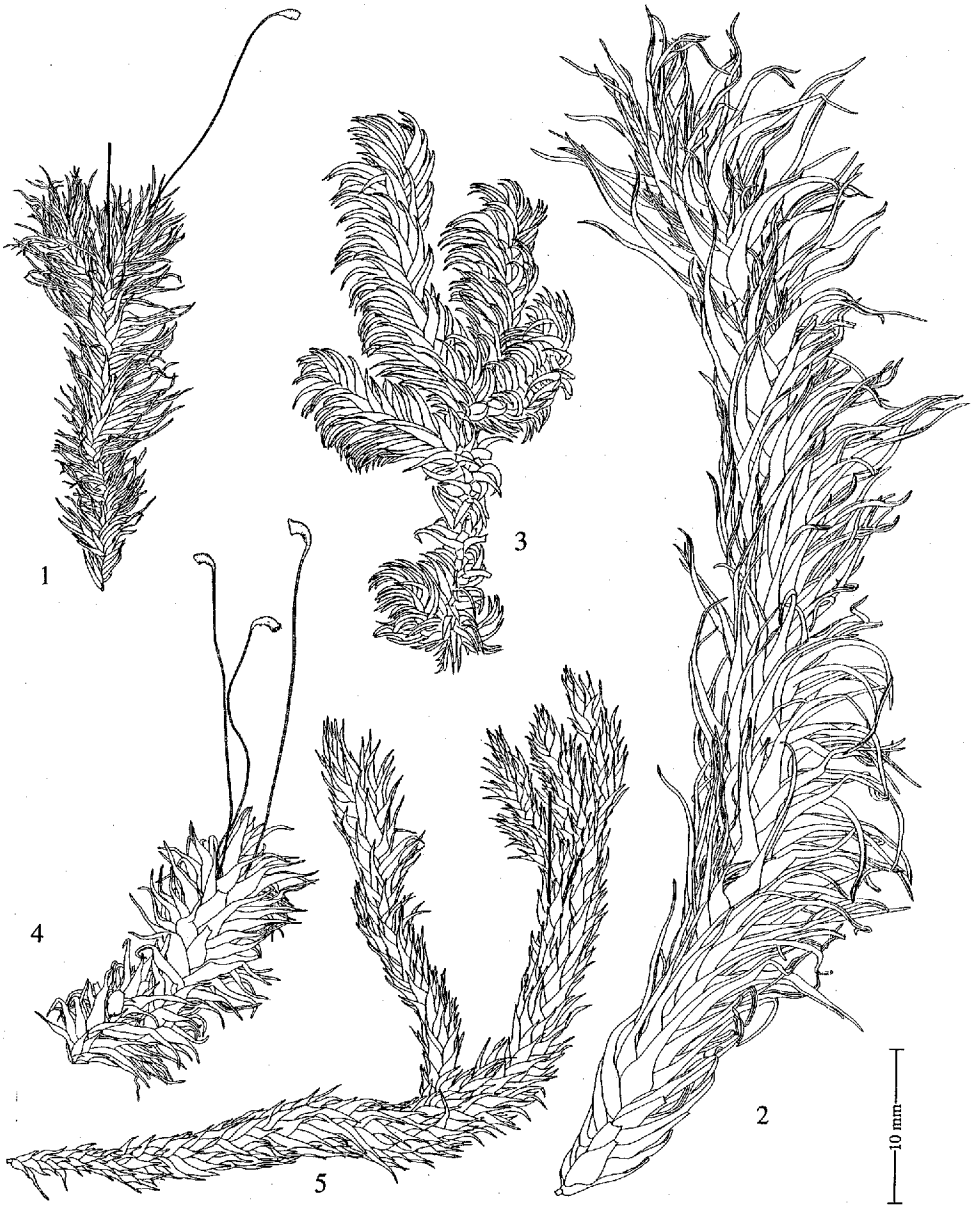

Figure IV. Habits of 5 taxa of Leucobryum. 1. L. bowringii Mitt. 2. L. sumatranum Broth. ex Fl. 3. L. sericeum Broth. ex Geh. 4. L. sanctum (Brid.) Hampe. 5. L. arfakianum C. Müll. ex Geh. Fig. 1 was drawn from lectotype of L. bowringii (NY); 2, from holotype of L. sumatranum (FH); 3, from holotype of L. sericeum (H); 4, from holotype of Dicranum glaucum var. sanctum (B); 5, from isolectotype of L. arfakianum (FI).

is not clear. Leaf arrangement and posture are variable to a certain extent owing to growing habitat or maturity.

2. Stems

Kawai (1980) studied detailed anatomical characters of stems in five species of Japanese Leucobryum by staining methods. He distinguished tow different types of stem anatomy in Leucobryum as follows:

1 (type III in Kawai 1980). Stem differentiates into an epidermis, cortex, leptom and a hadrom. L. scabrum, L. javense and L. textorii (= L. juniperoideum) were included in this type.

2 (type IV in Kawai 1980). Stem differentiates into an epidermis, cortex, leptom, hydrom sheath and a hadrom. L. neilgherrense (= L. juniperoideum) and L. bowringii were included in this type.

However, according to my observations of stem anatomy, differentiation between epidermis and cortex, that between cortex and leptome, and that between cortex and central tissue are indistinct. My observations also show a certain variability within a species. Therefore, in this study, I distinguished three parts in the cross-section of a stem, which are epidermal layer, cortical layer and central strand. In my classification, the epidermal layer includes a part of cortex which defined by Kawai (1980), and the cortical layer includes leptome and a part of cortex. The

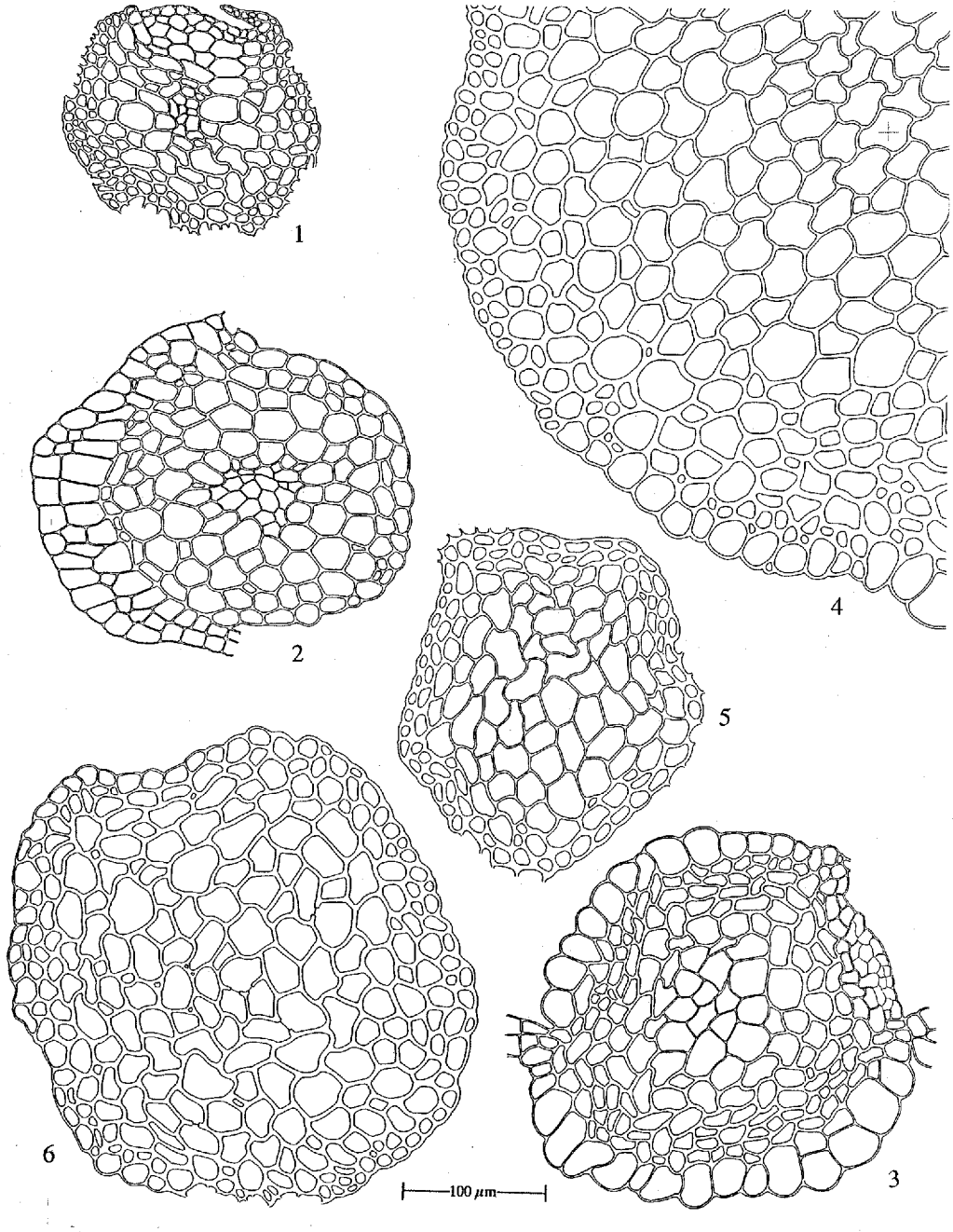

Figure V. Cross-sections of stems of 6 taxa of Leucobryum. 1. L. bowringii Mitt. 2. L. imbricatum Broth. 3. L. arfakianum C. Müll. ex Geh. 4. L. javense (Brid. ex Schwägr.) Mitt. 5. L. aduncum Dozy & Molk. 6. L. glaucum (Hedw.) Ångstr. in Fries. Fig. 1 was drawn from lectotype of L. bowringii (NY); 2, from lectotype of L. imbricatum (H); 3, from isolectotype of L. arfakianum (FI); 4, from Joncheere (L); 5, from lectotype of L. aduncum (L); 6, from Europe, Sept. 1797, s. n. (B).

central strand by my definition corresponds to the hydrom sheath and the hadrom by Kawai (1980). My classification is not anatomically distinct, but it is reasonable judging from the variability within a species, and it is effective concerning for systematic study of Leucobryum.

Based on the three parts of stem tissues mentioned above, I recognize here three principal types of stem structure.

Type A. The differentiation between the epidermal and the cortical layers is distinct, but the central strand is indistinct (Fig. V: 4-6). This type is nearly equivalent to type III by Kawai (1980). Taxa which belong to this type are L. javense and its varieties, L. scabrum, L. aduncum and its varieties, L. chlorophyllosum, L. boninense, L. juniperoideum and L. glaucum. The cortical layer of this type is usually composed of nearly uniform cells. However, the cortical layer cells of some robust taxa, such as L. javense and its varieties, are getting gradually smaller and the walls are thinner inward. In this case, however, the central strand is not differentiated. Sometimes the stems of L. juniperoideum have weakly differentiated central areas. The area is composed of smaller and thin-walled cells, but the cell walls are colored with light brown and different from the true central strand which is composed of small cells with colorless very thin walls. Because of the

structural variability of stems of L. juniperoideum, Kawai (1980) classified the species into type III (as L. textorii) and type IV (as L. neilgherrense). My observations prove that the materials of L. neilgherrense used by Kawai (1980) had weakly differentiated central area, but the cell walls were tinged with light brown. In conclusion, I determined that the stems of L. juniperoideum (syn. L. textorii and L. neilgherrense) belong to type A.

Type B. The differentiation between the epidermal and the cortical layers is distinct, and the central strand is clearly differentiated (Fig. V: 1, 3). The central strand is composed of small cells with colorless very thin walls. This type is nearly equivalent to type IV by Kawai (1980). Among the taxa treated in this study, L. humillimum, L. bowringii, L. sumatranum, L. sericeum, L. sanctum and L. arfakianum belong to type B. Among them, the central strands of L. sanctum and L. arfakianum are different from those of other taxa. In L. sanctum and L. arfakianum, the central strand is surrounded by one to three layers of large and thin walled cells (Fig. V: 3). The taxa which belong to type B are easily distinguished from type A by distinct central strand. However, the central strands of juvenile plants of type B are sometimes undifferentiated.

Type C. The central strand is distinctly differentiated, but the differentiation between the

epidermal and the cortical layers is not clear because of their nearly uniform cells (Fig. V: 2). Among the taxa treated in this study, only L. imbricatum belongs to type C.

In some cases, the abaxial leucocysts of leaves decurrent on stems and look like outer layers of stems in cross-sections. However, the leucocysts on stems are large and thin-walled, so that they are distinguished from the epidermis.

3. Leaves

(a) General morphology

The leaves of this genus are composed of leucocysts and chlorocysts (Fig. VI, VII). The leucocysts are hyaline empty cells which are devoid of any protoplasmic contents. The chlorocysts are green living cells which are enclosed by leucocysts in a single central layer and form a reticulum. The leaves of this genus are composed mainly of costa which is composed of a single layered chlorocyst sandwiched by two to several layers of leucocysts. The laminal areas are restricted to small narrow areas at the both margins of leaf base, and are composed of single layer of leucocysts. The most of laminal cells are quadrate or rectangular, but they are linear at margin (Fig. VI: 4, 5). These border cells are characterized by oblique cross and often pored walls, but the differentiation between the border cells and the

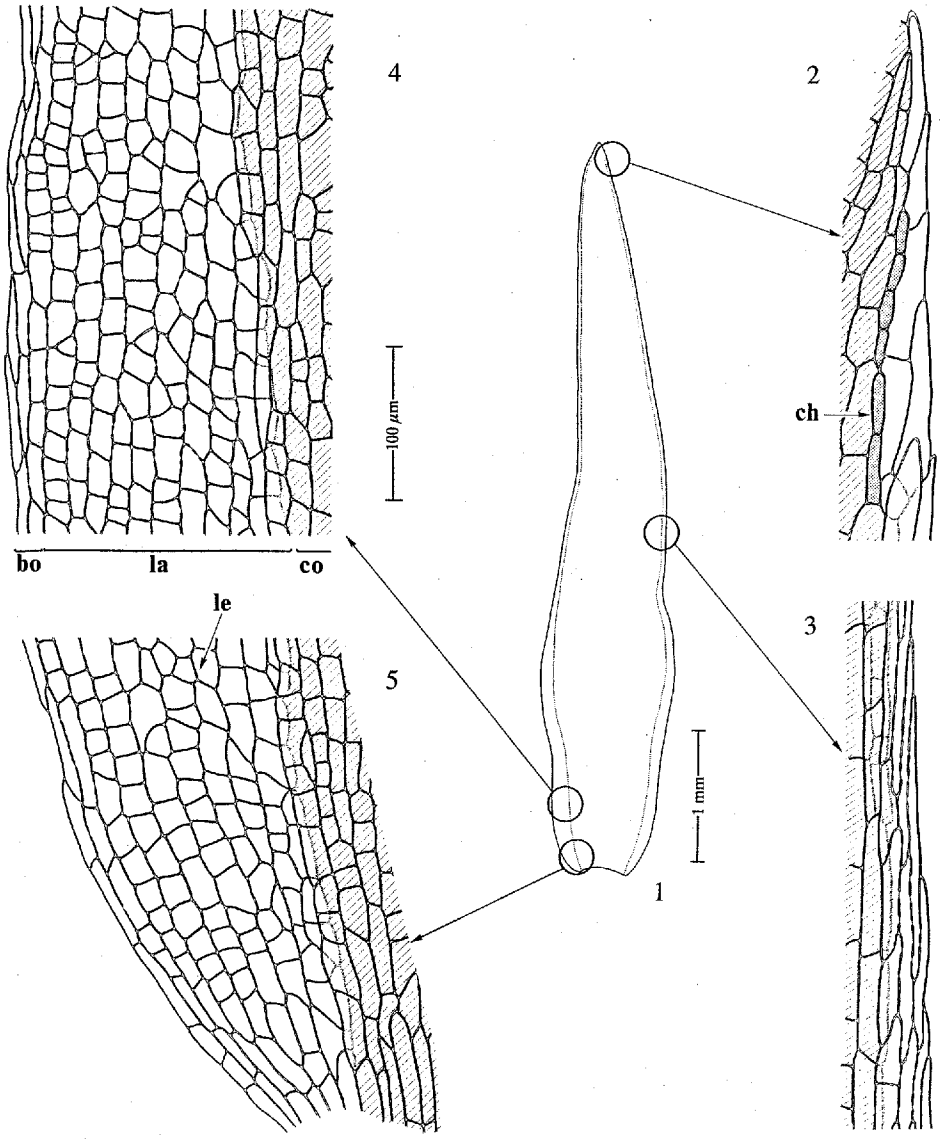

Figure VI. General morphology of leaf of Leucobryum. 1. Leaf (expanded). 2. Cells near leaf apex (adaxial view). 3. Median cells of leaf (abaxial view). 4. Basal cells of leaf (abaxial view). 5. Alar cells of leaf (abaxial view). bo shows border; ch, chlorocyst; co, costa; la, lamina; le, leucocyst. All figures were drawn from isotype of L. textorii (= L. juniperoideum; L).

laminal cells is often indistinct. The margin of upper part of leaf is usually composed of a few rows of linear cells (Fig. VI: 2, 3).

Castaldo et al. (1979), Ligrone (1985), Robinson (1985) and Yamaguchi and Iwatsuki (1987) studied the structure of leaves of Leucobryum using SEM or TEM. According to them, the chlorocysts are arranged in longitudinal rows interconnected by numerous anastomoses, and communicate each other by plasmodesmata that cross their transverse cell walls. The cell walls of leucocysts are thin and unipored both on the inner transverse and longitudinal faces. The leucocysts usually have external pores on the abaxial surfaces of cells at the apical and basal regions of leaves. The structure of leucocysts is effective in reducing water stress by either enhancing water absorption and storage or by lowering water loss (Hébant 1977, Proctor 1979, 1982, Ligrone 1985). Robinson (1985) also suggested that the leucocysts enhanced photosynthesis by having air bubbles mixed with the water in the cells.

In cross-sections of leaves the chlorocysts, except for the chlorocyst at the center, are rhombic and generally surrounded by four leucocysts (two on abaxial side and two on adaxial side; Fig. VII). The central chlorocyst in cross-section of leaf (Fig. VII: cch) is trapezoid and surrounded by one leucocyst on the adaxial side and three on

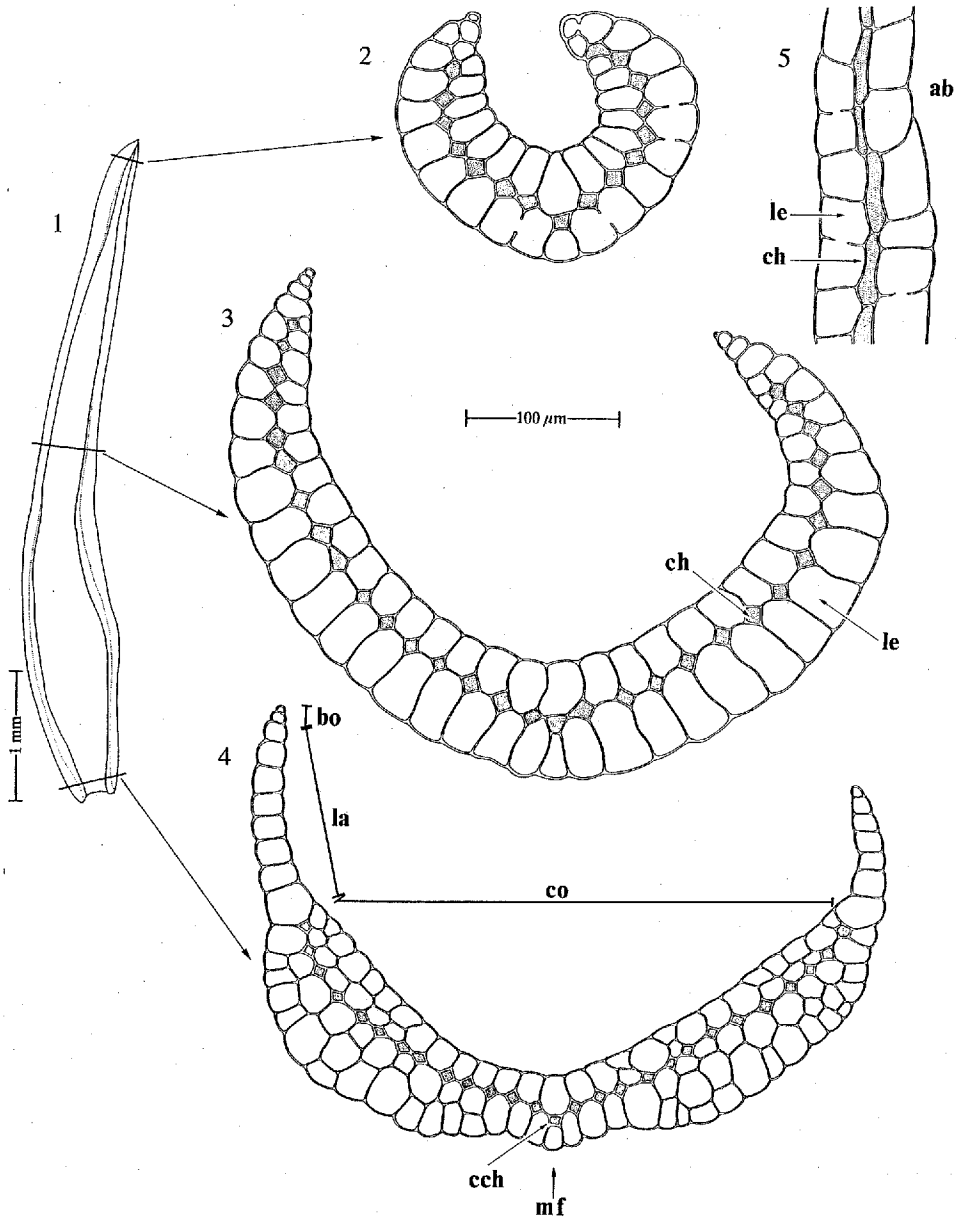

Figure VII. General morphology of leaf of Leucobryum. 1. Leaf. 2–4. Cross-sections of leaf (2, apical; 3, median; 4, basal portions). 5. Longitudinal section of leaf (apical portion). ab shows abaxial side; bo, border; cch, central chlorocyst; ch, chlorocyst; co, costa; la, lamina; le, leucocyst; mf, median furrow. Figs. 1–4 were drawn from isotype of L. textorii (= L. juniperoideum; L); 5, from holotype of L. holleanum (= L. juniperoideum; L).

the abaxial side. In cross-sections of leaf base show median furrow around the central chlorocyst (Fig. VII: 4). The median furrow regions are usually composed of two layered leucocysts. At the leaf base, the leucocysts are usually subdivided and becoming two or more layered on either side of the median furrow. The side part is more ore less convex in cross-sections.

The anatomical study of leaves in cross-sections had been reported by Cardot (1901). He classified the relative position of the chlorocysts, as centric, hypocentric or hypercentric according to whether they are median in vertical position or nearer to the abaxial or adaxial leaf face. He also defined homostrosic in which the leucocysts were arranged in two layers, and heterostrosic in which the leucocysts were arranged in more than two layers.

Cardot's system is not so effective in taxonomy of Leucobryum treated in this study, because most taxa are heterostrosic and centric at leaf bases (Fig. VIII). Moreover, each taxon shows a certain variability in the structure of leaf base. However, the leaves of L. sericeum, L. sanctum and L. arfakianum enhance a tendency to be homostrosic at bases. The leaves of L. sanctum and L. arfakianum are clearly hypocentric at bases, and this character is taxonomically important.

(b) Shape

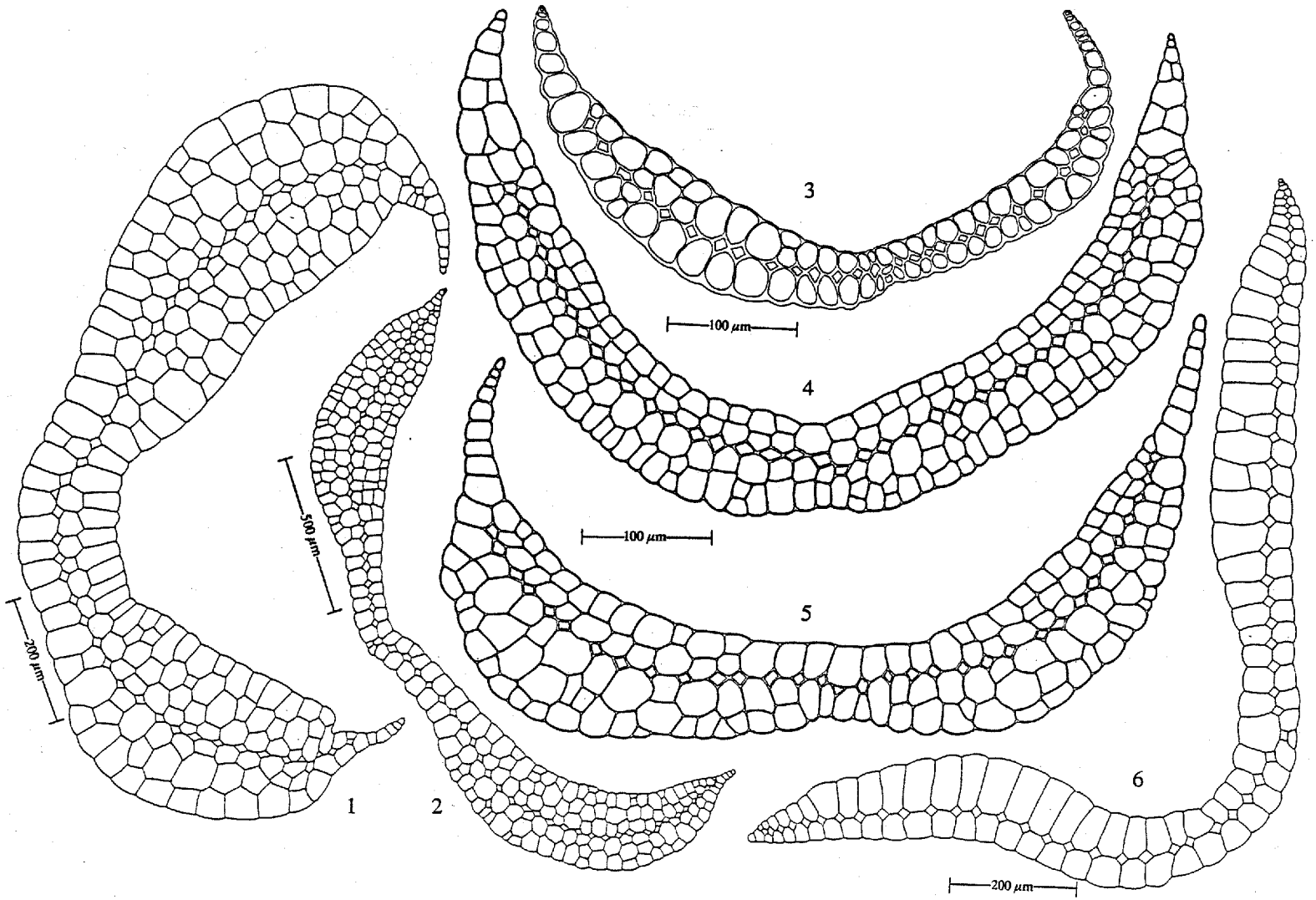

Figure VIII. Cross-sections of leaves. 1. Leucobryum scabrum Lac. 2. L. javense var. cyathifolium (Dix.) T. Yamaguchi. 3. L. bowringii Mitt. 4. L. glaucum (Hedw.) Ångstr. 5. L. juniperoideum (Brid.) C. Müll. 6. L. sanctum (Brid.) Hampe. Figure 1 was drawn from holotype of L. scabrum (L); 2, from holotype of L. cyathifolium (BM); 3, from lectotype of L. bowringii (NY); 4, from Europe, Sept. 1797, s. n. (B); 5, from syntype (Teneriffa) of Dicranum juniperoideum (B); 6, from holotype of D. glaucum var. sanctum (B)

In wet conditions, leaves of most taxa treated in this study are lanceolate from an oblong base. When leaves are pressed and expanded, the ratio of length to width become available, and the exact leaf shapes, such as lanceolate (Fig. IX: 10) or linear lanceolate (Fig. IX: 8), are determined. Moreover, when leaf apices are pressed and expanded, shape of leaf apices can be used as taxonomic characters, such as acuminate (Fig. IX: 8) or broadly acute (Fig. IX: 6). Most of the taxa treated in this study have straight leaves, but some taxa, such as L. javense var. javense, L. aduncum var. aduncum and L. sericeum, have falcate leaves. The leaves of L. javense var. cyathifolium and L. sanctum are somewhat squarrose.

(c) Proration of abaxial leucocysts

Most taxa treated in this study have projecting cell ends at leaf tips. While, some taxa have abaxially scabrous leaf surface at least to 1/10 from apex (Fig. X). They are caused by proration or undulation of abaxial leucocysts. The proration on the abaxial surface of apical parts of leaves is one of the important taxonomic characters, and it is classified into four types as follows: 1. smooth, 2. papillosely prorate, 3. undulate and 4. undulate and spinosely prorate (Fig. XI).

(d) Decurrence of abaxial leucocysts on stem

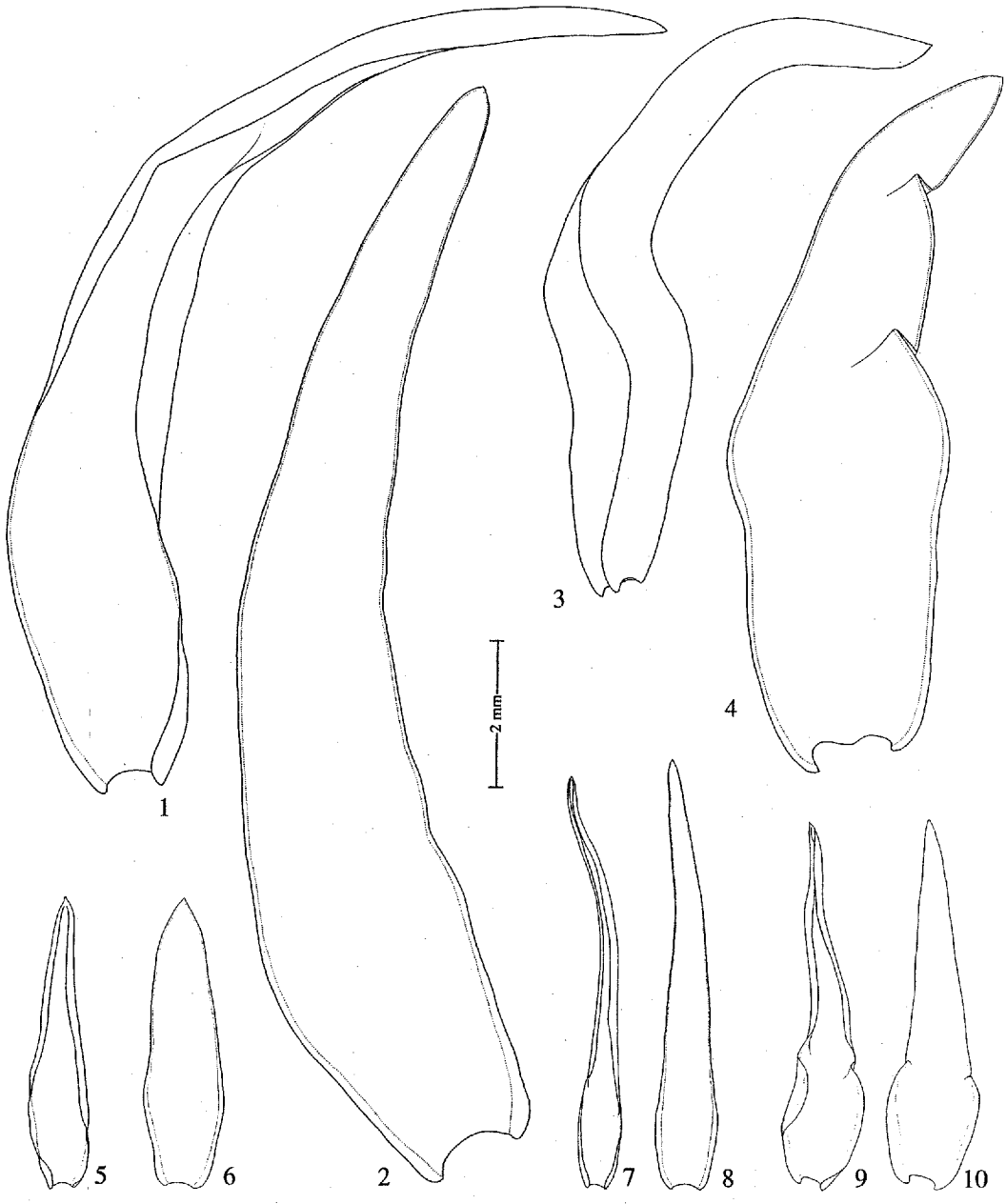

Figure IX. Leaves of 5 taxa of Leucobryum. 1, 2. L. javense (Brid. ex Schwägr.) Mitt. 3, 4. L. javense var. cyathifolium (Dix.) T. Yamaguchi. 5, 6. L. humillimum Card. 7, 8. L. bowringii Mitt. 9, 10. L. juniperoideum (Brid.) C. Müll. 2, 4, 6, 8, 10, expanded. Figs. 1, 2 were drawn from Joncheere 1621 (L); 3, 4, from holotype of L. cyathifolium (BM); 5, 6, from isotype of L. galeatum (BM); 7, 8, from holotype of L. deciduum (PC); 9, 10, from isolectotype of L. humile (KYO).

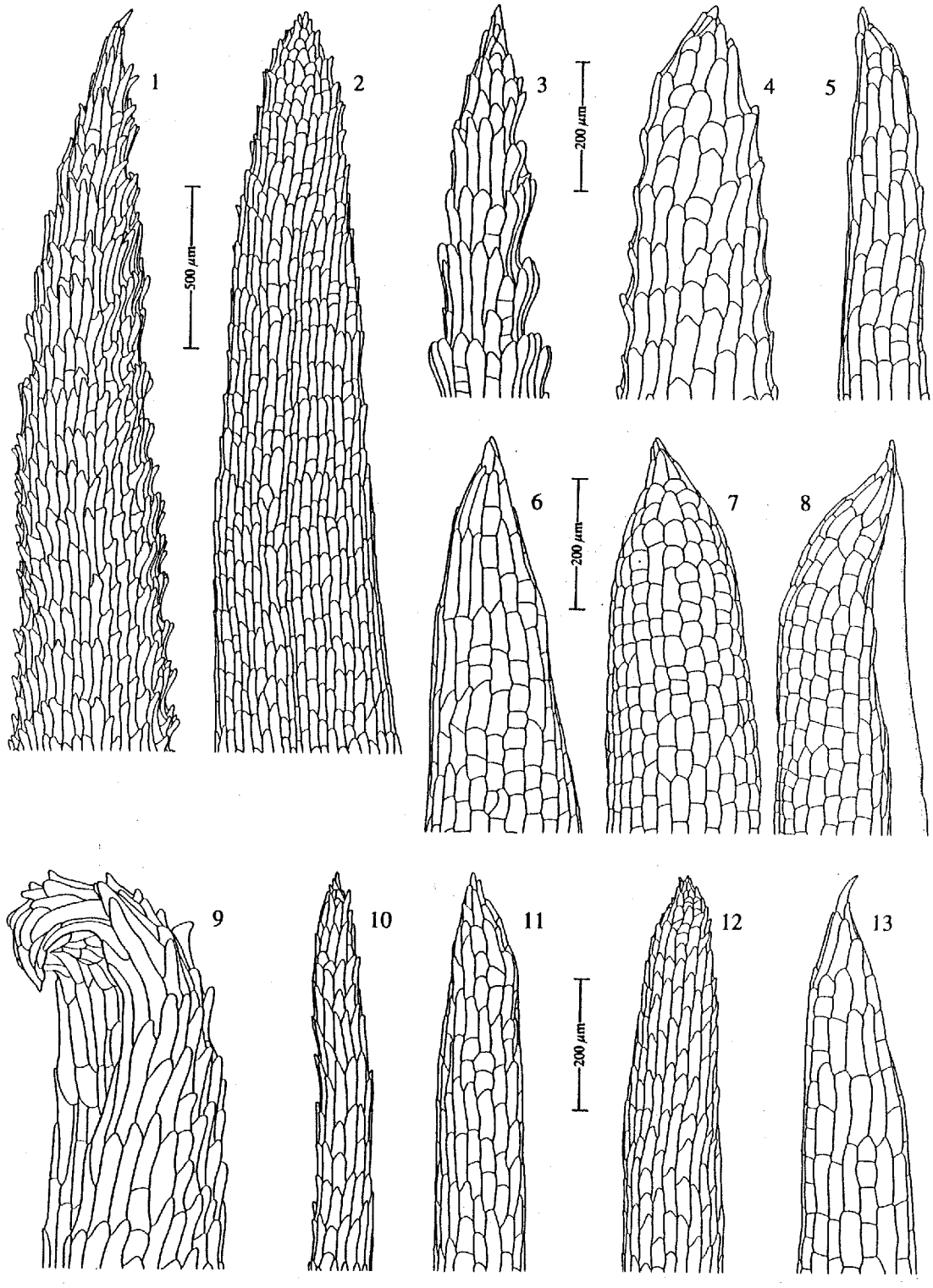

Figure X. Leaf apices of 12 taxa of Leucobryum. 1. L. scabrum Lac. 2. L. javense (Brid. ex Schwägr.) Mitt. 3. L. aduncum Dozy & Molk. 4. L. boninense Sull. & Lesq. 5. L. chlorophyllosum C. Müll. 6. L. juniperoideum (Brid.) C. Müll. 7, 8. L. humillimum Card. 9. L. javense var. cyathifolium (Dix.) T. Yamaguchi. 10. L. sericeum Broth. ex Geh. 11. L. bowringii Mitt. 12. L. sanctum (Brid.) Hampe. 13. L. arfakianum C. Müll. ex Geh. Fig. 1 was drawn from Yamaguchi 7188 (HIRO); 2, from Joncheere 1621 (L); 3, from lectotype of L. aduncum (L); 4, from holotype of L. boninense (FH); 5, from isotype of L. chlorophyllosum (L); 6, from syntype (Teneriffa) of Dicranum juniperoideum (B); 7, 8, from isotype of L. mittenii (BM); 9, from holotype of L. uncinatum (FH); 10, from holotype of L. sericeum (H); 11, from Faurie 62 labeled as L. bowringii f. brevifolium (KYO); 12, from holotype of Dicranum glaucum var. sanctum (B); 13, from holotype of L. papuense var. pendulum (L).

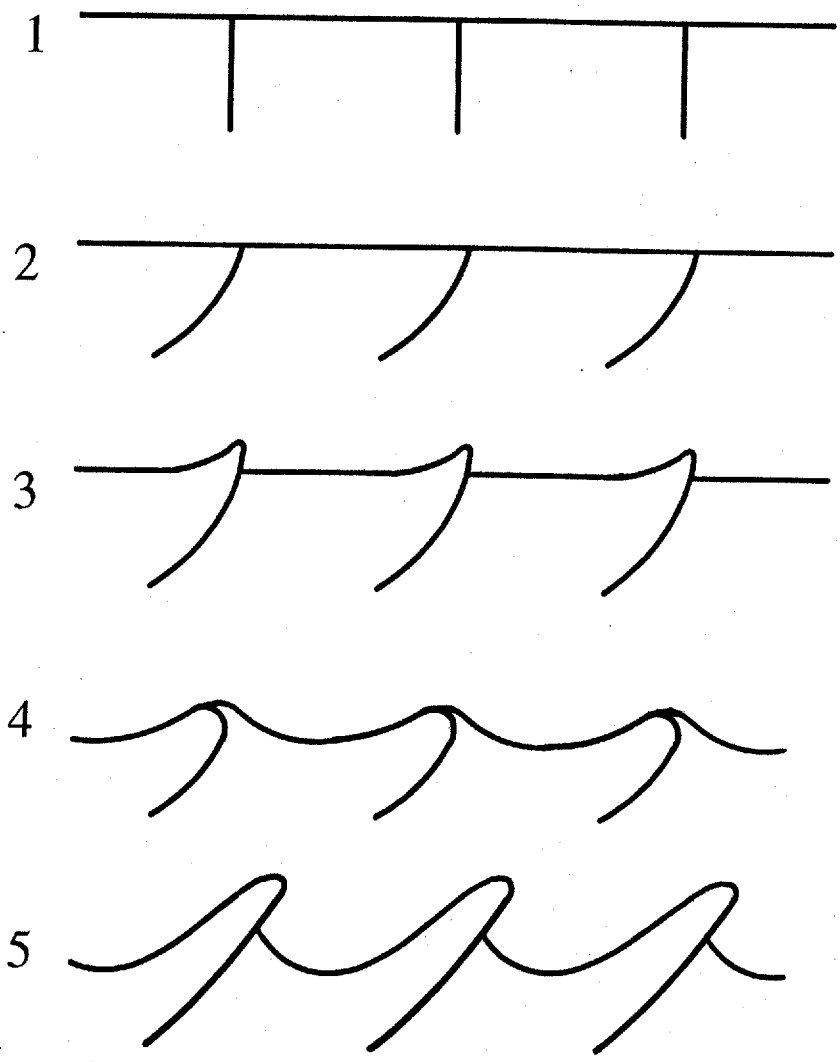

Figure XI. Schematic representation of proration on abaxial side of apical part of leaf. 1, 2. Smooth. 3. Papillosely prorate. 4. Undulate. 5. Undulate and spinosely prorate.

The abaxial leucocysts of extremely basal parts of leaves more or less overlap on cortical cells of stems. In some cases, such as in L. javense var. cyathifolium, L. javense var. novae-guineae, L. javense var. uncinatum, L. sanctum and L. arfakianum, the overlapped construction is recognized as a distinct decurrency. The decurrent part of these taxa, except for L. arfakianum, is composed of multilayered leucocysts. In L. sanctum and L. arfakianum, the abaxial leucocysts are long decurrent and reach to the insertional part of the next lower leaf, and consequently overlap the whole stem. According to Yamaguchi and Iwatsuki (1987), the anatomy of leaves and stems of L. neo-caledonicum is similar to L. sanctum and L. arfakianum. Considering the anatomical affinities, a phylogenetic relationship between L. sanctum, L. arfakianum and L. neo-caledonicum can be recognized.

4. Rhizoids

In Leucobryum the bases of stems and branches bear rhizoids like other mosses. However, characteristic rhizoids at the leaf apex are also found (Correns 1899, Cardot 1901, Burrell 1907, Plitt 1909, Williams 1913, Crundwell 1979, Fig. XIII: 1, 3). The formation of rhizoids at the leaf apex has been considered as a mode of asexual reproduction (Correns 1899, Burrell 1907, Plitt 1909). Buds with rhizoids at leaf apices were also observed (Burrell

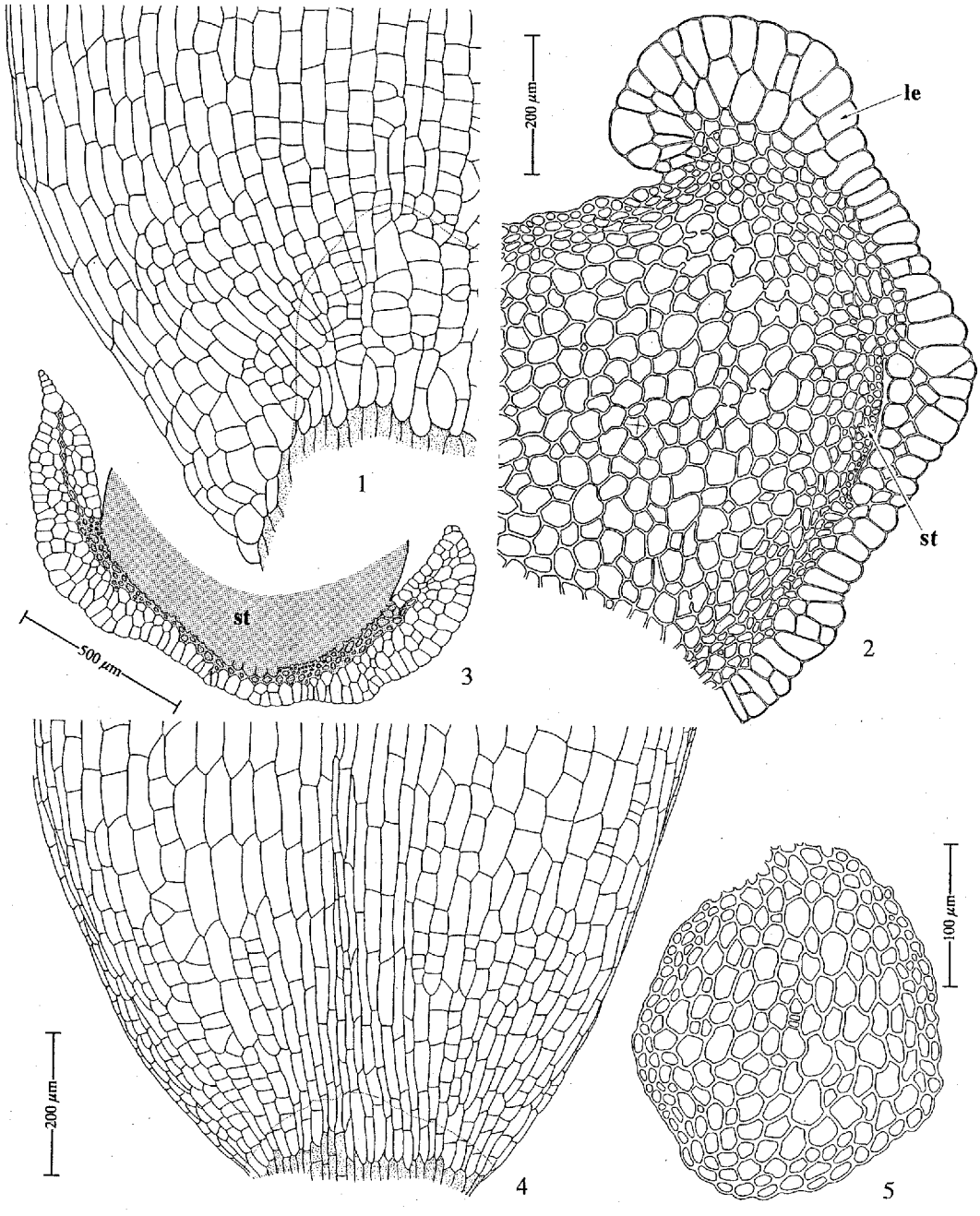

Figure XII. Decurrence of abaxial leucocysts of leaf on stem. 1–3. Distinctly decurrent type. 1. Leaf base (abaxial view). 2. Cross-section of stem. le shows abaxial leucocyst of leaf which decurrent on stem; st, stem. 3. cross-section of leaf at decurrent portion. 4, 5. Indistinctly decurrent type. 4. Leaf base (abaxial view). 5. Cross-section of stem. Figs. 1–3 were drawn from holotype of L. cyathifolium (BM); 4, 5, from holotype of L. armatum (H).

1907, Fig. XIII: 4). The rhizoids at the leaf apex are born from the adaxially exposed chlorocysts (Correns 1899, Cardot 1901, Fig. XIII: 2). The chlorocysts are usually covered by the leucocysts, but exposed chlorocysts are mainly found at adaxial side of apex (rarely at basal margins on adaxial side and lower central parts on abaxial side). These exposed chlorocysts often bear the rhizoids. I observed the leaves of L. javense var. novae-guineae (holotype specimen) frequently form rhizoids at the basal margins of leaves on abaxial side.

The other characteristic rhizoids formation is found at the lower abaxial side of inner perichaetial leaves. The rhizoids found on the inner perichaetial leaves are very fine and densely branched, and form a tometum enclosed by the perichaetial leaves (Bruch et al. 1847, Correns 1899, Plitt 1909, Grout 1905, Williams 1913, Crum 1981, Salazar Allen 1989). The differentiation between the rhizoids on perichaetial leaves and those on ordinary leaves is structurally and functionally distinct. Bruch et al. (1847), Correns (1899), Plitt (1907) and Grout (1905) considered the formation of rhizoids on perichaetial leaves as a mode of asexual reproduction, because of the growing of young plant on the tomenta. However, as mentioned later, the young plants growing on the tomenta originate from the germinations of spores dropped onto the tomenta, and some of

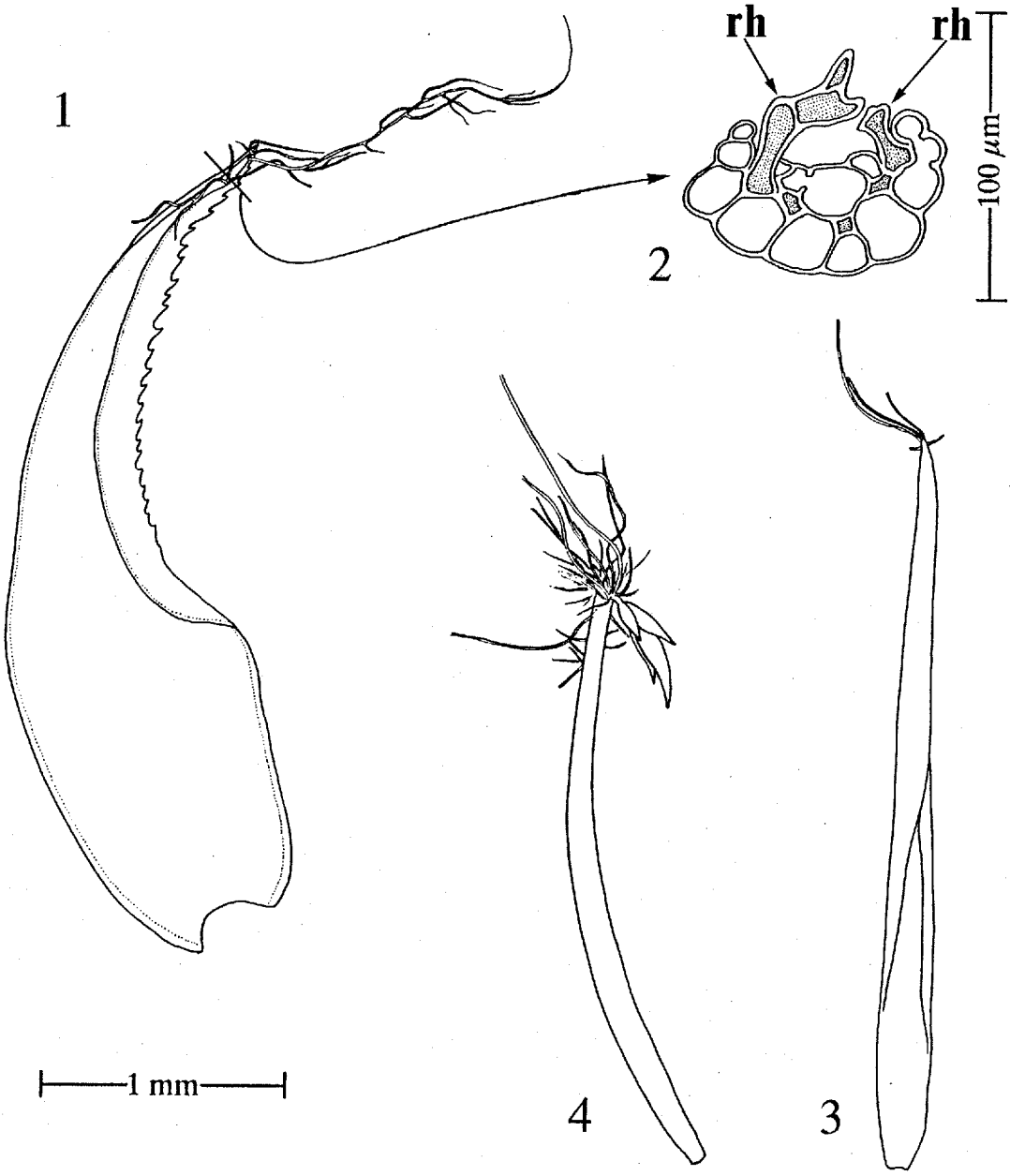

Figure XIII. Rhizoids at leaf apex. 1. Ordinary leaf. 2. Cross-section of leaf 1 at apex. rh shows rhizoid. 3, 4. Deciduous leaves (fig. 4 shows bud formation at apex). Figs. 1, 2 were drawn from lectotype of L. aduncum (L); 3, 4, from holotype of L. holleanum (= L. juniperoideum; L).

which grow to dwarf male plants (Williams 1913, Grout 1937, Florschütz 1964, Blackstock 1987, Yamaguchi & Iwatsuki 1987). Therefore, the formation of rhizoids on the perichaetial leaves is related to the sexual reproduction.

5. Sexual organs

Most taxonomists, with the exceptions of Fleischer (1904) and Yamaguchi and Iwatsuki (1987), did not describ any sexual organs of Leucobryum in detail. However, in the course of this study, I recognized that the characters of sexual organs were extremely important for classification of the genus Leucobryum.

(a) Position of perichaetia and perigonia

In acrocarpous mosses, the branching pattern related to distribution of sexual organs is principally classified into the two types (Meusel 1935). In the first type, the sexual organs are terminal on the specialized short lateral branches, and the main stem continuously grow upward. This type of branching is defined as monopodial. In the second type, the sexual organs are terminal on the main stems, and the subfloral innovations are changed into the main stems. Therefore, the growth of stems is regulated by the formation of sexual organs. This type of branching is defined as sympodial.

The branching in acrocarpous mosses is mostly

sympodial. However, there are some cases that both types of branchings exist in a single family, e. g., Pottiaceae (cf. Saito 1975) and Bryaceae (cf. Ochi 1959), while both two types exist in a single genus, e. g., Fissidens (cf. Iwatsuki & Suzuki 1982) and Grimmia (cf. Deguchi 1979).

In the taxa of Leucobryum treated in this study, two branching types, sympodial and monopodial are found, but is mixed types mentioned above are also recognized. These types are represented by the female plants because the normal male plants are found only in a few species.

Type A. Perichaetia are terminal on the main stems (sympodial branching; Fig. XIV: 1, XV: 2, XVI: A). Fig. XVI(A): 1 shows the typical form of this type. However, this type includes some modifications as follows: (1) The sexual branches look like lateral branches because of the unformed perichaetia at stem apices (Fig. XV: 2, XVI: 2). (2) The subfloral innovations are relatively short, so that the sexual branches look like short lateral branches (Fig. XVI: 3, 4). Among the taxa treated in the present study, L. juniperoideum, L. humillimum, L. glaucum and L. bowringii belong to this type.

Type B. Perichaetia are terminal on the short lateral branches (never terminal on the main stems; monopodial branching; Fig. XIV: 2, Fig. XV: 4, Fig. XVI: B). The taxa belong to this type are often relatively robust, such as L.

Figure XIV. Branching showing position of perichaetia of 3 taxa of Leucobryum. 1. L. glaucum (Hedw.) Ångstr. in Fries. 2. L. javense (Brid. ex Schwägr.) Mitt. 3–7. L. aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. Fig. 1 was drawn from Zanten 3319 (NICH); 2, from Joncheere 1621 (L); 3, from isotype of L. scalare var. tjibodense (HIRO); 4, 5, from Touw 10733 (L); 6, from holotype of L. perichaetiale (BM); 7, from isolectotype of L. scalare var. marschmeyeri (HIRO).

Figure XV. Branching showing position of perichaetia of 3 taxa of Leucobryum. 1, 3, 5. Female plants. 2, 4, 6. Branching showing position of perichaetia. 1, 2. L. bowringii Mitt. 3, 4. L. sumatranum Broth. ex Fl. 5, 6. L. sericeum Broth. ex Geh. Figs 1, 2 were drawn from Yamaguchi 9313 (HIRO); 3, from holotype of L. sumatranum (FH); 4, from Wilde & Wilde-Duyfjes 15066A (L); 5, 6, from Deguchi 22292 (KOCHI).

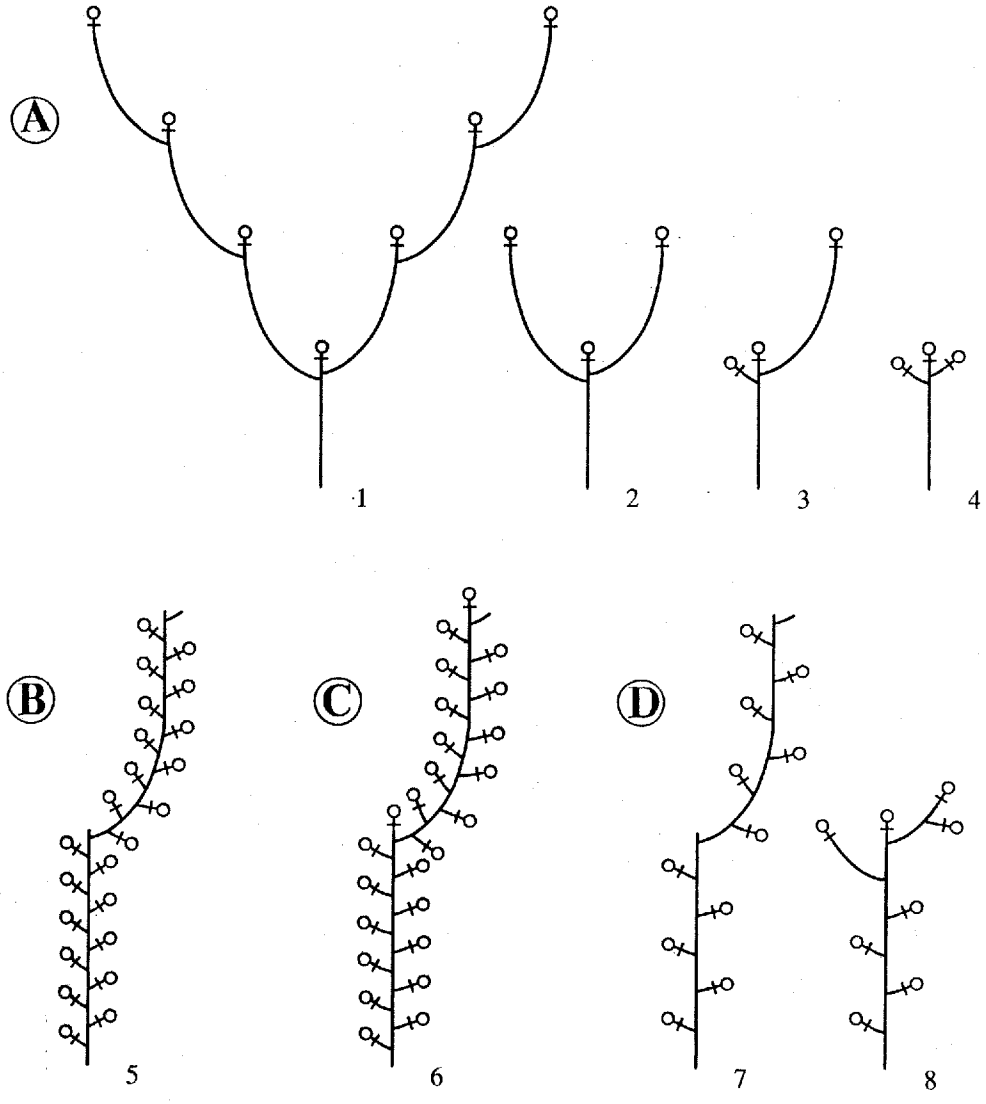

Figure XVI. Schematic representation of branching and distribution of perichaetia. ♀ represents perichaetium.

javense and its varieties, L. aduncum var. aduncum, L. aduncum var. teysmannianum, L. boninense, L. sumatranum, L. sanctum and L. arfakianum. The sexual branches are usually much shorter than those of type A (Table 7). Therefore I consider that the distribution of perichaetia and the length of sexual branches are useful for classification of Leucobryum.

Type C. Perichaetia are mainly terminal on the short lateral branches, but rarely terminal on the main stems (Fig. XV: 6, XVI: C). This type seems to be formed by a slight modification of type B. Among the taxa treated in this study, L. sericeum belongs to this type.

Type D. Perichaetia are terminal on short or elongate lateral branches, on subfloral innovations, or on main stems (Fig. XIV: 3-7, XVI: D). The taxa of this type include L. aduncum var. scalare and L. chlorophyllosum.

The branching and the distributional patterns of the perigonia of the normal male plants are similar to the female plants of the same taxa, although I could not examine adequate number of samples.

(b) Archegonia and antheridia

The length of archegonia seem to be correlated with the position of perichaetia, type A-D mentioned above, and no relation to the plant size. The archegonia of the taxa belong to type A are 1.2-1.8 mm long, and longer than those

Table 7. Length of female branches of three species of Leucobryum in Japan

Species	Min. (mm)	Mean (mm)	Max. (mm)	Standard deviation	Number of specimens examined	Number of materials
L. juniperoideum	0.8	2.0	12.0	1.7	19	55
L. bowringii	1.0	4.3	16.2	3.0	20	50
L. scabrum	0.2	0.5	1.0	0.1	19	43

belong to type B, C and D (Fig. XVII: 1-16). The archegonia of the taxa belong to type B, C and D are shorter, 0.5-1.2 mm in length, except for L. sumatranum (about 1.5 mm long).

The size of antheridia is variable within a taxon or even in a specimen, because of the variety of the size of male plants. The antheridia of dwarf male plants are much smaller than those of normal male plants (Fig. XVII, 20-23).

(c) Perichaetial and perigonial leaves

Large part of the perichaetial leaves is composed of the basal part with relatively broad lamina. The apical part of perichaetial leaves is narrowed, short and almost filled with costa. Size and shape of perichaetial leaves of Leucobryum are more or less differentiated from ordinary leaves. The perichaetial leaves around unfertilized archegonia are not well developed, especially for the inner leaves (Fig. XVIII: A, XIX: A, XXI: A, XXII: A, XXIV: A). When the sporophytes matured, the perichaetial leaves reach maximum size and show the characters for the taxon (Fig. XVIII: B, XIX: B, XX, XXI: B, XXII: B, XXIII: BXXIV: B). Therefore, the differentiation of the perichaetial leaves is examined using those around mature sporophytes. They are classified into three types as follows:

Type A. The inner perichaetial leaves (1.0-) 1.4-1.8 times longer than the stem leaves near the perichaetium.

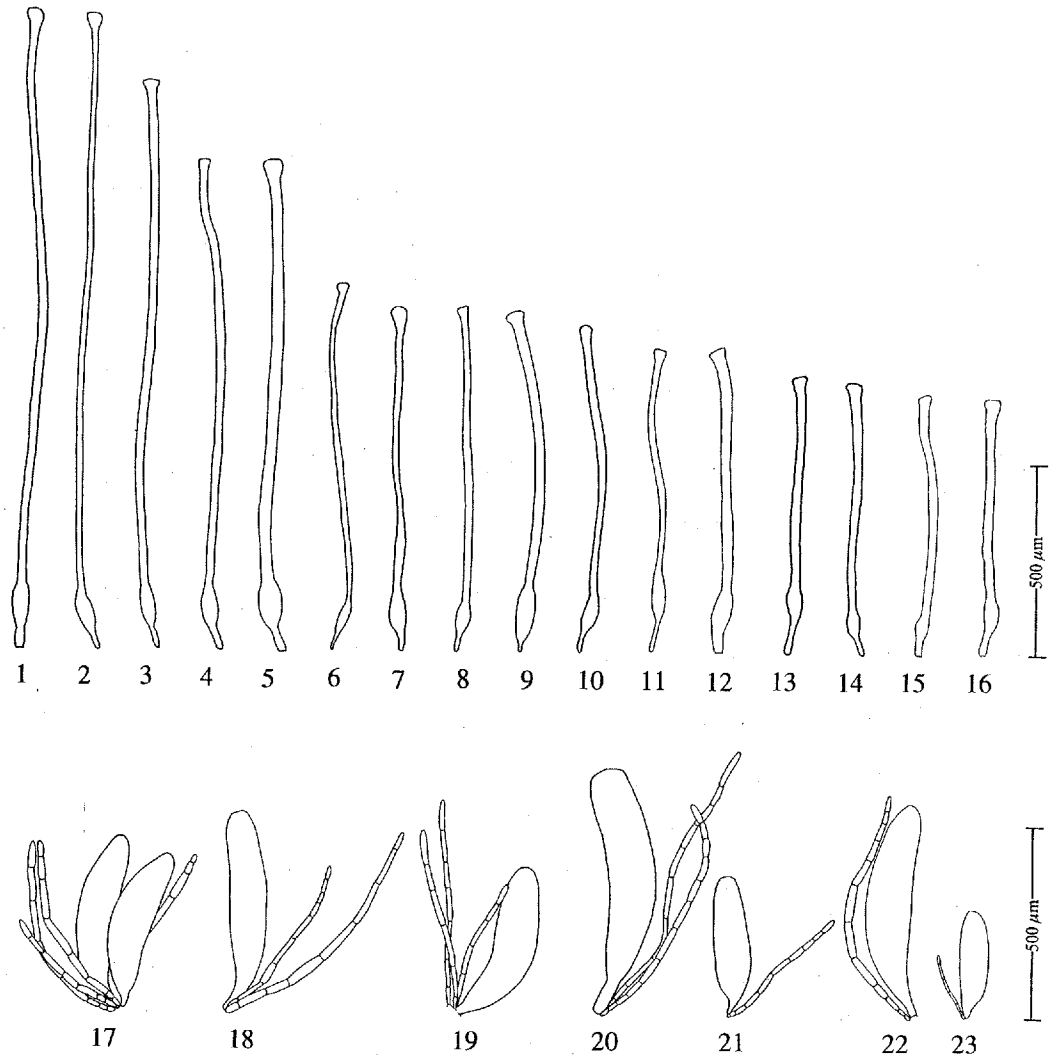

Figure XVII. 1–16. Archegonia. 17–23. Antheridia (19, 21, 23 from dwarf male plants). 1, 20, 21. L. bowringii Mitt. 2. L. glaucum (Hedw.) Ångstr. in Fries. 3. L. sumatranum Broth. ex Fl. 4, 22, 23. L. juniperoideum (Brid.) C. Müll. 5. L. humillimum Card. 6. L. arfakianum C. Müll. ex Geh. 7. L. sericeum Broth. ex Geh. 8, 17. L. aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 9. L. javense (Brid. ex Schwägr.) Mitt. var. javense. 10. L. javense var. novae-guineae (Bartr.) T. Yamaguchi. 11. L. aduncum Dozy & Molk. var. aduncum. 12, 19. L. scabrum Lac. 13. L. chlorophyllosum C. Müll. 14. L. sanctum (Brid.) Hampe. 15, 18. L. boninense Sull. & Lesq. 16. L. aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. Figs. 1, 20, 21 were drawn from Yamaguchi 9313 (HIRO); 2, from Zanten 3319 (NICH); 3, from Wilde & Wilde-Duyfjes 15066A (L); 4, 22, from Noguchi 16753 (NICH); 5, from Nishimura 1514 (HIRO); 6, from holotype of L. papuense var. pendulum (L); 7, from holotype of L. sericeum (H); 8, from isotype of L. scalare var. tjibodense (HIRO); 9, from Joncheere 1621 (L); 10, from holotype of L. antarense (L); 11, from lectotype of L. aduncum (L). 12, 19, from Iwatsuki & Minamidani s. n., Musci Japonici Exsiccati 28: 1378 (NICH); 13, from isotype of L. chlorophyllosum (L); 14, from lectotype of L. papuense (H); 15, 18, from holotype of L. boninense (FH); 16, from holotype of L. teysmannianum (L); 17, from lectotype of L. scalare (FH); 23, from Une 3545 (HIRO).

The taxa belong to this type include L. aduncum var. scalare (Fig. XXI), L. juniperoideum (Fig. XXII) and L. humillimum.

Type B. The inner perichaetial leaves (0.5-) 0.7-1.0 times longer than the stem leaves near the perichaetium. The taxa belong to this type include L. aduncum var. aduncum (Fig. XX), L. chlorophyllosum, L. boninense, L. glaucum (Fig. XXIII) and L. bowringii (Fig. XXIV).

Type C. The inner perichaetial leaves 0.3-0.6 times longer than the stem leaves near the perichaetium. The taxa belong to this type include L. javense var. javense (Fig. XVIII), L. scabrum (Fig. XIX), L. sumatranum, L. sericeum, L. sanctum and L. arfakianum.

The inner perichaetial leaves of the perichaetia terminal on the main stems usually longer than the stem leaves, except for L. glaucum and L. bowringii, while those of the perichaetia terminal on lateral branches are more or less shorter than the stem leaves, except for L. aduncum var. scalare. The specimens with mature sporophytes treated in this study are not so many, so that the further examinations are needed. However, the comparison between the inner perichaetial leaves around mature sporophytes and the stem leaves near the perichaetia seems to be taxonomically important.

I critically examined the perichaetial leaves of more than 19 specimens (with mature sporophytes) each of L.

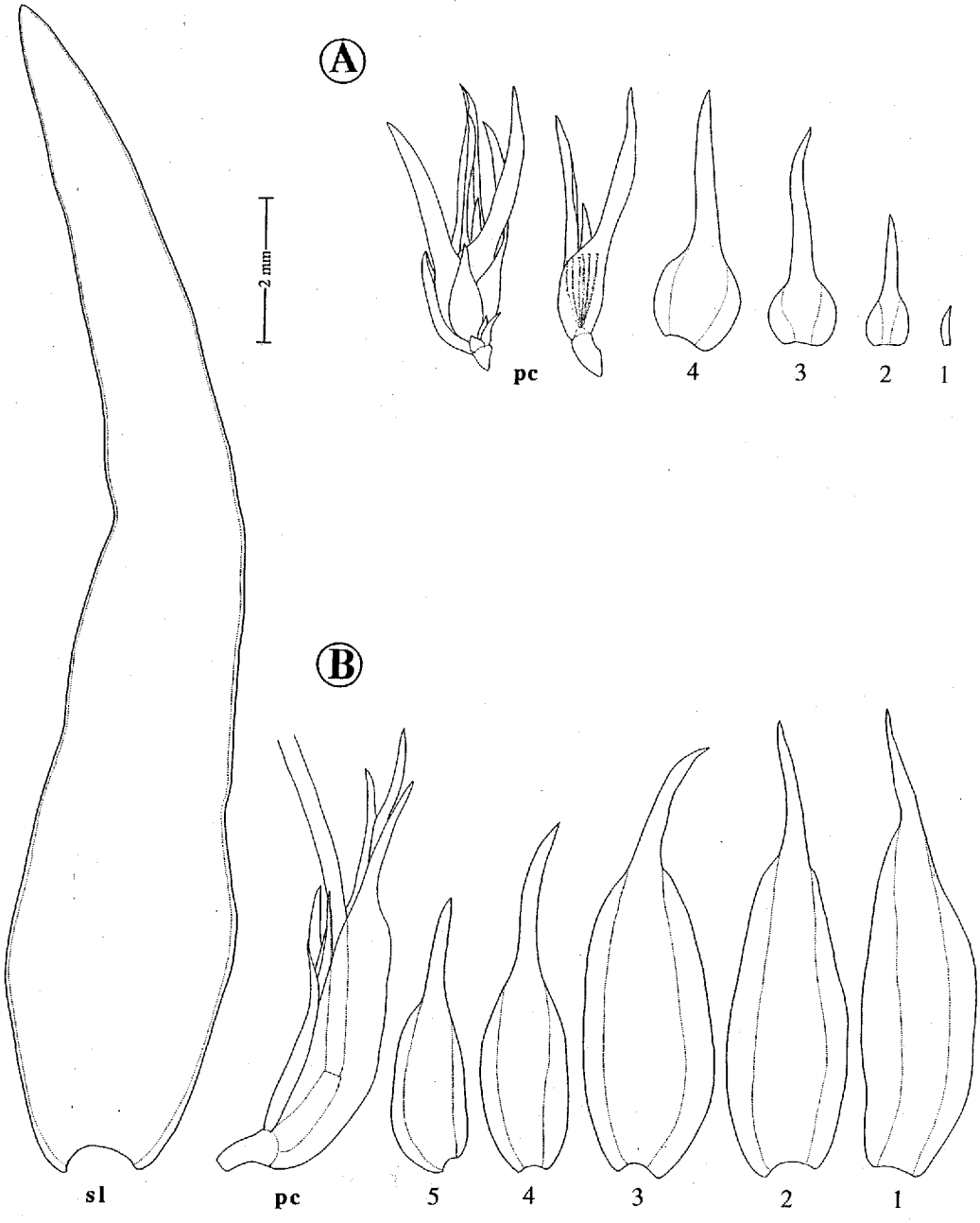

Figure XVIII. Perichaetial leaves of Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. A. Perichaetium and perichaetial leaves (expanded) around unfertilized archegonia. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaf (expanded) near perichaetia A and B. All figures were drawn from Joncheere 1621 (L).

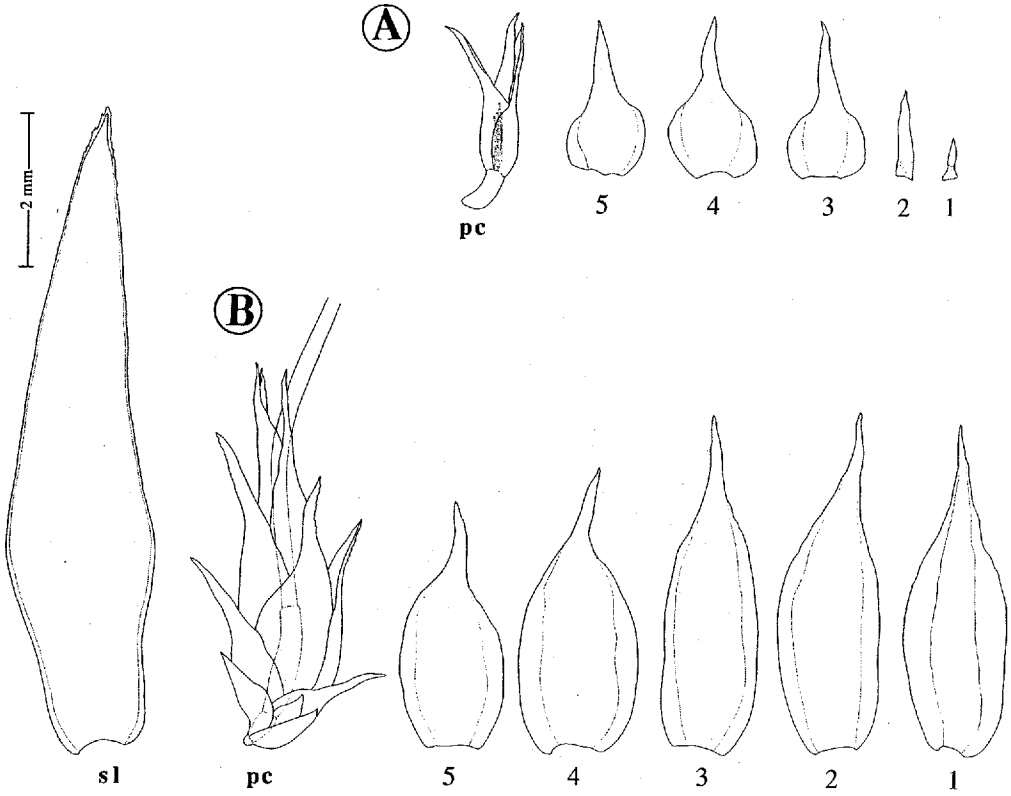

Figure XIX. Perichaetial leaves of Leucobryum scabrum Lac. A. Perichaetium and perichaetial leaves (expanded) around unfertilized archegonia. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaf (expanded) near perichaetia A and B. All figures were drawn from Iwatsuki & Minamidani s. n., Musci Japonici Exsiccati 28: 1378 (NICH).

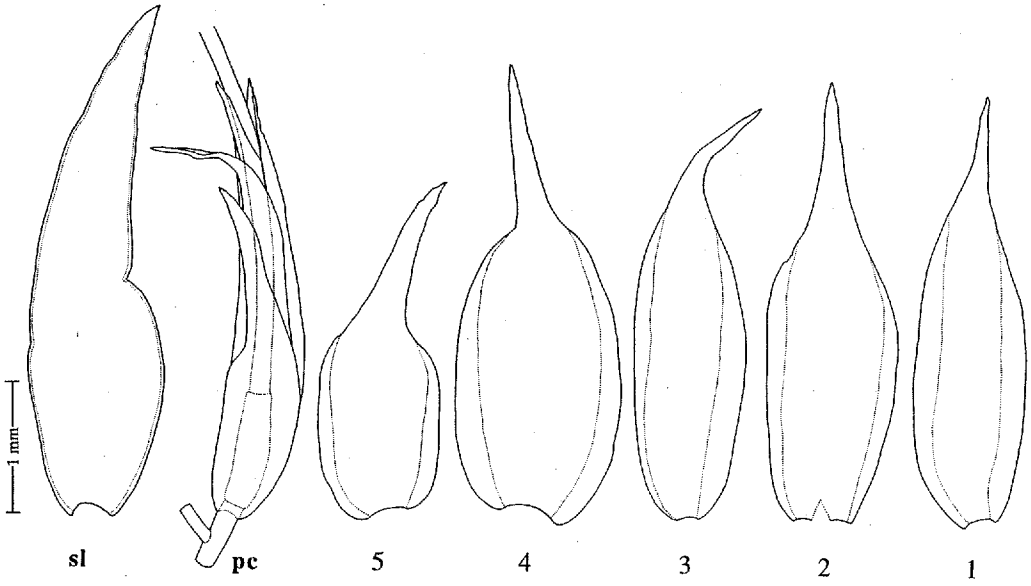

Figure XX. Perichaetium and perichaetial leaves (expanded) around mature sporophyte of Leucobryum aduncum Dozy & Molk. var. aduncum. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaf (expanded) near perichaetium. All figures were drawn from lectotype of L. aduncum (L).

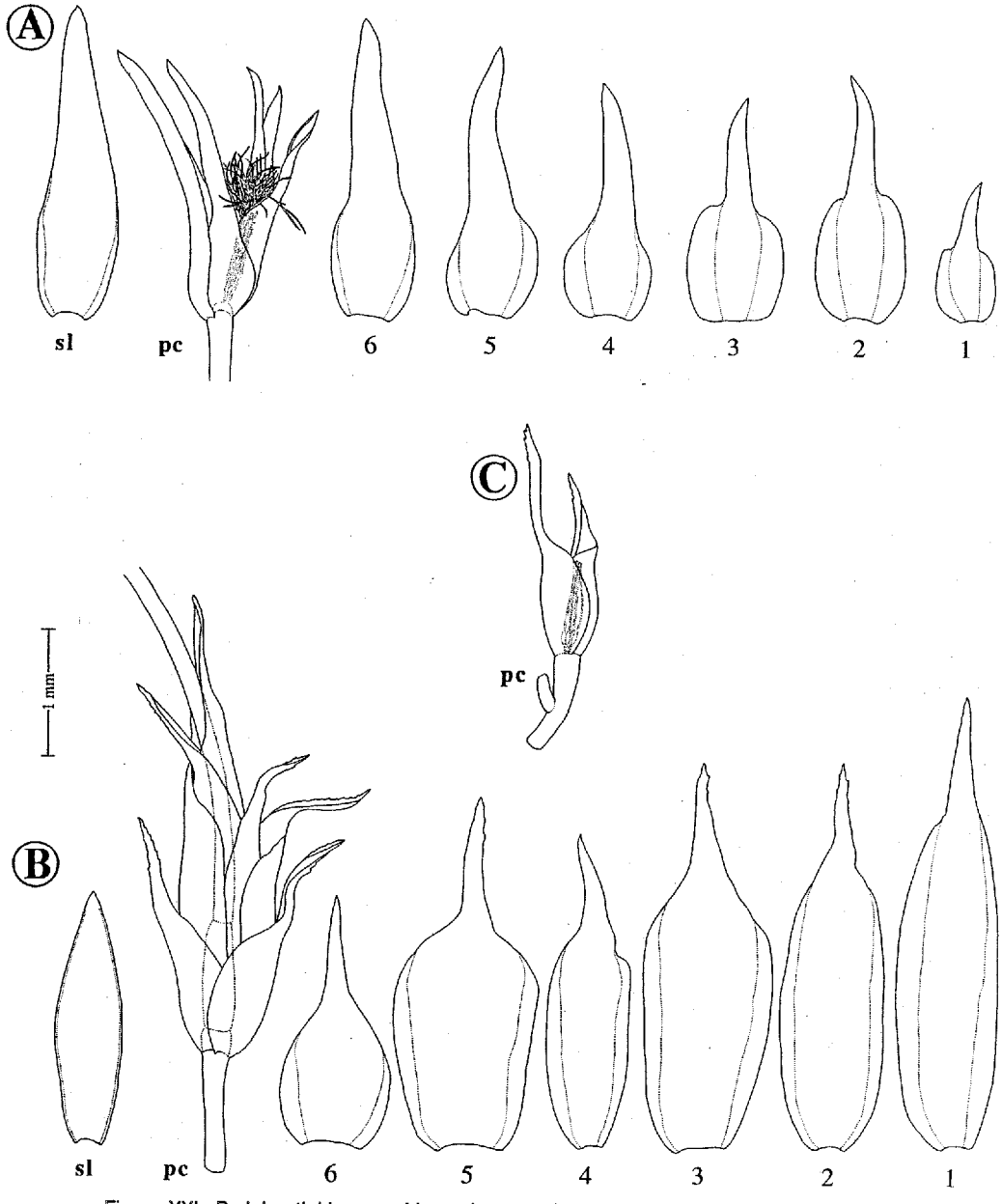

Figure XXI. Perichaetial leaves of Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. A. Perichaetium and perichaetial leaves (expanded) around unfertilized archegonia. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. C. Unfertilized perichaetium. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaves (expanded) near perichaetia A and B respectively. Fig. A was drawn from holotype of L. krempfii (PC); B, C, from isolectotype of L. scalare var. marschmeyeri (HIRO).

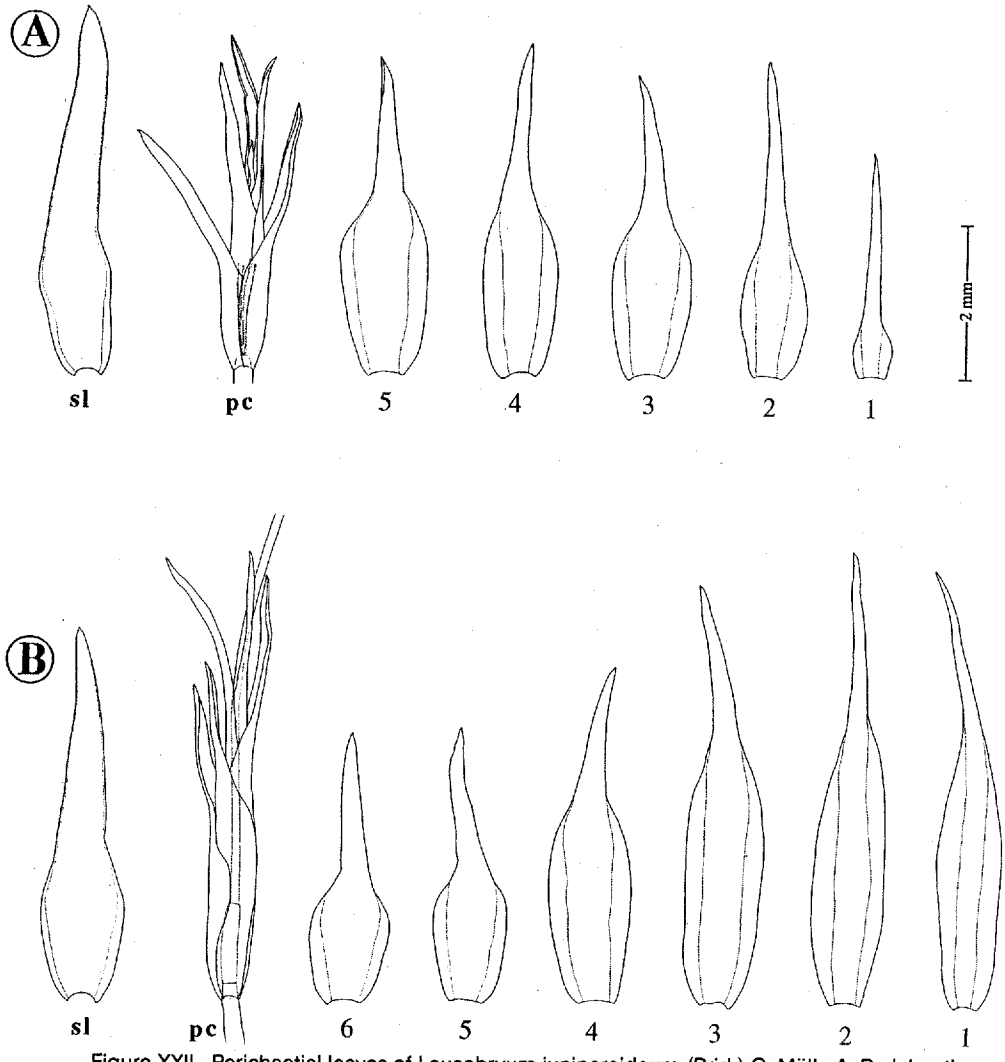

Figure XXII. Perichaetial leaves of Leucobryum juniperoideum (Brid.) C. Müll. A. Perichaetium and perichaetial leaves (expanded) around unfertilized archegonia. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaves (expanded) near perichaetia A and B respectively. All figures were drawn from Noguchi 16753 (NICH).

