Lejeuneaceae subfamily Ptychanthoideae (Hepaticae) in West Java

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Abstract

The subfamily Ptychanthoideae of the family Lejeuneaceae (Hepaticae) in West Java is still poorly known. A study of Ptychanthoideae in this area reveals the occurrence of 26 species, in 8 genera: *Acrolejeunea* (Spruce) Schiffn. (3 species), *Archilejeunea* (Spruce) Schiffn. (1 species), *Lopholejeunea* (Spruce) Schiffn. (10 species), *Mastigolejeunea* (Spruce) Schiffn. (3 species), *Ptychanthus* Nees (1 species), *Schiffneriolejeunea* Verd. (2 species), *Spruceanthus* Verd. (2 species) and *Thysananthus* Lindenb. (4 species). *Mastigolejeunea indica* and *Thysananthus minor* are newly reported for Java. The altitudinal and geographical ranges of the species of Ptychanthoideae from West Java are presented as well as a key to the species and an assessment of their phytogeography. It appears that the species are rather widespread; none of the species are endemic to Java or western Malesia. The widespread distribution of the species is probably due to their dispersal by spores, which may be easily carried by the wind over long distances, and by the rather old geological age of the group.

Introduction

Lejeuneaceae is a large, mostly tropical family of leafy liverworts, containing about 1000 species in 75 genera. According to Gradstein *et al.* (2001), Lejeuneaceae is subdivided into two subfamilies, Lejeuneoideae and Ptychanthoideae; the latter group is treated in this paper.

Ptychantheae is the only tribe of Ptychanthoideae, while Lejeuneoideae consists of three tribes, Brachiolejeuneeae, Lejeuneeae and Cololejeuneeae.

The subfamily Ptychanthoideae is characterized by the capsule valves spreading widely after dehiscence, elaters usually 72 per capsule, underleaves undivided, ventral merophytes 4 or more cells wide, and ocelli absent. In Lejeuneoideae the capsule valves are not spreading after dehiscence, elaters are 34 or less per capsule, underleaves bifid or undivided, ventral merophytes usually 1-4 cells wide, and ocelli sometimes present.

Ptychanthoideae include fewer genera and species than Lejeuneoideae and are generally better known (Gradstein, 1991). They contain about 175 species in 19 genera worldwide; 14 genera occur in tropical America. Most species are xerotolerant epiphytes of forest canopies or rather open, wooded vegetation, and usually occur at rather low elevation (Thiers and Gradstein, 1989; Gradstein *et al.*, 2001).

Based on several references (Verdoorn, 1933, 1934; Mizutani, 1961; Gradstein, 1975, 1991, 1994; Gradstein *et al.* 2002; Zhu and Gradstein, 2005; Gradstein *et al.*, 2005; Hasan and Ariyanti, 2004; Ariyanti and Gradstein, 2007), there are about 30 species of Ptychanthoideae in Java, in 10 genera: *Acrolejeunea* (Spruce) Schiffn, *Archilejeunea* (Spruce) Schiffn., *Caudalejeunea* (Steph.) Schiffn., *Dendrolejeunea* (Spruce) Lacout., *Lopholejeunea* (Spruce) Schiffn., *Mastigolejeunea* (Spruce) Schiffn., *Ptychanthus* Nees, *Schiffneriolejeunea* Verd., *Spruceanthus* Verd., and *Thysananthus* Lindenb. In addition, there is an old, unconfirmed report of the Pacific genus, *Phaeolejeunea* Mizut., from Java (Zhu and Gradstein, 2005, p. 88, originally described as *Lopholejeunea latistipula* (Schiffn.) Schiffn. var. *minor* Schiffn.).

Information about the distribution of the species of Ptychanthoideae within Java is very scarce. The publications on this subject are mostly from the 19th or early 20th century and outdated (e.g., Reinwardt, Blume and Nees von Esenbeck, 1824; Nees von Esenbeck, 1830; Sande Lacoste, 1856; Schiffner, 1898; Stephani, 1912; Verdoorn, 1933, 1934).

The aim of this study was to improve our understanding of the diversity of Ptychanthoideae in West Java (including West Java Province and Banten Province).

Material and Methods

The study was based on herbarium specimens of *Ptychanthoideae* collected from West Java and Banten province. A total number of 362 specimens deposited in the Herbarium Bogoriense (BO) and Herbarium Biotrop (BIOT), and some in the Herbarium of the University of Göttingen, Germany (GOET) and Herbarium Bangi, Malaysia (UKMB) kept in BIOT as duplicates, were examined. Additional specimens were collected by the

first author at several locations in West Java, i.e. Telaga Warna, Ciater, Bogor Botanical Garden, Bodogol Education Center and Conservation – Mt. Gede Pangrango National Park and Mt. Halimun Salak National Park.

Morphological characters were studied with a 10 × 4, 10 × 10, 10 × 20 and 10 × 40 magnification. Specimens with similar characteristic were grouped and identified using recent literature on the species of Ptychanthoideae, such as Thiers and Gradstein (1989), Gradstein *et al.* (2001), Gradstein *et al.* (2002) and Zhu and Gradstein (2005). Descriptions and illustrations of each species were prepared and an identification key to the species was developed.

Taxonomic treatment

Key to the species of West Javan Ptychanthoideae

1. Branching always *Frullania* type…….....18. ***Ptychanthus striatus***
1. Branching *Lejeunea* or *Frullania type*.....…….2

2. Branching *Frullania* and *Lejeunea* type (*Schiffneriolejeunea*)…...…...….3
2. Branching *Lejeunea*-type only……..…….……... 4

3. Lobule forming a distinct sac at the base and flattened above with 2 large teeth. Teeth erect, not pointing outwards towards leaf apex. Leaves squarrose when moist.. 20. ***Schiffneriolejeunea tumida*** var. ***haskarliana***
3. Lobule not forming a distinct sac at the base, free margin of the lobule plane and clearly visible, with 2 teeth. Teeth almost equal in size and pointing outwards towards leaf apex. Leaves not squarrose when moist .....19. ***Schiffneriolejeunea pulopenangensis***

4. Lobes with a distinct vitta …….... 25. ***Thysananthus retusus***
4. Lobes without vitta ……..…….…….5

5. Cells of the lobe with cordate trigones…….....…….....6
5. Cells of the lobe not with cordate trigones……...…… 14

6. Leaves and underleaves entire. Dorsal epidermis cells larger than inner stem cells ….....…….....……...…….……..7
6. Leaves and underleaves usually toothed. Dorsal epidermis cells not larger than inner stem cells (*Thysananthus*)…….....……12

7. Perianth 3 keels, with 1-2 innovations (*Mastigolejeunea*).....8
7. Perianth 8-10 keels, innovation lacking (*Acrolejeunea*)……..... 10

8. Leaf lobule with several large, triangular teeth.....
.....…..16. ***Mastigolejeunea indica***
8. Leaf lobule with one tooth……..…….…….……..…….....9

9. Lobule tooth 3-5 cells long, sharp, curved.....17. ***Mastigolejeunea virens***
9. Lobule tooth 1 cell long, blunt, not curved.....
.....15. ***Mastigolejeunea auriculata***

10. Lobule semicircular in outline, with 4-10 teeth, all or at least some teeth 2-3 cells long..... 2. ***Acrolejeunea fertilis***
10. Lobule not semicircular, with 2-3 teeth ….....…….…….....11

11. Lobule narrow rectangular, with 2 teeth ……..1. ***Acrolejeunea arcuata***
11. Lobule ovate-rectangular, with 3 teeth ….....3. ***Acrolejeunea pycnoclada***

12. Plant very small, less than 1 mm wide ..... 24. ***Thysananthus minor***
12. Plant more than 1 mm wide ….……..……..…….....13

13. Upper part of leaf asymmetrical, turned to the ventral side (“ventrad”), leaf apex recurved.....23. ***Thysananthus convolutus***
13. Upper part of leaf symmetrical, not turned to the ventral side, leaf apex plane or recurved ..... 26. ***Thysananthus spathulistipus***

14. Stems robust, ventral merophyte 8-12 cells wide (*Spruceanthus*)….....15
14. Stems thinner, ventral merophyte 4-6 cells wide…..... 16

15. Leaf apex sharply acute….....22. ***Spruceanthus semirepandus***
15. Leaf apex rounded to obtuse.....21. ***Spruceanthus polymorphus***

16. Stem epidermis cells not larger than the inner cells. Plants light green. Perianth keels smooth or weakly toothed. Innovations present.....
.....4. ***Archilejeunea planiuscula***
16. Stem epidermis cells larger than the inner cells. Plants blackish-green, rarely brown. Perianth keels distinctly toothed (*Lopholejeunea*). Innovations lacking.....17

17. Leaf lobule connected to the leaf lobe by only one single cell…….....18
17. Leaf lobule connected to the leaf lobe across several cells…….....21

18. Leaf lobe acute ….....…….....5. ***Lopholejeunea applanata***
18. Leaf lobe rounded or obtuse ……..…….…… 19

19. Lobule deeply constricted in the middle, free margin strongly involute ..... 7. ***Lopholejeunea herzogiana***
19. Lobule not deeply constricted in the middle, free margin not involute.....20

20. Underleaves distant to contiguous, orbicular. Female bracteole entire .....8. ***Lopholejeunea nigricans***
20. Underleaves imbricate, wider than long. Female bracteole toothed..... .....…….....6. ***Lopholejeunea eulopha***

21. Underleaves very large, 6-8 × as wide as the stem ….....…….....…22
21. Underleaves smaller, 4-6 × as wide as the stem …….....…… 23

22. Plants pale brown in the dried condition. Leaf lobules small, 1/5-1/4 of leaf length. Female bracteole toothed. Dioicous ....13. ***Lopholejeunea wiltensii***
22. Plants blackish or dark brown to blackish in the dried condition. Leaf lobules larger, 1/3-2/5 of leaf length. Female bracteole usually entire. Autoicous.....14. ***Lopholejeunea zollingeri***

23. Plants minute, less than 1 mm wide.....10. ***Lopholejeunea horticola***
23. Plants medium sized, more than 1 mm wide…….…….…..…....24

24. Margins of underleaves and leaves recurved. Underleaf large, more than ½ x lobe length….....….11. ***Lopholejeunea recurvata***
24. Margins of underleaves and leaves plane. Underleaf less than ½ x lobe length….....25

25. Female bracteole entire. Female bract lobule very small or lacking .....12. ***Lopholejeunea subfusca***
25. Female bracteole crenate. Female bract lobule large..... ..... 9. ***Lopholejeunea ceylanica***

Species descriptions

1. ***Acrolejeunea arcuata*** (Nees) Grolle & Gradst., J. Hattori Bot. Lab. 38: 332 (1974).
Jungermannia arcuata Nees, Enum. Pl. Crypt. Javae 1:38 (1830). *Ptychocoleus arcuatus* (Nees) Trevis., Mem. Reale Ist. Lomb. Sci. Mat. Nat., Ser. 3, 4: 405

(1877). –**Type**: Indonesia. Java: Lebak Mts., *Reinwardt s.n.* (holotype, STR; isotypes, G, NY, W) – cf. Gradstein *et al.* (2002).

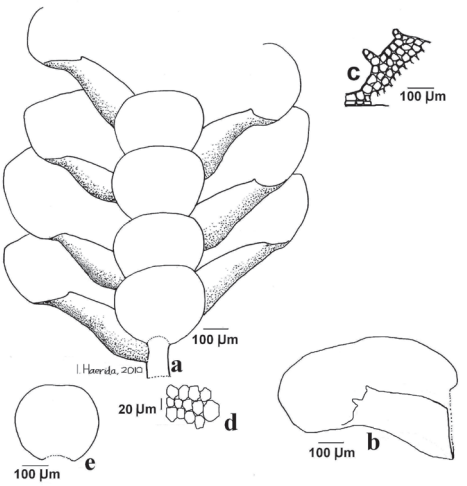

Figure 1. *Acrolejeunea arcuata* (Nees) Grolle & Gradst. Shoot (a); leaf-lobe (b); lobule (c); cells of midleaf (d); underleaf (e). Drawn from *Kornochalert 1408*, BIOT.

Plants up to 2 cm long, about 0.9 mm wide, dark brown to reddish brown in dried condition. Branching *Lejeunea*-type. Stem diameter 95-108 µm. Leaves closely imbricate, obliquely spreading. Lobe ovate-orbicular to obovate, 520-650 µm long, 410-520 µm wide, margin entire, apex subobtuse to sometimes rounded; cells of lobe thin-walled, hyaline, somewhat elongate, trigones ± cordate, intermediate thickening scarce; marginal cells 5-11 × 6-11 µm, mid-leaf cells 19-29 × 11-26 µm, basal cells 24-30 × 10-13 µm; oil bodies not seen. Lobule narrow rectangular, 300-400 µm long, 145-160 µm wide, apex truncate with 2 teeth, each tooth consisting of 2-3 cells, 2-3 cells long. Underleaves closely imbricate, subtriangular to suborbicular, 260-315 µm long, 295-435 µm wide, margins entire, apex truncate, base slightly auriculate, insertion line shallowly curved. Generative structures not seen.

Distribution: Java, Sumatra, Borneo, Philippines, Papua, Peninsular Malaysia.

*Specimen examined***:** INDONESIA. **West Java**, Mt. Patuha, on bark of tree along the road to crater, 2000 m, *Kornochalert 1408* (BIOT!).

Notes: Diagnostic characters of *Acrolejeunea arcuata* are: 1) lobules 2(-3) times longer than wide, with 2 teeth, 2) lobe ovate-orbicular with entire margins, 3) cordate trigones. This species was found at *ca* 2000 m and occurs only at higher elevations in the mountains (Gradstein, 1975). It is readily

distinguished from other species of *Acrolejeunea* by the very long and narrow lobule with 2 teeth and the often reddish-brown color.

2. ***Acrolejeunea fertilis*** (Reinw. *et al.*) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 128 (1893); *Jungermannia fertilis* Reinw. *et al.*, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 211 (1824); *Ptychocoleus fertilis* (Reinw. *et al.*) Trevis., Mem. Reale Ist. Lomb.Sci. Mat. Nat., Ser. 3, 4: 405 (1877). –**Type**: Indonesia. Java, Lebak Mts., *Reinwardt s.n.* (holotype, STR; isotypes, G, NY, W) – cf. Gradstein *et al.* (2002).

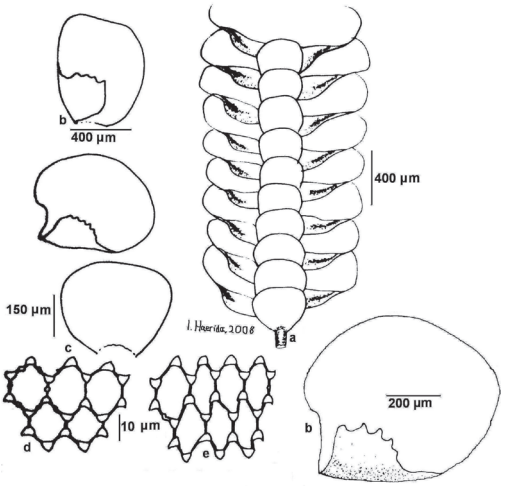

Figure 2. *Acrolejeunea fertilis* (Reinw. et al.) Schiffn. Shoot (a); leaf-lobe (b); underleaf (c); cells of midleaf (d); cells of basal part of the leaf (e); Drawn from *van Borssum Waalkes 549*, BO.

Plants up to 1 cm long, about 0.8 mm wide, dark green to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 100-124 µm. Leaves closely imbricate, obliquely spreading, squarrose. Lobe ovate-orbicular to subrectangular, 600-825 µm long, 500-660 µm wide, margin entire, apex truncate to sometimes rounded; cells of lobe thin-walled, light-yellow, somewhat elongate, trigones cordate, intermediate thickening scarce; marginal cells 7-8 × 7-10 µm, mid-leaf cells 18-23 × 12-20 µm, basal cells 17-30 × 13-17 µm; oil bodies not seen. Lobule semicircular, 200-290 µm long, 220-250 µm wide, apex obliquely truncate with 4-9 teeth, each tooth consisting of 2-3 cells, 1-2 cells long. Underleaves closely imbricate, broadly orbicular, 300-350 µm long, 310-570 µm wide, margins entire, apex truncate, base cuneate, insertion line shallowly curved. Generative structures not seen.

Specimens examined: INDONESIA. **Banten**, Pulau Panaitan, *van Borssum Waalkes 549* (BO!). **West Java**, Depok, Kampus Universitas Indonesia, 60-80 m, *Afiatri Putika 80* (BO!).

Distribution: Java, Sumatra, Borneo, Philippines, Moluccas, Papua, Peninsular Malaysia, Indochina, India, Sri Lanka.

Notes: Diagnostic characters of *Acrolejeunea fertilis* are: 1) lobule semicircular with 4-9 teeth, 2) lobe ovate-orbicular with entire margins, 3) trigones cordate. The species occurs in the lowlands, at *ca* 60-80 m, and is distinguished from other Javanese members of the genus *Acrolejeunea* by the squarrose leaves and the semicircular lobule with 4-9 teeth.

3. ***Acrolejeunea pycnoclada*** (Taylor) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 128 (1893); *Ptychanthus pycnocladus* Taylor, London J. Bot. 5: 385 (1846); *Ptychocoleus pycnocladus* (Taylor) Steph., Sp. Hepat. 5: 52 (1912). –**Type**: Peninsular Malaysia, without loc., *Cantor s.n.* (holotype, FH; isotypes, G, MANCH, NY, S, U, W) – cf. Gradstein *et al.* (2002).