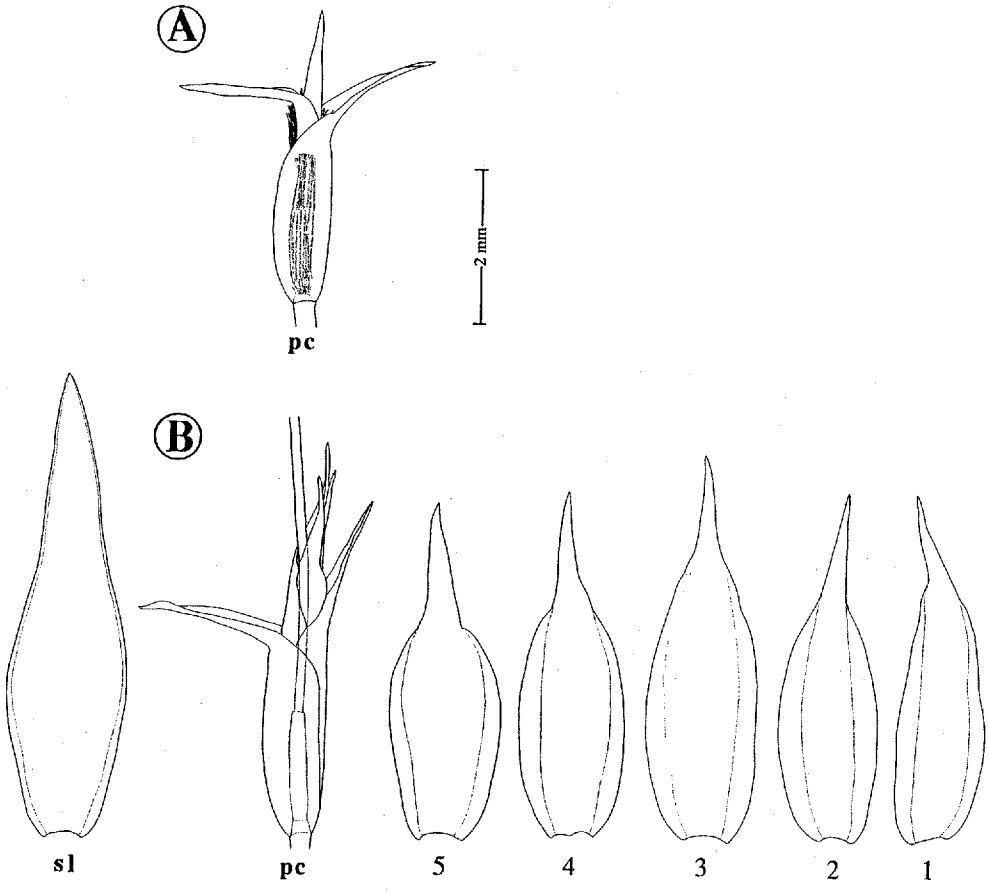

Figure XXIII. Perichaetial leaves of Leucobryum glaucum (Hedw.) Ångstr. in Fries. A. Unfertilized perichaetium. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaf (expanded) near perichaetia A and B. All figures were drawn from Zanten 3319 (NICH).

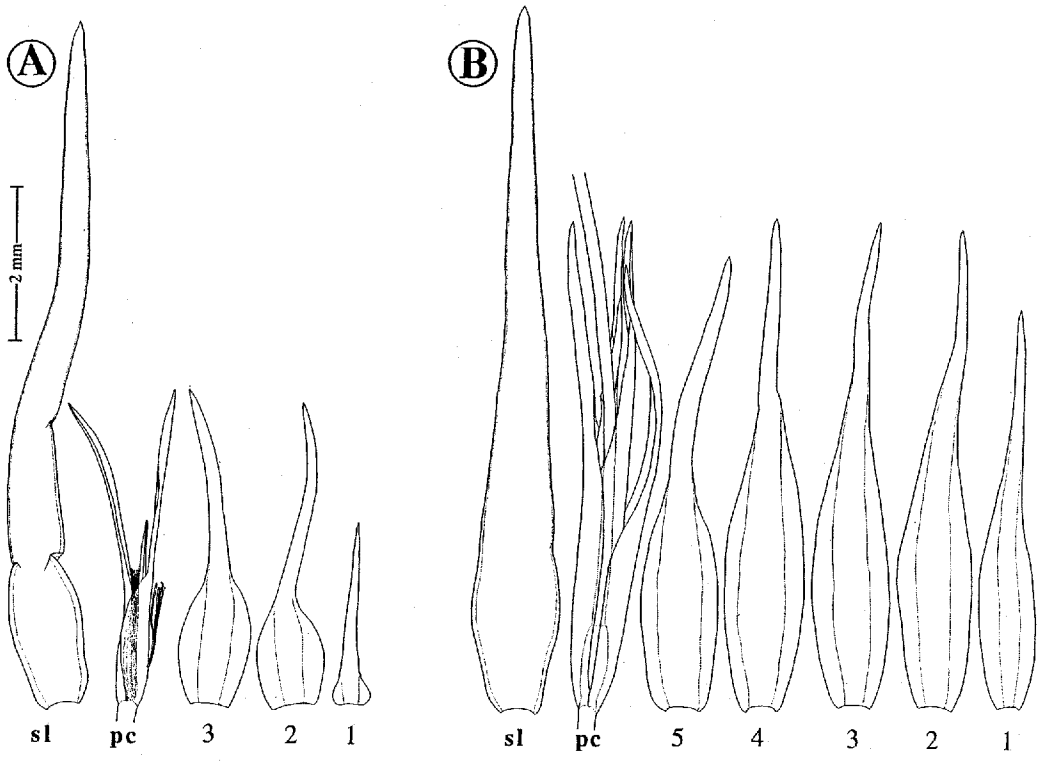

Figure XXIV. Perichaetial leaves of Leucobryum bowringii Mitt. A. Perichaetium and perichaetial leaves (expanded) around unfertilized archegonia. B. Perichaetium and perichaetial leaves (expanded) around mature sporophyte. Numbers show the order of perichaetial leaves from the innermost leaf (number 1); pe, perichaetium; sl, stem leaves (expanded) near perichaetia A and B respectively. All figures were drawn from Yamaguchi 9313 (HIRO).

bowringii, L. juniperoideum and L. scabrum from Japan. I found a significant difference between the length of inner perichaetial leaves and that of stem leaves among L. bowringii, L. juniperoideum and L. scabrum (Table 8).

The perigonia are bud-like and very small. The inner perigonial leaves are composed of the round sheathing base which envelops the antheridia (Fig. XXV).

6. Sporophytes

The characters of the sporophytes of Leucobryum are quite similar to those of Dicranum (Fig. XXVI). The genus Leucobryum has a typical dicranoid peristome and this is one of the basic reasons that Leucobryum remains in Dicranales (Fleischer 1904, Edwards 1979). The characters of sporophyte, especially for peristome teeth, are almost same among the taxa treated in this study. For classification of the taxa of Leucobryum, I used the position of sporophytes and the inclination of capsules.

V. Sexual reproduction

In the genus Leucobryum, male plants are rare, so that sexual reproduction is infrequent. In this chapter, I discuss sexual reproduction of this genus using data of three species widely distributed in Japan: L. bowringii, L.

Table 8. Ratio of length of inner perichaetial leaves to ordinary leaves near the perichaetium of three species of Leucobryum in Japan[1]

Species	Min. (mm)	Mean (mm)	Max. (mm)	Standard deviation	Number of specimens examined	Number of materials
L. juniperoideum	0.96	1.36	1.79	0.21	19	55
L. bowringii	0.52	0.72	0.93	0.10	20	54
L. scabrum	0.33	0.44	0.57	0.05	19	44

[1]Length of inner perichaetial leaf / Length of ordinary leaf near the perichaetium. The length of inner perichaetial leaf was measured from the longest leaf among inner two leaves. The length of ordinary leaf was average of three longest leaves near the perichaetium.

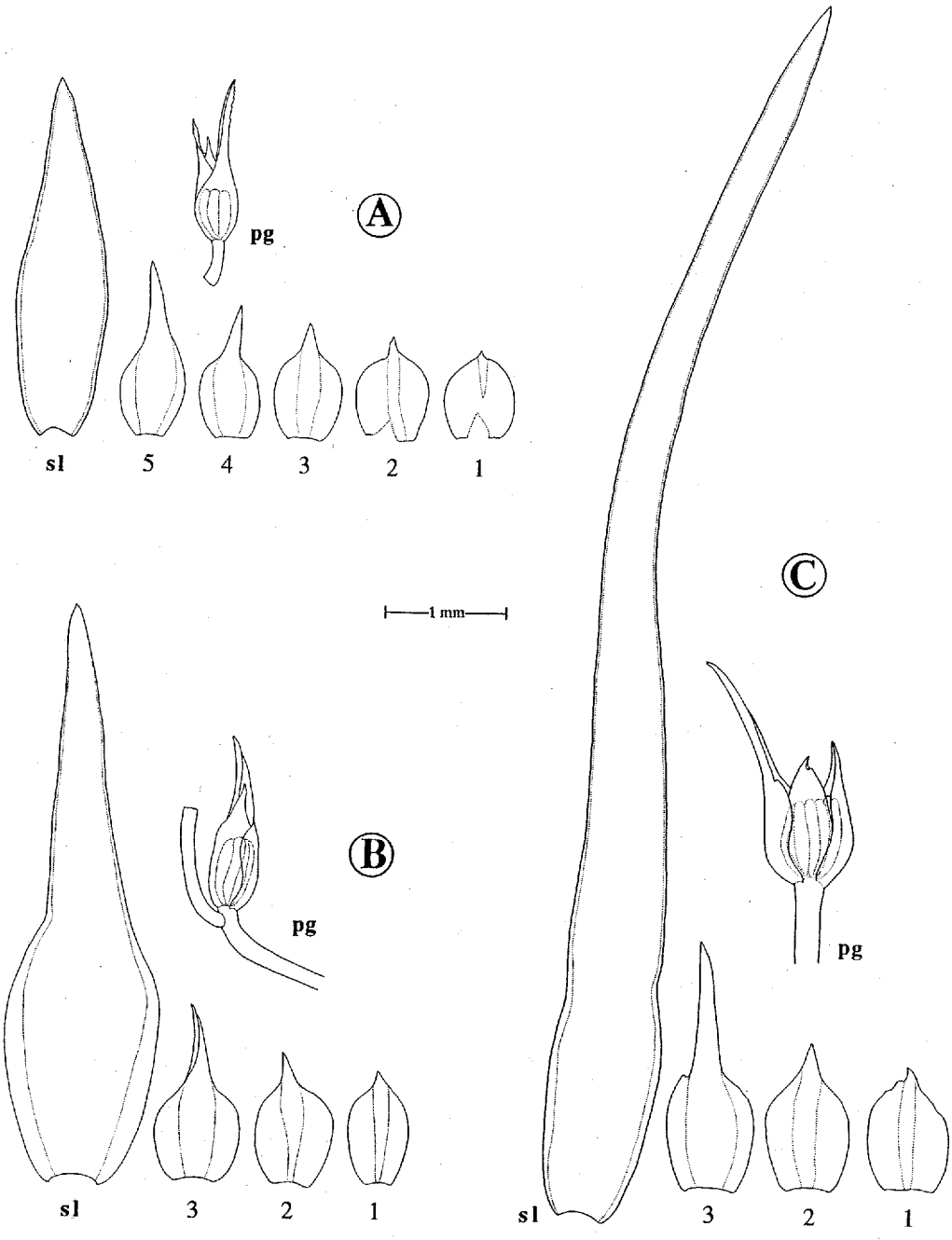

Figure XXV. Perigonial leaves (expanded) of 3 taxa of Leucobryum. A. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. B. L. juniperoideum (Brid.) C. Müll. C. L. bowringii Mitt. Numbers show the order of perigonial leaves from the innermost leaf (number 1); pg, perigonium; sl, stem leaves near perigonia A, B and C respectively. Fig. A was drawn from lectotype of L. scalare (FH); B, from Noguchi 16753 (NICH); C, from Yamaguchi 9313 (HIRO).

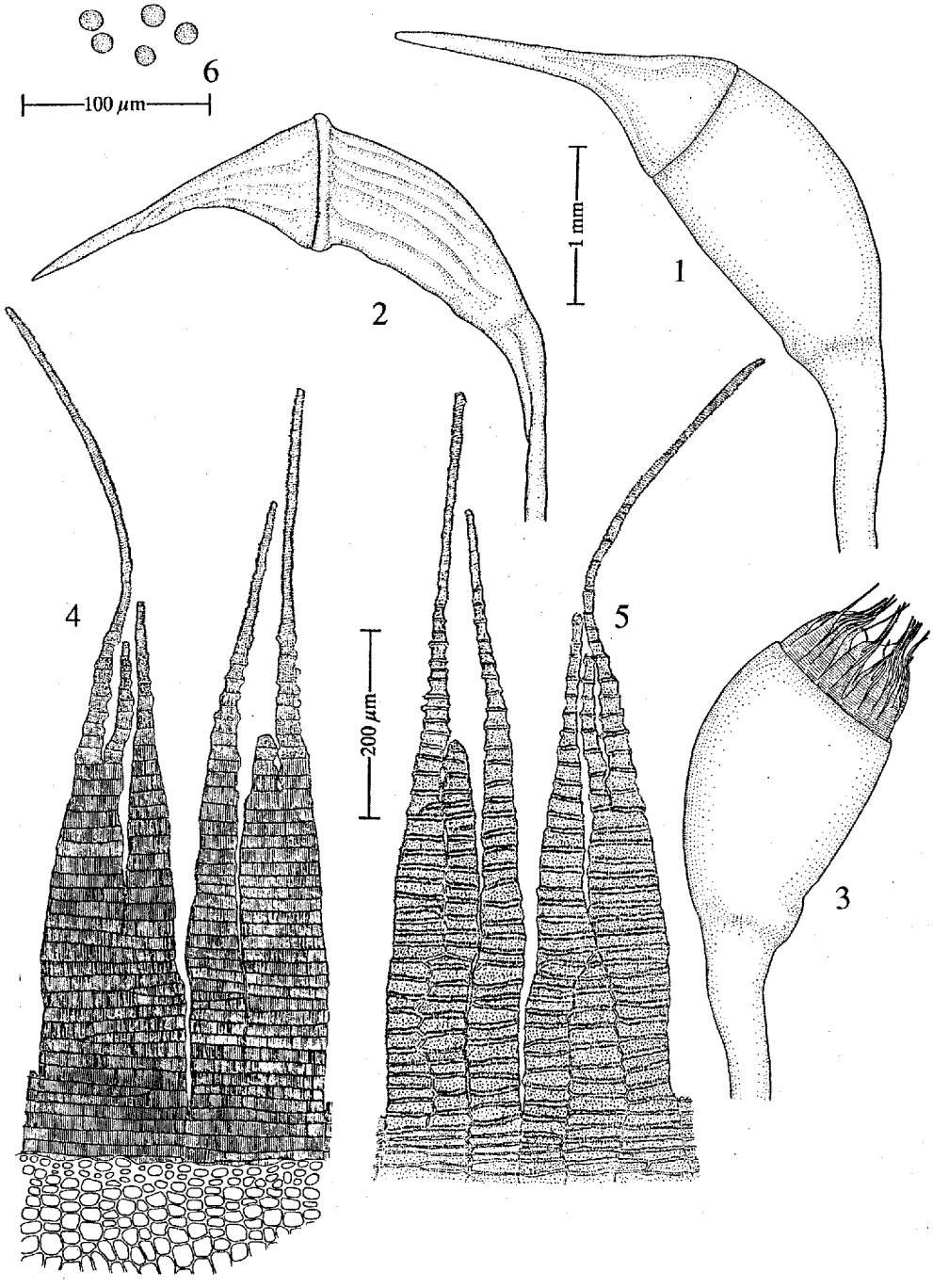

Figure XXVI. Sporophytes of Leucobryum scabrum Lac. 1–3. Capsules. 4, 5. peristome teeth (4, dorsal view; 5, ventral view). 6. Spores. All figures were drawn from Iwatsuki & Minamidani s. n., Musci Japonici Exsiccati 28: 1378 (NICH).

juniperoideum and L. scabrum. These species produce sporophytes more or less frequently.

1. Sexuality

Fleischer (1904), Williams (1913) and Yamaguchi and Iwatsuki (1987) critically described the sexuality of the Leucobryum, but many other authors did not mention this character. Most species of Leucobryum have dioicous inflorescence, but Fleischer (1904) described L. chlorophyllosum as an autoicous species. If Fleischer was right, this is only autoicous species in the genus. My critical examination of the type specimen of L. chlorophyllosum, however, proved that there are female and normal male plants in the packet. Therefore, sexuality of all species of Leucobryum previously examined until now are dioicous.

In the genus Leucobryum, two types of male plants have been reported by many authors. The first type is the normal male plants which are as large as the female plants (Fleischer 1904, Yamaguchi & Iwatsuki 1987), or somewhat smaller than the female plants (Dixon 1924, Blackstock 1987). The second type is the dwarf male plants which are much smaller (usually only a few mm long) than the female plants, and always epiphytic on various parts of the female plants. The dwarf male plants grow on stem leaves of female plants (Crum & Steere 1957, Crum 1976, Scott & Stone 1976,

Yamaguchi & Iwatsuki 1987), or on the tomentum enclosed by the perichaetial leaves (Williams 1913, Woesler 1935, Grout 1937, Florschütz 1964, Blackstock 1987, Yamaguchi & Iwatsuki 1987). These sexual conditions are classified into four types according to Wyatt and Anderson (1984), as follows:

1. Dioicous. The condition with equal sized male and female plants (Fig. XXVII: 1, 2, XXVIII: 1, 2)

2. Heterodioicous. The condition in which the male plants are smaller than female plants, but they are free-living and independent (Fig. XXIX: 3-9).

3. Pseudoautoicous. The condition of male plants that are tiny and bud-like, epiphytic on the stems of female plants, and generally attached to a mass of tomentum (Fig. XXVII: 3-5, XXVIII: 3-6, XXIX: 2).

4. Phyllodioicous. The condition of male plants that are tiny and bud-like, epiphytic on the leaves of female plants (Fig. XXX: 3, 4).

Among these classification (Wyatt & Lewis 1984), the condition of pseudoautoicous is not strictly adapted to the Leucobryum, because the dwarf male plants of Leucobryum attach to a tomentum enclosed by perichaetial leaves and not to that on stems. L. bowringii shows the heterodioicous condition, but the independent small male plants seem to be developed from dwarf male plants.

In the course of this study, I found two types of sexuality in the same species, or even in the same specimen. I critically examined three species of Leucobryum, L. juniperoideum, L. bowringii and L. scabrum to clarify the sexual conditions and the formation of the dwarf male plants. Table 9 shows the sexual conditions and the fertilities of three species. The occurrence of normal male plants is rare (in L. scabrum, no normal male plants are observed). According to Une (unpublished data), however, dwarf male plants of L. scabrum grow into the normal sized plants by trans-plantation onto the soil with the distilled water. Therefore, the dwarf male plants of these isosporous species are not genetically controlled, and the dwarf male plants possibly grow larger if they were removed from the female plants. Une (1985a) defined the term pseudonanandrous as the condition of dioicous which includes nongenetically controlled dwarf male plants.

The growing positions of the dwarf male plants in three species of Leucobryum are shown in Table 10. In L. juniperoideum the dwarf male plants grow mainly on the tomentum enclosed by the perichaetial leaves of the female plants, while in L. scabrum they are restricted on the stem leaves of female plants. In L. scabrum the formation of tomenta were not observed. In L. bowringii the dwarf male plants grow both on the tomenta and on stem leaves of female

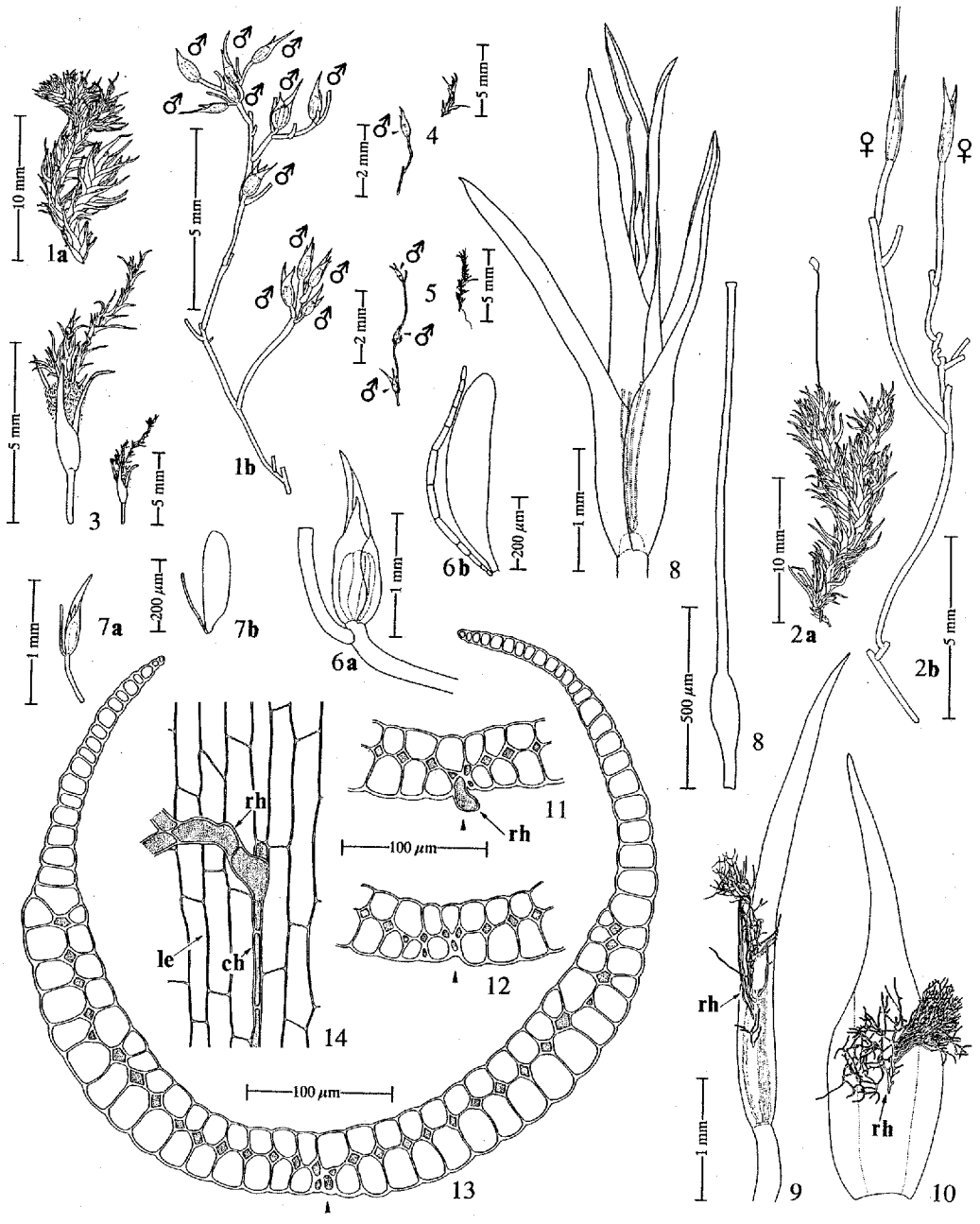

Figure XXVII. Sexuality of Leucobryum juniperoideum (Brid.) C. Müll. 1a, 1b. Normal male plant and its branching. 2a, 2b. Female plant and its branching. 3. Dwarf male plants growing on tomentum enclosed by perichaetial leaves. 4, 5. Dwarf male plants and their branching. 6a–7b. Perigonia and antheridia from normal male plant (6a, 6b) and dwarf male plant (7a, 7b). 8a, 8b. Perichaetium and archegonium. 9, 10. Inner perichaetial leaves showing formations of tomenta (10, expanded abaxial view). 11–13. Cross-sections of inner perichaetial leaf at basal part. Arrow shows the central position in cross-section. 14. Median cells at sheathing base of inner perichaetial leaf, showing base of rhizoid which forms tomentum. ♂ and ♀ represent perigonium and perichaetium respectively; ch, chlorocyst; le, leucocyst; rh, rhizoid. Figures 1a, 1b, 2a, 2b, 4, 6a, 6b, 8a, 8b were drawn from Noguchi 16753 (NICH); 3, 5, 7a, 7b, 10–14, from Une 3545 (HIRO); 9, from Iwatsuki 12012 (NICH).

Figure XXVIII. Sexuality of Leucobryum bowringii Mitt. 1a, 1b. Normal male plant and its branching. 2a, 2b. Female plant and its branching. 3. Dwarf male plants growing on tomentum enclosed by perichaetial leaves. 4a–6b. Dwarf male plants and their branching. 7a–9b. Perigonia and Antheridia from dwarf male plants 7a and 8a, and from normal male plant 9a. 10a, 10b. Perichaetium and archegonium. ♂and ♀ represent perigonium and perichaetium respectively; rh, rhizoid which forms tomentum. Figs. 1a, 1b, 2a, 2b, 7a, 7b, 9a, 9b, 10a, 10b were drawn from Yamaguchi 9313 (HIRO); 3, 4a–6b, 8a, 8b from Yamada 572 (NICH).

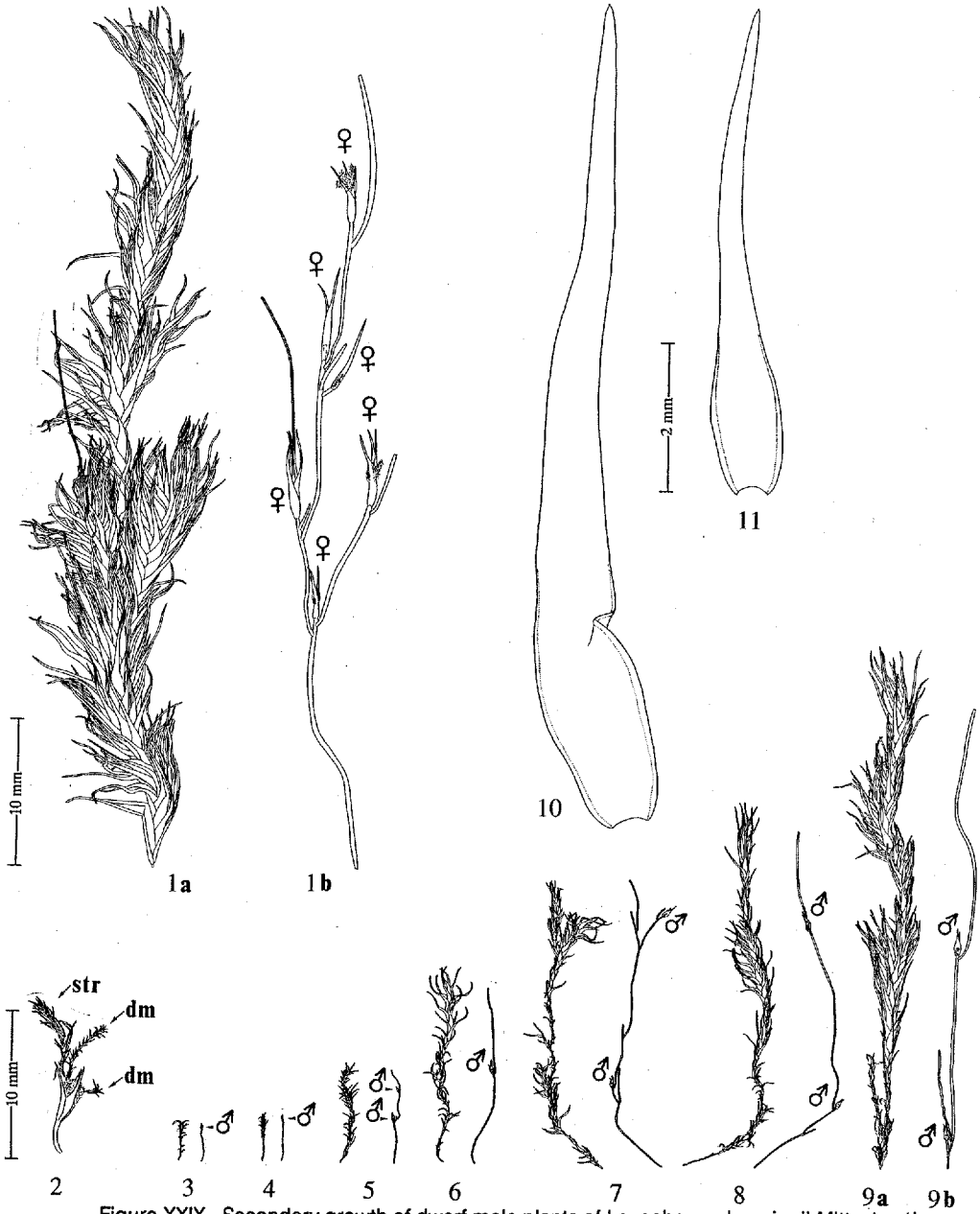

Figure XXIX. Secondary growth of dwarf male plants of Leucobryum bowringii Mitt. 1a, 1b. Female plant and its branching. 2. Dwarf male plants growing on tomentum enclosed by perichaetial leaves. 3–9b. Dwarf male plants and their branching. 10, 11. Stem leaves (expanded) of female plant 1a and male plant 9a respectively. ♂ and ♀ represent perigonium and perichaetium respectively; dm, dwarf male plant; str, sterile plant. All figures were drawn from Noguchi 26323 (NICH).

Figure XXX. Sexuality of Leucobryum scabrum Lac. 1a, 1b. Female plant and its branching. 2a, 2b. Dwarf male plant and its branching. 3a–4b. Dwarf male plants (3b, showing branching) growing on female stem leaves. 5a, 5b. Perigonium and antheridium from dwarf male plant. 6a, 6b. Perichaetium and archegonium. ♂ and ♀ represent perigonium and perichaetium respectively. Figs. 1a, 1b, 4a–6b. were drawn from Iwatsuki & Minamidani s. n., Musci Japonici Exsiccati 28: 1378 (NICH); 2a–3b, from Une 4329 (HIRO).

Table 9. Occurrence of male and female plants, and fertility of three species of Leucobryum in Japan

Species	Number of specimens[1] (Number of fruiting specimens)							Fertility[2] (%)
	♀	♀+♂	♂	♀♂+♂	♀♂	Sterile	Total	
L. juniperoideum	123 (3)	9 (9)	9 (0)	6 (6)	27 (27)	171	345	13.0
L. bowringii	96 (9)	12 (12)	4 (0)	12 (12)	24 (24)	116	264	21.6
L. scabrum	246 (0)	0 (0)	0 (0)	0 (0)	20 (20)	45	311	6.4

[1] ♀: Female plants. ♂: Normal male plants. ♀♂: Dwarf male plants. Sterile: No sex organ.

[2] (Specimens with sporophytes / Total number of specimens examined) x 100.

Table 10. Growing positions of dwarf male plants of three species of Leucobryum in Japan

Species	Growing positions of dwarf male plants		Number of specimens examined
	on tomentum enclosed by perichaetial leaves	on stem leaf of female or among female shoots	
L. juniperoideum	31	2	33
L. bowringii	21	20	36
L. scabrum	0	20	20

plants in almost equal frequency. The dwarf male plants detached from the tomenta often elongate and finally grow independent male plants (Fig. XXIX).

The tomenta in the perichaetia derive from the rhizoids on the abaxial, lower central parts of inner perichaetial leaves which envelop the archegonia (Fig. XXVII: 9, 10, XXVIII: 10). The tomenta are not observed in the perichaetia with mature sporophyte and usually restricted to those with unfertilized archegonia. The rhizoid forming cells are restricted to abaxially exposed chlorocysts which lie usually on the lower median part of perichaetial leaf (Fig. XXVII: 11-14).

This is the first report of presence of the dwarf and the normal male plants in L. bowringii and L. scabrum. Blackstock (1987) studied the male gametophores of L. glaucum and L. juniperoideum. He described the distribution and variation in size of male plants associated with female plants. He concluded that large sized male plants were derived from dwarf male plants, because of the absence of colonies of normal male plants. However, I found the colonies which contain only normal male plants in L. juniperoideum and L. bowringii (Table 9). I considere the male spores of these two species seem to be able to germinate without the influence of female plants and grow independently to the male plants.

2. Geographical distributions of female and male plants of L. juniperoideum, L. bowringii and L. scabrum in Japan

The distributional patterns of female and male plants of three species of Leucobryum in Japan are similar to those of Macromitrium gymnostomum and M. japonicum reported by Une (1985b) (Fig. XXXI-XXXIII). In L. juniperoideum and L. bowringii the occurrence of the normal male plants are rare, and their distribution range is restricted to the relatively low altitude and latitude compared with that of dwarf male plants. The fact seems to suggest that the survival capacity against the low temperature of male plants especially of normal male plants is lower than that of female plants, as mentioned by Une (1985c).

VI. Asexual reproduction

In most cases the taxa of Leucobryum form the caducous leaves which have function of asexual reproduction. This type of caducous leaves is defined as gemmae (Imura & Iwatsuki 1990). The ordinary leaves also bear rhizoids at apices and are considered to be related to asexual reproduction. The caducous leaves are formed at stem apices or on the specialized branchlets (Fig. XXXIV: 1). The abaxial leucocysts at the base of caducous leaves are scarcely decurrent on stems or branchlets, so that the

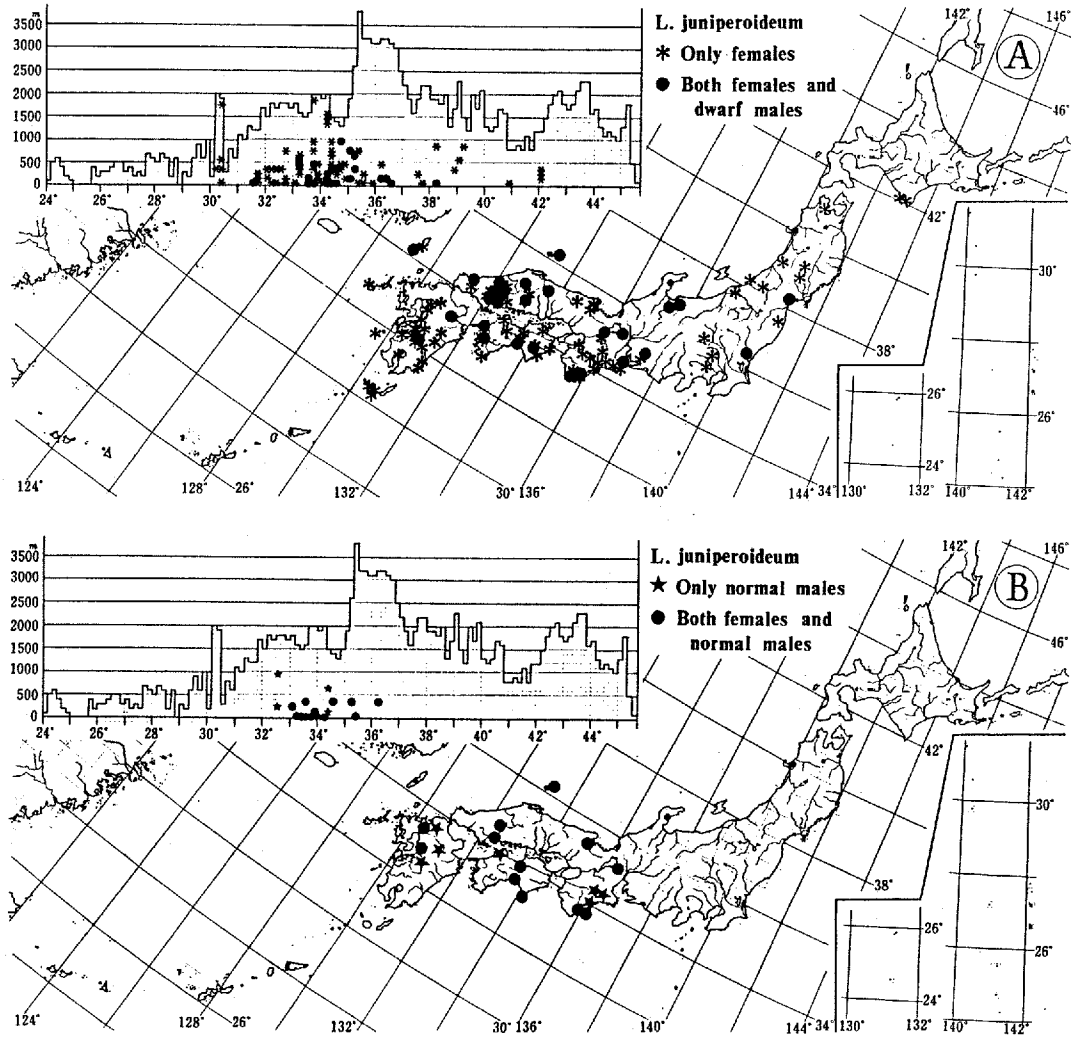

Figure XXXI. Geographical distributions of female and male plants of Leucobryum juniperoideum (Brid.) C. Müll. in Japan.

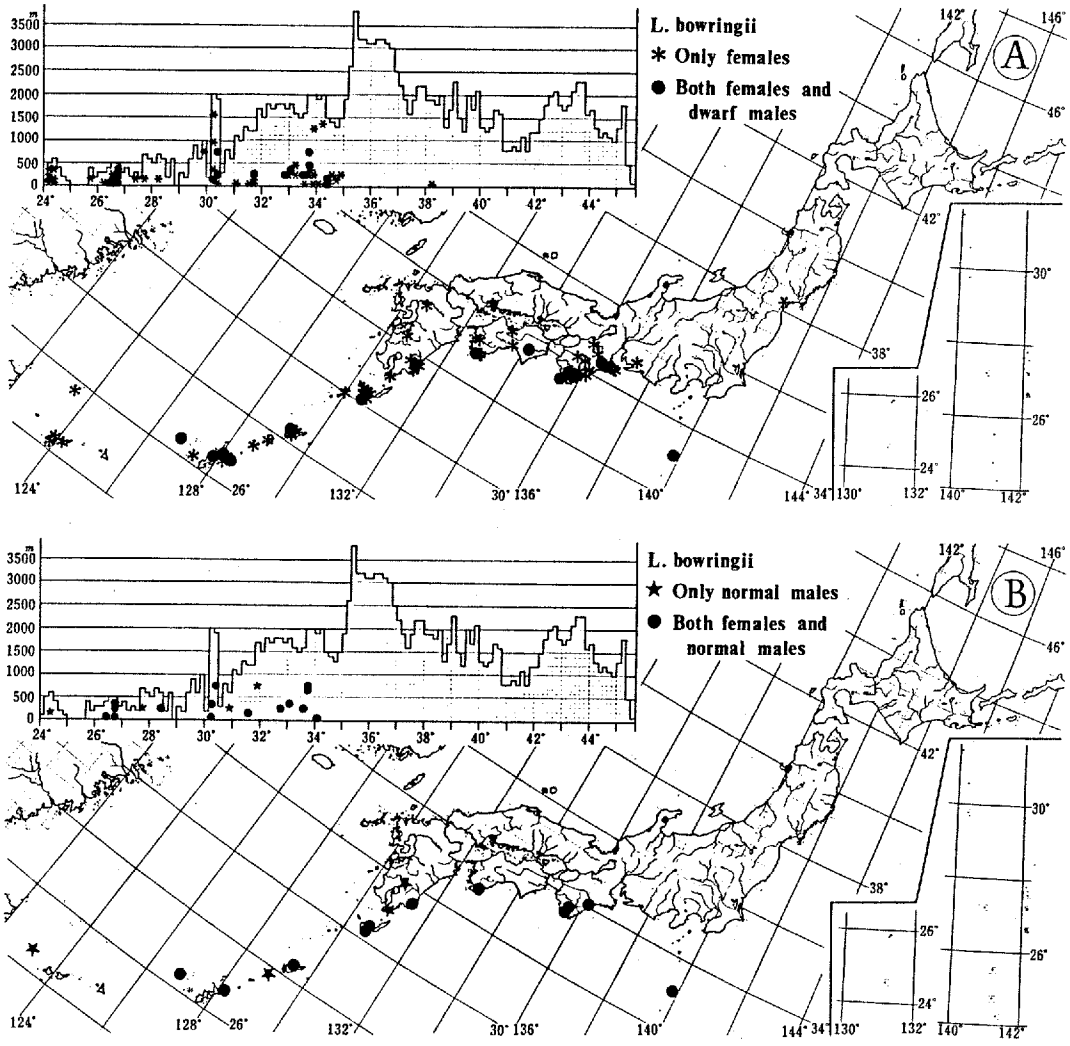

Figure XXXII. Geographical distributions of female and male plants of Leucobryum bowringii Mitt. in Japan.

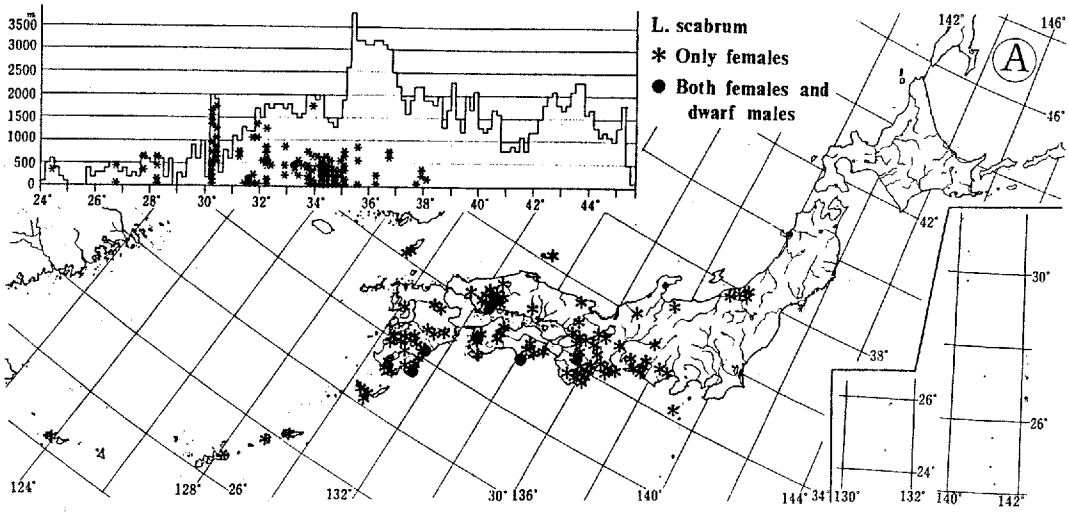

Figure XXXIII. Geographical distributions of female and male plants of Leucobryum scabrum Lac. in Japan.

caducous leaves are easily detached from the stems or branchlets (Fig. XXXIV: 6). Moreover, the caducous leaves are much smaller than the ordinary leaves (Fig. XXXIV: 2, 3).

In L. imbricatum extremely specialized gemmae are found at the stem apex enclosed by ordinary leaves (Fig. XXXV). This type gemmae is similar to those of Brothera leana.

VII. Synopsis of the genus Leucobryum in Asia

In this study I encountered 17 taxonomic characters (Table 11) and compared each taxon reported in this area.

Among 17 characters, following nine characters are newly adapted to the taxonomical study of Asian Leucobryum: (1) the central strand of stem, (2) the manner of proration of abaxial leucocysts at apical parts of leaves, (3) the decurrency of abaxial leucocysts, (4) the ratio between thickness of the thickest part and thickness of the median furrow in cross-section of leaf, (5) the position of perichaetia, (6) the ratio between length of the mature inner perichaetial leaf and length of the stem leaf near the perichaetium, (7) the length of archegonia, (8) the presence of the normal male plants, and (9) the growing habitat of the dwarf male plants.

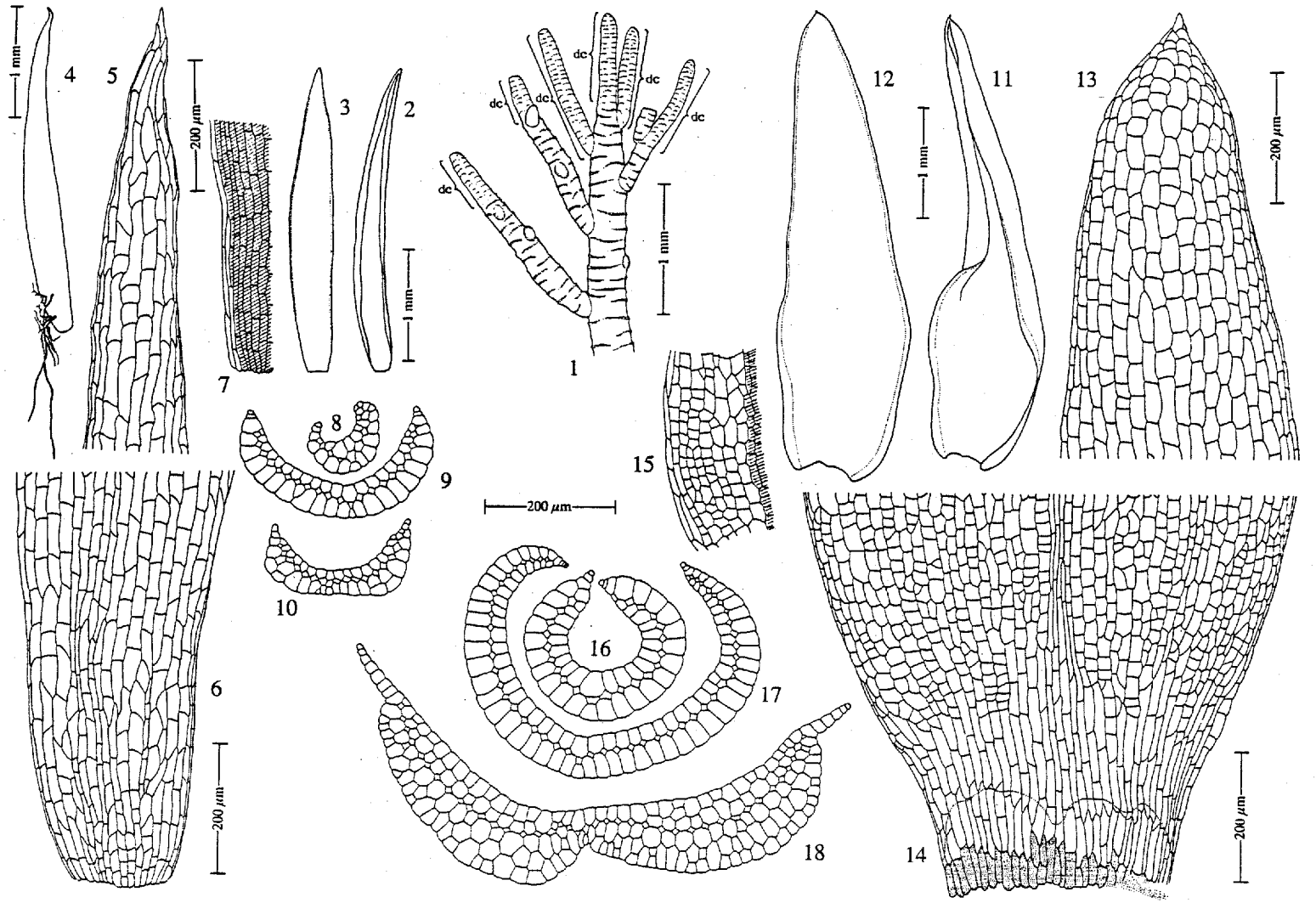

Figure XXXIV. Asexual reproduction of Leucobryum humillimum Card. by deciduous leaves. 1. Branching. dc shows portion which produces deciduous leaves. 2—4. Deciduous leaves (3, 4, expanded). 5. Apex of deciduous leaf. 6. Base of deciduous leaf (abaxial view). 7. Basal cells of deciduous leaf (adaxial view). 8—10. Cross-sections of deciduous leaf (8, apical; 9, median; 10, basal portions). 11, 12. Ordinary leaves (12, expanded). 13. Apex of ordinary leaf. 14. Base of ordinary leaf (abaxial view). 15. Basal cells of ordinary leaf (adaxial view). 16—18. Cross-sections of ordinary leaf (16, apical; 17, median; 18, basal portions). All figures were drawn from lectotype of L. cucullifolium (PC).

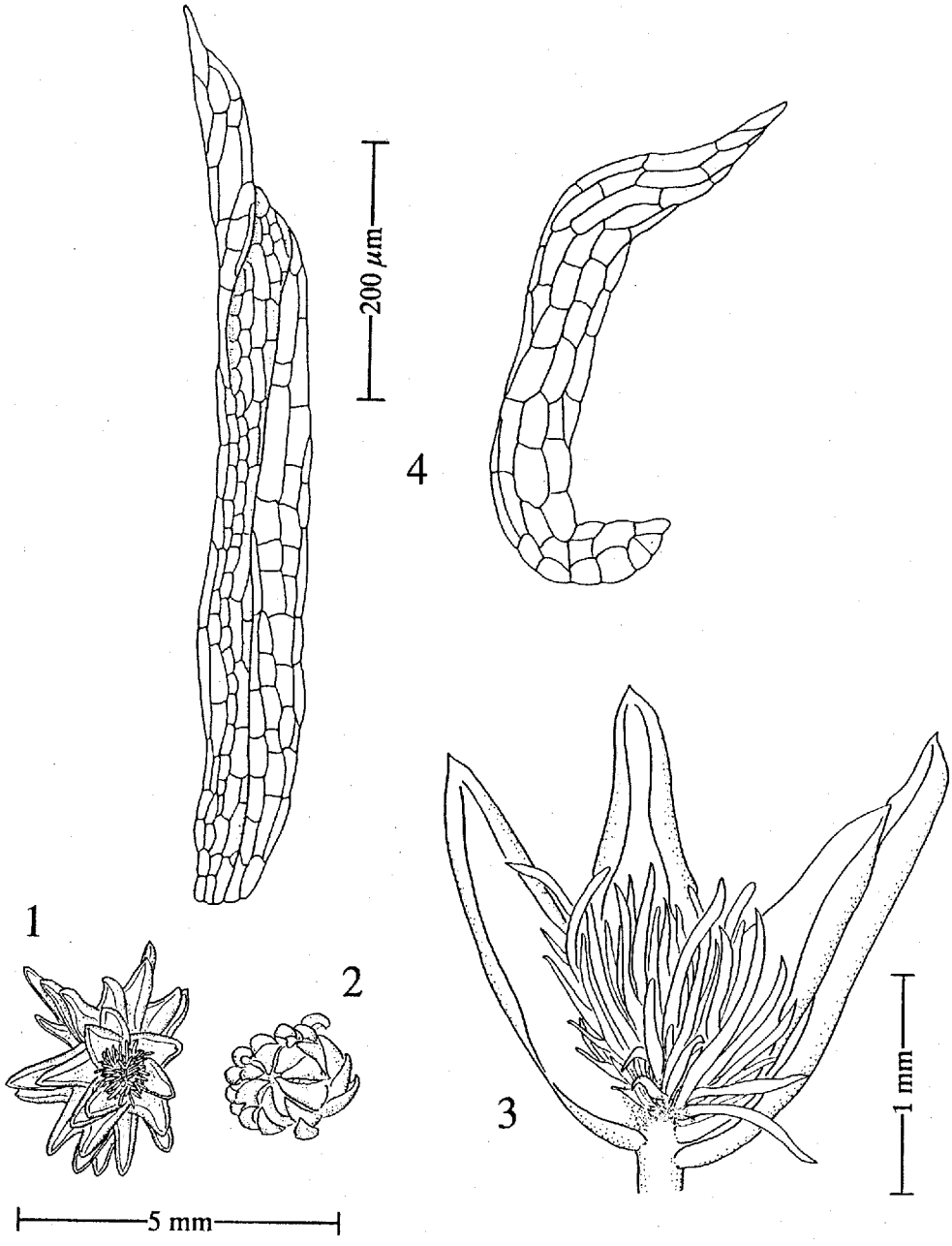

Figure XXXV. Asexual reproduction of Leucobryum imbricatum Broth. by gemmae. 1–3. Shoot apices (1, wet condition; 2, dry condition). 4. Gemmae. All figures were drawn from lectotype of L. imbricatum (H).

Tabele 11. Comparison of some selected characters among the 19 taxa of Asian Leucobryum

Taxa	Maximum length of plant (mm)	Central strand of stem	Leaf arrangement and posture when dry
Leucobryum javense	80	absent	widely spreading, somewhat falcate secund, flexuose above
L. javense var. cyathifolium	80	absent	erect spreading, somewhat falcate secund or squarrose
L. javense var. novae-guineae	150	absent	appressed to erect spreading
L. javense var. uncinatum	80	absent	erect to widely spreading
L. scabrum	60	absent	erect spreading, somewhat falcate secund
L. aduncum	50	absent	falcate secund, somewhat arranged in 5 rows
L. aduncum var. teysmannianum	55	absent	erect spreading, arranged in 5 rows
L. aduncum var. scalare	35	absent	closely imbricate, forming conical point at shoot apex
L. chlorophyllosum	20	absent	erect to widely spreading
L. boninense	50	absent	erect spreading or slightly falcate secund
L. juniperoideum	35	absent	erect spreading
L. humillimum	30	present	imbricate to erect spreading
L. imbricatum	30	present	closely imbricate
L. glaucum	50	absent	erect spreading
L. bowringii	60	present	erect to widely spreading, flexuose and contorted above
L. sumatranum	120	present	erect to widely spreading, somewhat falcate secund, flexuose and contorted above
L. sericeum	35	present	falcate secund
L. sanctum	70	present	widely spreading, somewhat squarrose
L. arfakianum	60	present	appressed to erect spreading

Table 11. Continued

Taxa	Leaf length (mm)	Leaf length / width	Leaf apices	Proration on abaxial side of leaf acumina
Leucobryum javense	8.0-18.0	5.3-5.8	acute to bluntly mucronate	papillosely prorate to 3/10
L. javense var. cyathifolium	9.1-13.0	3.1-4.3	round and apiculate	papillosely prorate to 1/10
L. javense var. novae-guineae	6.6-10.0	3.7-5.0	acute to bluntly mucronate	papillosely prorate to 3/10
L. javense var. uncinatum	8.4-9.7	4.4-5.1	acute and uncinate	papillosely prorate to 4/10
L. scabrum	7.9-8.2	4.3-4.6	acute	undulate and spinosely prorate to 6/10
L. aduncum	3.5-4.1	2.8-4.8	acute	undulate and spinosely prorate to 6/10
L. aduncum var. teysmannianum	3.7-4.3	3.4-4.3	acute	undulate and spinosely prorate to 5/10
L. aduncum var. scalare	2.0-3.5	3.2-4.6	acute	undulate and spinosely or papillosely prorate to 5/10
L. chlorophyllosum	2.5-4.0	5.7-7.8	acute	undulate to 5/10
L. boninense	4.1-7.4	3.7-6.7	acute to bluntly mucronate	papillosely prorate to 6/10
L. juniperoideum	3.1-5.7	3.6-6.0	acute to bluntly mucronate	smooth
L. humillimum	3.0-4.5	3.0-5.3	mucronate	smooth
L. imbricatum	2.4-2.9	2.7-4.7	mucronate	smooth
L. glaucum	5.6-6.8	3.7-4.7	acute to bluntly mucronate	smooth
L. bowringii	4.2-11.0	4.9-13.8	acute	smooth
L. sumatranum	10.0-18.0	6.7-8.0	acute	smooth
L. sericeum	6.5-7.4	9.3-15.0	acute	papillosely prorate to 1/10
L. sanctum	5.3-7.1	4.3-5.3	acute to bluntly mucronate	papillosely prorate to 1/10
L. arfakianum	4.1-6.6	3.5-4.9	acute	smooth

Table 11. Continued

Taxa	Number of cell rows of hyaline lamina and border at leaf base	Decurrency of abaxial leucocysts
Leucobryum javense	6-11	± decurrent on stem
L. javense var. cyathifolium	5-7	distinctly decurrent on stem
L. javense var. novae-guineae	2-7	distinctly decurrent on stem
L. javense var. uncinatum	3-4	distinctly decurrent on stem
L. scabrum	5-7	± decurrent on stem
L. aduncum	3-6	indistinct
L. aduncum var. teysmannianum	4-5	indistinct
L. aduncum var. scalare	3-6	indistinct
L. chlorophyllosum	6-8	indistinct
L. boninense	5-8	indistinct
L. juniperoideum	7-14	indistinct
L. humillimum	4-11	indistinct
L. imbricatum	3-5	indistinct
L. glaucum	5-10	indistinct
L. bowringii	7-12	indistinct
L. sumatranum	7-18	indistinct
L. sericeum	5-8	indistinct
L. sanctum	2-4	distinctly decurrent on stem
L. arfakianum	2-6	distinctly decurrent on stem

Table 11. Continued

Taxa	Structure of leaf bases in cross-sections		
	Thickness of the thickest part / thickness of median furrow	Number of leucocyst layers	vertical position of chlorocysts
Leucobryum javense	2.0-3.5	6-7	centric to hypocentric
L. javense var. cyathifolium	2.5-4.0	6-7	centric to hypocentric
L. javense var. novae-guineae	3.0-3.6	5-6	centric to hypocentric
L. javense var. uncinatum	3.5-4.0	5-6	centric to hypocentric
L. scabrum	1.9-2,2	6-8	centric to hypocentric
L. aduncum	2.3-3.6	5-6	centric
L. aduncum var. teysmannianum	3.0-3.5	4-5	centric
L. aduncum var. scalare	2.0-4.0	3-6	centric to hypercentric
L. chlorophyllosum	1.2-1.7	3-5	centric to hypercentric
L. boninense	2.1-3.1	4-6	centric to hypercentric
L. juniperoideum	1.8-3.0	5-8	centric to hypercentric
L. humillimum	1.6-2.3	4-6	centric to hypercentric
L. imbricatum	1.4-1.7	4	hypercentric
L. glaucum	1.2-1.6	5-6	centric to hypercentric
L. bowringii	1.5-2.5	4-6	centric to hypercentric
L. sumatranum	1.6-1.8	3-4	centric to hypocentric
L. sericeum	1.5-1.6	2-3	centric
L. sanctum	1.5-1.7	2-3	hypocentric
L. arfakianum	1.3-2.0	2	hypocentric

Table 11. Continued

Taxa	Position of perichaetia	Length of mature inner perichaetial leaf / length of ordinary leaf near the perichaetium
Leucobryum javense	terminal on short lateral branches	ca. 0.4
L. javense var. cyathifolium	terminal on short lateral branches	mature perichatial leaves not seen
L. javense var. novae-guineae	terminal on short lateral branches	mature perichatial leaves not seen
L. javense var. uncinatum	terminal on short lateral branches	mature perichatial leaves not seen
L. scabrum	terminal on short lateral branches	0.3¬0.6
L. aduncum	terminal on short lateral branches	0.9-1.0
L. aduncum var. teysmannianum	terminal on short lateral branches	mature perichaetial leaves not seen
L. aduncum var. scalare	terminal on short or long lateral branches, sometimes on stems	1.4-1.8
L. chlorophyllosum	terminal on short or long lateral branches, sometimes on stems	ca. 1.0
L. boninense	terminal on short lateral branches	0.7-1.0
L. juniperoideum	terminal on stems and subfloral innovations	1.0-1.8
L. humillimum	terminal on stems and subfloral innovations	1.4-1.6
L. imbricatum	not seen	mature perichaetial leaves not seen
L. glaucum	terminal on stems and subfloral innovations	0.7-0.8
L. bowringii	terminal on stems and subfloral innovations, or on long lateral branches	0.5-0.9
L. sumatranum	terminal on short lateral branches	ca. 0.3
L. sericeum	terminal on short lateral branches, sometimes on stems	ca. 0.5
L. sanctum	terminal on short lateral branches	ca. 0.3
L. arfakianum	terminal on short lateral branches	0.5-0.6

Table 11. Continued

Taxa	Length of archegonia (mm)	Normal male plants	Dwarf male plants
Leucobryum javense	ca. 0.9	not seen	growing on female stem leaves
L. javense var. cyathifolium	ca. 0.7	not seen	not seen
L. javense var. novae-guineae	0.9-1.2	not seen	not seen
L. javense var. uncinatum	not seen	not seen	not seen
L. scabrum	ca. 0.8	not seen	growing on female stem leaves
L. aduncum	0.5-0.8	not seen	growing on perichaetia
L. aduncum var. teysmannianum	ca. 0.7	not seen	not seen
L. aduncum var. scalare	0.7-0.9	present	growing on perichaetia
L. chlorophyllosum	0.7-0.8	present	growing on perichaetia and female stem leaves
L. boninense	0.6-0.8	present	not seen
L. juniperoideum	1.2-1.6	present	growing on perichaetia
L. humillimum	ca. 1.3	present	growing on perichaetia
L. imbricatum	not seen	not seen	not seen
L. glaucum	1.7-1.8	present	growing on perichaetia
L. bowringii	1.2-1.8	present	growing on perichaetia and female stem leaves
L. sumatranum	ca. 1.5	not seen	growing on perichaetia
L. sericeum	0.9-1.0	not seen	growing on perichaetia
L. sanctum	ca. 0.7	not seen	growing on perichaetia
L. arfakianum	1.0-1.2	not seen	growing on perichaetia

Table 12. Synopsis of the genus Leucobryum in Asia

Leucobryum Hampe

1. L. javense (Brid. ex Schwägr.) Mitt.
   Basionym: Sphagnum javense Brid. ex Schwägr.

1a. L. javense var. cyathifolium (Dix.) T. Yamaguchi, stat. nov.
   Basionym: L. cyathifolium Dix.
   Synonym: L. brassii Bartr., syn. nov.

1b. L. javense var. novae-guineae (Bartr.) T. Yamaguchi, stat. nov.
   Basionym: L. novae-guineae Bartr.
   Synonym: L. antarense Zant., syn. nov.

1c. L. javense var. uncinatum (Fl.) T. Yamaguchi, stat. nov.
   Basionym: L. uncinatum Fl.

2. L. scabrum Lac.

3. L. aduncum Dozy & Molk.
   Synonym: L. pentastichum Dozy & Molk. = L. candidum (Brid. ex P. Beauv.) Wils. var. pentastichum (Dozy & Molk.) Dix., syn. nov.

3a. L. aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi, stat. nov.
   Basionym: L. teysmannianum Dozy & Molk.

3b. L. aduncum var. scalare (C. Müll. ex Fl.) A. Eddy
   Basionym: L. scalare C. Meull. ex Fl.
   Synonym: L. scalare var. marschmeyeri Fl.
   L. scalare var. tjibodense Fl.
   L. flavulum Card. in Ren. & Card., syn. nov.
   L. subscalare Broth. ex Vard., syn. nov.

Table 12. Continued

L. krempfii Thér., syn. nov.

L. poilanei Thér., syn. nov.

L. perichaetiale Dix., syn. nov.

L. aduncum var. arnottii Thér., syn. nov.

L. microleucophanoides Dix. ex Johnson, syn. nov.

4. L. chlorophyllosum C. Müll.

Synonym: L. stenophyllum Besch., syn. nov.

L. byssaceum C. Müll. ex Johnson, syn. nov.

5. L. boninense Sull. & Lesq.

Synonym: L. salmonii Card. in Ren. & Card., syn. nov.

L. scaberulum Card. in Ren. & Card., syn. nov.

L. armatum Broth., syn. nov.

L. scaberulum var. divaricatum Dix., syn. nov.

L. nakaii Hor., syn. nov.

6. L. juniperoideum (Brid.) C. Müll.

Basionym: Dicranum juniperoideum Brid.

Synonym: L. neilgherrense C. Müll.

L. holleanum Dozy & Molk.

L. triviale C. Müll., syn. nov.

L. retractum Besch., syn. nov.

L. japonicum (Besch.) Card. in Broth.

L. altiusculum Besch.

L. brevicaule Besch.

L. humile Broth. ex Besch.

L. lacteorum Besch.

Table 12. Continued

L. textorii Besch.

L. holleanum var. fragilifolium Fl., syn. nov.

L. ferriei Card. in Ren. & Card.

L. neilgherrense var. minus Card., syn. nov.

L. rhizophyllum Warnst.

L. angustissimum Broth., syn. nov.

7. L. humillimum Card.

Basionym: Ochrobryum wightii Besch.

Synonym: L. galeatum Besch. = L. neilgherrense C. Müll. var. galeatum (Besch.) Dix., syn. nov.

L. mittenii Besch., syn. nov.

L. wichurae Broth. ex Besch., syn. nov.

L. cuculliphyllum Fl., syn. nov.

L. cucullifolium Card. in Ren. & Card., syn. nov.

L. propaguliferum (Dix.) Robinson, syn. nov.

8. L. imbricatum Broth.

9. L. glaucum (Hedw.) Ångstr. in Fries

Basionym: Dicranum glaucum Hedw.

10. L. bowringii Mitt.

Synonym: L. ceylanicum (Besch.) Card., syn. nov.

L. yamatense Besch.

L. nagasakense Broth.

L. brotheri Card. in Ren. & Card.

L. deciduum Card. in Ren. & Card., syn. nov.

Table 12. Continued

	L. stenobasis Card. in Ren. & Card., syn. nov.
	L. confine Card.
	L. subsericeum Dix., syn. nov.
11. L. sumatranum Broth. ex Fl.	
Synonym:	L. pulchrum Broth.
12. L. sericeum Broth. ex Geh.	
Synonym:	L. bowringii Mitt. var. sericeum (Broth. ex Geh.) Dix.
13. L. sanctum (Brid.) Hampe	
Basionym:	Dicranum glaucum Hedw. var. sanctum Brid.
Synonym:	L. auriculatum C. Müll. in Geh.
	L. papuense Par.
14. L. arfakianum C. Müll. ex Geh.	
Synonym:	L. subsanctum Broth.
	L. papuense var. pendulum Zant.
	L. sanctum (Brid.) Hampe var. arfakianum (C. Müll. ex Geh.) A. Eddy

As a result, I recognized 19 taxa of Leucobryum in Asia (Table 12).

VIII. Taxonomic treatment

In the following treatment, the names of herbaria are abbreviated according to Index Herbariorum I, Ed. 8 (Holmgren et al. 1990). Only representative specimens are listed.

Unless otherwise indicated, descriptions of species were based on female plants. The illustrations were mostly based on the type specimens, and, when necessary, additional illustrations were made, based on other appropriate specimens. Synonyms listed in this treatment are restricted to the Asian taxa.

Leucobryum Hampe

Linnaea 13: 42 (1839). Type: Leucobryum glaucum (Hedw.) Ångstr. in Fries.

Plants whitish green when moist in field, whitish in dried herbarium specimens, forming cushions or mats. Stems erect, rarely pendulous, sometimes with a central strand. Leaves crowded, thick and fleshy, linear lanceolate to lanceolate, narrowed to subtubulous point from a oblong to ovate base, acute to mucronate, often with rhizoids at apex;

laminae consisting of leucocysts, narrow, usually restricted to basal parts, ± bordered by linear cells, the linear border cells extending to near the leaf apex; costae broad, occupying greater parts of leaves, consisting of 2-8 layer leucocysts and 1 layered of chlorocysts which sandwiched by leucocysts and form reticula; in cross-sections near leaf base ± hollowed at median part. Caducous leaves often differentiated.

Dioicous. Male plants dimorphous; dwarf male plants tiny, growing on tomentum enclosed by perichaetial leaves or on ordinary leaves of female plants; normal male plants as large as female plants, perigonia small, bud-like; perigonial leaves cochleariform, enveloping a whole cluster of antheridia; antheridia oblong with numerous paraphyses. Perichaetia terminal on short lateral branches or on main stems; perichaetial leaves differentiated, the basal parts broader and longer than those of ordinary leaves, the perichaetial leaves around unfertilized archegonia often with rhizoids on lower adaxial surface and forming a mass of tomentum. Sporophytes dicranoid. Setae elongate, erect, sometimes clustered. Capsules inclined to horizontal, rarely erect, ovoid to ellipsoid, ± strumose; opercula long rostrate. Annulus of 1-2 rows of cells when present. Apices of peristome teeth divided to the middle, papillose above, vertically striolate below on the dorsal surface,

densely papillose below on the ventral surface. Spores spherical, minutely papillose. Calyptra cucullate.

Key to the taxa of Leucobryum in Asia

1. Leaves smooth above on abaxial side except extreme leaf tips 2
1. Leaves scabrous or undulate above on abaxial side 8
   2. Leaves auriculate, abaxial leucocysts distinctly decurrent on stems .....14. L. arfakianum
   2. Leaves not auriculate, abaxial leucocysts not decurrent on stems 3
3. Leaves usually lustrous, linear lanceolate, flexuose and contorted above when dry 4
3. Leaves not lustrous, lanceolate, straight above when dry 5
   4. Plants medium in size (up to 60 mm long). Leaves 4.2-11.0 mm long. Perichaetia terminal on stems and subfloral innovations, or on long lateral branches .. ..10. L. bowringii
   4. Plants robust (up to 120 mm long). Leaves 10.0-18.0 mm long. Perichaetia terminal on short lateral branches .....11. L. sumatranum
5. Stems without a central strand. Leaves erect spreading, acute to bluntly mucronate 6

5. Stems with a central strand. Leaves imbricate to erect spreading, distinctly mucronate 7

6. In cross-sections near leaf bases leucocysts in 2 cell layers at the central parts, the thickest parts 1.8-3.0 times thicker than the central part ....6. L. juniperoideum

6. In cross-sections near leaf bases leucocysts in (2-) 3-4 cell layers at the central parts, the thickest parts 1.2-1.6 times thicker than the central part ... .9. L. glaucum

7. Caducous leaves not well differentiated but narrower than ordinary leaves, faintly attached on stems or specialized branches. In cross-sections near leaf apices abaxial leucocysts in 1 cell layer, almost as thick as adaxial leucocysts .....7. L. humillimum

7. Caducous leaves highly differentiated, linear, usually helicoid or twisted, forming a cluster at shoot apex enclosed by ordinary leaves. In cross-sections near leaf apices abaxial leucocysts in 1-2 cell layers, distinctly thicker than adaxial leucocysts ....8. L. imbricatum

8. Stems with a central strand 9

8. Stems without a central strand 10

9. Leaves not auriculate, abaxial leucocysts not decurrent on stems .....12. L. sericeum

9. Leaves auriculate, abaxial leucocysts distinctly decurrent on stems .....13. L. sanctum

10. Plants small to medium in size. Leaves 2.0-6.0 (-7.5) mm long 11

10. Plants robust. Leaves (6.5-) 8.0-18.0 mm long ...15

11. Plants medium in size. Leaves more than 4.0 mm long, papillosely prorate above on abaxial side .....5. L. boninense

11. Plants usually small. Leaves to 4.3 mm long, undulate and spinosely prorate or undulate (not prorate) at upper part on abaxial side 12

12. Leaves narrowly lanceolate, 5.7-7.8 times longer than wide, undulate above on abaxial side .....4. L. chlorophyllosum

12. Leaves lanceolate, 2.8-4.8 times longer than wide, undulate and spinosely prorate above on abaxial side 13

13. Leaves 2.0-3.5 mm long, spirally arranged, usually closely imbricate and forming conical points at shoot apices .....3b. L. aduncum var. scalare

13. Leaves 3.5-4.3 mm long, more or less arranged in 5 rows, erect spreading or falcate secund, not forming conical points at shoot apices 14

14. Leaves falcate secund, somewhat arranged in 5 rows .....3. L. aduncum var. aduncum

14. Leaves erect spreading, distinctly arranged in 5 rows .....3a. L. aduncum var. teysmannianum

15. Leaves undulate and spinosely prorate to 3/5 above on abaxial side .....2. L. scabrum

15. Leaves papillosely prorate to 2/5 above on abaxial side 16

16. Abaxial leucocysts weakly decurrent on stems ....1. L. javense var. javense

16. Abaxial leucocysts distinctly decurrent on stems ... .17

17. Leaves distinctly uncinate at apex ....1c. L. javense var. uncinatum

17. Leaves not uncinate at apex 18

18. Leaves erect spreading, somewhat falcate secund or squarrose, rounded and apiculate at apex ....1a. L. javense var. cyathifolium

18. Leaves appressed to erect spreading, acute to bluntly mucronate ....1b. L. javense var. novae-guineae

1. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense

(Fig. XVIII, XXVI, XXXVI-XL, CXLI: 1)

J. Linn. Soc. Bot. Suppl. 1: 25 (1859).

Basionym: Sphagnum javense Brid. ex Schwägr., Spec. Musc. Suppl. 2(1): 4, t. 102 (1823). Type: "In silvis

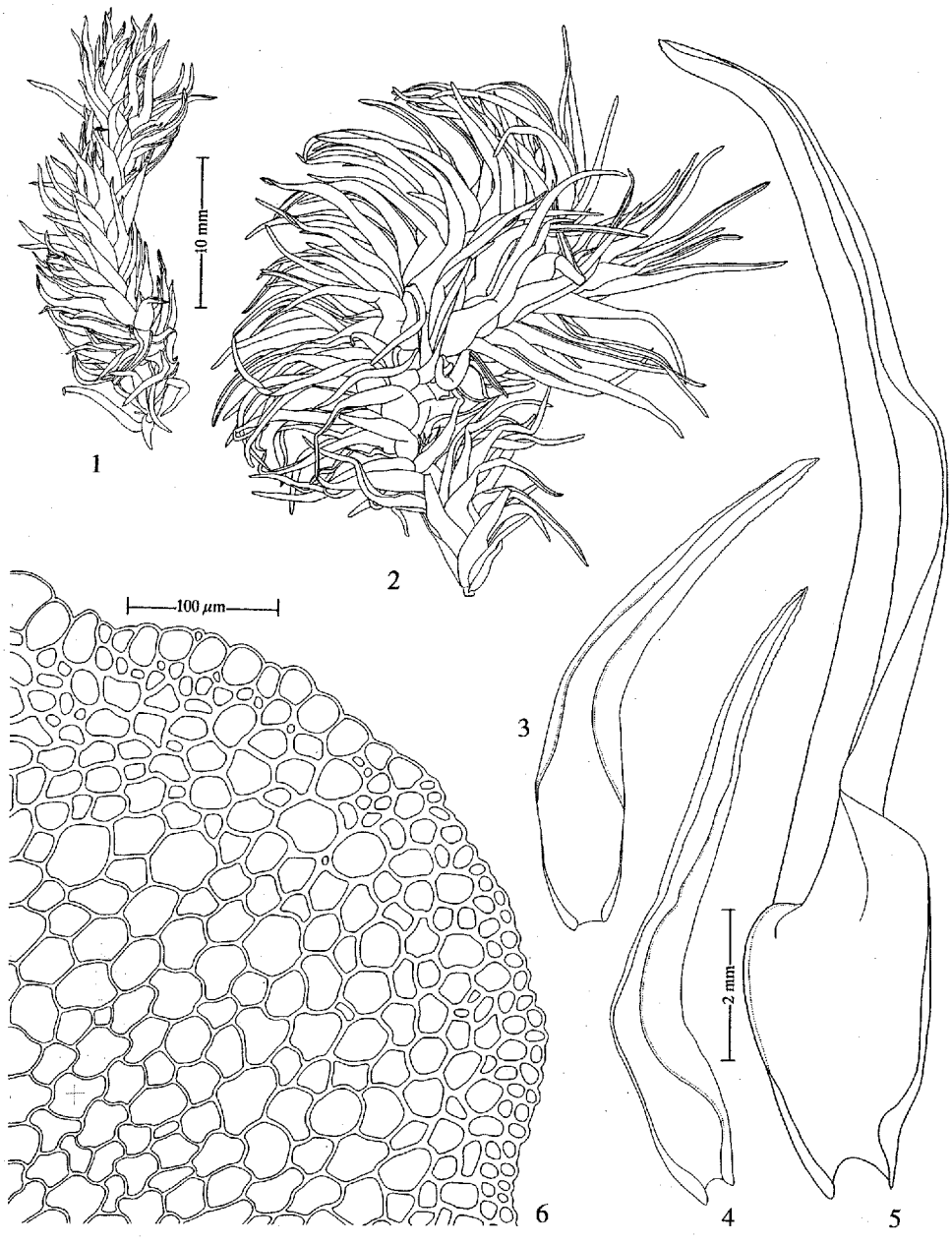

Figure XXXVI. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. 1, 2. Plants. 3–5. Leaves. 6. Cross-section of stem. Figs. 1, 3, 4 were drawn from holotype of Sphagnum javense (B); 2, 5, 6 from Joncheere 1621 (L)..

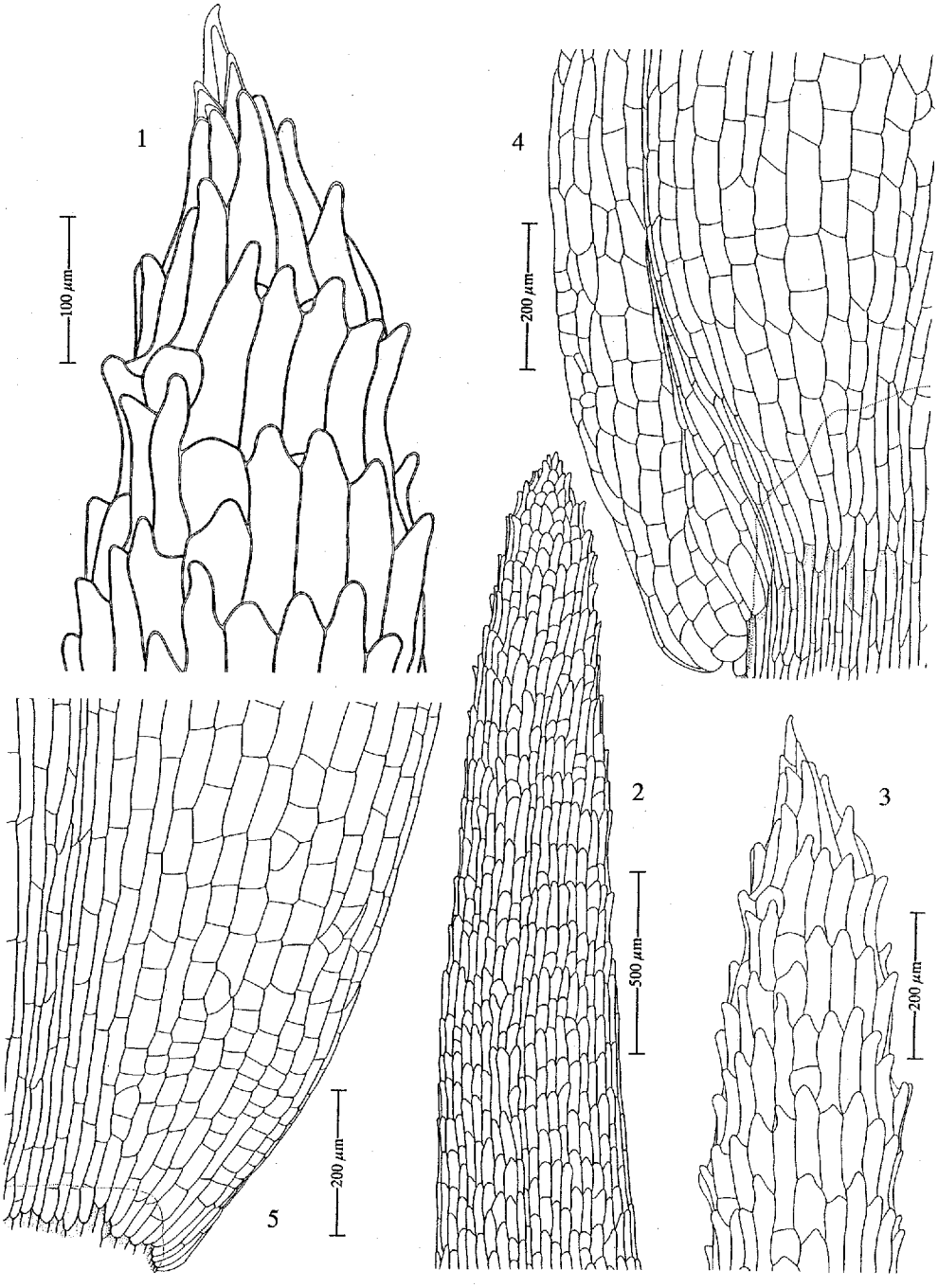

Figure XXXVII. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. 1–3. Leaf apices. 4, 5. Leaf bases (abaxial view). Figs. 1, 3, 5 were drawn from holotype of Sphagnum javense (B); 2, 4, from Joncheere 1621 (L).

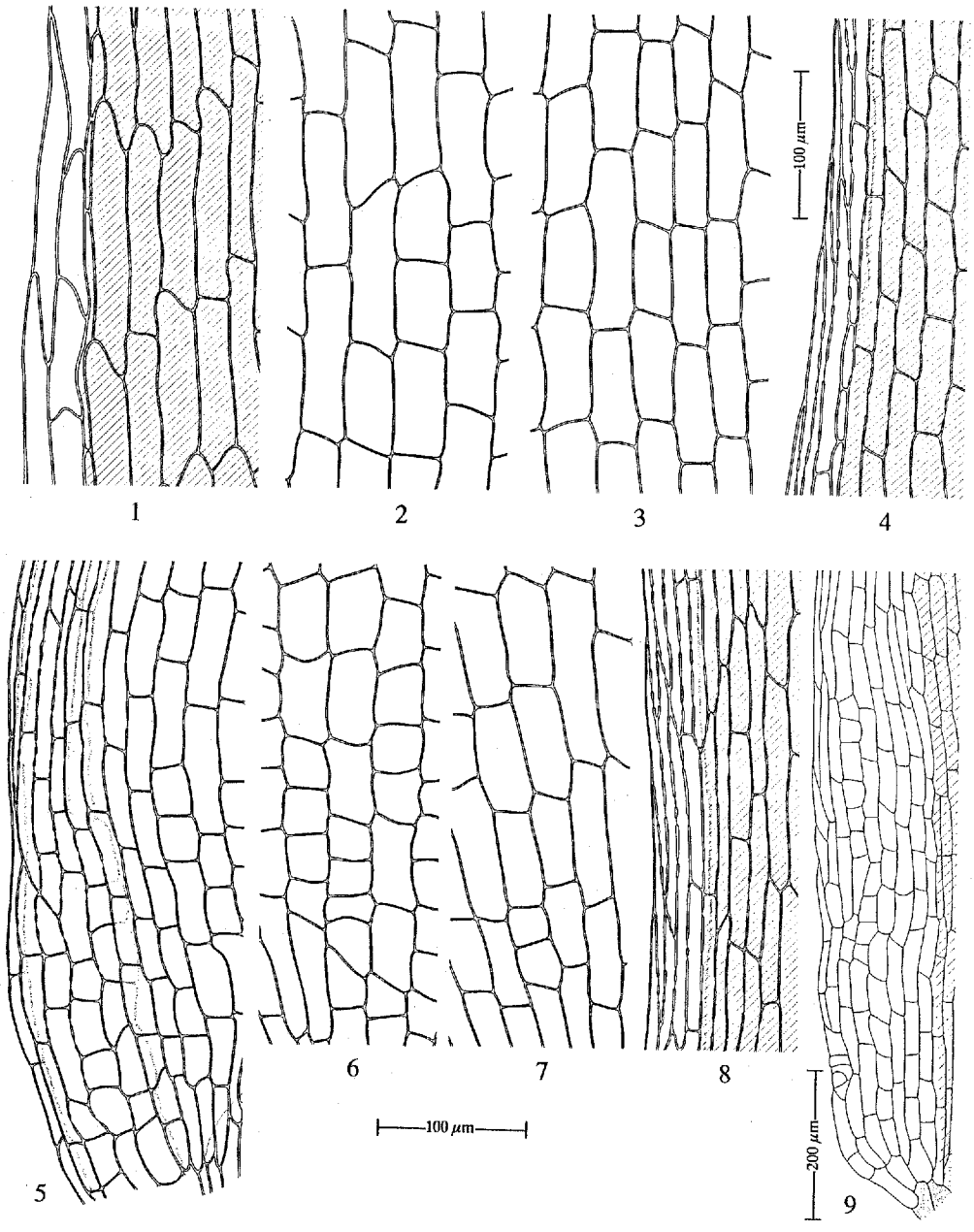

Figure XXXVIII. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. 1. Cells near leaf apex (adaxial view). 2–4. Median cells of leaf (2, abaxial view; 3, 4, adaxial view). 5–9. Basal cells of leaf (5, 6, abaxial view; 7–9, adaxial view). Figs. 1–8 were drawn from holotype of Sphagnum javense (B); 9, from Joncheere 1621 (L).

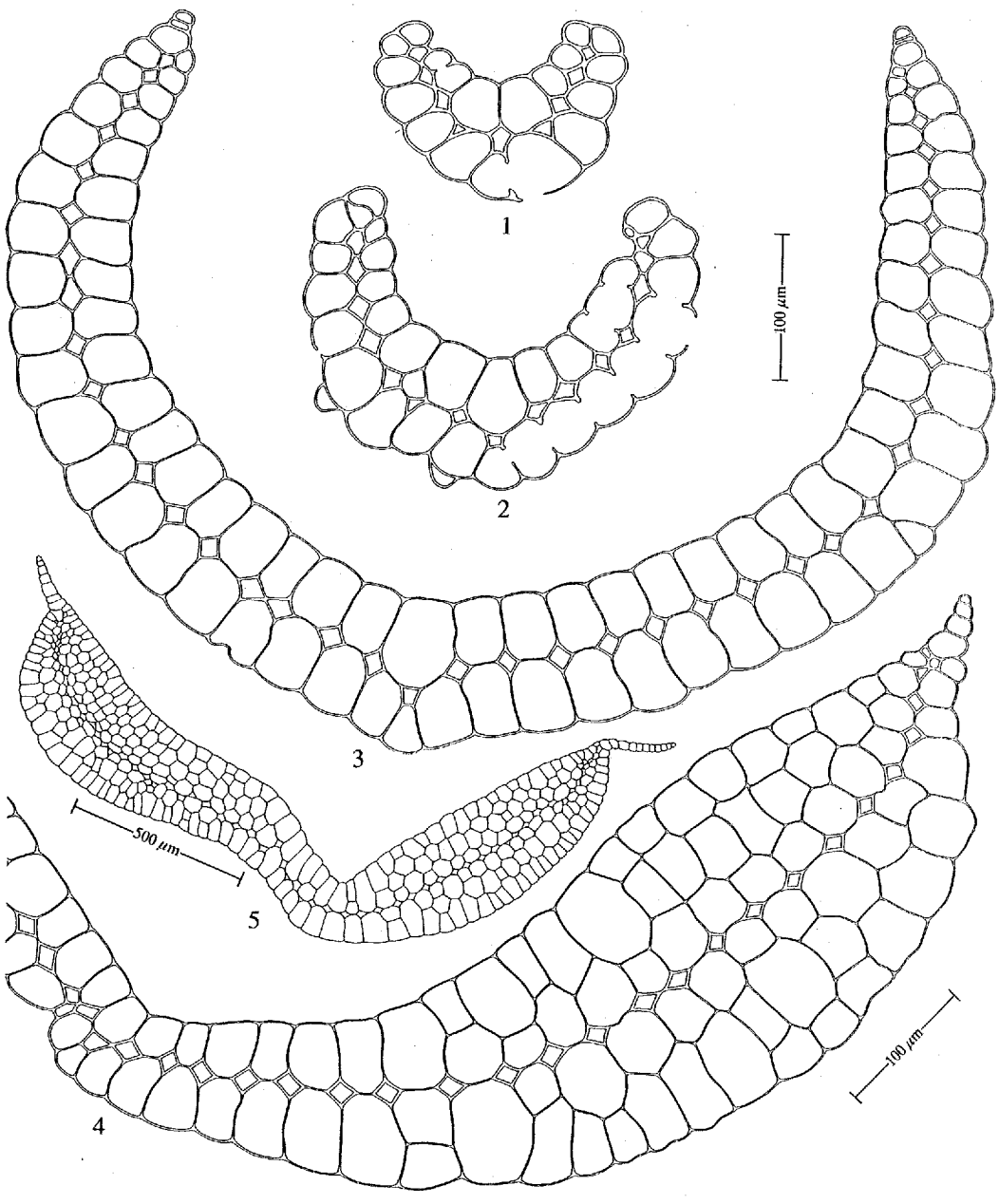

Figure XXXIX. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. 1–5. Cross-sections of leaves (1, 2, apical; 3, median; 4, 5, basal portions). Figs. 1–4 were drawn from holotype of Sphagnum javense (B); 5, Joncheere 1621 (L).

Figure XL. Leucobryum javense (Brid. ex Schwägr.) Mitt. var. javense. 1–4. Perichaetia (1, 4, with sporophyte). 5. Dwarf male plant. 6. Perigonia. 7. Antheridium. 8. Archegonium. 9. Paraphysis. All figures were drawn from Joncheere 1621 (L).

insulae Javae ad montem coeruleum legit (anno MDCCLXVIII. mense Octobri e Bridelio) Commersonus" – holotype (B).

Plants whitish tinged with yellow or purple when dry, forming loose tufts or cushions. Stems to 80 mm long with leaves; central strand not differentiated in cross-sections of stems but the cortical cells gradually smaller and thinner-walled inward. Leaves widely spreading, somewhat falcate secund, rarely erect spreading, sometimes flexuose above; 8-18 x 1.5-3.1 mm, lanceolate to narrowly lanceolate, gradually narrowed to subtubulous point from oblong base, acute to bluntly mucronate, papillosely prorate from the apex to 3/10 of the leaf length on abaxial surface; laminae consisting of 3-6 rows of quadrate to rectangular cells near base, bordered by 2-3 rows of linear cells; in cross-sections near leaf base leucocysts in 3-4 cell layers on adaxial side and 3-4 cell layers on abaxial side at the thickest part; abaxial leucocysts ± decurrent on stems.

Dioicous. Dwarf male plants growing on stem leaves of female plants; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes very small (e. g. inner perichaetial leaf 6.4 x 1.6 mm when the stem leaf near the perichaetium 15.5 x 2.9 mm), 0.4 times longer than ordinary leaves; archegonia ca. 0.9 mm long. Perfect sporophytes not observed.

Representative specimens examined: Japan, Ryukyu Islands, Amami-ôshima, Mt. Yuwan, 680 m alt., 15 Dec. 1985, Yamaguchi 9054 (HIRO). Taiwan, Taichung, Tungshih, Mahanshan, 6 Dec. 1958, Wang 22 (NICH). China, Hainan, Kwantung, 6 Feb. 1962, Chen et al. 364 (L). Himalaya, central region, Hooker s. n., in herb. Mitten 1270 (NY). India, Mt. Khasia, Hooker & Thompson s. n., in herb. Mitten 1276 (NY). Sri Lanka, Rambodde, 1847, Gardner 49, in herb. Mitten 1278 (NY). Thailand, Udawn, snadstone massive Phu(Mt.) Krading, 16°50'N 101°45'E, 1200 m alt., 14 Jan. 1966, Touw 10897 (L). Cambodia, Province de Kampot, Poporkuil, ca. 1000 m alt., 4-6 Dec. 1964, Kira et al. 11 (HIRO). Vietnam, Tonkin, July 1927, Pételot s. n. (NICH 214153). Malay Peninsula, Pahang, Fraser's Hill, ca. 900 m alt., 25 Aug. 1974, Balgooy 2062B (L). Philippines, Mindanao, 5 Oct. 1965, Robbins 3989, mixed with L. javense var. cyathifolium (L). Borneo, Sarawak, Belengki, Bakelalan, 4500 ft. alt., 16 Aug. 1955, Brooke 10479 (L). Sulawesi, Mt. Wawonseru, SW of Soroako, 2°15'S 121°-121°45'E, 1050-1200 m alt., 27 June 1979, Hennipman 6034E (L). Sumatra, Brastagi-Tonkkeh, summit of Delangsikut, 1700 m alt., 19 June 1952, Wijk 1964 (L). Java, Prov. Preanger, Gedeh, Jan. 1894, Shiffner 10353 (L). Seram, Kecamatan Seram Utara, Manusela National Park, along a trail between

Kanikeh and Wae Angsela, 3°06-08'S 129°28-29'E, 1060 m alt., 2 Jan. 1985, Akiyama 8681 (KYO, HIRO).

Habitat: Usually on moist humus, occasionally on tree trunks and soil in shaded forests.

Distribution: Japan, Taiwan, China, Himalaya, India, Sri Lanka, Thailand, Cambodia, Vietnam, Malay Peninsula, Philippines, Borneo, Sulawesi, Sumatra, Java, Seram, New Guinea.

The present variety is characterized by (1) robust plants, (2) long and usually falcate leaves up to 18 mm long, (3) abaxially papillosely proration of leaf apices down to 3/10 of the leaf length, (4) perichaetia which are terminal on short lateral branches, and (5) inner perichaetial leaves which are shorter than stem leaves.

L. javense var. javense has general appearances similar to L. scabrum Lac., but the leaves of L. scabrum are smaller (up to 8.2 mm long), while those of L. javense var. javense are larger (8.0-18.0 mm long). Moreover, in L. scabrum the apical part of leaves is abaxially undulate and spinosely prorate in upper 3/5 of the leaf length, while in L. javense var. javense papillosely prorate in upper 3/10. L. scabrum usually grows on soil or rocks and forming relatively compact mats, whereas L. javense var. javense usually grows on humus and forming loose cushions or tufts.

L. javense is classified into four varieties based on the growing habits and leaf structure.

1a. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi, stat. nov. (Fig. XLI-XLV, CXLI: 8)

Basionym: Leucobryum cyathifolium Dix., J. Linn. Soc. Bot. 45: 499 (1922). Type: New Guinea, Port Moresby District, Mt. Durigolo near Boku, 1916, Clark s. n. (in herb. Dixon, ref. no. 9) – holotype (BM).

Leucobryum brassii Bartr., Brittonia 9: 36 (1957), syn. nov. Type: New Guinea, Milne Bay District, Maneau Range, north slopes of Mt. Dayman, 2230 m alt., on ground and lower tree trunks in mossy forest, 23 May 1953, Brass 22466 – holotype (FH).

Plants whitish when dry, forming loose tufts. Stems to 80 mm long with leaves; central strand not differentiated in cross-sections of stems but the walls of cortical cells thinner inward. Leaves erect spreading, somewhat falcate secund or squarrose; 9.1-13.0 x 2.0-3.5 mm, lanceolate, gradually narrowed to broadly channeled point from oblong base, rounded and apiculate at apex (Fig. XLII: 2), papillosely prorate from the apex to 1/10 of the leaf length on abaxial surface; laminae and borders consisting of 5-7 rows of narrowly rectangular cells near base, the differentiation between laminal cells and border cells

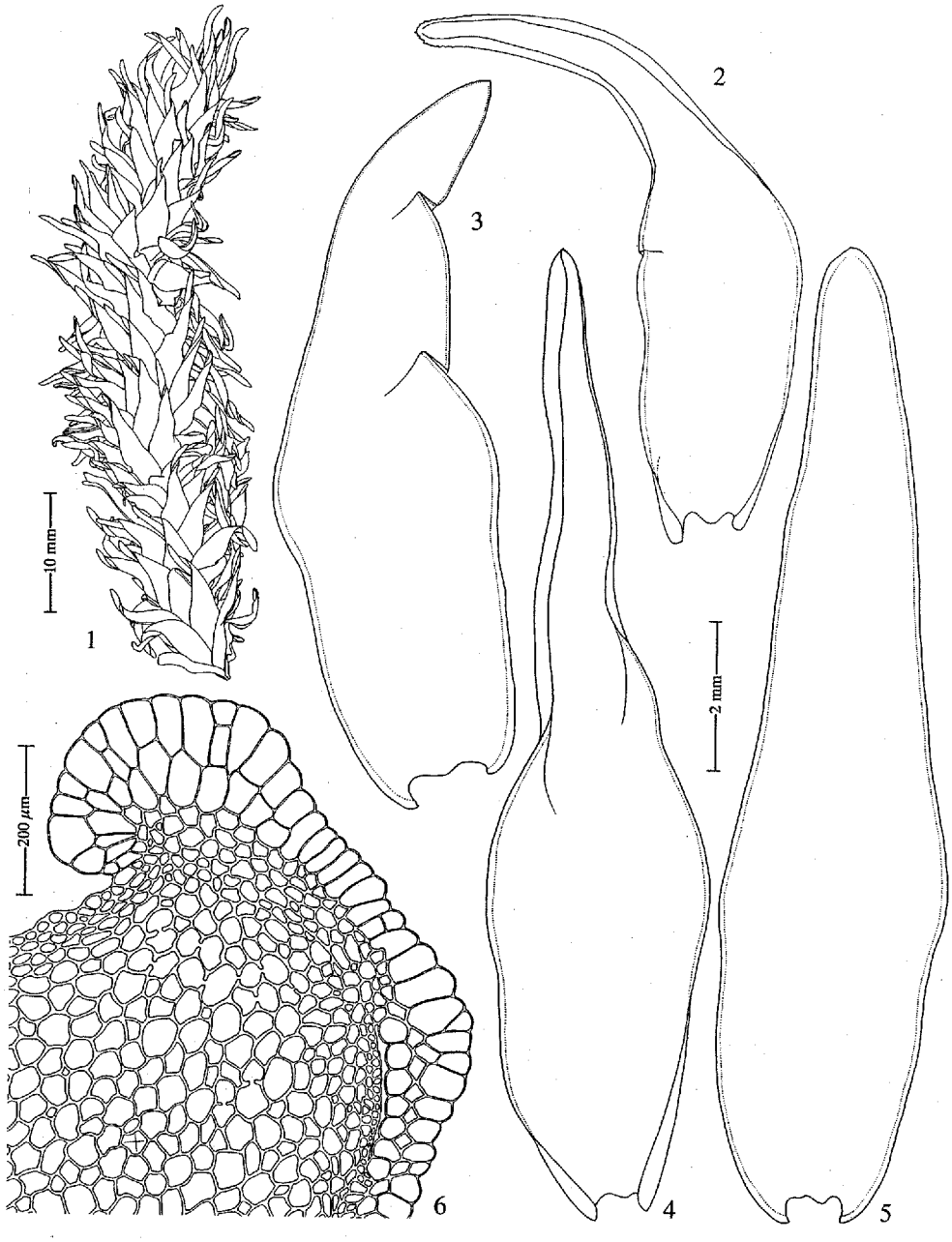

Figure XLI. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi. 1. Plant. 2–5. Leaves (3, 5, expanded). 6. Cross-section of stem. Figs. 1, 4, 5 were drawn from holotype of L. brassii (FH); 2, 3, 6, from holotype of L. cyathifolium (BM).

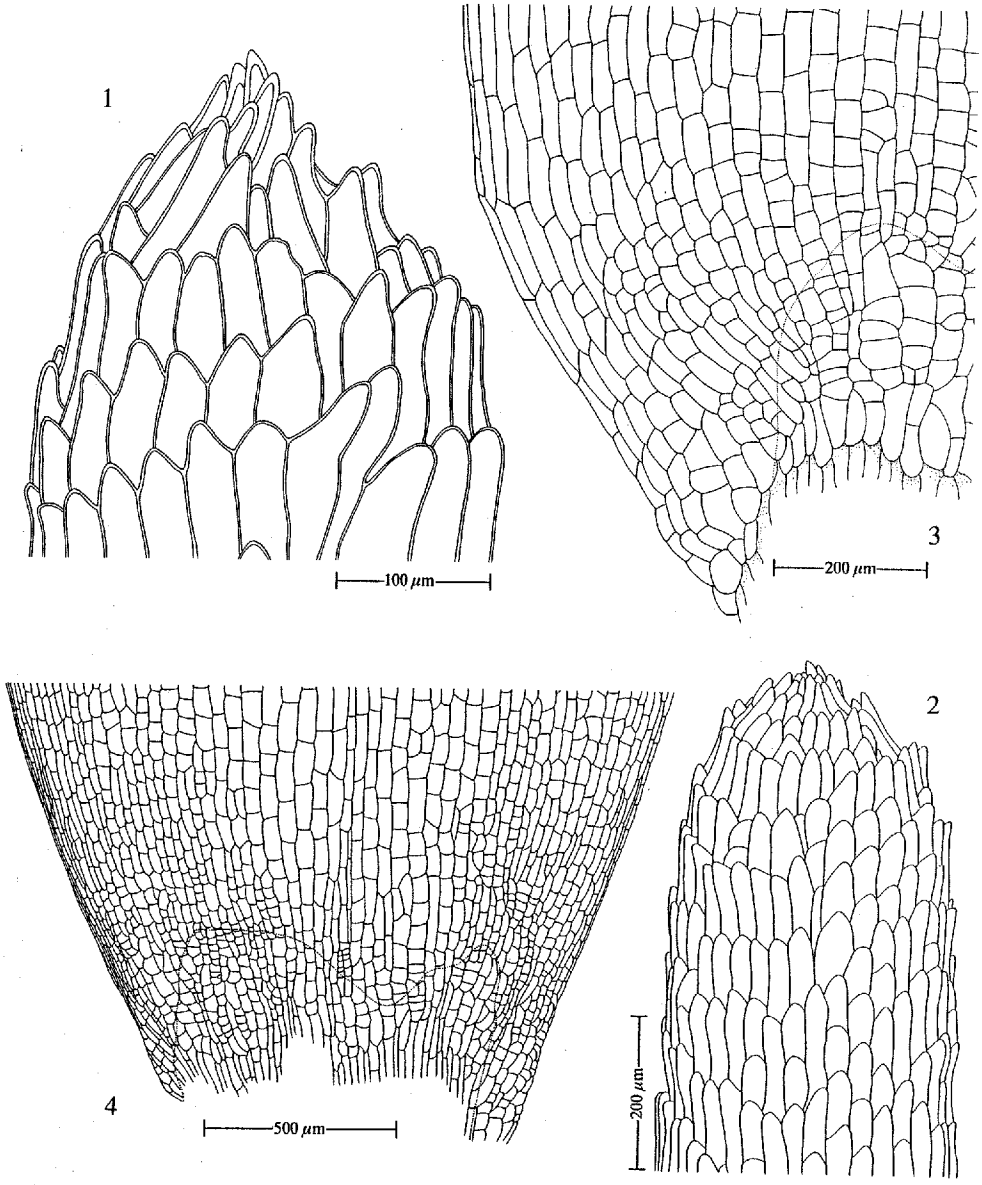

Figure XLII. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi. 1, 2. Leaf apices. 3, 4. Leaf base (abaxial view). All figures were drawn from holotype of L. cyathifolium (BM).

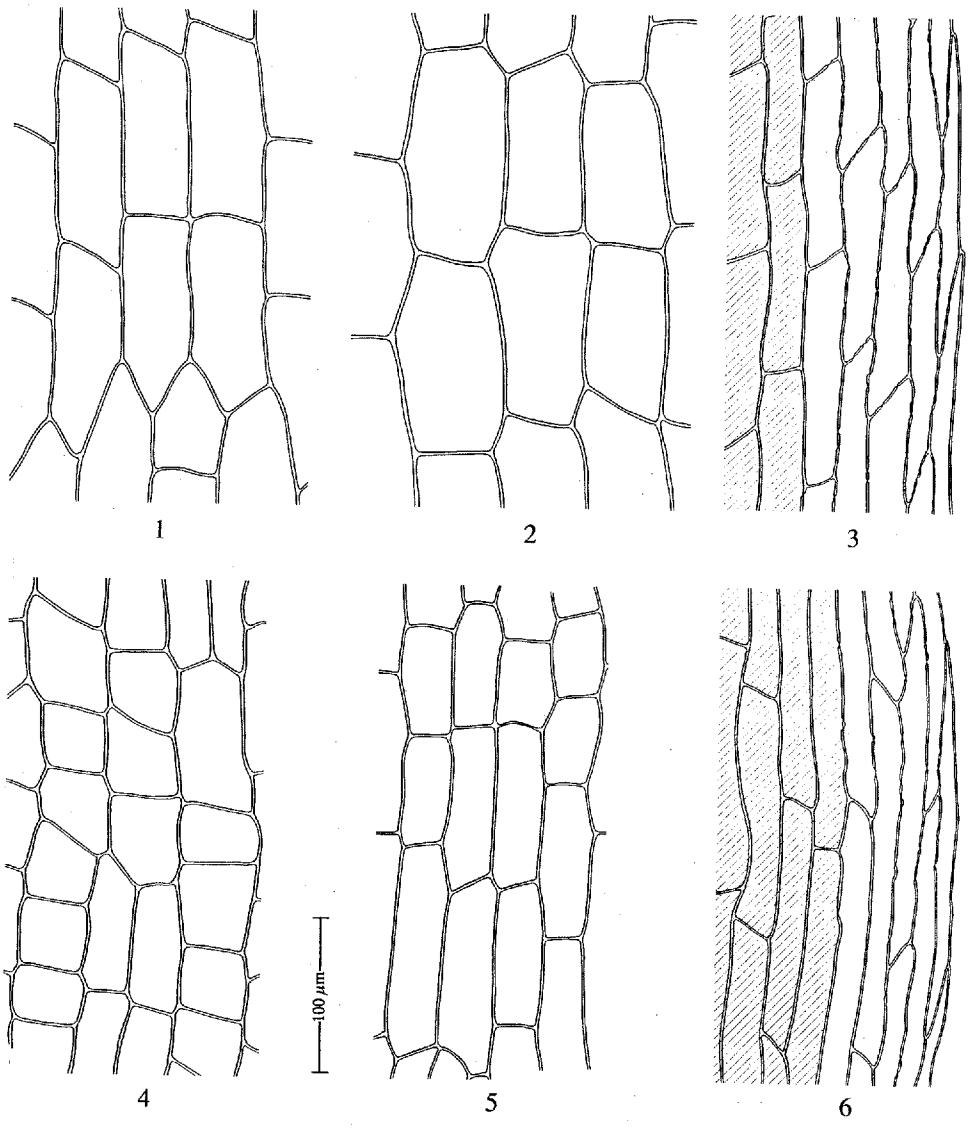

Figure XLIII. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi. 1–3. Median cells of leaf (1, 3, abaxial view; 2, adaxial view). 4–6. Basal cells of leaf (4, 6, abaxial view; 5, adaxial view). All figures were drawn from holotype of L. cyathifolium (BM).

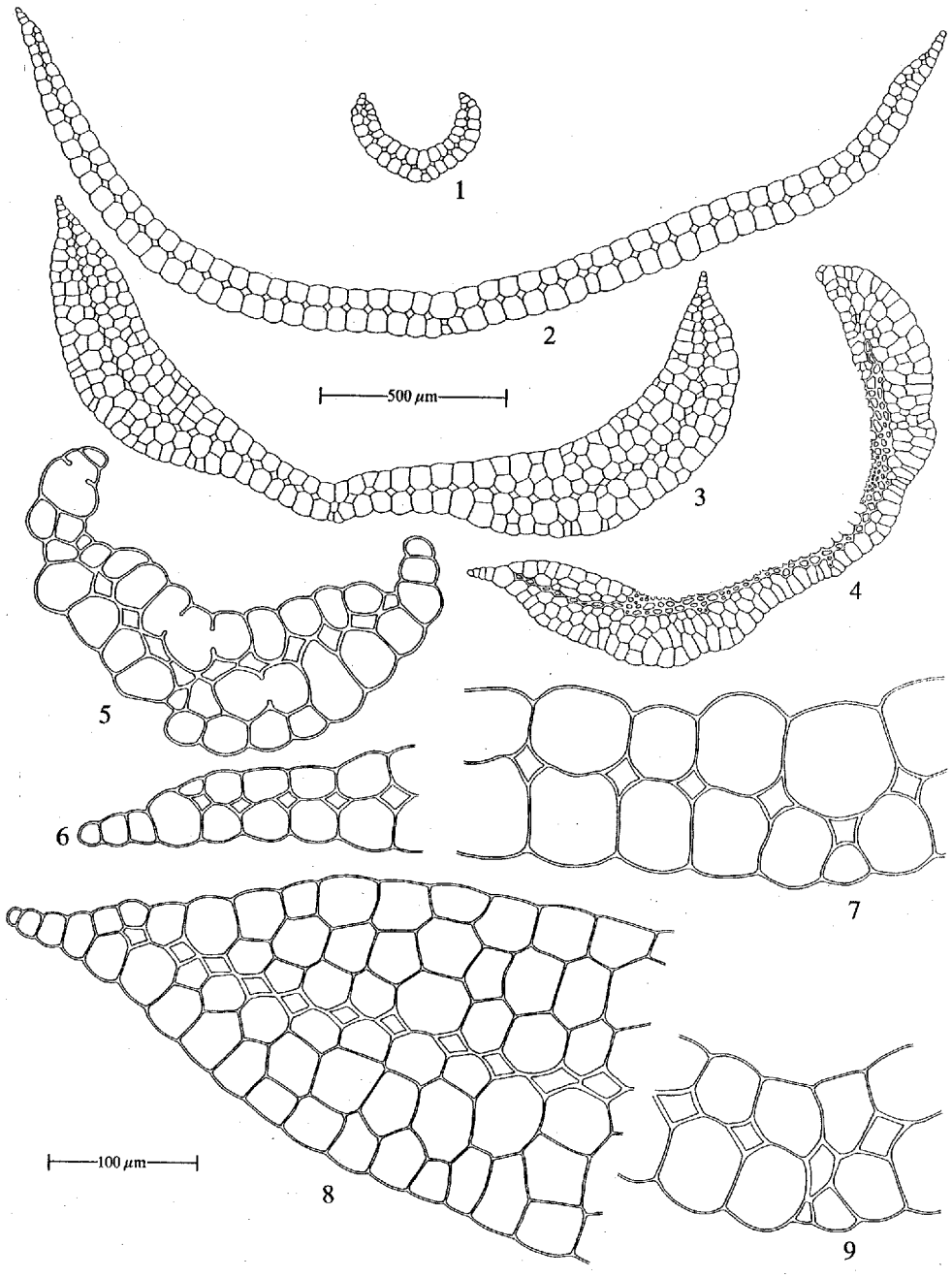

Figure XLIV. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi. 1–9. Cross-sections of leaves (1, 5, apical; 2, 6, 7, median; 3, 4, 8, 9, basal portions). All figures were drawn from holotype of L. cyathifolium (BM).

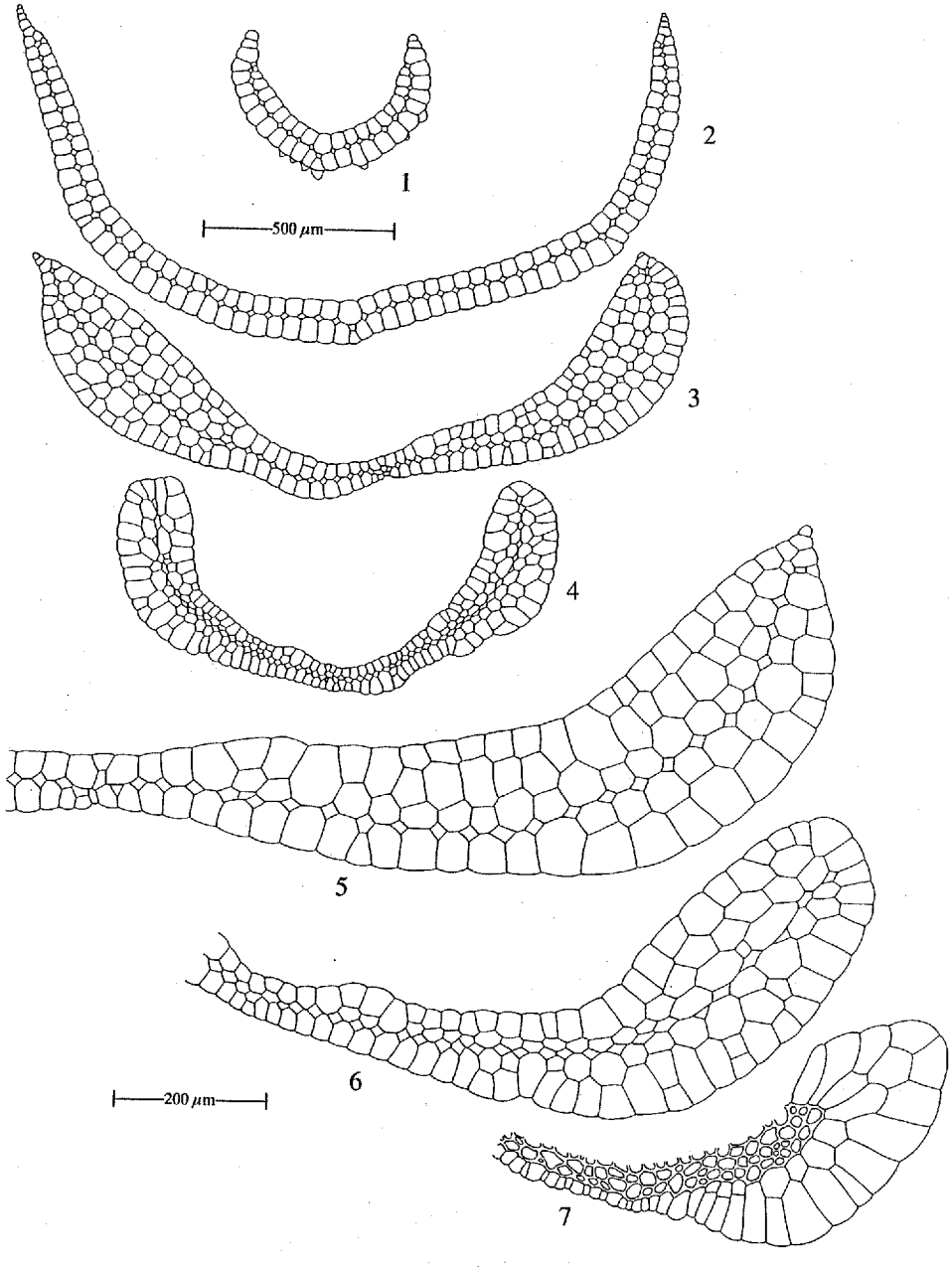

Figure XLV. Leucobryum javense var. cyathifolium (Dix.) T. Yamaguchi. 1–7. Cross-sections of leaf (1, apical; 2, median; 3–7, basal portions). All figures were drawn from holotype of L. brassii (FH).

indistinct; alar parts bulged, the edges rounded (Fig. XLV: 6, 7) in cross-sections, without 1 cell layered wings; in cross-sections near leaf base leucocysts in 3-4 cell layers on adaxial side and 3-4 cell layers on abaxial side at the thickest part; abaxial leucocysts distinctly decurrent on stems, in cross-sections at insertional parts to stem usually 3-4 cell layers of leucocysts at the thickest part (Fig. XLIV: 4).

Dioicous. Male plants not observed. Perichaetia terminal on short lateral branches, small and bud-like; archegonia ca. 0.7 mm long. Sporophytes not observed.

Representative specimens examined: Philippines, Mindanao, 5 Oct. 1965, Robbins 3989, mixed with L. javense var. javense (L). Borneo, Sarawak, 4th Division, Gunong Mulu National Park, G. Mulu, 4°05'N 114°55'E, 1900 m alt., 30 May 1978, Touw 21109 (L). New Guinea, Morobe, Mt. Kaindi, 8000 ft. alt., 1 Sept. 1965, Hewson 479 (L); Vogelkop Peninsula, Arfak Mts., Mt. Saru-mot near Iray, Angi Gigi Lake, 2100 m alt., 26 Jan. 1962, Sleumer & Vink 4468 (L); Western Highlands, Minj valley, Kubor Ranges, 8000 ft. alt., 1 Aug. 1957, Robbins 581 (L); Milne Bay District, Mt. Gamatawa, 6000 ft. alt., 18 July 1973, Cruttwell 84 (L).

Habitat: On soil or tree trunks.

Distribution: Philippines, Borneo, New Guinea.

The present variety is differentiated from var. javense by (1) somewhat squarrose leaves, (2) rounded and apiculate leaf apices, (3) bulged alar parts of leaves with rounded edges in cross-sections, and (4) distinct decurrency of abaxial leucocysts of leaves.

1b. Leucobryum javense var. novae-guineae (Bartr.) T. Yamaguchi, stat. nov. (Fig. XLVI-XLIX, CXLI: 7)

Basionym: Leucobryum novae-guineae Bartr., Svensk. Bot. Tidskr. 47(3): 397 (1953). Type: New Guinea, Mt. Hagen distr., Western Highlands, Wahgi Valley (south or the Bismarck Mts.), Nondugl, 1600 m alt., IX.-XI. 1951, Nils and Creta Gyldenstolpe 39 – holotype (FH).

Leucobryum antarense Zant., Nova Guinea, Botany 16: 276. (1964), syn. nov. Type: New Guinea, Star Mts., Mt. Antares, bivouac 39a, 1500 m alt., hanging down from branch of tree at edge of rain forest, 27 June 1959, Zanten 716 – holotype (L).

Plants darkish or brownish when dry, forming loose tufts or pendulous. Stems elongate, to 150 mm long with leaves; central strand not differentiated in cross-sections of stems but the walls of cortical cells thinner inward. Leaves appressed to erect spreading, somewhat arranged in 5-rows; 6.6-10.0 x 1.2-1.8 mm, lanceolate, gradually narrowed to broadly and deeply channeled point from oblong base,

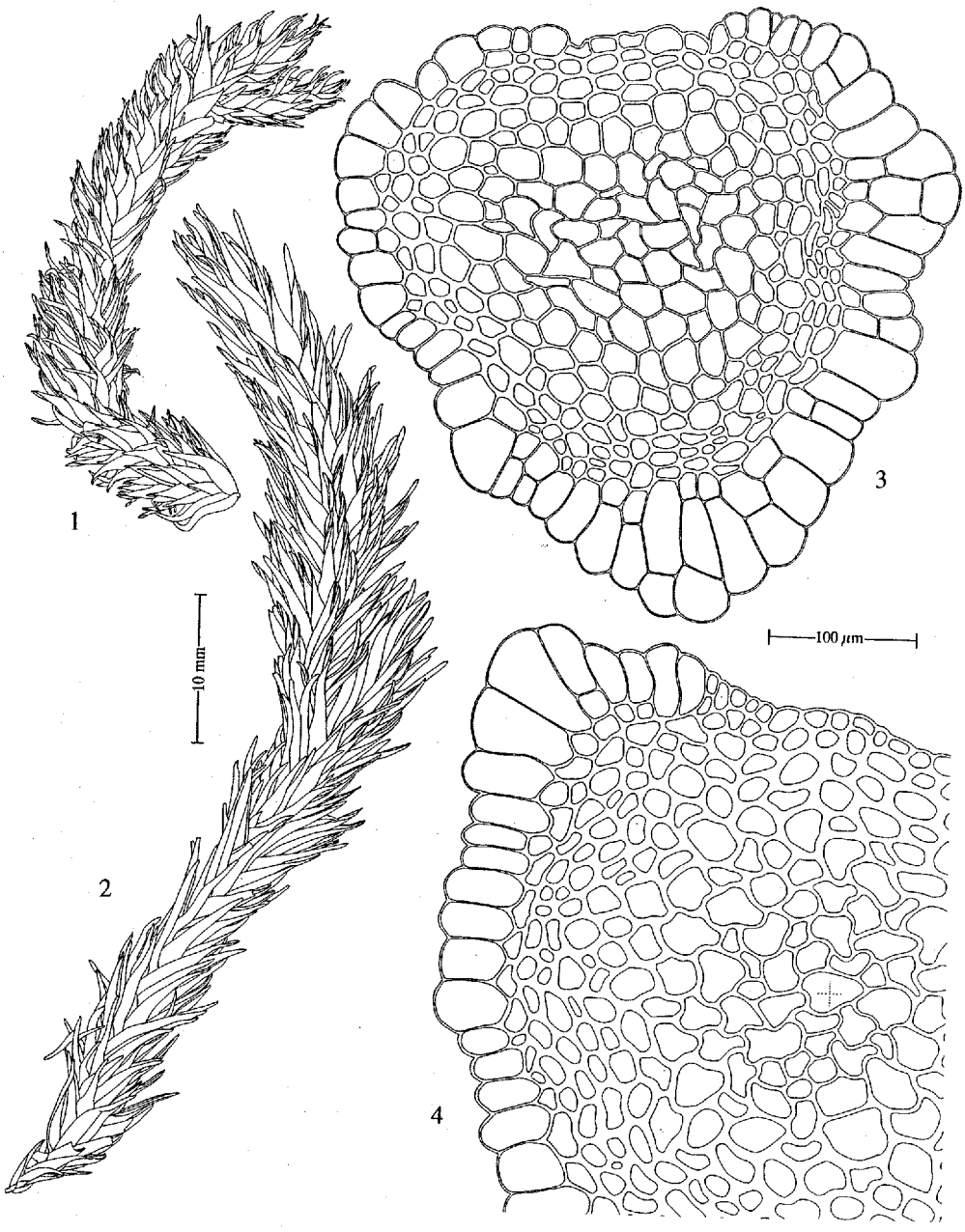

Figure XLVI. Leucobryum javense var. novae-guineae (Bartr.) T. Yamaguchi. 1, 2. Plants. 3, 4. Cross-sections of stems. Figs. 1, 3 were drawn from holotype of L. novae-guineae (FH); 2, 4, from holotype of L. antarense (L).

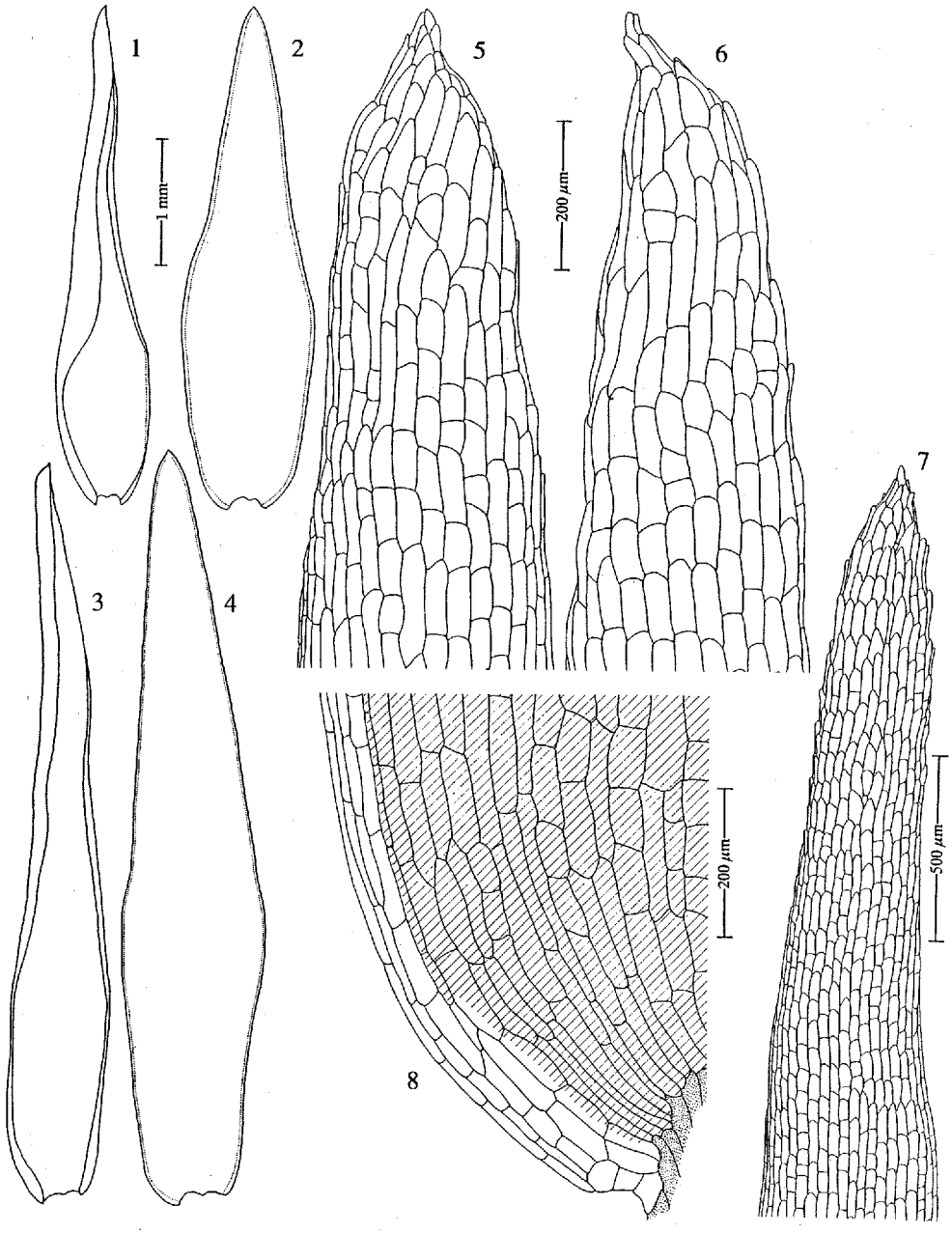

Figure XLVII. Leucobryum javense var. novae-guineae (Bartr.) T. Yamaguchi. 1–4. Leaves (2, 4, expanded). 5–7. Leaf apices. 8. Leaf base (adaxial view). Figs. 1, 2, 7 were drawn from holotype of L. novae-guineae (FH); 3–6, 8, from holotype of L. antarense (L).

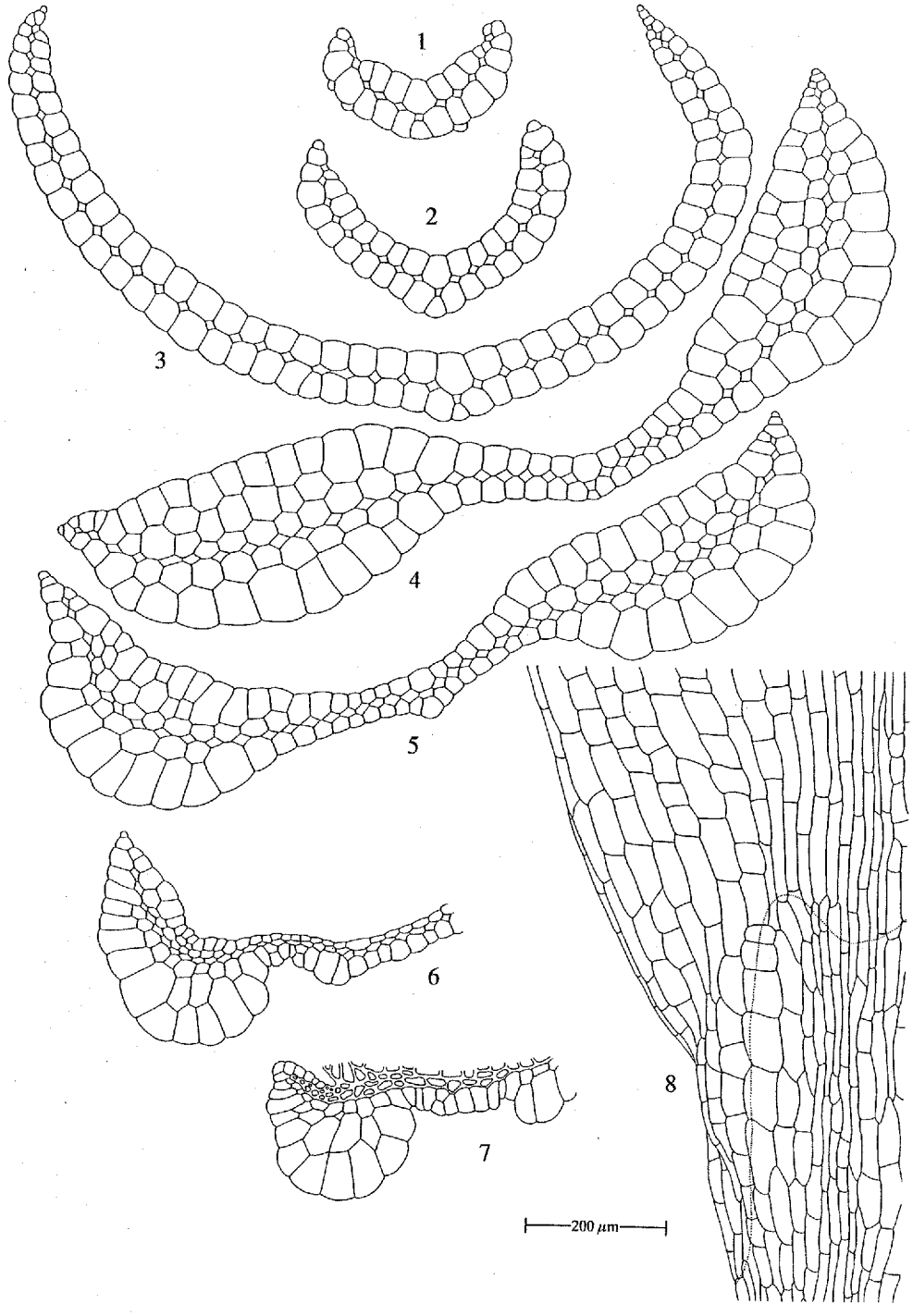

Figure XLVIII. Leucobryum javense var. novae-guineae (Bartr.) T. Yamaguchi. 1–7. Cross-sections of leaf (1, 2, apical; 3, median; 4–7, basal portions). 8. Leaf base (abaxial view). All figures were drawn from holotype of L. antarense (L).

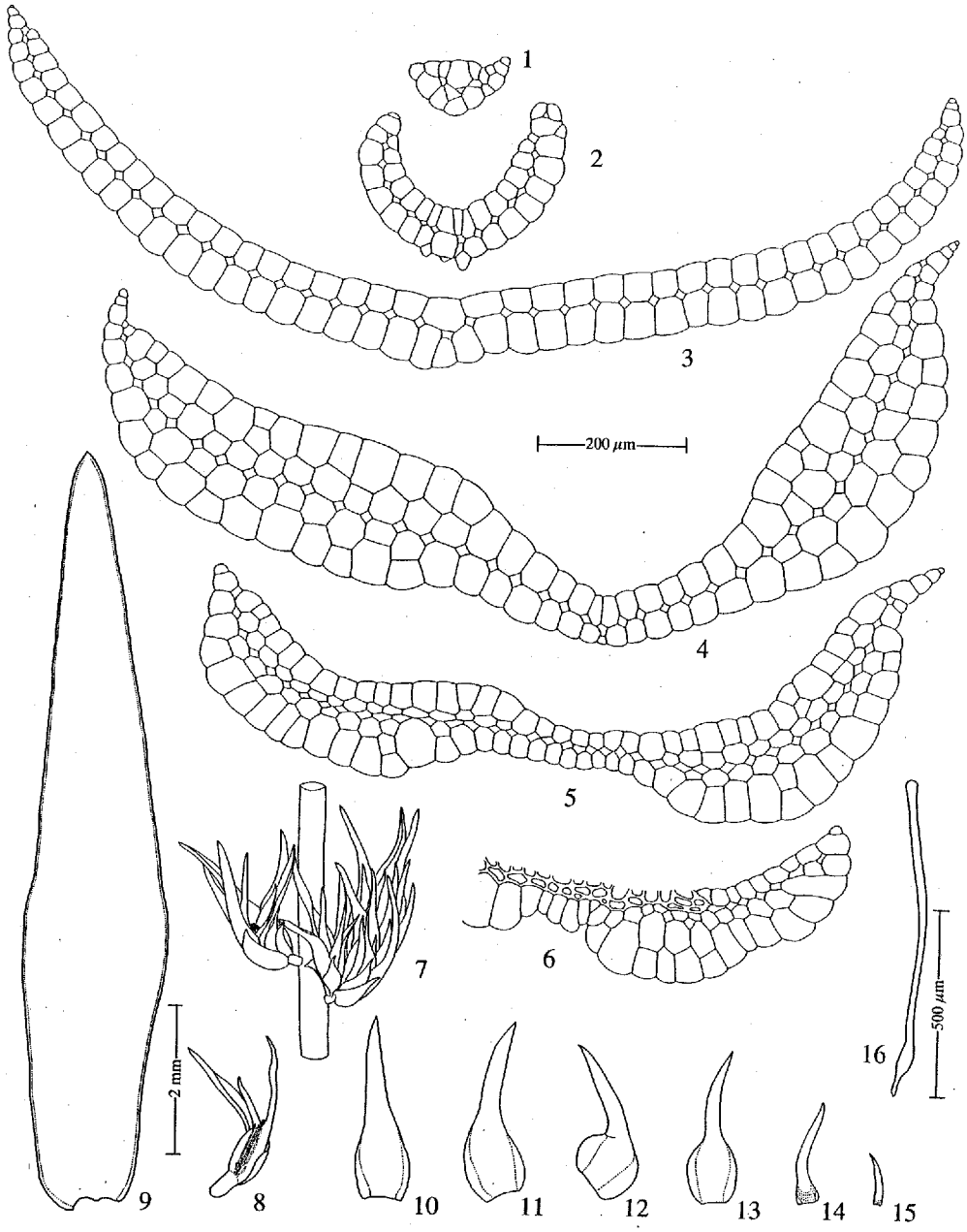

Figure XLIX. Leucobryum javense var. novae-guineae (Bartr.) T. Yamaguchi. 1–6. Cross-sections of leaf (1, 2, apical; 3, median; 4–6, basal portions). 7, 8. Perichaetia. 9. Stem leaves (expanded) near perichaetium 8. 10–15. Perigonial leaves [expanded; numbers show the order of perigonial leaves from the innermost leaf (number 15)]. 16. Archegonium. Figs. 1–6 were drawn from holotype of L. novae-guineae (FH); 7–16, from holotype of L. antarense (L).

acute to bluntly mucronate, papillosely prorate from the apex to 3/10 of the leaf length on abaxial surface; laminae and borders consisting of 2-7 rows of narrowly rectangular cells near base, the differentiation between laminal cells and border cells indistinct; alar parts bulged, the edge of alar part with narrow (1-2 cell rows) wing in cross-sections (Fig. XLVIII: 6, 7); in cross-sections near leaf base leucocysts in 2-3 cell layers on adaxial side and 3 cell layers on abaxial side at the thickest part; abaxial leucocysts distinctly decurrent on stems, in cross-sections at insertional parts to stem usually 3 cell layers of leucocysts at the thickest part (Fig. XLVI: 3, XLVIII: 6, 7, XLIX: 6).

Dioicous. Male plants not observed. Perichaetia terminal on short lateral branches, small and bud-like; archegonia 0.9-1.2 mm long. Sporophytes not observed.

Representative specimens examined: Borneo, Sarawak, 4th Division, Gunung Mulu National Park, G. Mulu, summit area, 4°05'N 114°55'E, 2375 m alt., 29 May 1978, Touw 20979 (L). Seram, Kecamatan Seram Utara, Sawai, Gunung Musisi, Manusela National Park, 3°03'S 129°14'E, 1300 m alt., 25 Jan. 1985, Akiyama 9790 (KYO, HIRO). New Guinea, Star Mts., Mt. Antares, 1500 m alt., 27 June 1959, Zanten 348 – paratype of L. antarense (L, HIRO); Star Mts., Sibil-valley, Basis Camp, 1300 m alt., 26 Aug. 1959, Zanten 817 – paratype of L.

antarense (L); West Sepik Distr., Star Mts., 5°00'S 141°05'E, 3050 m alt., 5 Apr. 1975, Touw 15749 (L).

Habitat: On tree trunks or soil at tree base.

Distribution: Borneo, Seram, New Guinea.

The present variety is differentiated from var. javense by (1) appressed to erect spreading leaves, (2) bulged alar parts of leaves with narrow wings, (3) distinct decurrency of abaxial leucocysts of leaves.

1c. Leucobryum javense var. uncinatum (Fl.) T. Yamaguchi, stat. nov. (Fig. L, LI, CXLI: 6)

Basionym: Leucobryum uncinatum Fl., Musc. Fl. Buitenzorg 1: 149 (1904). Type: Borneo, Nieuwenhuis s. n. – holotype (FH).

Plants dark or brownish when dry, forming loose tufts. Stems to 80 mm long with leaves; central strand not differentiated in cross-sections of stems but the walls of cortical cells thinner inward. Leaves erect to widely spreading; 8.4-9.7 x 1.8-1.9 mm, lanceolate, gradually narrowed to broadly channeled point from oblong base, acute and distinctly uncinate at apex (Fig. L: 6-9), papillosely prorate from the apex to 2/5 of the leaf length on abaxial surface; laminae and borders consisting of 3-4 rows of narrowly rectangular cells near base, the differentiation between laminal cells and border cells indistinct; alar

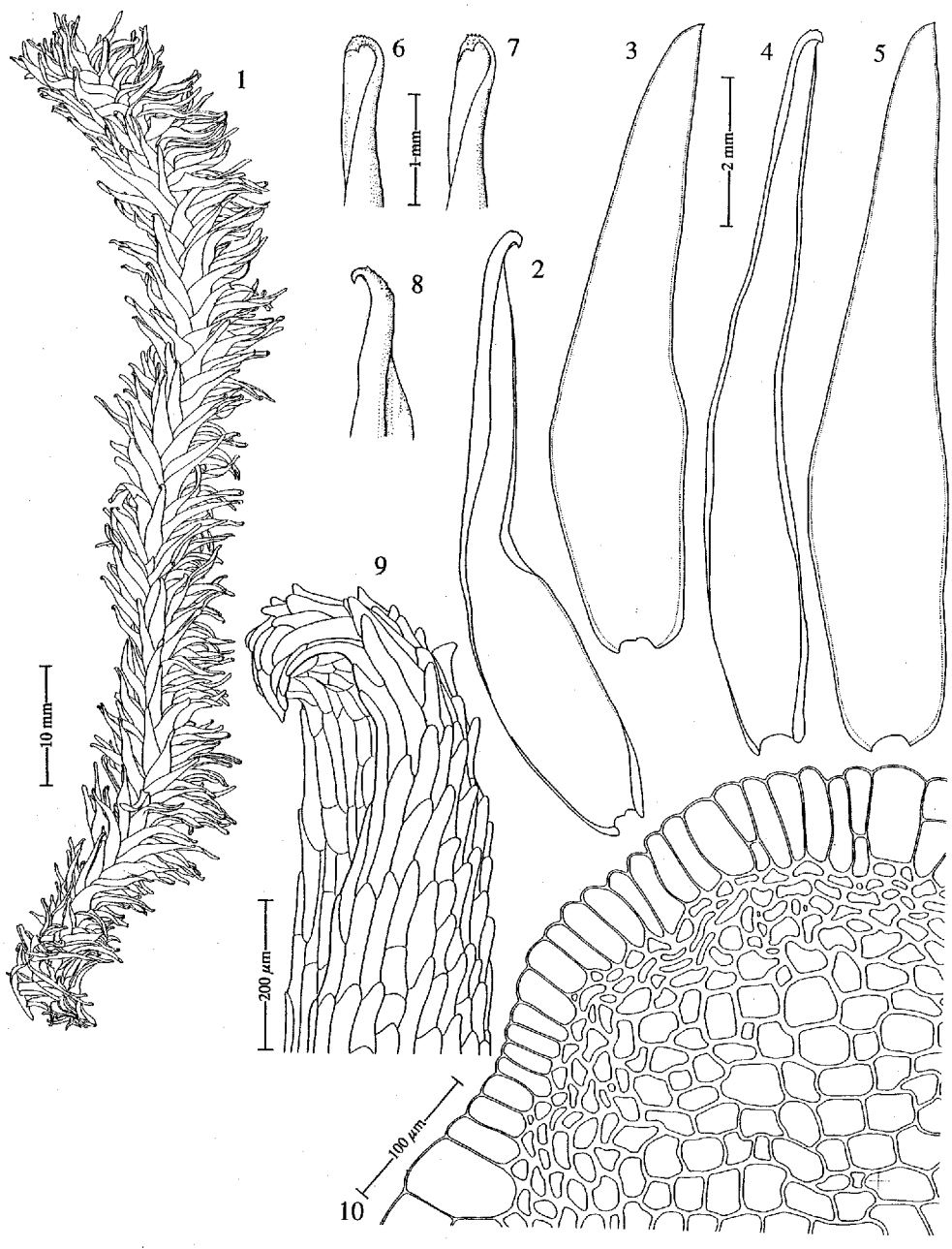

Figure 1. Leucobryum javense var. uncinatum (Fl.) T. Yamaguchi. 1. Plant. 2–5. Leaves (3, 5, expanded). 6–9. Leaf apices. 10. Cross-section of stem. All figures were drawn from holotype of L. uncinatum (FH).

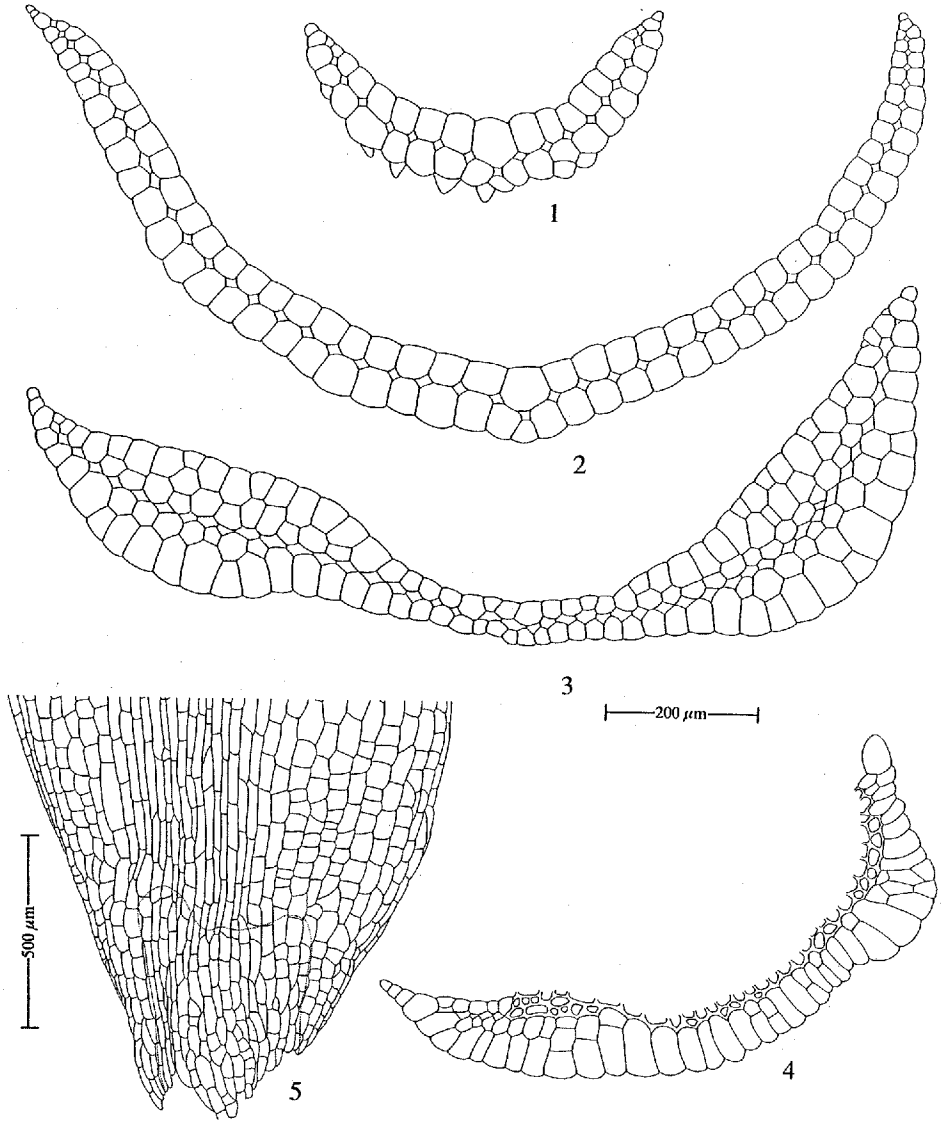

Figure LI. Leucobryum javense var. uncinatum (Fl.) T. Yamaguchi. 1–4. Cross-sections of leaf (1, apical; 2, median; 3, 4, basal portions). 5. Leaf base (abaxial view). All figures were drawn from holotype of L. uncinatum (FH).

parts somewhat bulged; in cross-sections near leaf base leucocysts in 2-3 cell layers on adaxial side and 3 cell layers on abaxial side at the thickest part; abaxial leucocysts distinctly decurrent on stems, in cross-sections at insertional parts to stem 2-3 cell layers of leucocysts at the thickest part (Fig. LI: 4).

Dioicous. Male plants not observed. Perichaetia terminal on short lateral branches, small and bud-like; matured archegonia not observed. Sporophytes not observed.

Representative specimens examined: Borneo, Sarawak, 4th Division, Gunong Mulu National Park, G. Mulu, summit area, 4°05'N 114°55'E, 2375 m alt., 29 May 1978, Touw 20978 (L).

Habitat: On humus.

Distribution: Borneo.

L. javense var. uncinatum is closely related to var. novae-guineae, but is differentiated from var. novae-guineae and other taxa of Leucobryum by the distinctly uncinate leaf apices.

2. Leucobryum scabrum Lac. (Fig. XIX, XXX, XXXIII, LII-LV, CXLI: 3)

Ann. Mus. Bot. Lugd. Bat. 2: 292 (1866). Type: Japan, Siebold s. n. – holotype (L).

Plants grayish or whitish tinged with brown when dry, forming compact tufts or mats. Stems to 60 mm long with

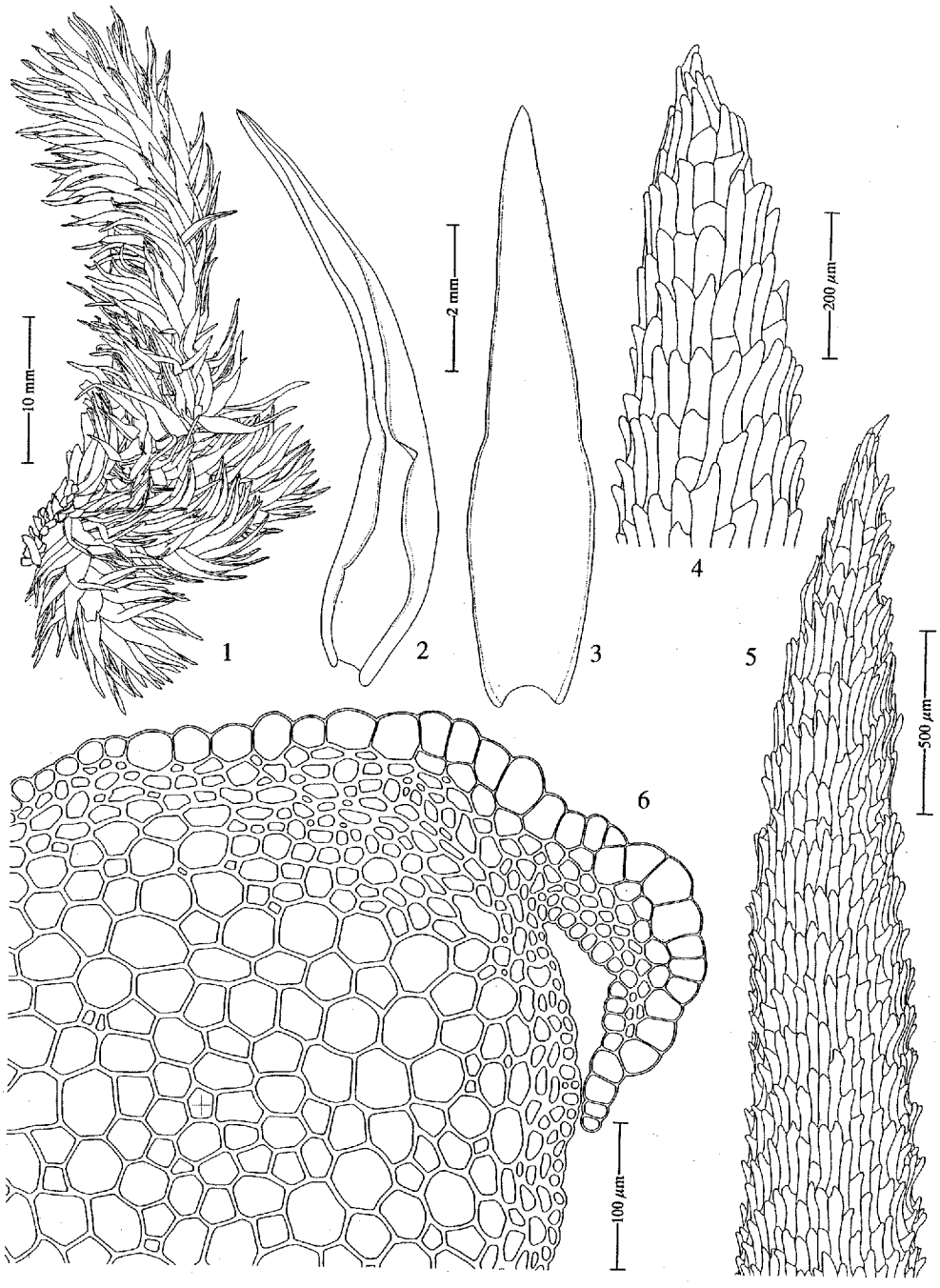

Figure LII. Leucobryum scabrum Lac. 1. Plant. 2, 3. Leaves (3, expanded). 4, 5. Leaf apices. 6. Cross-section of stem. Figs. 1–4 were drawn from holotype of L. scabrum (L); 5, 6, from Yamaguchi 7188 (HIRO).

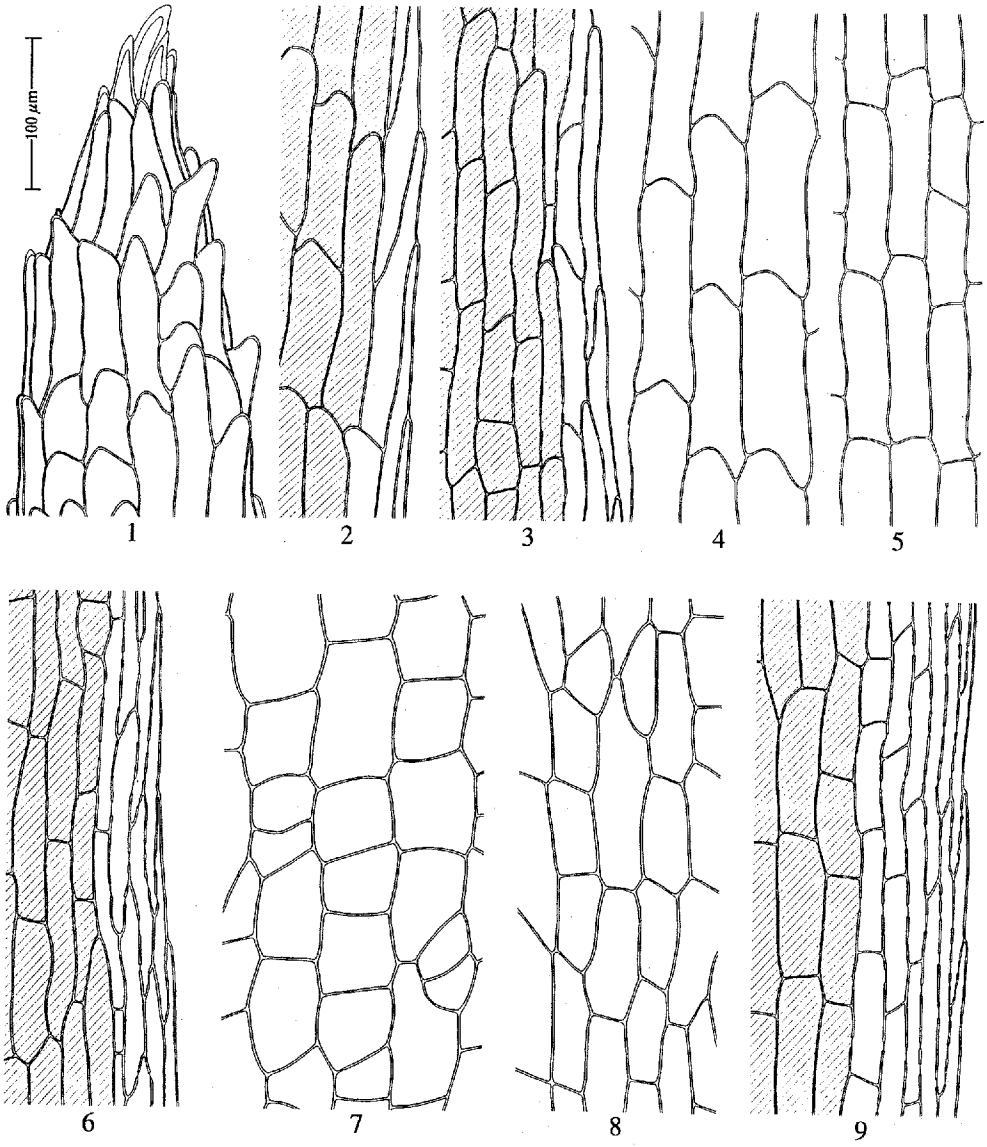

Figure LIII. Leucobryum scabrum Lac. 1–3. Cells near leaf apex (1, 2, abaxial view; 3, adaxial view). 4–6. Median cells of leaf (4, abaxial view; 5, 6, adaxial view). 7–9. Basal cells of leaf (7, 9, abaxial view; 8, adaxial view). All figures were drawn from holotype of L. scabrum (L).

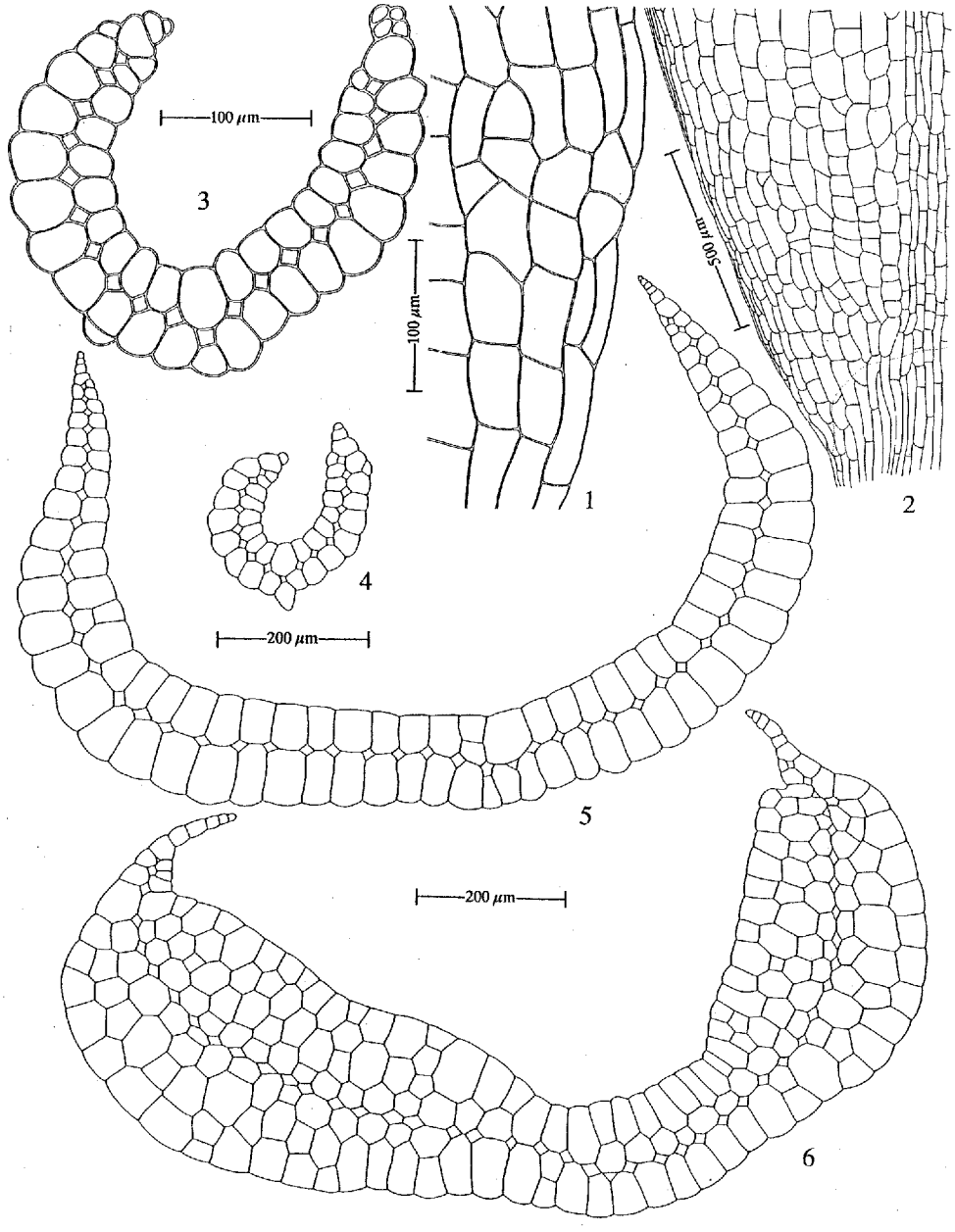

Figure LIV. Leucobryum scabrum Lac. 1, 2. Leaf bases (abaxial view). 3–6. Cross-sections of leaf (3, 4, apical; 5, median; 6, basal portions). All figures were drawn from holotype of L. scabrum (L).

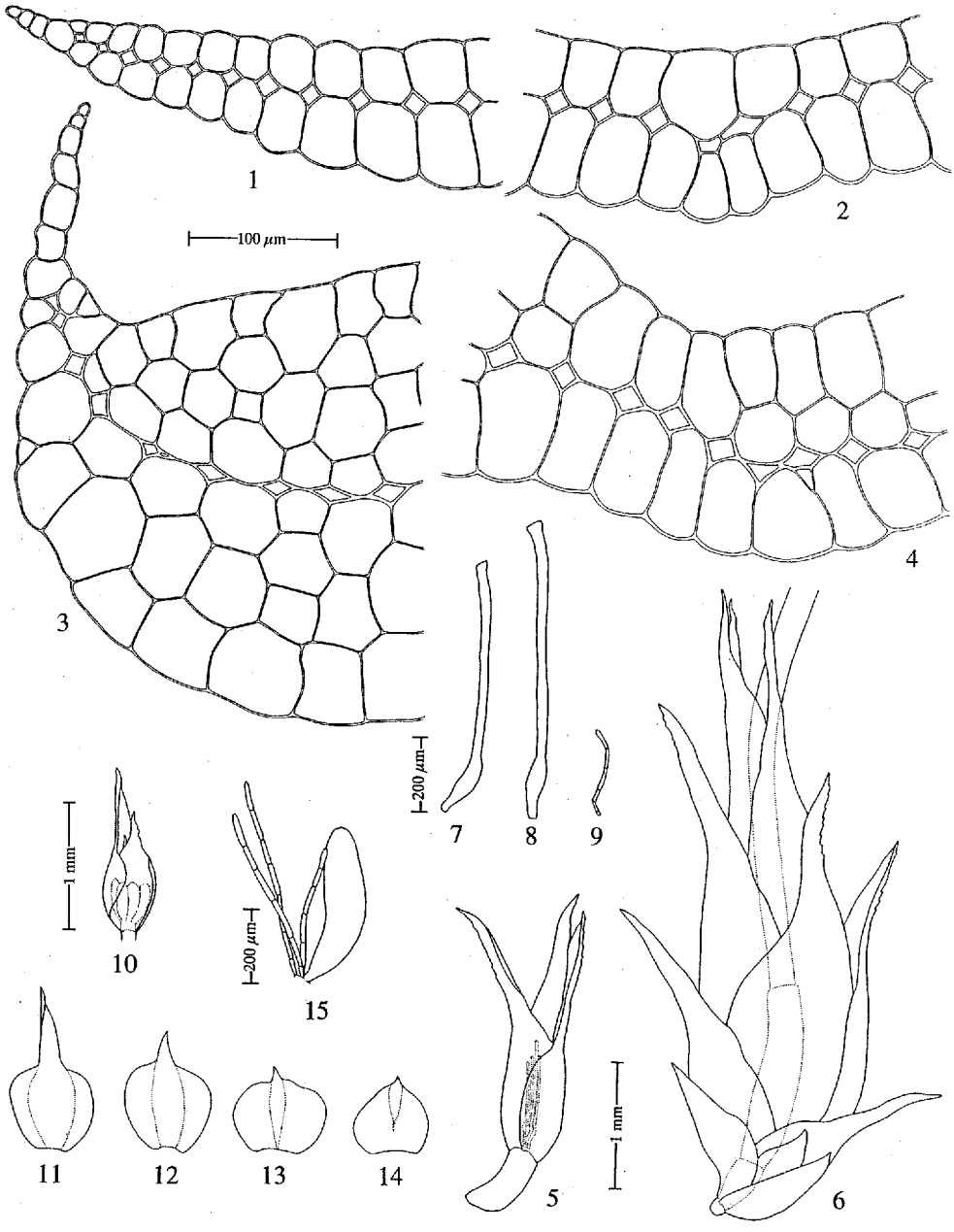

Figure LV. Leucobryum scabrum Lac. 1–4. Cross-sections of leaf (1, 2, median; 3, 4, basal portions). 5, 6. Perichaetia (6, with sporophyte). 7, 8. Archegonia. 9. Paraphysis. 10. Perigonium. 11–14. Perigonial leaves [expanded; numbers show the order of perigonial leaves from the innermost leaf (number 14)]. 15. Antheridium. Figs. 1–4 were drawn from holotype of L. scabrum (L); 5–15, from Iwatsuki & Minamidani s. n., Musci Japonici Exsiccati 28: 1378 (NICH).

leaves; central strand not differentiated in cross-sections of stems. Leaves erect spreading, somewhat falcate secund; 7.9-8.2 x 1.7-1.9 mm, lanceolate to narrowly lanceolate, gradually narrowed to subtubulous point from oblong base, acute, undulate and spinosely prorate from the apex to 3/5 of the leaf length on abaxial surface; laminae and borders consisting of 5-7 rows of narrowly rectangular cells near base, the differentiation between laminal cells and border cells indistinct; in cross-sections near leaf base leucocysts in 3-4 cell layers on adaxial side and 3-4 cell layers on abaxial side at the thickest part, the thickest parts distributed near edge sides and abruptly thinned to the wing parts in cross-sections; abaxial leucocysts ± decurrent on stems.

Dioicous. Dwarf male plants growing on stem leaves of female plants; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes very small (e. g. inner perichaetial leaf 4.2 x 1.4 mm when the stem leaf near the perichaetium 8.2 x 1.9 mm), 0.3-0.6 times longer than ordinary leaves; archegonia ca. 0.8 mm long. Setae 25-32 mm long. Capsules inclined, ovoid to ellipsoid; urns 1.6-1.8 mm long, 1.0-1.1 mm wide. Apices of peristome teeth divided to 2/3 of the length, ca. 0.9 mm long, ca. 0.15 mm

wide at base, the prongs often subdivided. Spores 10-12 μm in diameter.

Representative specimens examined: Japan, Kyushu, Miyazaki-ken, Koyu-gun, Tsuno-cho, Mt. Osuzu, Keyaki Valley, trail to Sagiri Falls, 360-580 m alt., 13-14 May 1976, Iwatsuki & Minamidani, Musci Japonici Exsiccati 28: 1378 (NICH 155711); Shikoku, Ehime-ken, Uwajima-shi, Nametoko Gorge, Mt. Sanbonkui, 500 m alt., 2 Aug. 1984, Yamaguchi 7188 (HIRO). Taiwan, Nantou-hsien, Luku-hsiang, Sunlink-sea, 1700 m alt., 31 May 1984, Yamaguchi et al. 6762 (HIRO).

Habitat: On soil and rocks, sometimes on rock cliffs splashed with water.

Distribution: Japan, Taiwan.

The present species is characterized by (1) large plants, (2) usually falcate leaves up to 8.2 mm long, (3) abaxially undulate and spinosely prorate in upper 3/5 of the leaf length, (4) thickest parts of leaf bases which are distributed near edge and abruptly thinned to the wing parts in cross-sections, (5) perichaetia which are terminal on short lateral branches, and (6) inner perichaetial leaves shorter than stem leaves.

The present species shows similar appearance to small sized L. javense var. javense as mentioned in the taxonomic note of the latter taxon. In Japan (Ryukyu Isls., Amami Isl.) both taxa grow in the same place, but it is easily

distinguished by naked eyes because L. scabrum forms rather compact mats on soil and rocks, while L. javense var. javense forms loose tufts on humus.

3. Leucobryum aduncum Dozy & Molk. var. aduncum (Fig. XX, LVI-LX, CXLII: 2)

Pl. Jungh. 3: 319 (1854). Type: Java, Junghuhn s. n. (Herb. Lugd. Bat. 20. Ind. Or. no. 910.132-1671) – lectotype (L).

Leucobryum pentastichum Dozy & Molk., Pl. Jungh. 3: 319 (1854) = Leucobryum candidum (Brid. ex P. Beauv.) Wils. var. pentastichum (Dozy & Molk.) Dix., New Zealand Inst. Bull. 3(3): 97 (1923), syn. nov. Type: Java, Junghuhn s. n. (Herb. Lugd. Bat., 20. Ind. Or. no. 910.132-790) – holotype (L).

Plants grayish or whitish tinged with brown when dry, forming tufts. Stems to 50 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves falcate secund, somewhat arranged in 5 rows; 3.4-4.1 x 0.8-1.2 mm, lanceolate, gradually narrowed to subtubulous point from ovate to oblong base, acute, undulate and spinosely prorate from the apex to 3/5 of the leaf length on abaxial surface; laminae and borders consisting of 3-6 rows of narrowly rectangular to linear cells near base, the quadrate laminal cells restricted to alar parts; in cross-sections near leaf base leucocysts in 2-3 cell layers on

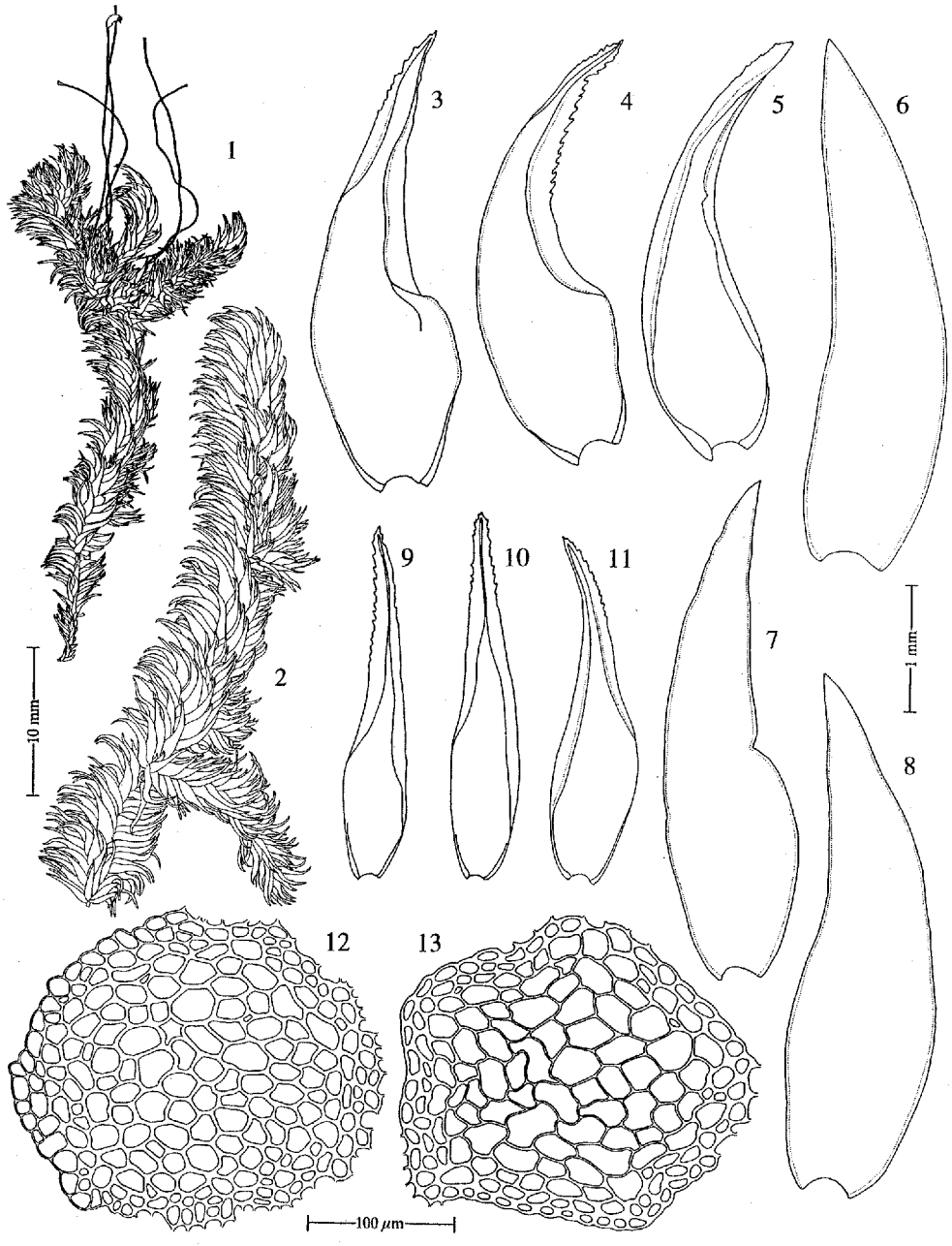

Figure LVI. Leucobryum aduncum Dozy & Molk. var. aduncum. 1, 2. Plants. 3–11. Leaves (6–8, expanded). 12, 13. Cross-sections of stems. Figs. 1, 3, 4, 7–11, 13 were drawn from lectotype of L. aduncum (L); 2, 5, 6, 12, from holotype of L. pentastichum (L).