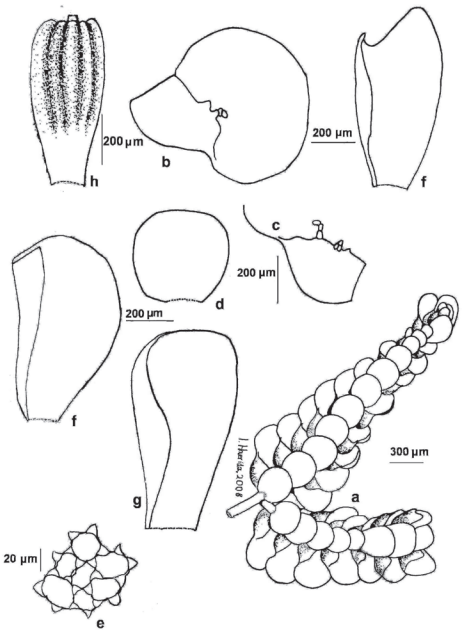

Figure 3. *Acrolejeunea pycnoclada*; (Taylor) Schiffn. Shoot (a); leaf lobe (b); leaf lobule (c); underleaf (d); leaf cells (e); female bract (f); female bracteole (g); perianth (h). Drawn from *Haerida 1484*, BO.

Autoicous. Plants up to 2 cm long, 0.5-0.7 mm wide, 1-1.5 mm wide in wet condition; dull green when fresh, greenish-brown in dried condition. Branching *Lejeunea*-type. Stem diameter 100-145 µm; cross-section of the stem with epidermis cells larger than medulla cells. Leaves imbricate, widely spreading, convolute when dry. Lobe ovate, 680- 1050 µm long, 370-850 µm wide, margin entire, apex rounded; cells of lobe thin-walled, hyaline, in mid-

leaf elongate, trigones cordate, intermediate thickening frequent; marginal cells 7-16 × 6-13 µm, mid-leaf cells 17-31 × 11-25 µm, basal cells 24-52 × 11- 31 µm; oil bodies (7-)8-20 per cell, homogeneous, hyaline, globose to ellipsoidal. Lobule ovate to rectangular, large, 365-680 µm long, 170-310 µm wide, inflated, apex obliquely truncate with 2 conspicuous teeth, first tooth consisting of 3-4 cells, second tooth consisting of 2-3 cells, an additional small tooth present at the distal end of the free margin beyond the first tooth. Underleaves distant to contiguous, obovate-orbicular to wider than long, 270-480 µm long, 350-700 µm wide, margin entire, apex rounded to almost truncate, base cuneate, insertion line shallowly curved. Androecia intercalary on branches, bracts in 3-11 pairs, very similar to leaves but lobules slightly larger, 400-420 µm long, 180-250 µm wide, bract lobule 1/2-2/3 of the bract lobe, epistatic, bracteoles similar to underleaves in size and shape. Gynoecia on short or long branches, innovations lacking, bracts and bracteoles in 2 pairs, bract oblong to broadly oblong 720-1070 µm long, 270-500 µm wide, conspicuously incurved in the upper part, margin entire, apex obtuse to orbicular, sinus up to 1/3 of lobe length; bracteole oblong to broadly oblong 890-1010 µm long, 520-660 µm wide, margin entire to slightly undulate, apex truncate. Perianth immersed, obovate, 975 µm long, 430 µm wide, inflated, with ± 10 inflated keels, margins entire. Sporophytes and asexual reproduction not seen.

Distribution: Java, Sumatra, Borneo, Moluccas, Philippines, Papua New Guinea, Pacific, Peninsular Malaysia, Thailand, India, Sri Lanka, tropical Africa.

Specimens examined: INDONESIA. **West Java**, G. Gede, above Sukabumi, 1500-1900 m, *Verdoorn 46b* (BO!); Ciater, Subang, Sari Ater, *ca* 1500 m, *Haerida 1480, 1481, 1484, 1486, 1487* (BO!).

Notes: Diagnostic characters of *Acrolejeunea pycnoclada* are: 1) lobule with 2 conspicuous teeth and an additional, third small tooth present at the distal end of the free margin, beyond the first tooth, 2) trigones cordate, 3) female bracts conspicuously incurved in the upper part, covering the immersed perianth, 4) perianth with 10 keels. This species was found at ca 1500-1900 m but it has also been recorded at lower elevations, from sealevel upwards. It differs from other members of the genus *Acrolejeunea* by the lobule with 2 conspicuous teeth and a 3rd small tooth at the very end of the free margin, near the junction with the ventral margin of the leaf lobe, and by the conspicuously incurved female bracts.

4. ***Archilejeunea planiuscula*** (Mitt.) Steph., Sp. Hepat. 4: 731 (1911) ; *Lejeunea planiuscula* Mitt., J. Proc. Lin.. Soc. 5: 111 (1861). –**Type**: Burma.

Rangoon, *McClelland s.n.* (holotype, NY) – cf. Thiers and Gradstein (1989).
- *Archilejeunea caramuensis* Steph., Hedwigia 34: 59 (1895). –Type: Philippines.Caramuan, 1884-85, *Micholitz 70* (G) – cf. Verdoorn (1934).
- *Archilejeunea falcata* Steph., Hedwigia 34: 60 (1895). –Type: Papua New Guinea. Madang Prov.: Stephansort, 1888, *Kärnbach s.n.* (G) – cf. Verdoorn (1934).
- *Mastigolejeunea paradoxa* Verd., Nova Guinea 18:5 (1935). –Type: Indonesia. West Irian, Jayawijaya Prov., Prauwenbivak, *Lam 1182a* (holotype, FH) – cf. Gradstein *et al.* (2002).

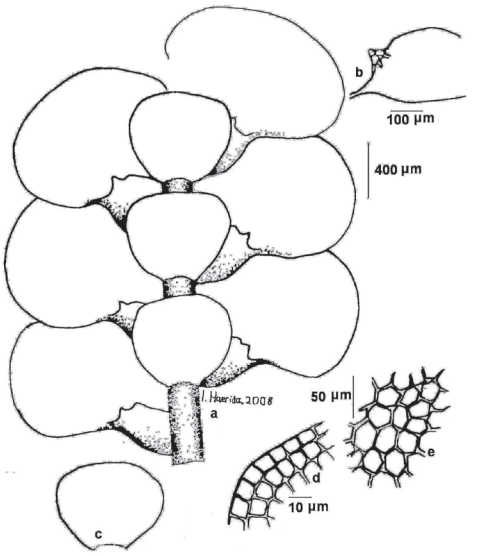

Figure 4. *Archilejeunea planiuscula* (Mitt.) Steph. Shoot (a); leaf lobule (b); underleaf (c); cells of leaf margin (d); cells of midleaf (e). Drawn from *Haerida 1489*, BO.

Plants up to 3 cm long, 0.8-2 mm wide; light green when fresh, darker green in dried condition. Branching *Lejeunea*-type. Stem diameter 90-135 µm; epidermis cells not large than inner cells; ventral merophyte 4-6 cells wide. Leaves contiguous, widely spreading. Lobe orbicular to oblong, 500-900 µm long, 370-700 µm wide, margin entire, apex rounded; cells of lobe thin-walled, hyaline, isodiametrical hexagonal, trigones triangular, never cordate, intermediate thickening scarce; marginal cells 3.5-7.5 × 5-10 µm, mid-leaf cells 17-24 × 14-18 µm, basal cells 22-37 × 13-17 µm; oil bodies not seen. Lobule ovate, 240-340 µm long, 130-200 µm wide, apex obliquely truncate with 1-2 teeth, first tooth with 2 cells long, second tooth small, 1 cell long, sometimes lacking. Underleaves distant to contiguous, obdeltoid, 280-420 µm long, 260-460 µm wide, margin entire, apex truncate, insertion line almost straight. Generative structures not seen [innovations present; perianth with 5 smooth or weakly toothed keels].

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *Verdoorn 12a, 12b, 12c, 12e, 131, 134, 232*, *Meijer B55a, B61a, B49, B76, B3664, B27a, B56, B84a* (BO!); Cibodas Bot. Garden, 1450 m, *Schiffner 233*, *Haerida 813* (BO!); Ujung Kulon Nat. Park, *Dewi Dw922* (BO!).

Distribution: Java, Peninsular Malaysia, Papua New Guinea, Philippines, Solomon Is., Pacific, Australia, Indochina, India, Sri Lanka.

Notes: Diagnostic characters of *Archilejeunea planiuscula* are: 1) underleaves obdeltoid, 2) trigones triangular, never cordate, 3) plant light green in color when fresh. This species was found at *ca* 200-1450 m. It is readily distinguished from other members of the subfamily by the rather light green color and flat appearance of the plants, lobules with 1-2 teeth, isodiametrical leaf cells with small, simple trigones, obdeltoid underleaves and thin stems (ventral merophyte 4-6 cells wide) with epidermis cells not larger than inner cells.

5. ***Lopholejeunea applanata*** (Reinw. *et al.*) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 129 (1893); *Jungermannia applanata* Reinw. *et al.*, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 210 (1824); *Phragmicoma applanata* (Reinw. *et al.*) Nees, Naturgesch. Eur. Leberm. 3: 248 (1838); *Lejeunea applanata* (Reinw. *et al.*) Nees, in Gottsche *et al.*, Syn. Hepat.: 314 (1845); *Symbiezidium applanatum* (Reinw. *et al.*) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877). –**Type**: Indonesia. Java, collector unknown (holotype, STR; isotypes, G, S, W) – cf. Zhu and Gradstein (2005).
- *Lopholejeunea fleischeri* Steph., Sp. Hepat. 5: 79. 1912. –Type: Indonesia. Java, Tjibodas, Apr 1900, *M. Fleischer s.n.* (holotype, G) – cf. Zhu and Gradstein (2005).

Plants up to 5 cm long, 1-1.5 mm wide; dark brown in the dried condition. Branching *Lejeunea*-type. Stem diameter 120-200 µm. Leaves imbricate, widely spreading. Lobe ovate, 800-1200 µm long, 500-800 µm wide, margin entire sometimes crenulate towards the apex, apex acute to acuminate; cells of lobe thick-walled, yellow, rectangular to isodiametric, trigones triangular, intermediate thickening frequent; marginal cells 15-21 × 12-15 µm, mid-leaf cells 26-30 × 20-24 µm, basal cells 30-40 × 20-31 µm; oil bodies not seen. Lobule ovate, 230-320 µm long, 170-220 µm wide, inflated, apex truncate with 1 small tooth, connected to the leaf lobe across only one single cell. Underleaves large, imbricate, broadly orbicular, 300-400 µm long, 400-900 µm wide, margin entire, apex truncate, insertion line deeply curved. Androecia intercalary on branches, bracts in 3-12 pairs, ovate with obtuse apex, 200-300 µm long, 150-220 µm wide, bract lobule about ½ of the lobe

length; bracteoles similar to underleaves in size and shape. Gynoecia not seen.

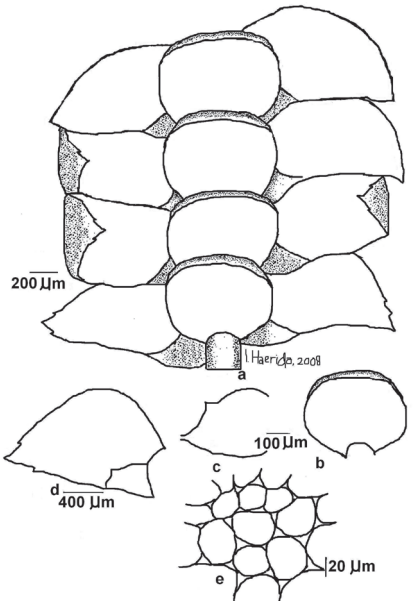

Figure 5. *Lopholejeunea applanata* (Reinw. *et al.*) Schiffn. Shoot (a); underleaf (b); leaf lobule (c); leaf lobe (d); cells of midleaf (e). Drawn from *Meijer 3696*, BO.

Distribution: Java, Sumatra, Borneo, Philippines, Peninsular Malaysia, Papua New Guinea, Pacific, Indochina, Sri Lanka, India.

Specimens examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Meijer B3696* (BO!); above Cibodas, Cibeureum, *Hasskarl s.n.* (BO!); G. Pangrango, "bij Tjisaroea" *ca* 1200 m, *Verdoorn 44b* (BO!); G. Patuha, Lake Situ Patengan, *ca* 1500 m, *Kornochalert 1413* (BIOT!).

Notes: Diagnostic characters of *Lopholejeunea applanata* are: 1) leaf lobes acute to acuminate at apex, 2) lobule apex connected to the lobe across only one single cell. This species grows at *ca* 1200-1500 m. It differs from other Javanese members of the genus *Lopholejeunea* by the acute to acuminate leaf apex and large, imbricate underleaves.

6. ***Lopholejeunea eulopha*** (Taylor) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 129 (1893); *Lejeunea eulopha* Taylor, London J. Bot. 5: 391 (1846); *Phragmicoma eulopha* (Taylor) Mitt., in Seeman, Fl. Vit. 413 (1873); *Symbiezidium eulophum* (Taylor) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877). –**Type**: Pacific islands: locality unknown,

Nightingale s.n. (holotype, FH; isotypes, FH, NY) – cf. Zhu and Gradstein (2005).
- *Lopholejeunea nymannii* Steph., Sp. Hepat. 5: 84. 1912. –Type: Indonesia. Java, G. Salak, *E. Nyman s.n.* (holotype, G; isotype, W) – cf. Zhu and Gradstein 2005.

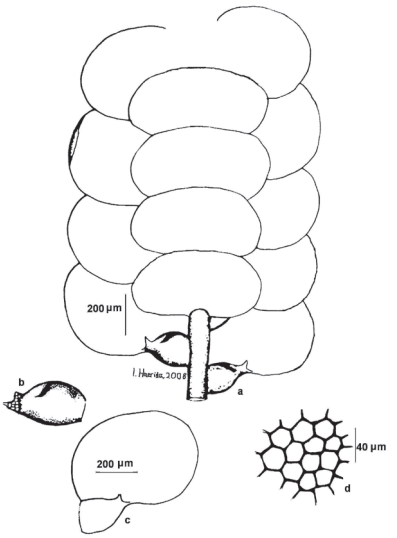

Figure 6. *Lopholejeunea eulopha* (Taylor) Schiffn. Shoot (a); leaf lobule (b); leaf lobe (c); cells of midleaf (d). Drawn from *Haerida 710*, BO.

Dioicous, sometimes autoicous. Plants up to 3 cm long, 1-1.5 mm wide, brownish green to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 130-190 µm. Leaves imbricate, widely spreading. Lobe oblong-ovate, 430-1090 µm long, 340-900 µm wide, margin entire, apex obtuse; cells of lobe thin-walled, pale brown, hexagonal to nearly isodiametric, trigones triangular, intermediate thickening frequent; marginal cells 7-15 × 10-17 µm, mid-leaf cells 14-31 × 10-21 µm, basal cells 22-40 × 18-24 µm; oil bodies (11-)18-20 per cell, homogeneous, hyaline, ellipsoidal. Lobule ovate, 120-270 µm long, 110-200 µm wide, inflated, apex with 1 triangular tooth consisting of 3-5 cells, connected to the leaf lobe by only one single cell. Underleaves imbricate, large, reniform, 300-500 µm long, 410-1070 µm wide, margin entire, apex rounded, insertion line deeply curved. Generative structures not seen.

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *Meijer 94b, Schiffner 245, van Steenis s.n.* (BO!); Bogor, without locality, *Verdoorn s.n.* (BO!); Cibodas Bot. Garden, 1400 m. *Ariyanti 471* (BIOT!); G. Halimun Nat. Park, *Haerida 710* (BO!); G. Guntur, "bij Kawah Kamoedjan" 1500-1700 m.alt., *Verdoorn 50h, 50d* (BO!); G. Megamendung, *Verdoorn 68* (BO!);

Kota Batu, *Schiffner s.n.* (BO!); Kampung Jember, Geger Bentang ca 1350 m, *Neervoort 3087* (BO!); Ujung Kulon Nat. Park, *Dewi Dw922d* (BO!); G. Patuha, Lake Situ Patengan ca 1500 m, *Kornochalert 1418*, *Dian Apriana & Afiatri Putrika 25* (BIOT!).

Distribution: Java, Sumatra, Borneo, Bali, Sulawesi, Moluccas, Philippines, West Irian, Papua New Guinea, Solomon Is., Pacific, Australia, Indochina, India, Sri Lanka, China, Japan, tropical Africa, tropical America.

Notes: Diagnostic characters of *Lopholejeunea eulopha* are: 1) lobule ovate, with 1 triangular tooth consisting of 3-5 cells, 2) lobule apex connected to the leaf lobe across only one cell, 3) large, reniform underleaves. This common species grows at *ca* 200-1700 m. It resembles *L. applanata* by the very large, imbricate underleaves but differs by the rounded leaf apex.

7. ***Lopholejeunea herzogiana*** Verd., Rec. Trav. Bot. Neerl. 30: 217 (1933). – **Type**: Indonesia. Java, Cibodas, "ad arborum truncos," 1420 m, 1894, *Schiffner s.n.* (FH, lectotype designated by Zhu and Gradstein, 2005).
– *Lopholejeunea pullei* Verd., Nova Guinea 18: 4 (1935). –Type: Indonesia. Irian Jaya, Hellwig Mts., "an Gymnospermen", 2600 m, 10 Jan 1913, *Pulle s.n.* (holotype, FH; isotype, U) – cf. Zhu and Gradstein 2005.