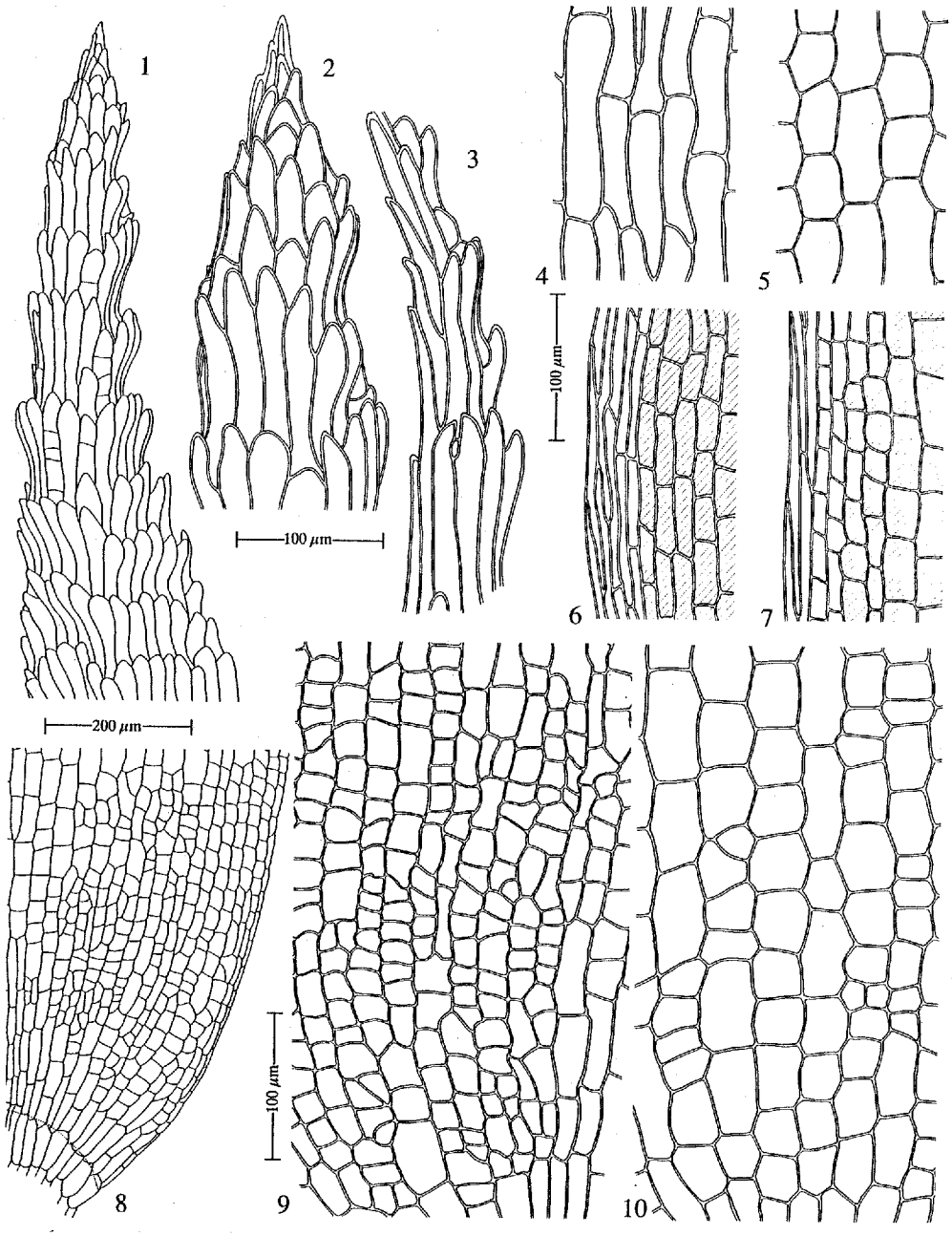

Figure LVII. Leucobryum aduncum Dozy & Molk. var. aduncum. 1–3. Leaf apices (3, lateral view). 4–6. Median cells of leaf (4, abaxial view; 5, 6, adaxial view). 7–10. Basal cells of leaf (7–9, abaxial view; 10, adaxial view). All figures were drawn from lectotype of L. aduncum (L).

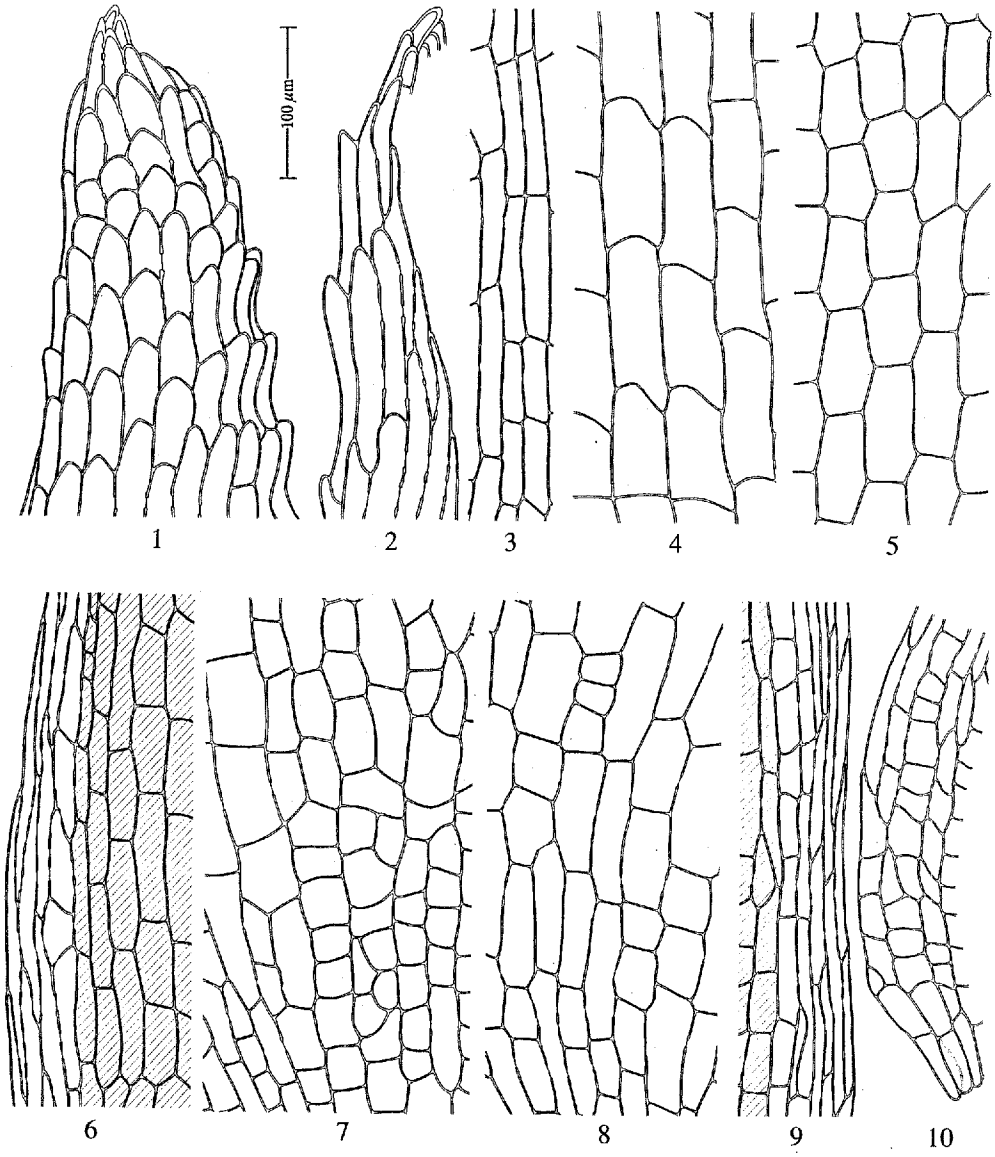

Figure LVIII. Leucobryum aduncum Dozy & Molk. var. aduncum. 1–3. Cells near leaf apex (1, abaxial view; 2, 3, adaxial view). 4–6. Median cells of leaf (4, abaxial view; 5, 6, adaxial view). 7–10. Basal cells of leaf (7, 10, abaxial view; 8, 9, adaxial view). All figures were drawn from holotype of L. pentastichum (L).

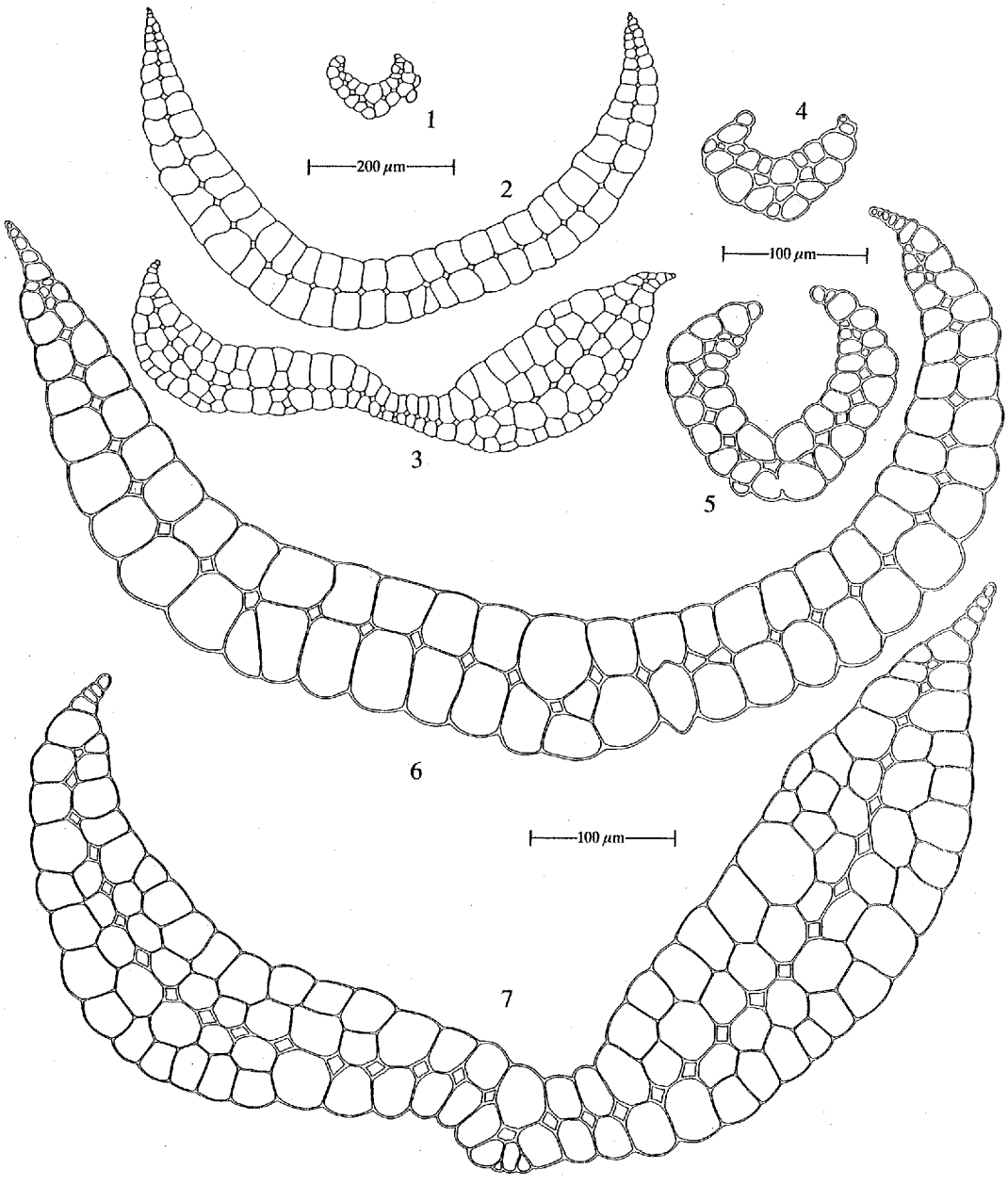

Figure LIX. Leucobryum aduncum Dozy & Molk. var. aduncum. 1–7. Cross-sections of leaves (1, 4, 5, apical; 2, 6, median; 3, 4, basal portions). Figs. 1–3 were drawn from lectotype of L. aduncum (L); 4–7, from holotype of L. pentastichum (L).

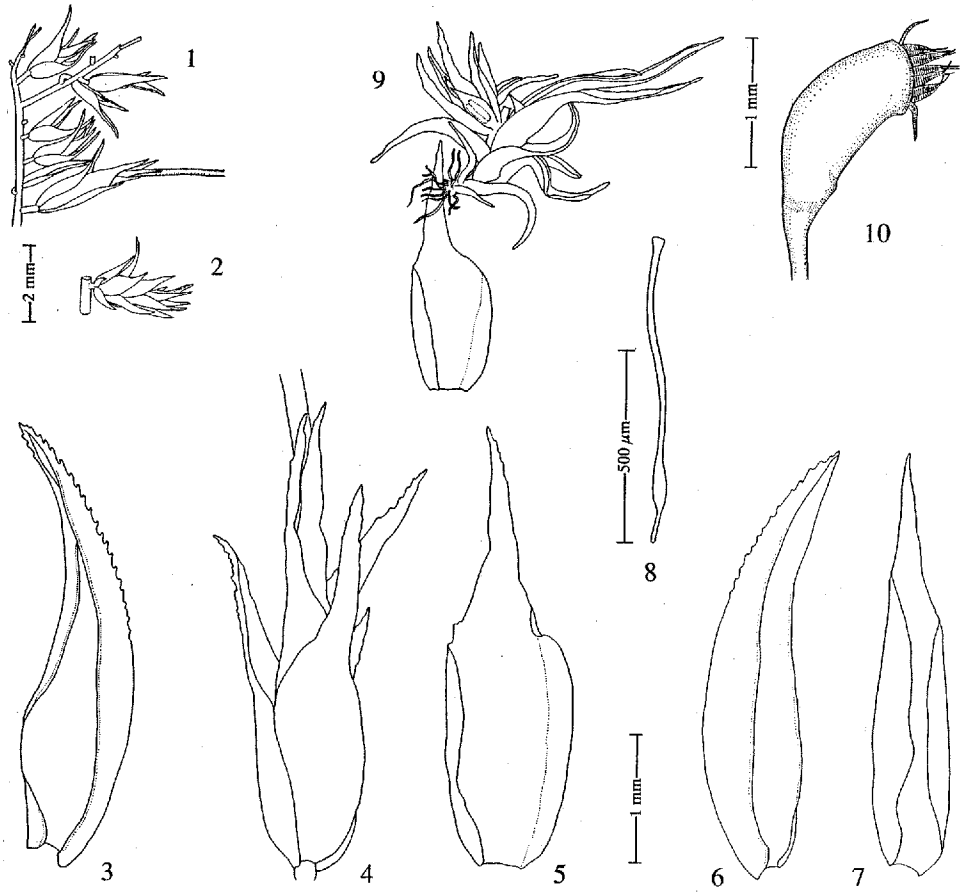

Figure LX. Leucobryum aduncum Dozy & Molk. var. aduncum. 1, 2, 4. Perichaetia. 3. Stem leaf near perichaetium 4. 5. Inner perichaetial leaf from perichaetium 4. 6. Stem leaf near perichaetial leaf 7. 7. Inner perichaetial leaf. 8. Archegonium. 9. Dwarf male plant growing on perichaetial leaf. 10. Capsule. Figs. 1, 3, 4, 5, 8–10 were drawn from lectotype of L. aduncum (L); 2, from holotype of L. pentastichum (L); 6, 7, from paratype of L. aduncum (L).

adaxial side and 2-3 cell layers on abaxial side at the thickest part; abaxial leucocysts of leaves hardly decurrent on stems; abaxial leucocysts of leaf bases vertically subdivided and forming groups of small quadrate cells (LVII: 9); abaxial leucocysts at insertional parts to stem clearly enlarged and in 1 cell row (Fig. LVII: 8).

Dioicous. Dwarf male plants usually growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes as long as or somewhat shorter than ordinary leaves; archegonia 0.5-0.8 mm long. Setae 16-18 mm long. Capsules inclined, ovoid to ellipsoid; urns ca. 1.3 mm long, ca. 0.6 mm wide

Representative specimens examined: Thailand, Nakorn Ratchasima Province, Sikiew District, Khao Phrik, 14°55'N 101°35'E, 630 m alt., 9 May 1976, Maxwell B36 (L). Cambodia, Province de Koh Kong, Chékô, 10 Mar. 1965, Kira et al. 137 (HIRO). Vietnam, 14 Feb. 1971, Khiem 198 (L). Malay Peninsula, Selangor, Kanching Forest Reserve, 80 m alt., 16 Jan. 1954, Steenis 18513 (L). Philippines, Palawan, Victoria Mountains, Mar.-Apr. 1951, Edaño 14260 (L). Borneo, Interior Res., Sipitang, Mengalong Forest Reserve, 21 June 1960, Meijer B12423 (L). Sulawesi, Batu Besi, between Tabarano and Larona River, 2°15'-3°S 121°-

121°45'E, 300 m alt., 19 July 1979, Balgooy 4081A (L). Sumatra, Harau-canyon, Pajakumbuh, ca. 600 m alt., 31 July 1955, Meijer 6022 (L). Java, Holle and Teysmann s. n. (Herb. Lugd. Bat. 20. Ind. Or. no. 910.132-1683) – paratype of L. aduncum (L). Lesser Sunda Islands, W. Flores-Manggarai, 5 Mar. 1981, Schmutz 4856 (L). Seram, Kacamatan Taniwel, Batu Putih (limestone cliff) and Batu Soli (limestone cliff) near Buria, 2°55-57'S 128°27-28'E, 360 m alt., 4 Feb. 1985, Akiyama 10067 (KYO, HIRO).

Habitat: On logs, tree trunks, humus and rocks.

Distribution: Thailand, Cambodia, Vietnam, Malaya, Philippines, Borneo, Sulawesi, Sumatra, Java, Lesser Sunda Islands, Seram, New Guinea.

L. aduncum and its varieties are characterized by (1) small to medium sized plants, (2) abaxially undulate and spinosely prorate leaf apices, and (3) perichaetia usually terminal on short lateral branches. Among the taxa included in L. aduncum group, var. aduncum is characterized by (1) falcate secund leaves arranged somewhat in 5 rows, and (2) inner perichaetial leaves which are as long as or somewhat shorter than the ordinary leaves around the perichaetium.

L. pentastichum and L. teysmannianum have been considered closely related to Australian L. candidum (Brid. ex P. Beauv.) Wils. (Dixon 1923, Dixon 1932b, Johnson 1964, Enroth 1989, Eddy 1990), based on the common characters such

as the leaves in 5 rows and the scabrous leaf apices. Dixon (1923) combined L. pentastichum with L. candidum as L. candidum (Brid. ex P. Beauv.) Wils. var. pentastichum (Dozy & Molk.) Dix. Johnson (1964) synonymized L. teysmannianum under L. candidum var. pentastichum. Eddy (1990) included both L. candidum var. pentastichum and L. teysmannianum in L. candidum. Furthermore, Enroth (1989) treated above three species, L. candidum, L. pentastichum and L. teysmannianum, as synonyms of L. javense.

The pentastichous leaf arrangement is found in some species of Leucobryum, such as L. aduncum var. aduncum and L. boninense. Therefore, the pentasticous leaf arrangement is not a specific characters observed only in L. candidum. According to Yamaguchi and Iwatsuki (1987), L. candidum is characterized by (1)relatively large plants (stems to 7 cm long with leaves), (2) leaves sometimes arranged spirally or in 5 ranks on stems, (3) leaves with spinosely prorate abaxial cells in the upper half, and (4) small inner perichaetial leaves which are 0.6-0.7 (-0.9) times longer than ordinary leaves. Yamaguchi and Iwatsuki (1987) also mentioned that the leaves (3.0-) 4.0-6.0 x 1.0-1.3 mm. L. pentastichum and L. teysmannianum are medium sized and somewhat soft plants, while L. candidum is relatively large plants. I concluded that L. pentastichum and L. teysmannianum should be compared with L. aduncum based on

the habits and the sexual organs. I do not agree with treatment by Enroth (1989) who synonymized L. teysmannianum, L. pentastichum and L. candidum under L. javense.

3a. Leucobryum aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi, stat. nov. (Fig. LXI, LXIII, CXLII: 4)

Basionym: Leucobryum teysmannianum Dozy & Molk., Bryol. Jav. 1: 17, t. 15 (1855). Type: Java, Teysmann s. n. (Herb. Lugd. Bat. no. Ind. Or. no. 910.139-2186) – holotype (L).

Plants grayish or whitish tinged with brown when dry, forming tufts. Stems to 55 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves erect spreading, distinctly arranged in 5 rows; 3.7-4.3 x 1.0-1.1 mm, lanceolate, gradually narrowed to subtubulous point from oblong base, acute, undulate and spinosely prorate down to mid leaf on abaxial surface; laminae, borders and alar parts similar to those of var. aduncum; in cross-sections near leaf base leucocysts usually in 2 cell layers on adaxial side and 2-3 cell layers on abaxial side at the thickest part; abaxial leucocysts of leaves hardly decurrent on stems; groups of small quadrate cells and enlarged cells at insertional parts indistinct.

Dioicous. Male not observed. Perichaetia terminal on short lateral branches, small and bud-like when

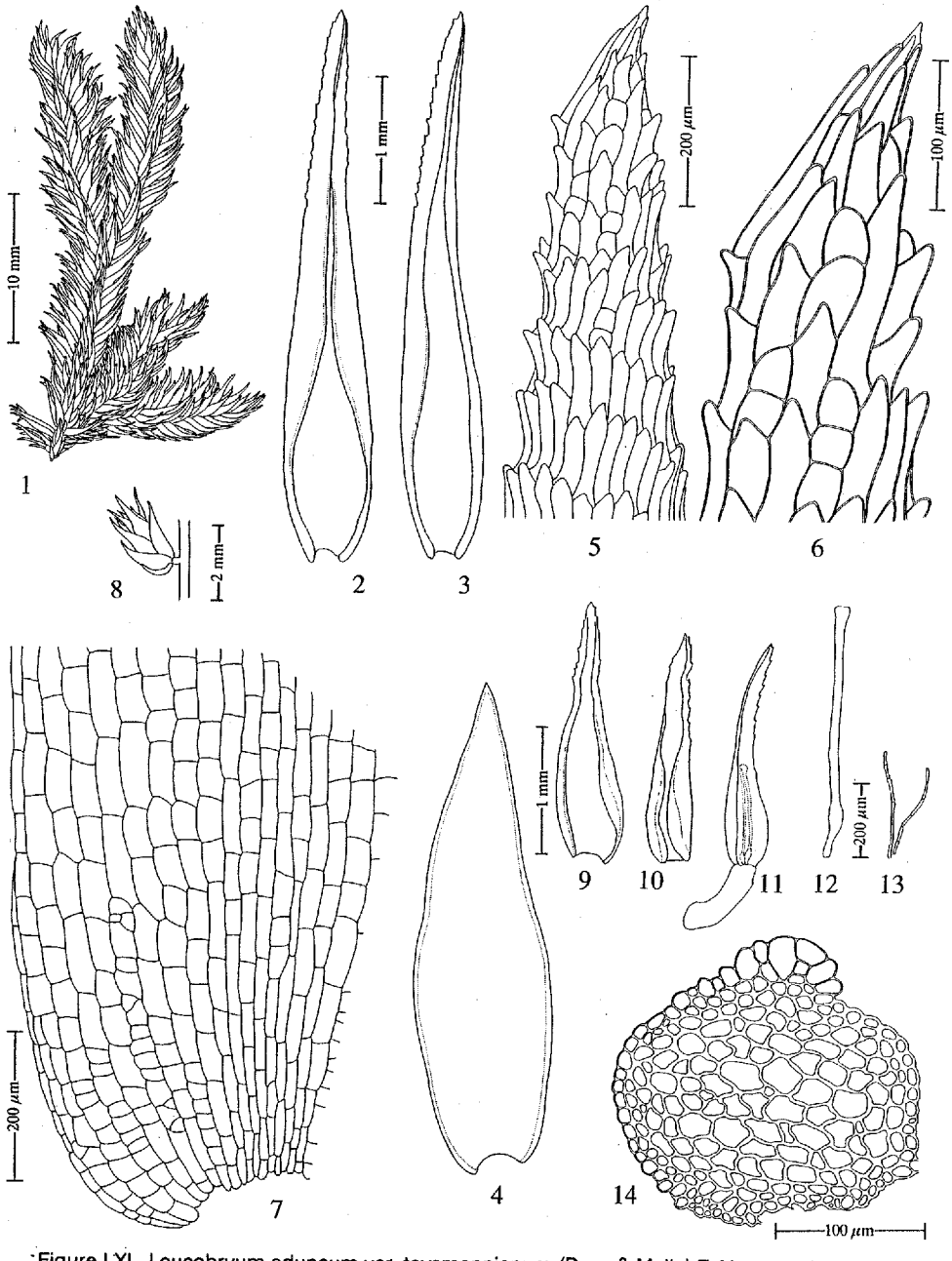

Figure LXI. Leucobryum aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. 1. Plant. 2–4. Leaves (4, expanded). 5, 6. Leaf apices. 7. Leaf base (abaxial view). 8, 11. Perichaetia. 9, 10. Inner perichaetial leaves. 12. Archegonium. 13. Paraphyses. 14. Cross-section of stem. All figures were drawn from holotype of L. teysmannianum (L).

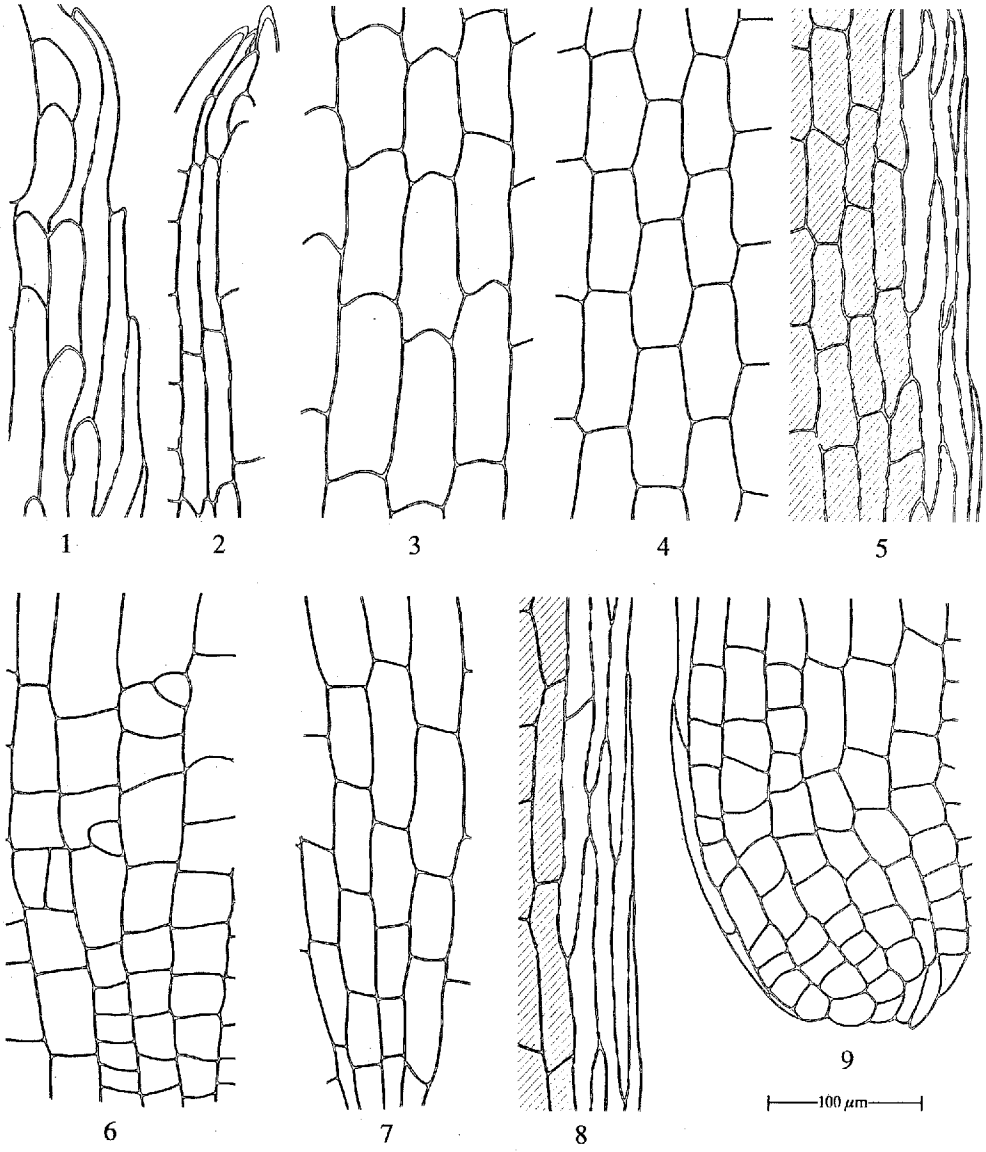

Figure LXII. Leucobryum aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. 1, 2. Cells near leaf apex (1, abaxial view; 2, adaxial view). 3–5. Median cells of leaf (3, 5, abaxial view; 4, adaxial view). 6–9. Basal cells of leaf (6, 8, 9, abaxial view; 7, adaxial view). All figures were drawn from holotype of L. teysmannianum (L).

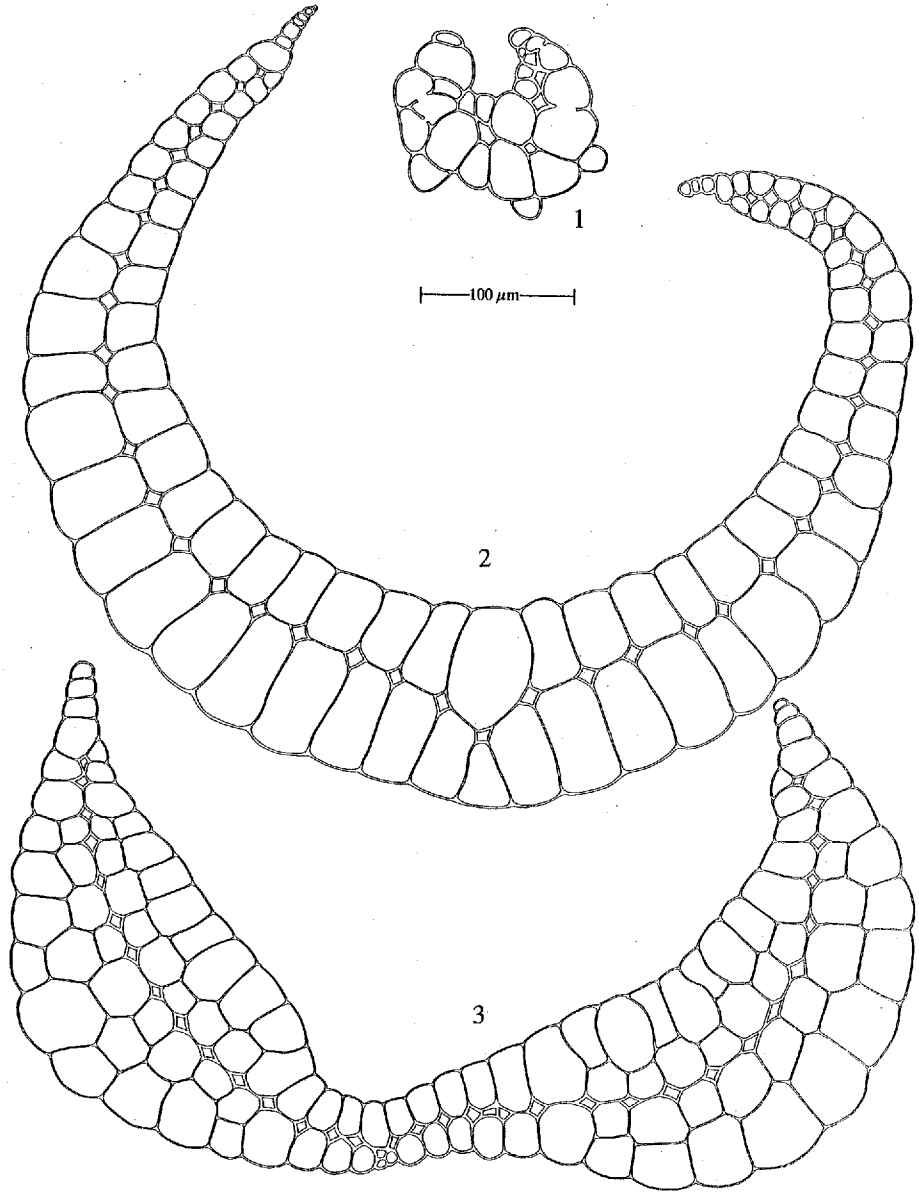

Figure LXIII. Leucobryum aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. 1–3. Cross-sections of leaf (1, apical; 2, median; 3, basal portions). All figures were drawn from holotype of L. teysmannianum (L).

unfertilized; archegonia ca. 0.7 mm long. Sporophytes not observed.

Representative specimens examined: Thailand, Phuket Island, near Thalang, 8°N 98°20'E, 300-350 m alt., 25 Jan. 1966, Touw 11225 (L). Sumatra, Harau-canyon, Pajakumbuh, 600 m alt., 31 July 1955, Meijer 6014 (L). Mentawei Islands, N. Pagai, Sikakap, 7 July 1953, Borssum Waalkes 2701 (L). Java, Prov. Preanger, Pangerango, Tjibodas, 1500 m alt., 18 Apr. 1894, Schiffner 10373 (L). New Guinea, Morobe District, Oomsis, 25 Apr. 1959, Brass s. n. (L).

Habitat: On tree trunks, rocks and soil.

Distribution: Thailand, Sumatra, Java, New Guinea.

L. aduncum var. teysmannianum is characterized by (1) distinct pentastichous leaf arrangement, (2) straight leaves which are 3.7-4.3 mm long and gradually narrowed from oblong base, and (3) indistinct differentiation of abaxial leucocysts at leaf bases. L. aduncum var. aduncum is closely related to var. teysmannianum, but differs in having falcate leaves and differentiated abaxial leucocysts at leaf bases. L. aduncum var. scalare is also related to this taxon, but differs in having closely imbricated and spirally arranged small (2.0-3.5 mm long) leaves.

3b. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy (Fig. XXI, XXV: A, LXIV-LXX, CXL: 4)

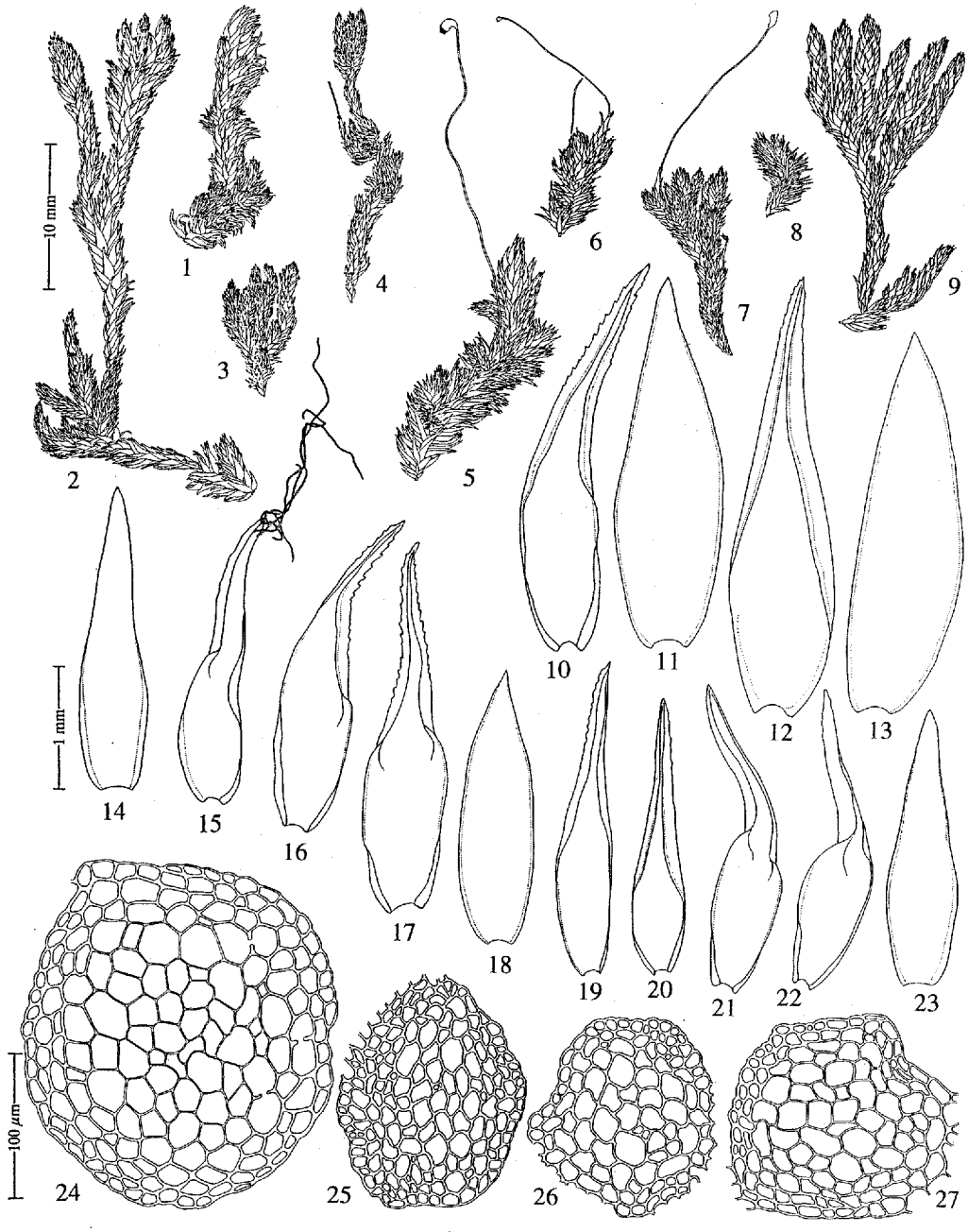

Figure LXIV. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1–9. Plants. 10–23. Leaves (11, 13, 14, 18, 23, expanded). 24–27. Cross-sections of stems. Figs. 1, 27 were drawn from lectotype of L. scalare (FH); 2, from holotype of L. scalare var. tjibodense (FH); 3, 4, from lectotype of L. scalare var. marschmeyeri (FH); 5, 10, 11, 20, from isotype of L. poilanei (NICH); 6, 9, from Micholitz 264 determinated as L. subscalare by Brotherus (H); 7, 18, from Touw 10733 (L); 8, from holotype of L. krempfii (PC); 12, 13, 24, form isotype of L. aduncum var. arnottii (GE); 14, 15, 26, from holotype of L. krempfii (PC); 16, 17, from isotype of L. scalare var. tjibodense (HIRO); 19, from isotype of L. flavulum (FI); 21–23, 25, from holotype of L. microleucophanoides.

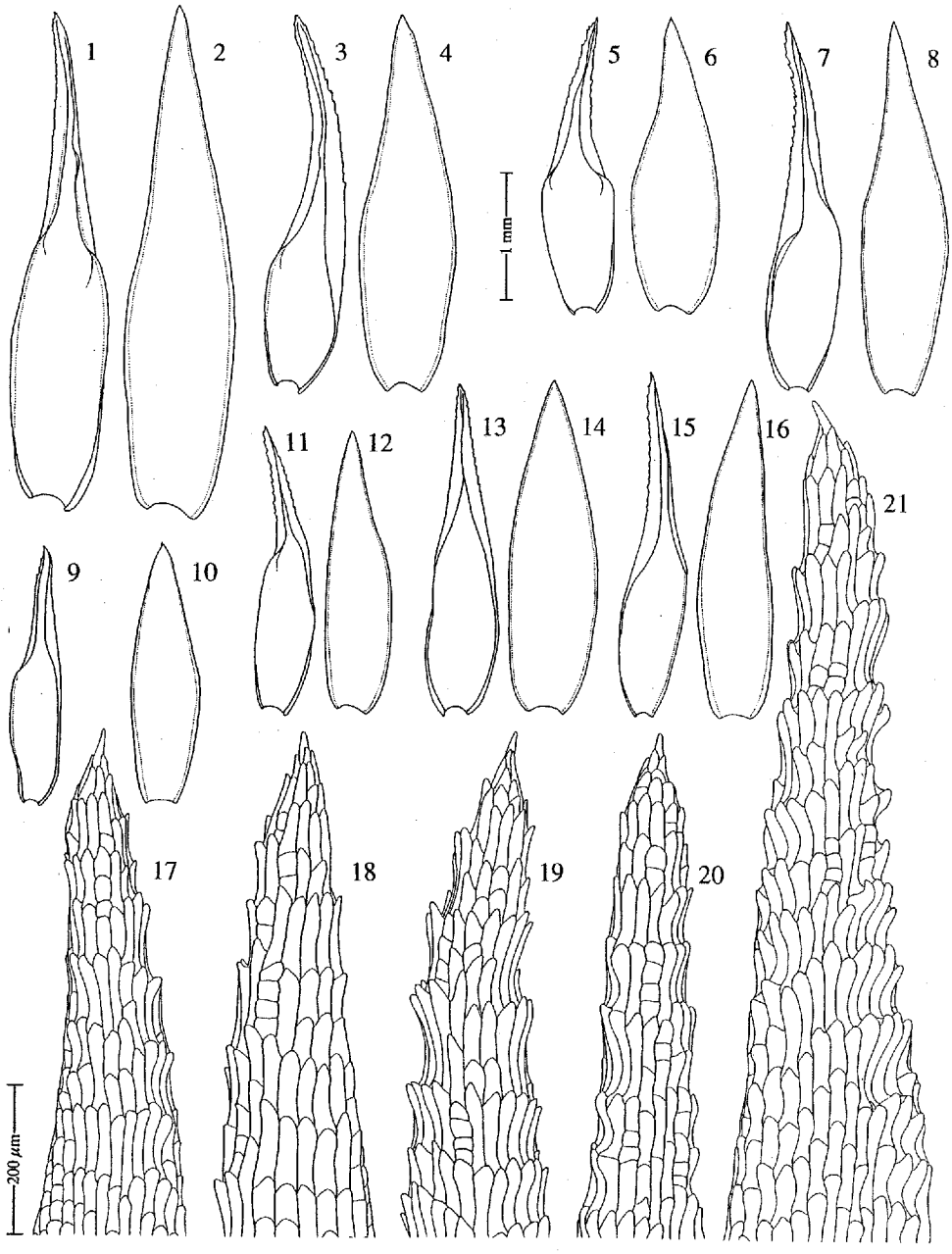

Figure LXV. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1–16. Leaves (2, 4, 6, 8, 10, 12, 14, 16, expanded). 17–21. Leaf apices. Figs. 1–4, 21 were drawn from lectotype of L. scalare (FH); 5–8, from isotype of L. scalare var. tjibodense (HIRO); 9, 10, 17, from holotype of L. perichaetiale (BM); 11, 12, from isolectotype of L. scalare var. marschmeyeri (HIRO); 13, 14, from Micholitz 264 determinated as L. subscalare by Brotherus (H); 15, 16, 20, from isotype of L. flavulum (FI); 18, form isotype of L. aduncum var. arnottii (GE); 19, from isotype of L. poilanei (NICH).

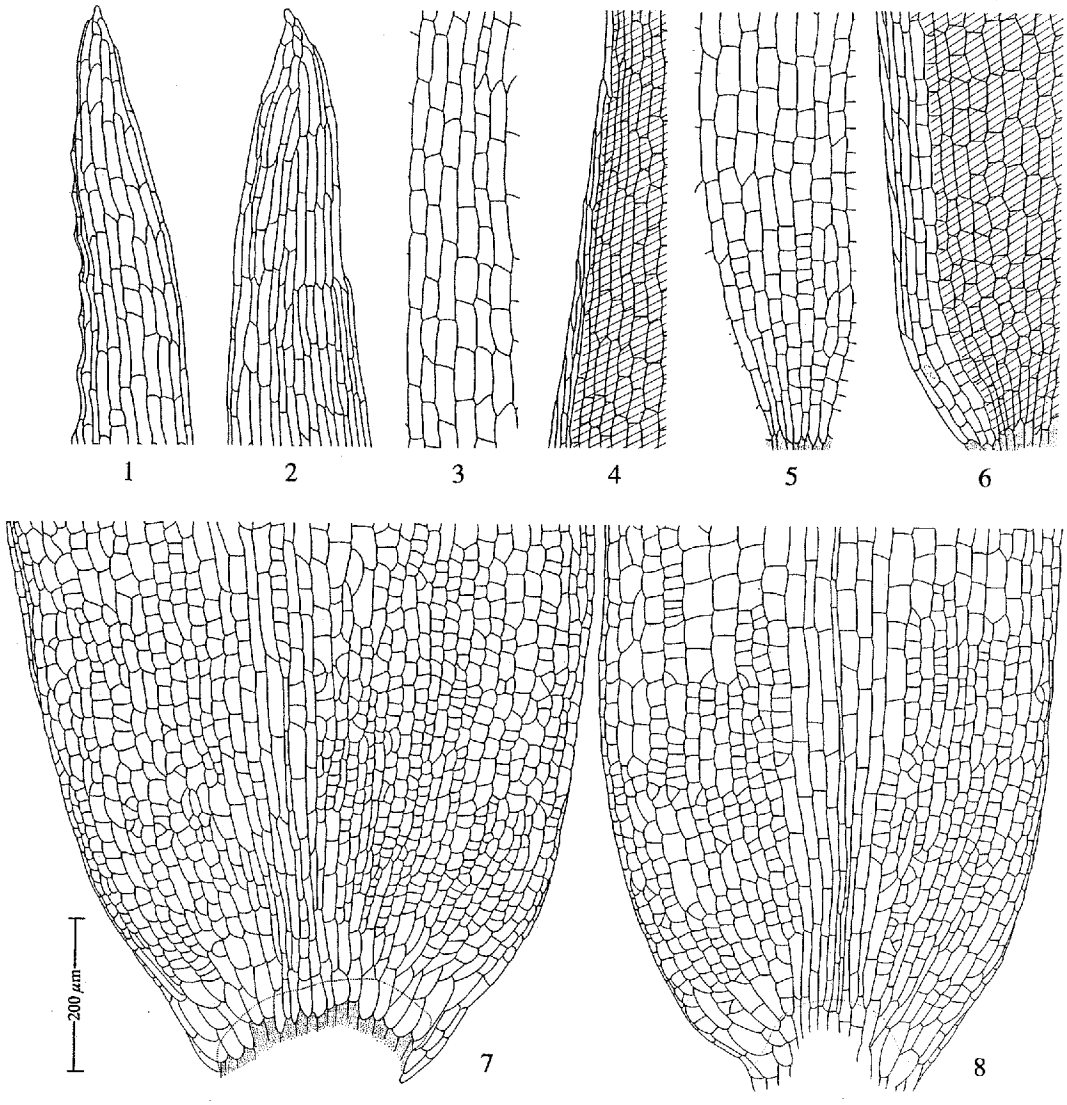

Figure LXVI. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1, 2. Cells near leaf apex (1, abaxial view; 2, adaxial view). 3, 4. Median cells of leaf (3, abaxial view; 4, adaxial view). 5, 6. Basal cells of leaf (5, abaxial view; 6, adaxial view). 7, 8. Leaf bases (abaxial view). Figs. 1–6 were drawn from holotype of L. krempfii (PC); 7, from lectotype of L. scalare (FH); 8, from isotype of L. poilanei (NICH).

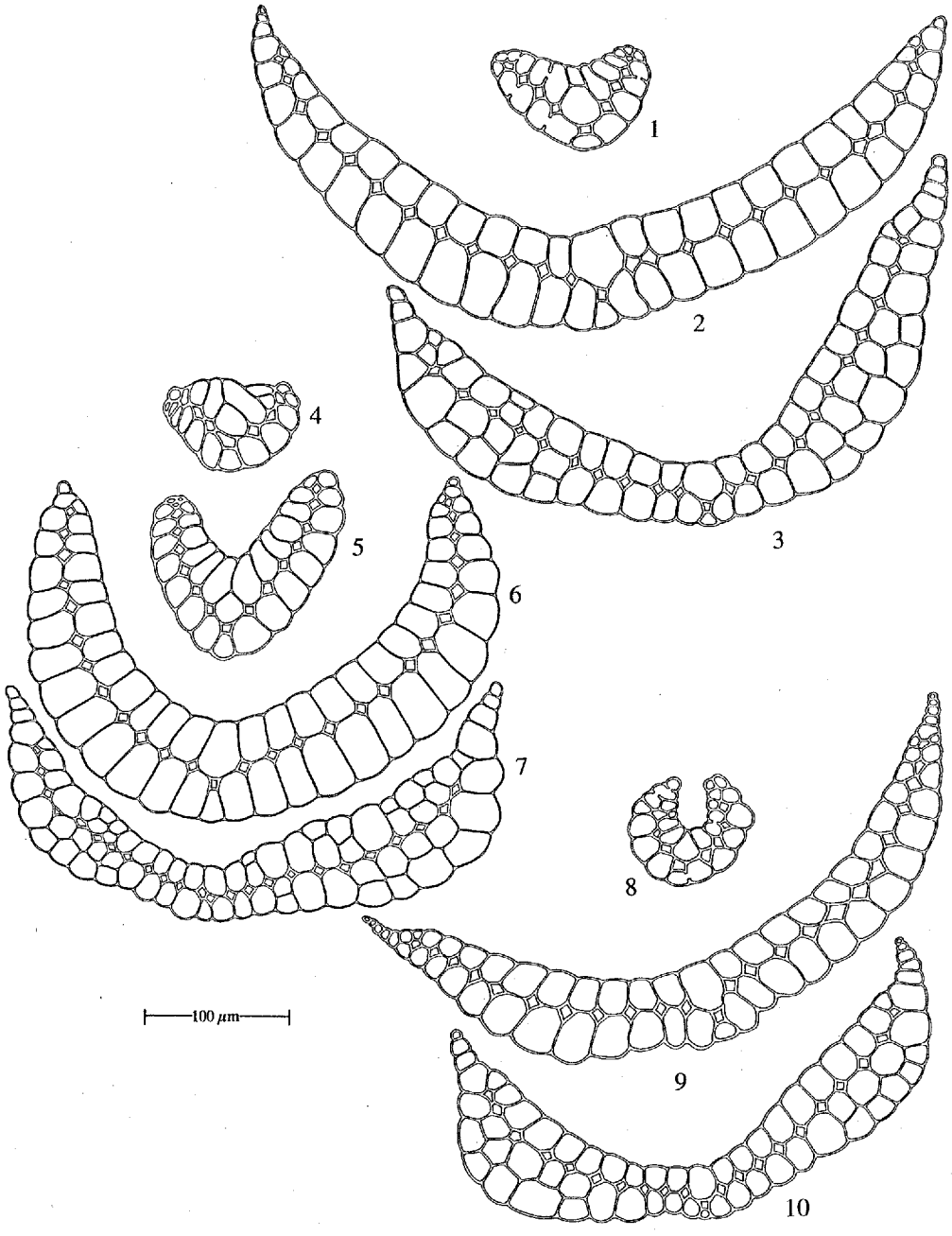

Figure LXVII. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1–10. Cross-sections of leaves (1, 4, 5, 8, apical; 2, 6, 9, median; 3, 7, 10, basal portions). Figs. 1–3 were drawn from holotype of L. microleucophanoides (BM); 4–7, from holotype of L. krempfii (PC); 8–10, from holotype of L. perichaetiale (BM).

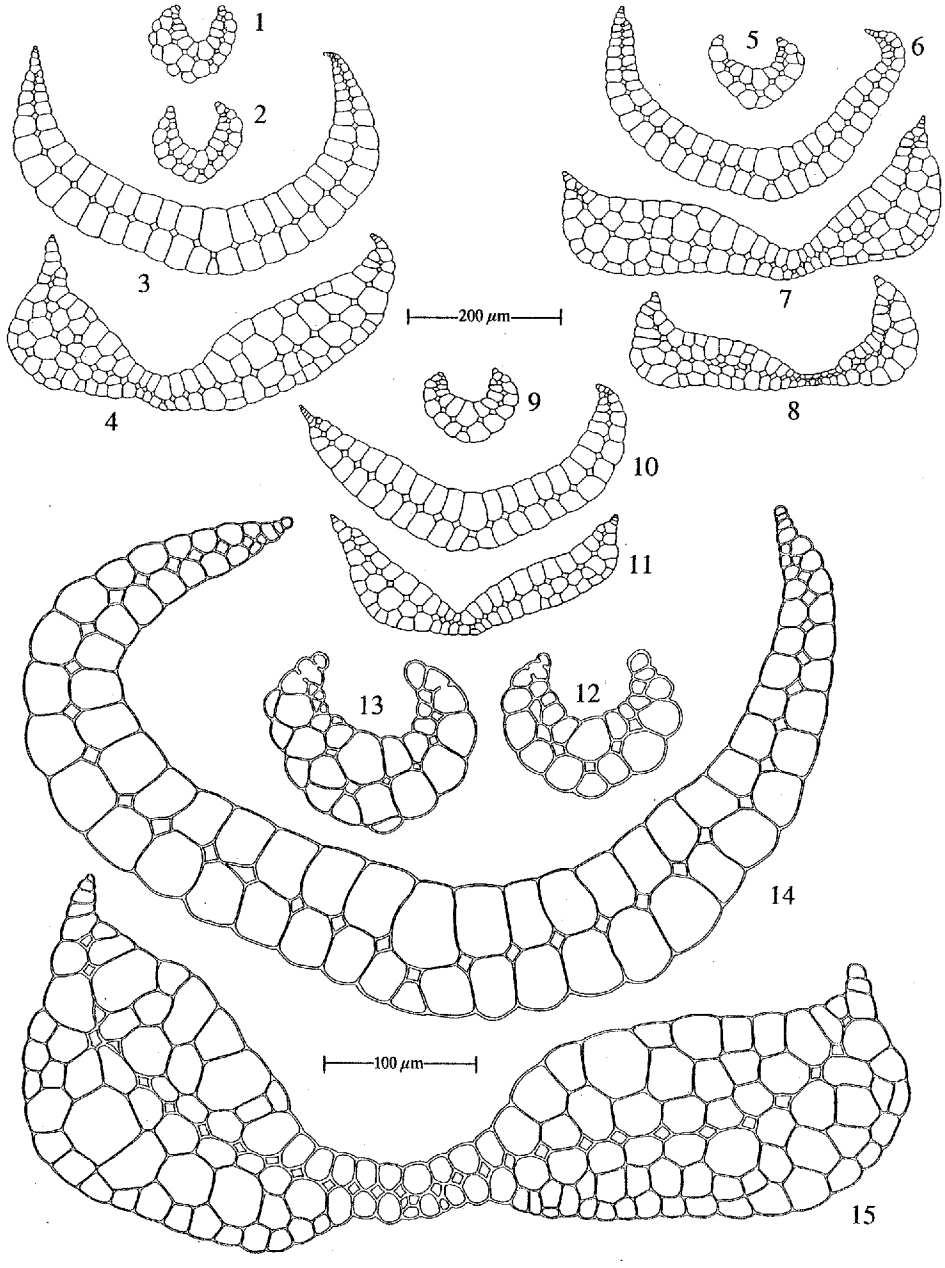

Figure LXVIII. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1–15. Cross-sections of leaves (1, 2, 5, 9, 12, 13, apical; 3, 6, 10, 14, median; 4, 7, 8, 11, 15, basal portions). Figs. 1–4 were drawn from isotype of L. poilanei (NICH); 5–8, from lectotype of L. scalare (FH); 9–11, from isotype of L. flavulum (FI); 12–15, form isotype of L. aduncum var. arnottii (GE).

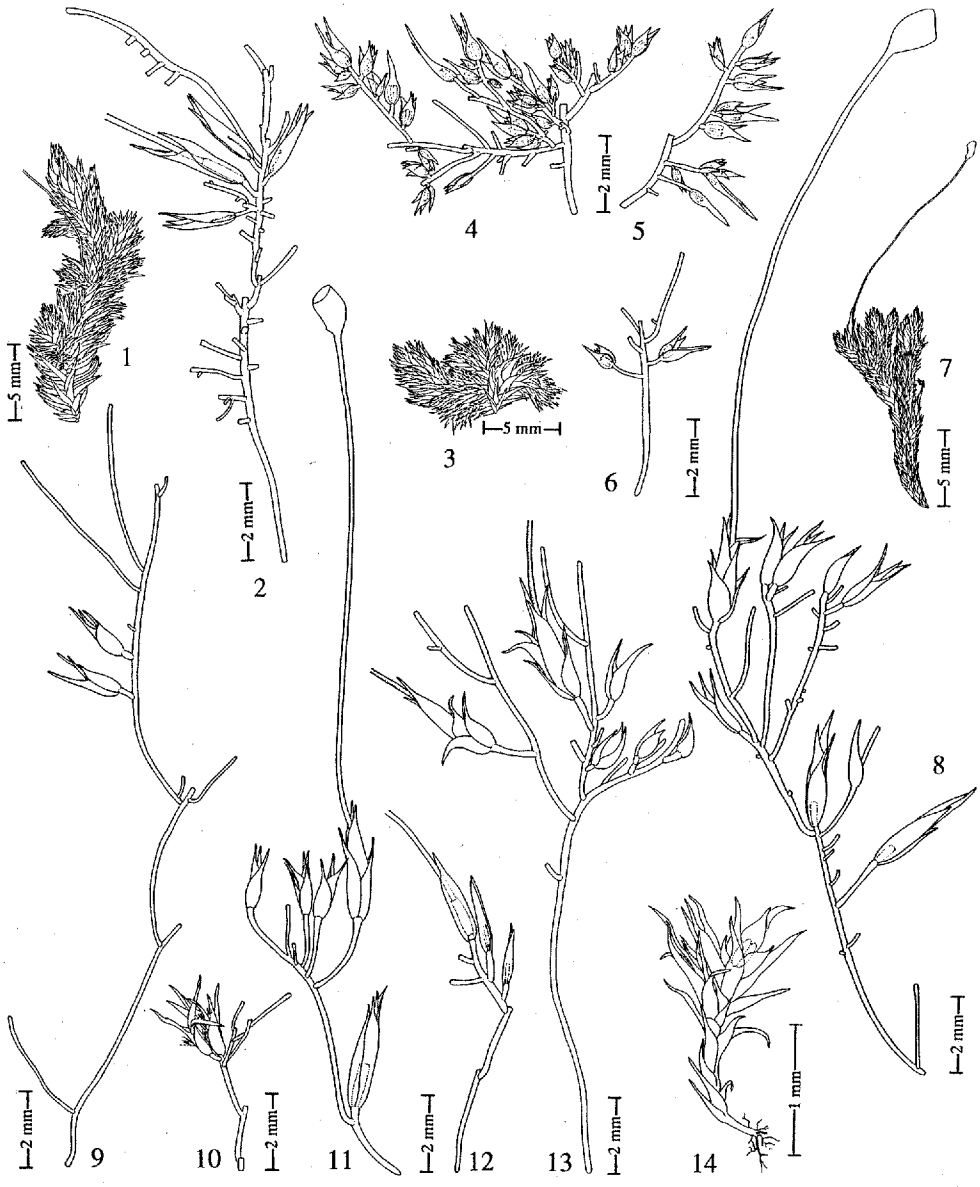

Figure LXIX. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1, 7. Female plants. 2, 8–13. Branching of female plants showing position of perichaetia (2, 8, from female plants 1 and 7 respectively). 3. Male plant. 4–6. Branching of male plants (4, from male plant 3). 14. Dwarf male plant. Figs. 1–5 were drawn from isotype of L. poilanei (NICH); 6, from lectotype of L. scalare (FH); 7, 8, 11, from Touw 10733 (L); 9, from isotype of L. scalare var. tjibodense (HIRO); 10, from holotype of L. krempfii (PC); 12, 14, from holotype of L. perichaetiale (BM); 13, from isolectotype of L. scalare var. marschmeyeri (HIRO).

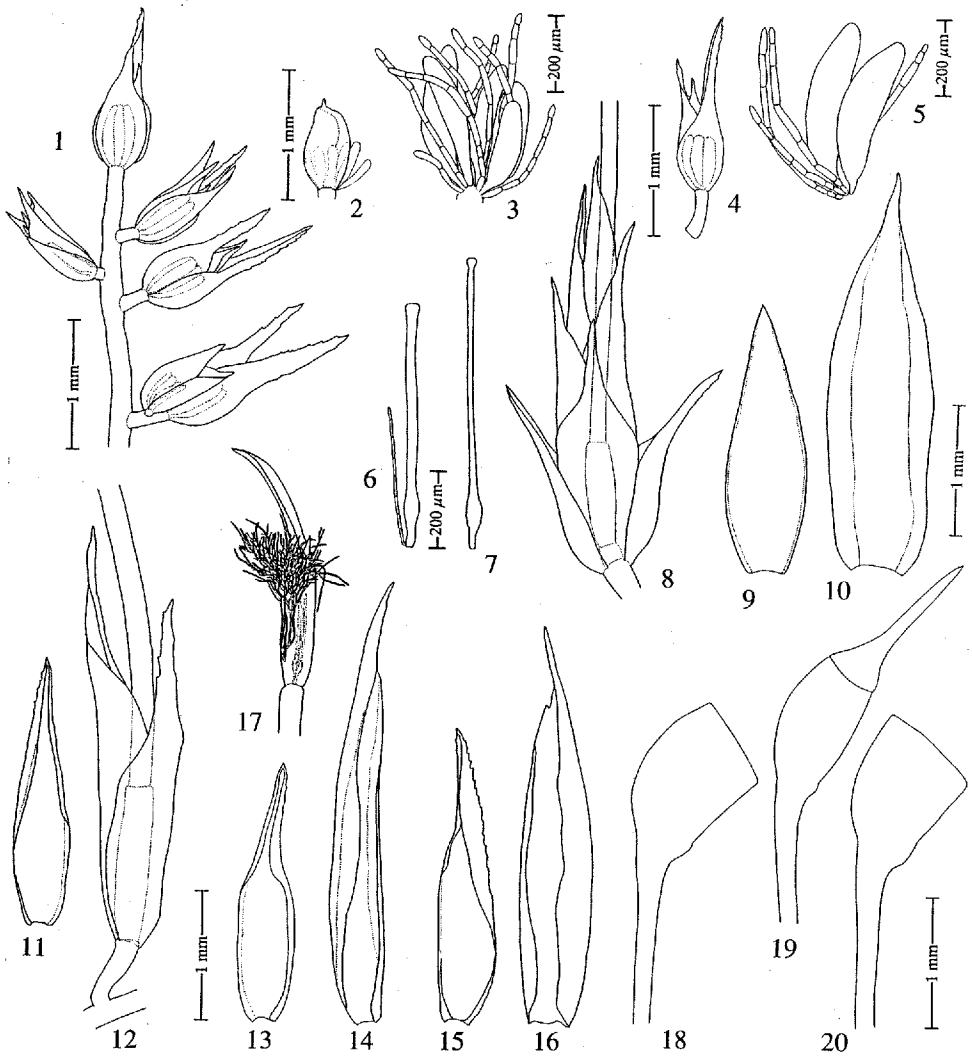

Figure LXX. Leucobryum aduncum var. scalare (C. Müll. ex Fl.) A. Eddy. 1, 2, 4. Perigonia. 3, 5. Antheridia. 6, 7. Archegonia. 8, 12. Perichaetia with sporophytes. 9, 11. Stem leaves near perichaetia 8 and 12 respectively (9, expanded). 10. Inner perichaetial leaf from perichaetium 8. 13, 15. Stem leaves near perichaetial leaves 14 and 16 respectively. 14, 16. Inner perichaetial leaves. 17. Inner perichaetial leaves with tomentum. 18–20. Capsules. Figs. 1–3, 6, 11, 12 were drawn from isotype of L. poilanei (NICH); 4, 5, from lectotype of L. scalare (FH); 7–10, 18–20, Touw 10733 (L); 13, 14, from holotype of L. perichaetiale (BM); 15, 16, from isolectotype of L. scalare var. marschmeyeri (HIRO); 17, from holotype of L. krempfii (PC).

Malesian Mosses 2: 11, f. 170 (1990).

Basionym: Leucobryum scalare C. Müll. ex Fl., Musci Fl. Buitenzorg 1: 143 (1904). Type: Philippines, Luzon, Benguet, 5000 ft. alt., Micholitz 173 (Leucobryum scalare C. Müll. n. sp. in sched.) – lectotype (FH).

Leucobryum scalare var. marschmeyeri Fl., Musci Fl. Buitenzorg 1: 144 (1904). Type: Timor, bei Koepang, an morscher Rinde, Oct. 1899, Marschmeyer s. n. (Musci Frond. Archipelagi Indici ser. VIII, no. 352) – lectotype (FH), isolectotype (HIRO).

Leucobryum scalare var. tjibodense Fl., Musci Fl. Buitenzorg 1: 145 (1904). Type: Java, Berggarten von Tjibodas, 1450 m alt., an Baumrinde, June 1900, Fleischer s. n. (Musci Archipelagi Indici ser. IV, no. 151) – holotype (FH), isotype (HIRO).

Leucobryum flavulum Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 28 (1905), syn. nov. Type: Sri Lanka, Hinidoon Kanda hills, Oct. 1901, Wright s. n. (in herb. E. Levier) – holotype (PC), isotype (FI).

Leucobryum subscalare Broth. ex Vard., Rev. de Bot. 29: 292 (1917), syn. nov. Type: Vietnam, Annam, Plaine de Chu-Mai a Thua-Liu, pied des arbrisseaux (nos. 416-417) – syntypes (not seen).

Leucobryum krempfii Thér., Recueil Publ. Soc. Havraise, Etud. Div. 1919: 35, pl. 1, f. 3 (1919), syn. nov. Type:

Vietnam, Annam, Vallee du Fong Man, 1200 m alt., June 1912, Krempf 1624pp – holotype (PC).

Leucobryum poilanei Thér., Rev. Bryol. n. sér. 2: 18, f. 2 (1929), syn. nov. Type: Cambodia, Pron Thma So, près village Ko-Virk pro, 800-100 m alt, 5 May 1928, Poilane 15222 – isotype (NICH).

Leucobryum perichaetiale Dix., J. Siam Soc., Nat. Hist. Suppl. 9(1): 11 (1932), syn. nov. Type: Thailand, Pãyap, Doi Sutêp, ca. 1500 m alt., 6 Sept. 1914, Kerr s. n. (in herb. Dixon, ref. no. 8) – holotype (BM).

Leucobryum aduncum var. arnottii Thér., Bull. Soc. Bot. Genève sér. 2, 26: 82 (1936), syn. nov. Type: Indes-orientales, 1838, Arnott 38 – holotype (PC), isotype (GE).

Leucobryum microleucophanoides Dix. ex Johnson, Gard. Bull. Straits Settlem, ser. 3, 20: 333, f. 12 (1964), syn. nov. Type: Malaya, Kedah, Inchang Estate, on decaying trunk, 24 Apr. 1940, Spare s. n. (in herb. Dixon, ref. no. 2941) – holotype (BM).

Plants grayish or whitish tinged with brown when dry, forming compact cushions. Stems to 35 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves closely imbricate, forming conical point at shoot apex; 2.0-3.5 x 0.5-1.0 mm, lanceolate, gradually or abruptly narrowed to subtubulous point from oblong to ovate base, acute, undulate and spinosely prorate down to mid leaf

on abaxial surface; laminae, borders and alar parts similar to those of var. aduncum; in cross-sections near leaf base leucocysts in 1-3 cell layers on adaxial side and 2-3 cell layers on abaxial side at the thickest part; abaxial leucocysts of leaves hardly decurrent on stems; abaxial leucocysts of leaf bases vertically subdivided and forming conspicuous groups of small quadrate cells (LXVI: 7, 8); abaxial leucocysts at insertional parts to stem clearly enlarged and in 1 cell row (Fig. LXVI: 7, 8).

Dioicous. Male plants dimorphous; dwarf male plants tiny, growing on tomentum enclosed by perichaetial leaves; normal male plants as large as female plants, perigonia small, terminal on short or long lateral branches. Perichaetia terminal on short or long lateral branches, sometimes terminal on main stems, the mature perichaetia with sporophytes prominent, protruded from shoots; inner perichaetial leaves around mature sporophytes 1.4-1.8 times longer than ordinary leaves near the perichaetia. Setae 13-24 mm long. Capsules inclined to horizontal, subglobose to ovoid; urns 1.0-1.1 mm long, 0.6-0.8mm wide.

Representative specimens examined: China, Hainan, Kwangtung, 13 Feb. 1962, Chen et al. 861B (L). India, Madras State, Madura District, Palni Hills, Kodaikanal and surrounding region, Foreau 1923 (L). Sri Lanka, Ratnapura District, Sri Pada (Adams Peak), descent to Carney, 23 Feb.

1978, Ruinard 23/176 (L). Myanmar, Southern Shan Sates, 4500 ft. alt., Jan. 1899, Micholitz s. n., labeled as Leucobryum subscalare Broth. n. sp., sub. no. 264 (H). Thailand, Lôi, Kao Krading, ca. 1200 m alt., Mar. 1924, Kerr s. n. (in herb Dixon, ref. no. 84) – paratype of L. perichaetiale (BM); Lôi, Po Tong, ca. 1000 m alt., Mar. 1924, Kerr s. n. (in herb. Dixon, ref. no. 102) – paratype of L. perichaetiale (BM). Cambodia, Province de Koh Kong, Chékô, 5 Mar. 1965, Kira et al. 189 (HIRO). Vietnam, 15 June 1963, Pócs 2507/1 (L). Malay Peninsula, Singapore, Bukit-Timah, 100 m alt., Fleischer s. n. – paratype of L. scalare (FH); Perak, Hermitage Hill, 1500 ft. alt., 19 Dec. 1939, Spare s. n. (in herb. Dixon ref. no. 2760) – paratype of L. microleucophanoides (BM); Perak, Hermitage Hill, 3000 ft. alt., 19 Dec. 1939, Spare s. n. (in herb. Dixon 2776) – paratype of L. microleucophanoides (BM); Kedah, Gunong Bongsu Forest Reserve, 21 July 1941, Spare s. n. (in herb. Dixon, ref. no. 3048) – paratype of L. microleucophanoides (BM); Kedah, Gunong Bongsu Forest Reserve, 21 July 1940, Spare s. n. (in herb. Dixon, ref. no. 3070) – paratype of L. microleucophanoides (BM); Perak, Lembok Kluang, 17 Nov. 1940, Spare s. n. (in herb. Dixon, ref. no. 3642) – paratype of L. microleucophanoides (BM). Philippines, Negros, Negros Occidental Province, Mt. Canlaon National Park near Bacolod City, ca. 4000 ft. alt., 3 Apr. 1981, Tan & Alvarez 81-306

(NICH). Borneo, Sandakan Res., Leila Forest Reserve, 31 Jan. 1960, Meijer B10058 (L). Sumatra, Taluk, Kilirandjau, 24 Nov. 1955, Meijer B9652 (L). Java, Sindanglaya, 1000 m alt., an Felsen, June 1901, Fleischer s. n. – paratype of L. scalare (FH); Papandajan bei Garoet, 1300 m alt., Fleischer s. n. – paratype of L. scalare (FH); Ardjoeno bei Lalidjiwa, 2000 m alt., Fleischer s. n. – paratype of L. scalare var. marschmeyeri (FH). Sumbawa, Sambori, 4000 ft. (1200 m) alt., Warburg s. n. – paratype of L. scalare (FH). Bali, Penulisan temple complex, 1700 m alt., 10 July 1975, Veldkamp 7139 (L). Seram, Kecamatan Kairatu, en route from Kamarian to the upper elevation of Gunung(Mt.) Totaniwel, 3°23-26'S 128°25-28'E, ca. 700 m alt., 22 Aug. 1986, Akiyama 15881 (KYO, HIRO). New Guinea, Central Mountains, Swart Valley, Kadubaka, 1600-2000 m alt., 7 Oct. 1957, Bergman M39 (L).

Habitat: On logs, tree trunks and rocks.

Distribution: China, India, Sri Lanka, Myanmar, Thailand, Cambodia, Vietnam, Malay Peninsula, Philippines, Borneo, Sumatra, Java, Seram, New Guinea, New Caledonia.

The present variety is characterized by (1) closely imbricated small leaves, (2) conical appearance at shoot apices, and (3) distinctly differentiated abaxial leucocysts of leaf bases which form group of small quadrate cells.

I could not locate type specimen of L. subscalare, but I could examine a specimen from Myanmar (coll. Micholitz s. n.) determined as L. subscalare by Brotherus, and found L. subscalare was identical with the present variety.

The present variety is closely related L. aduncum var. aduncum and L. aduncum var. teysmannianum as mentioned in each taxonomic note of latter two taxa.

4. Leucobryum chlorophyllosum C. Müll. (Fig. LXXI-LXIII, CXL: 5)

Syn. 2: 535 (1851). Type: Sumbawa, Zollinger s. n. (Herb. Lugd. Bat. 20. Ind. Or. no. 910.137-1201) – isotype (L).

Leucobryum stenophyllum Besch., Ann. Sc. Nat. Bot. sér. 5, 18: 204 (1873), syn. nov. Type: New Caledonia, Prony, Sept. 1869, Balansa 2531 – holotype (PC).

Leucobryum byssaceum C. Müll. ex Johnson, Gard. Bull. Straits Settlem. ser. 3, 20: 334, f. 8: c, f. 9: h (1964), syn. nov. Type: New Guinea, distr. Moresby, Mt. Mo-roka, 1300 m alt., July-Aug. 1893, Loria s. n. (det. Müller, sub. no. 703, in herb. Levier) – holotype (BM).

Plants greenish white wen dry, forming loose to compact cushions. Stems to 20 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves erect to widely spreading; 2.9-4.0 x 0.4-0.6 mm, linear to narrowly lanceolate, gradually narrowed to subtubulous point

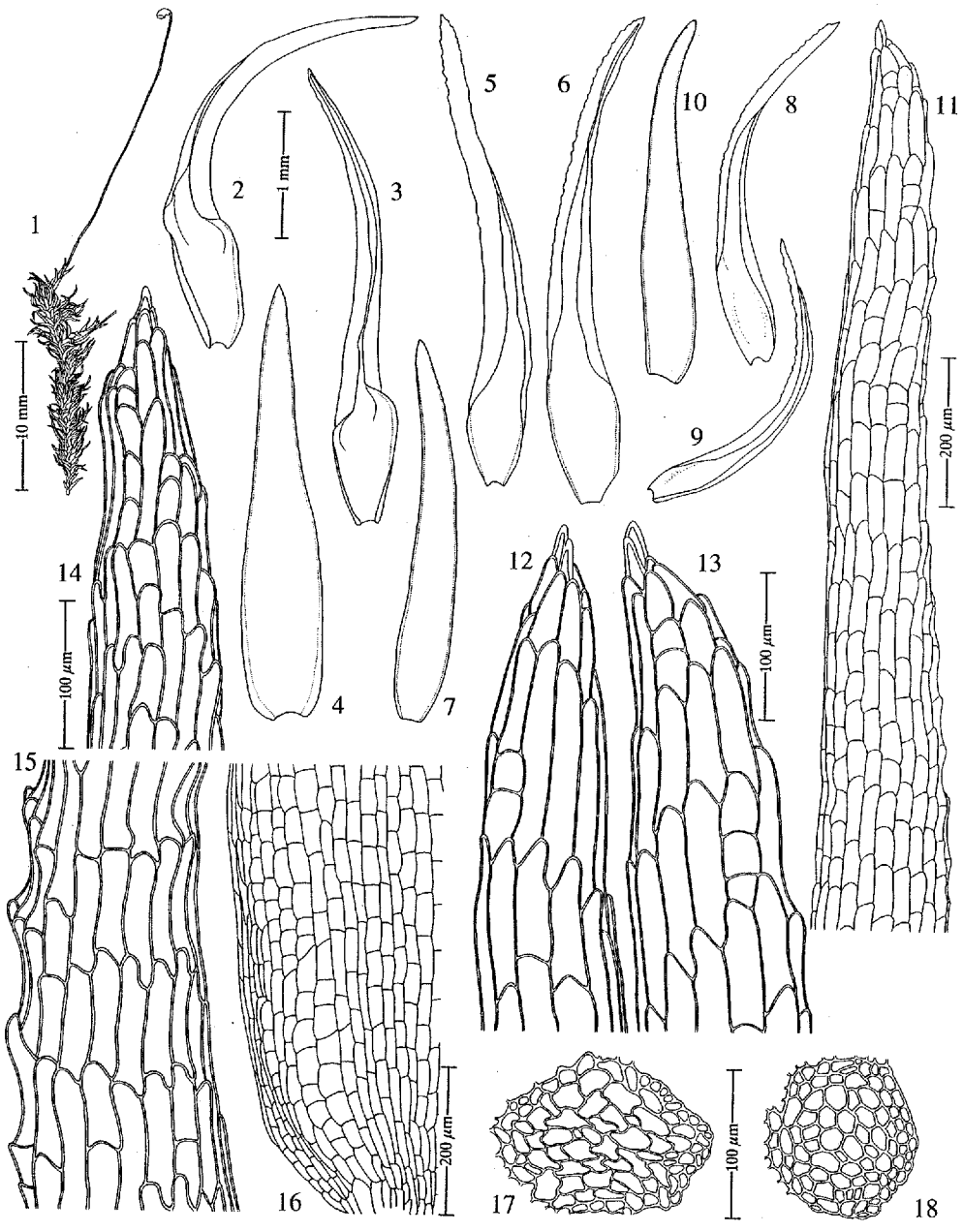

Figure LXXI. Leucobryum chlorophyllosum C. Müll. 1. Plant. 2–10. Leaves (4, 7, 10, expanded). 11–14. Leaf apices. 15. Apical part of leaf (lateral view). 16. Leaf base (abaxial view). 17, 18. Cross-sections of stems. Figs. 1–4, 11–13, 17 were drawn from isotype of L. chlorophyllosum (L); 5–7, from holotype of L. stenophyllum (PC); 8–10, 14–16, 18, from holotype of L. byssaceum (BM).

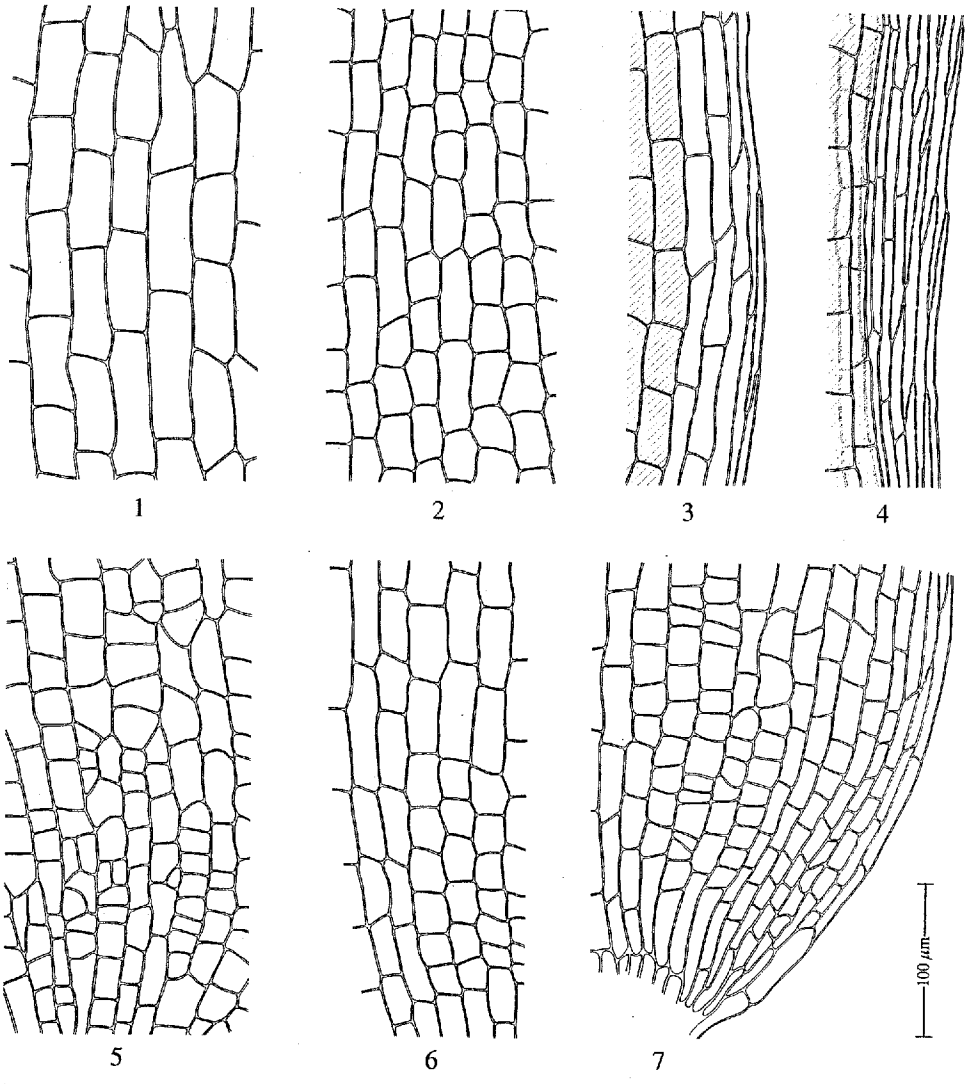

Figure LXXII. Leucobryum chlorophyllosum C. Müll. 1–3. Median cells of leaf (1, 3, abaxial view; 2, adaxial view). 4–7. Basal cells of leaf (4, 5, 7, abaxial view; 6, adaxial view). All figures were drawn from isotype of L. chlorophyllosum (L).

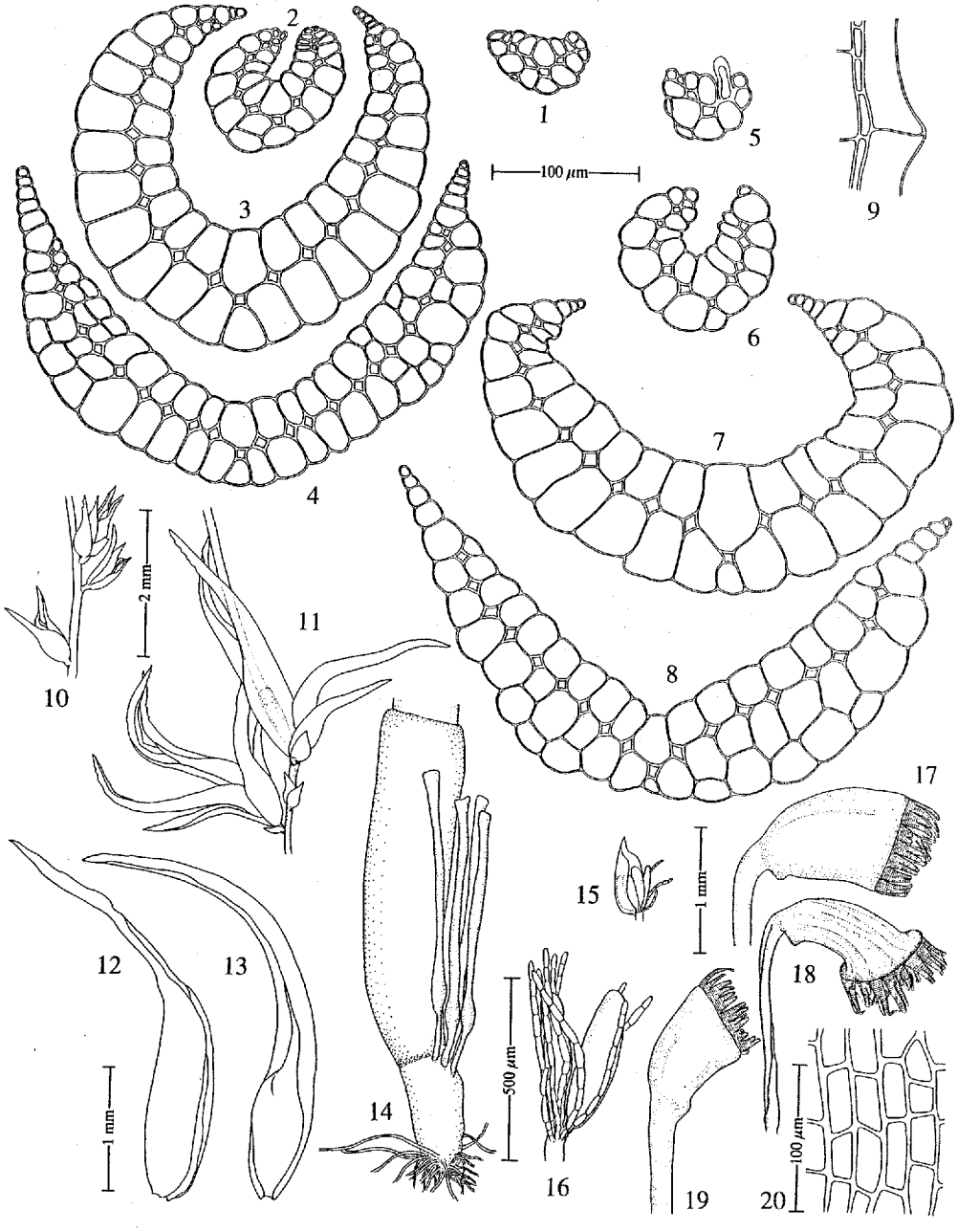

Figure LXXIII. Leucobryum chlorophyllosum C. Müll. 1–8. Cross-sections of leaves (1, 2, 5, 6, apical; 3, 7, median; 4, 8, basal portions). 9. Longitudinal section of leaf near apex. 10. Perigonia. 11. Perichaetia. 12, 13. Inner perichaetial leaves. 14. Vaginula and archegonia. 15. Inner perigonial leaf. 16. Antheridium. 17–19. Capsules. 20. Exothecial cells. Figs. 1–4 were drawn from holotype of L. byssaceum (BM); 5–8, 10–20, from isotype of L. chlorophyllosum (L); 9, from holotype of L. stenophyllum (PC); 11, from holotype of L. scaberulum var. divaricatum (BM).

from oblong base, acute, weakly scabrous down to mid leaf on abaxial surface due to undulation or minute proration of leucocysts (Fig. LXXI: 11-15); laminae and borders consisting of 6-8 rows of narrowly rectangular cells near base, the differentiation between laminal cells and border cells indistinct; in cross-sections near leaf base leucocysts in 1-2 cell layers on adaxial side and 2 (-3) cell layers on abaxial side at the thickest part; abaxial leucocysts of leaves hardly decurrent on stems.

Dioicous. Male plants dimorphous; dwarf male plants tiny, usually growing on tomentum enclosed by perichaetial leaves; normal male plants as large as female plants, perigonia small, bud-like, terminal on short or long lateral branches. Perichaetia terminal on short or long lateral branches, sometimes terminal on main stems; inner perichaetial leaves around mature sporophytes almost as long as ordinary leaves near the perichaetium. Setae 14-20 mm long. Capsules inclined to horizontal, ovoid; urns 0.8-1.0 mm long, 0.6-0.8 mm wide; opercula long rostrate, ca. 1.4 mm long. Annulus of 1 (-2) rows of cells. Apices of peristome teeth divided to the middle, ca. 0.5 mm long, ca. 0.09 mm wide at base. Spores 14-18 μm in diameter.

Representative specimens examined: Vietnam, Prov. Hoa-Binh, Montes Nui Bieu, 400 m alt., 5 Jan. 1966, Pócs 31471/ac (NICH). Philippines, Luzon, Sierra Madre

Mountains, NNW of Dingalan, Auroa Memorial Park, 15°29'N 121°23'E, 600-700 m alt., 23 Mar. 1968, Jacobs B785 (L). Borneo, Sandakan Res., Upper Kinabatangan River, E of Lanas, 9 Dec. 1960, Meijer B10923 (L). Java, Leuwiliang above tea estate, Tji Anten, 1000 m alt., 21 Sept. 1952, Meijer B1136 (L). Lesser Sunda Islands, Flores, Prov. Manggarai, Paku, Poco Pakikaka area, near confluent of Wae Ngencung, 350-380 m alt., 28 June 1988, Schmutz 6750 (L). Seram, Kacamatan Seram Utara, Sawai, Manusela National Park, along a trail between Wae Niniyoa and Wae Puo, 3°00-03'S 129°14'E, 200-1000 m alt., 22 Jan. 1985, Akiyama 9567 (KYO, HIRO). New Guinea, Morobe District, Oomsis, 200 m alt., 25 Apr. 1959, Brass 29268a (L).

Habitat: On logs and tree trunks, or on soil at tree base.

Distribution: Vietnam, Philippines, Borneo, Java, Lesser Sunda Islands, Seram, New Guinea, New Caledonia.

The present species is characterized by (1) narrow leaves (5.7-7.8 times longer than wide), (2) weakly scabrous leaves on abaxial surface due to undulation or minute proration of leucocysts, and (3) usually 3-4 cell layered leucocysts near leaf bases in cross-sections.

Fleischer (1904) described the present species as monoicous (Einhäusig). I carefully examined the holotype specimen of the present species and found female plants and

independent normal male plants among the shoots. I am sure that the present species is dioicous.

5. Leucobryum boninense Sull. & Lesq. (Fig. LXIV-LXXXI, CXLI: 4)

Proc. Am. Ac. Arts Sc. 4: 277 (1859). Type: Japan, Bonin Islands, Hillsides, in dense tufts on rotten stumps, 1 Nov. 1854, Wright s. n. (in herb. Sullivant, ref. no. 5) – holotype (FH).

Leucobryum salmonii Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 27 (1905), syn. nov. Type: China, Kwangtung, Lo Fan Shan, 900 ft. alt., Aug. 1883, Salmon s. n. (Hort. Bot. Hongkong, no. 81) – holotype (PC).

Leucobryum scaberulum Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 26 (1905), syn. nov. Type: China, Hongkong, 31 Oct. 1889, Ford s. n. (Herb. Hongkong Botanic Garden no. 222) – isotype (BM).

Leucobryum armatum Broth., Symb. Sin. 4: 28 (1929), syn. nov. Type: China, Kweitschou, Nandjing-schan, ca. 750 m alt., on soil, 25 July 1917, Handel-Mazzetti 10985 – holotype (H).

Leucobryum scaberulum var. divaricatum Dix., Hong Kong Natural. Suppl. 2: 7 (1933), syn. nov. Type: China, Hongkong, Victoria Peak, below 1000 ft. alt., between

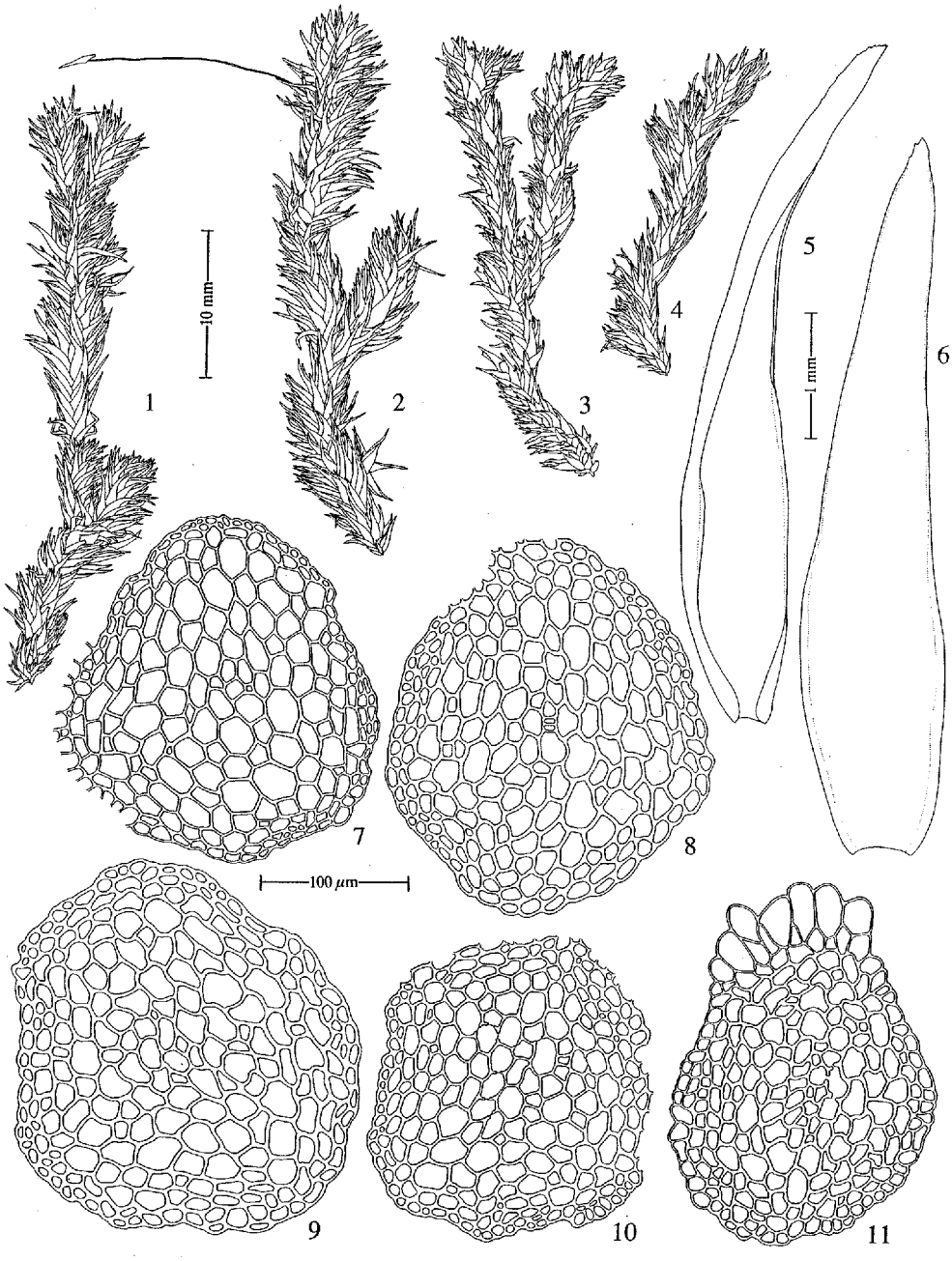

Figure LXXIV. Leucobryum boninense Sull. & Lesq. 1–4. Plants (1, male plant). 5, 6. Leaves (6, expanded). 7–11. Cross-sections of stems. Figs. 1, 2, 5, 6, 10 were drawn from holotype of L. boninense (FH); 3, 8, from holotype of L. armatum (H); 4, 9, from isotype of L. scaberulum (BM); 7, from Lai 16511 (HIRO); 11, from holotype of L. scaberulum var. divaricatum (BM).

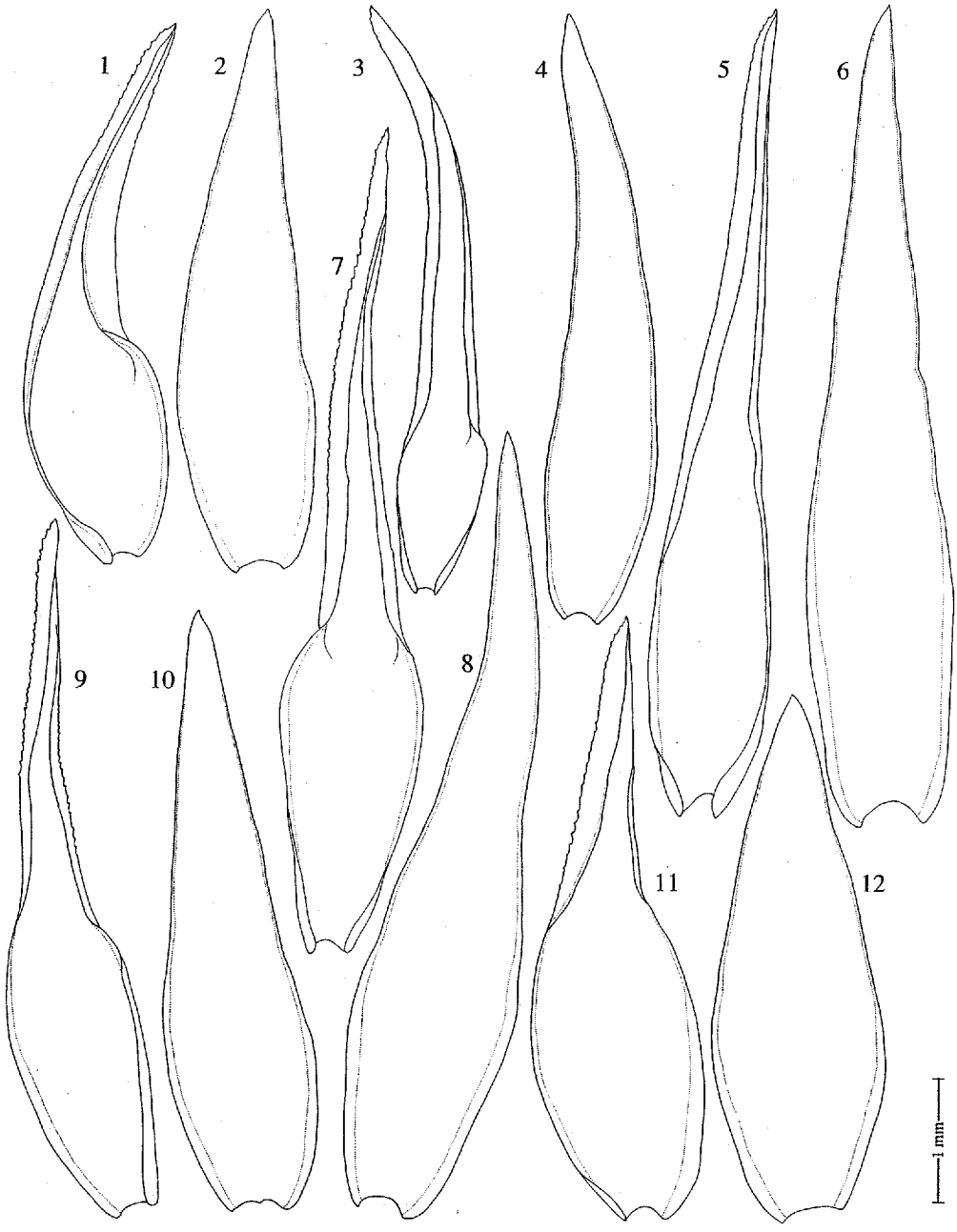

Figure LXXV. Leucobryum boninense Sull. & Lesq. 1–12. Leaves (2, 4, 6, 8, 10, 12, expanded). Figs. 1, 2 were drawn from holotype of L. boninense (FH); 3, 4, Furuki and Imura s. n. (Yamaguchi 8828, HIRO); 5, 6, from holotype of L. salmonii (PC); 7, 8, from holotype of L. scaberulum var. divaricatum (BM); 9, 10, from isotype of L. scaberulum (BM); 11, 12, from holotype of L. armatum (H).

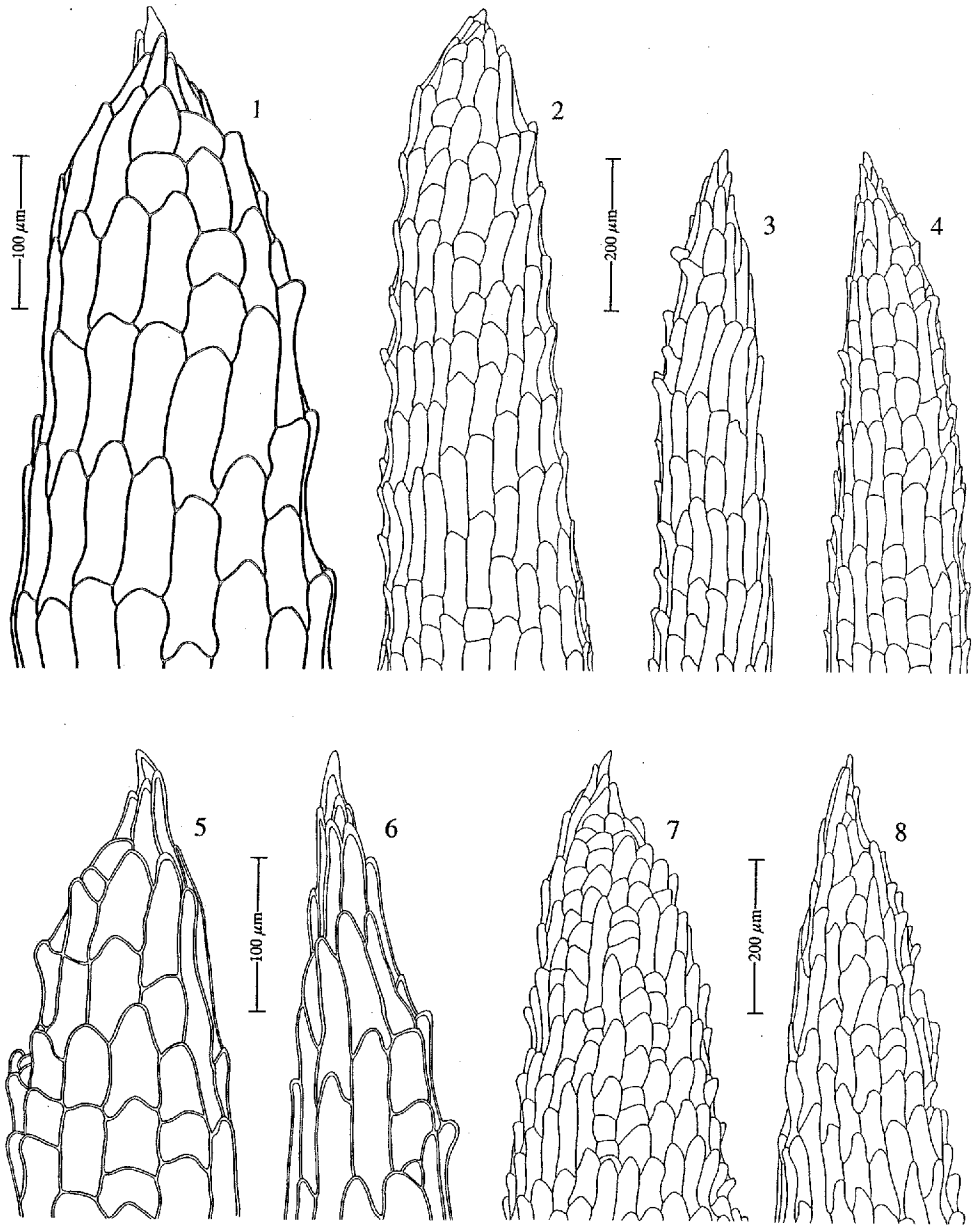

Figure LXXVI. Leucobryum boninense Sull. & Lesq. 1–8. Leaf apices. Figs. 1, 2 were drawn from holotype of L. boninense (FH); 3, from isotype of L. scaberulum (BM); 4, from holotype of L. salmonii (PC); 5, Lai 16511 (HIRO); 6, from holotype of L. scaberulum var. divaricatum (BM); 7, 8, from holotype of L. armatum (H).

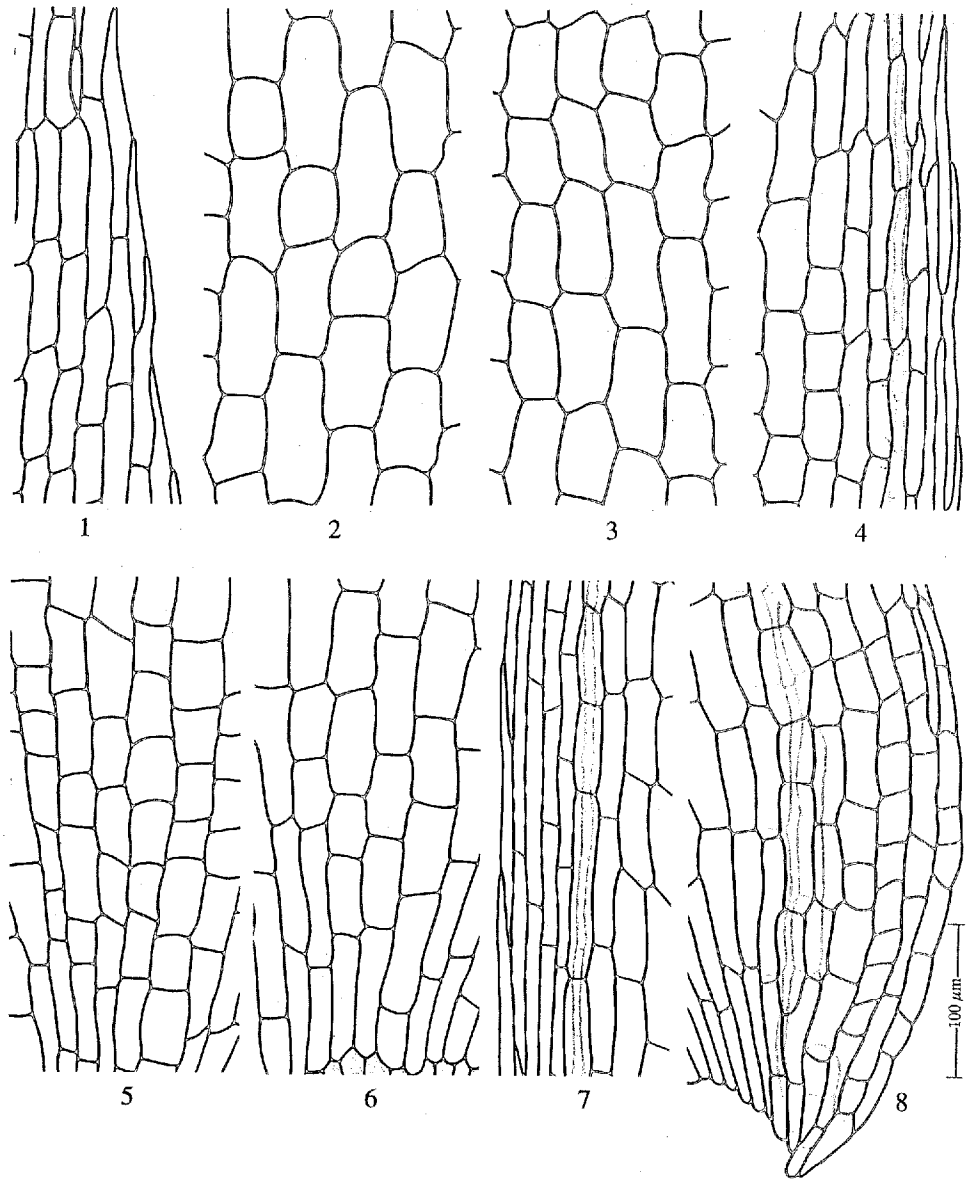

Figure LXXVII. Leucobryum boninense Sull. & Lesq. 1. Cells near leaf apex (adaxial view). 2–4. Median cells of leaf (2, abaxial view; 3, 4, adaxial view). 5–8. Basal cells of leaf (5, abaxial view; 6–8, adaxial view). All figures were drawn from holotype of L. boninense (FH).

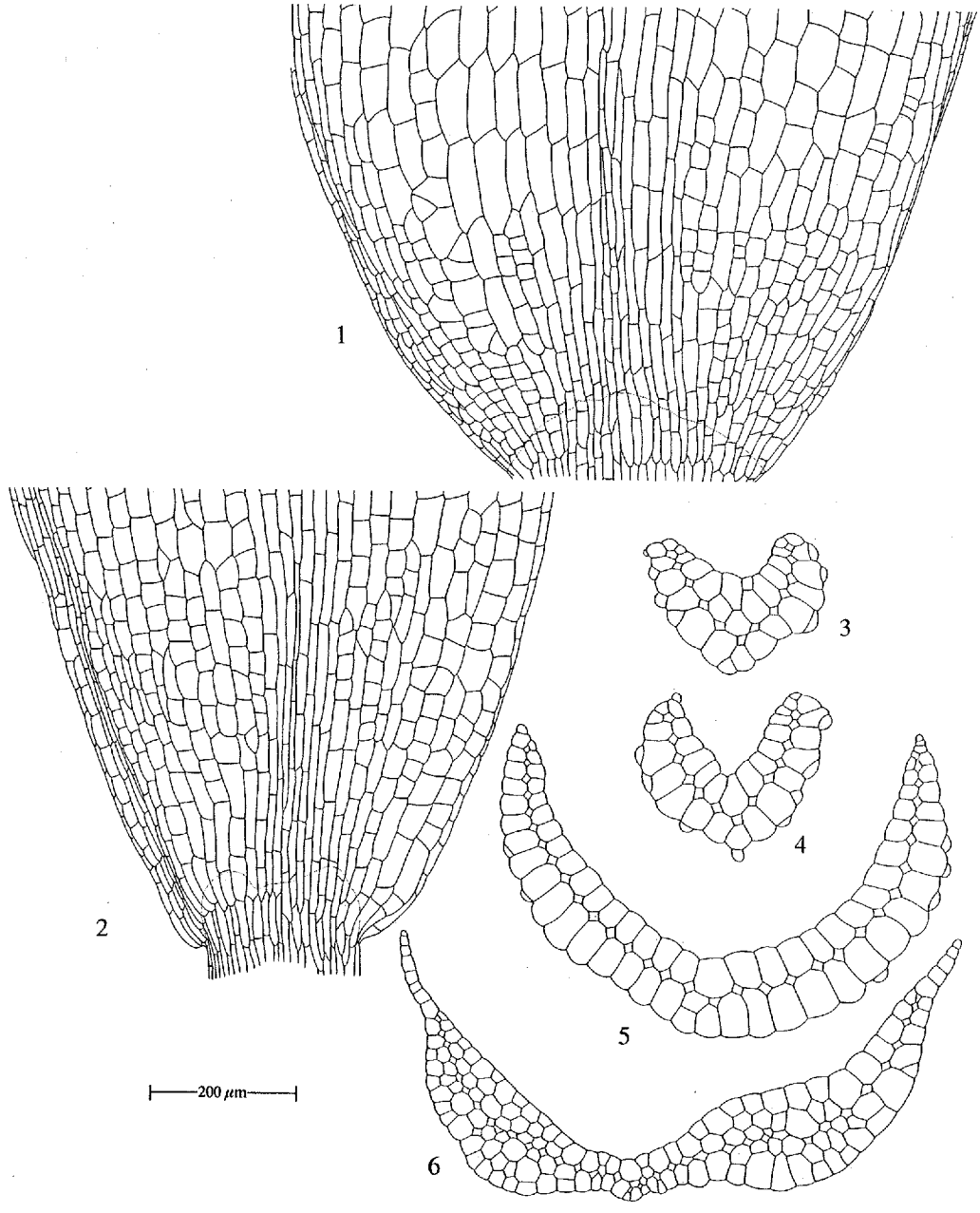

Figure LXXVIII. Leucobryum boninense Sull. & Lesq. 1, 2. Leaf bases (abaxial view). 3–6. Cross-sections of leaf (3, 4, apical; 5, median; 6, basal portions). Figs. 1, 3–6 were drawn from holotype of L. armatum (H); 2, from holotype of L. boninense (FH).

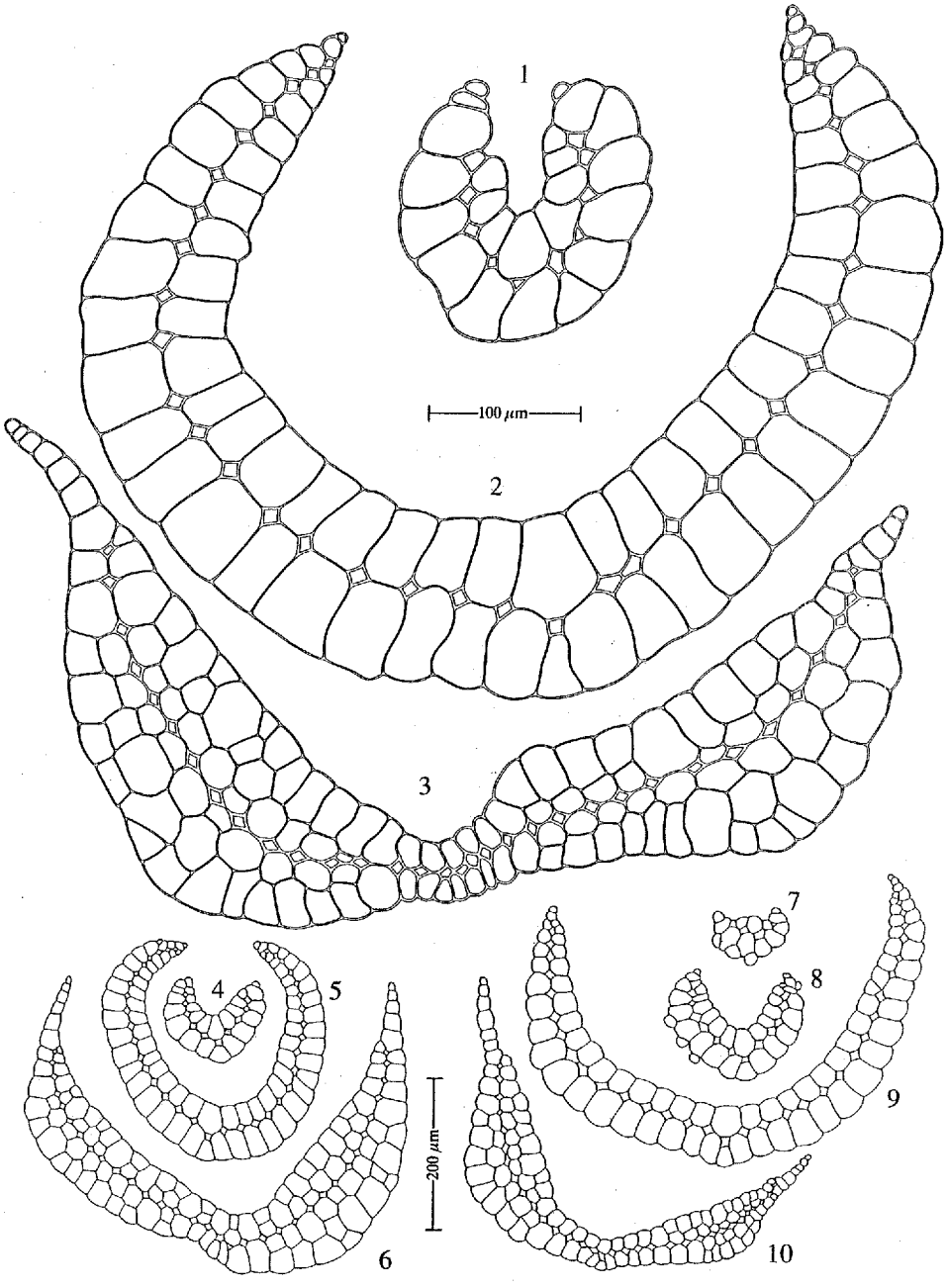

Figure LXXIX. Leucobryum boninense Sull. & Lesq. 1–10. Cross-sections of leaves (1, 4, 7, 8, apical; 2, 5, 9, median; 3, 6, 10, basal portions). Figs. 1–3 were drawn from holotype of L. boninense (FH); 4–6, from holotype of L. salmonii (PC); 7–9, from isotype of L. scaberulum (BM).

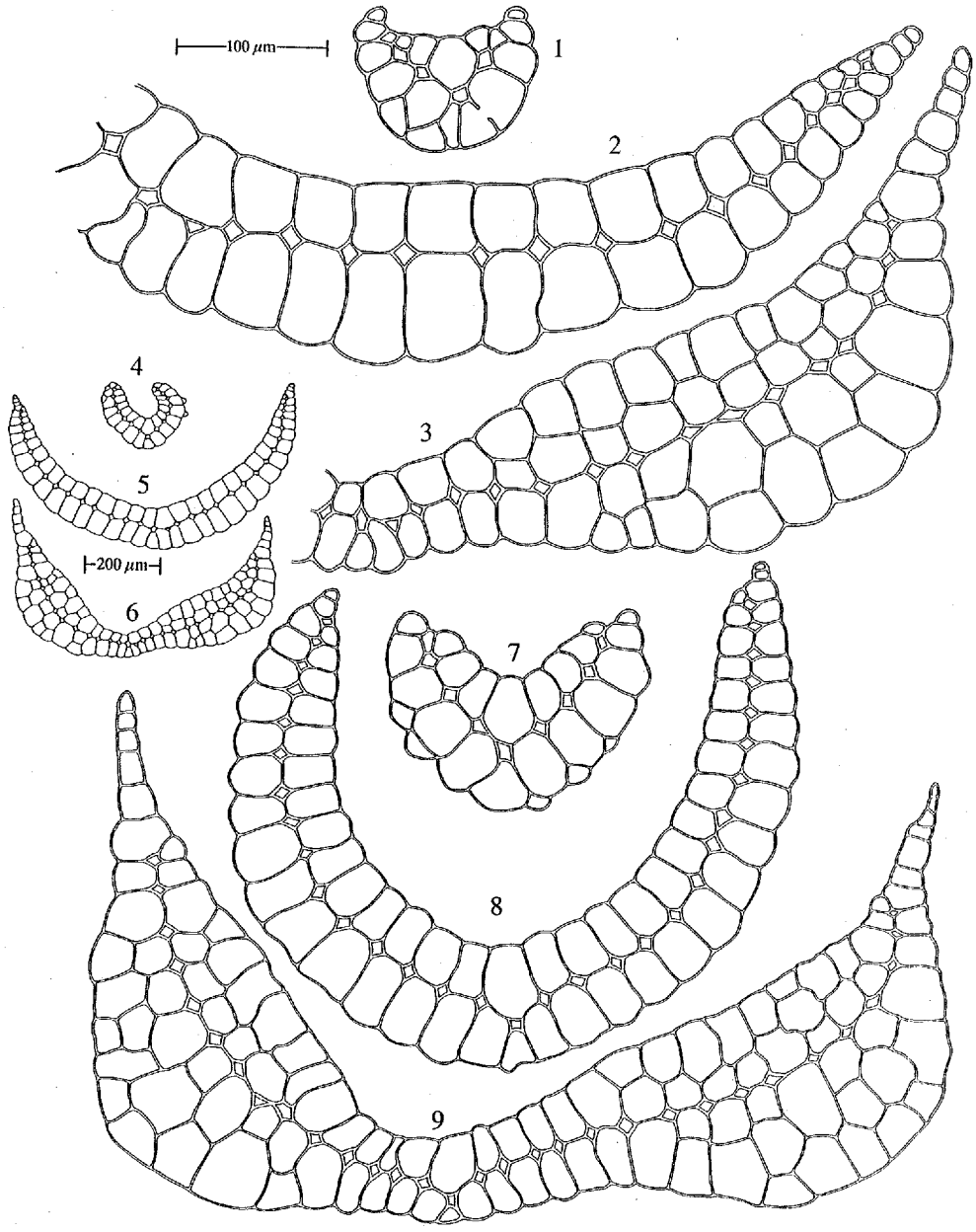

Figure LXXX. Leucobryum boninense Sull. & Lesq. 1–9. Cross-sections of leaves (1, 4, 7, apical; 2, 5, 8, median; 3, 6, 9, basal portions). Figs. 1–6 were drawn from holotype of L. boninense (FH); 7–9, from Lai 16511 (HIRO).

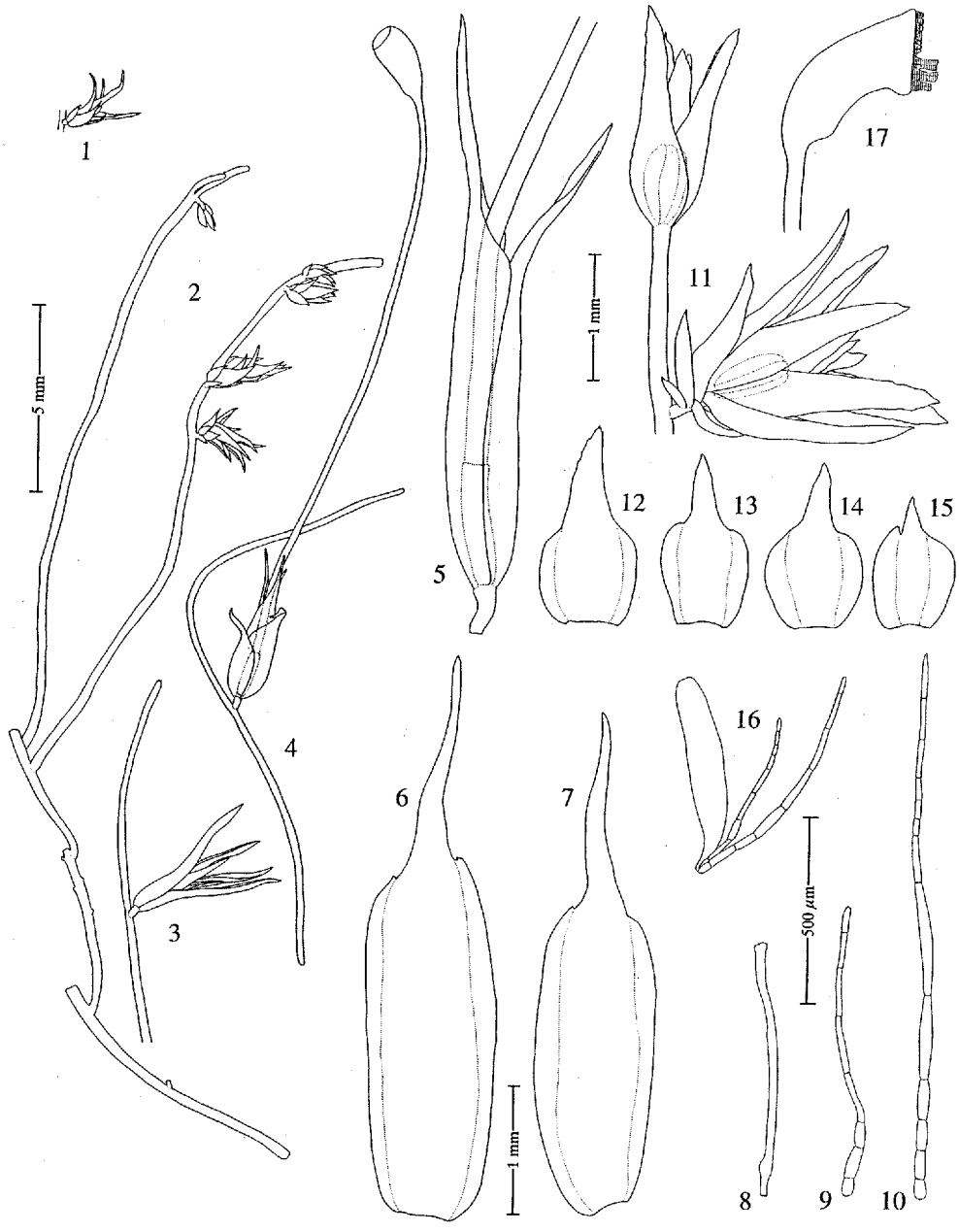

Figure LXXXI. Leucobryum boninense Sull. & Lesq. 1–5. Perichaetia. 6, 7. Inner perichaetial leaves. 8. Archegonium. 9, 10. Paraphyses. 11. perigonia. 12–15. Perigonial leaves [expanded; numbers show the order of perigonial leaves from the innermost leaf (number 15)]. 16. Antheridium. 17. Capsule. Fig. 1 was drawn from holotype of L. salmonii (PC); 2, from holotype of L. armatum (H); 3, from isotype of L. scaberulum (BM); 4, Furuki & Imura s. n. (Yamaguchi 8828, HIRO); 5–17, from holotype of L. boninense (FH).

boulders, 11 Jan. 1930. Herklots s. n. (in herb. Dixon, ref. no. 203) – holotype (BM).

Leucobryum nakaii Hor., Bot. Mag. Tokyo 49: 217. 2 (1935), syn. nov. Type: Japan, Bonin Islands, Hahajima, Mt. Chibusayama, Apr. 1934, Nakai s. n. – holotype (not seen).

Plants whitish green when dry, forming compact tufts or cushions. Stems to 50 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves erect spreading or slightly falcate secund, somewhat arranged in 5 rows; 4.1-7.4 x 0.9-1.4 mm, broadly to narrowly lanceolate, gradually narrowed to subtubulous point from oblong to ovate base, acute to bluntly mucronate, papillosely prorate from the apex to 3/5 of the leaf length on abaxial surface; laminae and borders consisting of 5-8 rows of narrowly rectangular to linear cells near base, the differentiation between laminal cells and border cells indistinct; alar parts consisting of 5-6 rows of quadrate to rectangular cells; in cross-sections near leaf base leucocysts in 2-3 cell layers on both sides; abaxial leucocysts hardly decurrent on stems.

Dioicous. Male plants as large as female plants; perigonia bud-like, terminal on short or elongated lateral branches; dwarf male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes 0.7-1.0 times longer than

ordinary leaves near the perichaetium; archegonia 0.6-0.8 mm long. Setae 15-16 mm long. Capsules inclined, ovoid to ellipsoid; urns 1.3-1.6 mm long, 0.6-0.9 mm wide.

Representative specimens examined: Japan, Bonin Islands, Chichijima Island, Mt. Chuo, Higashi-daira, 230 m alt., 12 July 1985, Imura & Furuki s. n., in herb. Yamaguchi 8828 (HIRO); Ryukyu Islands, Oknawa Island, Yona, 27 Mar. 1986, Nakatsubo s. n. (HIRO). Taiwan, Pingtung Co., Nanjenshan Reserve Area, 300 m alt., 29 Jan. 1985, Lai 16511 (HIRO). China, prov. Szechuan, in monte Go-lo-san prope Chungking, 700 m alt., Apr. 1940, Chen s. n., as Musci Sinici Exsiccati 1: 7 (NICH).

Habitat: On logs and rocks.

Distribution: Japan, Taiwan, China.

The present species is characterized by (1) papillose proration of apical parts of leaves on abaxial surface, and (2) perichaetia terminal on short lateral branches.

Some plants of the present species show weak proration of leucocysts which are restricted to apical part of leaves. Such plants frequently occurs in Japanese and Taiwanese populations. The plants with leaves with weakly prorated abaxial leucocysts are often confused with L. juniperoideum. However, L. juniperoideum is distinguished from L. boninense by (1) the perichaetia usually terminal on main stems, (2) smooth abaxial surface of apical parts of leaves, and (3)

broad laminal parts composed of 5-12 quadrate to rectangular cells and bordered by 2-3 rows of linear cells.

L. scabrum and L. aduncum are related to the present species, but differs in undulate and spinosely prorated leucocysts on abaxial surface of leaves.

Type specimen of L. nakaii collected from Bonin Islands (type locality of L. boninense) seems to be burned during the World War II. According to the original description and illustrations by Horikawa (1935), L. nakaii is identical with the present species, especially by the same character of inner perichaetial leaves smaller than ordinary leaves.

6. Leucobryum juniperoideum (Brid.) C. Müll. (Fig. XXII, XXV: B, XXVII, XXXI, LXXXII-XCIII, CXL: 2)

Linnaea 18: 689 (1845).

Basionym: Dicranum juniperoideum Brid., Bryol. Univ. 1: 409 (1826). Type: Teneriffa (without collector name) – syntype (B).

Leucobryum neilgherrense C. Müll., Bot. Zeit. 12: 556 (1854). Type: India, Neilgher, Perrottet s. n. – holotype (not seen).

Leucobryum holleanum Dozy & Molk., Bryol. Jav. 1: 17, t. 13 (1855). Type: Java, Holle s. n. (Herb. Lugd. Bat. 20. Ind. Or. no. 910.132-1639) – holotype (L).

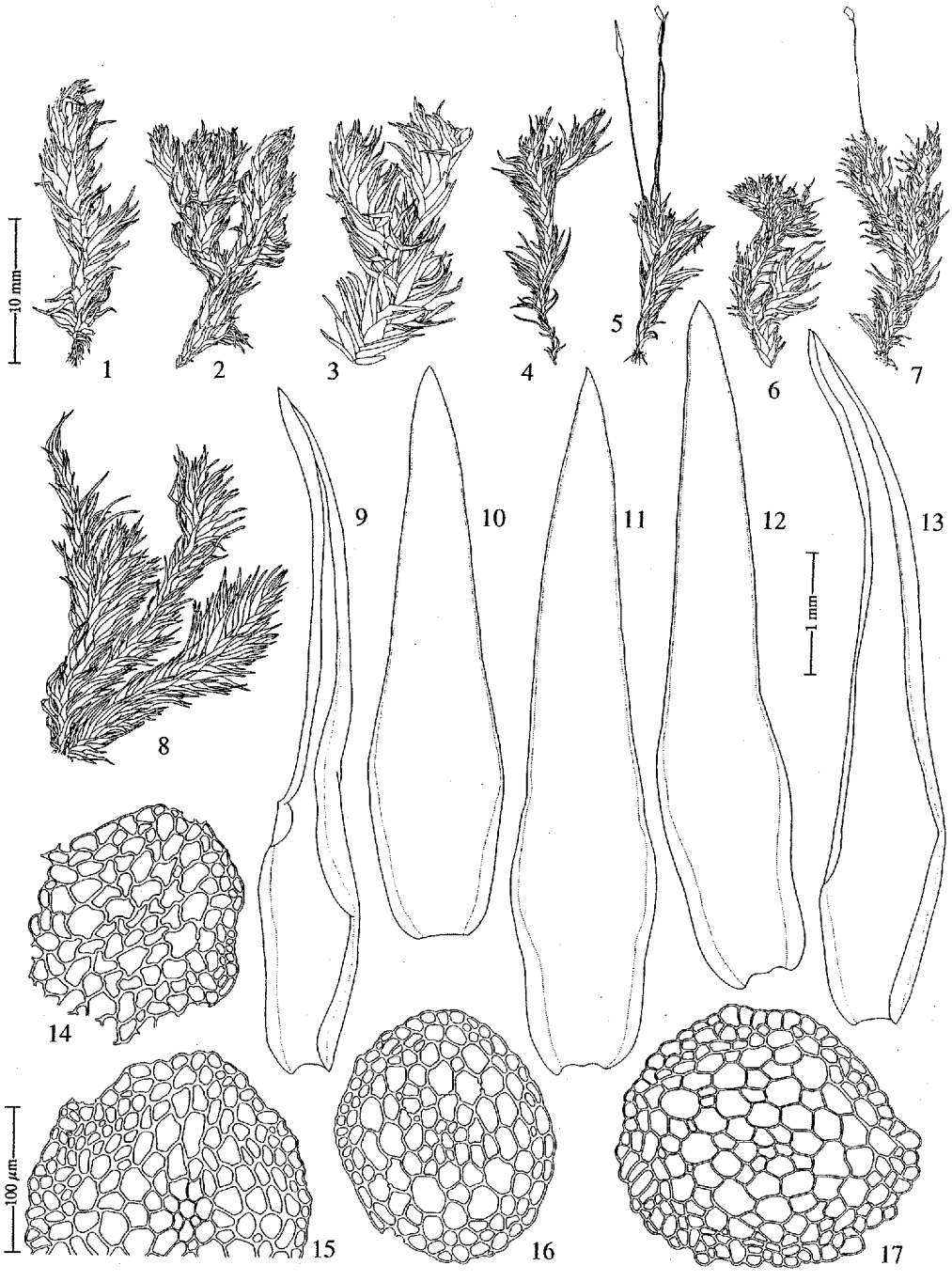

Figure LXXXII. Leucobryum juniperoideum (Brid.) C. Müll. 1–8. Plants (4, 6, male plants). 9–13. Leaves (10–12, expanded). 14–17. Cross-sections of stems. Figs. 1, 9, 10, 17 were drawn from syntype (Teneriffa) of Dicranum juniperoideum (B); 2, 16, from isotype of L. textorii (L); 3, 11, from holotype of L. holleanum var. fragilifolium (FH); 4, 5, 12, 13, 15, from holotype of L. angustissimum (H); 6, 7, from Noguchi 16753 (NICH); 8, 14, from holotype of L. holleanum (L).

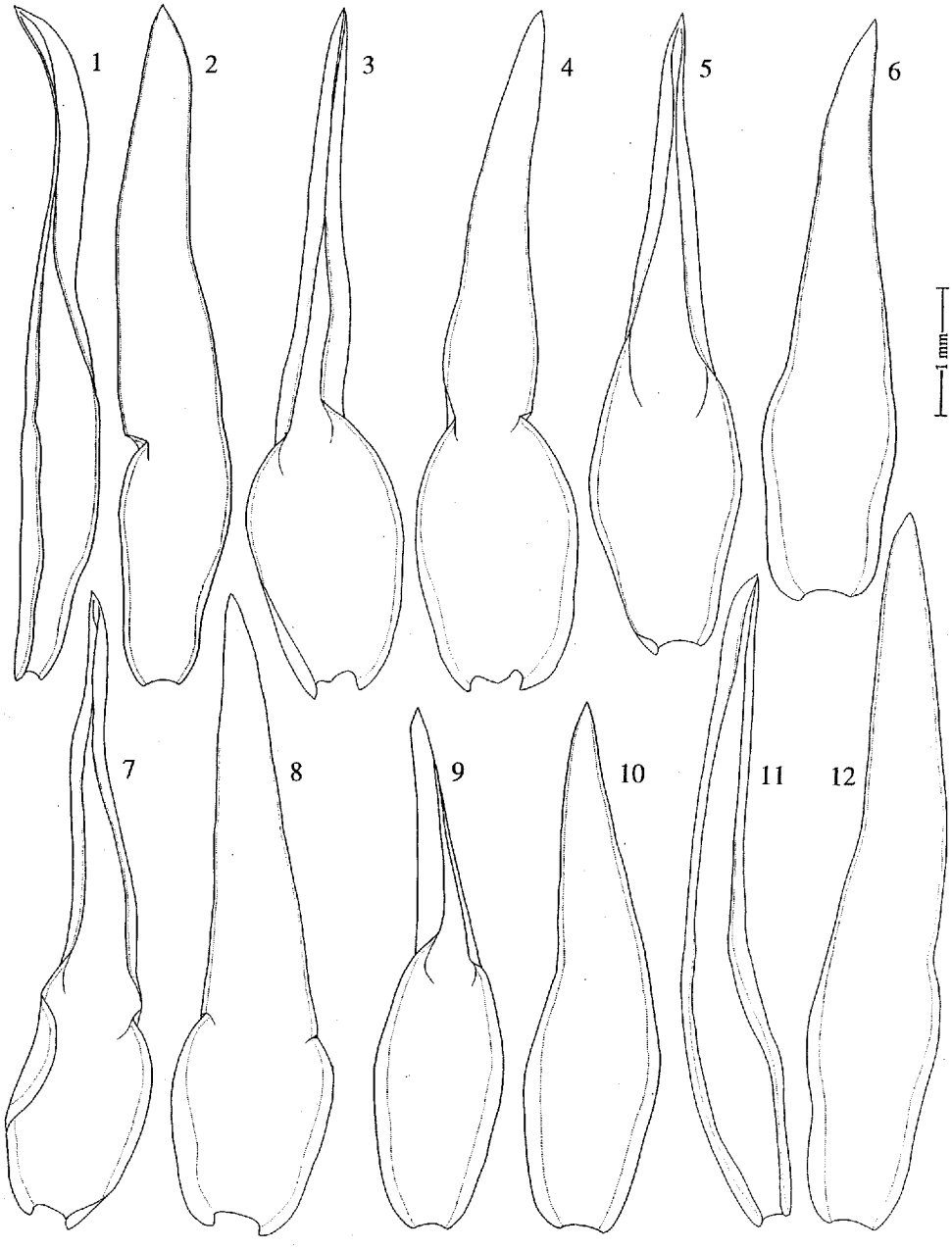

Figure LXXXIII. Leucobryum juniperoideum (Brid.) C. Müll. 1–12. Leaves (2, 4, 6, 8, 10, 12, expanded). Figs. 1, 2 were drawn from holotype of L. retractum (PC); 3, 4, from isotype of L. altiusculum (KYO); 5, 6, from holotype of L. holleanum (L); 7, 8, from isolectotype of L. humile (KYO); 9, 10, from isotype of L. rhizophyllum (MAK); 11, 12, from isotype of L. textorii (L).

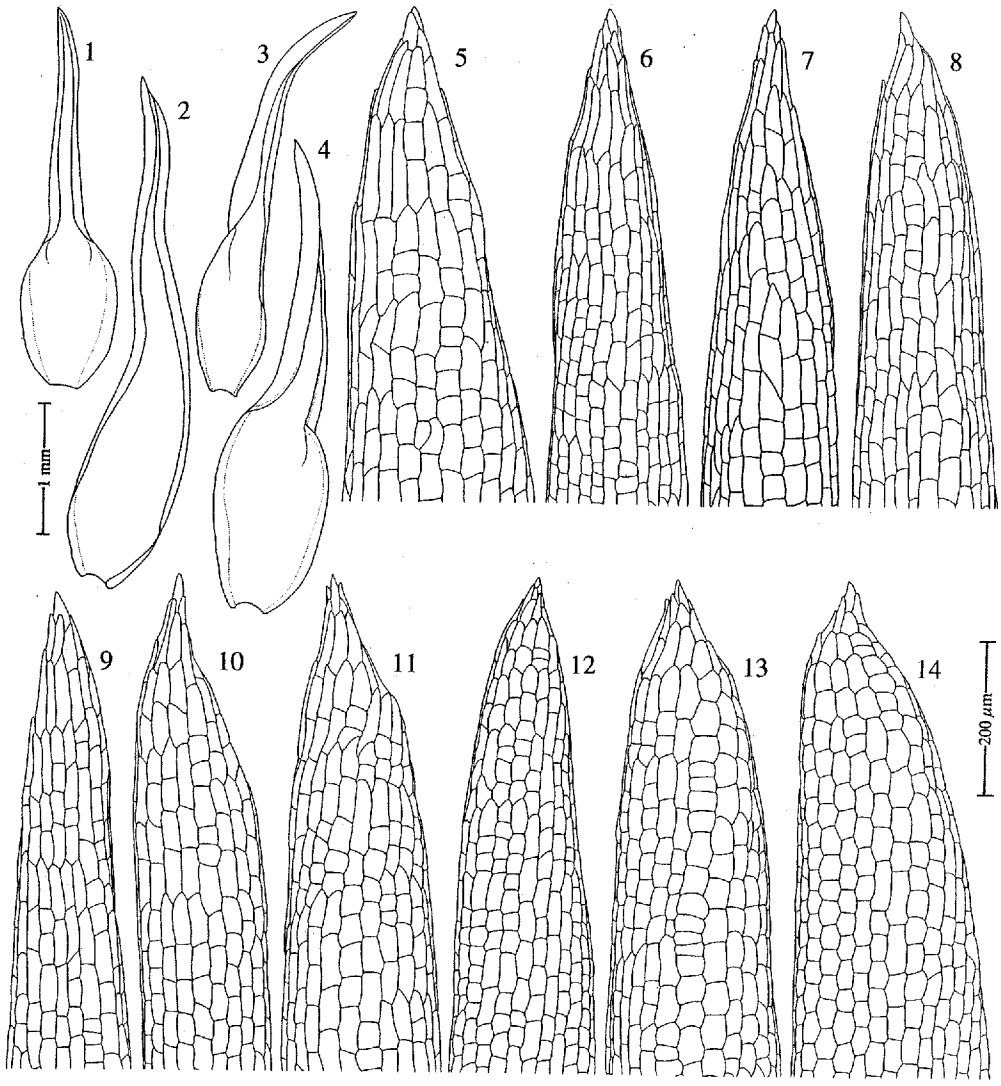

Figure LXXXIV. Leucobryum juniperoideum (Brid.) C. Müll. 1–4. Leaves. 5–14. Leaf apices. Figs. 1, 9 were drawn from isotype of Ochrobryum japonicum (KYO); 2, 6, from isolectotype of L. brevicaule (KYO); 3, from isotype of L. ferriei (BM); 4, 10, from isotype of L. lacteorum (KYO); 5, from syntype (Teneriffa) of Dicranum juniperoideum (B); 7, from holotype of L. holleanum (L); 8, from isotype of L. altiusculum (KYO); 11, from isolectotype of L. humile (KYO); 12, from isotype of L. rhizophyllum (MAK); 13, from isotype of L. textorii (L); 14, from holotype of L. retractum (PC).

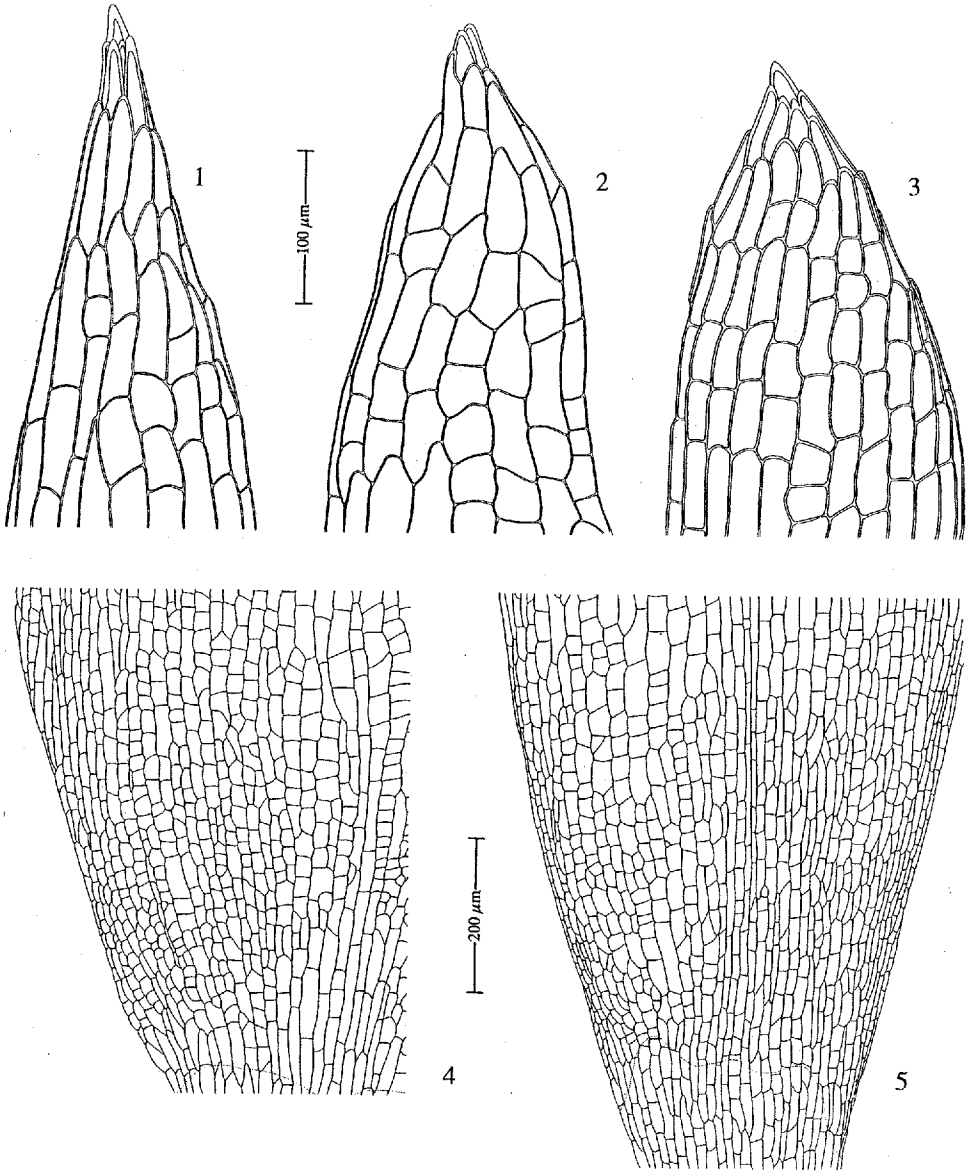

Figure LXXXV. Leucobryum juniperoideum (Brid.) C. Müll. 1–3. Leaf apices. 4, 5. Leaf bases (abaxial view). Fig. 1 was drawn from holotype of L. holleanum (L); 2, from isotype of L. textorii (L); 3, 4, from syntype (Teneriffa) of Dicranum juniperoideum (B); 5, from isotype of L. rhizophyllum (MAK).

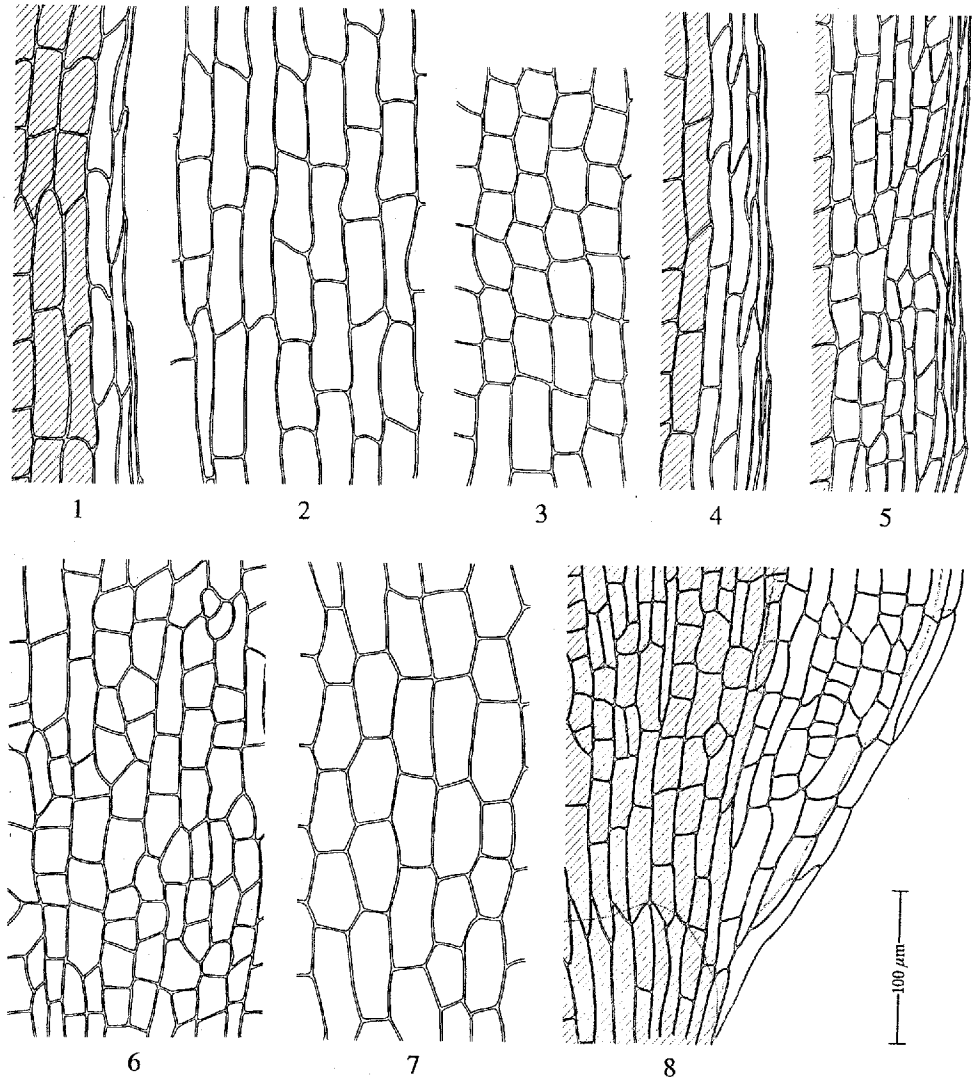

Figure LXXXVI. Leucobryum juniperoideum (Brid.) C. Müll. 1. Cells near leaf apex (abaxial view). 2–4. Median cells of leaf (2, 4, abaxial view; 3, adaxial view). 5–8. Basal cells of leaf (5, 6, 8, abaxial view; 7, adaxial view). All figures were drawn from syntype (Teneriffa) of Dicranum juniperoideum (B).

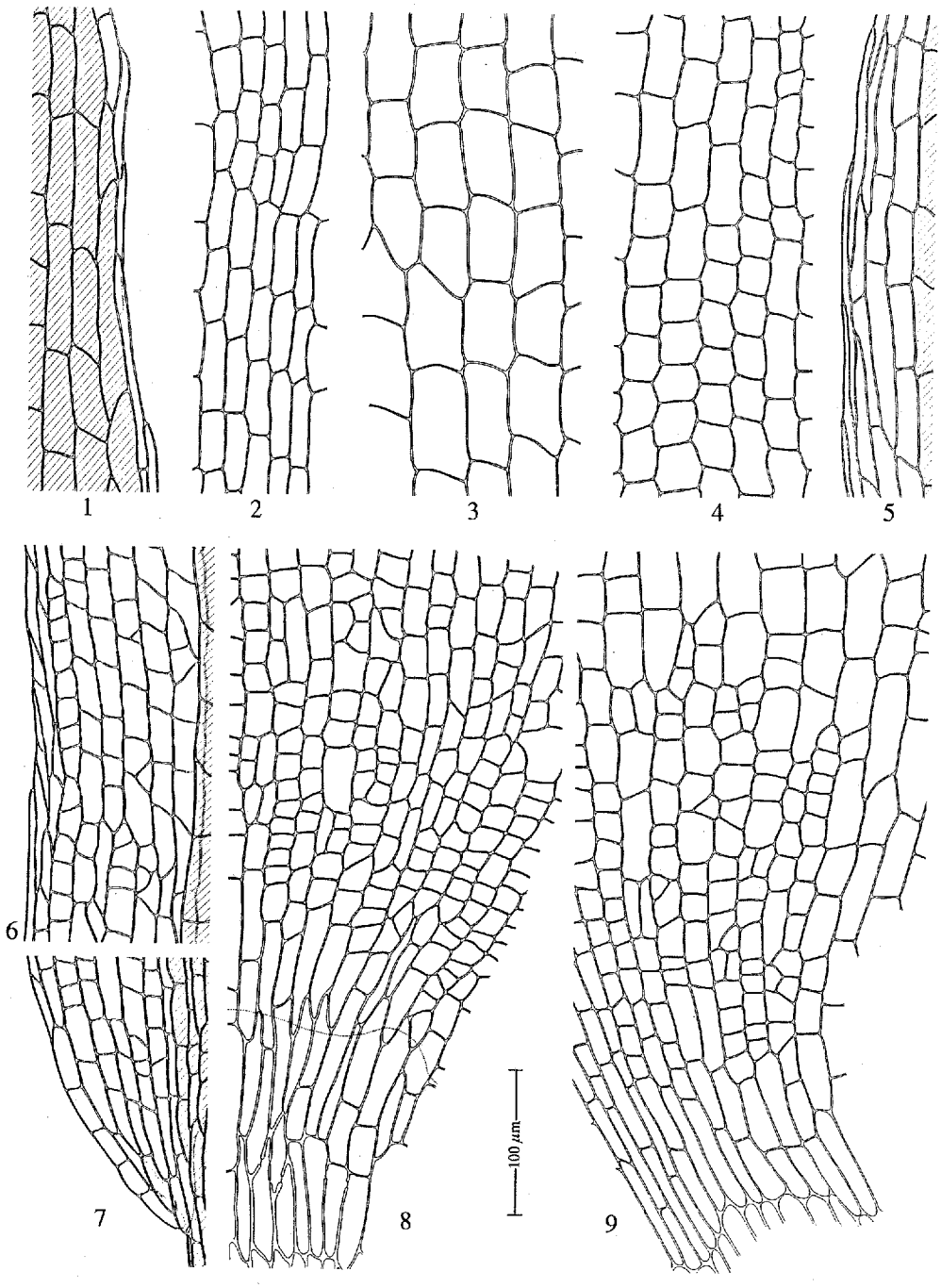

Figure LXXXVII. Leucobryum juniperoideum (Brid.) C. Müll. 1, 2. Cells near leaf apex (1, abaxial view; 2, adaxial view). 3–5. Median cells of leaf (3, 5, abaxial view; 4, adaxial view). 6–9. Basal cells of leaf (6–8, abaxial view; 9, adaxial view). All figures were drawn from holotype of L. holleanum (L).

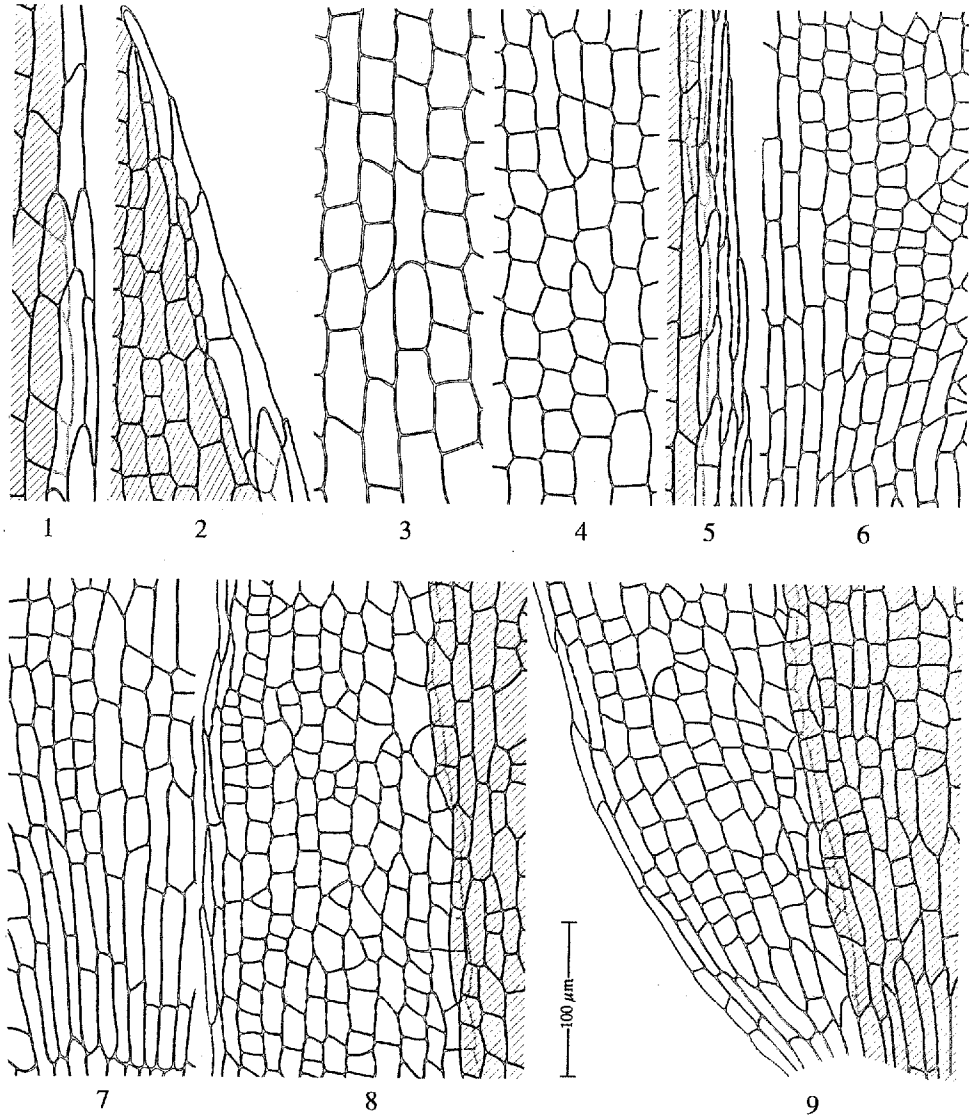

Figure LXXXVIII. Leucobryum juniperoideum (Brid.) C. Müll. 1, 2. Cells near leaf apex (1, abaxial view; 2, adaxial view). 3–5. Median cells of leaf (3, 5, abaxial view; 4, adaxial view). 6–9. Basal cells of leaf (6, 8, 9, abaxial view; 7, adaxial view). All figures were drawn from isotype of L. textorii (L).

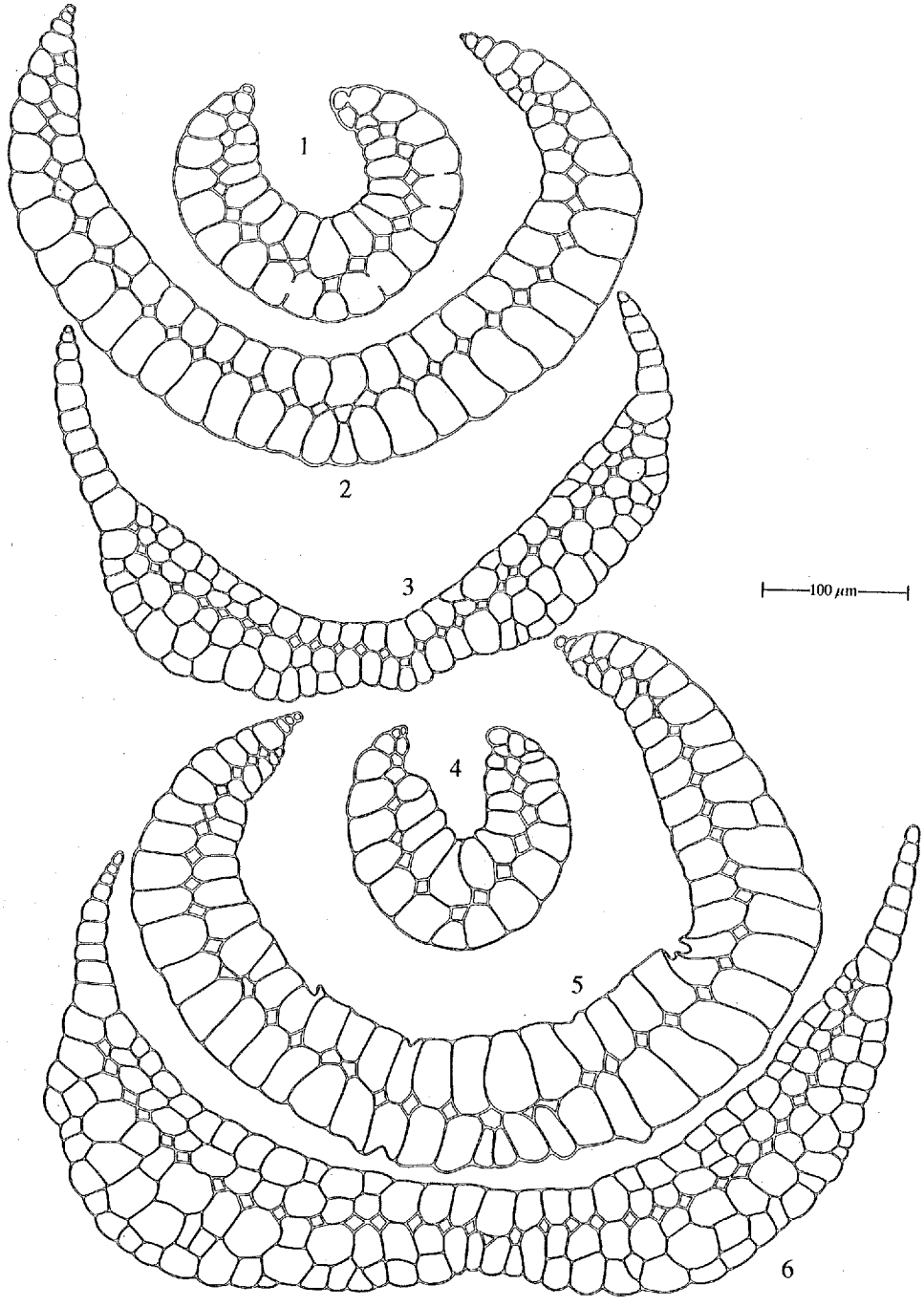

Figure LXXXIX. Leucobryum juniperoideum (Brid.) C. Müll. 1–6. Cross-sections of leaves (1, 4, apical; 2, 5, median; 3, 6, basal portions). Figs. 1–3 were drawn from isotype of L. textorii (L); 4–6, from syntype (Teneriffa) of Dicranum juniperoideum (B).

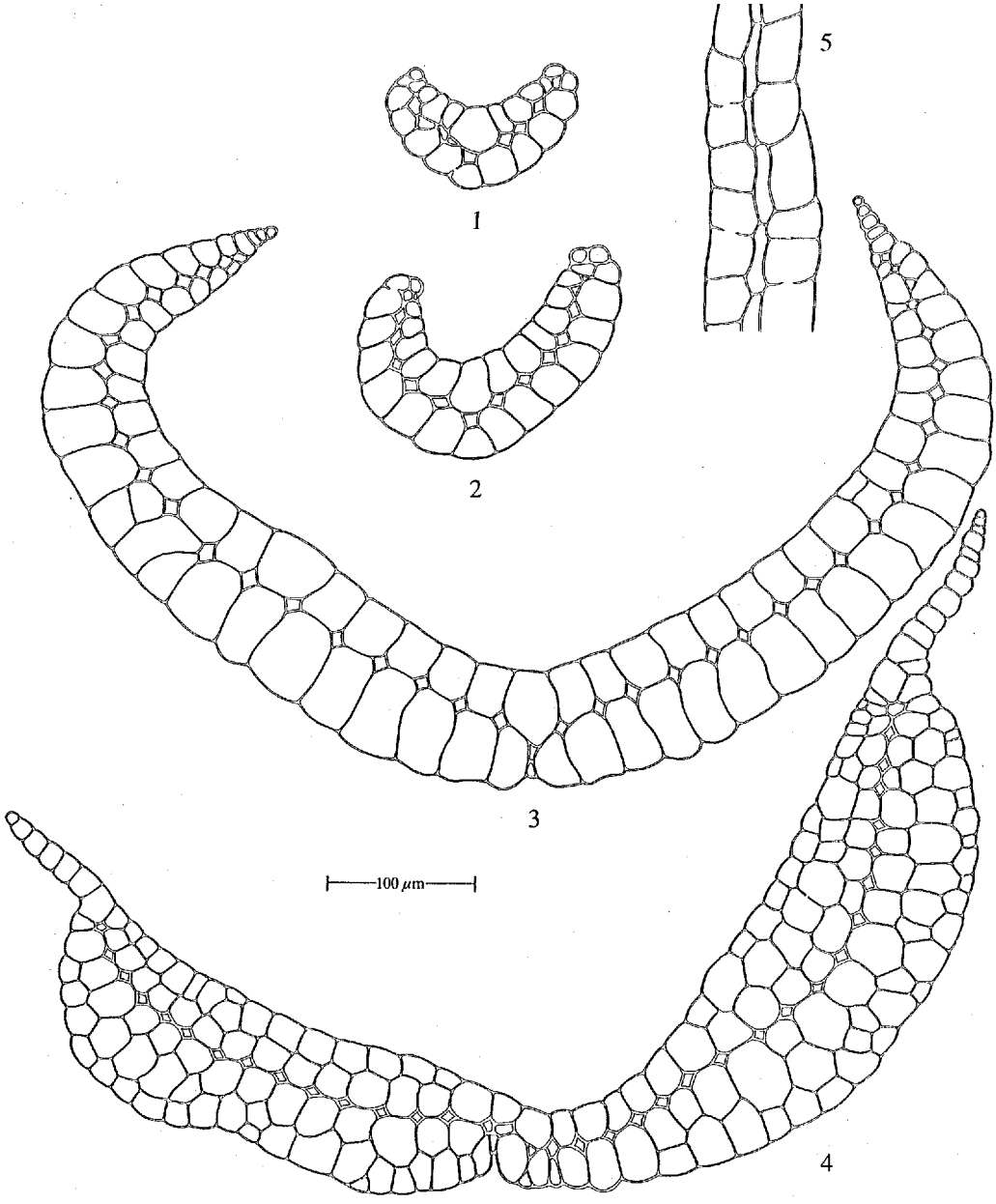

Figure XC. Leucobryum juniperoideum (Brid.) C. Müll. 1–4. Cross-sections of leaf (1, 2, apical; 3, median; 4, basal portions). 5. Longitudinal section of leaf near apex (abaxial side on the right side). All figures were drawn from holotype of L. holleanum (L).

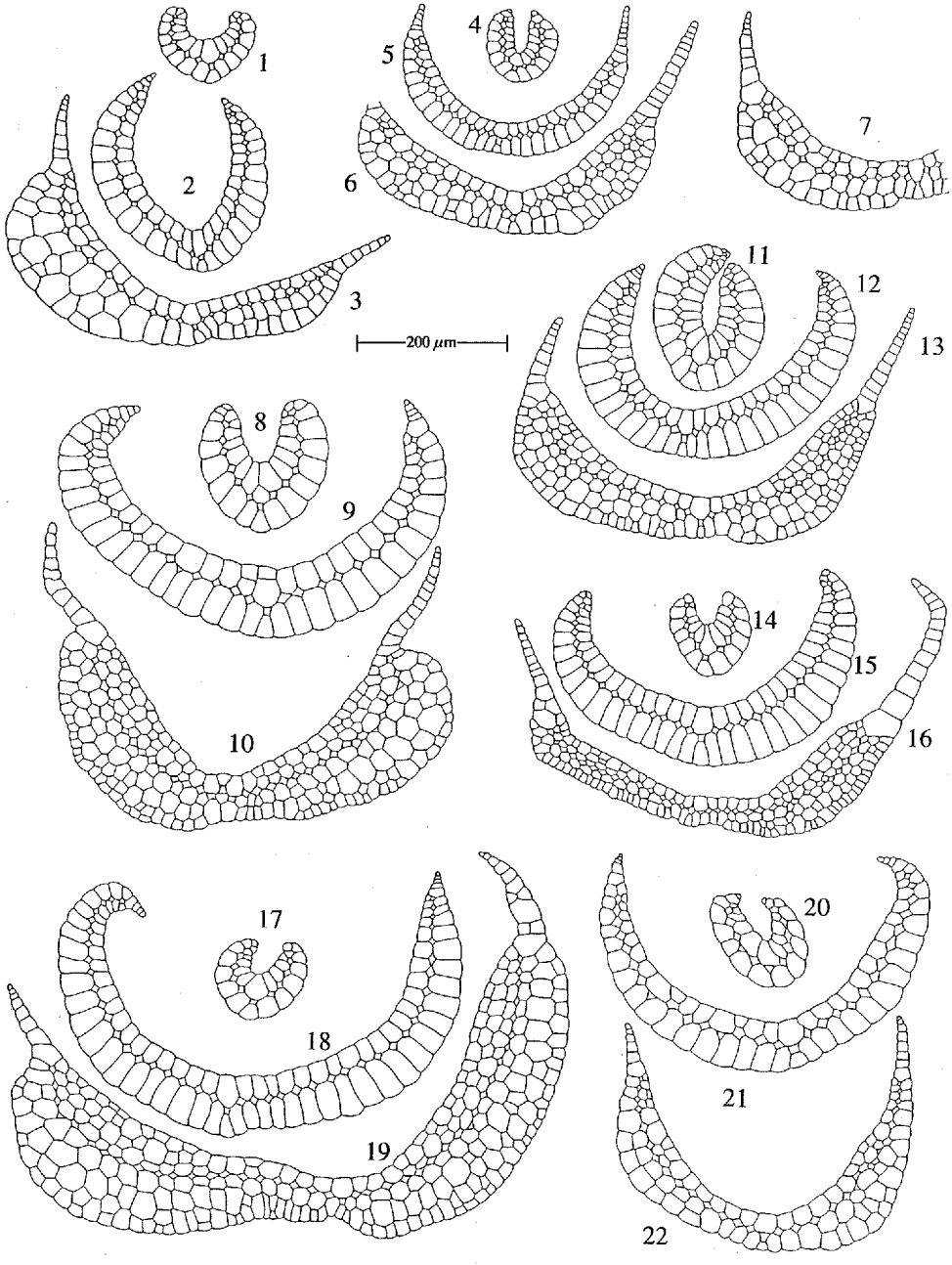

Figure XCI. Leucobryum juniperoideum (Brid.) C. Müll. 1–22. Cross-sections of leaves (1, 4, 8, 11, 14, 17, 20, apical; 2, 5, 9, 12, 15, 18, 21, median; 3, 6, 7, 10, 13, 16, 19, 22, basal portions). Figs. 1–3 were drawn from isotype of L. ferriei (BM); 4–6, from isotype of Ochrobryum japonicum (KYO); 7, from holotype of L. retractum (PC); 8–10, from isolectotype of L. humile (KYO); 11–13, from isotype of L. rhizophyllum (MAK); 14–16, from isolectotype of L. brevicaule (KYO); 17–19, from isotype of L. altiusculum (KYO); 20–22, from isotype of L. lacteorum (KYO).