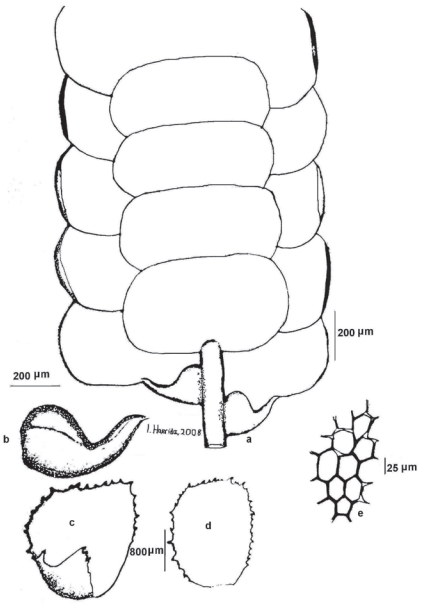

Figure 7. *Lopholejeunea herzogiana* Verd. Shoot (a); leaf lobule (b); female bract (c); female bracteole (d); cells of midleaf (e). Drawn from *Verdoorn 64a*, BO.

Plants robust, up to 4 cm long, 1-2.5 mm wide; blackish brown in the dried condition. Branching *Lejeunea*-type. Stem diameter 130-220 µm. Leaves imbricate, widely spreading. Lobe obovate-triangular to broadly orbicular, 650-1050 µm long, 660-1420 µm wide, margin entire, apex obtuse to rounded, sometimes recurved; cells of lobe thick-walled, brownish-orange, rectangular to hexagonal, trigones triangular, intermediate thickening frequent; marginal cells 12-18 × 12-17 µm, mid-leaf cells 21-26 × 20-30 µm, basal cells 24-50 × 20-30 µm; oil bodies not seen. Lobule ovate, large, 300-540 µm long, 220-310 µm wide, inflated, free margin strongly involuted and with a conspicuous constriction in the middle, connected to the leaf lobe across only one single cell. Underleaves closely imbricate, reniform to transversely rectangular, 400-520 µm long, 600-1310 µm wide, margin entire, apex truncate, insertion line deeply curved. Androecia not seen. Gynoecia on short or long branches, innovations lacking, bracts and bracteoles in 1-2 pairs, bract ovate to nearly rectangular, 2-3 mm long, 1.5-2 mm wide, margin toothed, apex truncate, sinus up to 1/2 of lobe length, bract lobule ovate, margin ciliate-dentate, apex truncate to nearly acute; bracteole oblong 1.3-2.2 mm long, 0.5-1.4 mm wide, margin toothed, apex rounded. Perianth immersed, obovate, 550 µm long, 530 µm wide, inflated, with 5-7 keels, margins widely winged and toothed. Sporophytes and asexual reproduction not seen.

Specimens examined: INDONESIA. **West Java**, Telaga Warna, Puncak Pass, *ca* 1500 m, *Verdoorn 64a* (BO!); Cibodas Bot. Garden, *Meijer B3800b* (BO!); G. Pangerango, "bij Tjisaroea", *ca* 1200 m, *Verdoorn 44c* (BO!).

Distribution: Java, Peninsular Malaysia, West Irian, Papua New Guinea, New Caledonia.

Notes: Diagnostic characters of *Lopholejeunea herzogiana* are: 1) strongly winged and toothed obovate perianth, 2) lobule conspicuously constricted in the middle and with strongly involuted free margin, 3) lobule apex connected to the leaf lobe across only one single cell, 4) large, ± reniform underleaf with deeply curved insertion line. This rare species was found at ca 1200-1500 m. and usually grows in the mountains at higher elevation. It is readily separated from other species of the genus by the peculiar lobule with deep constriction in the middle.

8. ***Lopholejeunea nigricans*** (Lindenb.) Schiffn., Consp. Hepat. Arch. Ind. 293 (1898); *Lejeunea nigricans* Lindenb., in Gottsche *et al.,* Syn. Hepat. 316 (1845); *Symbiezidium nigricans* (Lindenberg) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877). –**Type**: Indonesia. Java, without locality, collector unknown (holotype, W; isotypes, G, S) – cf. Zhu and Gradstein (2005).

– *Lejeunea intermedia* Lindenb., in Gottsche *et al.,* Syn. Hepat. 316 (1845); *Symbiezidium intermedium* (Lindenberg) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877); *Lopholejeunea intermedia* (Lindenberg) Steph., Sp. Hepat. 5:77 (1912). Type: Indonesia. Java, without locality, collector unkown (holotype, W) – cf. Zhu and Gradstein 2005.
– *Lejeunea javanica* Nees, in Gottsche *et al.*, Syn. Hepat. 320 (1845); *Symbiezidium javanicum* (Nees) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877); *Lopholejeunea javanica* (Nees) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 129 (1893). –Type: Indonesia. Java, without locality, collector unknown (holotype, W; isotypes, G, S) – cf. Zhu and Gradstein (2005).

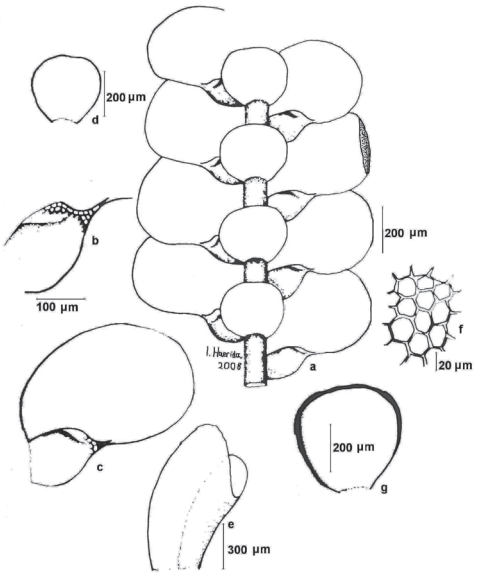

Figure 8. *Lopholejeunea nigricans* (Lindenb.) Schiffn. Shoot (a); leaf lobule (b); leaf lobe (c); underleaf (d); female bract (e); cells of midleaf (f); female bracteole (g). Drawn from *Meijer 387c*, BO.

Plants up to 1 cm long, 0.5-0.7 mm wide, blackish brown in dried condition. Branching *Lejeunea*-type. Stem diameter 40-110 µm. Leaves imbricate, widely spreading. Lobe oblong-orbicular, 250-500 µm long, 200-400 µm wide, margin entire, apex rounded; cells of lobe thick-walled, dark brown, isodiametric to hexagonal, trigones triangular, intermediate thickening scarce; marginal cells 6-10 × 5-10 µm, mid-leaf cells 16-22 × 7-20 µm, basal cells 20-28 × 16-20 µm; oil bodies not seen. Lobule ovate, 120-230 µm long, 80-150 µm wide, inflated, apex obliquely truncate, plane, connected to the leaf lobe across only one single cell. Underleaves distant to contiguous, obdeltoid to orbicular, 120-200 µm long, 150-190 µm wide, margin entire,

apex rounded to almost truncate, insertion line shallowly curved. Androecia not seen. Gynoecia on short or long branches, innovations lacking, bract oblong, 510-700 µm long, 270-330 µm wide, margin entire, apex obtuse to orbicular, sinus up to 2/3 of lobe length, bract lobule about the same length as the bract lobe; bracteole obdeltoid to orbicular 330-700 µm long, 350-500 µm wide, margin entire, sometimes recurved, apex broadly rounded. Perianth exserted, obovate, 300-900 µm long, 250-500 µm wide, inflated, with 4 keels, margins toothed. Sporophytes and asexual reproduction not seen.

Distribution: Java, Sumatra, Borneo, Sulawesi, Moluccas, West Irian, Papua New Guinea, Australia, Peninsular Malaysia, Philippines, Indochina, India, Bhutan, Nepal, China, Japan, tropical Africa, tropical America.

Specimens examined: INDONESIA. **West Java**, without locality, collector unknown (BO!); Bogor Bot. Garden, *van Borssum Waalkes 122, Meijer B995, B368, 55d4, Verdoorn 242* (BO!); Telaga Warna, Puncak Pass, 1500 m, *Verdoorn 64d, 64b* (BO!); G. Pangrango, "Tjisaroea", *ca* 1200 m, *Verdoorn 44a* (BO!); G. Guntur, "Kawah Kamoedjan", 1500-1700 m, *Verdoorn 50c* (BO!).

Notes: Diagnostic characters of *Lopholejeunea nigricans* are: 1) ovate leaf lobules, apex of lobule connected to the leaf lobe across only one single cell, 2) entire margin of female bract and bracteole, 3) female bract lobule of almost the same length as the bract lobe, 4) perianth long exserted beyond the bracts, with 4 toothed keels (rarely entire). This species was found at *ca* 200-1700 m. It is separated from other species of the genus by the combination of characters mentioned above.

9. ***Lopholejeunea ceylanica*** Steph., Sp. Hepat. 5: 86 (1912). –**Type**: Sri Lanka. Horton Plain, *Giesenhagen s.n.* (G, lectotype designated by Verdoorn, 1934).
– *Lopholejeunea levieri* Schiffn., Ann. Bryol. 6: 134 (1933). –Type: Indonesia. Sumatra, Mt. Singalang, "inter *Riccardiam hymenophylloideum*", 1878, *Beccari s.n.* (holotype, FH) – cf. Zhu and Gradstein (2005).
–*Lopholejeunea schiffneri* Verd., Ann. Bryol. 6: 134 (1933). –Type: Indonesia. Java, Cibodas, "ad cortices," Jan 1895, *Massart 1546 p.p.* (holotype, FH) – cf. Zhu and Gradstein (2005).

Dioicous. Plants up to 1.5 cm long, about 0.8 mm wide; blackish brown in the dried condition. Branching *Lejeunea*-type. Stem diameter 90-120 µm. Leaves imbricate, widely spreading. Lobe ovate-orbicular, 450-870 µm long, 350-750 µm wide, margin entire, apex rounded to obtuse; cells of lobe thick-walled,

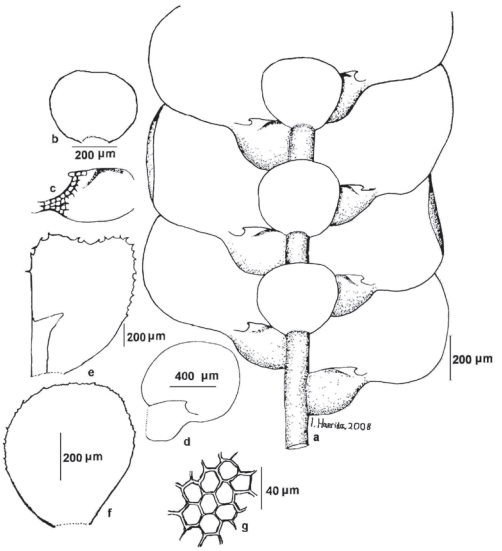

Figure 9. *Lopholejeunea ceylanica* Steph. Shoot (a); underleaf (b); leaf lobule (c); leaf lobe (d); female bract (e); female bracteole (f); cells of midleaf (g). Drawn from *Haerida 1479*, BO.

brown, hexagonal to isodiametric, trigones triangular, intermediate thickening scarce; marginal cells 8-11 × 4-8 µm, mid-leaf cells 14-30 × 15-23 µm, basal cells 27-32 × 22-25 µm; oil bodies not seen. Lobule oblong 250-450 µm long, 200-300 µm wide, inflated, apex truncate with 1 small, unicellular tooth pointing towards the leaf apex, connected to the leaf lobe across 2-3 cells. Underleaves distant, orbicular, 150-300 µm long, 190-350 µm wide, margin entire, apex rounded, insertion line nearly straight. Androecia intercalary on branches, bracts in 5-9 pairs, similar to leaves but lobules larger, 400-430 µm long, 250-350 µm wide, bract lobule about 2/3 of the bract lobe, bracteoles similar to underleaves in size and shape. Gynoecia on short or long branches, innovations lacking, bract oblong to broadly obovate 1000-1370 µm long, 1050-1200 µm wide, margin crenate, apex truncate to orbicular, bract lobule large, about the same length as the bract lobe, oblong, margin entire, apex acute; bracteole obovate 900-1200 µm long, 1050-1100 µm wide, margin entire, crenulate towards the apex, apex rounded. Perianth immersed, obovate, 850 µm long, 630 µm wide, inflated, with 4 keels, margins toothed. Sporophytes and asexual reproduction not seen.

Specimens examined: INDONESIA. **West Java**, Telaga Warna, *Haerida 1479* (BO!); Cibodas Bot. Garden, *ca* 1450 m, *Meijer B3801, 3810*, *Neervoort 811, 3353* (BO!); G. Pangrango, tea estate Mandalawangi, *ca* 1600 m, *Meijer B387g* (BO!); G. Gede, Kandang Badak 2400 m, subalpine forest (forest canopy *ca* 10 m high), common on tree trunks, *Gradstein10241* (BIOT!, GOET!);

G. Cikurai, W slope, *ca* 1700 m, *Verdoorn 59j* (BO!); Cigombong (Pondok Gedelanden), *ca* 500 m, *Verdoorn 43c* (BO!); G. Patuha, *Kornochalert 1405* (BIOT!).

Distribution: Java, Sumatra, Borneo, Peninsular Malaysia, Sri Lanka, Indochina.

Notes: Diagnostic characters of *Lopholejeunea ceylanica* are: 1) lobule large, *ca* ½ x leaf length, with one small, unicellular tooth pointing towards the leaf apex, 2) apex of leaf- lobule attached to the lobe across 2-3 cells, 3) crenate margin of female bract, 4) female bract lobule large, acute. This species grows at *ca* 500-2400 m. It resembles the very common *L. subfusca* but differs by the more brownish color, the larger lobule (*ca* ½ × leaf length; in *L. subfusca ca* 1/3 × leaf length) and the large lobule of the female bract (very small in *L. subfusca*).

10. ***Lopholejeunea horticola*** Schiffn., Ann. Bryol. 6: 133 (1933). –**Type**: Indonesia. Java, Bogor Bot. Garden, on trees ("In horto Buitenzorgensi ad arbores"), Dec 1894, *Massart 941* (holotype, FH; isotypes, FH, W) – cf. Zhu and Gradstein (2005).
– *Lopholejeunea glomerata* Herzog, Ann. Nat. Mus. Wien 53: 370 (1942). –Type: Indonesia. Sumatra, Padang, *Schild 119* (holotype, W) – cf. Zhu and Gradstein (2005).

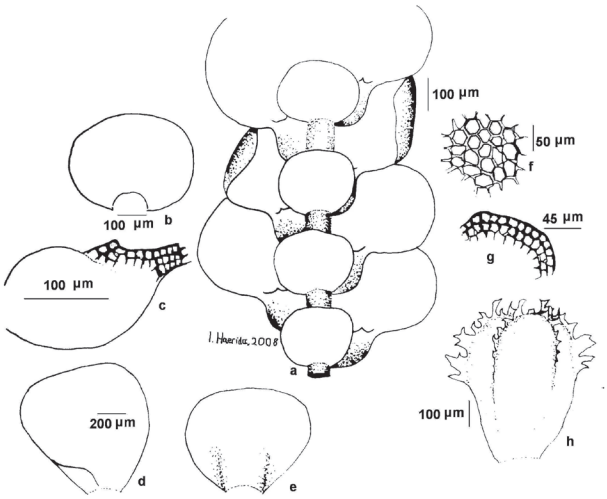

Figure 10. *Lopholejeunea horticola* Schiffn. Shoot (a); underleaf (b); leaf lobule (c); female bract (d), female bracteole (e); cells of midleaf (f); cells of margin of leaf (g); perianth (h). Drawn from *Haerida 809*, BO.

Dioicous. Plants up to 2 cm long, 0.6-0.9 mm wide, dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 90-190 µm. Leaves imbricate, obliquely spreading. Lobe orbicular, oblong to quadrate, 450-800 µm long, 270-600 µm wide, margin entire, apex rounded to obtuse; cells of lobe thick-walled, dark brown, hexagonal, trigones triangular, intermediate thickening scarce; marginal cells 7-10 × 6-8 µm, mid-leaf cells 17-27 × 11-23 µm, basal cells 28-36 × 18-30 µm; oil bodies not seen. Lobule ovate, 190-360 µm long, 120-200 µm wide, inflated, apex obliquely truncate, plane, sometimes with 1 small tooth, connected to the leaf lobe across 2-3 cells. Underleaves distant to contiguous, broadly-orbicular, 200-350 µm long, 330-610 µm wide, margin entire, bases cuneate, apex rounded to almost truncate, insertion line nearly straight. Androecia intercalary on branches, bracts in 3-11 pairs, similar to leaves but lobules larger, 190-230 µm long, 140-180 µm wide, bract lobule 2/3 of the bract lobe, strongly inflated, bracteoles similar to underleaves in size and shape, 100-180 µm long, 120-200 µm wide. Gynoecia on short or long branches, innovations lacking, bract obovate or oblong ± 1200 µm long, 900 µm wide, margin entire, apex obtuse to truncate, bract lobule large, about the same length as the bract lobe, oblong, margin entire, apex obliquely truncate; bracteole obovate, about 800 µm long, 900 µm wide, margin entire, apex truncate. Perianth immersed, obovate, about 800 µm long, 570 µm wide, inflated, with 4 keels, margins strongly toothed. Sporophytes and asexual reproduction not seen.