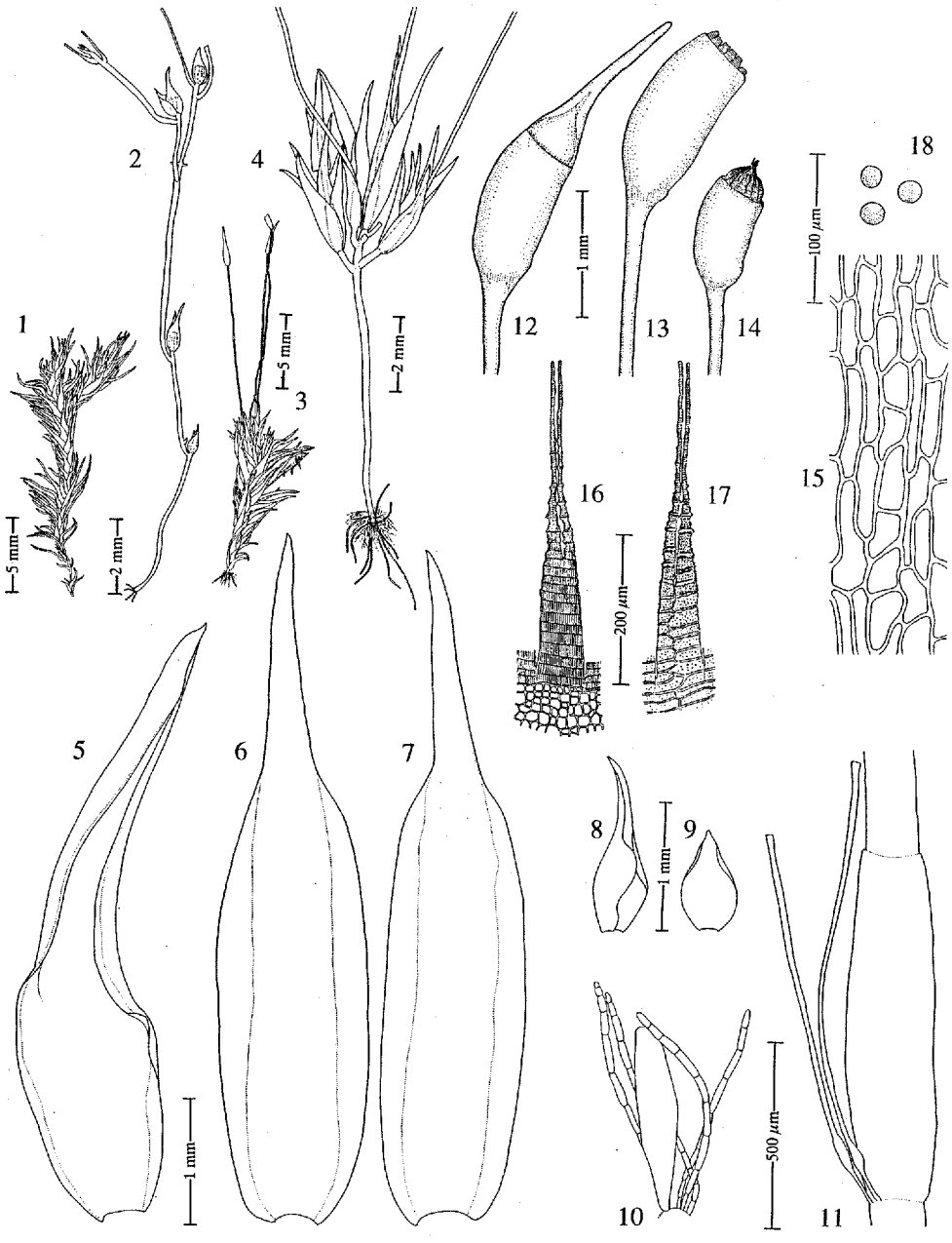

Figure XCII. Leucobryum juniperoideum (Brid.) C. Müll. 1. Male plant. 2. Branching of male plant 1, showing position of perigonia. 3. Female plant. 4. Branching of female plant 3, showing position of perichaetia. 5. Stem leaf. 6, 7. Inner perichaetial leaves (expanded). 8, 9. Inner perigonial leaves. 10. Antheridium. 11. Vaginula and archegonia. 12–14. Capsules. 15. Exothecial cells. 16, 17. Peristome teeth (16, dorsal view; 17, ventral view). 18. Spores. Figs. 1–11 were drawn from holotype of L. angustissimum (H); 12–18. Noguchi 16753 (NICH).

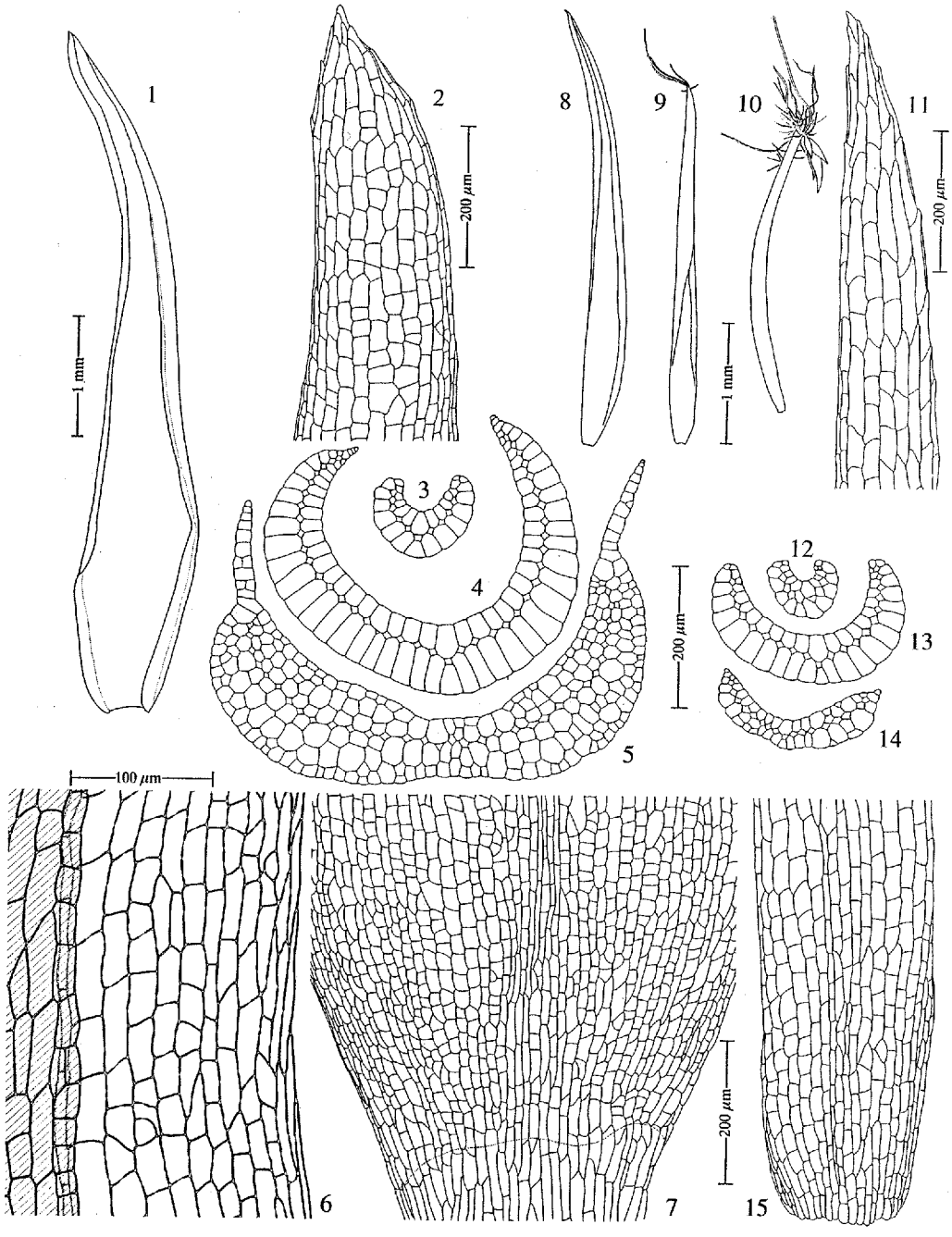

Figure XCIII. Leucobryum juniperoideum (Brid.) C. Müll. 1–7. Ordinary stem leaves. 8–15. Deciduous leaves. 1, 8–10. Leaves (9, with rhizoids; 10, with a bud). 2, 11. Leaf apices. 3–5, 12–15. Cross-sections of leaves (3, 12, apical; 4, 13, median; 5, 14, basal portions). 6. Basal cells of leaf (adaxial view). 7, 15. Leaf bases (abaxial view). All figures were drawn from holotype of L. angustissimum (H).

Leucobryum triviale C. Müll., Linnaea 36: 30 (1869), syn. nov. Type: "E Calcutta forsan ex sikkim habeo. In Khasiya et alibi haud rarum videtur" – syntypes (not seen).

Leucobryum retractum Besch., Ann. Sc. Nat. Bot. sér. 7, 17: 334 (1893), syn. nov. Type: Japan, Yokoska, Savatier 109 – holotype (PC).

Ochrobryum japonicum Besch., J. de Bot. 11: 151 (1897) = Leucobryum japonicum (Besch.) Card. in Broth., Nat. Pfl. 1(3): 346 (1901). Type: Japan, forêt de Mimmaya, 9 July 1894, Faurie 14045 – isotype (KYO).

Leucobryum altiusculum Besch., J. de Bot. 12: 285 (1898). Type: Japan, Kominato, 9 Dec. 1885, Faurie 60 – holotype (PC), isotype (KYO).

Leucobryum brevicaule Besch., J. de Bot. 12: 285 (1898). Type: Japan, cascades d'Osaka, 28 Nov. 1893, Faurie 11289 – isolectotype (KYO).

Leucobryum humile Broth. ex Besch., J. de Bot. 12: 286 (1898). Type: Japan, Mayebara, 7 Nov. 1893, Faurie 11128 – isolectotype (KYO).

Leucobryum lacteorum Besch., J. de Bot. 12: 286 (1898). Type: Japan, Akan, 3 Aug. 1893, Faurie 10745 – isotype (KYO).

Leucobryum textorii Besch., J. de Bot. 12: 288 (1898). Type: Japan, Textor s. n. – holotype (PC).

Leucobryum holleanum var. fragilifolium Fl., Hedwigia 38 (Beibl.): 128 (1899), syn. nov. Type: Java, Tjibodas im Berggarten auf einem gefälltem Bäumstamm in ausgebreiteten Polstern, 1450 m alt., 20 July 1898, Fleischer s. n. (Musci Frond. Archipelagi indici ser. I, no. 6) – holotype (FH), isotype (HIRO).

Leucobryum ferriei Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 28 (1905). Type: Japan, Omura, 15 Jan. 1898, Ferrie s. n. (det. Cardot, no. 155; in herb. Levier) – isotypes (BM, FI).

Leucobryum neilgherrense var. minus Card., Beih. Bot. Centralbl. 19(2): 97 (1905), syn. nov. Type: Taiwan, Taitum, Faurie 50 – holotype (not seen).

Leucobryum rhizophyllum Warnst., Hedwigia 57: 81, f. 17 (1915). Type: Japan, Prov. Idsu, Badeort Yugashima, in schattigen Wäldern an faulenden Baumstämmen am 26. April 1914, Sakurai 567 – isotype (MAK).

Leucobryum angustissimum Broth., Symb. Sin. 4: 28 (1929), syn. nov. Type: China, Hunan, den ganz verwitterten Stirnchnitt eines Cunninghamia-Strunkes im Walde ober Tungdjiapai bei Hsikwangschan im Bezirke Hsinhwa ganz überziehend, wtp. St., 700 m alt., 2 Sept. 1918, Handel-Mazzetti 12597 – holotype (H).

Plants whitish tinged with brown when dry, forming compact cushions or tufts. Stems to 35 mm long with leaves;

central strand not differentiated in cross-sections of stems, but sometimes with weak central area which composed of small cells with colored thin walls. Leaves erect spreading; 2.9-5.7 x 0.6-1.3 mm, lanceolate, acute to bluntly mucronate, gradually narrowed to subtubulous point from oblong to ovate base, smooth on abaxial surface, weakly scabrous at tips due to minutely projected leucocysts; laminae consisting of 5-12 rows of quadrate to rectangular cells near base, bordered by 2-3 rows of linear cells, laminae consisting of 2-3 rows of rectangular cells extended beyond mid leaf; in cross-sections near leaf base leucocysts in 2-4 cell layers on adaxial side and 3-4 cell layers on abaxial side at the thickest part, the central parts hollowed, consisting of 2 layered leucocysts, the thickest parts 1.8-3.0 times thicker than the central parts; abaxial leucocysts hardly decurrent on stems.

Dioicous. Male plants dimorphous; dwarf male plants small, usually growing on tomentum enclosed by perichaetial leaves, or detached from perichaetia and epiphytic on stem leaves of female plants; normal male plants as large as female plants, independent, perigonia small, usually terminal on stems and subfloral innovations. Perichaetia terminal on stems and subfloral innovations; inner perichaetial leaves around mature sporophytes 1.0-1.8 times longer than ordinary leaves near the perichaetia; archegonia

1.2-1.6 mm long. Setae 5-17 mm long. Capsules inclined, ovoid to ellipsoid; urns 0.8-1.5 mm long, 0.5-0.8 mm wide. Apices of peristome teeth divided to the middle, ca.0.45 mm long, ca. 0.07 mm wide at base. Spores 15-16 μm in diameter.

Representative specimens examined: Russia, Far East, the southern part, the bay Plastum, 4 Oct. 1974, Bardunov s. n. (NICH 352366). Japan, Honshu, Koya, 26 Nov. 1893, Faurie 11267 – isoparatype of L. brevicaule (KYO); Kyushu, Nagasaki, Mar. 1895, Faurie 15292 – isoparatype of L. humillimum (KYO): Kyushu, Unzen, 5 Mar. 1895, Faurie 15336 – isoparatype (KYO); Kyushu, Nagasaki, 9 Mar. 1895, Faurie 15450 – isoparatype of L. humillimum (KYO); Honshu, Mie-ken, Minamimuro-gun, Kiho-cho, Onodani, 70 m alt., 26 Dec. 1965, Nakajima s. n., in herb. Noguchi 16753 (NICH); Honshu, Hiroshima-ken, Hiba-gun, Shimoyukawa, Mt. Shitomi, 760 m alt., 30 Aug. 1980, Une 3545 (HIRO); Honshu, Hiroshima-ken, Saeki-gun, Yuki-cho / Yoshiwa-mura, Iwaidani Valley, 500-600 m alt., 24 Aug. 1976, Iwatsuki 12012 (NICH); Textor s. n., labeled as Leucobryum glaucum ß minus C. Müll. (L). Korea, Mt. Soyo, 200-300 m alt., 18 Oct. 1959, Hong 1365 (HIRO). Taiwan, Nantou-hsien, Luku-hsiang, Chitou, 1100-1400 m alt., 30 May 1984, Yamaguchi et al. 6573 (HIRO). China, Western Hubei Province, Metasequoia Region of Lichuan Xian (Hsien), Vicinity of Hongwanxi on the E side of the valley, 30°10'N,

108°45'E, 1100-1350 m alt., 7 Oct. 1980, 1980 Sino-Amer. Exped. no. 2074 (HIRO). India, Madras State, Madura District, Palni Hills, Kodaikanal and surrounding region, Shembaganur, 1923, Foreau s. n. (L). Sri Lanka, Nuwara District, Hakgala Gardens and hakgala Forest, 19 Feb. 1978, Ruinard 19/116 (L). Sumatra, Brastagi-Tonkkeh, summit of Delangsikut, 1500 m alt., 19 June 1952, Wijk 1617 (L). Java, Prov. Preanger, in Cinchoneto "Daradjat" prope Garut, 1730 m alt., 12 Feb. 1894, Shiffner 10336 (L). New Guinea, div. Hollandia, Baliem, Wiligimaeu, 1600 m alt., 29 June 1961, Versleegh s. n. mixed with 12562BW (L).

Habitat: On soil, rocks and tree trunks.

Distribution: Europe, Macaronesia, Madagascar, Turkey, Caucasus, Japan, Korea, Taiwan, China, Himalaya, India, Sri Lanka, Myanmar, Tahiland, Philippines, Borneo, Sulawesi, Sumatra, Java, New Guinea.

The present species is characterized by (1) abaxially smooth leaf apices, (2) broad laminae which consist of 5-12 rows of quadrate to rectangular cells near base and bordered by 2-3 rows of linear cells, and (3) perichaetia terminal on stems and subfloral innovations.

In L. juniperoideum the central area of stems are sometimes weakly differentiated as a group of small cells, but the walls of the central small cells are more or less tinged with brown and different from the central strand such

as that of L. humillimum. L. humillimum is closely related to the present species, but differs in having the distinct central strand of stems which is composed of hyaline and thin-walled cells, and distinctly mucronate leaf apices.

L. glaucum is also closely related to the present species, but differs in having indistinctly hollowed central parts in cross-sections of leaf bases, which are composed of (2-) 3-4 layered of leucocysts.

I could not locate type specimens of L. triviale and L. neilgherrense var. minus. L. triviale were treated as synonym of L. neilgherrense by Renauld and Cardot (1905). According to the detailed original description of L. triviale by Müller (1869), it seems to be identical with L. juniperoideum. Original description of L. neilgherrense var. minus by Cardot (1905) was very brief and only showed smaller sized plants compared with L. neilgherrense, I consider that L. neilgherrense var. minus is also identical with the present species based on the diagnostic characters mentioned by Cardot (1905).

7. Leucobryum humillimum Card. (Fig. XXXIV, XCIV-C, CXLI: 2)

Mem. Soc. Nat. Cherbourg 32: 15, f. 29 (1901).

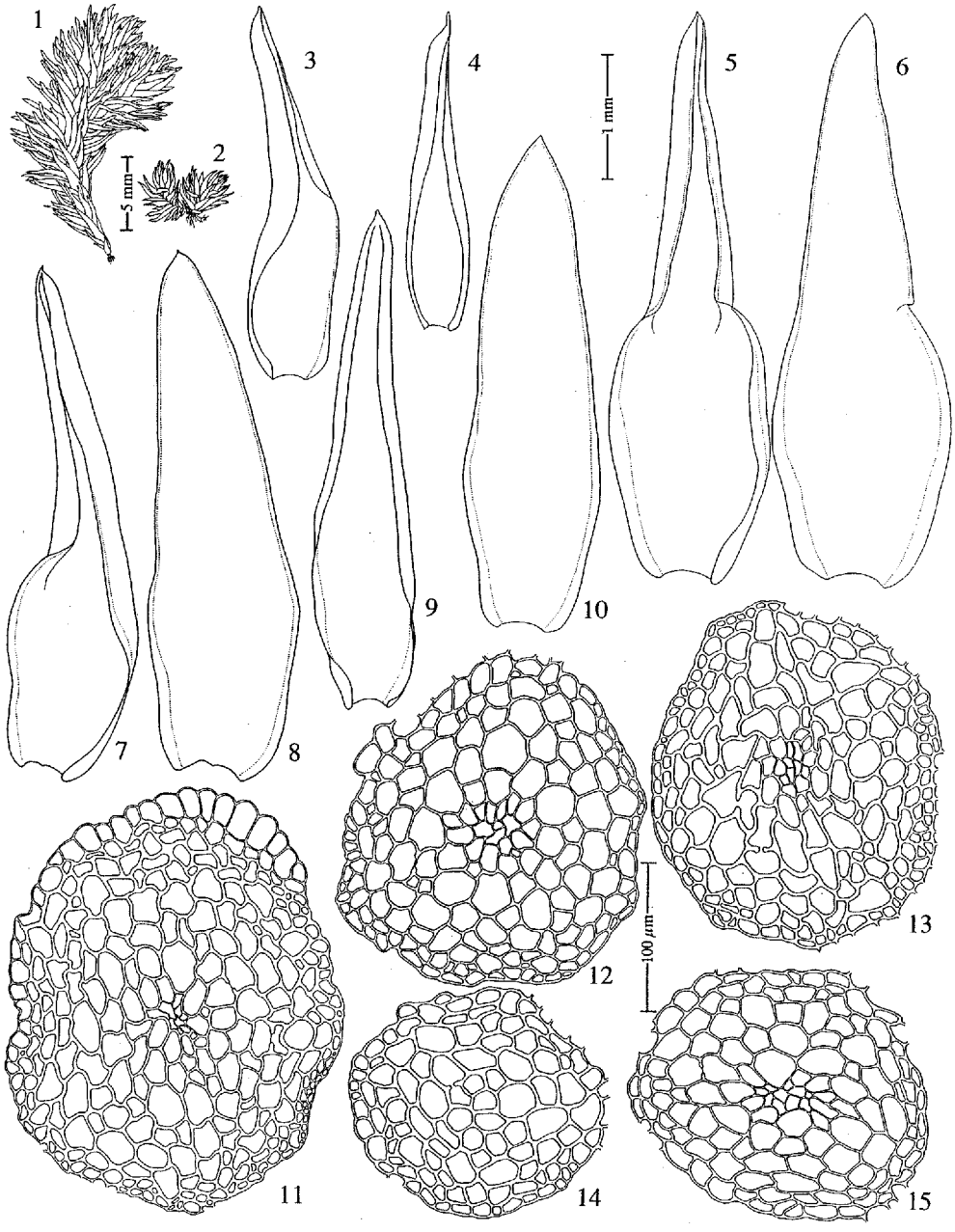

Figure XCIV. Leucobryum humillimum Card. 1, 2. Plants. 3–10. Leaves (6, 8, 10, expanded). 11–15. Cross-sections of stems. Fig. 1 was drawn from isotype of L. galeatum (KYO); 2–4, 15, from Thwaites 82 labeled as Schistomitrium cucullatum (NY); 5, 6, 11, from isosyntype (Faurie 11245) of L. wichurae (KYO); 7, 8, from lectotype of L. cucullifolium (PC); 9, 10, 12, from isotype of L. galeatum (BM); 13, from hb. Cardot 105, determinated as L. mittenii by Bescherelle (PC); 14, from isotype of L. mittenii (BM).

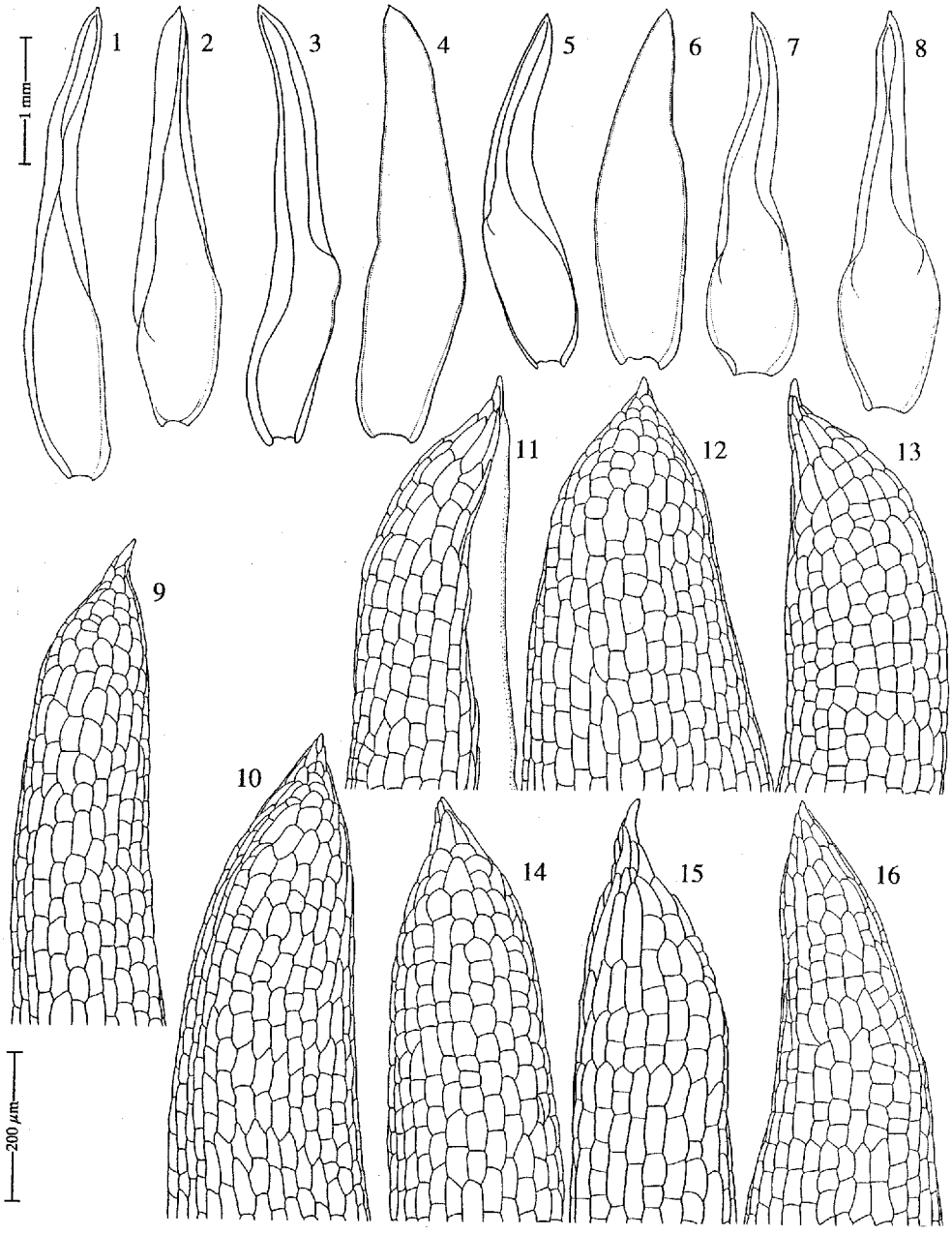

Figure XCV. Leucobryum humillimum Card. 1–8. Leaves (4, 6, expanded). 9–16. Leaf apices (11, 13, lateral view). Figs. 1, 2, 11, 14 were drawn from isotype of L. mittenii (BM); 3–6, 9, 10, from holotype of Ochrobryum wightii (PC); 7, 8, 15, from hb. Cardot 105, determinated as L. mittenii by Bescherelle (PC); 12, from lectotype of L. cucullifolium (PC); 13, from isotype of L. galeatum (BM); 16, from isosyntype (Faurie 11245) of L. wichurae (KYO).

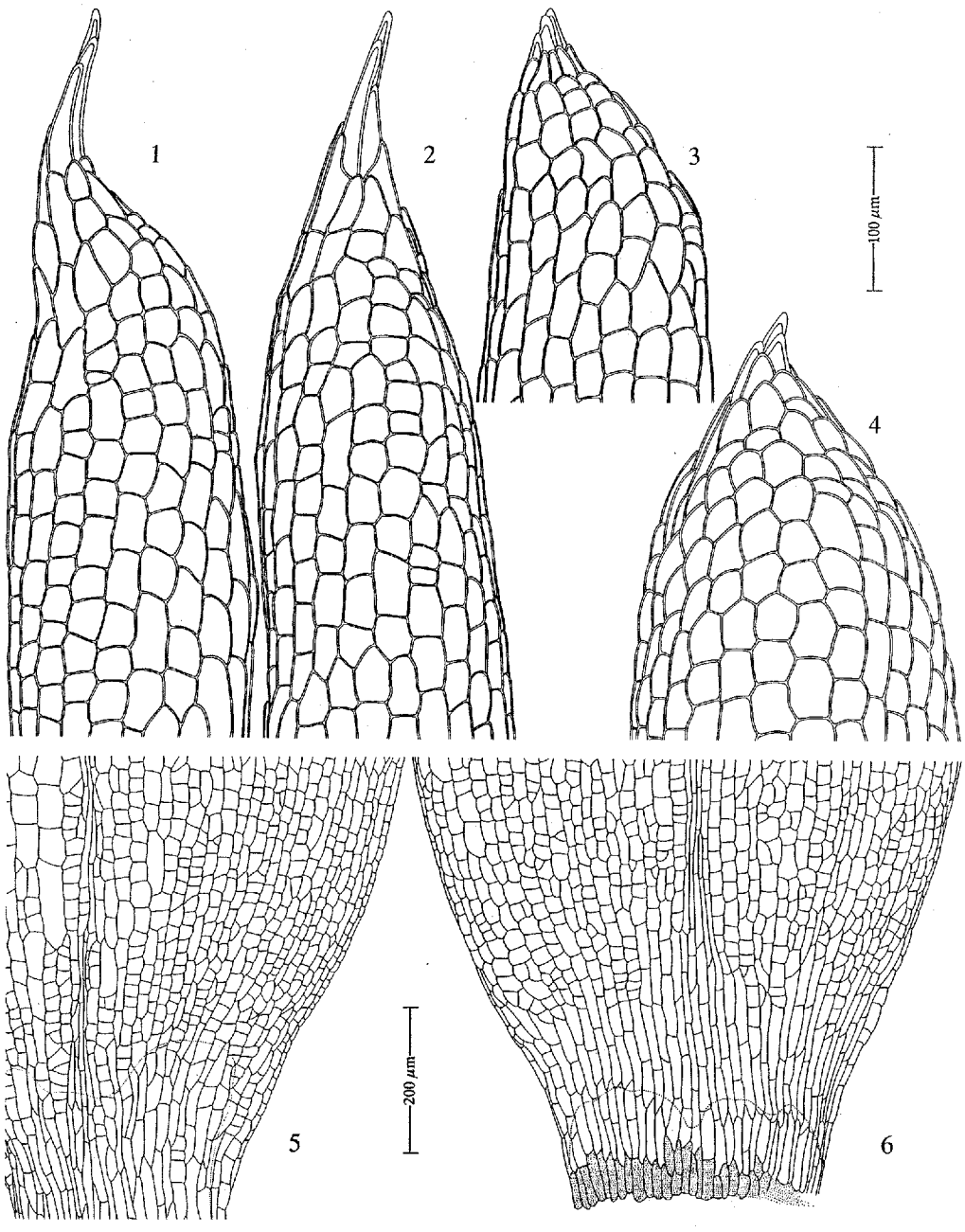

Figure XCVI. Leucobryum humillimum Card. 1–4. Leaf apices (1, 3, lateral view). 5, 6. Leaf bases (abaxial view). Figs. 1–3 were drawn from Thwaites 82 labeled as Schistomitrium cucullatum (NY); 4, from isotype of L. galeatum (BM); 5, from isosyntype (Faurie 11245) of L. wichurae (KYO); 6, from lectotype of L. cucullifolium (PC).

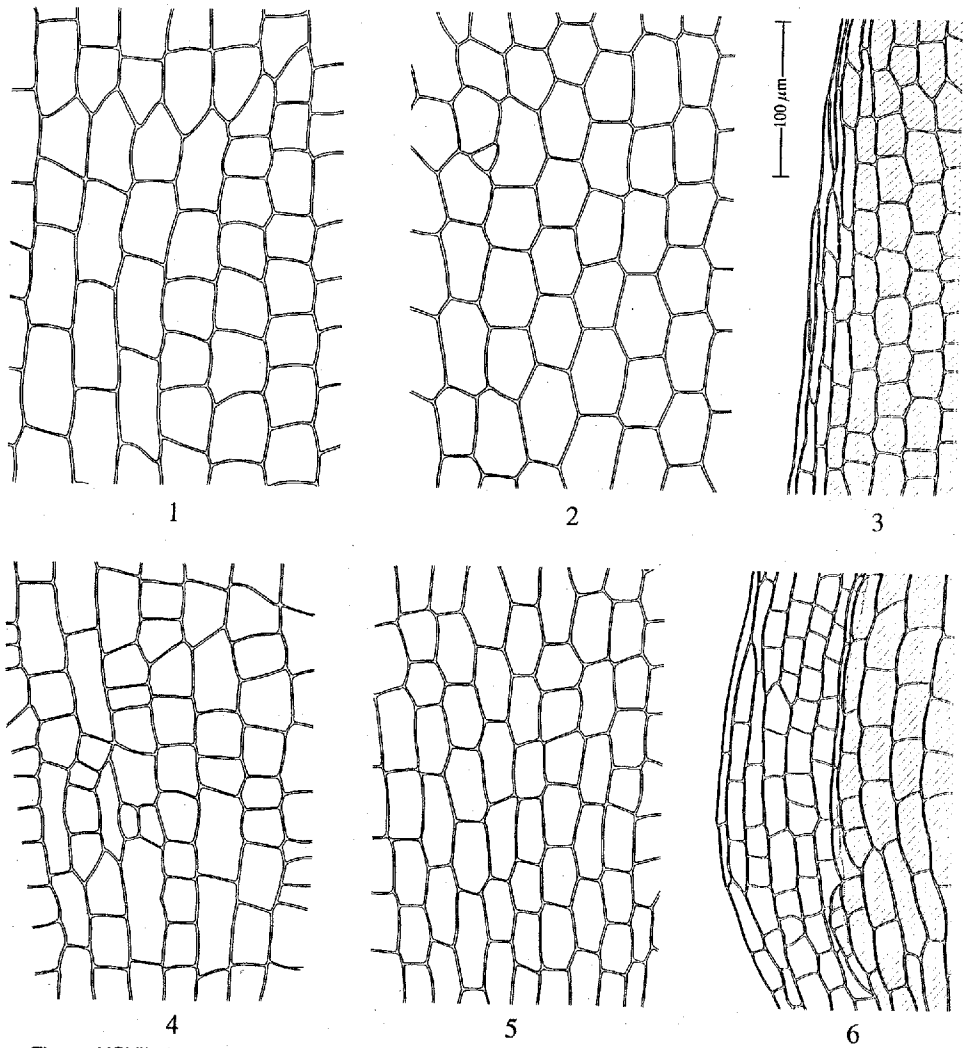

Figure XCVII. Leucobryum humillimum Card. 1–3. Median cells of leaf (1, 3, abaxial view; 2, adaxial view). 4–6. Basal cells of leaf (4, 6, abaxial view; 5, adaxial view). All figures were drawn from Thwaites 82 labeled as Schistomitrium cucullatum (NY).

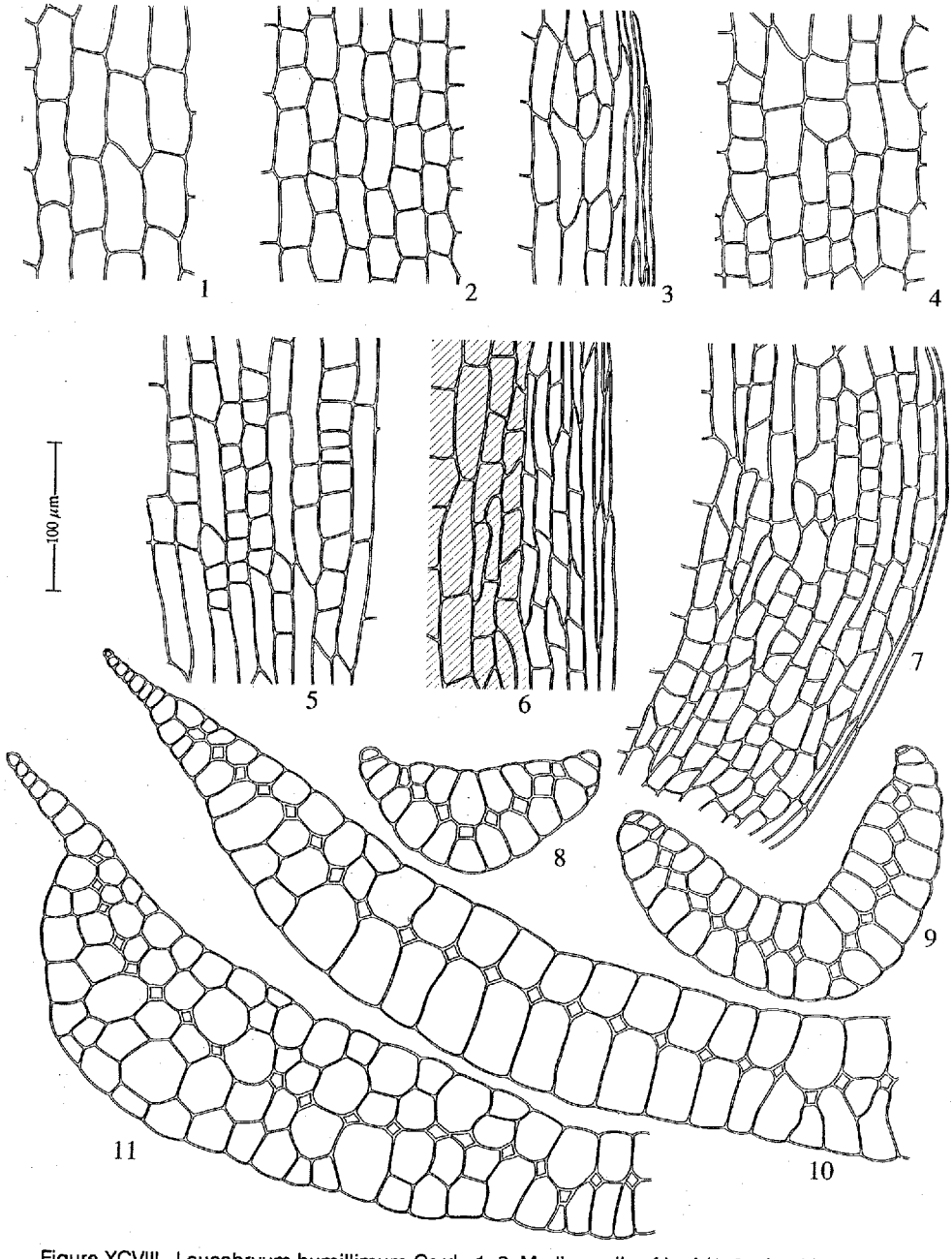

Figure XCVIII. Leucobryum humillimum Card. 1–3. Median cells of leaf (1, 3, abaxial view; 2, adaxial view). 4–7. Basal cells of leaf (4, 6, 7, abaxial view; 5, adaxial view). 8–11. Cross-sections of leaf (8, 9, apical; 10, median; 11, basal portions). All figures were drawn from isotype of L. galeatum (BM).

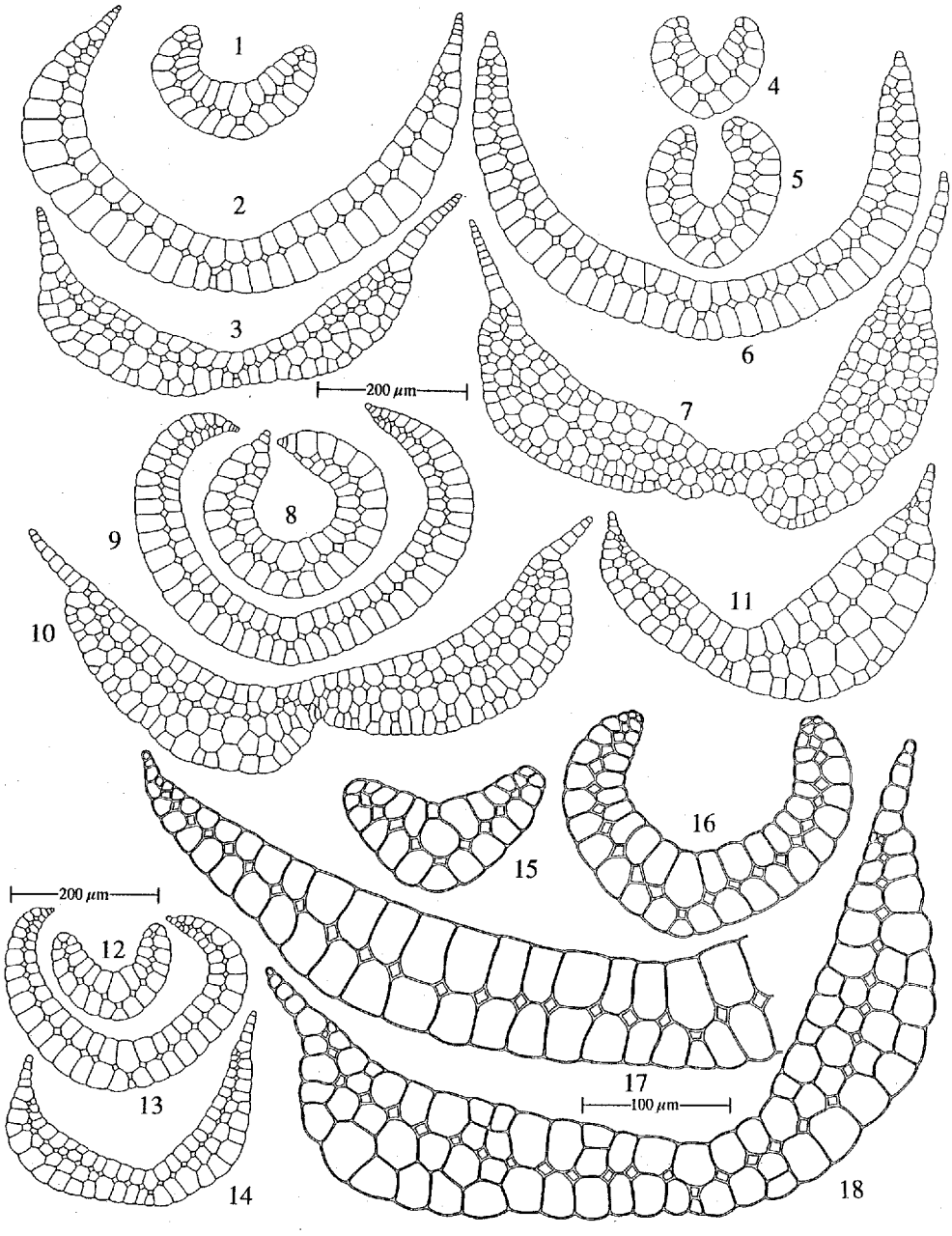

Figure XCIX. Leucobryum humillimum Card. 1–18. Cross-sections of leaves (1, 4, 5, 8, 12, 15, 16, apical; 2, 6, 9, 13, 17, median; 3, 7, 10, 11, 14, 18, basal portions). Figs. 1–3 were drawn from isotype of L. mittenii (BM); 4–7, from isosyntype (Faurie 11245) of L. wichurae (KYO); 8–10, from lectotype of L. cucullifolium (PC); 11–14, from holotype of Ochrobryum wightii (PC); 15–18, from Thwaites 82 labeled as Schistomitrium cucullatum (NY).

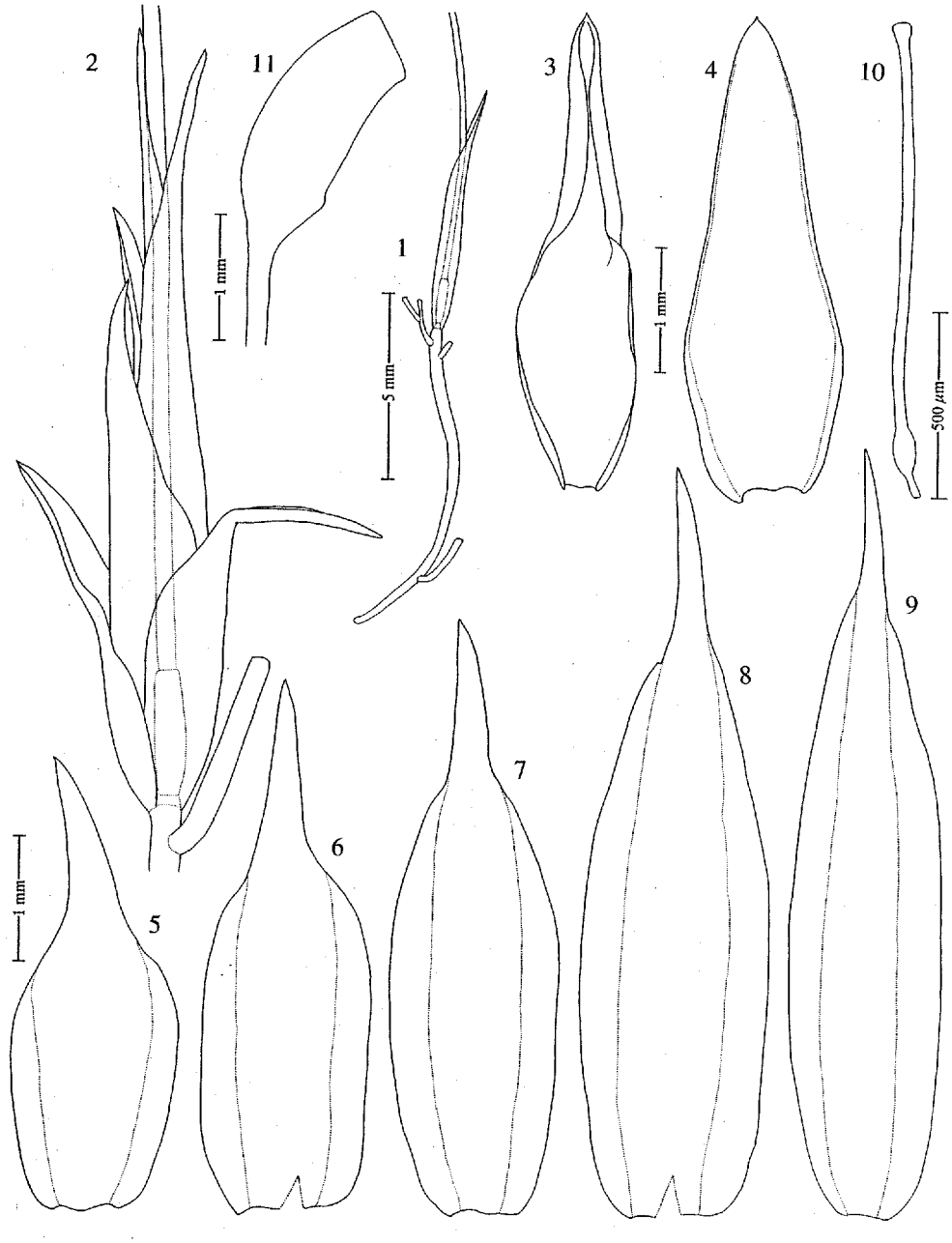

Figure C. Leucobryum humillimum Card. 1, 2. Perichaetia. 3, 4. Stem leaves near perichaetium 1 (4, expanded). 5–9. Perichaetial leaves from perichaetium 1 [expanded; numbers show the order of perichaetial leaves from the innermost leaf (number 9)]. 10. Archegonium. 11. Capsule. All figures were drawn from Nishimura 1514 (HIRO).

Basionym: Ochrobryum wightii Besch., J. de Bot. 11: 149, f. 6 (1897). Type: India, Madras, Wight s. n. – holotype (PC).

Leucobryum galeatum Besch., J. de Bot. 12: 286 (1898) = Leucobryum neilgherrense var. galeatum (Besch.) Dix., Hong Kong Natural. Suppl. 2: 7 (1933), syn. nov. Type: China, Hongkong, 19 Mar. 1895, Faurie 15472 – isotypes (BM, KYO).

Leucobryum mittenii Besch., J. de Bot. 12: 287 (1898), syn. nov. Type: India, Mt. Khasia, Hooker and Thomson et Thomson 1247 – isotype (BM).

Leucobryum wichurae Broth. ex Besch., J. de Bot. 12: 288 (1898), syn. nov. Type: Japan, Kochi, 22 Nov. 1893, Faurie 11245 – isosyntype (KYO).

Leucobryum cuculliphyllum Fl., Musci Fl. Buitenzorg 1: 152 (1904), syn. nov. Type: Sri Lanka, bei Wattescalle an morscher Rinde, 900-1200 m alt., Feb. 1898, Fleischer s. n. (Musci Frond. Archipelagi Indici ser. VI, no. 259) – isotype (HIRO).

Leucobryum cucullifolium Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 30 (1905), syn. nov. Type: India, Sikkim-Himalaya, prope Kurseong, Punkabari, 16 Dec. 1899, Decoly and Schaul s. n. (in herb. Levier) – lectotype (PC).

Ochrobryum propaguliferum Dix., Not. R. Bot. Gard. Edinburgh 19: 281, f. 1 (1938) = Leucobryum propaguliferum (Dix.) Robinson, Bryologist 68: 91 (1965), syn. nov. Type:

Sri Lanka, base of Hunasgiriya, under rock, 29 Sept. 1928, Alston 1895 – holotype (BM).

Plants whitish tinged with brown when dry, forming compact cushions. Stems to 30 mm long with leaves; central strand well differentiated in cross-sections of stems, composed of small, hyaline and thin-walled cells. Leaves imbricate to erect spreading; 2.7-4.5 x 0.7-1.5 mm, broadly lanceolate or oblong, distinctly mucronate at apex, sometimes with a spinous apical cell, gradually narrowed to subtubulous point from oblong to ovate base, smooth on abaxial surface; apical cells nearly quadrate on abaxial surface; laminae consisting of 4-8 rows of quadrate to rectangular cells near base, bordered by 2-3 rows of linear cells; in cross-sections near leaf base leucocysts in 2-3 cell layers on both sides; abaxial leucocysts hardly decurrent on stems.

Dioicous. Male plants dimorphous; dwarf male plants small, usually growing on tomentum enclosed by perichaetial leaves; normal male plants as large as female plants, perigonia small, terminal on stems of subfloral innovations. Perichaetia terminal on main stems or subfloral innovations; inner perichaetial leaves around mature sporophytes 1.4-1.6 times longer than ordinary leaves near the perichaetia; archegonia ca. 1.3 mm long. Setae 7-10 mm long. Capsules

inclined, ovoid to ellipsoid; urns 0.7-1.3 mm long, 0.4-0.6 mm wide.

Representative specimens examined: Japan, Honshu, Hiroshima-ken, Ootake-shi, a valley of north of Arashitaniyama, 180-250 m alt., 4 Aug. 1977, Nishimura 1514 (HIRO). Korea, Mt. Chii, 700 m alt., 16 Aug. 1960, Hong 2080 (HIRO). China, Kwangtung, Fengkai, Nov. 1980, Li 1369 (NICH). Himalaya, without definit locality and collector name, in Hb. Roy. Kew 1875, no. 105, labeled as Leucobryum mittenii Besch. (BM). Nepal, in montibus circa Khatmandu, Feb.-Apr. 1900, Rana s. n. (in herb. Levier, Leucobryum laticuspes Broth., nov. spec. in sched.) – paratype of L. cucullifolium (PC). India, Wight s. n. (in herb. Dixon, ref. no. 52) – paratype of Ochrobryum propaguliferum (BM). Sri Lanka, Hatton, on rock near Hambantotuoya, 17 Mar. 1929, Alston 2607 – paratype of Ochrobryum propaguliferum (BM); Thwaites 82, labeled as Schistomitrium cucullatum T. et M. – original specimen of S. cucullatum Twait. & Mitt., nom. nud. (NY).

Habitat: On soil and rocks.

Distribution: Japan, Korea, China, Himalaya, India, Sri Lanka.

The present species is characterized by (1) distinctly differentiated central strand of stem, (2) mucronate leaf apices which sometimes have spinous apical cells, and (3)

nearly quadrate cells on abaxial surface of apical parts of leaves.

In mature plants the present species always have well differentiated central strand of stem. However, in some cases, such as in juvenile condition, the central strand is hardly differentiated (Fig. XCIV: 14). When the central strand is not differentiated, the present species is differentiated from other Asian species of Leucobryum, except for L. imbricatum, by conspicuous mucronate leaf apices.

Most of the Asian species of Leucobryum produce deciduous leaves, especially in L. humillimum (Fig. XXXIV). L. mittenii and L. propaguliferum were described based on the formation of deciduous leaves as one of the diagnostic characters.

8. Leucobryum imbricatum Broth. (Fig. CI-CIII, CXLI: 9)

Rec. Bot. Surv. India 1: 314 (1899). Type: India, Coorg, on tree trunks in dry open jungle near Verajpet, Mar. 1898, Walker 292 – lectotype (H).

Plants whitish tinged with brown when dry, forming compact cushions. Stems to 30 mm long with leaves; central strand well differentiated in cross-sections of stems. Caducous leaves highly differentiated, linear, twisted or bent, forming a cluster of gemmae at shoot apex enclosed by

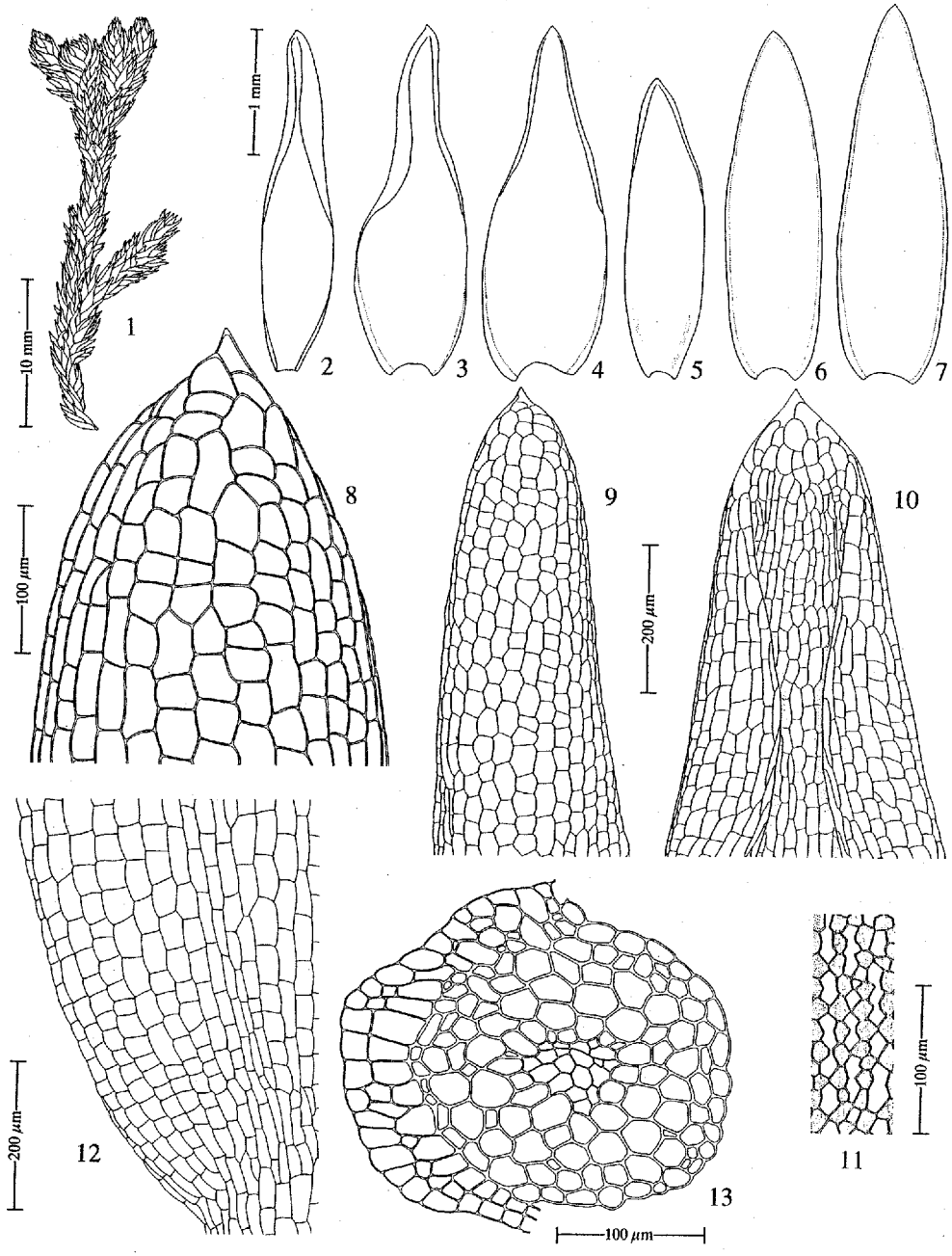

Figure CI. Leucobryum imbricatum Broth. 1. Plant. 2–7. Leaves (6, 7, expanded). 8–10. Leaf apices (10, adaxial view). 11. Chlorocysts near the leaf apex. 12. Leaf base (abaxial view). 13. Cross-section of stem. All figures were drawn from lectotype of L. imbricatum (H).

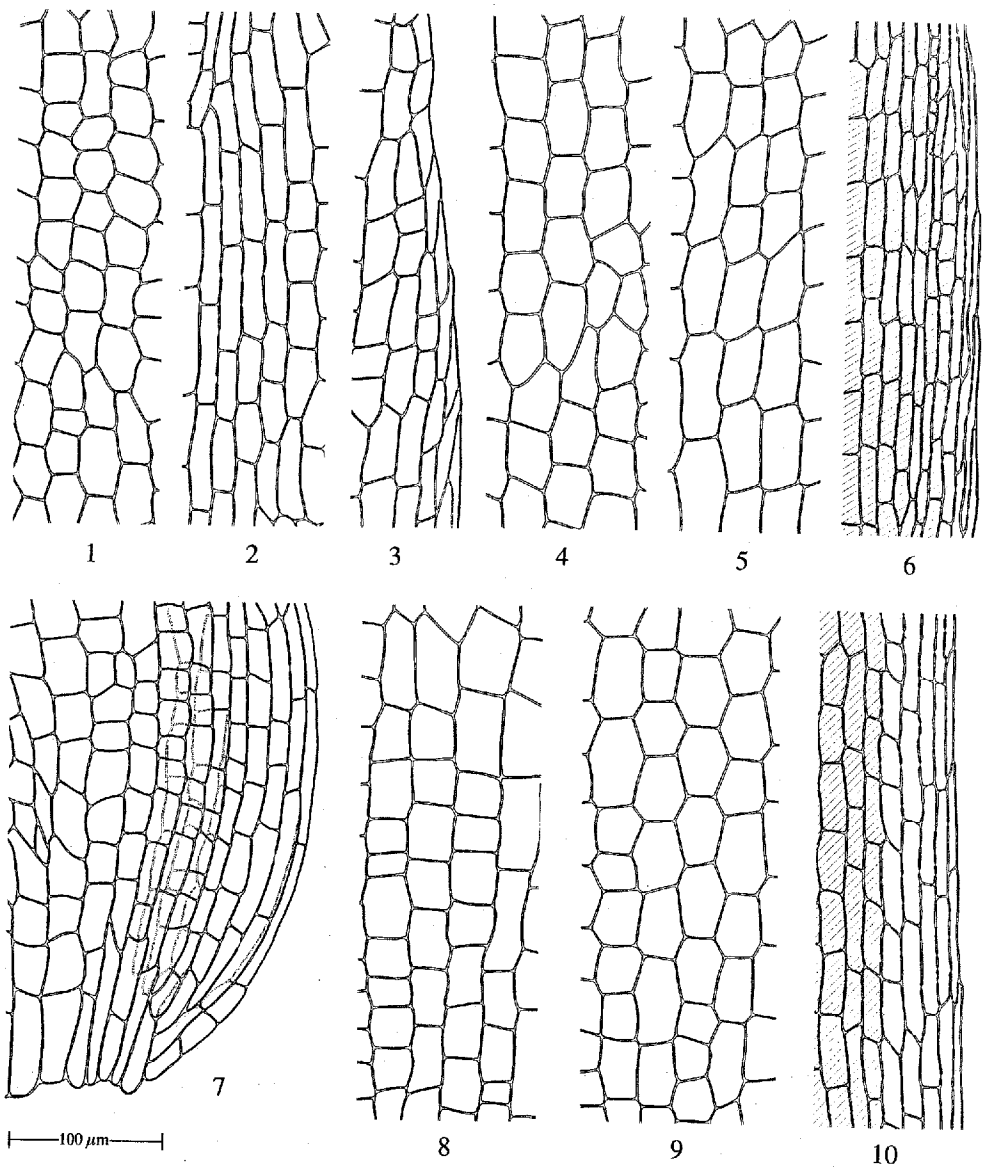

Figure CII. Leucobryum imbricatum Broth. 1–3. Cells near leaf apex (1, 3, abaxial view; 2, adaxial view). 4–6. Median cells of leaf (4, abaxial view; 5, 6, adaxial view). 7–10. Basal cells of leaf (7, 8, abaxial view; 9, 10, adaxial view). All figures were drawn from lectotype of L. imbricatum (H).

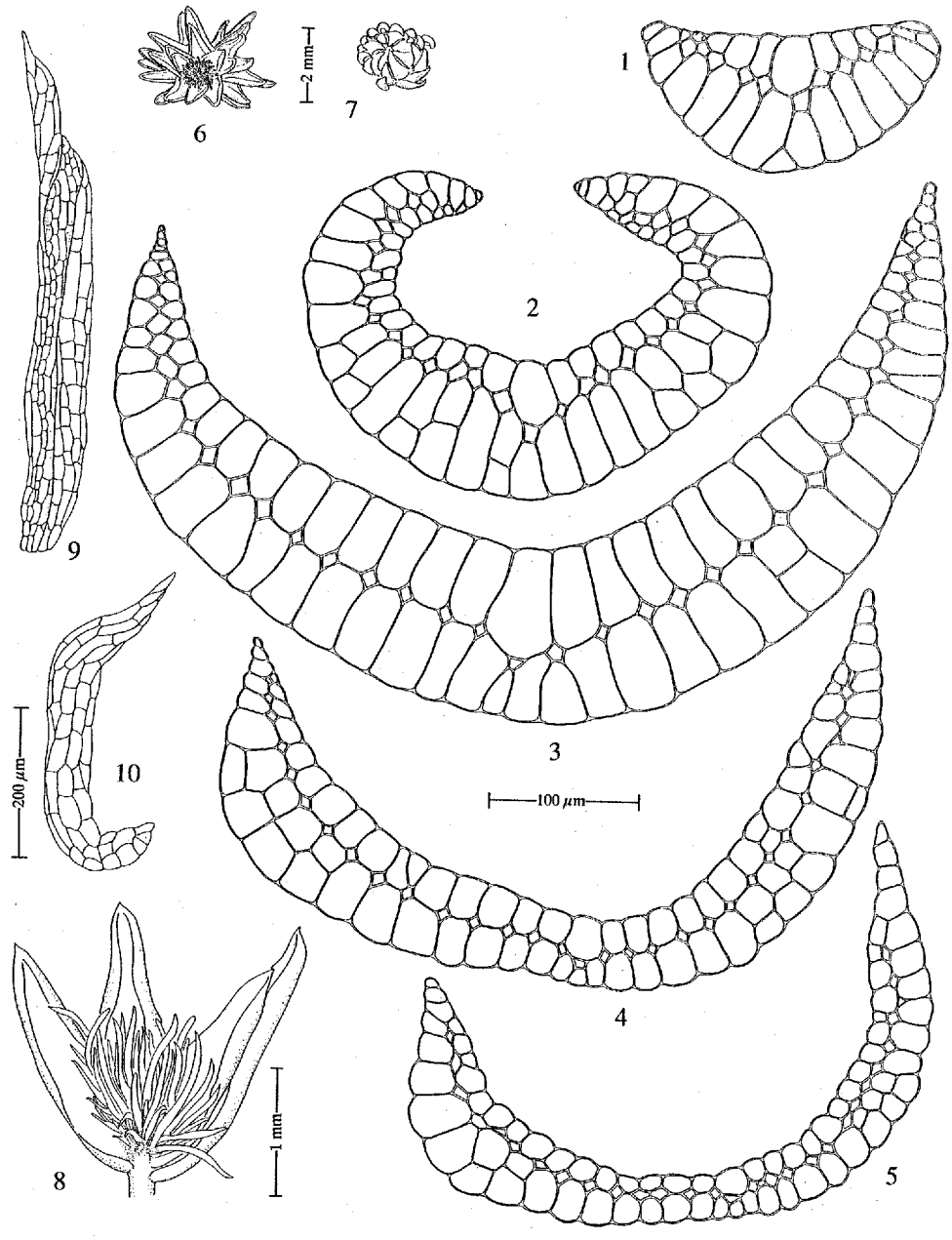

Figure CIII. Leucobryum imbricatum Broth. 1–5. Cross-sections of leaf (1, 2, apical; 3, median; 4, 5, basal portions). 6–8. Shoot apices (6, wet condition; 7, dry condition). 9, 10. Gemmae. All figures were drawn from lectotype of L. imbricatum (H).

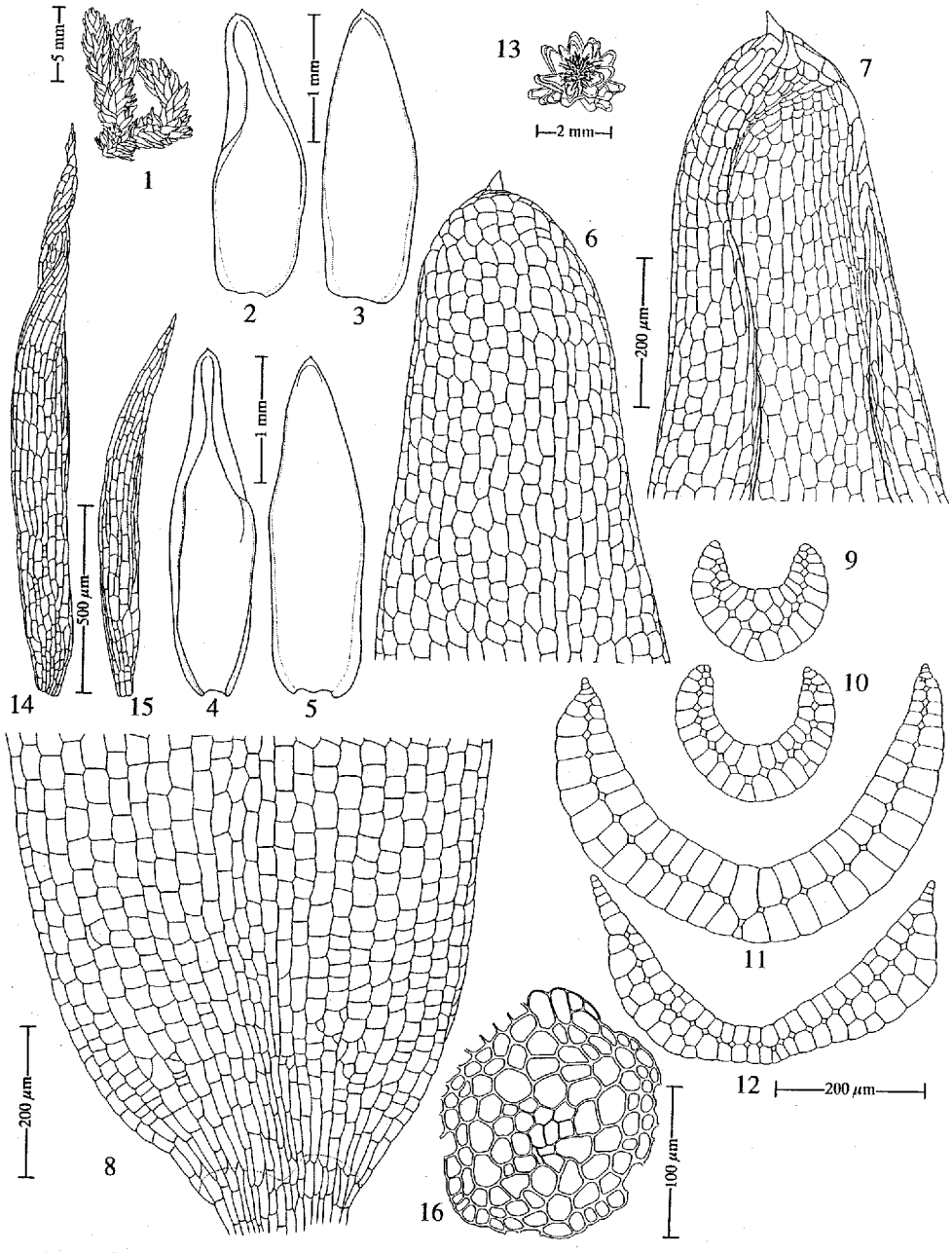

Figure CIV. Leucobryum incurvifolium C. Müll. 1. Plant. 2–5. Leaves (3, 5, expanded). 6, 7. Leaf apices (7, adaxial view). 8. Leaf base (abaxial view). 9–12. Cross-sections of leaf (9, 10, apical; 11, median; 12, basal portions). 13. Shoot apex, when dry. 14, 15. Gemmae. 16. Cross-section of stem. All figures were drawn from isotype of L. incurvifolium (FH).

stem leaves when dry. Leaves closely imbricated; 2.4-2.8 x 0.6-1.0 mm, broadly lanceolate to oblong, mucronate, with a hyaline conical cell at apex, abruptly narrowed to subtubulous or broadly channeled point from ovate base, smooth on abaxial surface; abaxial leucocysts on abaxial surface at apical part nearly quadrate; laminae and borders consisting of 3-5 rows of narrowly rectangular to linear cells near base, the differentiation between laminal cells and border cells indistinct; in cross-sections near leaf apex leucocysts in 1 cell layer on adaxial side and 1-2 cell layers on abaxial side, the adaxial layer conspicuously thinner than the abaxial layer (Fig. CIII: 2); chlorocysts at apical part well visible from adaxial side because of the thin layered adaxial leucocysts, roundish polygonal, forming a network composed of bead-like chlorocysts; in cross-sections near leaf base leucocysts in 1-2 cell layers on both sides, somewhat hypercentric; abaxial leucocysts hardly decurrent on stems.

Sexual organs and sporophytes not observed.

Representative specimens examined: India, Coorg, Murnad, on tree trunks in dry open places, Dec. 1897, Walker 107 – paratype of L. imbricatum (BM).

Habitat: On tree trunks in dry open sites.

Distribution: Endemic to S. India.

The present species is characterized by (1) well differentiated central strand of stem, (2) mucronate leaf apex with a hyaline conical cell, (3) abaxial leucocysts (1-2 cell layer) thicker than adaxial leucocysts (1 cell layer) at apical part of leaf in cross-section, and (4) highly differentiated caducous leaves (gemmae).

L. humillimum is similar to the present species in general appearance, but differs in having homostrosic leucocysts and centric position of chlorocysts at apical part of leaf in cross-section and absence of specialized gemmae.

L. incurvifolium C. Müll. (Fig. CIV) from Central America is closely related to the present species, having specialized gemmae at shoot apices, differentiated central strand of stems and mucronate leaf apices with a hyaline point. However, adaxial leucocysts (1-2 cell layer) of L. incurvifolium thicker than abaxial leucocysts (1 cell layer) in cross-section at apical part of leaf (Fig. CIV: 9).

9. Leucobryum glaucum (Hedw.) Ångstr. in Fries (Fig. XXIII, CV-CIX, CXL: 1)

Summ. Veg. Scand. 1: 94 (1846).

Basionym: Dicranum glaucum Hedw., Spec. Musc.: 135 (1801). Type: "In sylvis uliginosis, pinetis, ericetis, pratisque paludosis caespitose vitam degit, totius Europae

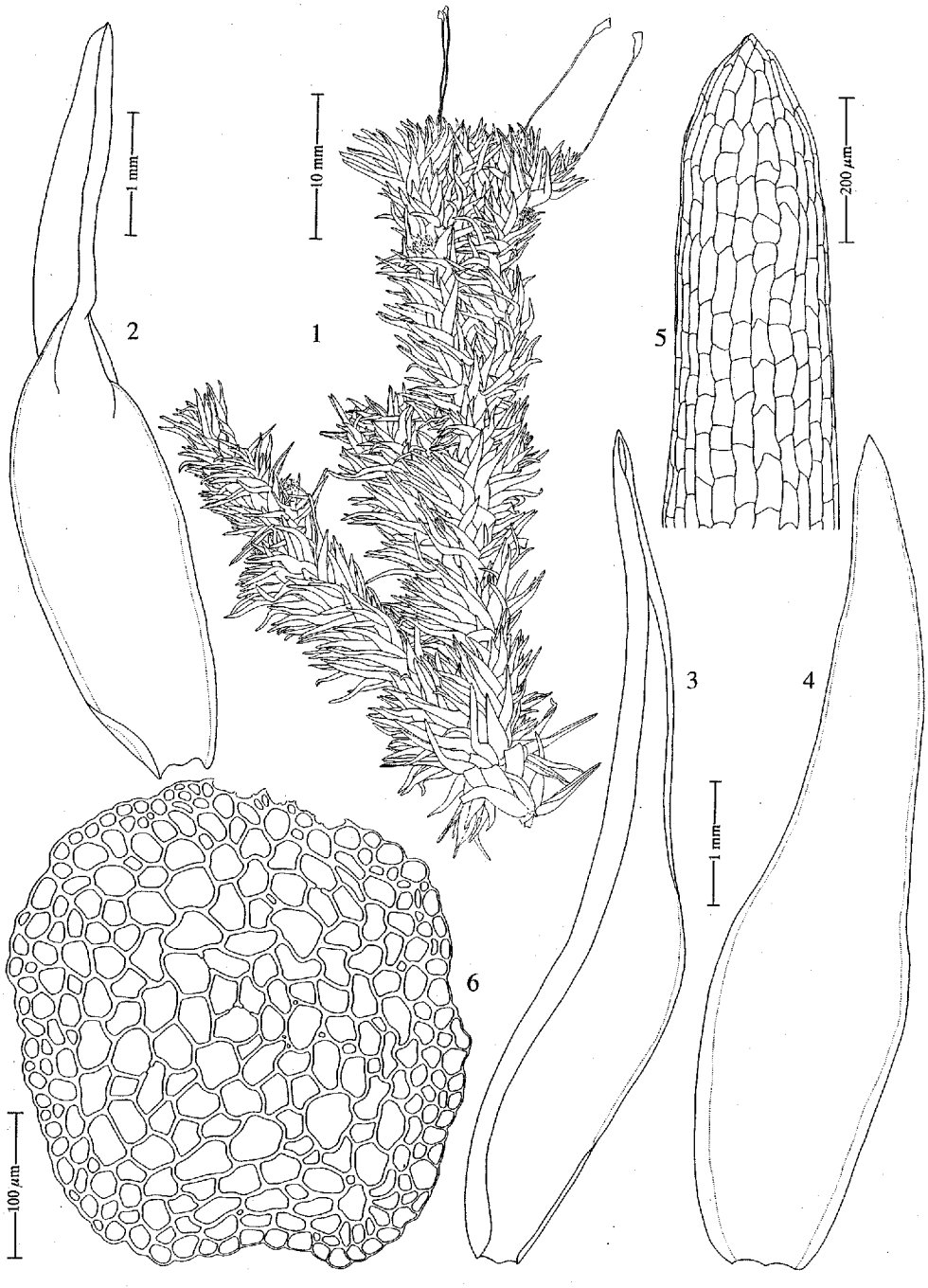

Figure CV. Leucobryum glaucum (Hedw.) Ångstr. in Fries. 1. Plant. 2–4. Leaves (4, expanded). 5. Leaf apex. 6. Cross-section of stem. Figs. 1, 2, 5 were drawn from Europe, Sept. 1797, s. n. (B); 3, 4, 6 from Zanten 3319 (NICH).

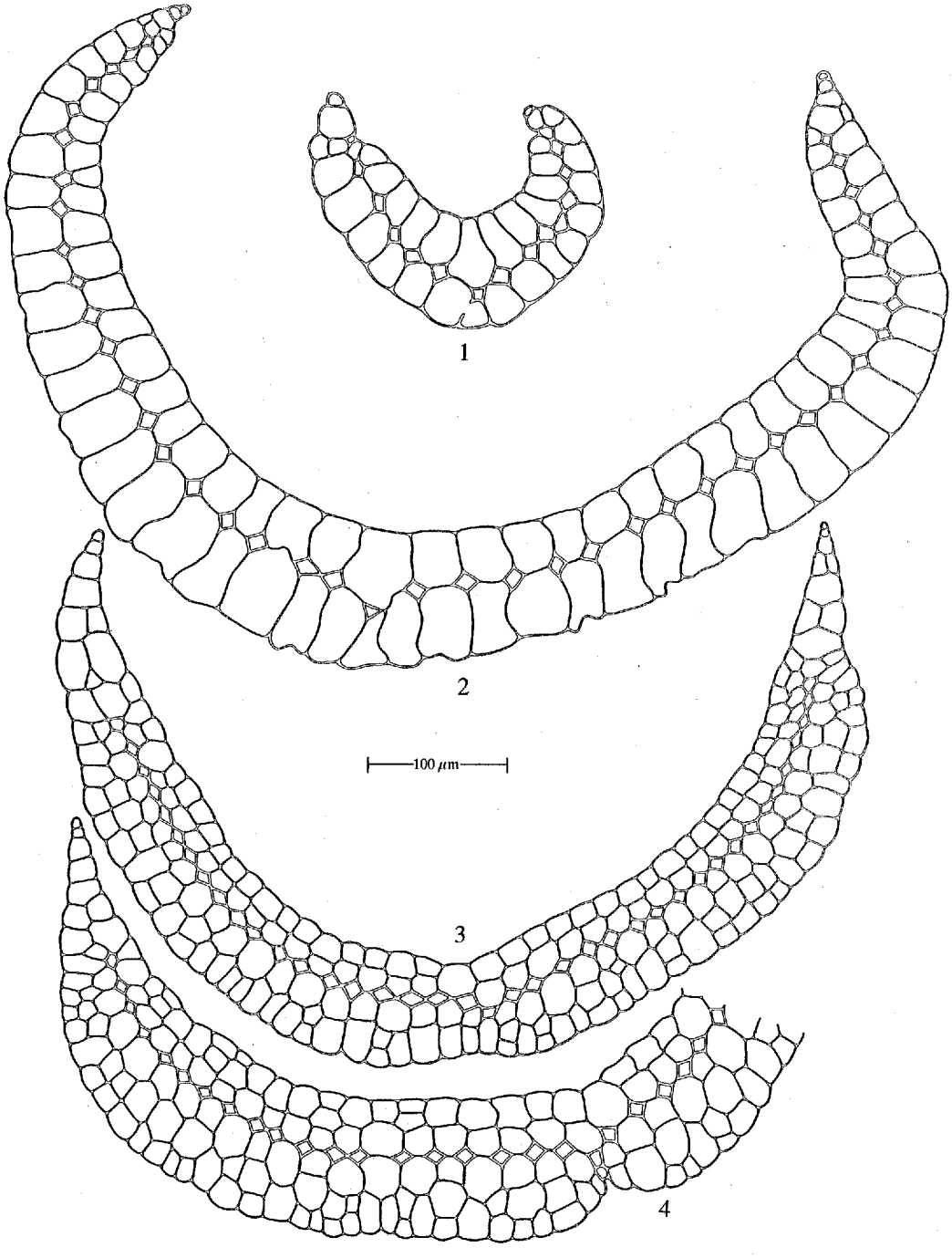

Figure CVI. Leucobryum glaucum (Hedw.) Ångstr. in Fries. 1–4. Cross-sections of leaf (1, apical; 2, median; 3, 4, basal portions). All figures were drawn from Europe, Sept. 1797, s. n. (B).

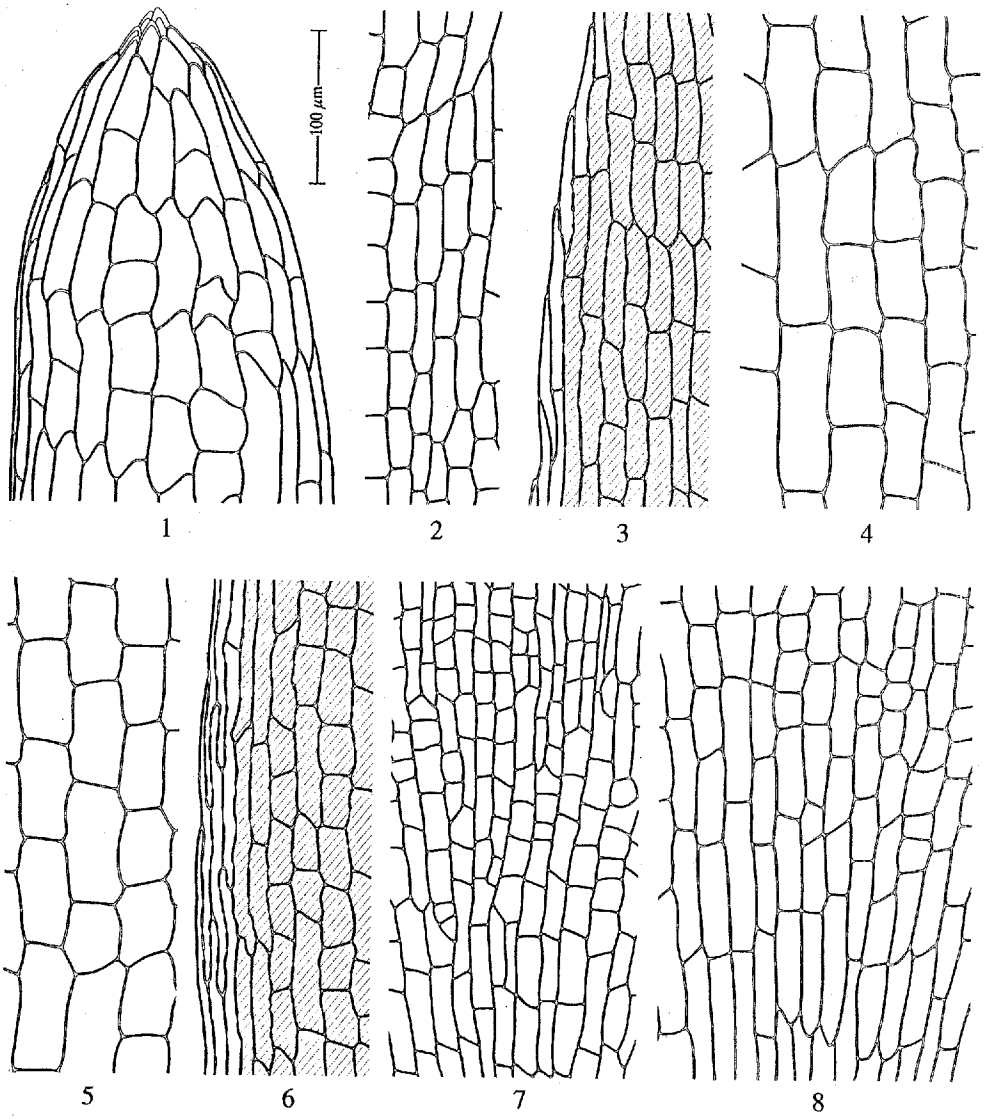

Figure CVII. Leucobryum glaucum (Hedw.) Ångstr. in Fries. 1–3. Cells near leaf apex (1, abaxial view; 2, 3, adaxial view). 4–6. Median cells of leaf (4, abaxial view; 5, 6, adaxial view). 7, 8. Basal cells of leaf (7, abaxial view; 8, adaxial view). All figures were drawn from Europe, Sept. 1797, s. n. (B).