Specimens examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Neervoort 2098* (BO!); G. Gede, Cibeureum, above "Soekaboemi", 1200-1400 m, *Verdoorn 47b, 47a, 46 c* (BO!); G. Gede Pangrango Nat. Park, Bodogol, *Haerida 809* (BO!); G. Malabar, SW slope, *ca* 1650 m, *Verdoorn 62a* (BO!); G. Guntur, "Kawah Kamoedjan", *ca* 1500-1700 m, *Verdoorn 50a* (BO!); G. Gegerbentang, E slopes, *ca* 1500-2000 m, *Verdoorn 67h* (BO!); without locality, Pondok, *Kurz s.n.* (BO!); G. Patuha, *ca* 2000-2400 m, *Verdoorn 60a* (BO!).

Distribution: Java, Sumatra, Bali, Moluccas, Peninsular Malaysia, Thailand.

Notes: Diagnostic characters of *Lopholejeunea horticola* are: 1) minute plant, less than 1 mm wide, 2) lobule apex connected to the leaf lobe across 2-3 cells, 3) female bract lobule almost as large as the lobe, 4) margins of female bract entire, 5) immersed perianth. This species grows at *ca* 800-2400 m. It closely resembles the very common *L. subfusca* but differs by the much smaller plant size and the large female bract lobule (very small in *L. subfusca*).

11. ***Lopholejeunea recurvata*** Mizut., J. Hattori Bot. Lab. 46: 369 (1979). –**Type**: Indonesia. Java, Gn. Gede, Cibodas, 1420 m, on bark of trees, Jun 1930, *F. Verdoorn s.n.* (holotype, NICH; isotypes, FH, JE, L, S, U) – cf. Zhu and Gradstein (2005).

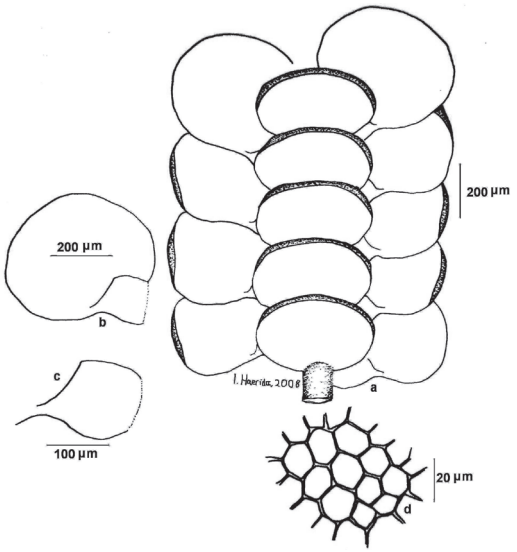

Figure 11. *Lopholejeunea recurvata* Mizut. Shoot (a); leaf lobe (b); leaf lobule (c); cells of midleaf (d). Drawn from *Verdoorn 20f*, BO.

Autoicous. Plants up to 1.5 cm long, 1-1.2 mm wide; dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 60-130 µm. Leaves imbricate, widely spreading. Lobe oblong-rectangular, 430-760 µm long, 390-530 µm wide, margin entire, apex truncate; cells of lobe thick-walled, brownish-orange, hexagonal to isodiametric, trigones triangular, intermediate thickening scarce; marginal cells 6-11 × 6-9 µm, mid-leaf cells 13-20 × 10-17 µm, basal cells 26-33 × 11-19 µm; oil bodies not seen. Lobule ovate, 160-220 µm long, 130-180 µm wide, inflated, apex obliquely truncate, plane, connected to the leaf lobe across 2-3 cells. Underleaves contiguous to imbricate, wider than long, 150-250 µm long, 220-400 µm wide, margin entire, apex recurved, rounded to almost truncate, insertion line curved. Androecia intercalary on branches, bracts in 4-8 pairs, similar to leaves but lobules larger, 200-250 µm long, 100-150 µm wide, bract lobule 1/2-2/3 of the bract lobe, bracteoles similar to underleaves in size and shape. Gynoecia not seen.

Specimen examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Verdoorn 20f* (BO!).

Distribution: Java, Sumatra, Bali, Peninsular Malaysia, Papua New Guinea.

Notes: Diagnostic characters of *Lopholejeunea recurvata* are: 1) recurved margins of leaf lobes and underleaves, 2) lobule apex connected to the leaf lobe across 2-3 cells. This rare species grows at *ca* 500-1900 m. It differs from other Javanese species of the genus by the recurved leaf margins.

12. ***Lopholejeunea subfusca*** (Nees) Schiffn., Bot. Jahrb. Syst. 23: 593 (1897); *Jungermannia subfusca* Nees, Enum. Pl. Crypt. Jav. 1: 36 (1830); *Lejeunea subfusca* (Nees) Nees & Mont., Ann. Sci. Nat., Bot., Sēr. 2, 5: 61 (1836); *Phragmicoma subfusca* (Nees) Nees, Naturgesch. Eur. Leberm. 3: 248 (1838); *Symbiezidium subfuscum* (Nees) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 403 (1877); *Lopholejeunea sagraeana* var. β *subfusca* (Nees) Schiffn., Consp. Hepat. Archip. Ind.: 294 (1898). –**Type**: Indonesia. Java, without locality, *Blume s.n.* (holotype, STR; isotypes, W, S) – cf. Zhu and Gradstein (2005).

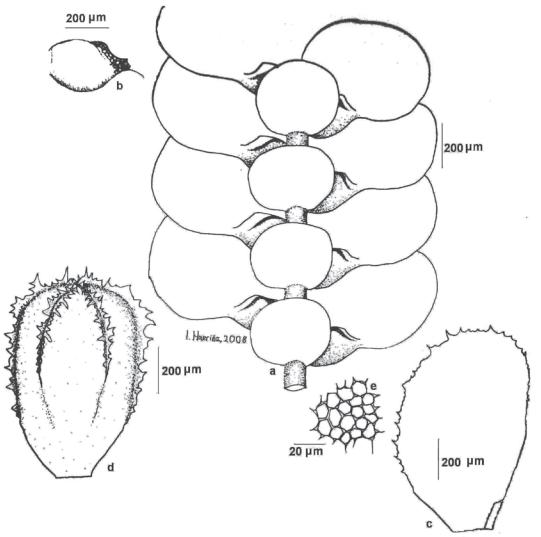

Figure 12. *Lopholejeunea subfusca* (Nees) Schiffn. Shoot (a); leaf lobule (b); female bract (c); perianth (d); cells of midleaf (e). Drawn from *Haerida 850*, BO.

Autoicous. Plants up to 2 cm long, 1-1.3 mm wide, dark brown to black in dried condition. Branching *Lejeunea*-type. Stem diameter 90-120 µm. Leaves imbricate, widely spreading. Lobe oblong-orbicular, 410-700 µm long, 420-620 µm wide, margin entire, apex rounded; cells of lobe thick-walled, pale brown to orange, hexagonal to isodiametric, trigones triangular, intermediate thickening scarce; marginal cells 6-9 × 5-7 µm, mid-leaf cells 17-24 × 15-20 µm, basal cells 22-30 × 16-23 µm; oil bodies not seen. Lobule ovate, small, 180-220 µm long, 120-150 µm wide, inflated, apex obliquely truncate, plane, connected to the leaf lobe across 2-4 cells. Underleaves distant to

contiguous, broadly-orbicular, 220-400 µm long, 340-610 µm wide, margin entire, apex truncate, insertion line shallowly curved. Androecia intercalary on branches, bracts in 3-16 pairs, similar to leaves but lobules larger, 230-430 µm long, 170-320 µm wide, bract lobule almost the same size of the bract lobe, bracteoles similar to underleaves in shape, 170-270 µm long, 180-450 µm wide. Gynoecia on short or long branches, innovations lacking, bracts and bracteoles in 2 pairs, bract ovate to broadly oblong 700-850 µm long, 700-860 µm wide, margin irregularly toothed, apex orbicular to nearly truncate, sinus up to 1/4 of lobe length, bract lobule very small; bracteole broadly orbicular 170-280 µm long, 180-450 µm wide, margin entire, apex rounded. Perianth immersed, obovate, about 870 µm long, 600 µm wide, inflated, with 2 keels, margins toothed. Sporophytes and asexual reproduction not seen.

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *Meijer 92b, 26b, Verdoorn 124, 141, 249* (BO!); Cibodas Bot. Garden, *Neervoort 952*, *Verdoorn 20e, 20d, Schiffner 250* (BO!), ibid., *Lee & Nova Indri 49* (BIOT!, UKMB!), ibid., *ca* 1425 m, *Meijer B4017, B3800* (BO!); G. Gede Pangrango Nat. Park, Bodogol, *ca* 800 m, *Haerida 850, 844* (BO!); G. Pangrango, ravine above Kampong G. Mas, *Meijer B616i* (BO!); Geger Bentang, *Neervoort 1344* (BO!); G. Halimun Nat. Park, Citalahab, 1065 m, *Radhiah Zakaria 254c* (BIOT!); G. Papandayan, Tji Paroegpoeg, *ca* 2300-2500 m, *Verdoorn 54b* (BO!); G. Cikurai, W slope, *ca* 1700 m, *Verdoorn 59i* (BO!); G. Patuha, *Kornochalert 1416, 1400* (BIOT!).

Distribution: Java, Sumatra, Borneo, Bali, Sulawesi, Moluccas, Philippines, Papua New Guinea, Pacific, Peninsular Malaysia, Indochina, China, Japan, India, Sri Lanka, Nepal, tropical Africa, tropical America.

Notes: Diagnostic characters of *Lopholejeunea subfusca* are: 1) lobule apex truncate, connected to the leaf lobe across 2-4 cells, 2) very small size of female bract lobule, 3) entire margin of female bracteole, 4) immersed perianth. This very common species is very grows at *ca* 200-2500 m. Like in several other Javanese species of *Lopholejeunea*, the lobule apex is connected to the leaf lobe surface across 2-4 cells; the flat leaves with rounded apex, the orbicular, distant underleaves, the rather small leaf lobule, and the characters of the gynoecium mentioned above, readily separate this species from its relatives.

13. ***Lopholejeunea wiltensii*** Steph., Hedwigia 35:112 (1896). – **Type**: Indonesia. Sumatra, Padang, *A. Wiltens* (holotype, G) – cf. Zhu and Gradstein (2005).

– *Lopholejeunea serrifolia* Steph., Sp. Hepat. 5: 84 (1912). –Type: Indonesia. Java, without locality, collector unknown (G, lectotype designated by Mizutani, 1979).

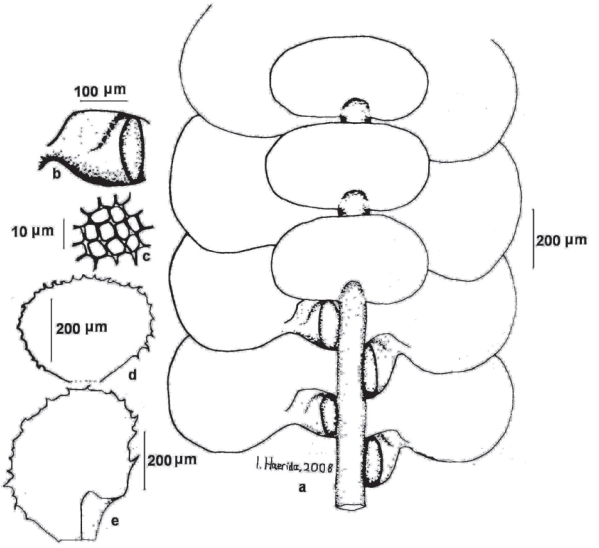

Figure 13. *Lopholejeunea wiltensii* Steph. Shoot (a); leaf lobule (b); cells of midleaf (c); female bracteole (d); female bract (e). Drawn from *Verdoorn 30d*, BO.

Dioicous. Plants up to 4 cm long, 0.9-1.3 mm wide; pale brown in dried condition. Branching *Lejeunea*-type. Stem diameter 50-100 µm. Leaves imbricate, widely spreading. Lobe broadly ovate to broadly orbicular, 500-650 µm long, 580-610 µm wide, margin entire, apex rounded; cells of lobe thick-walled, pale yellow, quadrate to isodiametric, trigones triangular, intermediate thickening scarce; marginal cells 5-7 × 2-6 µm, mid-leaf cells 11-13 × 7-10 µm, basal cells 20-25 × 13-23 µm; oil bodies not seen. Lobule triangular to quadrate, small, 190-220 µm long, 110-130 µm wide, inflated at the basal part forming somewhat a longitudinally elliptical sac, apex obliquely truncate with 1 tooth consisting of 1-2 cells, connected to the leaf lobe across 2-3 cells. Underleaves distant to contiguous, reniform, 210-360 µm long, 310-610 µm wide, margin entire, apex rounded to almost truncate, insertion line strongly curved. Androecia not seen. Gynoecia on short or long branches, innovations lacking, bract oblong-ovate to broadly ovate, about 470 µm long, 460 µm wide, margin irregularly toothed, apex obtuse to orbicular, sinus up to 1/3 of lobe length, bract lobule oblong about 1/3 of the bract lobe length, margin entire; bracteole broadly ovate about 350 µm long, 410 µm wide, margin irregularly toothed, apex truncate. Perianth immersed, obovate, about 970 µm long, 670 µm wide, inflated, with 4 keels, margins toothed. Sporophytes and asexual reproduction not seen.

Distribution: Java, Sumatra, Peninsular Malaysia, Philippines, Sulawesi, Moluccas, West Irian, Papua New Guinea, New Caledonia.

Specimens examined: **West Java**, Cibodas Bot. Garden, 1400 m, *Ariyanti 458* (BIOT!), *ibid*., along the road to Huis ten Bosch, *Meijer B1078* (BO!); above Cibodas, Cibeureum, *Schiffner 252, 253*, *Verdoorn 30d, 30c, 30a* (BO!); G. Gede, Soekaboemi, *Verdoorn 46a* (BO!); G. Pangrango, "Tjisaroea", *ca* 1200 m, *Verdoorn 44a* (BO!); Tugu, tea estate G. Mas, *Meijer & van der Wijk B659b* (BO!); above tea estate G. Mas, Jalan Mandalawangi, *Meijer B335a* (BO!); G. Guntur, "Kawah Kamoedjan", *ca* 1500-1700 m, *Verdoorn 50b* (BO!).

Notes: Diagnostic characters of *Lopholejeunea wiltensii* are: 1) pale color of the plant in the dried condition, 2) lobule small, in the basal part forming a somewhat longitudinally elliptical sac, 3) lobule apex connected to the leaf lobe across 2-3 cells, 4) reniform underleaves. This species grows at *ca* 1200-1900 m. *Lopholejeunea wiltensii* is closely related to *L. zollingeri* and was sometimes considered a synonym of the latter. It differs from *L. zollingeri* by the characters given in the key.

14. ***Lopholejeunea zollingeri*** (Steph.) Schiffn., Consp. Hepat. Arch. Ind.: 296 (1898); *Lejeunea zollingeri* Steph., Hedwigia 29: 14 (1890). –**Type**: Indonesia. Java, without locality, collector unknown (W, lectotype designated by Mizutani, 1979).
– *Lopholejeunea latialata* Mizut., J. Hattori Bot. Lab. 46: 365 (1979). –Type: Indonesia. Java: without locality, collector unknown, ex Herb. Sande Lacoste (holotype, L) – cf. Zhu and Gradstein (2005).

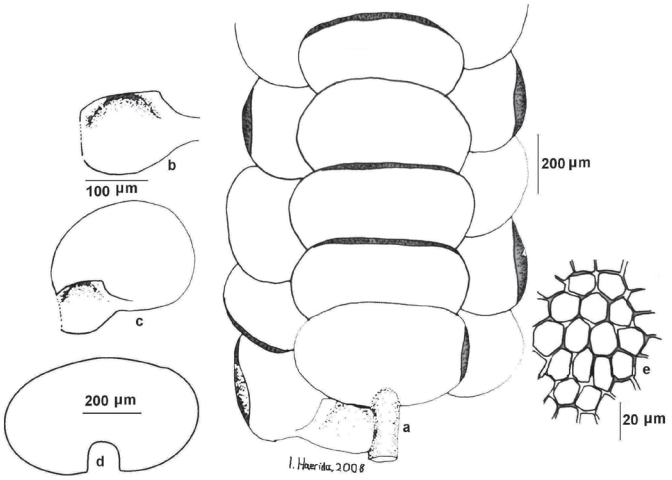

Figure 14. *Lopholejeunea zollingeri* (Steph.) Schiffn. Shoot (a); leaf lobule (b); leaf lobe (c); underleaf (d); cells of midleaf (e). Drawn from *Meijer 387c*, BO.

Autoicous. Plants up to 3 cm long, 0.7-1.2 mm wide, blackish brown in dried condition. Branching *Lejeunea*-type. Stem diameter 60-160 µm. Leaves imbricate, widely spreading. Lobe orbicular to broadly ovate, 200-420 µm long, 230-460 µm wide, margin entire, apex rounded, usually recurved; cells of lobe thick-walled, brown, hexagonal to isodiametric, trigones triangular, intermediate thickening frequent; marginal cells 5-11 × 7-9 µm, mid-leaf cells 11-19 × 9-15 µm, basal cells 25-30 × 19-22 µm; oil bodies not seen. Lobule ovate, large, almost 1/3 of the leaf lobes length, 190-210 µm long, 160-180 µm wide, inflated at the middle part forming a globose sac, apex obliquely truncate with 1 small tooth or without tooth but forming a sharp angle, connected to the leaf lobe across 3-4 cells. Underleaves closely imbricate, reniform, 190-420 µm long, 370-710 µm wide, margin entire, apex rounded to almost truncate, insertion line strongly arched. Androecia intercalary on branches, bracts in 4-9 pairs, similar to leaves but lobules larger, 200-220 µm long, 160-190 µm wide, bract lobule 1/3 of the bract lobe, bracteoles similar to underleaves in shape, 110-170 µm long, 180-300 µm wide. Gynoecia not seen.

Specimens examined: INDONESIA. **West Java**, G. Pangrango, tea estate Mandalawangi, *ca* 1600 m, *Meijer B387c* (BO!); G. Patuha, ca 1600 m, *Kornchalert 1413, Gradstein 12169* (BIOT!).

Distribution: Java, Sumatra, Borneo, Sulawesi, Peninsular Malaysia, Philippines, Papua New Guinea, Sri Lanka, China, Japan, Fiji.

Notes: Diagnostic characters of *Lopholejeunea zollingeri* are: 1) broadly orbicular leaf lobe with recurved apex, 2) leaf lobule large, apex connected to the leaf lobe across 3-4 cells, 3) closely imbricate, large, reniform underleaves with strongly arched insertion line. This species grows at *ca* 1350-1600 m. *Lopholejeunea zollingeri* has very large, reniform underleaves like in *L. wiltensii*, *L. eulopha* and *L. applanata* but differs from the latter two by the lobule apex which is attached to the lobe across 3-4 cells (across 1 cell in *L. eulopha* and *L. applanata*). For differences with *L. wiltensii* see the characters given in the key.

15. ***Mastigolejeunea auriculata*** (Wils.) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 129 (1893); *Jungermannia auriculata* Wils., in Drummond, Musci Amer. Exsicc. (Southern States) nr. 170 (1841); *Ptychocoleus auriculatus* (Wils.) Trevis., Mem. Reale Ist. Sci. Mat. Nat., Ser. 3, 4: 405 (1877). –**Type**: USA. Louisiana, New Orleans, *Drummond s.n.* (holotype, BM; isotypes, MANCH, PC) –cf. Gradstein *et al.* (2002).
–*Phragmicoma humilis* Gottsche, in Gottsche *et al.*, Syn. Hepat. 299 (1845); *Mastigolejeunea humilis* (Gottsche) Schiffn., in Engler and Prantl, Nat.

Pflanzenfam. 1, 3: 129 (1893). –Type: Indonesia. Java, without locality, *Junghuhn s.n.* (isotypes, B, W) – cf. Gradstein *et al.* (2002).

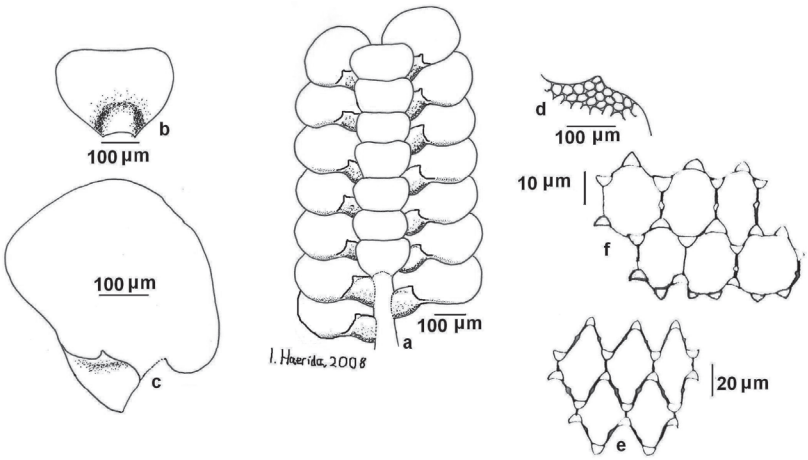

Figure 15. *Mastigolejeunea auriculata* (Wils.) Schiffn. Shoot (a); underleaf (b); leaf lobe (c); leaf lobule (d); cells of basal part of the leaf (e); cells of midleaf (f). Drawn from *Meijer 92a*, BO.

Plants up to 2 cm long, 0.8-1 mm wide, dull green to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 70-170 µm. Leaves imbricate, obliquely spreading, somewhat squarrose. Lobe ovate, 440-1030 µm long, 410-730 µm wide, margin entire, apex rounded to obtuse; cells of lobe thick-walled, light yellow, rhomboidal to hexagonal, trigones cordate, intermediate thickening scarce; marginal cells 11-15 × 6-10 µm, mid-leaf cells 18-21 × 9-12 µm, basal cells 25-34 × 16-19 µm; oil bodies not seen. Lobule oblong to subrectangular, 190-440 µm long, 130-200 µm wide, apex truncate to obliquely truncate with 1 small tooth. Underleaves imbricate, obdeltoid to nearly triangular, 200-530 µm long, 220-490 µm wide, margin entire, apex truncate, base cuneate, insertion line curved. Androecia not seen. Gynoecia on short or long branches, with 1-2 lejeuneoid innovations, bract oblong to broadly oblong, 1000-1070 µm long, 600-800 µm wide, margin entire, apex subrounded to nearly truncate, sinus 1/3 to 2/3 of lobe length, bract lobule oblong-ovate to subrectangular, 500-670 µm long, 340-360 µm wide, margin somewhat undulated towards the apex; bracteole obdeltoid 600-770 µm long, 850-960 µm wide, margin entire, apex truncate. Perianth obovate, 1010 µm long, 440 µm wide, with 3 keels, margins entire. Asexual reproduction not observed.

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *van Borssum Waalkes 122a, Meijer 92a, 552d* (BO!). **Banten**, Taman Nasional Ujung Kulon, *Dewi Dw 922b* (BO!).

Distribution: Java, Borneo, Sulawesi, Moluccas, West Irian, Papua New Guinea, Australia, Solomon Is., India, Indochina, China, Japan, tropical Africa, tropical America.

Notes: Diagnostic characters of *Mastigolejeunea auriculata* are: 1) leaf lobe ovate in shape, margins entire, 2) leaf cells elongate, with cordate trigones 3) lobule with truncate to obliquely truncate apex, with 1 small tooth, 4) underleaves obdeltoid, 5) perianth 3-keeled, with smooth keels and 1-2 innovations. This species grows at *ca* 200-1700 m. It is very similar to *M. virens* but differs by the very short, blunt lobule tooth.

16. ***Mastigolejeunea indica*** Steph., Sp. Hepat. 4: 776 (1912). –**Type**: India. Nicobar Is., *Man s.n.* (holotype, G) –cf. Gradstein *et al.* (2002).
–*Thysananthus integrifolius* Steph., Sp. Hepat. 4: 788 (1912). *Mastigolejeunea integrifolia* (Steph.) Verdoorn, Blumea 1: 231, 239 (1934). –Type: Australia. Torres Str., Possession I., *Micholitz s.n.* (holotype, G; isotype, FH) –cf. Gradstein *et al.* (2002).

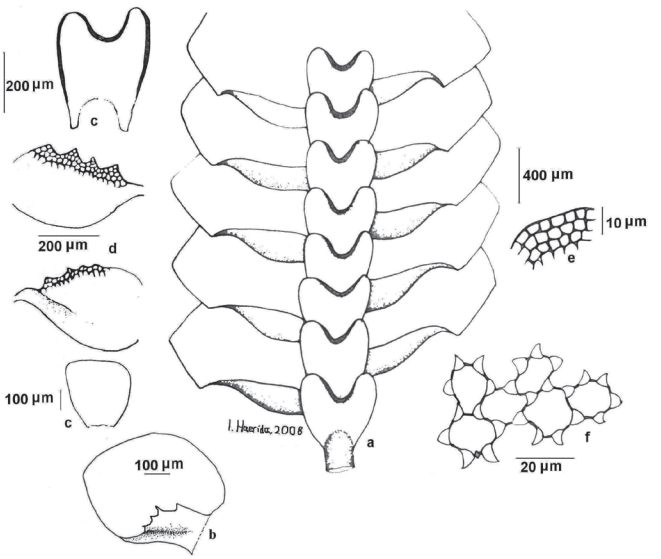

Figure 16. *Mastigolejeunea indica* Steph. Shoot (a); leaf lobe (b); underleaf (c); leaf lobule (d); cells of margin of leaf (e); cells of midleaf (f). Drawn from *Meijer 75a*, BO.

Dioicous. Plants up to 2.5 cm long, 0.6-1 mm wide, 1-1.5 mm wide in wet condition, greenish-brown in dried condition, becoming more green towards the apex of the plant. Branching *Lejeunea*-type. Stem diameter 100-250 µm, epidermis cells very unequal in size, dorsal one much large than ventral ones, hyalodermis lacking. Leaves imbricate, obliquely spreading, convolute when

dry. Lobe ovate-oblong, 520-1150 µm long, 300-890 µm wide, margin entire, apex acute to obtuse; cells of lobe thin-walled, light yellow, rhomboidal, trigones cordate, intermediate thickening scarce; marginal cells 6-11 × 3-5 µm, mid-leaf cells 7-18 × 6-14 µm, basal cells 21-35 × 17-20 µm; oil bodies not seen. Lobules ovate to triangular, 180-390 µm long, 160-280 µm wide, slightly inflated along the keel, apex obliquely truncate with 3-4 triangular teeth, each tooth consisting of 3-4 cells, 2-3 cells long, first and second tooth sometimes blunt, only 1-2 cells long, sometimes with or without fourth, 1-2 cells long tooth. Underleaves imbricate, obdeltoid, 230-520 µm long, 250-540 µm wide, margin entire, apex truncate, usually recurved and seemingly emarginate, base auriculate, insertion line curved. Generative structures not seen.

Specimens examined: Inodnesia. **West Java**, Bogor Bot. Garden, *ca* 250m, *Meijer 75a* (BO!).

Distribution: Java, China, India (Nicobar), Philippines, Papua New Guinea, Australia.

Notes: Diagnostic characters of *Mastigolejeunea indica* are: 1) plant like *M. auriculata* but lobule with 3-4 large teeth, 2) stem cross section with very unequal epidermis cells, dorsal ones much large than ventral ones (hyalodermis lacking). *Mastigolejeunea indica* is new to Java. The species has only been collected in the Botanical Garden of Bogor, at *ca* 250 m. It is readily separated from all other species of the genus *Mastigolejeunea* by the lobule with 3-4 large triangular teeth (usually only one tooth in other species of the genus).

17. ***Mastigolejeunea virens*** (Ångstr.) Steph., in Sp. Hepat. 4: 776. 1912; *Thysananthus virens* Ångstr., Őfv. K.Vetensk Akad. Főrh. 5: 131. 1873. – **Type**: Society Is., Moorea, *Andersson s.n.* (holotype, S; isotypes, FH, G) –cf. Gradstein *et al.* (2002).
–*Mastigolejeunea humilis sensu* Verdoorn 1933 *p.p.*

Autoicous. Plants up to 3 cm long, 0.9-2 mm wide, brown to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 60-190 µm. Leaves closely imbricate, widely spreading. Lobe ovate to oblong, 340-920 µm long, 200-640 µm wide, margin entire, apex rounded to obtuse; cells of lobe thick-walled, light-yellow, rhomboidal, trigones cordate, intermediate thickening scarce; marginal cells 6-11 × 5-6 µm, mid-leaf cells 11-16 × 5-7 µm, basal cells 18-26 × 8-10 µm; oil bodies not seen. Lobule ovate, 140-280 µm long, 60-170 µm wide, inflated, apex obliquely truncate with 1 long tooth consisting of 3-5 cells. Underleaves imbricate, quadrangular to nearly

triangular, 190-560 µm long, 250-600 µm wide, margin entire, apex truncate, sometimes recurved forming a hearth shaped. Androecia intercalary on branches, bracts in 5 pairs, similar to leaves but lobules larger, bract lobule 2/3 of the bract lobe, 100-110 µm long, 50-60 µm wide, bracteoles similar to underleaves in size and shape, 90-120 µm long, 100-120 µm wide. Gynoecium with 1-2 subfloral innovations; innovation type lejeuneoid; bract lobe ovate-oblong, ventral margin incurved, margin entire, apex rounded, 1160 µm long, 460 µm wide; bract lobule about ½ of bract lobe length, oblong, margin crenulate; bracteole oblong, margin entire, apex rounded. Perianth 820 µm long, oblong, inflated, with 3 keels, margins entire. Sporophytes and asexual reproduction not seen.

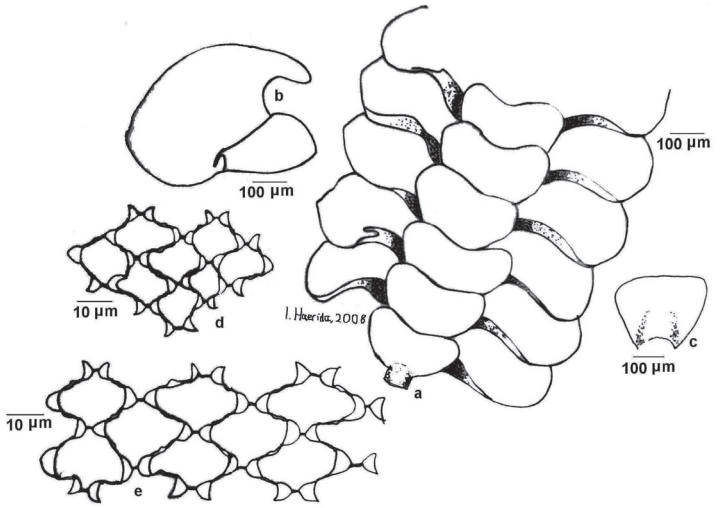

Figure 17. *Mastigolejeunea virens* (Ångstr.) Steph. Shoot (a); leaf lobe (b); underleaf (c); cells of midleaf (d); cells of basal part of the leaf (e). Drawn from *Meijer 62a*, BO.

Specimens examined: INDONESIA. **West Java**, Bogor, without locality, *Verdoorn* 149 (BO!); Bogor Bot. Garden, *Schiffner 257*, *W. Meijer B24, 62a, B55f, B998b, Verdoorn 12z, 12d, 143, 255* (BO!); Cibodas Bot. Garden, *Neervoort 154, 918, Meijer B3720, B3815* (BO!), *ibid*., *Lee & Nova Indri 62* (BIOT!, UKMB!), *ibid*., *Ariyanti 472* (BIOT!); Telaga Bodas, *Verdoorn 58a, 58b* (BO!); G. Megamendung, above "Toegoe", *Schiffner 256* (BO!).

Distribution: Java, Borneo, Moluccas, Philippines, Peninsular Malaysia, Thailand, Sri Lanka, Papua New Guinea, Australia, Pacific Islands.

Notes: The occurrence of *Mastigolejeunea virens* in Java has not been reported before, therefore this species is new for Java. Verdoorn (1933)

treated the species as a synonym of *M. humilis* (= *M. auriculata*), but it is readily separated from the latter by the longer lobule tooth (see key). The diagnostic characters of *Mastigolejeunea virens* are: 1) leaf lobe rounded to obtuse at apex, 2) lobule with 1 long tooth consisting of 3-5 cells, 3) perianth with 3 keels. This species grows at *ca* 200-1500 m.

18. ***Ptychanthus striatus*** (Lehm. & Lindenb.) Nees, Naturgesch. Eur. Leberm. 3: 212 (1838); *Jungermannia striata* Lehm. & Lindenb., Nov. Stirp. Pug. 4: 16 (1832); *Bryopteris striata* (Lehm. & Lindenb.) Mitt., in Seemann, Fl. Vit. 411 (1873). –**Type**: Nepal. *Wallich s.n. & s.d.* (holotype, S; isotypes, G, W) –cf. Gradstein *et al.* (2002).
–*Jungermannia retusa* Reinw. *et al.* var. β Nees, Enum. Pl. Crypt. Javae 1: 39 (1830); *Ptychanthus retusus* (Reinw. *et al.*) Nees var. β Nees, in Gottsche et al., Syn. Hepat. 292. 1845; *Ptycholejeunea retusa* (Reinw. *et al.*) Steph., Hedwigia 28: 258 (1889); *Ptychanthus retusus* (Reinw. *et al.*) Steph., Sp. Hepat. 4: 743 (1912); *Ptychanthus striatus* var. *retusus* (Reinw. *et al.*) Verd., Ann. Bryol. Suppl. 4: 122 (1934). –Type: Indonesia. Java, without locality, *Blume s.n.* (holotype, STR; isotype, W) –cf. Gradstein *et al.* (2002).

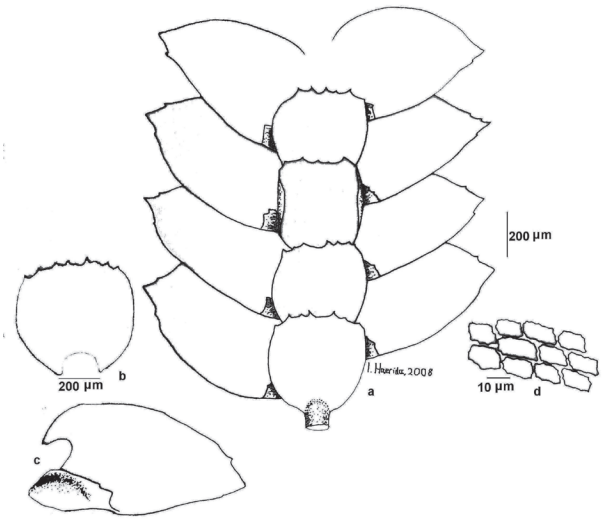

Figure 18. *Ptychanthus striatus* (Lehm. & Lindenb.) Nees. Shoot (a); underleaf (b); leaf lobe (c); cells of midleaf (d). Drawn from *Meijer 840*, BO.