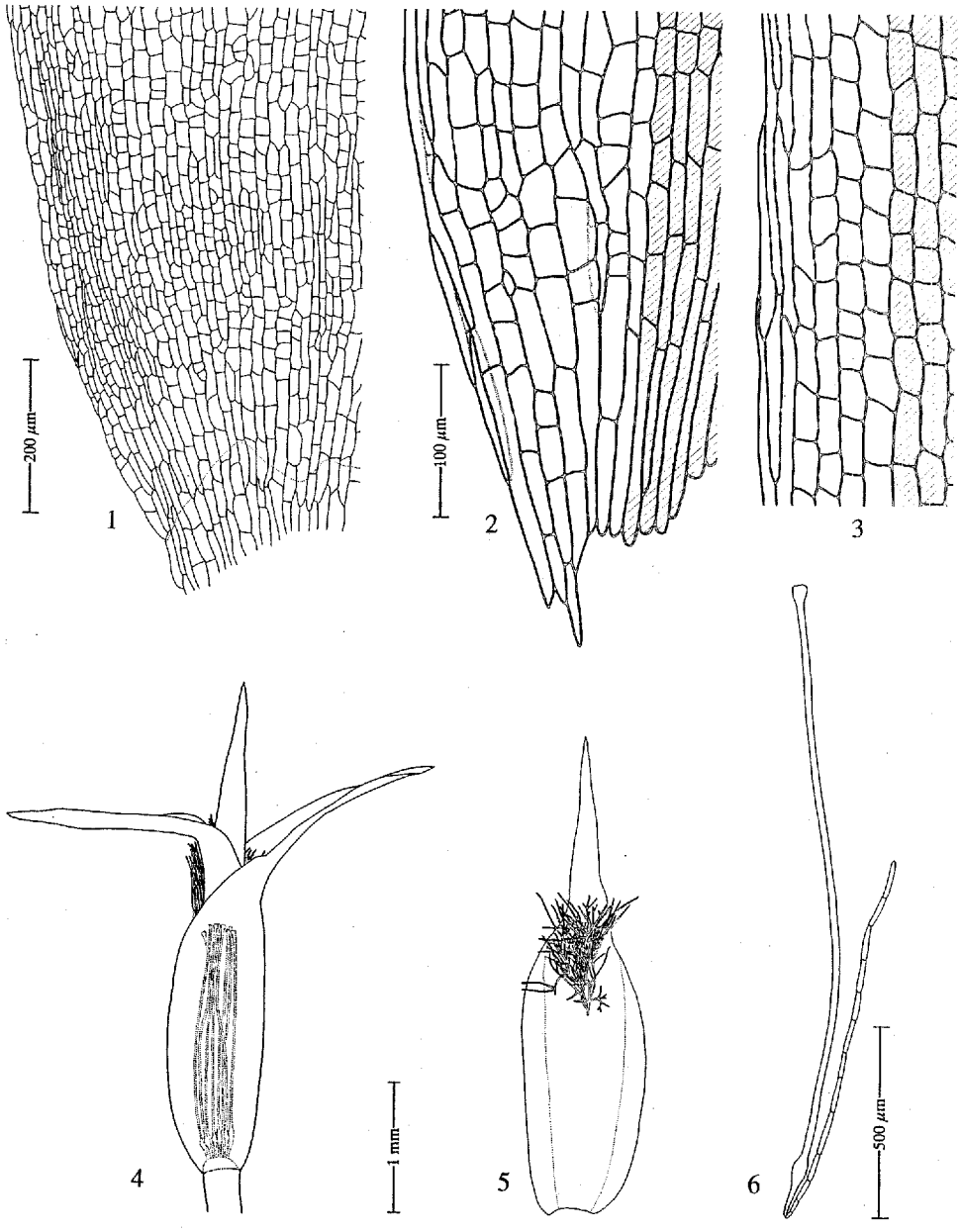

Figure CVIII. Leucobryum glaucum (Hedw.) Ångstr. in Fries. 1. Leaf base (abaxial view). 2, 3. Basal cells of leaf (adaxial view). 4. Perichaetium. 5. Inner perichaetial leaf (expanded) showing formation of tomentum on abaxial side. 6. Archegonium. Figs. 1–3 were drawn from Europe, Sept. 1797, s. n. (B); 4–6, from Zanten 3319 (NICH).

Figure CIX. Leucobryum glaucum (Hedw.) Ångstr. in Fries. 1. Branching showing position of perichaetia. 2. Perichaetium. 3. Stem leaf (expanded) near perichaetium 2. 4. Inner perichaetial leaf (expanded) from perichaetium 2. 5. Vaginula and Archegonia. 6. Capsule. All figures were drawn from Zanten 3319 (NICH).

et Americae septemtrionalis nec non Jamaicae incola" – syntypes (not seen).

Plants whitish green when dry, forming tufts or cushions. Stems to 50 mm long with leaves; central strand not differentiated in cross-sections of stems. Leaves erect spreading; 5.9-6.8 x 1.3-1.6 mm, lanceolate, gradually narrowed to subtubulous point from oblong base, acute to bluntly mucronate, smooth on abaxial surface; laminae consisting of 4-7 rows of quadrate to rectangular cells near base, bordered by 2-3 rows of linear cells, the laminal area composed of rectangular cells extended to mid leaf; in cross-sections near leaf base leucocysts in 2-3 cell layers on both sides at the thickest part, the central part indistinctly hollowed, in (2-) 3-4 layers of leucocysts, the thickest part 1.2-1.6 times thicker than the central part; abaxial leucocysts hardly decurrent on stems.

Dioicous. Dwarf male plants usually growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia terminal on main stems and subfloral innovations; inner perichaetial leaves around mature sporophytes 0.7-0.8 times longer than ordinary leaves near the perichaetia; archegonia 1.7-1.8 mm long. Setae 8-11 mm long. Capsules inclined, ovoid to ellipsoid; urns ca. 1.6 mm long, ca. 0.8 mm wide.

Representative specimens examined: Japan, Hokkaido, Kushiro-shicho, Wakoto side of Lake Kussharo, 120 m alt., 30 Sept. 1985, Furuki 6177 (HIRO). Japan, Honshu, Iwate-ken, Mt. Hayachine, 1800 m alt., 29 Aug. 1967, Komizuuchi and Ishizuka 23 (HIRO). Japan, Honshu, Gunma-ken, Nikko National Park, Mt. Shibutsu, 1880 m alt., 23 Aug. 1955, Kurachi 2023 (NICH). Europe, without definite locality, labeled as "In dem kleinen ... buch auf dem Boden mit Mlütchen im ... September 1797" (B). Netherlands, Prov. of Gelderland, Speulder forest near Putten, 26 Feb. 1966, Zanten 3319 (NICH).

Habitat: Usually on humus near damp sites, occasionally on soil, rotten longs, stumps, or on tree base in moist forests.

Distribution: Japan. Widely distributed throughout temperate to cool temperate regions in N. Hemisphere.

L. glaucum shows similar appearance with L. juniperoideum, but is differentiated from L. juniperoideum by (1) laminae consist of 4-7 rows of quadrate to rectangular cells near base, (2) indistinctly hollowed central parts in cross-sections near leaf bases which are composed of (2-) 3-4 layers of leucocysts, and (3) short perichaetial leaves 0.7-0.8 times longer than ordinary leaves near the perichaetium when sporophytes are matured.

L. glaucum usually grows on moist humus near damp sites, while L. juniperoideum grows on soil, rocks, logs and tree base in Japan. Different growing habitats of these two species are also reported in Europe by Bonnot (1964), Crundwell (1972) and Blackstock (1987).

10. Leucobryum bowringii Mitt. (Fig. XXIV, XXV: C, XXVIII, XXIX, XXXII, CX-CXXII, CXLII: 1)

J. Linn. Soc. Bot. Suppl. 1: 26 (1859). Type: Sri Lanka, Gardner 1279 – lectotype (NY).

Ochrobryum ceylanicum Besch., J. de Bot. 11: 148 (1897) = Leucobryum ceylanicum (Besch.) Card., Mem. Soc. Sc. Nat. Cherbourg 32: 15, f. 27 (1901), syn. nov. Type: Sri Lanka, Central Province, Thwaites 81 – holotype (PC), isotype (BM).

Leucobryum yamatense Besch., J. de Bot. 12: 288 (1898). Type: Japan, Yamato, Mt. Kasuga, 15 July 1883, Okubo s. n. – isotype (NICH).

Leucobryum nagasakense Broth., Hedwigia 38: 208 (1899). Type: Japan, Nagasaki, 20 Jan. 1861, Wichura 1416c – holotype (H).

Leucobryum brotheri Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 36 (1905). Type: Java, Sri Lanka, Hantanna Dschungl bei Peradenniya, 1500 m alt., Feb. 1898, without collector name (Musci Frond. Archipelagi Indici ser. I, no. 7, Leucobryum bowringii Mitt. in sched.) – isosyntype

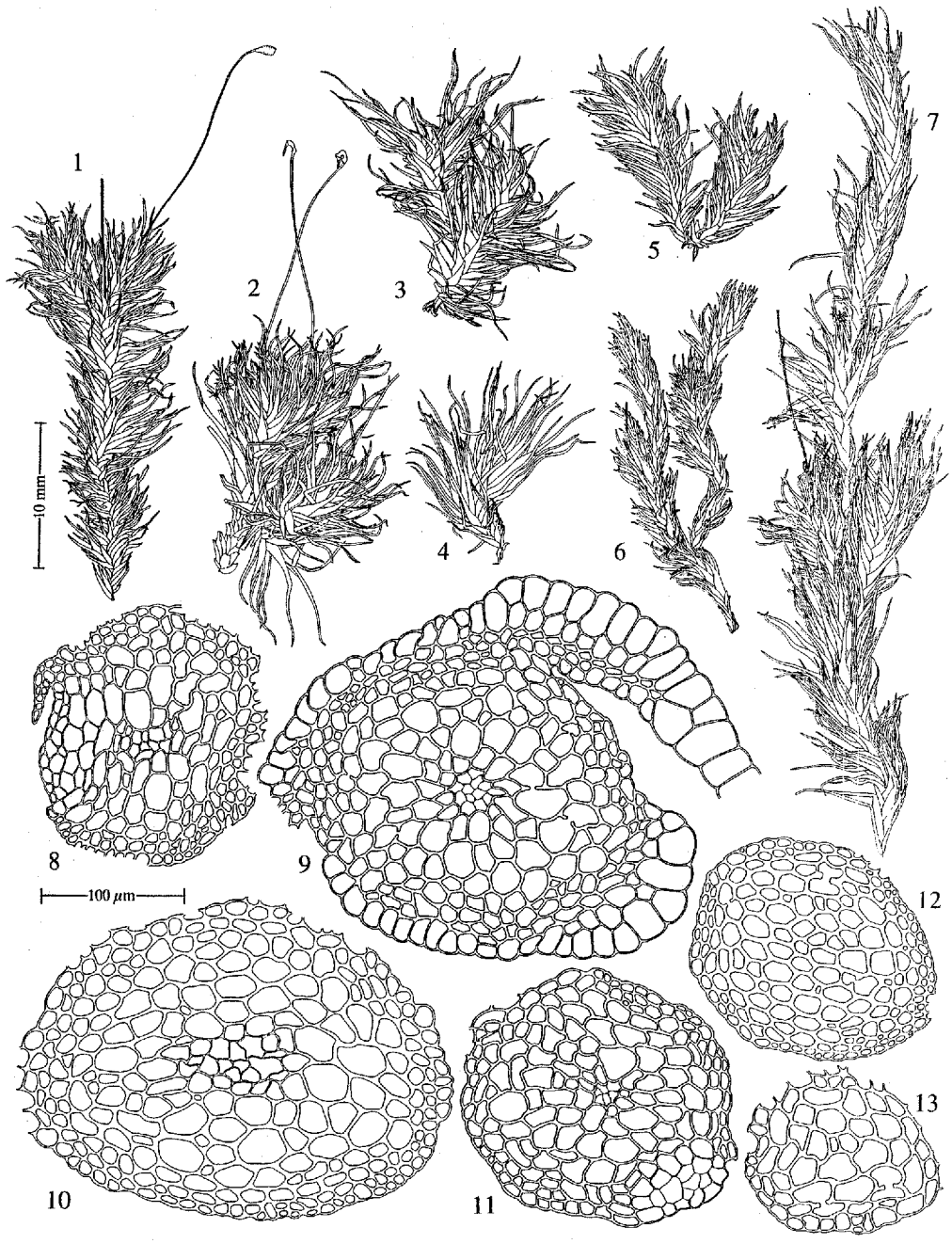

Figure CX. Leucobryum bowringii Mitt. 1–7. Plants. 8–13. Cross-sections of stems. Figs. 1, 8 were drawn from lectotype of L. bowringii (NY); 2, 3, from Yamaguchi 9313 (HIRO); 4, from Faurie 62 labeled as L. bowringii f. brevifolium (KYO); 5, 13, from isosyntype (Wright s. n.) of L. stenobasis (FI); 6, 12, from isosyntype (Gollan s. n.) of L. stenobasis (FI); 7, from Noguchi 26323 (NICH); 9, from holotype of L. subsericeum (BM); 10, from holotype of L. nagasakense (H); 11, from isotype of Ochrobryum ceylanicum (BM).

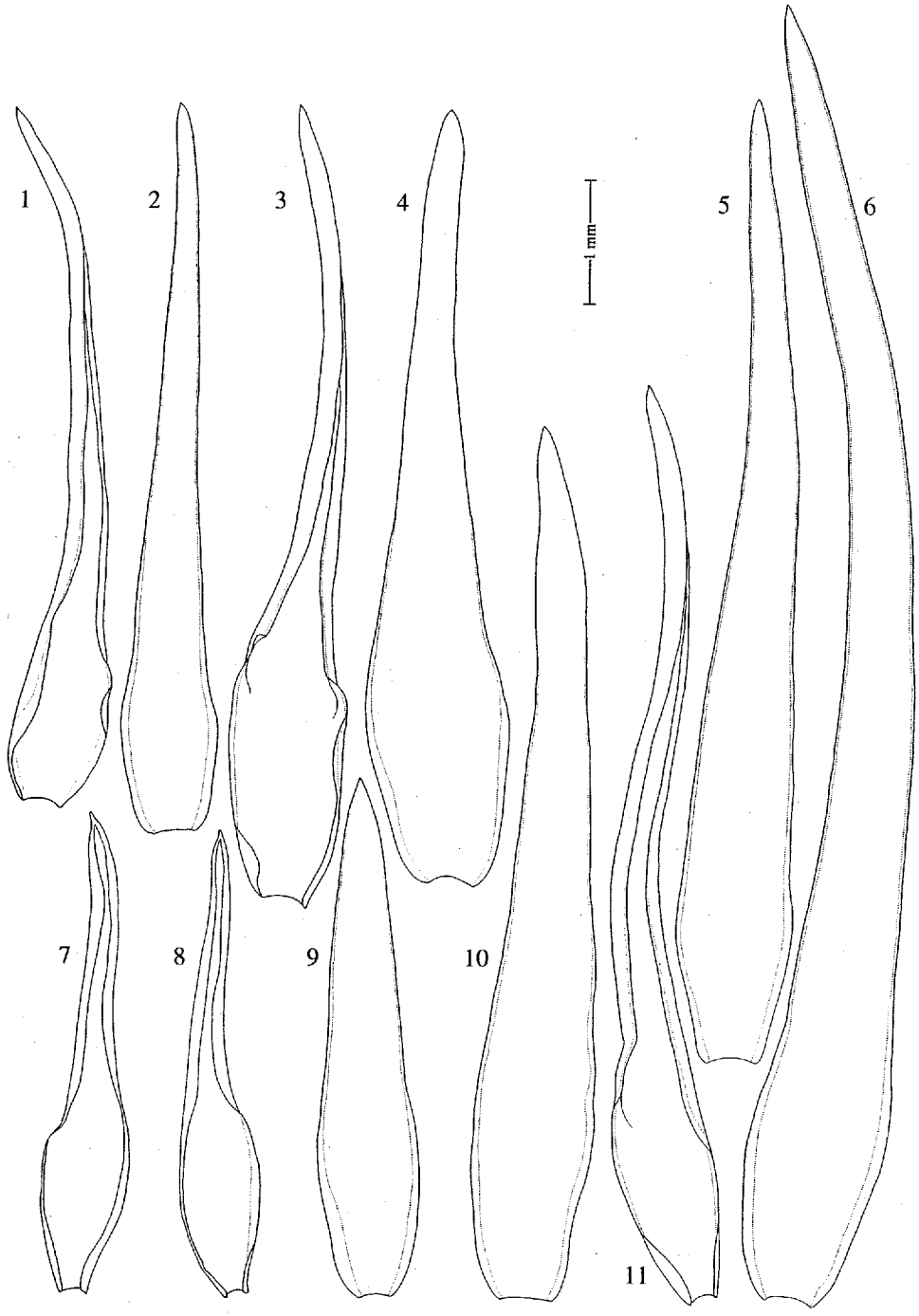

Figure CXI. Leucobryum bowringii Mitt. 1–11. Leaves (2, 4, 5, 6, 9, 10, expanded). Figs. 1, 2 were drawn from lectotype of L. bowringii (NY); 3, 4, from Faurie 62 labeled as L. bowringii f. brevifolium (KYO); 5, from Fleischer s. n., Musci Archipelagi Indici 4: 152, labeled as L. angustifolium var. macrophyllum (FH); 6, from Yamaguchi 9313 (HIRO); 7–9, from isotype of Ochrobryum ceylanicum (BM); 10, 11, from isotype of L. confine (KYO).

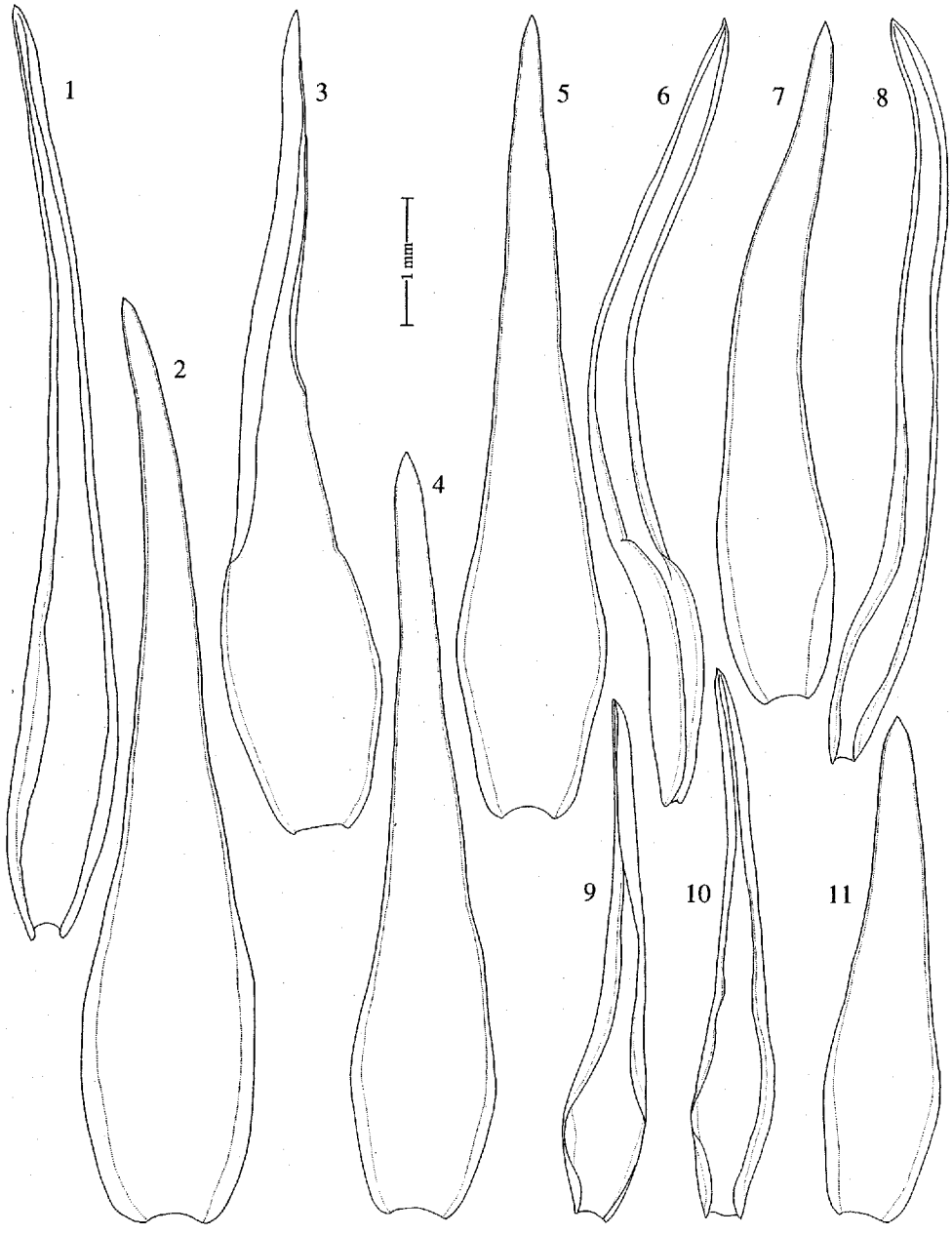

Figure CXII. Leucobryum bowringii Mitt. 1–11. Leaves (2, 4, 5, 7, 11, expanded). Figs. 1, 2, were drawn from holotype of L. nagasakense (H); 3, 4, from isotype of L. yamatense (NICH); 5, from holotype of L. subsericeum (BM); 6–8, from isosyntype (Wright s. n.) of L. stenobasis (FI); 9–11, from isosyntype (Gollan s. n.) of L. stenobasis (FI).

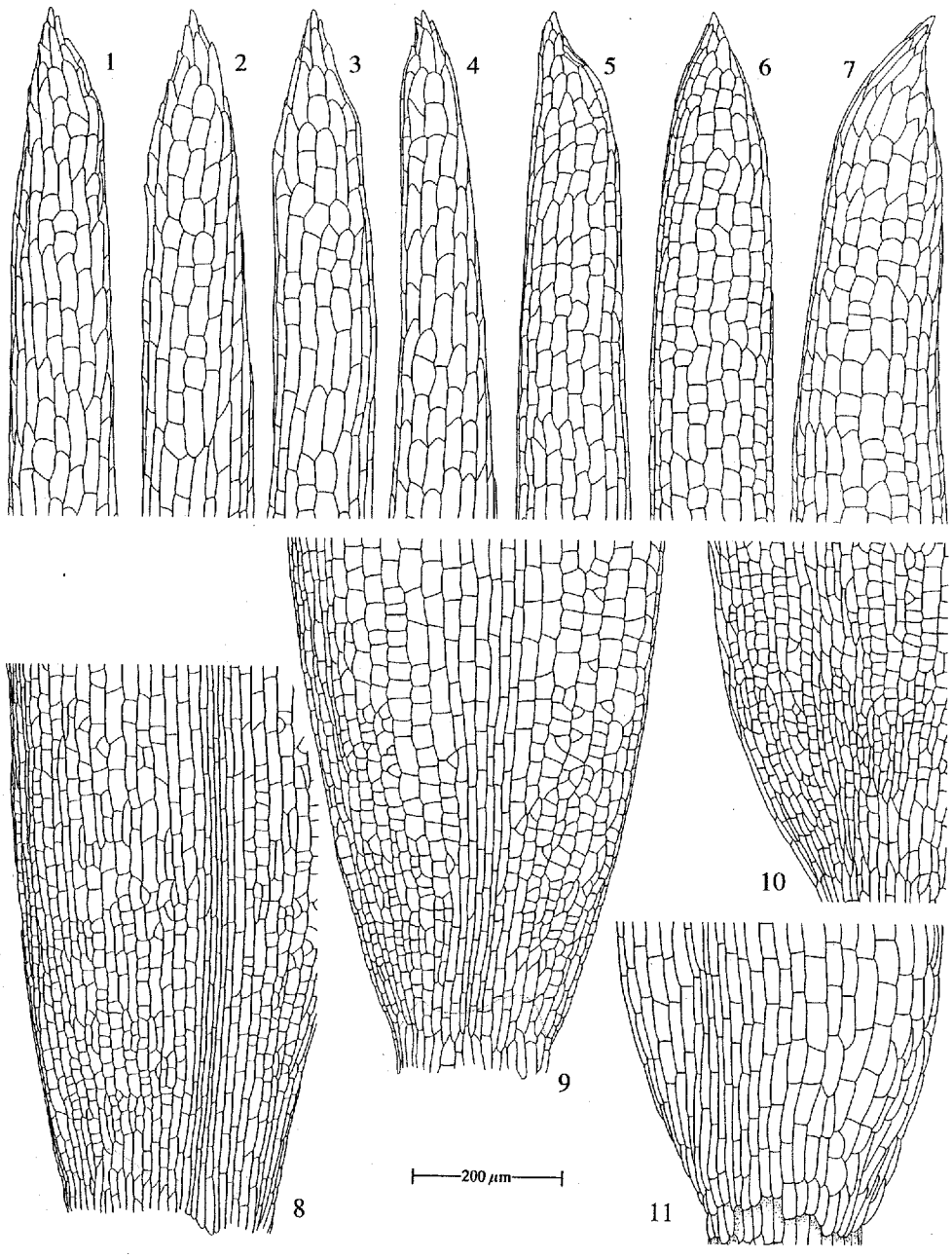

Figure CXIII. Leucobryum bowringii Mitt. 1–7. Leaf apices. 8–11. Leaf bases (abaxial view). Fig.1 was drawn from Faurie 62 labeled as L. bowringii f. brevifolium (KYO); 2, 3, from isotype of L. yamatense (NICH); 4, from isotype of L. confine (KYO); 5, 6, 8, from isosyntype (Gollan s. n.) of L. stenobasis (FI); 7, 9, from isosyntype (Wright s. n.) of L. stenobasis (FI); 10, from isotype of Ochrobryum ceylanicum (BM); 11, from lectotype of L. bowringii (NY).

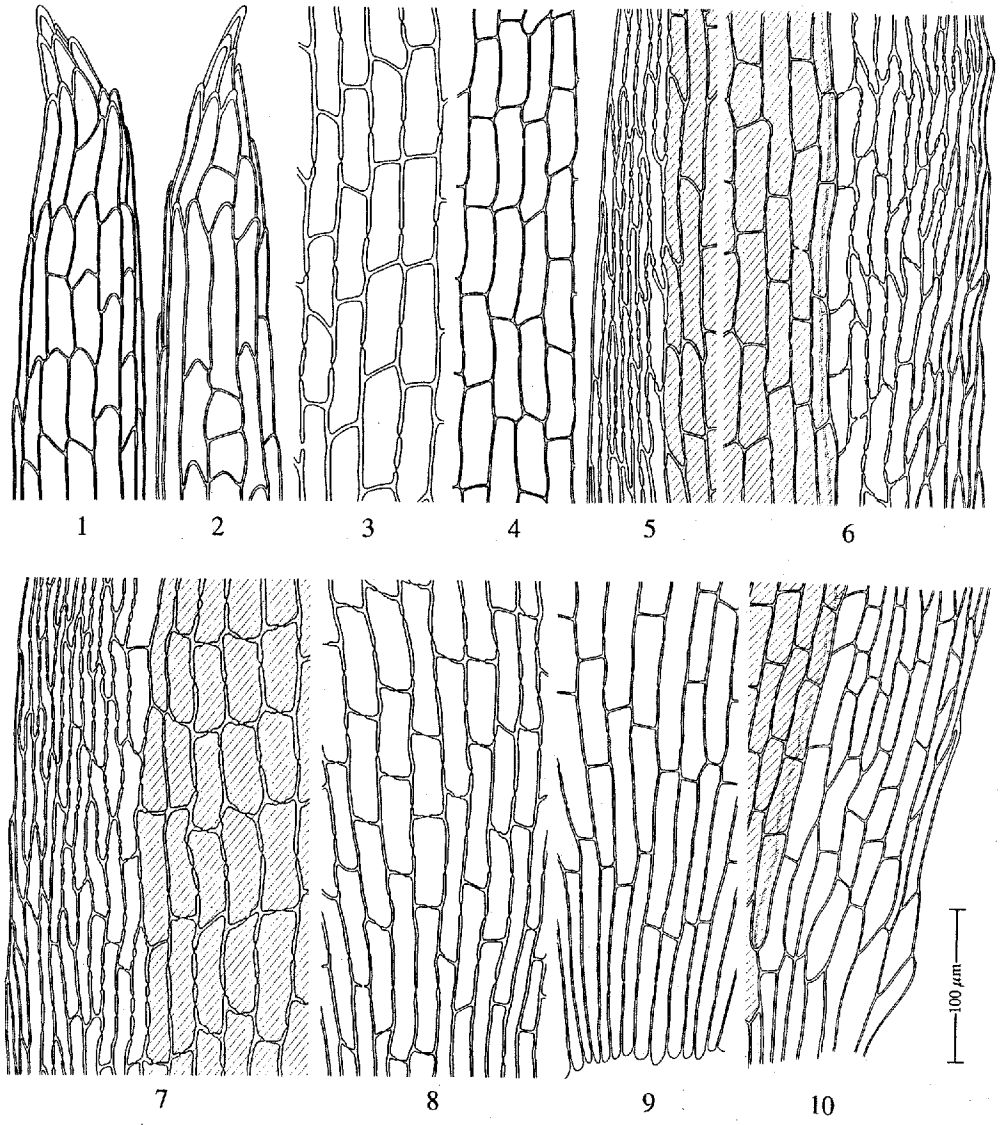

Figure CXIV. Leucobryum bowringii Mitt. 1, 2. Leaf apices. 3–5. Median cells of leaf (3, 5, abaxial view; 4, adaxial view). 6–10. Basal cells of leaf (7, 8, abaxial view; 6, 9, 10, adaxial view). All figures were drawn from lectotype of L. bowringii (NY).

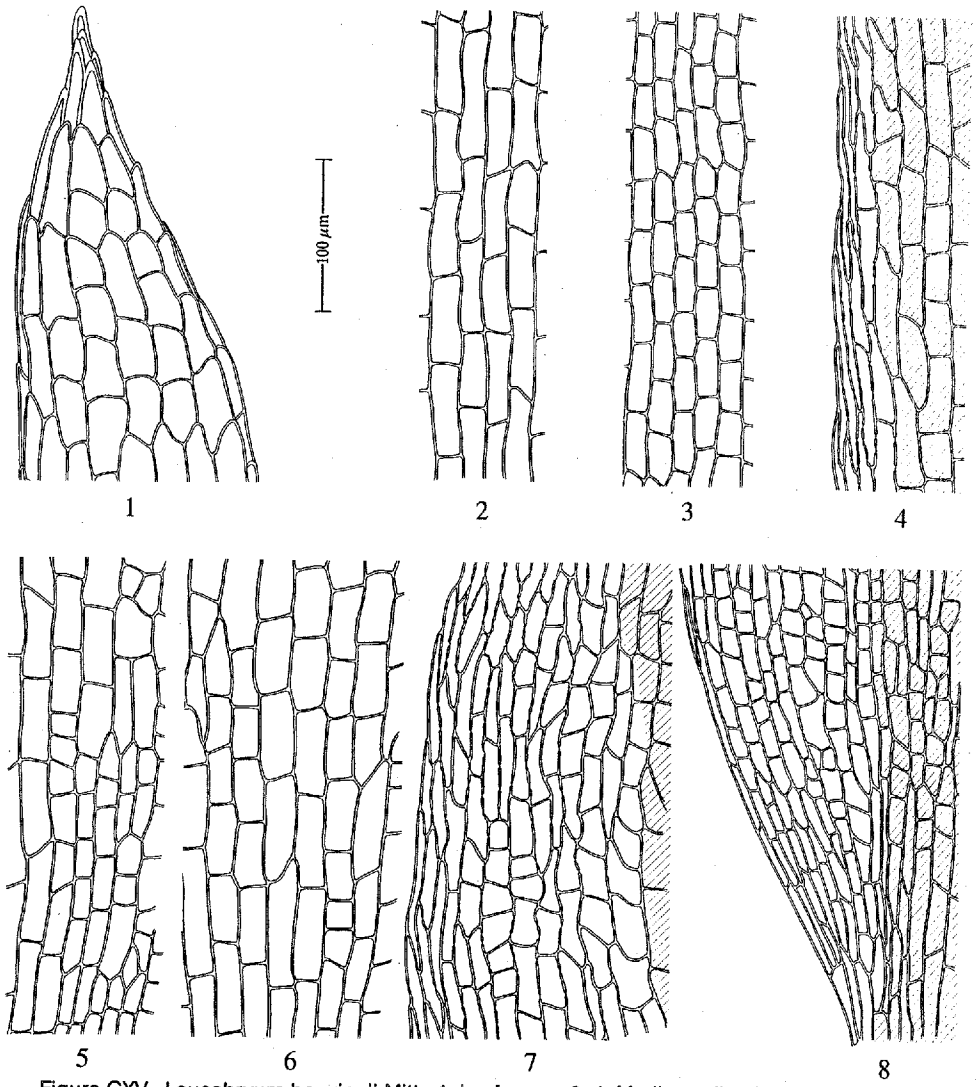

Figure CXV. Leucobryum bowringii Mitt. 1. Leaf apex. 2–4. Median cells of leaf (2, 4, abaxial view; 3, adaxial view). 5–8. Basal cells of leaf (5, 7, 8, abaxial view; 6, adaxial view). All figures were drawn from isotype of Ochrobryum ceylanicum (BM).

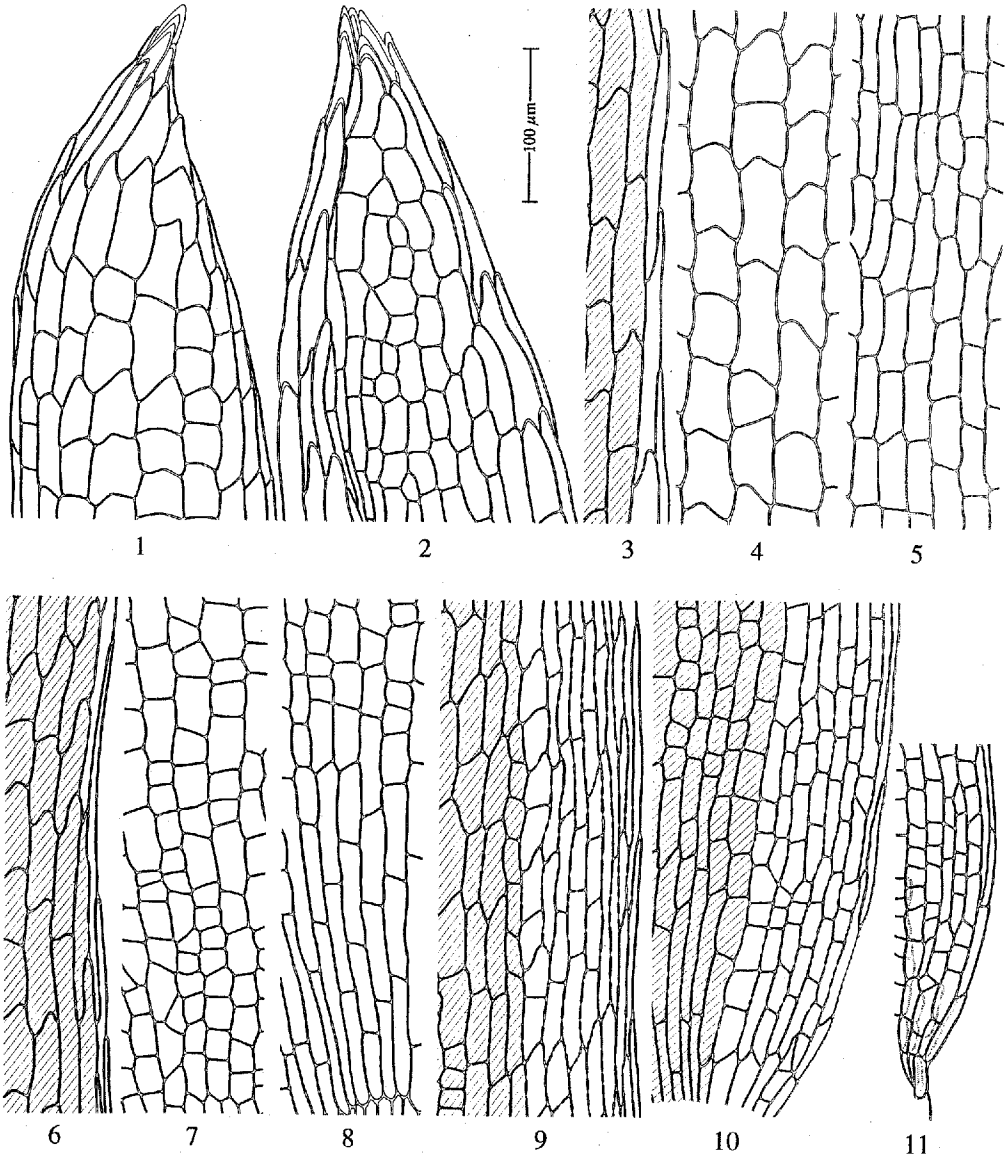

Figure CXVI. Leucobryum bowringii Mitt. 1, 2. Leaf apices (2, adaxial view). 3. Cells near leaf apex (abaxial view). 4–6. Median cells of leaf (4, 6, abaxial view; 5, adaxial view). 7–11. Basal cells of leaf (7, 11, abaxial view; 8–10, adaxial view). All figures were drawn from isosyntype (Wright s. n.) of L. stenobasis (FI).

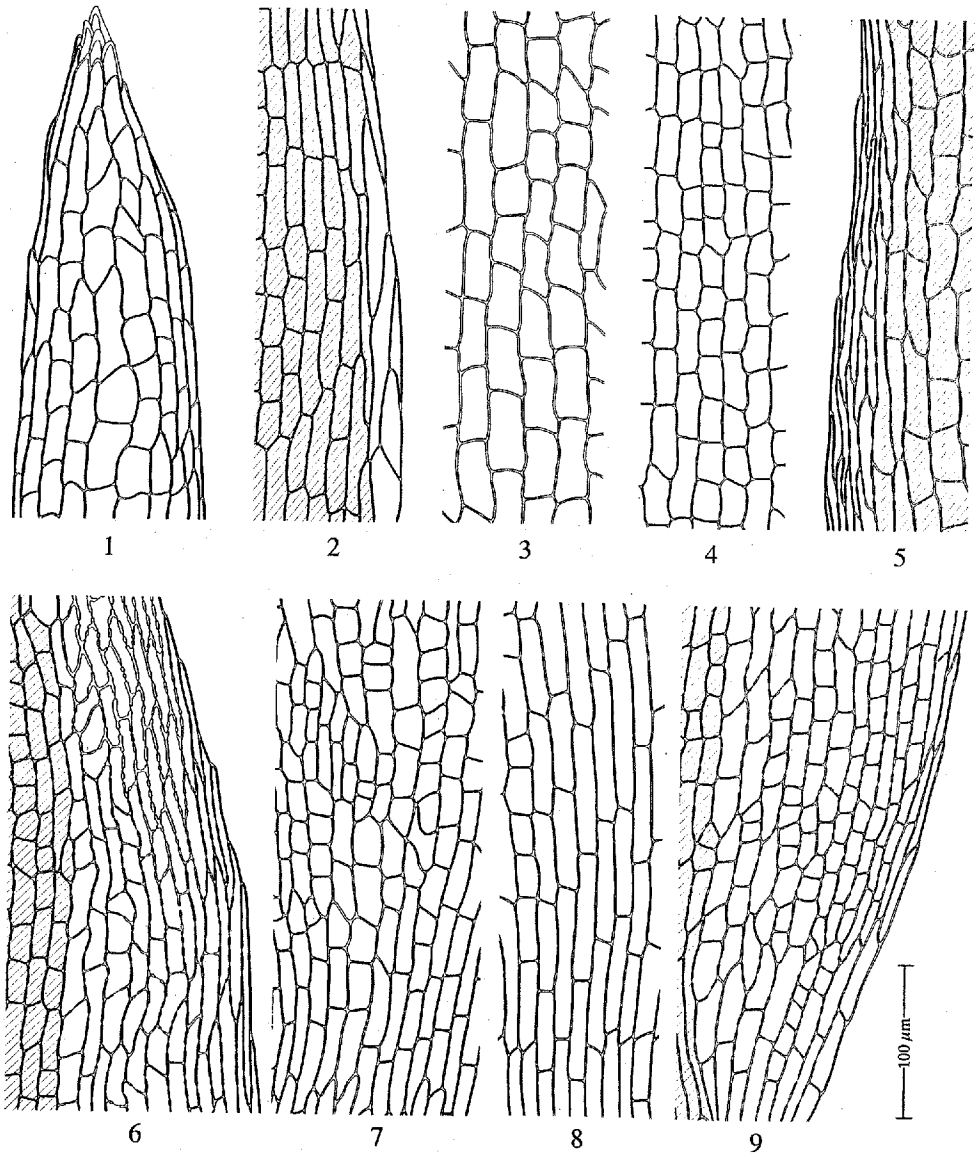

Figure CXVII. Leucobryum bowringii Mitt. 1. Leaf apex. 2. Cells near leaf apex (adaxial view). 3–5. Median cells of leaf (3, 5, abaxial view; 4, adaxial view). 6–9. Basal cells of leaf (7, abaxial view; 6, 8, 9, adaxial view; 6, from shoulder part). All figures were drawn from isosyntype (Gollan s. n.) of L. stenobasis (Fl).

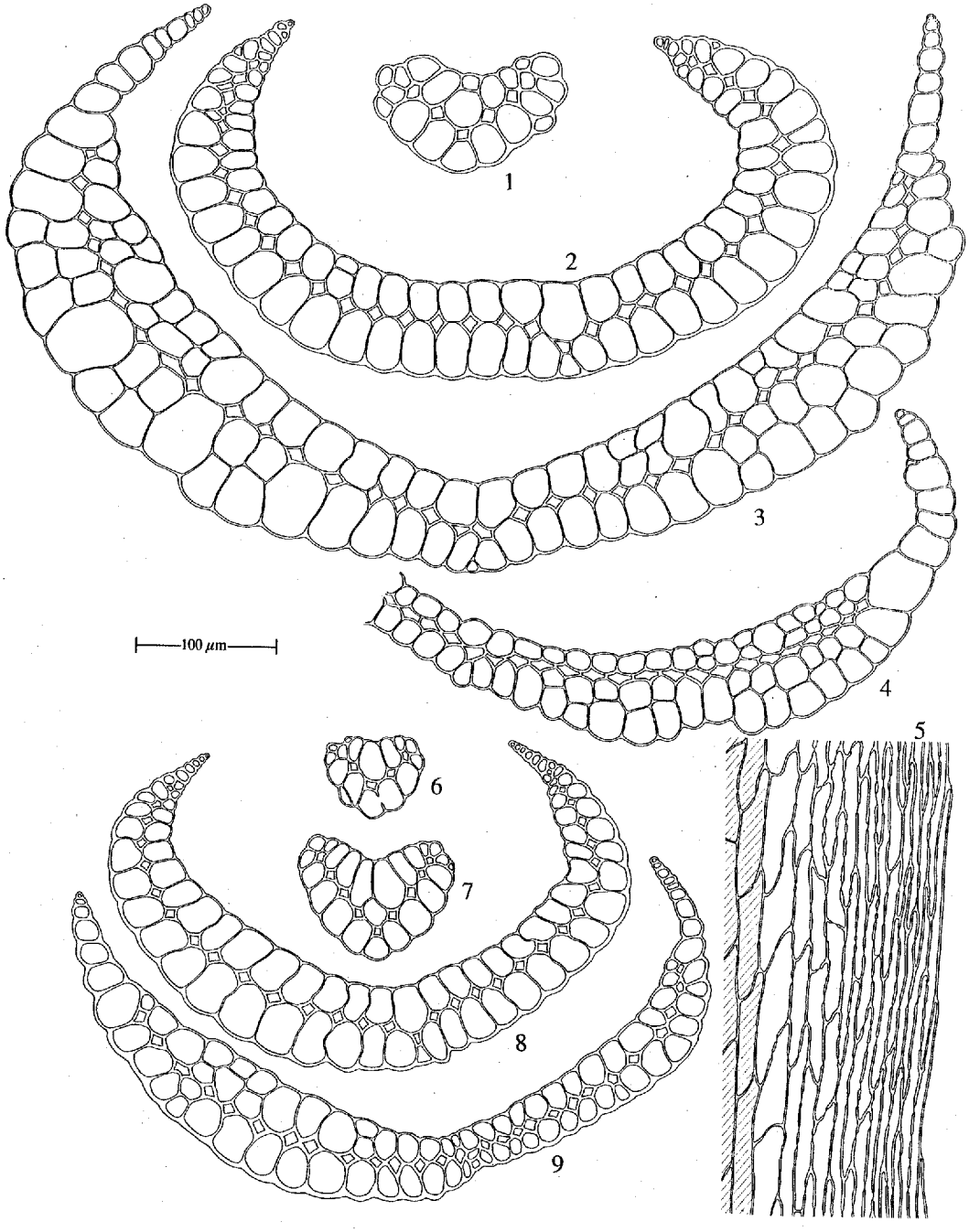

Figure CXVIII. Leucobryum bowringii Mitt. 1–4, 6–9. Cross-sections of leaves (1, 6, 7, apical; 2, 8, median; 3, 4, 9, basal portions). 5. Basal cells of leaf (abaxial view). Figs. 1–5 were drawn from holotype of L. nagasakense (H); 6–9, from lectotype of L. bowringii (NY).

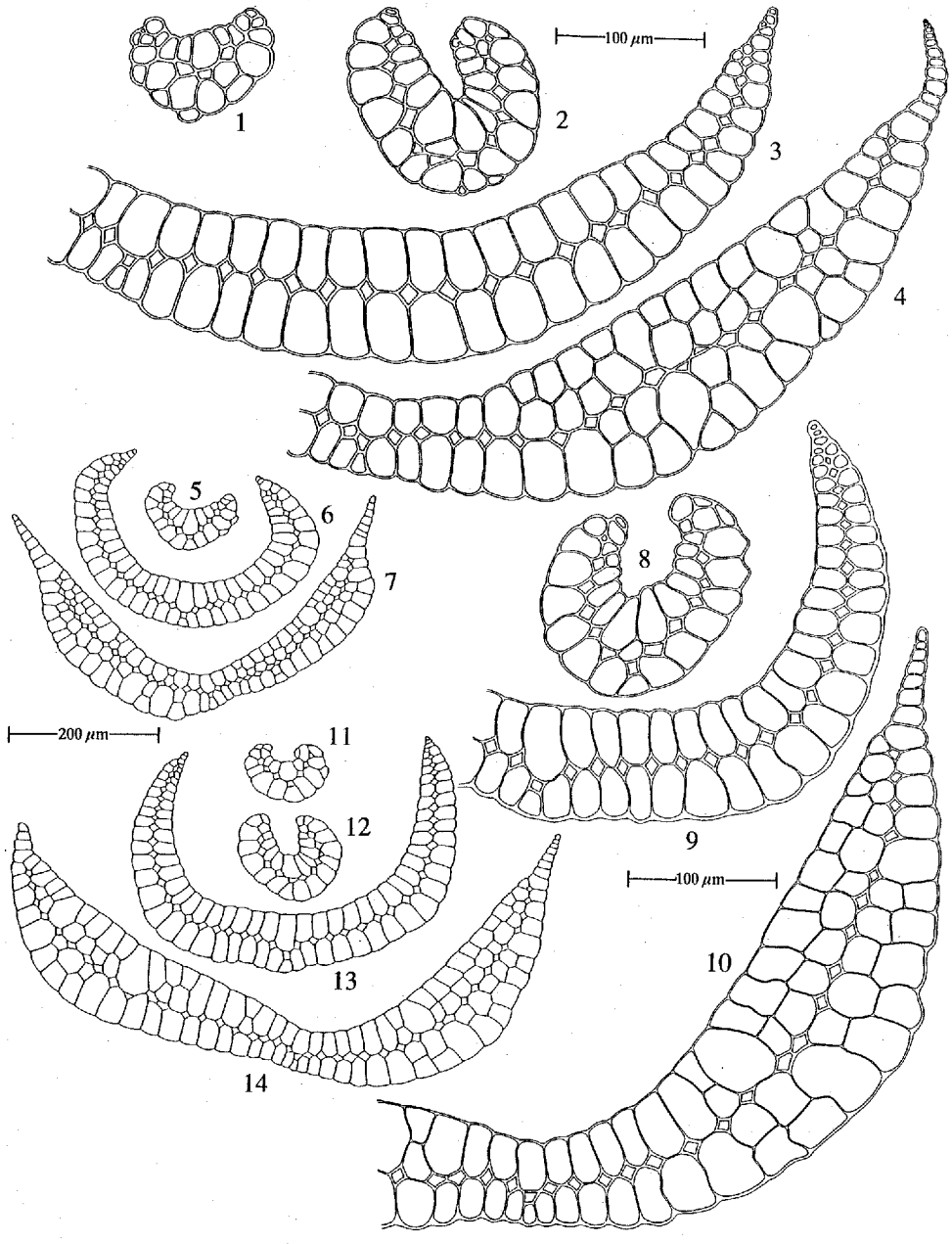

Figure CXIX. Leucobryum bowringii Mitt. 1–14. Cross-sections of leaves (1, 2, 5, 8, 11, 12, apical; 3, 6, 9, 13, median; 4, 7, 10, 14, basal portions). Figs. 1–4 were drawn from holotype of L. subsericeum (BM); 5–7, from isotype of L. confine (KYO); 8–14, from isotype of L. yamatense (NICH).

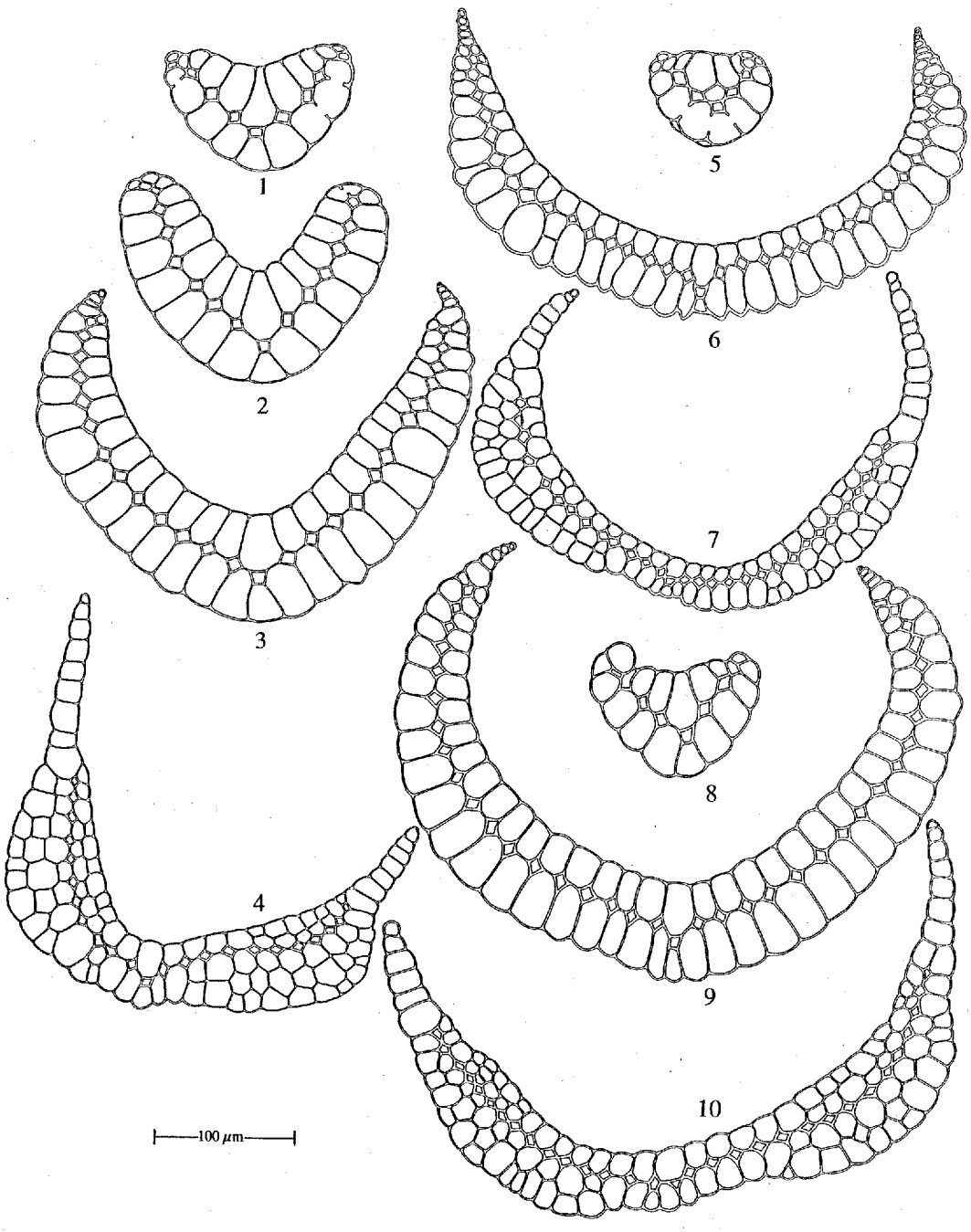

Figure CXX. Leucobryum bowringii Mitt. 1–10. Cross-sections of leaves (1, 2, 5, 8, apical; 3, 6, 9, median; 4, 7, 10, basal portions). Figs. 1–4 were drawn from isosyntype (Wright s. n.) of L. stenobasis (FI); 5–7, from isosyntype (Gollan s. n.) of L. stenobasis (FI); 8–10, from isotype of Ochrobryum ceylanicum (BM).

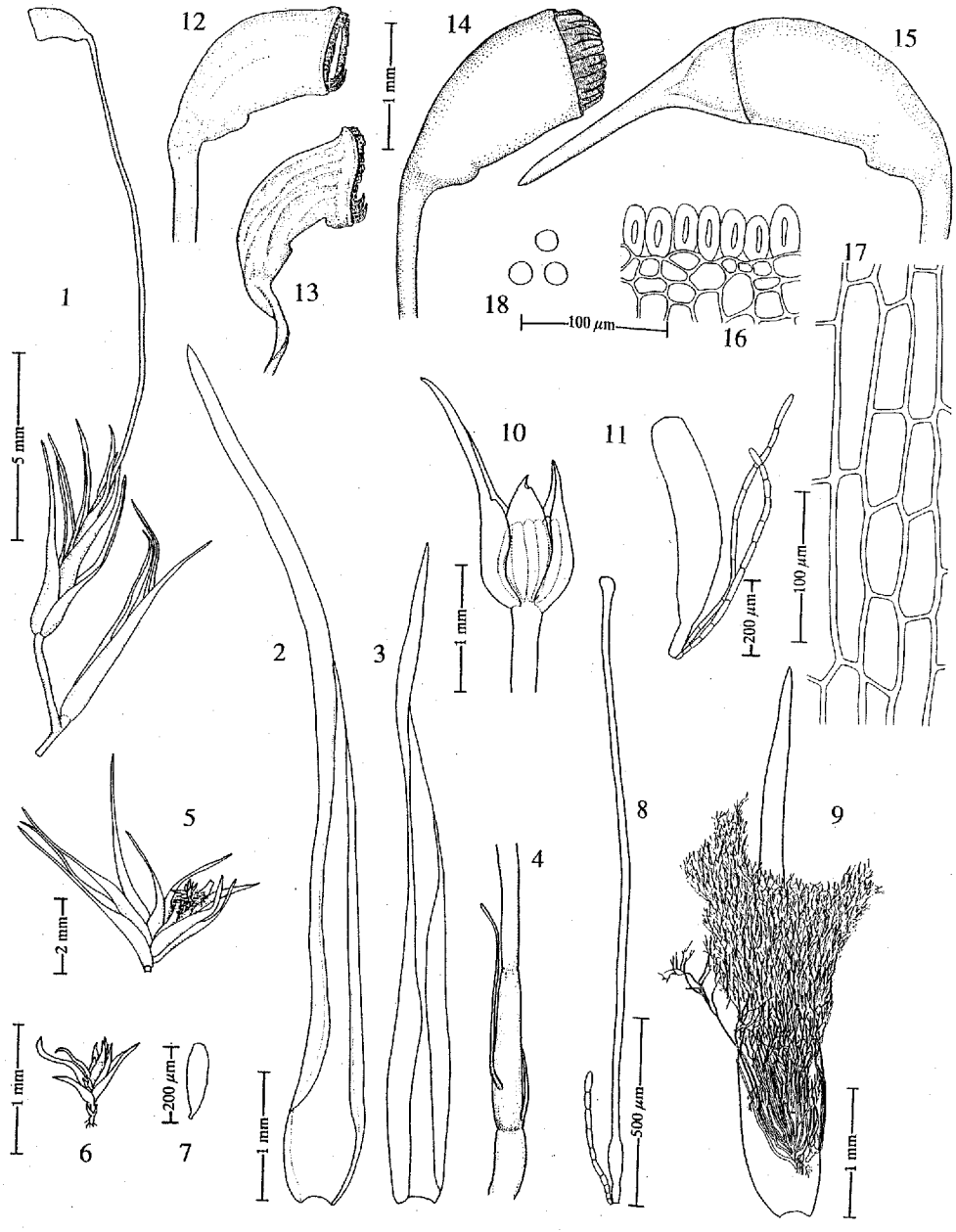

Figure CXXI. Leucobryum bowringii Mitt. 1. Perichaetium with sporophyte. 2. Stem leaf near perichaetium 1. 3. Inner perichaetial leaf from perichaetium 1. 4. Vaginula and archegonia. 5. Dwarf male plant growing on tomentum enclosed by perichaetial leaves. 6. Dwarf male plant. 7. Antheridium of dwarf male plant. 8. Archegonium. 9. Inner perichaetial leaf showing formation of tomentum on abaxial side. 10. Perigonium of normal male plant. 11. Antheridium of normal male plant. 12–15. Capsules. 16. Annulus. 17. Exothecial cells. 18. Spores. Figs. 1–7, 12, 13 were drawn from lectotype of L. bowringii (NY); 8, 10, 11, 15, from Yamaguchi 9313 (HIRO); 9, 14, 16–18, from Yamada 572 (NICH).

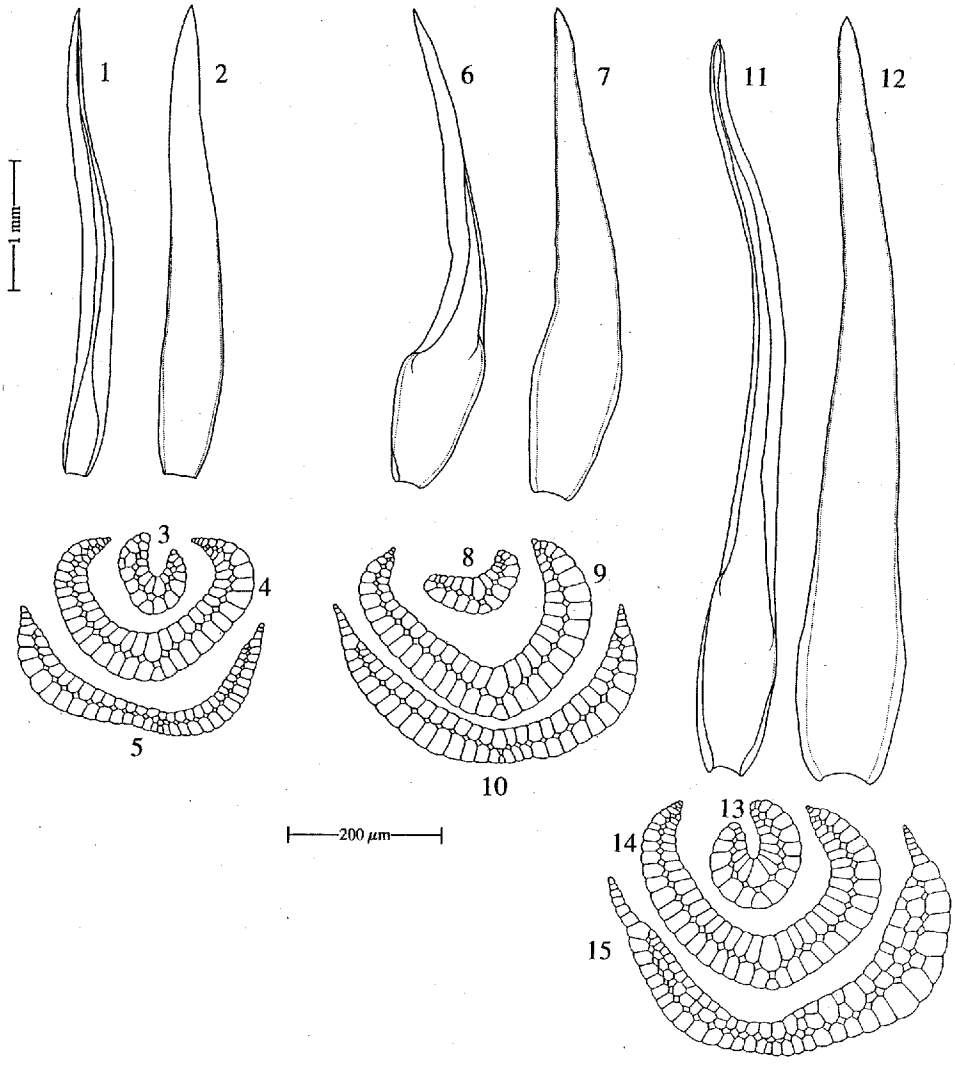

Figure CXXII. Leucobryum bowringii Mitt. 1–5. Deciduous leaves. 6–10. Ordinary leaves from branch. 11–15. Ordinary leaves from stem. 1, 2, 6, 7, 11, 12. Leaves (2, 7, 12, expanded). 3–5, 8–10, 13–15. Cross-sections of leaves (3, 8, 13, apical; 4, 9, 14, median; 5, 10, 15, basal portions). All figures were drawn from holotype of L. deciduum (PC).

(HIRO). Java, am Megamendong (Gedeh) an Bäumen, 1500 m alt., 25 Mar. 1899, Fleischer s. n. (Musci Archipelagi Indici ser. IV, no. 152, Leucobryum angustifolium Wils. n. var. macrophyllum Fl. in sched.) – isosyntype (HIRO).

Leucobryum deciduum Card. in Ren. & Card., Bull. Soc. R. Bot. Berg. 41(1): 42 (1905), syn. nov. Type: Vietnam, Tonkin, Dorr s. n. (in herb. Bescherelle, Leucobryum fragile Besch. in sched.) – holotype (PC).

Leucobryum stenobasis Card. in Ren. & Card., Bull. Soc. R. Bot. Belg. 41(1): 31 (1905), syn. nov. Type: India, N. W. Himalaya, below Kidarkanta, 9-10,000 ft. alt., 26 May 1881, Gollan s. n. – isosyntype (FI). Sri Lanka, Hinidoon Kanda hills, Oct. 1901, Wright 22 – isosyntype (FI).

Leucobryum confine Card., Beih. Bot. Centralbl. 19(2): 97, f. 4 (1905). Type: Taiwan, Kushaku, 6 June 1903, Faurie 111 – isotype (KYO).

Leucobryum subsericeum Dix., Hong Kong Natural. Suppl 2: 6, f. 2a (1933), syn. nov. Type: China, Kwangtung, Canton, White Cloud Mountain, 800 ft. alt., 26 Dec. 1930, Herklots s. n. (in herb. Dixon, ref. no. 302 B) – holotype (BM).

Plants whitish tinged with yellow when dry, usually lustrous, forming tufts. Stems to 60 mm long with leaves; central strand well differentiated in cross-sections of stems. Leaves erect to widely spreading, flexuose and

contorted above, 3.7-11.0 x 0.7-1.4 mm, lanceolate to linear lanceolate, acute, gradually narrowed to subtubulous point from oblong base, smooth on abaxial surface, weakly scabrous at tips due to minutely projecting leucocysts; laminae consisting of 5-9 rows of quadrate to rectangular cells near base, bordered by 2-3 rows of linear cells; laminae and borders near leaf shoulders consisting of 7-12 rows of narrowly rectangular to linear cells with thick and porous walls, the differentiation between laminal cells and border cells indistinct; abaxial leucocysts of costae usually thick-walled (Fig. CXIV: 3, 4); in cross-sections near leaf base leucocysts in 1-2 (-3) cell layers on both sides; abaxially exposed walls of leucocysts usually thick-walled in cross-sections (Fig. CXVIII: 1-4, 6-9); abaxial leucocysts hardly decurrent on stems.

Dioicous. Male plants dimorphous; dwarf male plants small, usually growing on tomentum enclosed by perichaetial leaves, often detached from tomenta and growing on or among female shoots; normal male plants independent, as large as female plants; perigonia small, bud-like, terminal on main stems and subfloral innovations. Perichaetia terminal on main stems and subfloral innovations, rarely on elongated lateral branches; inner perichaetial leaves around mature sporophytes 0.5-0.9 times longer than ordinary leaves near the perichaetia; archegonia 1.2-1.8 mm long. Setae 10-20 mm

long. Capsules horizontal to inclined, ovoid to ellipsoid; urns 1.1-1.8 mm long, 0.6-1.1 mm wide. Annulus of 1 row of cells. Apices of peristome teeth divided to 2/3 of the length, ca. 0.73 mm long, ca. 0.12 mm wide at base. Spores 15-20 μm in diameter.

Representative specimens examined: Japan, Japan, Honshu, Mie-ken, Ise Grand Shrine, Naigû, Nanzan, 12 Feb. 1961, Yamada 572 (NICH); Hoshu, Mie-ken, Watarai-gun, Omiya-cho, Takihara Shrine, 7 Jan. 1962, Yamada 729 (NICH); Kyushu, Yakushima Island, 400 m alt., June 1931(?), Kuwahara 841 (NICH); Ryukyu Islands, Okinawa Island, Mt. Yonaha, 210 m alt., 5 May 1986, Yamaguchi 9313 (HIRO). Taiwan, Taitum, 7 May 1903, Faurie 62 – duplicated original specimen of Leucobryum bowringii var. brevifolium Card., nom. nud. (KYO). China, Kwangtung, Ting-Wu Shan, 27 June 1980, Lin 104b (NICH); Hongkong, victoria Peak, Findlay Road, ca. 400 m alt., 13 June 1975, Touw 18898 (L). India, Mt. Khasia, Hooker and Thomson 1272, 1275 – paratypes of L. bowringii (NY). Sri Lanka, Kandy District, Knuckles, approach from Lebanon Estate, 12 Feb. 1978, Ruinard 12/98 (L). Thailand, Udawn, snadstone masive Phu(Mt.) Krading, 16°50'N 101°45'E, 1150-1200 m alt., 15 Jan. 1966, Touw 11074 (L). Cambodia, Province de Kampot, Poporkvil, ca. 1000 m alt., 4-6, Dec. 1964, Kira et al. 97 (HIRO). Vietnam, Prov. Hoa-binh, Montes Nui Bieu, 400 m alt., 5 Jan. 1966, Pócs 3147/a

(NICH). Philippines, Luzon, summit of Mt. Maquiling, 1000 m alt., 16 Dec. 1930, Herklots s. n., in herb. Dixon ref. no. 417a (L). Borneo, W Kalimantan, Gunung Palung nature Reserve, on Air Putih River, 20 km SE of Telukmelano, 1°15'S 110°05'E, 300-400 m alt., 17 Apr. 1985, Mori & Mitchell 17924 (L). Sulawesi, Mt. Roroka Timbu, summit, 0°30'S 119°30'-120°30'E, 2200 m alt., 15 May 1979, Balgooy 3357 (L). Sumatra, Mt. Korinchi, ravine of Sungai Kering, 2000 m alt., July 1956, Meijer B8853 (L). Java, Prov. Batavia, in monte Megamendong, ca. 1400 m alt., 5 Jan. 1894, Schiffner 10334 (L). Seram, Kecamatan Seram Utara, Sawai, Manusela National Park, along a trail between Wae Niniyoa and Wae Puo, ca. 1000 m alt., 3°00-03'S 129°14'E, 22 Jan. 1985, Akiyama 9634 (KYO, HIRO). New Guinea, Milne Bay District, Mt. Garatun, 4500 ft. alt., 11 June 1973, Cruttwell 60 (L). Solomon Islands, 20 July 1970, Robbins 4298 (L).

Habitat: On soil, humus, rocks and logs.

Distribution: Japan, Taiwan, China, Himalaya, India, Sri Lanka, Thailand, Cambodia, Vietnam, Malay Peninsula, Philippines, Borneo, Sulawesi, Sumatra, java, Seram, New Guinea, Solomon Islands.

The present species is characterized by (1) well differentiated central strand of stems, (2) lanceolate to linear lanceolate and usually lustrous leaves, (3) abaxial leucocysts with outer thick walls, (4) thick-walled laminal

and border cells at leaf shoulders, (5) perichaetia usually terminal on main stems or subfloral innovation, and (6) long archegonia up to 1.8 mm long.

The central strand of stems is sometimes weak or absent in juvenile plants of the present species. Plants of type specimens of L. stenobasis seem to be juvenile and have no central strand in stems (Fig. CX: 12, 13), but they are identical with L. bowringii because they have thick-walled marginal cells of leaves.

L. sumatranum is closely related to the present species, but differs in having long leaves (10.0-18.0 mm) and perichaetia terminal on short lateral branches.

L. sericeum is also similar to the present species in general appearance, but clearly differrentiated in having scabrous abaxial surface of leaves and perichaetia usually terminal on short lateral branches.

11. Leucobryum sumatranum Broth. ex Fl. (Fig. CXXIII, CXXIV, CXLII: 5)

Musci Fl. Buitenzorg 1: 149 (1904). Type: Sumatra, Tindjaulaoet, 3000 ft. alt, Nov. 1891, Micholitz 63 — holotype (FH), isotype (BM).

Leucobryum pulchrum Broth., Mitteil. Inst. Allg. Bot. Hamburg 7: 118 (1928). Type: Borneo, Bukit Raja, 1400 m

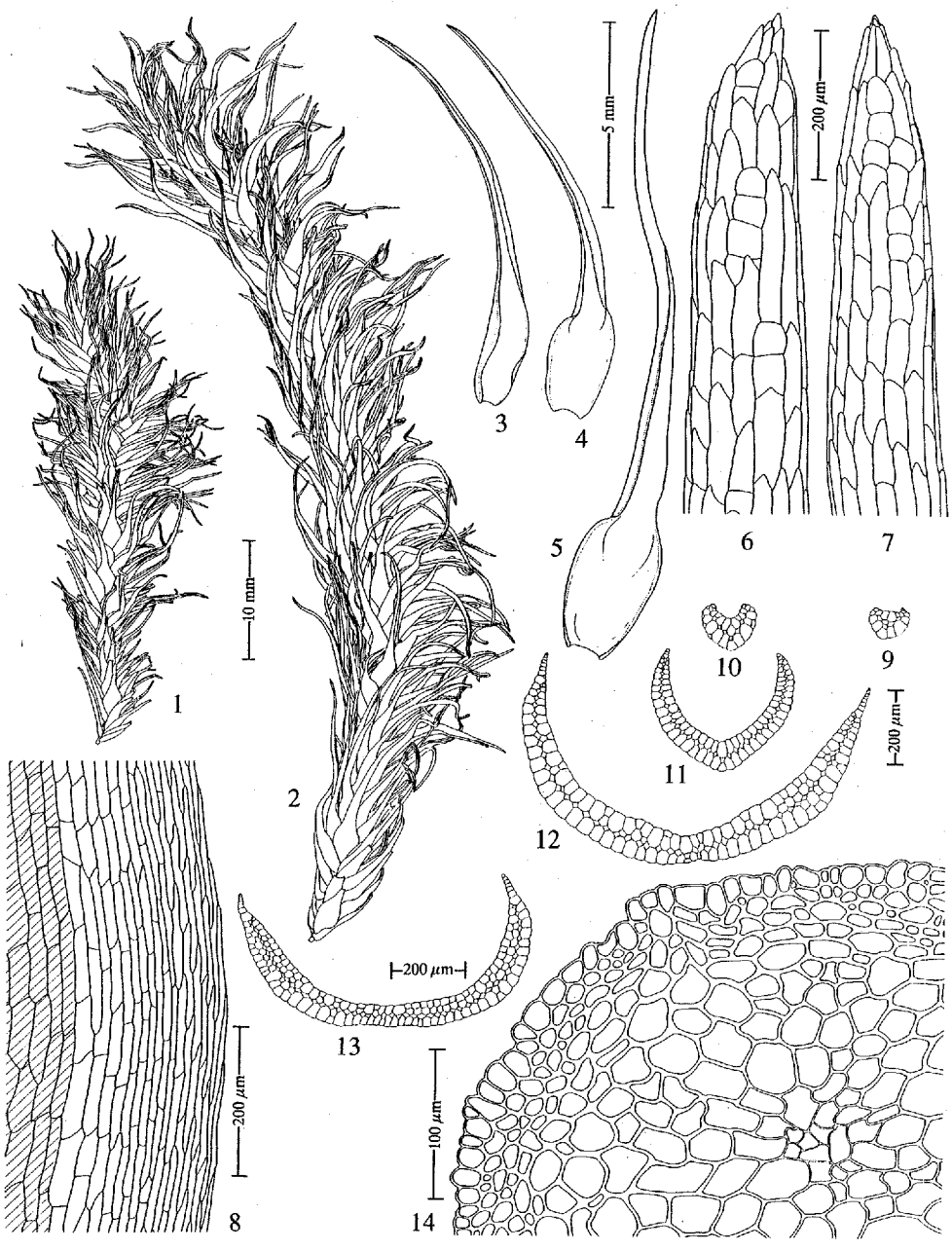

Figure CXXIII. Leucobryum sumatranum Broth. ex Fl. 1, 2. Plants. 3–5. Leaves. 6, 7. Leaf apices. 8. Basal cells of leaf (adaxial view). 9–13. Cross-sections of leaf (9, 10, apical; 11, median; 12, 13, basal portions). 14. Cross-section of stem. Figs. 1, 3, 4, 7, 9–14 were drawn from holotype of L. pulchrum (H); 2, 5, 6, from holotype of L. sumatranum (FH); 8, from Wilde & Wilde-Duyfjes 15066A (L).

Figure CXXIV. Leucobryum sumatranum Broth. ex Fl. 1. Branching showing position of perichaetia, and dwarf male plants growing on tomenta enclosed by perichaetial leaves. 2, 4. Dwarf male plants. 3, 5. Branching of dwarf male plants 2 and 4 respectively, showing position of perigonia. 6. Perichaetium with sporophyte. 7, 8. Stem leaves near perichaetium 6 (8, expanded). 9–13. Perichaetial leaves [expanded; numbers show the order of perichaetial leaves from the innermost leaf (number 13)]. 14. Perichaetium. 15. Antheridium. 16. Archegonium. All figures were drawn from Wilde & Wilde-Duyfjes 15066A (L).

alt., 21 Dec. 1924, Winkler 3196 – holotype (H), isotype (L).

Plants robust, whitish tinged with yellow when dry, usually lustrous, forming tufts. Stems to 120 mm long with leaves; central strand well differentiated in cross-sections of stems. Leaves erect to widely spreading, somewhat falcate secund, flexuose and contorted above; 10.0-18.0 x 1.5-2.5 mm, linear lanceolate, gradually narrowed to subtubulous point from oblong to ovate base, smooth on abaxial surface, weakly scabrous at tips due to minutely projecting leucocysts; anatomical structure of leaves similar to those of L. bowringii except for size and number of cell rows at marginal parts; laminae and borders at shoulder parts in 7-18 rows of narrowly rectangular to linear cells.

Dioicous. Dwarf male plants growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes ca. 0.3 times longer than ordinary leaves near the perichaetia; archegonia ca. 1.5 mm long. Setae 18-23 mm long. Capsules horizontal to inclined, ovoid to ellipsoid; urns 1.8-2.1 mm long, 0.9-1.0 mm wide.

Representative specimens examined: Payaly Peninsula, Pahang, Cemeron Highlands, 4800 ft. alt., 3 Apr. 1930,

Holttum 23381 (L); Selangor, G. Nuang, E. of Kuala Lumpur, ca. 4900 ft. alt., 23 Mar. 1960, Meijer B12226, B12277 (L). Borneo, Sarawak, 4th Division, Gunong Mulu National Park, G. Mulu, 4°05'N 114°55'E, 1320-1400 m alt., 27 May 1978, Touw 20909 (L); ditto, ca. 1900 m alt., 30 May 1978, Touw 21097 (L). Sumatra, Atjeh, Gunung Leuser Nature Reserve, Climbing Gunung Bandahara, ca. 6 km NE of Kampung Seldok (Alas Valley), ca. 25 km N of Kutatjane, ca. 1900 m alt., 20 Feb. 1975, Wilde & Wilde-Duyfjes 15066A (L).

Habitat: On humus and soil in mossy montane regions.

Distribution: Malay Peninsula, Borneo, Sumatra.

The present species is characterized by (1) robust plants, (2) long, linear and lustrous leaves, and (3) perichaetia terminal on short lateral branches.

This curious and beautiful species is quite similar to L. bowringii in many aspects, except for the robust habits and the formation of perichaetia terminal on short lateral branches.

12. Leucobryum sericeum Broth. ex Geh. (Fig. CXXV-CXXVII, CXLII: 3)

Biblioth. Bot. 44: 26, t. 4 (1898) = Leucobryum bowringii var. sericeum (Geh.) Dix., Ann. Bryol. 5: 24 (1932). Type: Borneo, Mt. Paojem, 1876, Teysmann (sub no. 11140) – holotype (H).

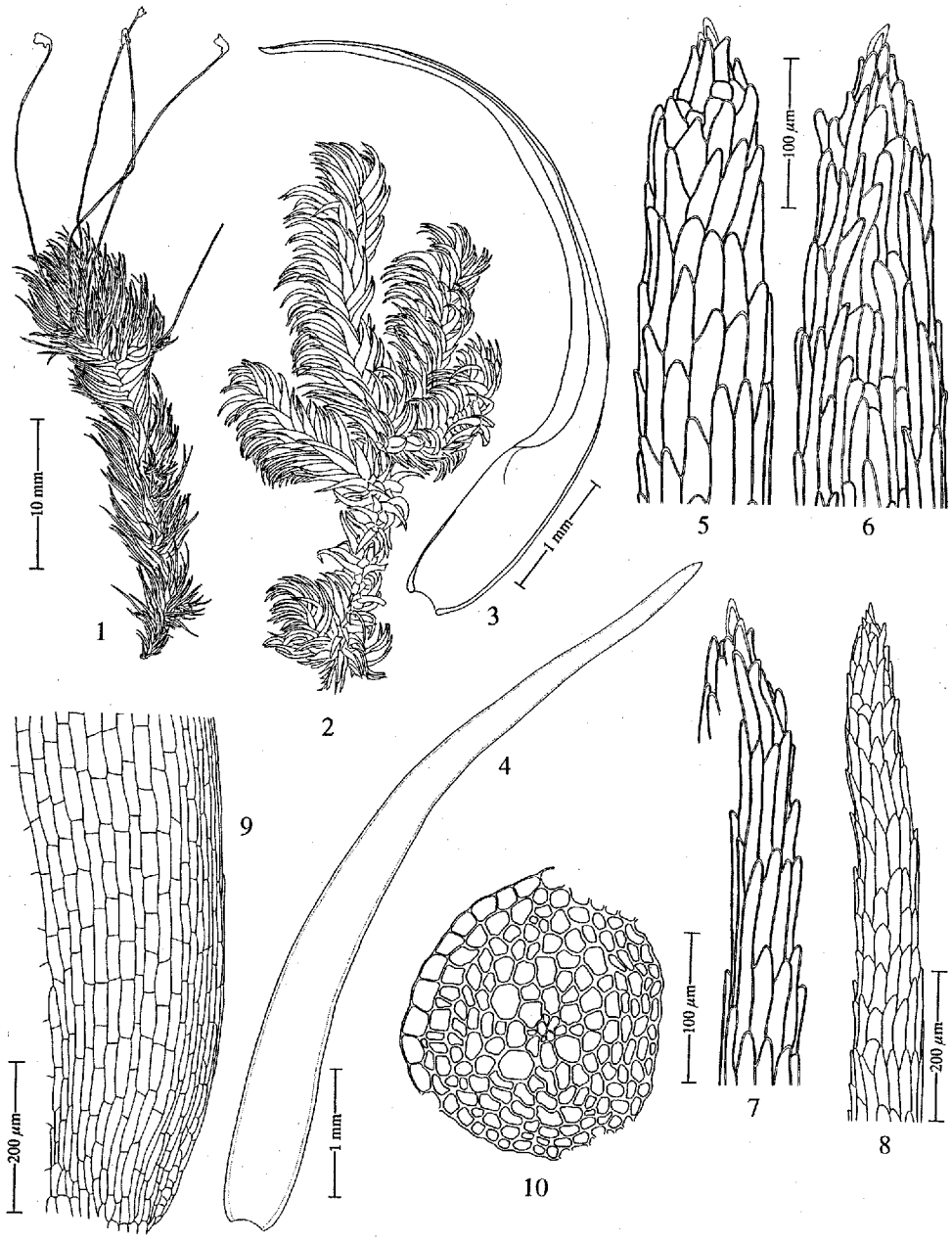

Figure CXXV. Leucobryum sericeum Broth. ex Geh. 1, 2. Plants. 3, 4. Leaves (4, expanded). 5–8. Leaf apices (6, adaxial view; 7, lateral view). 9. Leaf base (abaxial view). 10. Cross-section of stem. Figs. 1 was drawn from Deguchi 22292 (KOCHI); 2–10, from holotype of L. sericeum (H).

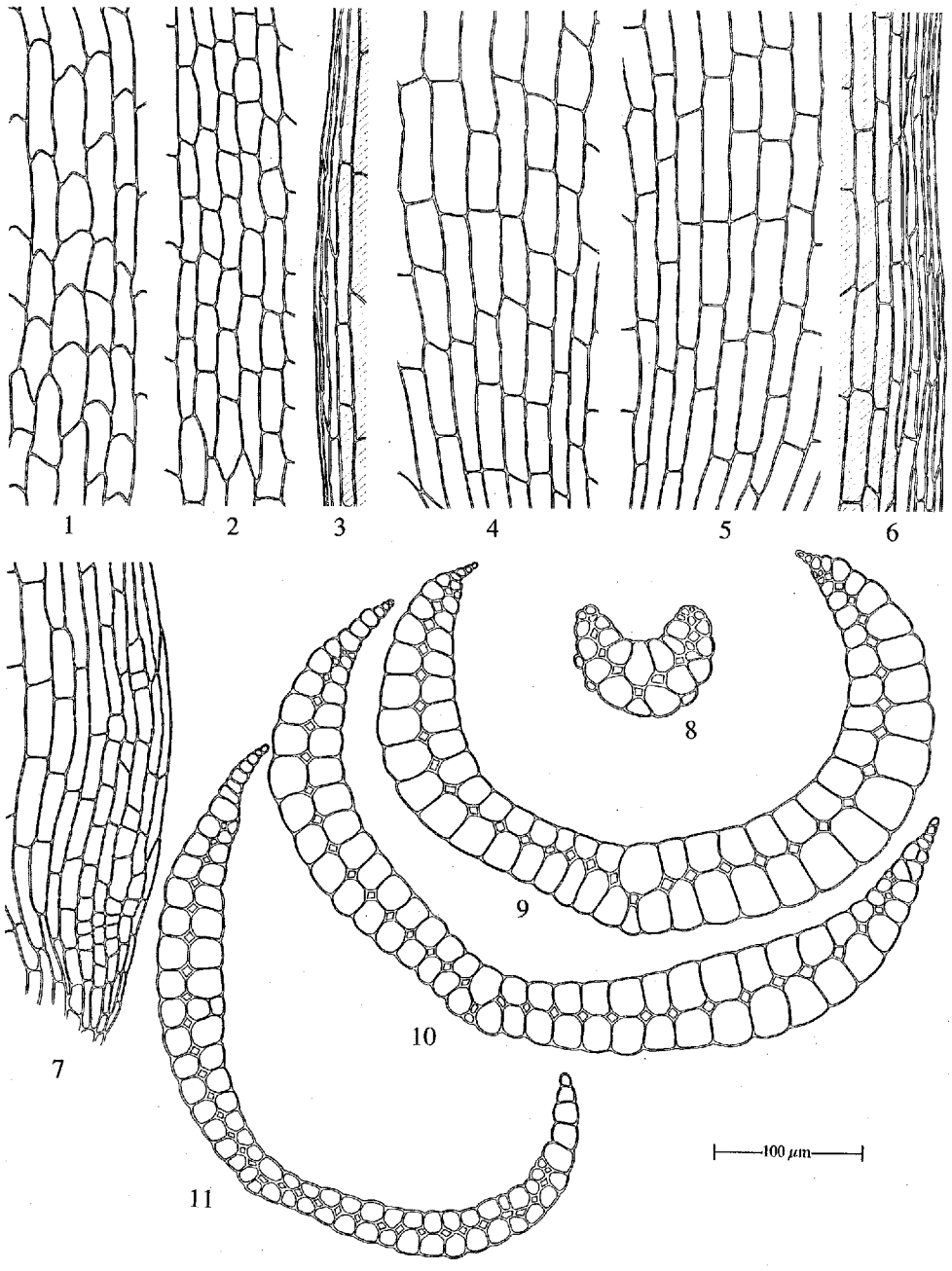

Figure CXXVI. Leucobryum sericeum Broth. ex Geh. 1–3. Median cells of leaf (1, 3, abaxial view; 2, adaxial view). 4–7. Basal cells of leaf (4, 7, abaxial view; 5, 6, adaxial view). 8–11. Cross-sections of leaf (8, apical; 9, median; ,10, 11, basal portions). All figures were drawn from holotype of L. sericeum (H).