Autoicous. Plants robust, up to 10 cm long, 1-1.5 mm wide, standing up away from the substrate or pendent, pinnate, greenish-brown in dried condition. Branching *Frullania*-type. Stem diameter 130-300 µm. Leaves imbricate, flat, obliquely spreading. Lobe broadly-ovate, 650-2170 µm long, 300-1260 µm wide, margin entire or slightly toothed towards the apex, apex acute, base auriculate at the proximal side; cells of lobe thick-walled, light-yellow,

rhomboidal to hexagonal, trigones cordate, intermediate thickening frequent; marginal cells 7-16 × 4-11 µm, mid-leaf cells 20-27 × 8-14 µm, basal cells 26-38 × 11-20 µm; oil bodies not seen. Lobule ovate, small, 240-370 µm long, 110-170 µm wide, inflated, apex with 1-2 teeth, teeth consisting of 1 small cell. Underleaves distant to contiguous, broadly-ovate, sometimes subrectangular in outline, 480-760 µm long, 470-1000 µm wide, base auriculate, margin entire, apex irregularly toothed. Androecia intercalary on branches, bracts in 5-10 pairs, bract lobe ovate, 560-1150 µm long, 300-520 µm wide, margin entire, apex acute, bract lobule 1/2 of the bract lobe, inflated, 390-500 µm long, 200-240 µm wide, bracteoles similar to underleaves in size and shape. Gynoecia on short or long branches, innovation type lejeuneoid, bract lobe ovate with small bract lobules, 1220-1320 µm long, 550-630 µm wide, margin toothed towards the apex, apex acute, bract lobules oblong, 460-710 µm long, 80-150 µm wide; bracteole broadly ovate, 1110-1150 µm long, 1220-1330 µm wide, margin toothed, apex rounded. Perianth immersed, elliptical, 1770 µm long, 730 µm wide, inflated, with ± 10 keels, margins entire. Sporophytes and asexual reproduction not seen.

Specimens examined: INDONESIA. **West Java**, G. Salak, *ca* 1000 m, *Zollinger 3560*, *Schiffner 259* (BO!); G. Gede, above Cibodas, 1600-1900 m. *Neervoort 107, 129, 227, 2775, 2401, 282, 2271, Verdoorn 30g, 30f, 21a, 30n, Iwamasa s.n., Meijer B4137, B4076, B160* (BO!), ibid., above Tanjung Mas waterfall (Pancuran Mas), *Alston 12807* (BO!), *ibid*., Cibeureum, *Schiffner 266, Verdoorn 30h, 30i, 30j, 30n* (BO!), *ibid*., trail Cibeureum falls to Kandang Badak 1700-2200 m, montane forest, epiphytes on trunk bases, common, *Gradstein 10215, 10217* (BIOT!, GOET!); G. Pangrango, "Tjisaroea", *ca* 1200 m, *Verdoorn 44a, 44b, 44c* (BO!); Tugu, slope of Gede-Pangrango, above G. Mas, *Meijer B3394a, B840, B421* (BO!); G. Geger Bentang, E slopes, 1500-2000 m, *Neervoort 2890, Verdoorn 67a, 67b, 267, Meijer B5584* (BO!); G. Megamendung, *Schiffner 265* (BO!); G. Malabar, SW slopes of Punciak Besar 1650-2300 m, *Verdoorn 61a, 61b, 61c, 62b, 62d* (BO!); G. Patuha, 2000-2400 m, *Verdoorn 60b* (BO!), *Kornochalert 1414* (BIOT!).

Distribution: Java, Sumatra, Peninsular Malaysia, Borneo, Sulawesi, Moluccas, Philippines, West Irian, Papua New Guinea, Australia, New Zealand, Pacific Islands, India, Sri Lanka, Taiwan, Indochina, China, Japan, tropical Africa.

Notes: Diagnostic characters of *Ptychanthus striatus* are: 1) *Frullania*-type branching, 2) lobe with acute apex and entire or toothed margins, 3) leaf cells elongate, with cordate trigones, 4) perianth with 10 smooth keels, and with innovation, 5) plant robust, pinnate, usually pendent. This species is common in the mountains where it occurs at *ca* 1000-2400 m. By its large

size, its pinnate, Frullania-type branching and acute leaf lobes the speciers is unmistakable and cannot be confused with any other Javanese member of Lejeuneaceae.

19. ***Schiffneriolejeunea pulopenangensis*** (Gottsche) Gradst., J. Hattori Bot. Lab. 38: 335 (1974); *Phragmicoma pulopenangensis* Gottsche, Syn. Hepat. 299 (1845); *Ptychocoleus pulopenangensis* (Gottsche) Trevis., Mem. Reale Ist. Lombardo Sci., Cl. Sci. Mat., Ser. 3, 4: 405 (1877). –**Type**: Peninsular Malaysia. Pulo Penang, *Delessert s.n.* (holotype, PC-Mont; isotypes, BM, S, W).

Plants up to 6 cm long, 1.5-2 mm wide, brown to dark brown in dried condition. Vegetative branching *Frullania*-type, or *Lejeunea*-type. Stem diameter 150-260 µm. Leaves imbricate, obliquely spreading, convolute when dry. Lobe broadly ovate to somewhat triangular, 700-1060 µm long, 500-850 µm wide, margin entire, apex obtuse to nearly acute; cells of lobe thick-walled, hyaline, rhomboidal to hexagonal, trigones cordate, intermediate thickening scarce; marginal cells 9-24 × 7-16 µm, mid-leaf cells 17-26 × 8-19 µm, basal cells 25-45 × 13-23 µm; oil bodies not seen. Lobule ovate, 300-420 µm long, 150-280

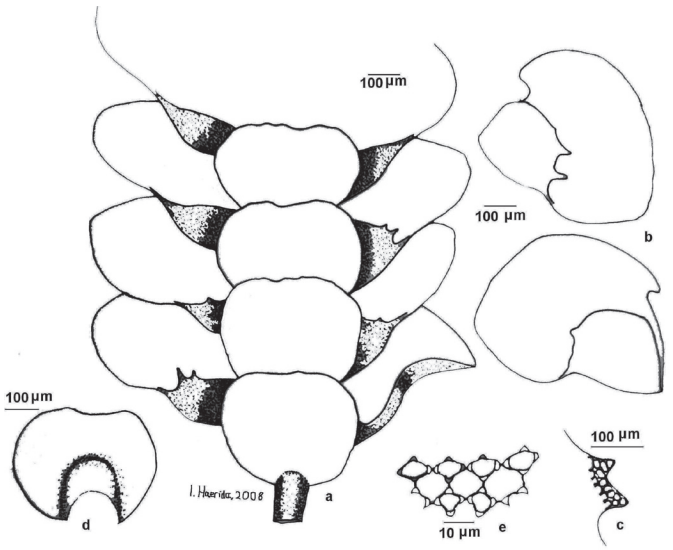

Figure 19. *Schiffneriolejeunea pulopenangensis* (Gottsche) Gradst. Shoot (a); leaf lobe (b); apex of leaf lobule (c); underleaf (d); cells of midleaf (e). Drawn from *Meijer & Alston 5329*, BO.

µm wide, apex with 2 conspicuous teeth that point outwards towards the leaf apex, first tooth consisting of 3-4 cells, second tooth consisting of 2-3 cells, lobule free margin plane, with 2 clearly visible teeth. Underleaves imbricate, obdeltoid-orbicular sometimes with recurved apex seemingly emarginate, 360-420 µm long, 480-610 µm wide, margin entire, apex truncate,

insertion line deeply curved. Androecia on lateral branches, inflated, in 3-11 pairs, about 1/3-1/2 of the vegetative lobe, hypostatic, bracteoles oblong to obdeltoid, apex truncate, smaller than the underleaves. Gynoecia not seen.

Specimen examined: INDONESIA. **West Java**, Bogor Bot. Garden, *Meijer & Alston 5329* (BO!).

Distribution: Indomalesia, Australia.

Notes: Diagnostic characters of *Schiffneriolejeunea pulopenangensis* are: 1) branching Lejeunea and Frullania type, 2) leaf lobule ovate, with plane free margin and with 2 long teeth that point outwards to the leaf apex, 3) leaves not squarrose when moist, convolute when dry, 4) trigones cordate. This species is apparently rare in Java and has only been collected in the Botanical Garden of Bogor at *ca* 250 m. The species is closely related to *S. tumida* but differs by the lobule without saccate base and by the flat leaves (squarrose in *S. tumida*).

20. ***Schiffneriolejeunea tumida*** var. ***haskarliana*** (Gottsche) Gradst. & Terken, Occas. Pap. Farlow Herb. 16: 77 (1981); *Phragmicoma hasskarliana* Gottsche, in Gottsche *et al.*, Syn. Hepat. 299 (1845); *Acrolejeunea hasskarliana* (Gottsche) Schiffn., in Engler and Prantl, Nat. Pflanzenfam. 1, 3: 129 (1893); *Ptychocoleus hasskarliana* (Gottsche) Steph., Sp. Hepat. 5: 44 (1912). –**Type**: Indonesia. Java, without locality, *Hasskarl 20* (holotype, B; isotypes, G, S, W) – cf. Gradstein and Terken (1981).
–*Mastigolejeunea badia* Gottsche ex Steph., Sp. Hepat. 4: 779 (1912). –Type: Solomon Is., Vanikoro, *Lesson s.n.* (isotypes, BM, FH) –cf. Gradstein and Terken (1981).

Plants up to 6 cm long, 2-3 mm wide; brown to dark brown in the dried condition. Vegetative branching Frullania-type, or Lejeunea-type. Stem diameter 160-270 µm. Leaves imbricate, obliquely spreading, somewhat squarrose, convolute when dry. Lobe broadly ovate to somewhat triangular, 900-1150 µm long, 700-1200 µm wide, margin entire, apex obtuse to nearly acute; cells of lobe thick-walled, hyaline, rhomboidal to hexagonal, trigones cordate, intermediate thickening scarce; marginal cells 13-24 × 9-22 µm, mid-leaf cells 19-29 × 18-27 µm, basal cells 25-40 × 18-32 µm; oil bodies not seen. Lobule ovate-rectangular, 300-620 µm long, 130-270 µm wide, apex with 2 teeth, each tooth consisting of 3-4 cells, lobule free margin strongly involute, forming a sac at the base of the lobule. Underleaves imbricate, obdeltoid sometimes with recurved apex seemingly emarginate, 420-840 µm long, 490-720 µm wide, margin entire, apex truncate, insertion line deeply curved. Generative structures not seen.

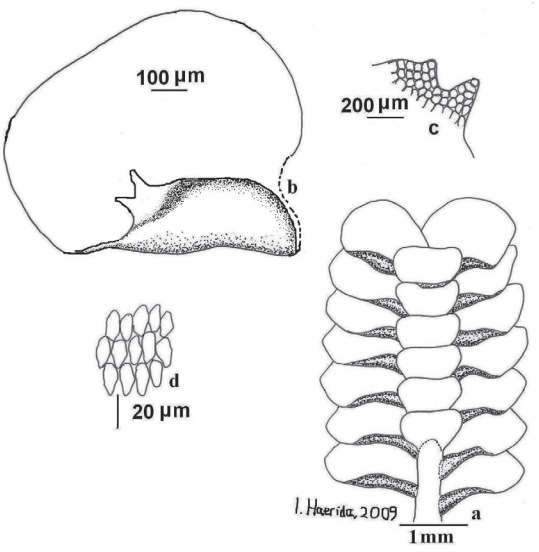

Figure 20. *Schiffneriolejeunea tumida* var. *haskarliana* (Gottsche) Gradst. & Terken. Shoot (a); leaf lobe (b); apex of leaf lobule (c); cells of midleaf (d). Drawn from *Haerida 724*, BO.

Specimens examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Neervoort 2120* (BO!), *ibid*., on bark of *Altingia excelsa*, *ca* 1400 m, *Gradstein 10202* (BIOT!, GOET!); above Cibodas, trail to Cibeureum waterfall, on tree trunk, *Lee & Nova Indri 58* (BIOT!, UKMB!); G. Halimun Nat. Park, *Haerida 724* (BO!).

Distribution: Java, Papua New Guinea, Solomon Is., Australia.

Notes: Diagnostic characters of *Schiffneriolejeunea tumida* var. *haskarliana* are: 1) branching *Lejeunea*- and *Frullania*-type, 2) leaf lobule with 2 conspicuous, erect teeth and with a sac at the base by the strongly involute free margin, 3) leaves somewhat squarrose when moist, convolute when dry, 4) cordate trigones. This species grows at *ca* 1000-1500 m. It is closely related to *S. pulopenangensis* but occurs at higher elevations; for morphological differences see under the latter species and the key.

21. ***Spruceanthus polymorphus*** (Sande Lac.) Verd., Ann. Bryol. Suppl. 4: 155 (1934); *Phragmicoma polymorpha* Sande Lac., Ned. Kruidk. Arch. 34: 420 (1854); *Phragmolejeunea polymorpha* (Sande Lac.) Schiffn., Forschungsr. Gazelle 4: 25. (1890); *Thysananthus polymorphus* (Sande Lac.) Schiffn., Consp. Hepat. Arch. Ind. 305 (1898); *Archilejeunea polymorpha* (Sande Lac.) B. Thiers & Gradst., Mem. N.Y. Bot. Garden 52: 10 (1989). –**Type**: Indonesia. Java, *Junghuhn s.n.* (holotype, L; isotype, NY) –cf. Gradstein *et al.* (2002).

Autoicous. Plants up to 4 cm long, 1.5-2.5 mm wide, pale green to greenish brown in dried condition. Branching *Lejeunea*-type. Stem diameter 100-250 µm; ventral merophyte 8-12 cells wide. Leaves imbricate, widely spreading. Lobe ovate-oblong, 730-1300 µm long, 430-640 µm wide, margins entire or toothed, plane or undulate, apex rounded to obtuse; cells of lobe isodiametric, with large, nodulose intermediate thickenings, hyaline, trigones not cordate; marginal cells 7-12 × 6-13 µm, mid-leaf cells 20-26 × 19-24 µm, basal cells 26-52 × 13-18 µm; oil bodies not seen. Lobule ovate, 110-230 µm long, 80-130 µm wide, apex obliquely truncate with 1-2 small teeth. Underleaves closely imbricate, obdeltoid to orbicular, 230-400 µm long, 400-500 µm wide, margin entire at lateral part, serrate towards the apex, apex rounded to truncate, insertion line shallowly curved. Androecia intercalary on branches, bracts up to 14 pairs, similar to leaves but lobules larger, 580-650 µm long, 250-300 µm wide, hypostatic, bracteoles similar to underleaves in size and shape. Gynoecia with 1-2 lejeuneoid innovations, bract ovate, about 900 µm long, 600 µm wide, margin entire, apex rounded, bract lobule ovate about 2/3 of the lobe length, toothed; bracteole orbicular to oblong, 530-600 µm long, 580-900 µm wide, margin toothed. Perianth oblong, about 1300 µm long, 430 µm wide, with 7 smooth keels, margins entire. Sporophytes and asexual reproduction not seen.

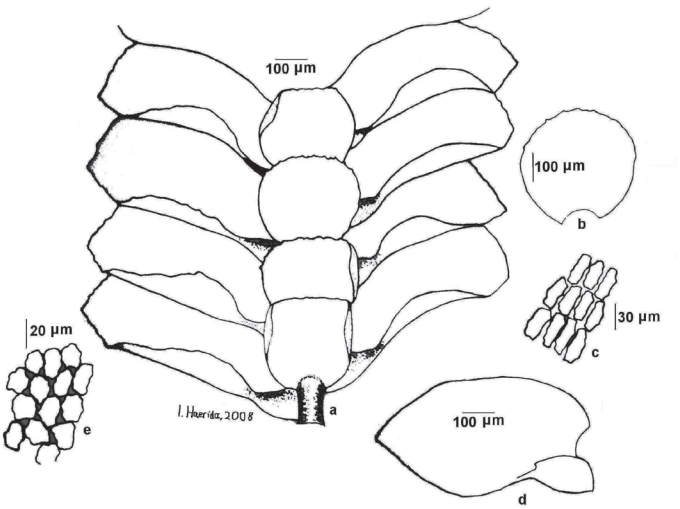

Figure 21. *Spruceanthus polymorphus* (Sande Lac.) Verd. Shoot (a); underleaf (b); cells of basal cells of the lobe (c); leaf lobe (d); cells of midleaf (e). Drawn from *Borssum Waalkes 450*, BO.

Specimens examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Meijer B3820, B178* (BO!), *ibid*., on bark of *Araucaria, ca* 1400 m, very common, *Gradstein 10207* (BIOT! GOET!), *ibid*., near the guest house, on base of

tree, *Gradstein 10206* (BIOT! GOET!); Gn. Pangrango, *Meijer B605* (BO!); Gn. Gede, 1500-1900 m, *Verdoorn 46e, 46d, 47c*, *Meijer B589a2* (BO!), ibid., N slope above "Artja", *ca* 1100 m, *Schiffner 287, 285* (BO!); Rawa Denok, *ca* 1900 m, *Neervoort 2380* (BO!); Gn. Halimun, *ca* 930 m, collector unknown (BIOT!); Gn. Cikurai, *ca* 1700 m, *Verdoorn 59a, 59b,59c, 59d, 59e, 59f* (BO!); Geger Bentang, *Neervoort 1366, 1089* (BO!); Gn. Malabar, *Verdoorn 62c* (BO!). **Banten**, Pulau Panaitan, Gn. Putri, *ca* 75 m, *van Borssum Waalkes 450* (BO!); Taman Nasional Ujung Kulon, *Dewi Dw928, 922c* (BO!).
Distribution: Java, Sumatra, Borneo, Sulawesi, Philippines, New Guinea, Australia, Pacific, Japan, Taiwan, India.

Notes: Diagnostic characters of *Spruceanthus polymorphus* are: 1) rather robust plant, ventral merophyte 8-12 cells wide, 2) underleaves serrate towards the apex, 3) leaf lobes rounded to obtuse at apex, with entire or toothed, plane or undulate margin, 4) leaf cells isodiametrical, 5) female bract lobe entire, female bracteole toothed 6) perianth with up to 7 smooth keels, 1-2 innovations present. This species grows at *ca* 75-1900 m. *Spruceanthus polymorphus* may be confused with *S. semirepandus* and *Archilejeunea planiuscula*. *S. semirepandus* differs by the acute leaf apex (rounded to obtuse in *S. polymorphus*) and *A. planiuscula* by the thinner stems and the segmented oil bodies (although we did not observe the oil bodies, they are supposedly homogeneous in *S. polymorphus*).

22. ***Spruceanthus semirepandus*** (Nees) Verd., Ann. Bryol. Suppl. 4: 153 (1934); *Jungermannia semirepanda* Nees, Enum. Pl. Crypt. Javae 1: 39 (1830); *Ptychanthus semirepandus* (Nees) Nees, Naturg. Eur. Leberm. 3: 212 (1838); *Phragmicoma semirepanda* (Nees) Gottsche, in Gottsche *et al*., Syn. Hepat. 302 (1845); *Lejeunea semirepanda* (Nees) Mitt., J. Proc. Linn. Soc. Bot. 5: 111 (1861). –**Type**: Indonesia. Java. *Blume s.n.* (holotype, STR?) – cf. Verdoorn (1934).

Autoicous. Plants robust, up to 8 cm long, 1.5-3 mm wide, pale brown to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 120-300 µm; ventral merophyte 8-12 cells wide. Leaves imbricate, widely spreading. Lobe ovate, 1000-2300 µm long, 550-1590 µm wide, margin entire, crenulate towards the sharply acute apex; cells of lobe thick-walled, light yellow, hexagonal and almost isodiametric, trigones not cordate, intermediate thickening frequent; marginal cells 5-15 × 4-10 µm, mid-leaf cells 20-31 × 13-20 µm, basal cells 30-41 × 21-30 µm; oil bodies not seen. Lobule ovate, 240-450 µm long, 120-220 µm wide, inflated, apex truncate with 1-2 small teeth. Underleaves imbricate, obdeltoid to rectangular, 500-1200 µm long, 390-850 µm wide, margin entire, apex truncate, base auriculate. Androecia not seen.

Gynoecia with 1-2 lejeuneoid innovations, bracts ovate about 3050 µm long, 1530 µm wide, margin toothed at the upper part, apex acute, bract lobule oblong, margin entire about 1/3 of the lobe lenght; bracteole broadly ovate to suborbicular with emarginate apex, toothed, about 2010 µm long, 1500 wide. Perianth, oblong-ovate, about 2700 µm long, 1600 µm wide, with 7-9 smooth keels, margins entire. Sporophytes and asexual reproduction not seen.

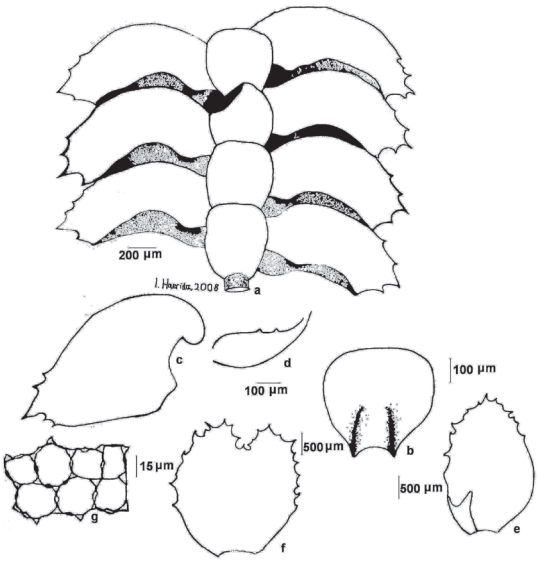

Figure 22. *Spruceanthus semirepandus* (Nees) Verd. Shoot (a); underleaf (b); leaf lobe (c); leaf lobule (d); female bract (e); female bracteole (f); cells of midleaf (g). Drawn from *Verdoorn 20c*, BO.

Specimens examined: INDONESIA. **West Java**, Cibodas Bot. Garden, *Verdoorn 20c, 20b* (BO!); Gn. Gede, *Iwamasa s.n.* (BO!); Gn. Malabar, 1800-2300 m, *Verdoorn 61d* (BO!); Gn. Cikurai, *ca* 1700 m, *Verdoorn 59k* (BO!); Gn. Patuha, *ca* 1500 m, *Kornochalert 1417* (BIOT!).

Distribution: Java, Borneo, Moluccas, Philippines, China, Taiwan, India, Sri Lanka, Japan.

Notes: Diagnostic characters of *Spruceanthus semirepandus* are: 1) robust plant, ventral merophyte to 12 cells wide, 2) underleaves with entire margin, 3) leaf lobe acute at apex, coarsely dentate at margin, 4) leaf cells isodiametric 4) female bract lobule entire, 5) perianth with 7-9 smooth keels, innovation present. This species grows at 1200-2300 m. It is closely related to *S. polymorphus* but the leaf apex in the latter species is broader, rounded to obtuse. By its acute leaves *S. semirepandus* may be confused with

Ptychanthus striatus but the very different branching types (*Lejeunea*-type in *Spruceanthus*, Frullania-type in *Ptychanthus*) readily separates the two.

23. ***Thysananthus convolutus*** Lindenb., in Gottsche *et al.*, Syn. Hepat. 288 (1845).–**Type**: Indonesia. Java, unknown locality, collector unknown., ex hb. Lindenberg (isosyntype: G) – cf. Gradstein *et al.* (2002).

Plants up to 5 cm long, 0.8-1.2 mm wide, pale brown to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 100-280 µm. Leaves closely imbricate, attached to the stem at an angle approx. 45-65º. Lobe ovate with recurved apex, asymmetric, upper part of leaf distinctly ventrad, 700-1150 µm long, 600-810 µm wide, margin toothed or entire, apex rounded; cells of lobe thick-walled, sometimes nodulose, trigones cordate, intermediate thickening frequent; marginal cells 7-20 × 6-11 µm, mid-leaf cells 22-40 × 11-13 µm, basal cells 36-52 × 11-15 µm; oil bodies not seen. Lobule ovate, 250-320 µm long, 110-130 µm wide, inflated, apex truncate with 1-2 teeth, first tooth consisting of 3-4 cells, second tooth small consisting of 1 cell, sometimes without first tooth. Underleaves imbricate, suboblong, 500-720 µm long, 290-430 µm wide, margins usually toothed, apex truncate, recurved, base not auriculate, insertion line shallowly curved. Generative structures not seen.

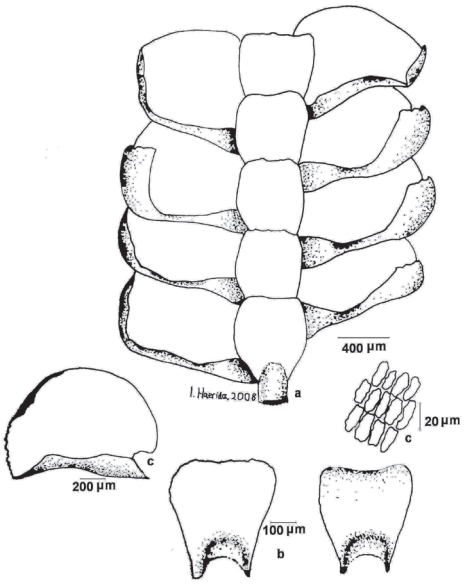

Figure 23. *Thysananthus convolutus* Lindenb. Shoot (a); underleaves (b); leaf lobe (c); cell of midleaf (d). Drawn from *Iwamasa 5435*, BO.

Specimens examined: INDONESIA. **West Java**, without locality, *Teysmann s.n.* (BO!); Kampung Dawuan, 1390 m, *Neervoort* 898 (BO!); Cibodas Bot. Garden, Pasir Sintek, *ca* 1410 m, *Neervoort* 3368 (BO!), *ibid.*, on bark of trees at garden entrance, abundant, *Gradstein 10205*, on bark of *Araucaria, Gradstein 10203* (BIOT!, GOET!); above Cibodas, trail to Cibeureum waterfall, *Lee & Nova Indri 45* (BIOT!, UKMB!); Cibeureum, *ca* 1600-1900 m, *Verdoorn 30k, 30q, 20L, 21b, Iwamasa 5435*, *Neervoort 195, 308*, *Dadi & Noerta 134, Meijer B3578, B3705, B3789, B3578*, *V. Schiffner 283, 282a* (BO!), *N.S. Ariyanti 472* (BIOT!); Gn. Gede, boven Soekaboemi, *ca* 1500-1900 m, *Verdoorn 46c, 46b, 46a* (BO!); Gede-Pangrango, Tugu, above G. Mas, along Jl. Mandalawangi, *Meijer B3374, B3325, B387f, B607* (BO!); Geger Bentang, 1400-1540 m, *Neervoort 1178*, *1059, 1024, 1806, 1019, 988*, *2987, 3005* (BO!); Rawa Panjang, *Neervoort 1166* (BO!); Cihoerang, *ca* 1380-1460 m, *Neervoort 138, 2241, 2242, Meijer B3681, B3741* (BO!); Telaga Warna, Puncak Pass, "Kratermuurtje", *Verdoorn 64f*, *64i, 64h, 64e* (BO!); Gn. Halimun-Salak Nat. Park, Gn. Kendeng, *ca* 1250 m, *Radhiah Zakaria 221c* (BIOT!); Gn. Malabar, SW slopes of Puncak Besar, 1800-2300 m, *Verdoorn 61h* (BO!).

Distribution: Java, Sumatra, Peninsular Malaysia, Borneo, Sulawesi, Moluccas, Papua New Guinea, Philippines, Solomon Is.

Notes: Diagnostic characters of *Thysananthus convolutus* are: 1) asymmetric leaf lobe with upper part ventrad and recurved, margin toothed or entire 2) underleaves suboblong, margins usually toothed or crenulate, 3) lobule with 2 teeth. This species grows at *ca* 1300-2300 m. Forms with toothed leaves may be confused with *T. spathulistipus* but the leaves in the latter species are symmetrical while those of *T. convolutus* are asymmetric. Forms with entire leaves may be confused with *Mastigolejeunea* but the dorsal epidermis cells in *Mastigolejeunea* are larger than the inner stem cells, while in *Thysananthus* the epidermis cells are not larger than the inner cells.

24. ***Thysananthus minor*** Verd., in Rec. Trav. Bot. Neerl. 30: 231 (1933). –**Type**: Indonesia. Sumatra, Brastagi, Petani Falls, 1930, *Verdooorn s.n.* (holotype, FH) –cf. Verdoorn (1933).

Dioicous. Plants small, up to 1.5 cm long, 0.5-0.7 mm wide, brown to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 100-130 μm. Leaves imbricate, convolute when dry, widely spreading. Lobe oblong-ovate, 430-900 μm long, 250-390 μm wide, lateral margin irregularly toothed toward the apex, apex acute; cells of lobe thick-walled, light yellow, rhomboidal, trigones cordate, intermediate thickening frequent; marginal cells 8-13 × 5-7 μm, mid-leaf cells 13-29 × 13-17 μm, basal cells 16-38 × 6-

14 µm; oil bodies not seen. Lobule ovate, 150-270 µm long, 50-90 µm wide, inflated, apex obliquely truncate with small tooth, Underleaves closely imbricate, oblong, 200-490 µm long, 150-650 µm wide, margin entire, apex truncate to emarginate, toothed, insertion line shallowly curved. Androecia not seen. Gynoecia with 2 lejeuneoid innovations, bract ovate, 970-1380 µm long, 440-550 µm wide, toothed at apex and upper margin, apex acute, sinus up to 1/2 of lobe length; bracteole oblong to broadly oblong about as long as bracts or shorter, 500-670 µm long, 350-410 µm wide, margin serrulate, coarsely serrate towards the apex, apex emarginate. Perianth, oblong, 1800 µm long, 500 µm wide, with 3 keels, margins serrulate in the upper part. Sporophytes and asexual reproduction not seen.

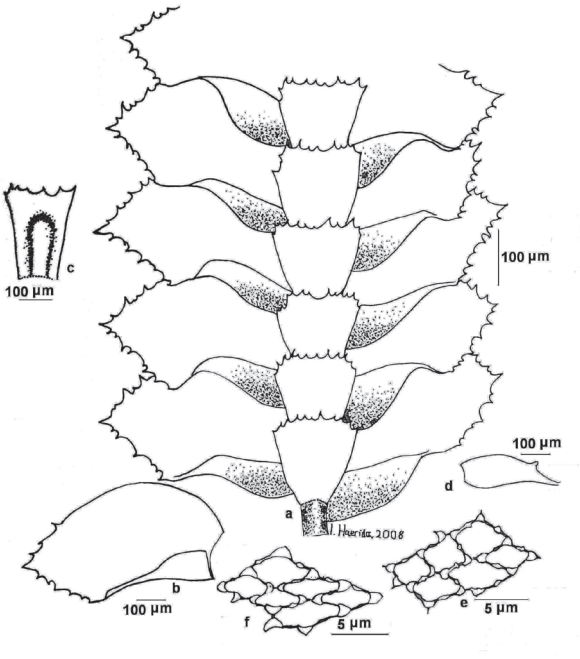

Figure 24. *Thysananthus minor* Verd. Shoot (a); leaf lobe (b); underleaf (c); lobule (d); cells of midleaf (e); cells of basal part of the lobe (f). Drawn from *Neervoort 1018*, BO.

Specimens examined: INDONESIA. **West Java**, Gn. Gede, above Cibodas, Geger Bentang, *ca* 1520-1700 m, *Neervoort 1112, 1018, 1088, Noerta & Soekar 1139* (BO!); G. Halimun Nat. Park, *ca* 1000 m, *Haerida 712* (BO!) *ibid*., *ca* 1200 m, collector unknown (BIOT!); Gn. Cikurai, W slope, *ca* 1700 m *Verdoorn 59g, 59h* (BO!).

Distribution: Java, Sumatra, Papua New Guinea.

Notes: Diagnostic characters of *Thysananthus minor* are: 1) very small plant, less than 1 mm wide, 2) leaf lobe irregularly toothed towards the apex, 3) underleaves toothed towards the apex, 4) lobule with only 1 small tooth. *Thysananthus minor* is new to Java. This species grows at *ca* 1000-1710 m and is very similar to *T. spathulistipus* but differs by the smaller size. Possibly it is just a form of the latter species.

25. ***Thysananthus retusus*** (Reinw. *et al.*) B. Thiers & Gradst., Mem. N.Y. Bot. Gard. 52: 67 (1989); *Jungermannia retusa* Reinw *et al.*, Acta Phys.-Med. Acad. Caes. Leop. Carol. Nat. Cur. 12: 214 (1824); *Ptychanthus retusus* (Reinw. *et al.*) Nees var. α, in Gottsche *et al.*, Syn. Hepat. 292 (1845). –**Type**: Indonesia. Java, *Blume s.n.* (holotype, STR; isotype, W) – cf. Gradstein *et al.* (2002).
–*Thysananthus planus* Sande Lac., Ned. Kruidk. Arch. 3, 4: 419 (1854).–Type: Indonesia. Java, *Junghuhn s.n.* (holotype, L; isotype, G) – cf. Gradstein *et al.* (2002).

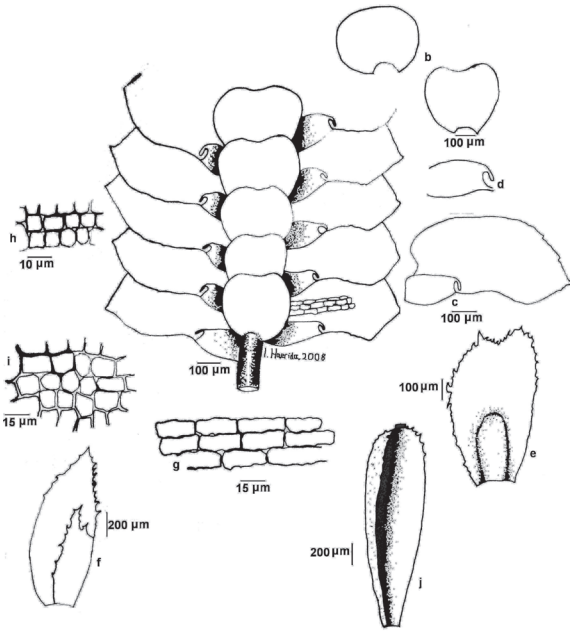

Figure 25. *Thysananthus retusus* (Reinw. *et al.*) B. Thiers & Gradst. Shoot (a); underleaves (b); leaf lobe (c); leaf lobule (d); female bracteole (e); female bract (f); vitta (g); cells of the margin of the leaf (h); cells of midleaf (i); perianth (j). Drawn from *Haerida 511*, BO.