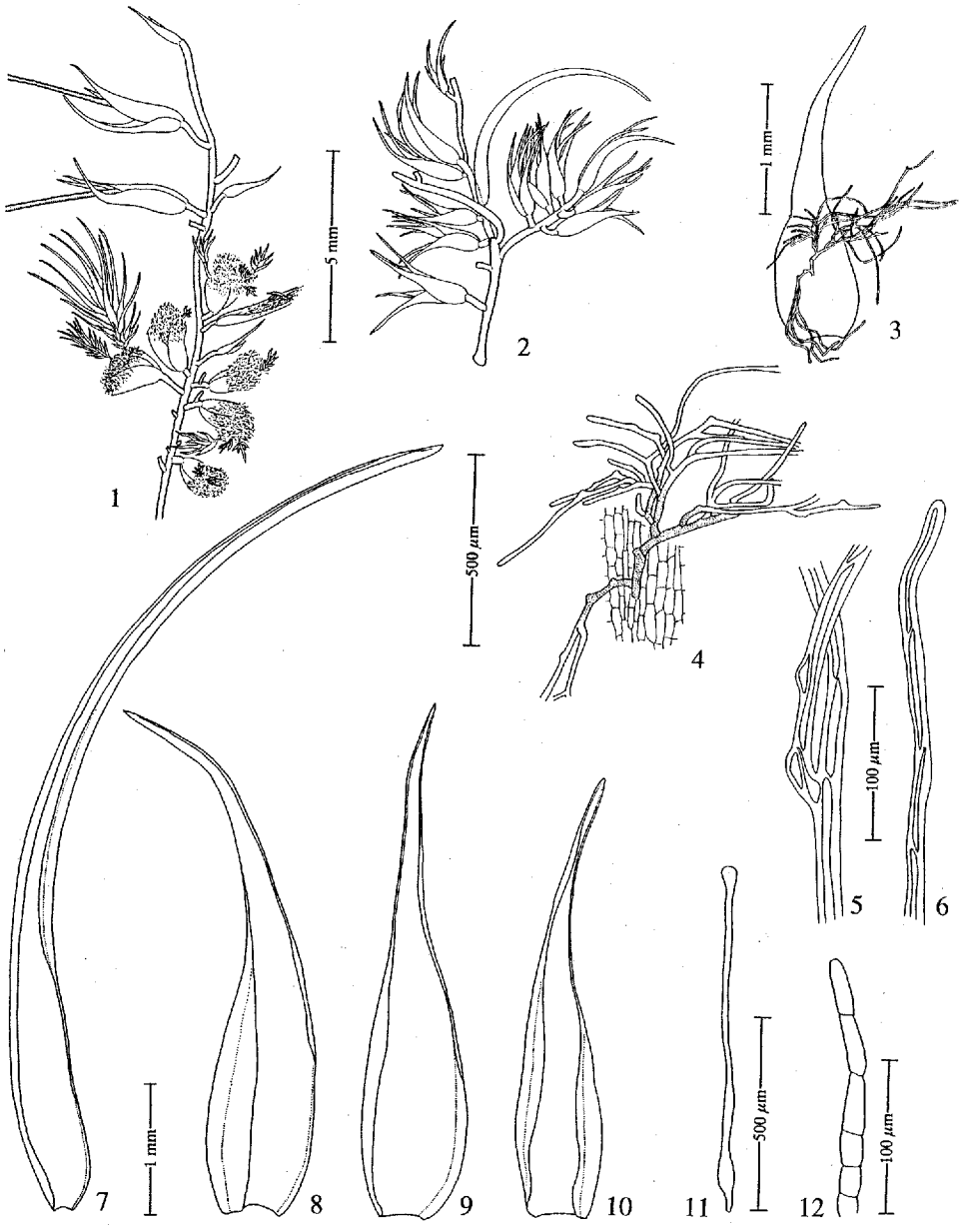

Figure CXXVII. Leucobryum sericeum Broth. ex Geh. 1, 2. Branching showing position of perichaetia (1, dwarf male plants growing on tomenta enclosed by perichaetial leaves). 3. Inner perichaetial leaf showing formation of tomentum on abaxial side. 4–6. Rhizoid on abaxial side of inner perichaetial leaf, which forms tomentum. 7. Stem leaf. 8–10. Perichaetial leaves [numbers show the order of perichaetial leaves from the innermost leaf (number 10)]. 11. Archegonium. 12. Paraphysis. Figs. 1, 7–10 were drawn from Deguchi 22292 (KOCHI); 2–6, from holotype of L. sericeum (H).

Plants whitish when dry, forming compact cushions. Stems to 35 mm long with leaves; central strand well differentiated in cross-sections of stems. Leaves strongly or slightly falcate secund; 6.5-7.4 x 0.5-0.7 mm, (shape), gradually narrowed to subtubulous point from oblong base, papillosely prorate from the apex to 1/10 of the leaf length on abaxial surface; laminae and borders consisting of 5-8 rows of narrowly rectangular to linear cells near base, the differentiation between laminal cells and border cells indistinct; in cross-sections near leaf base leucocysts almost in homostrosic, sometimes 2 cell layers on adaxial side; abaxial leucocysts hardly decurrent on stems.

Dioicous. Dwarf male plants growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia usually terminal on short lateral branches, sometimes terminal on stems; inner perichaetial leaves around mature sporophytes almost in half length of the ordinary leaves near the perichaetium; archegonia 0.9-1.0 mm long. Setae 23-24 mm long. Capsules inclined to horizontal, ovoid to ellipsoid; urns 1.2-1.3 mm long, ca. 0.8 mm wide.

Representative specimens examined: Philippines, Romblon, Romblon Prov., NW slope of Mt. Guitinguitin, near Barrio Jao-Asan, Sibuyan Island, 100-200 m alt., 12 Mar. 1980, Deguchi 22292 (KOCHI). Borneo, Sarawak, Kuching, Bako

Nat. Park, 1960, Meijer B12396 (L). Sulawesi, Powerstation Larona, 24 km from Malili, direction Soroako, 2°15'-3°S 121°-121°45'E, 18 June 1979, Hennipman 5924B (L). Seram, Kecamatan Kairatu, Tihulale, en route from the upper elevation to the top of Gunung(Mt.) Totaniwel, 3°29-31'S 128°30'E, 1100 m alt., 19 Aug. 1986, Akiyama 15833 (KYO, HIRO). Ambon, Liang, 3°31'S 128°18'E, 340 m alt., 13 July 1986, Akiyama 14251 (KYO, HIRO). Aru Islands, P. Wokam, Dosinamalaoe, 26 May 1938, Buwalda 5056 (L). New Guinea, Sorong, 15 Jan. 1950, Hellendoorn 93A (L).

Habitat: Usually on rotten logs, occasionally on tree trunks or tree base.

Distribution: Philippines, Borneo, Sulawesi, Seram, Ambon, Aru Islands, New Guinea.

The present species is characterized by (1) differentiated central strand of stems, (2) falcate linear leaves, (3) papillosely prorate abaxial surface of leaves at apical parts, (4) nearly homostrosic construction at leaf bases, and (5) perichaetia usually terminal on short lateral branches.

Because of the linear leaves the present species had been treated as L. bowringii var. sericeum by Dixon (1932b), or as a synonym of L. bowringii by Enroth (1989). However, L. sericeum and L. bowringii are clearly and easily

distinguished from each other by the proration of apical parts of leaves and the position of perichaetia.

13. Leucobryum sanctum (Brid.) Hampe (Fig. CXXVIII-CXXXIII, CXL: 3)

Linnaea 13: 42 (1839).

Basionym: Dicranum glaucum Hedw. var. sanctum Brid., Bryol. Univ. 1: 811 (1827). Type: Java, Blume s. n. – holotype (B).

Leucobryum auriculatum C. Müll. in Geh., Biblioth. Bot. 13: 2 (1889). Type: New Guinea, Fly River (Branch), Bauerlen (sub no. 149) – holotype (not seen).

Leucobryum papuense Par., Ind. Bryol.: 752 (1896). Type: New Guinea, 23 June 1875, Naumann s. n. – lectotype (H).

Plants whitish tinged with brown when dry, forming loose tufts. Stems to 70 mm long with leaves; central strand well differentiated in cross-sections of stems, the central strands consisting thin-walled small cells and surrounded with 2-3 rows of thin-walled large cells. Leaves widely spreading, somewhat squarrose (Fig. CXXVIII: 5); 5.3-7.1 x 1.0-1.5 mm, narrowly lanceolate to lanceolate, gradually narrowed to subtubulous point from oblong and clearly keeled base, acute to bluntly mucronate, papillosely prorate from the apex to 1/10 of the leaf length on abaxial

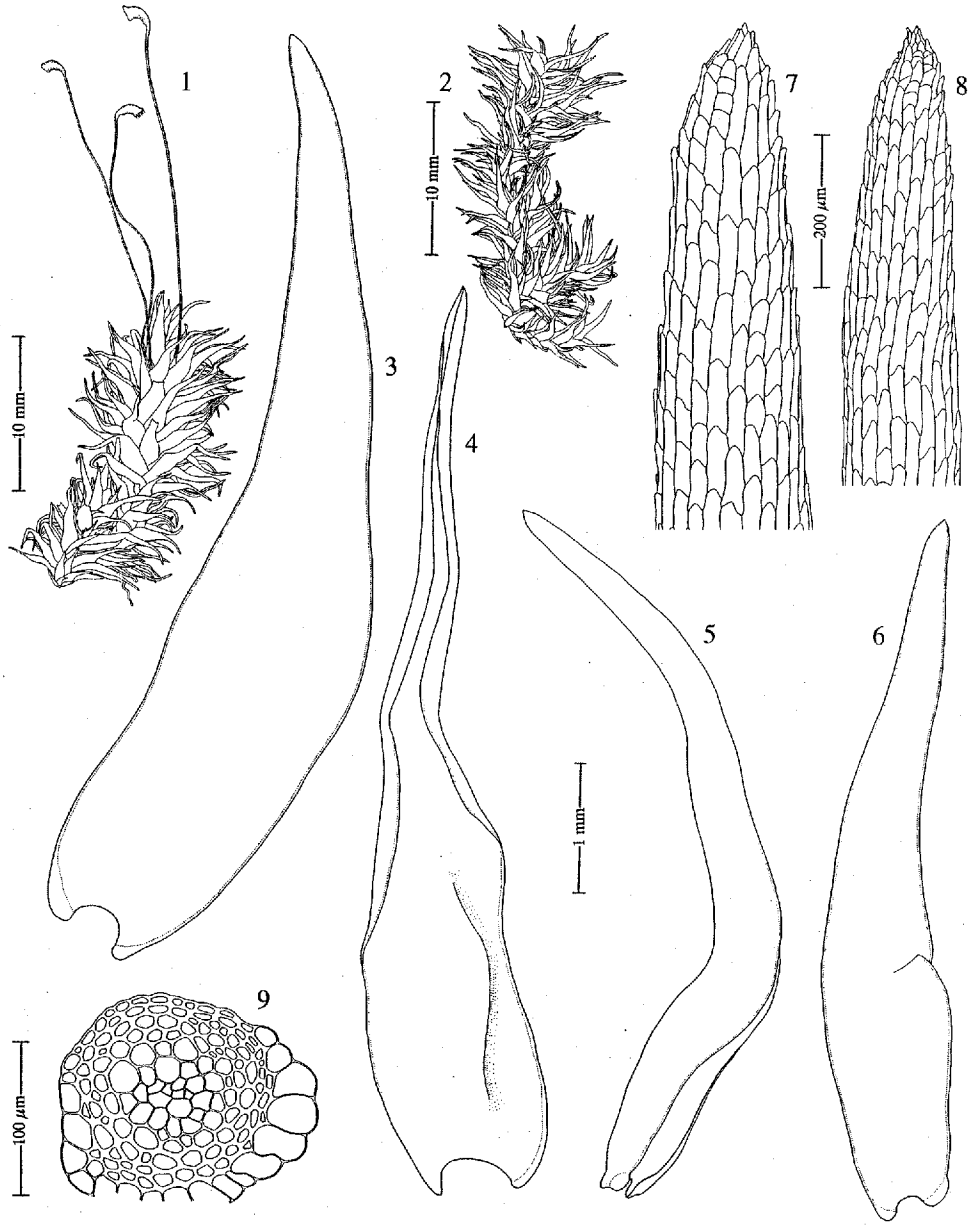

Figure CXXVIII. Leucobryum sanctum (Brid.) Hampe. 1, 2. Plants. 3–6. Leaves (3, 6, expanded). 7, 8. Leaf apices. 9. Cross-section of stem. Figs. 1, 4, 8 were drawn from holotype of Dicranum glaucum var. sanctum (B); 2, 5–7, 9, from lectotype of L. papuense (H); 3, from Hale & Banaag 25749 (NICH).

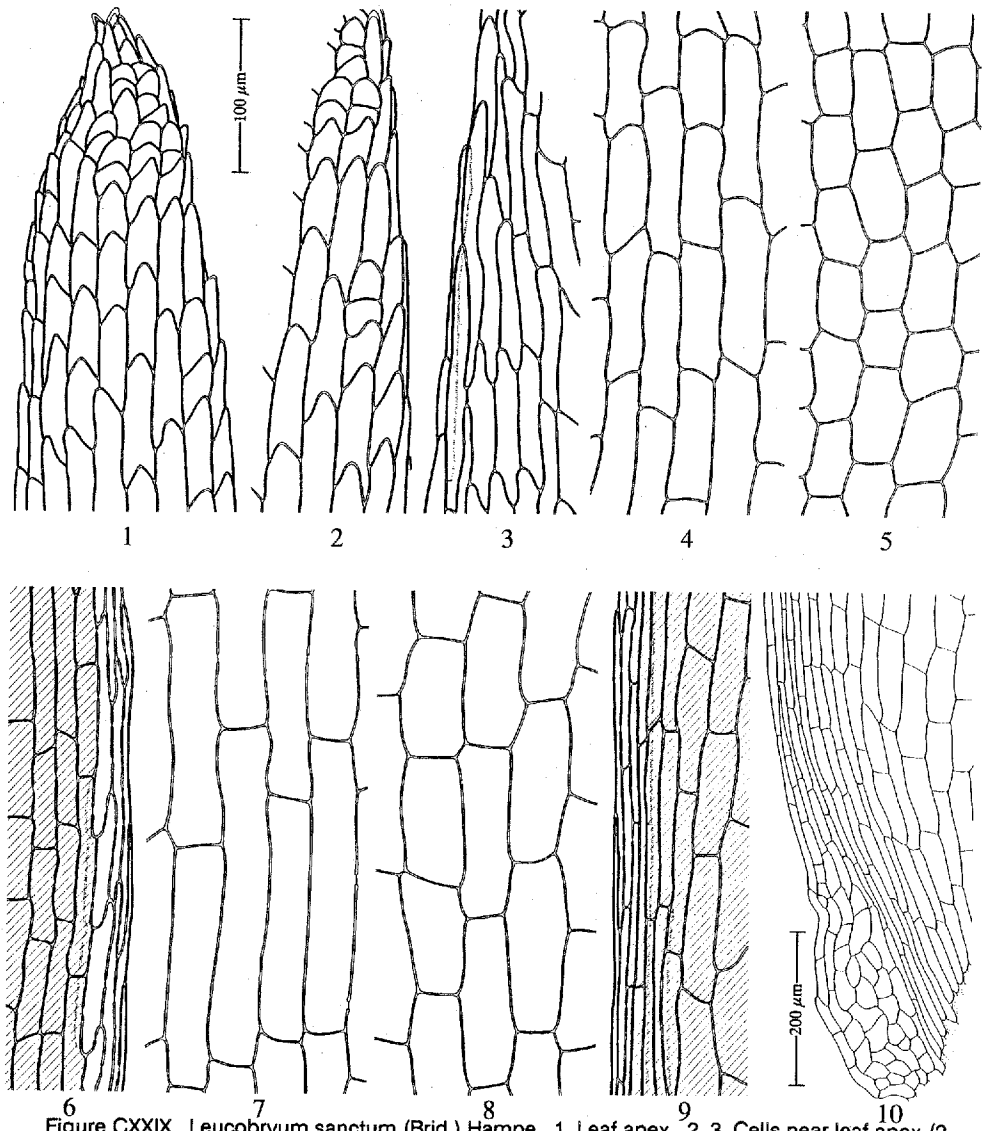

Figure CXXIX. Leucobryum sanctum (Brid.) Hampe. 1. Leaf apex. 2, 3. Cells near leaf apex (2, abaxial view; 3, adaxial view). 4–6. Median cells of leaf (4, 6, abaxial view; 5, adaxial view). 7–10. Basal cells of leaf (7, abaxial view; 8–10, adaxial view). All figures were drawn from holotype of Dicranum glaucum var. sanctum (B).

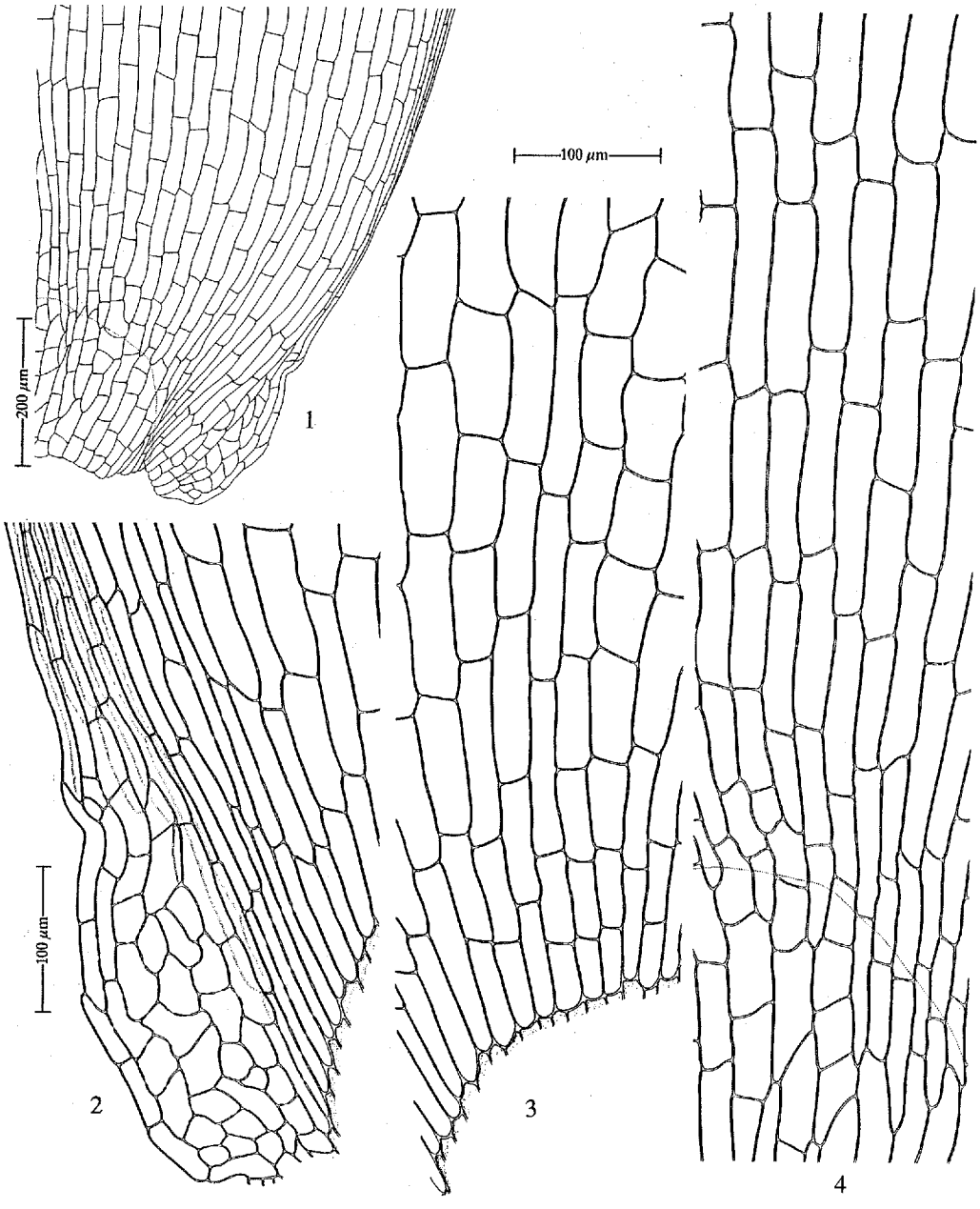

Figure CXXX. Leucobryum sanctum (Brid.) Hampe. 1–4. Basal cells of leaf (1, 4, abaxial view; 2, 3, adaxial view). All figures were drawn from holotype of Dicranum glaucum var. sanctum (B).

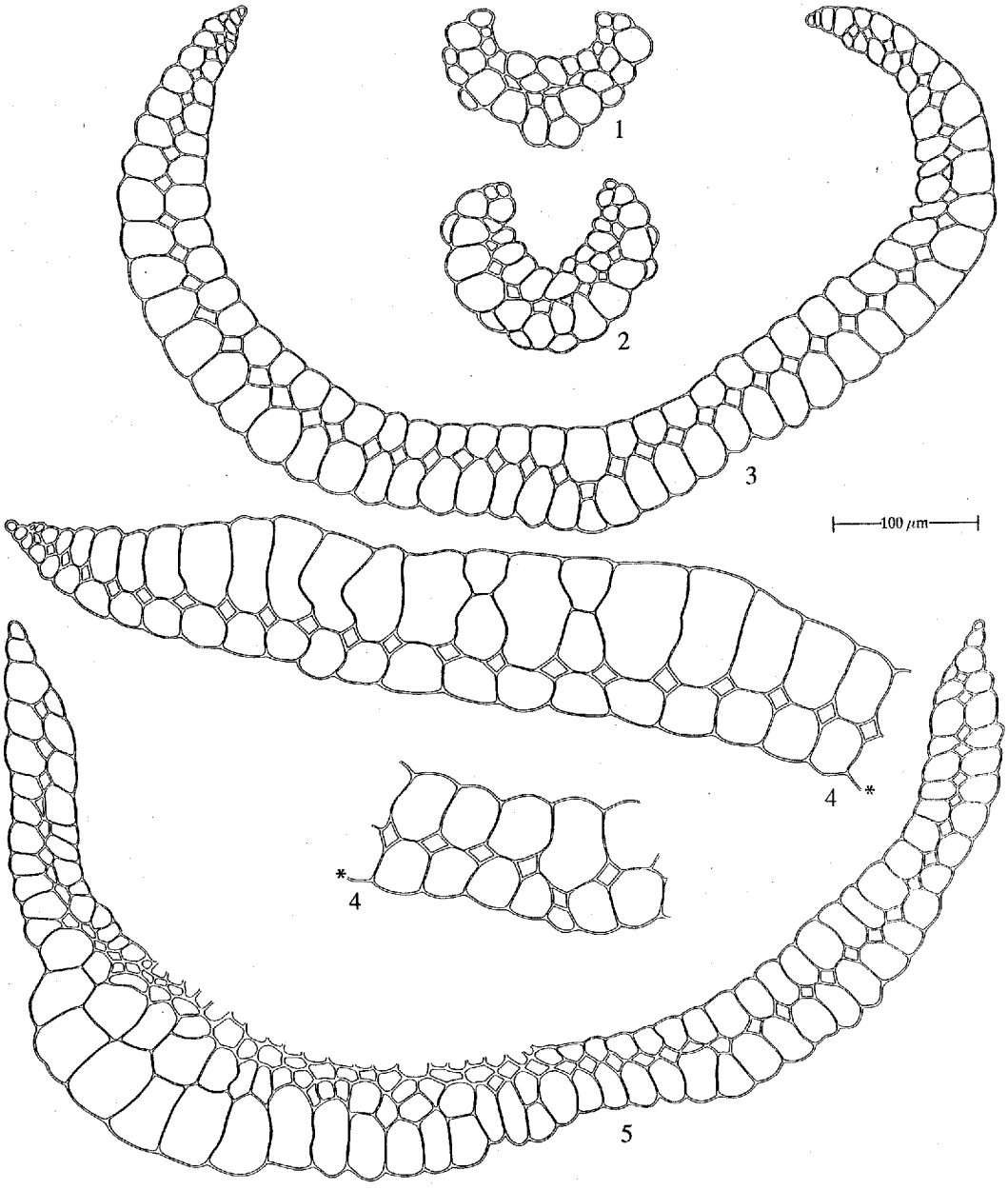

Figure CXXXI. Leucobryum sanctum (Brid.) Hampe. 1–5. Cross-sections of leaf (1, 2, apical; 3, median; 4, 5, basal portions). All figures were drawn from holotype of Dicranum glaucum var. sanctum (B).

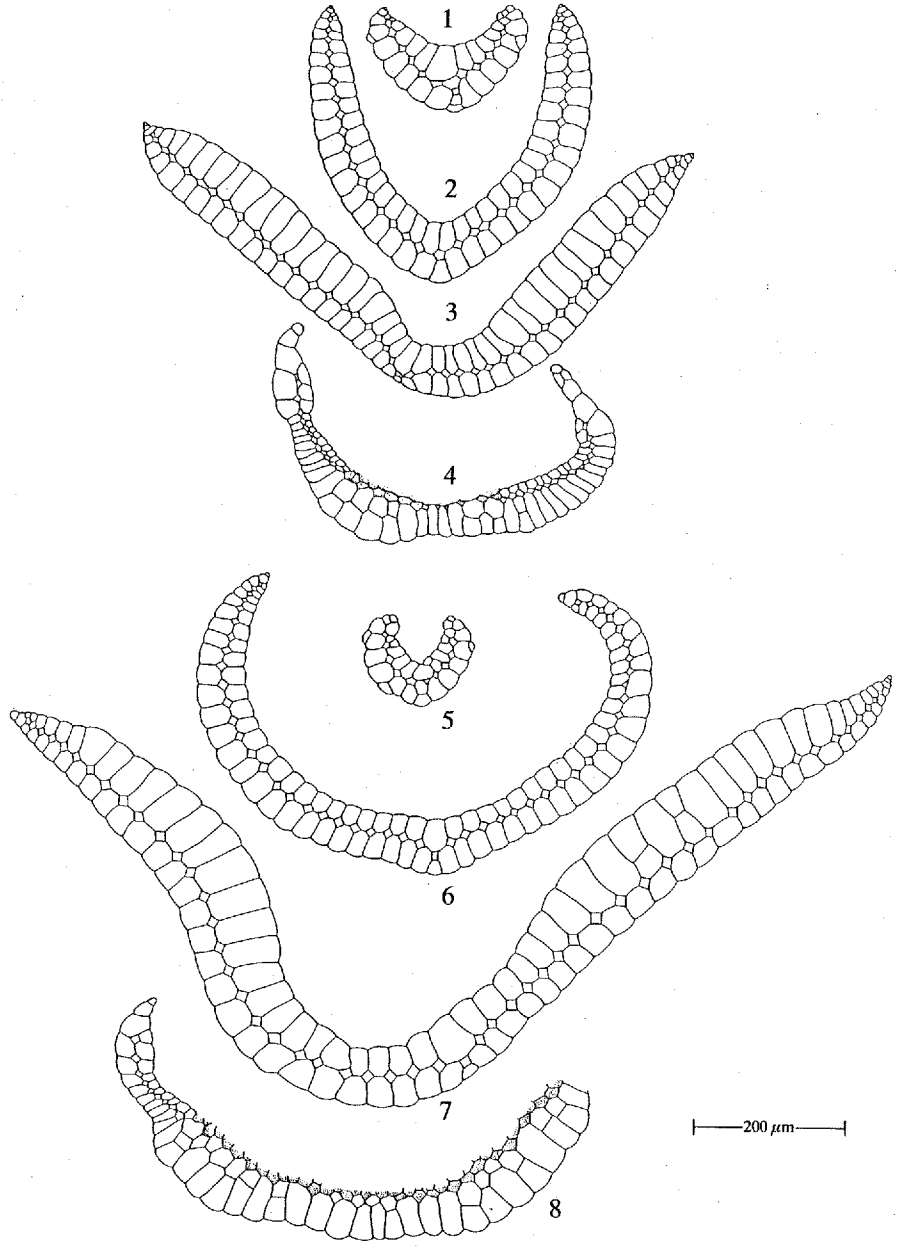

Figure CXXXII. Leucobryum sanctum (Brid.) Hampe. 1–8. Cross-sections of leaves (1, 5, apical; 2, 6, median; 3, 4, 7, 8, basal portions). Figs. 1–4 were drawn from lectotype of L. papuense (H); 5–8, from holotype of Dicranum glaucum var. sanctum (B).

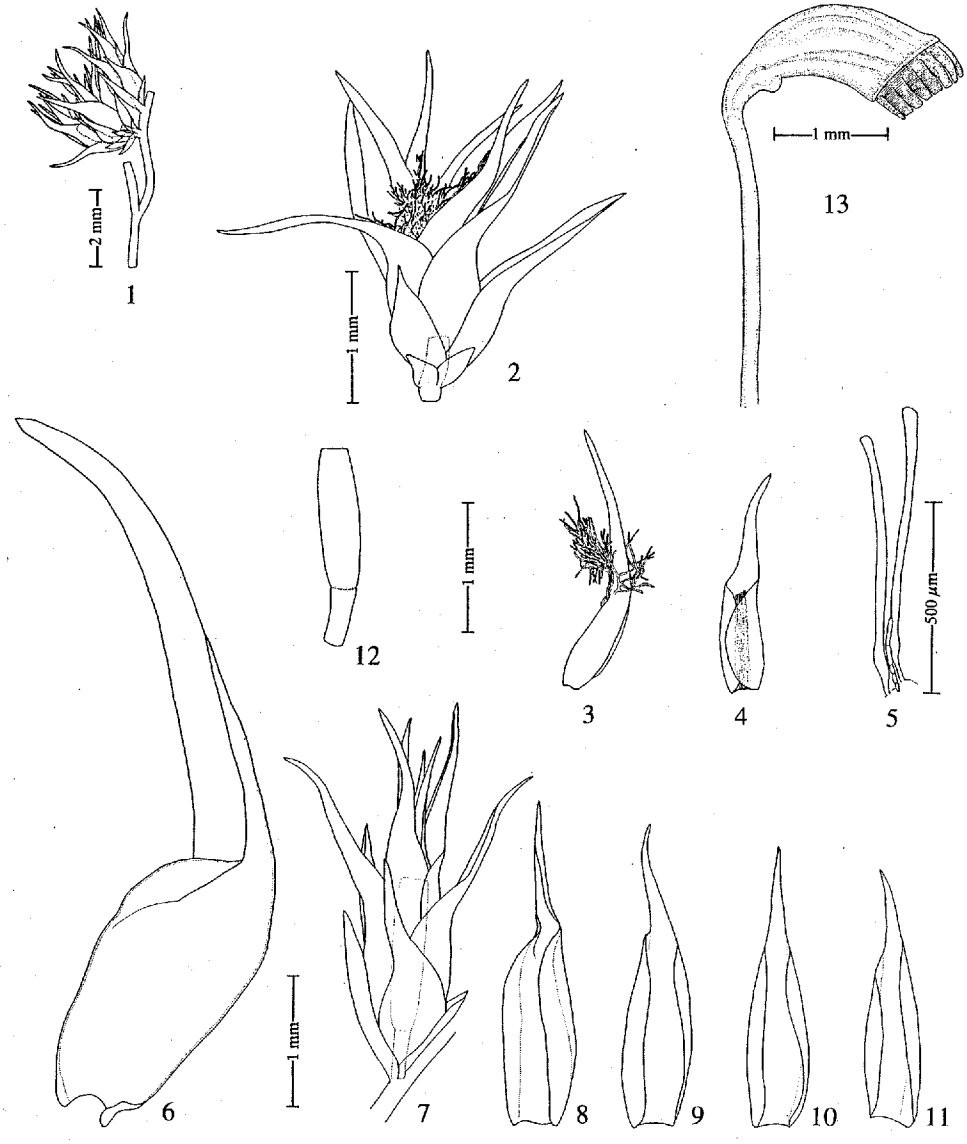

Figure CXXXIII. Leucobryum sanctum (Brid.) Hampe. 1. Branching showing position of perichaetia. 2. Perichaetium with tomentum. 3, 4. Inner perichaetial leaves(3, with tomentum on adaxial side) 5. Archegonia. 6. Stem leaf near perichaetium 7. 7. Perichaetium with sporophyte. 8–11. Inner perichaetial leaves from perichaetium 7 [numbers show the order of perichaetial leaves from the innermost leaf (number 11)]. 12. Vaginula. 13. Capsule. Figs. 1–12 were drawn from lectotype of L. papuense (H); 13, from holotype of Dicranum glaucum var. sanctum (B).

surface; laminae and borders consisting of 2-4 rows of narrowly rectangular to linear cells near base, the differentiation between laminal cells and border cells indistinct; abaxial leucocysts at leaf bases not subdivided, narrowly rectangular in surface view (Fig. CXXX: 4); alar parts distinctly auriculate (Fig. CXXX: 1, 2), consisting of 1 cell layered leucocysts; in cross-sections near leaf base chlorocysts distinctly in hypocentric, the leucocysts in 1-2 cell layers on adaxial side and 1 cell layer on abaxial side at the thickest part; abaxial leucocysts distinctly decurrent on stems; in cross-sections at insertional parts to stem usually 2 cell layers of leucocysts at the thickest part (Fig. CXXXI: 5, CXXXII: 4, 8).

Dioicous. Dwarf male plants growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes small, ca. 0.3 times longer than ordinary leaves near the perichaetia; archegonia ca. 0.7 mm long. Setae 25-30 mm long. Capsules horizontal, ellipsoid, strongly to slightly curved and asymmetrical, distinctly strumose (Fig. CXXXIII: 13); urns 1.3-1.5 mm long, ca. 0.8 mm wide.

Representative specimens examined: Thailand, Prachinburi, Khao Yai National Park, Kluey Mai (Orchid) Waterfall, 14°30'S 101°30'E, 650-680 m alt., 19 Feb. 1966,

Touw 12421 (L). Cambodia, Province de Koh Kong, Chékô, 11 Mar. 1965, Kira et al. 110a (HIRO). Malay Peninsula, Bukit Timar Nature Reserve, Taban Circle, 16 Apr. 1966, Sinclair 10885 (L). Philippines, Luzon, Cagayan Prov., ALSA logging area, south of Sta. Ana., ca. 100 m alt., July/Aug. 1964, Hale & Banaag 25749 (NICH). Borneo, E Kutai, Peak of B. papan, 200 m alt., 2 July 1952, Meijer B1345 (L). Nunukan Island, N of Tarakan, Nov./Dec. 1953, Meijer B4670 (L). Sulawesi, G. Paka-paka, Sept. 1913, Rachmat 681 (L). Sumatra, Ketambe, valley of Lau Alas, near tributary of Lau Ketambe, ca. 35 km NW of Kutatjane, 200-400 m alt., 5 Feb. 1975, Wilde & Wilde-Duyfjes 14528 (L). Enggano Islands, between Kajaäpoe and Kiah, 5°25'S 102°15'E, 4 July 1936, Lütjeharms 5396 (L). Mentawei Islands, N. Pagai, Sikakap, 7 July 1953, Borssum Waalkes & Pleyte 2890 (L). Banka Island, S. selan, Bt. Raja, Nov. 1917, Bünnemayer 2010 (L). Lesser Sunda Islands, W. Flores-Manggarai, 12 Mar. 1981, Schmutz 4851 (L). Seram, Kecamatan(District) Bula, Gunung(Mt.) Simfakan, 3°14'S 130°32-33'E, 10-100 m alt., 2 Mar. 1985, Akiyama 10839 (KYO, HIRO). New Guinea, Vogelkop Peninsula, Tamrau Range, Gunung Bagimata, 0°40'S 132°40'E, 1250-1500 m alt., 1 Jan. 1978, Zon s. n. (L). Woodlark Island, S. Selan, Bt. Raja, Nov. 1917, Bünnemayer 2010 (L). Caroline Islands, Ponape, Mt. Ninanri, 2550 ft. alt., 17 Aug. 1949, Glassman 2887 (L).

Habitat: On soil, humus, rocks and logs.

Distribution: India, Thailand, Cambodia, Malay Peninsula, Philippines, Borneo, Sulawesi, Sumatra, Java, Lesser Sunda Islands, Seram, New Guinea, Caroline Islands, Fiji.

The present species is characterized by (1) well differentiated central strand of stems composed of small thin-walled cells and surrounded with large thin-walled cells, (2) widely spreading somewhat falcate secund leaves, (3) clearly keeled basal parts of leaves, (4) papillosely prorate abaxial surface of apical parts of leaves, (5) distinctly auriculate alar parts of leaves, (6) hypocentric position of chlorocysts in cross-sections near leaf bases, and (7) perichaetia terminal on short lateral branches.

L. neo-caledonicum Duby ex Besch. from New Caledonia is closely related to L. sanctum and L. arfakianum, but differs in having distinctly hypocentric chlorocysts at leaf apices in cross-sections and absence of auriculate alar parts. The distinctions between L. sanctum and L. arfakianum will be discussed under the latter species.

14. Leucobryum arfakianum C. Müll. ex Geh. (Fig. CXXXIV-CXXXVIII, CXLI: 5)

Biblioth. Bot. 44: 5, t. 3 (1898) = Leucobryum sanctum var. arfakianum (C. Müll. ex Geh.) A. Eddy, Malesian Mosses 2:

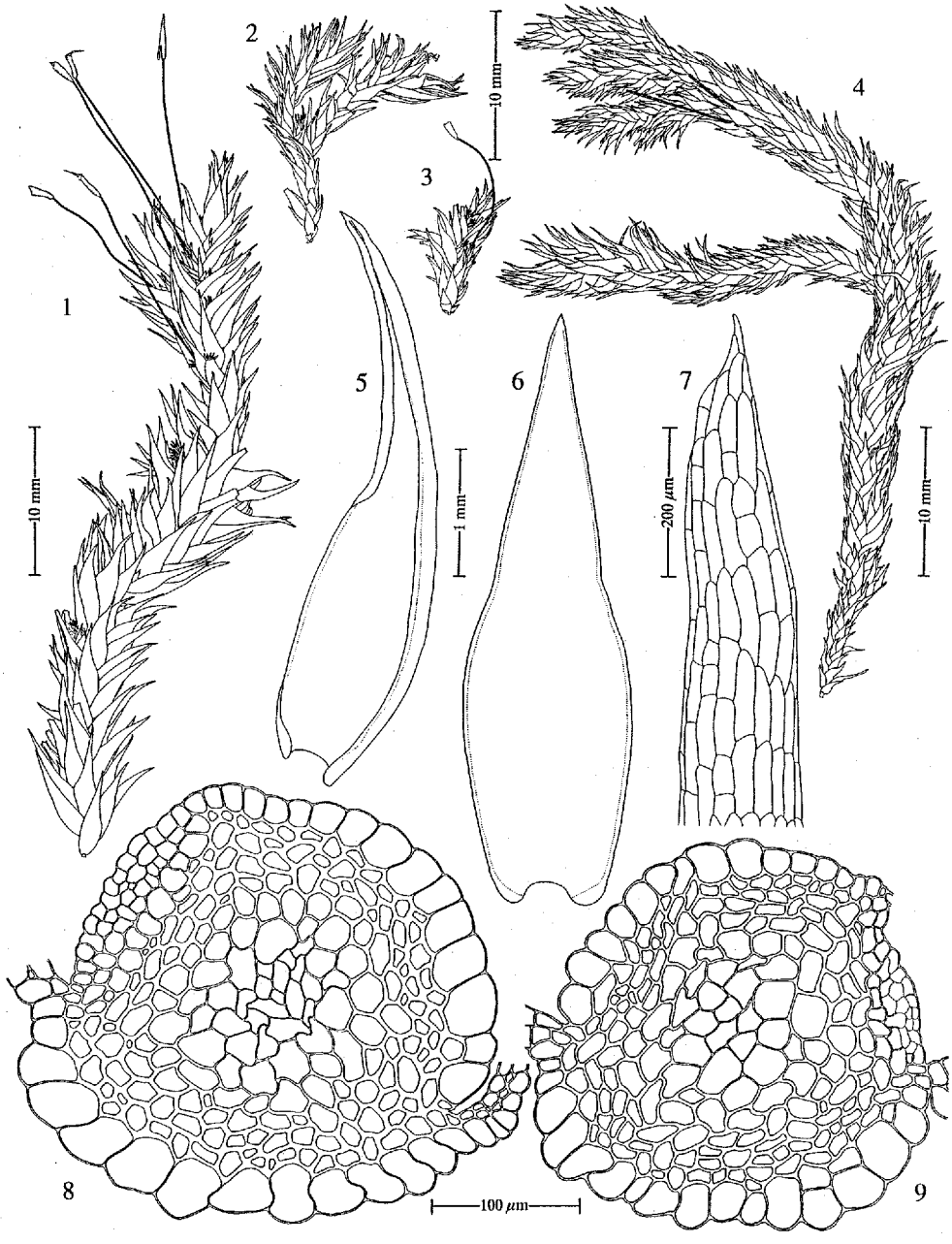

Figure CXXXIV. Leucobryum arfakianum C. Müll. ex Geh. 1–4. Plants. 5, 6. Leaves (6, expanded). 7. Leaf apex. 8, 9. Cross-sections of stems. Fig. 1 was drawn from lectotype of L. subsanctum (H); 2, 3, from Loria s. n., in hb. C. Müller 743, labeled as L. brevisetum (H); 4–7, 9, from isolectotype of L. arfakianum (Fl); 8, from holotype of L. papuense var. pendulum (L).

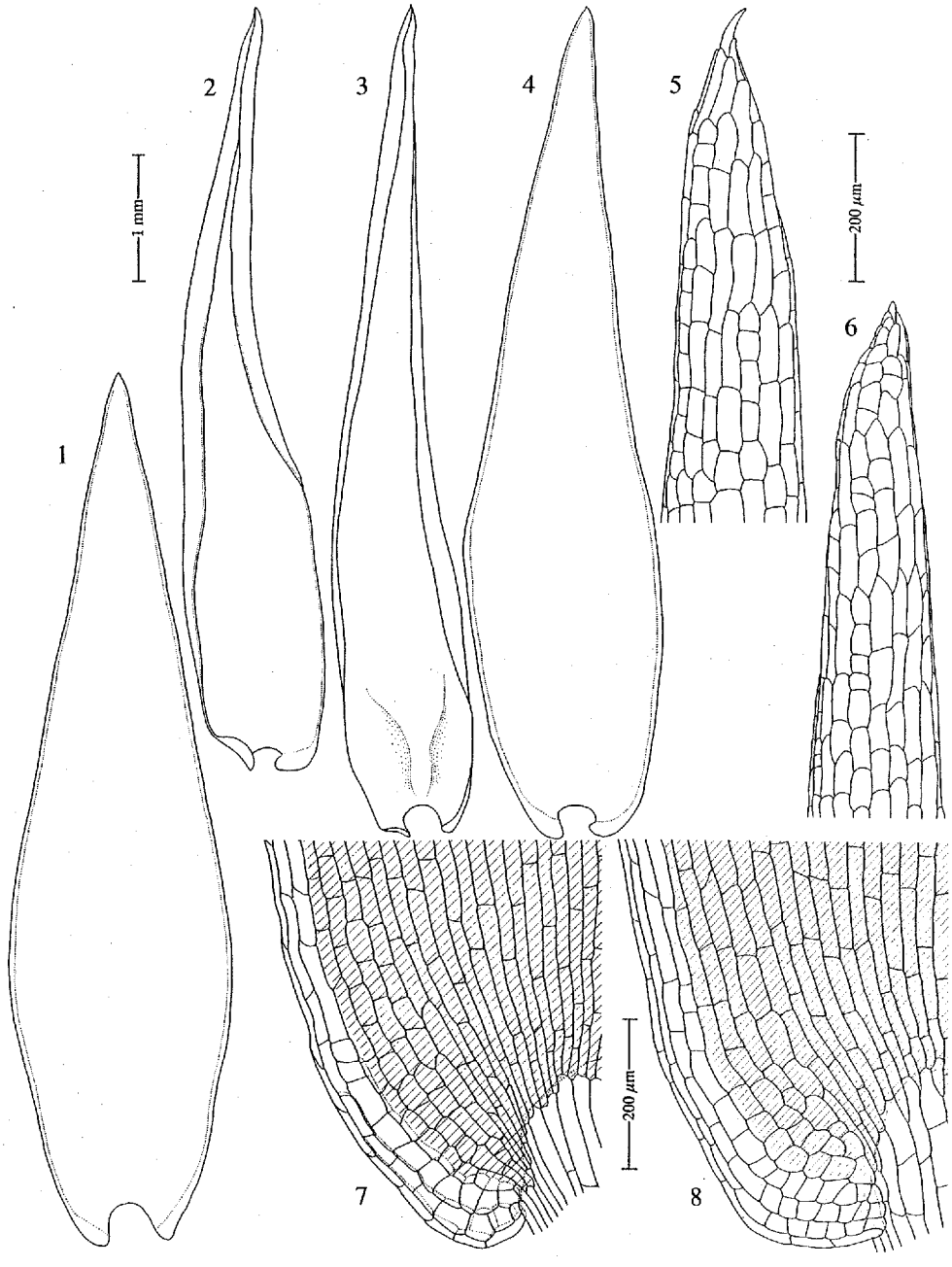

Figure CXXXV. Leucobryum arfakianum C. Müll. ex Geh. 1–4. Leaves (1, 4, expanded). 5, 6. Leaf apices. 7, 8. Leaf bases (abaxial view). Figs. 1 was drawn from lectotype of L. subsanctum (H); 2, 6, from Loria s. n., in hb. C. Müller 743, labeled as L. brevisetum (H); 3–5, 7, from holotype of L. papuense var. pendulum (L); 8, from isolectotype of L. arfakianum (FI).

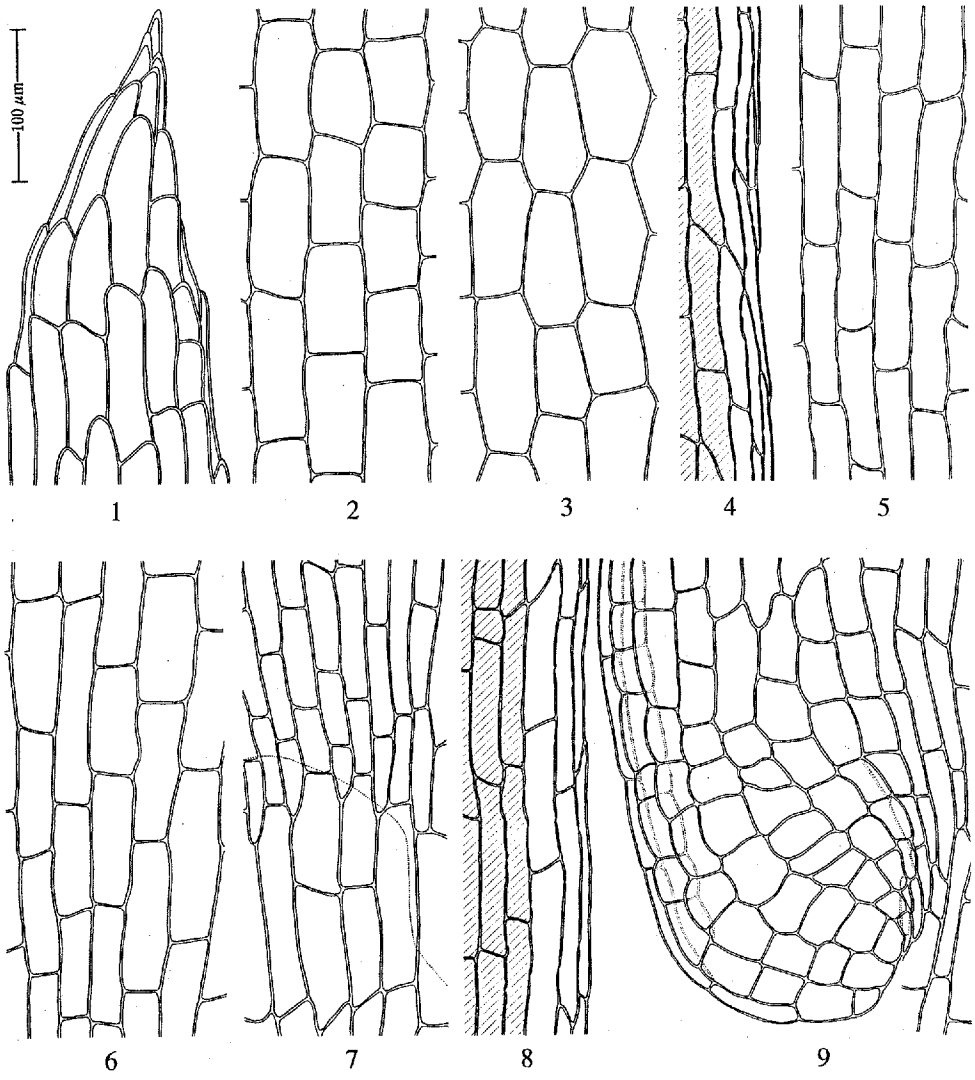

Figure CXXXVI. Leucobryum arfakianum C. Müll. ex Geh. 1. Leaf apex. 2–4. Median cells of leaf (2, 4, abaxial view; 3, adaxial view). 5–9. Basal cells of leaf (5, 7–9, abaxial view; 6, adaxial view). All figures were drawn from isolectotype of L. arfakianum (FI).

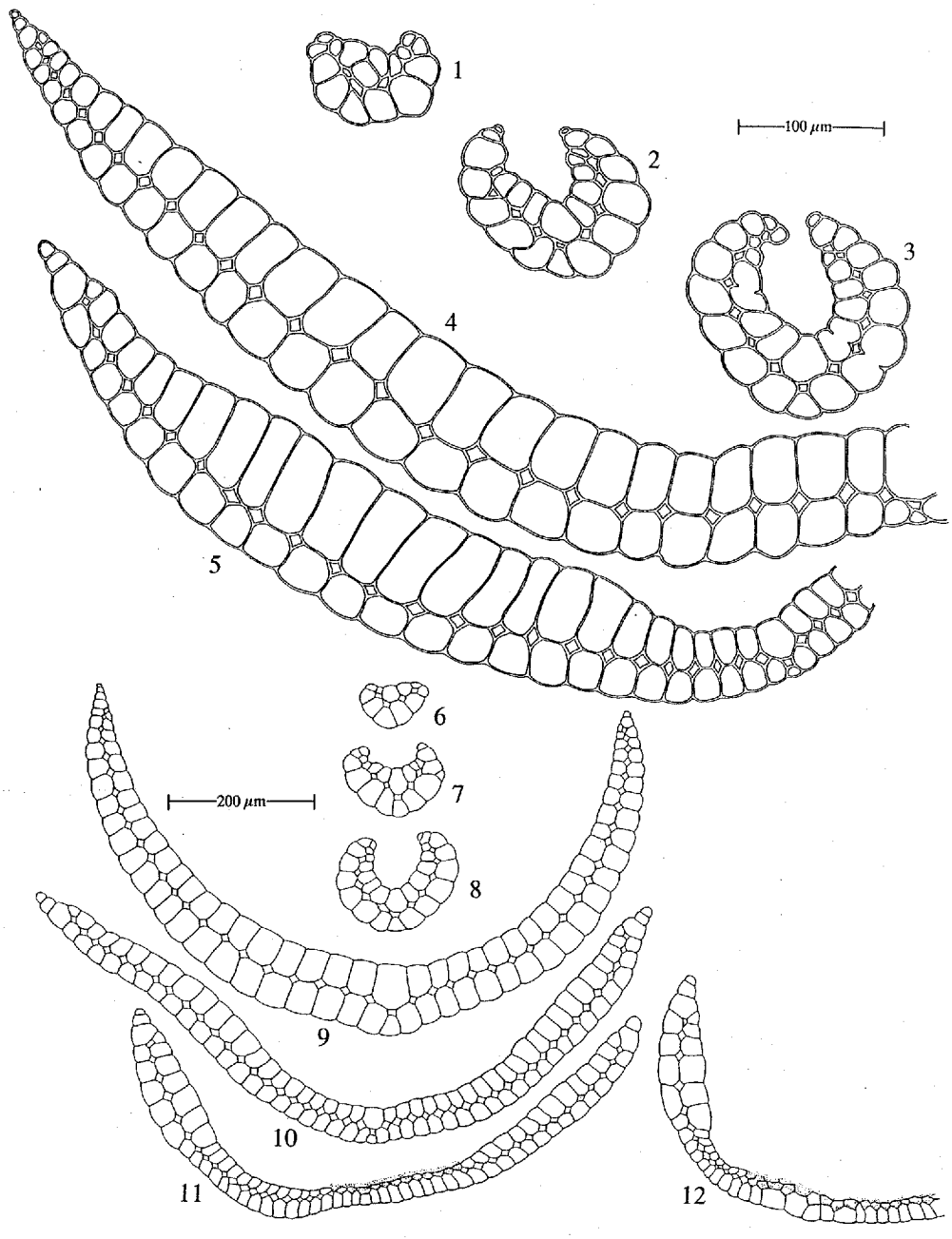

Figure CXXXVII. Leucobryum arfakianum C. Müll. ex Geh. 1–12. Cross-sections of leaves (1–3, 6–8, apical; 4, 9, median; 10–12, basal portions). All figures were drawn from isolectotype of L. arfakianum (FI).

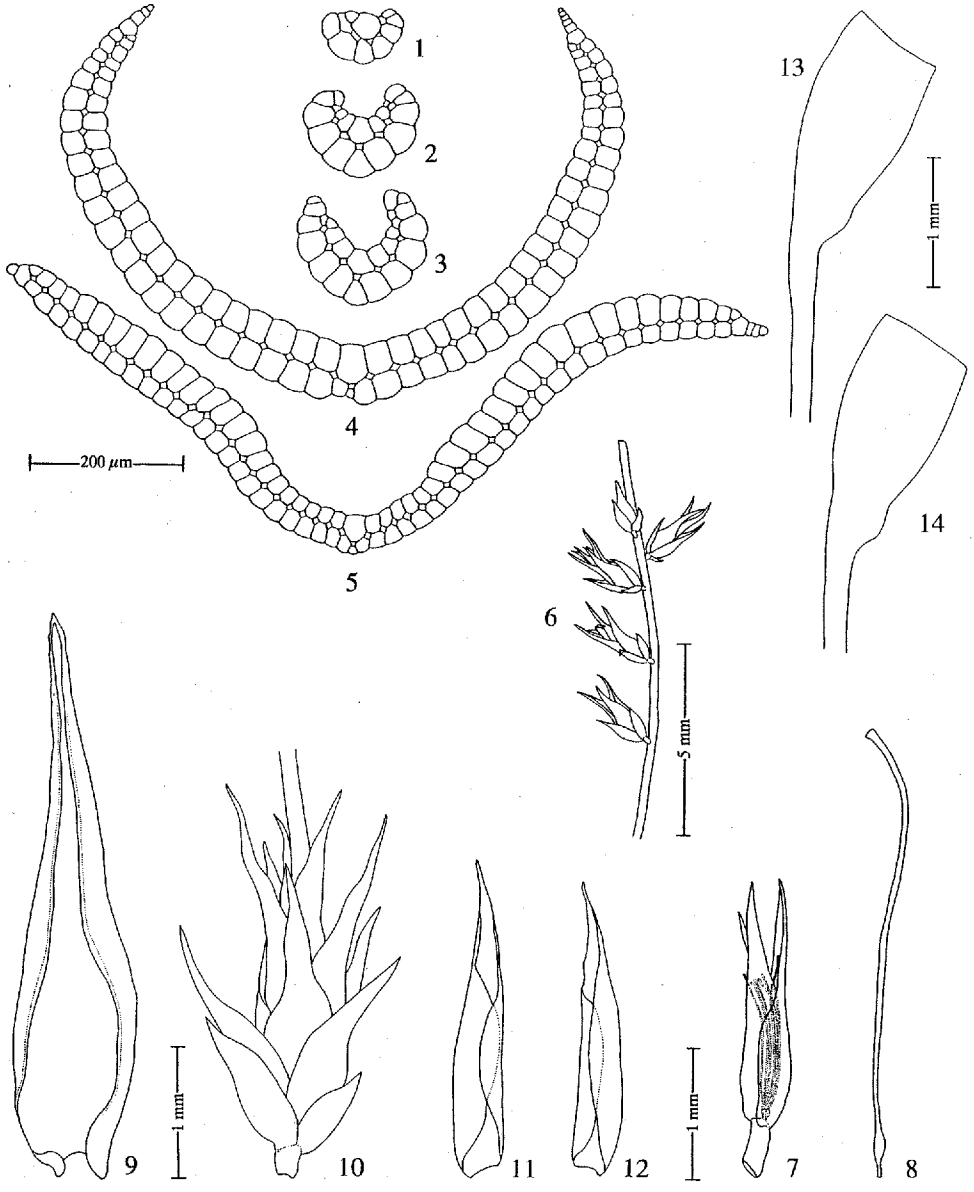

Figure CXXXVIII. Leucobryum arfakianum C. Müll. ex Geh. 1–5. Cross-sections of leaf (1–3, apical; 4, median; 5, basal portions). 6. Branching showing position of perichaetia. 7. Perichaetium. 8. Archegonium. 9. Stem leaf near perichaetium 10. 10. Perichaetium with sporophyte. 11, 12. Inner perichaetial leaves from perichaetium 10. 13, 14. Capsules. Figs. 1–8 were drawn from holotype of L. papuense var. pendulum (L); 9–12, from isolectotype of L. arfakianum (FI); 13, 14, from lectotype of L. subsanctum (H).

15, f. 173 (1990). Type: New Guinea, Mt. Arfak ad Hatam, 5-7000 ft. alt., July 1875, Beccari 163 – isolectotype (FI).

Leucobryum subsanctum Broth., Philipp. J. Sc. 2: 339 (1907). Type: Philippines, Mindoro, Mt. Halcon, 6500 ft. alt, on cliffs, Nov. 1906, Merrill 6161 – lectotype (H). Philippines, Luzon, Province of Bataan, summit of Mt. Mariveles, on trees, Oct. 1903, Merrill 3540, 3549 – paratypes (H). Philippines, Mindoro, Mt. Halcon, 4500 ft. alt., on prostrate logs, Nov. 1906, Merrill 6208 – paratype (H).

Leucobryum papuense var. pendulum Zant., Nova Guinea, Botany 16: 275 (1964). Type: New Guinea, Star Mts., Mt. Antares, bivouac 40, 2400 m alt., in hollow trunk of tree in mossy forest, pendulous, 18 July 1959, Zanten 621 – holotype (L), isotype (NICH).

Plants whitish tinged with brown when dry, usually pendulous from tree trunks or rarely from rock cliffs. Stems to 60 mm long with leaves; central strand well differentiated in cross-sections of stems, the central strands consisting thin-walled small cells and surrounded with 2-3 rows of thin-walled large cells. Leaves appressed to erect spreading; 4.1-6.6 x 1.1-1.7 mm, lanceolate, gradually narrowed to subtubulous point from oblong and weakly keeled base, acute, smooth on abaxial surface at apical parts; laminae and borders consisting of 2-6 rows of

narrowly rectangular to linear cells near base, the differentiation between laminal cells and border cells indistinct; abaxial leucocysts at leaf bases not subdivided, narrowly rectangular in surface view; alar parts auriculate, consisting of 1 cell layered leucocysts; in cross-sections near leaf base chlorocysts distinctly in hypocentric, the leucocysts almost in 1 cell layer on both sides; abaxial leucocysts distinctly decurrent on stems; in cross-sections at insertional parts to stem usually 1 cell layers of leucocysts at the thickest part (Fig. CXXXVII: 11, 12).

Dioicous. Dwarf male plants growing on tomentum enclosed by perichaetial leaves; independent normal male plants not observed. Perichaetia terminal on short lateral branches; inner perichaetial leaves around mature sporophytes small, ca. 0.5-0.6 times longer than ordinary leaves near the perichaetia; archegonia 1.0-1.2 mm long. Setae 10-15 mm long. Capsules erect to suberect, ellipsoid, nearly symmetrical, indistinctly strumose (Fig. CXXXVIII: 13, 14); urns ca. 1.7 mm long, ca. 0.8 mm wide.

Representative specimens examined: Philippines, Mindanao, 11 Oct. 1965, Robbins 4028 (L). Thailand, Nakornsrithamarat, granitic massive Khao(Mt.) Luang, 8°30'N 99°45'E, 1700-1740 m alt., 5 Feb. 1966, Touw 11860 (L). Sumatra, Climbing Gunung Bandahara, ca. 6 km NE of Kampung Seldok (Alas Valley), ca. 25 km N of Kutatjane, ca. 2000 m

alt., 20 Feb. 1975, Wilde & Wilde-Duyfjes 15096D (L). Borneo, West Coast Res., Mt. Tambuyokon, ca. 15 miles NE of Kinabalu Peak, 6000-7000 ft. alt., 6 July 1961, Meijer B11215 (L). Sulawesi, Roroka Timbu, 0°30'-1°30'S 119°30'-120°30'E, 2000-2250 m alt., 18 May 1979, Hennipman 5514 (L). Seram, Kecamatan Tehoru, Manusela National Park, en route from Wae Nua to Gunung(Mt.) Mapahue, 3°15'S 129°29'E, 830 m alt., 21 July 1986, Akiyama 14787 (KYO, HIRO). New Guinea, Moresby, Moroka, July 1893, Loria s. n., det. C. Müller sub. no. 743, as Leucobryum brevicaule C. Müll. n. sp. (H).

Habitat: Usually on tree trunks, rarely on rocks or soil in montane forest.

Distribution: Philippines, Thailand, Sumatra, Borneo, Sulawesi, Seram, New Guinea.

The present species is differentiated from closely related L. sanctum by (1) appressed to erect spreading leaves, (2) weakly keeled basal parts of leaves, (3) smooth abaxial surface of apical parts of leaves, (4) almost homostrosic leucocysts in cross-sections of leaf bases, (5) one cell layered leucocysts at decurrent part on stem, and (6) erect to suberect capsules.

IX. Distribution

The geographic distribution of the taxa treated in this study are classified into the following patterns.

1. Temperate to cool temperate regions of Northern Hemisphere: L. glaucum (Fig. CXL: 1).

2. Southwest Europe to Asia: L. juniperoideum (Fig. CXL: 2).

3. Eastern Asia: L. scabrum (Fig. CXLI: 3), L. boninense (Fig. CXLI: 4).

4. Eastern India to Eastern Asia: L. humillimum (Fig. CXLI: 2).

5. Southeast Asia to Eastern Asia: L. javense var. javense (Fig. CXLI: 1), L. bowringii (Fig. CXLII: 1).

6. Southeast Asia: L. arfakianum (Fig. CXLI: 5), L. javense var. novae-guineae (Fig. CXLI: 7), L. javense var. cyathifolium (Fig. CXLI: 8), L. aduncum var. aduncum (Fig. CXLII: 2), L. sericeum (Fig. CXLII: 3), L. aduncum var. teysmannianum (Fig. CXLII: 4), L. sumatranum (Fig. CXLII: 5).

7. Southeast Asia to South Pacific Islands: L. sanctum (Fig. CXL: 3), L. aduncum var. scalare (Fig. CXL: 4), L. chlorophyllosum (Fig. CXL: 5).

8. Endemic areas

   a. South India: L. imbricatum (Fig. CXLI: 9).

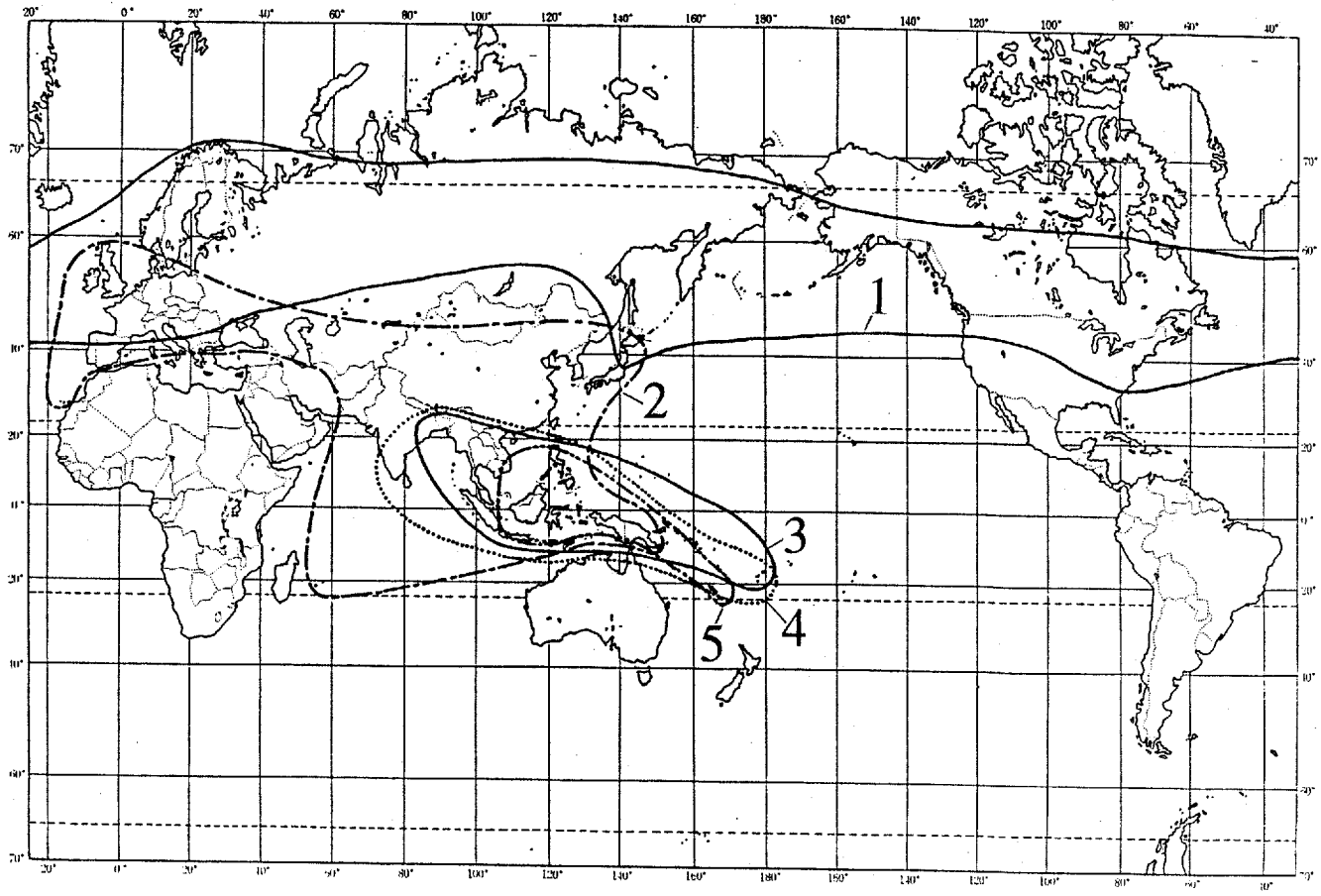

Figure CXXXIX. Distribution of 5 taxa of Leucobryum. 1. L. glaucum (Hedw.) Aongstr. in Fries. 2. L. juniperoideum (Brid.) C. Muell. 3. L. sanctum (Brid.) Hampe. 4. L. aduncum var. scalare (C. Muell. ex Fl.) A. Eddy. 5. L. chlorophyllosum C. Muell.

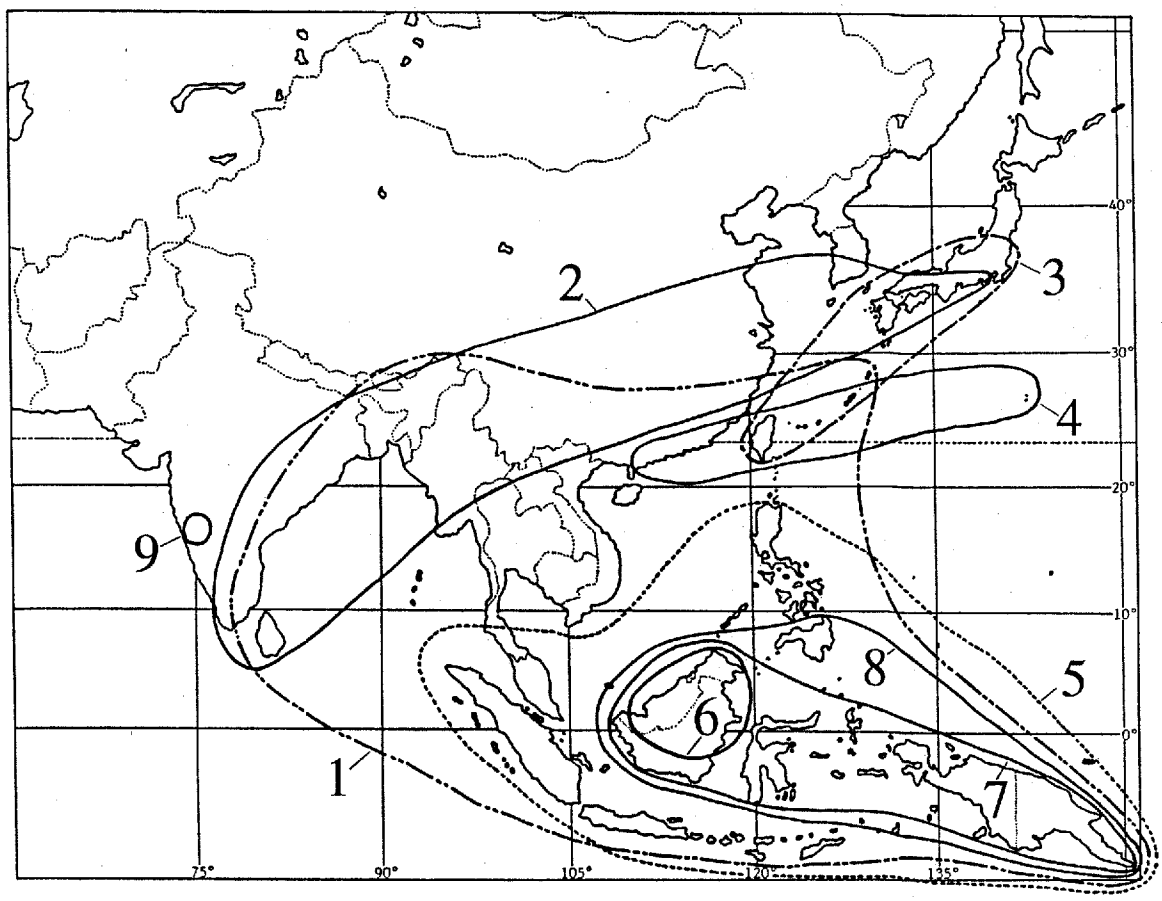

Figure CXL. Distribution of 9 taxa of Leucobryum. 1. L. javense (Brid. ex Schwaegr.) Mitt. var. javense. 2. L. humillimum Card. 3. L. scabrum Lac. 4. L. boninense Sull. & Lesq. 5. L. arfakianum C. Muell. ex Geh. 6. L. uncinatum Fl. 7. L. javense var. novae-guineae (Bartr.) T. Yamaguchi. 8. L. javense var. cyathifolium (Dix.) T. Yamaguchi. 9. L. imbricatum Broth.

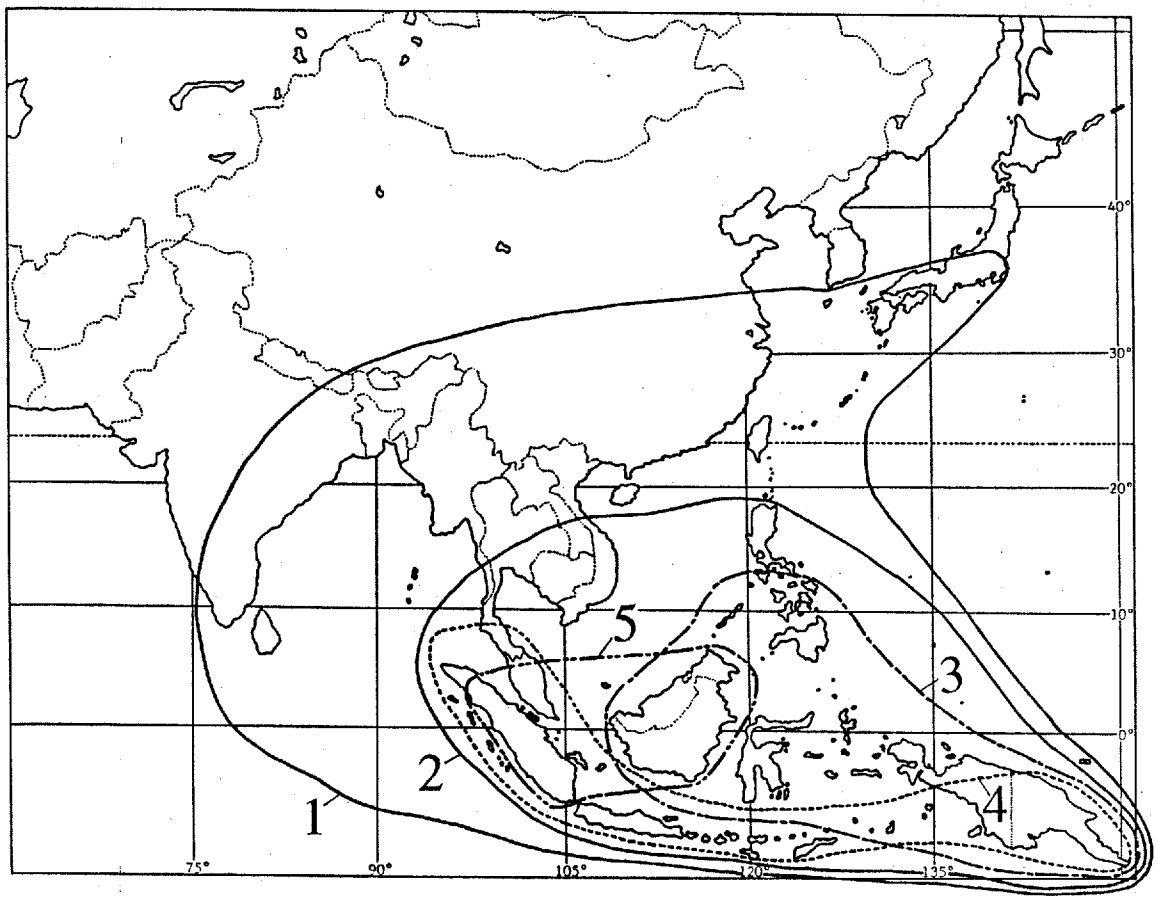

Figure CXLI. Distribution of 5 taxa of Leucobryum. 1. L. bowringii Mitt. 2. L. aduncum Dozy & Molk. var. aduncum. 3. L. sericeum Broth. ex Geh. 4. L. aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi. 5. L. sumatranum Broth. ex Fl.

b. Borneo: L. javense var. uncinatum (Fig. CXLI: 6).

X. Excluded species

1. Leucobryum candidum (Brid. ex P. Beauv.) Wils., Fl. Nov. Zel. 2: 64 (1854).

The present species was reported from southeast Asia by Zanten (1964, Johnson (1964) and Eddy (1990). However, I could not find the present species among the specimens examined. This species should be excluded from the Asian bryoflora.

2. Leucobryum pachyphyllum C. Müll., Flora 82: 435 (1896).

The present species was reported from New Guinea by Fleischer (1912). However, I could not find the present species among the specimens examined. I considered that the present species should be excluded from the Asian bryoflora.

3. Leucobryum siamicum Besch. in Ren. & Card., Bull. Soc. R. Bot. Belg. 42(1): 42 (1905).

I carefully examined the holotype specimen of L. siamicum deposited in PC, and found the following characters: (1) mucronate leaf apices, (2) 2-3 layered leucocysts on adaxial side in cross-sections near leaf apices and (3) homostrosic construction of leucocysts at

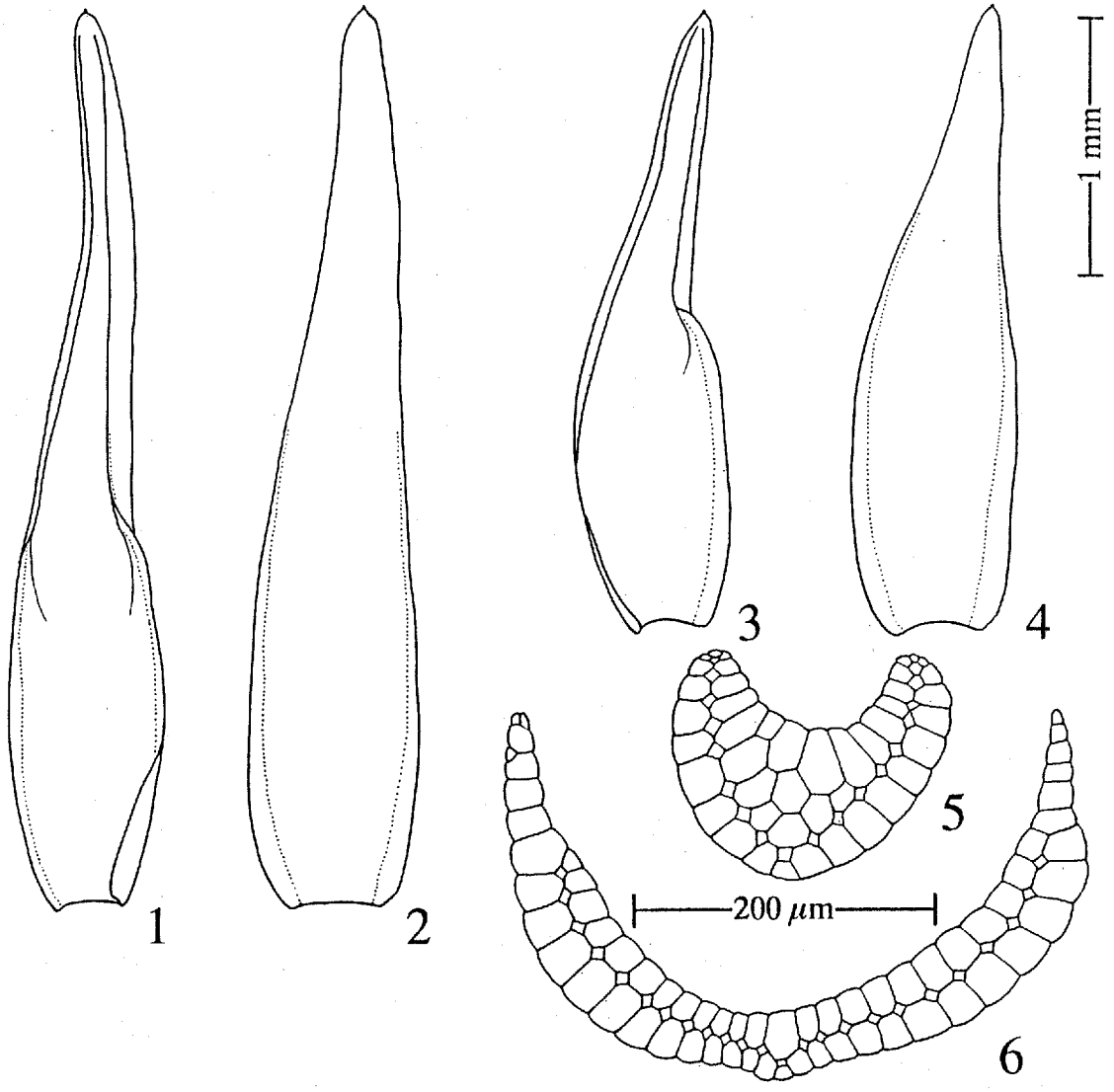

Figure CXLII. Schistomitrium apiculatum (Dozy & Molk.) Dozy & Molk. 1–4. Leaves (2, 4, expanded). 5, 6. Cross-sections of leaf (5, apical; 6, basal portions). All figures were drawn holotype of L. siamicum (PC).

leaf bases (Fig. CXXXIX). From these characters, L. siamicum is identical with Schistomitrium apiculatum (Dozy & Molk.) Dozy & Molk.

Schistomitrium apiculatum (Dozy & Molk.) Dozy and Molk., Musci Fr. Archip. Indici 3: 68, t. 24, 25 (1846).

Leucobryum siamicum Besch. in Ren. & Card., Bull. Soc. R. Bot. Belg. 42(1): 42 (1905), syn. nov. Type: Siam, without collector name (in herb. Renauld) – holotype (PC).

XI. Summary

Based on a taxonomic revision of the genus Leucobryum in Asia, examining about 3000 specimens including types, the following important taxonomic characters were newly recognized: (1) central strand of stem, (2) proration of abaxial side of leaf acumina, (3) decurrency of abaxial leucocysts, (4) ratio between thickness of the thickest part and thickness of the median furrow in the cross-sections of leaves, (5) position of perichaetia, (6) ratio between length of the matured inner perichaetial leaf and length of the stem leaf near the perichaetium, (7) length of archegonia, (8) presence of normal male plants, and (9) growing position of dwarf male plants. Among 78 taxa which had been reported from Asia, 33 taxa were newly reduced to synonyms, 4 taxa were newly reduced to lower status, 2 taxa

were excluded from Asian bryoflora, 4 taxa were combined with other genera, and the following 19 taxa were recognized as Asian Leucobryum. (1) Leucobryum javense (Brid. ex Schwägr.) Mitt., (2) L. javense var. cyathifolium (Dix.) T. Yamaguchi, stat. nov., (3) L. javense var. novae-guineae (Bartr.) T. Yamaguchi, stat. nov., (4) L. javense var. uncinatum (Fl.) T. Yamaguchi, stat. nov., (5) L. scabrum Lac., (6) L. aduncum Dozy & Molk., (7) L. aduncum var. teysmannianum (Dozy & Molk.) T. Yamaguchi, stat. nov., (8) L. aduncum var. scalare (C. Müll. ex Fl.) A. Eddy, (9) L. chlorophyllosum C. Müll., (10) L. boninense Sull. & Lesq., (11) L. juniperoideum (Brid.) C. Müll., (12) L. humillimum Card., (13) L. imbricatum Broth., (14) L. glaucum (Hedw.) Ångstr. in Fries, (15) L. bowringii Mitt., (16) L. sumatranum Broth. ex Fl., (17) L. sericeum Broth. ex Geh., (18) L. sanctum (Brid.) Hampe and (19) L. arfakianum C. Müll. ex Geh. An identification key was constructed on the basis of the morphological characters. For each species synonymy was given together with pertinent literature along with its type, detailed description and illustration, discussion on taxonomical status, selected specimens examined and geographical distribution.

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