Plants up to 2 cm long, 0.7-1 mm wide; pale green to brown in the dried condition. Branching *Lejeunea*-type. Stem diameter 100-120 µm. Leaves imbricate, convolute when dry, widely spreading. Lobe ovate to oblong, 740-840 µm long, 350-550 µm wide, margin entire, apex obtuse to acuminate; cells of lobe thick-walled, hyaline to light yellow, quadrangular to hexagonal,

trigones triangular, intermediate thickening scarce; marginal cells 6-8 × 3-5.5 µm, mid-leaf cells 8-15 × 7-10 µm, basal cells 13-19 × 5-8 µm, vittae consisting of 2-3 rows of rectangular cells, ending at 2/3 of the lobe length, 21-51 × 10-17 µm; oil bodies not seen. Lobule oblong-ovate 290-310 µm long, 140-150 µm wide, apex with 1 tooth consisting of 3-4 cells. Underleaves imbricate, orbicular, obdeltoid to subrectanglar sometimes recurved seemingly emarginate, 230-310 µm long, 290-390 µm wide, margins entire, apex rounded, sometimes with scattered small teeth towards the apex. Generative structures not seen.

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *W. Meijer 55d1* (BO!); Gn. Salak, *ca* 2000 m, *Kurz s.n.* (BO!); Gn. Gede-Pangerango Nat. Park, Bodogol, *Haerida 851, 811* (BO!, GOET!); G. Pancar, *ca* 400 m, *Schiffner 287* (BO!); Geger Bentang, *ca* 1620 m, *Neervoort 1070* (BO!).

Distribution: Java, Philippines, West Irian, Papua New Guinea, Australia, Pacific Islands.

Notes: Diagnostic characters of *Thysananthus retusus* are: 1) small plant with flattened leaves, 2) leaf with a distinct vitta, and with isodiametric non-vitta cells, 3) apical tooth of leaf lobule 3-4 cells long. This species grows at ca 400-2500 m. By the vitta, the small, isodiametric leaf cells and the long, curved lobule tooth *T. retusus* is a very distinct species that cannot be confused with any other member of Ptychanthoideae.

26. ***Thysananthus spathulistipus*** (Reinw. *et al.*) Lindenb., in Gottsche et al., Syn. Hepat. 287 (1845); *Jungermannia spathulistipa* Reinw. *et al.*, Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 212 (1824). –**Type**: Indonesia. Java, Bantam, Leback Mts., *Blume s.n.* (holotype, STR; isotypes, G, W) – cf. Gradstein *et al.* (2002).

Autoicous. Plants robust, up to 3 cm long, 0.5-1 mm wide, brownish green to dark brown in dried condition. Branching *Lejeunea*-type. Stem diameter 80-180 µm. Leaves imbricate, widely spreading. Lobe ovate-oblong, 820-1100 µm long, 320-630 µm wide, margin coarsely toothed towards the apex, apex acute; cells of lobe thick-walled, light yellow, rhomboidal, trigones cordate, intermediate thickening frequent, cell walls at the basal part sometimes with orange color; marginal cells 10-20 × 7-10 µm, mid-leaf cells 26-31 × 10-20 µm, basal cells 26-41 × 10-15 µm; oil bodies not seen. Lobule ovate, 240-330 µm long, 40-90 µm wide, inflated, apex truncate with 1 small tooth consisting of 1 cell. Underleaves imbricate, spathulate, 310-910 µm long, 350-480 µm wide, margin coarsely toothed towards the apex, apex truncate to sometimes

emarginate, insertion line almost straight. Androecia terminal on branches, bracts in 4-15 pairs, similar to leaves but lobules larger, bract lobule 2/3 of the bract lobe, bract lobe 270-370 µm long, 150-160 µm wide, hypostatic, bracteoles similar to underleaves in size and shape, 170-180 µm long, 200-230 µm wide. Gynoecia on short or long branches, with 1-2 lejeuneoid innovations, bract ovate 900-1000 µm long, 300-400 µm wide, crenulate towards the apex, apex acute, sinus up to 1/2 of lobe length; bracteole oblong to sub obovate 700-2200 µm long, 250-650 µm wide, margin crenate, apex truncate. Perianth oblong, about 2000 µm long, 550 µm wide, with 3 keels, margins toothed. Sporophytes and asexual reproduction not seen.

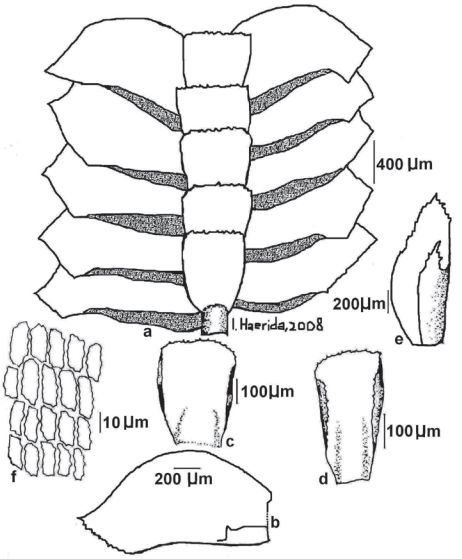

Figure 26. *Thysananthus spathulistipus* (Reinw. *et al*.) Lindenb. Shoot (a); leaf lobe (b); underleaf (c); female bracteole (d); female bract (e); cells of midleaf (f). Drawn from *Haerida 725*, BO.

Specimens examined: INDONESIA. **West Java**, Bogor Bot. Garden, *ca* 250 m, *Schiffner 281* (BO!); Cibodas Bot. Garden, *Verdoorn 20a, 20k, 30l, 30p, 30o, Neervoort 1506, 70* (BO!); Gn. Pangrango, *Meijer B895, B775, B286, B530, B447e, B519, B3339, B818c, B773a, B771a, B805, B811c, B811e, B385c, B752b, B753, B533c, B287b, B298b, B801a* (BO!); Gn. Gede, 1500-1900 m *Verdoorn 46m, 46l, 46j, 46h, 46g, 46f*, *Meijer B4093*, *Schiffner 291a, 289* (BO!); Gn. Gegerbentang, E slopes, 1500-2000 m, *Verdoorn 67f, 67e, 67g*, *Neervoort 1139, 1144, 1985, 1022, 1014*, *Noerta & Soekar 1144, 50/1089, Meijer B637a* (BO!); Gn. Halimun Nat. Park, *Gradstein s.n.*, *Haerida 725* (BO!); Mt. Kendeng, *ca* 1060-1350 m, *Radhiah Zakaria 173c, 181c, 218c, 226c* (BIOT!); G. Malabar *Verdoorn 61g, 61f, 61e, 61d* (BO!); Gn. Guntur, "Kawah Kamodjan", 1500-1700 m, *Verdoorn 50f, 50e* (BO!); Gn. Cikurai, *ca* 1700 m, *Verdoorn 59l* (BO!).

Distribution: Java, Sumatra, Peninsular Malaysia, Borneo, Bali, Soembawa, Sulawesi, Moluccas, West Irian, Papua New Guinea, Australia, Solomon Is., Thailand, India, Sri Lanka, tropical Africa.

Notes: Diagnostic characters of *Thysananthus spathulistipus* are: 1) leaves and underleaves symmetrical, with toothed margins, 2) spathulate underleaves, 3) coarsely toothed female bracts and bracteoles. This species grows at *ca* 200-2000 m and is most common in the mountains. It differs from other Javanese species of *Thysananthus* by the rather large plant size, the symmetrical, toothed leaves without vitta, the lobule with a short, blunt tooth, and the often narrowly spathulate underleaves.

Discussion and conclusion

This study revealed the occurrence of 26 species of Lejeuneaceae subfam. Ptychanthoideae in West Java, in 8 genera: *Acrolejeunea* (Spruce) Schiffn. (3 species), *Archilejeunea* (Spruce) Schiffn. (1 species), *Lopholejeunea* (Spruce) Schiffn. (10 species), *Mastigolejeunea* (Spruce) Schiffn. (3 species), *Ptychanthus* Nees (1 species), *Schiffneriolejeunea* Verd. (2 species), *Spruceanthus* Verd. (2 species) and *Thysananthus* Lindenb. (4 species). Two species found in this study were new records of the Hepaticae in Java: *Mastigolejeunea indica* and *Thysananthus minor.* The record of *Mastigolejeunea indica* is based on a specimen collected by the Dutch Bryologist, W. Meijer, in Bogor Botanical Garden in 1951 and in Meru Betiri National Park, East Java, in 2005. Five additional species recorded from Java in the literature (*Acrolejeunea tjibodensis* Verd., *Dendrolejeunea fruticosa* (Lindenb. & Gottsche) Lacout., *Phaeolejeunea latistipula* (Schiffn.) Mizut. [doubtful record], *Spruceanthus sulcatus* (Nees) Gradst. and *Thysananthus comosus* Lindenb.) were not found in this study.

Based on the number of known localities in West Java the species of Ptychanthoideae can divided into several categories. Species with "wide distribution" are known from more than 5 localities, with "moderately wide distribution" from about 4, with "rather limited distribution" from about 3, with "limited distribution" from about 2, and "very limited distribution" from only one locality.

Lopholejeunea eulopha, Lopholejeunea ceylanica, Lopholejeunea subfusca and *Thysananthus spathulistipus* are the most common species in West Java, with a wide distribution. *Thysananthus spathulistipus* (200-1700 m) was found in Bogor Bot. Garden, Cibodas, Gede Pangrango Nat. Park and Halimun Salak Nat. Park, and on Mt. Guntur, Mt. Cikurai and Mt. Malabar; *Lopholejeunea eulopha* (200-1700 m) in Bogor Bot. Garden, Ujung

Kulon Nat. Park and Halimun Salak Nat. Park, and on Mt. Guntur and Mt. Megamendung; *L. ceylanica* (500-1700 m) in Bogor Bot. Garden, Cibodas, Gede Pangrango National Park, Telaga Warna and on Mt. Cikurai; and *L. subfusca* (500-2500 m) in Bogor Bot. Garden, Cibodas, Gede Pangrango National Park and on Mt. Cikurai and Mt. Papandayan.

Lopholejeunea nigricans, Lopholejeunea horticola and *Thysananthus retusus* have a moderately wide distribution. *Lopholejeunea nigricans* (200-1700 m) has been recorded from Bogor Bot. Garden, Mt. Pangrango, Mt. Guntur and Telaga Warna (Puncak Pass); *L. horticola* (800-2400 m) from Mt. Gede (including Cibodas), Mt. Guntur, Mt. Patuha and Mt. Malabar; and *Thysananthus retusus* (400-2500 m) from Bogor Bot. Garden, Mt. Gede, Mt. Halimun Salak Nat. Park and Mt. Pancar.

Archilejeunea planiuscula, Lopholejeunea herzogiana, L. wiltensii, Mastigolejeunea virens, Ptychanthus striatus, Spruceanthus semirepandus, Thysananthus convolutus and *Thysananthus minor* have a rather limited distribution in West Java. *Archilejeunea planiuscula* (200-1450 m) was found in Ujung Kulon Nat. Park and on Mt. Gede; *Lopholejeunea herzogiana* (1200-1500 m) in Bogor Bot. Garden, Gede Pangrango Nat. Park and Telaga Warna (Puncak Pass); *L. wiltensii* (1200-1900 m) in Gede Pangrango Nat. Park and on Mt. Guntur; *Mastigolejeunea virens* (200-1500 m) in Bogor Bot. Garden and on Mt. Gede and Mt. Megamendung; *Ptychanthus striatus* (1000-2400 m) in Gede Pangrango Nat. Park and on Mt. Megamendung; *Spruceanthus semirepandus* (1200-2300 m) on Mt. Gede, Mt. Cikurai and Mt. Malabar; *Thysananthus convolutus* (1300-2300 m) on Mt. Gede, Telaga Warna (Puncak Pass) and Mt. Malabar; and *T. minor* (1000-1700 m) on Mt. Gede, in Mt. Halimun Salak Nat. Park and on Mt. Cikurai.

Acrolejeunea fertilis, A. pycnoclada, Lopholejeunea applanata, Mastigolejeunea auriculata and *Schiffneriolejeunea tumida* var. *haskarliana* were found in an even more limited distribution. *Acrolejeunea fertilis* was only found in the lowlands (60-80 m) in Pulau Panaitan and Depok; *A. pycnoclada* only at Mt. Gede and Ciater (Subang), in rather high altitude (1500-1900 m) although the species has also been recorded from lowlands (e.g. Bogor Bot. Garden) in the literature; *Schiffneriolejeunea tumida* var. *haskarliana* (440-1500 m) only from Mt. Gede and Mt. Halimun Salak Nat. Park; *Lopholejeunea applanata* (*ca* 1200 m) only from Gede Pangrango Nat. Park; and *Mastigolejeunea auriculata* (200-500 m) only from Bogor Bot. Garden and Ujung Nat. Park. This condition may be due to inadequate collections from the area.

Acrolejeunea arcuata, *Lopholejeunea recurvata, L. zollingeri*, *Mastigolejeunea indica,* and *Schiffneriolejeunea pulopenangensis,* finally, had the most limited distribution and were found in only one location, i.e. *Acrolejeunea arcuata* only on Mt. Patuha at 2000 m, *Lopholejeunea recurvata* on Mt. Gede at *ca*

1450 m, *L. zollingeri* on Mt. Pangrango at *ca* 1600 m, and *Mastigolejeunea indica* and *Schiffneriolejeunea pulopenangensis* only in Bogor Bot. Garden at about 200 m. The records of the latter two species only from Bogor Botanical Garden emphasize the importance of this garden as a habitat for Ptychanthoideae in West Java. A searching for additional localities of the rare species in West Java is needed.

According to Gradstein (1991) the endemic genera of Asiatic Ptychanthoideae are largely restricted to the subtropical and temperate areas of Asia and some are also known as fossils in Eocenic amber of Europe. They are considered to be palaeoendemic, the relictual groups. Endemic genera of Asiatic Lejeuneoideae, however, occur mainly in the tropical rain forests of the Malesian archipelago, are often highly specialized, and are lacking in the fossil record. They probably have co-evolved in the Tertiary with the rain forest and are to be considered neoendemics.

Ptychanthoideae seem to be older than Lejeuneoideae and may already have existed in the Mesozoic before the break-up of Laurasia and Gondwanaland. The Mesozoic age was recently confirmed based on fossil evidence and DNA sequence analysis by Wilson *et al*. (2007), who found that Lejeuneaceae started to diversify in the Late Cretaceous, about 60-90 million years ago.

The geographical distribution and altitudinal ranges of Ptychanthoideae in West Java are shown in Table 1; the definition of the distribution types follows Ariyanti and Gradstein (2007). The geographical ranges of the species were determined based on collected specimens and literature (e.g., Mizutani, 1961; Gradstein and Terken, 1981; Menzel 1988; Gradstein *et al.*, 2002; Zhu and Gradstein, 2005; Ariyanti and Gradstein, 2007).

The data show that the species of Ptychanthoideae of West Java can be subdivided into 4 groups by their geographical distributions: Malesian species (8 spp.), tropical Asiatic species (10 spp.), palaeotropical species (tropical Asia + Africa; 3 spp.) and pantropical species (throughout the tropics; 4 spp.). It appears that the species are rather widespread; none of the species are endemic to Java or western Malesia. The widespread distribution of the species is probably due to their dispersal by spores, which may be easily carried by the wind over long distances (van Zanten and Gradstein, 1987). But also the rather old age of Ptychanthoideae (Gradstein, 1991; Wilson *et al*., 2007) may play a role.

The majority of the species (about 20) are found at mid-montane elevations, at 1200-1500 m. Few species found below 100 m and above 2000 m. The data from West Java agree with the general pattern of altitudinal distribution reported for Lejeuneaceae. According to Gradstein (1995), the diversity of Lejeuneaceae decreases with elevation and accounts for about 45% of total hepaticae diversity in the lower montane forest

Table 1. Altitudinal and geographical distributions of the species of Ptychanthoideae recorded in West Java. Lowland: 0-1200 m. Montane: 1200-3000 m. A: Asiatic. M: Malesian. P: Pantropical. Pal: Palaeotropical (Asia, Africa). * species new to Java.

No.	Species	Altitudinal distribution		Geographical distribution
		Lowland	Montane	
1.	*Acrolejeunea arcuata*	-	+	M
2.	*Acrolejeunea fertilis*	+	-	M
3.	*Acrolejeunea pycnoclada*	+	+	Pal
4.	*Archilejeunea planiuscula*	+	+	A
5.	*Lopholejeunea applanata*	+	+	A
6.	*Lopholejeunea eulopha*	+	+	P
7.	*Lopholejeunea herzogiana*	-	+	M
8.	*Lopholejeunea nigricans*	+	+	P
9.	*Lopholejeunea ceylanica*	+	+	A
10.	*Lopholejeunea horticola*	+	+	A
11.	*Lopholejeunea recurvata*	+	+	M
12.	*Lopholejeunea subfusca*	+	+	P
13.	*Lopholejeunea wiltensii*	-	+	M
14.	*Lopholejeunea zollingeri*	-	+	A
15.	*Mastigolejeunea auriculata*	+	+	P
16.	*Mastigolejeunea indica**	+	-	M
17.	*Mastigolejeunea virens*	+	+	M
18.	*Ptychanthus striatus*	+	+	Pal
19.	*Schiffneriolejeunea pulopenangnesis*	+	-	M
20.	*Schiffneriolejeunea tumida var. haskarliana*	+	+	A
21.	*Spruceanthus polymorphus*	+	+	A
22.	*Spruceanthus semirepandus*	-	+	A
23.	*Thysananthus convolutus*	-	+	A
24.	*Thysananthus minor**	+	+	M
25.	*Thysananthus retusus*	+	+	A
26.	*Thysananthus spathulistipus*	+	+	Pal

(1000/1400-2000/2500 m), 30% in the upper montane forest (2000/2500-3000/4000 m) and 20% in the subalpine forest (above 3000/4000 m).

The members of the Ptychanthoideae of West Java are epiphytes and grow on the bark of trees, on treelets and shrubs. As indicated by Thiers and Gradstein (1989) and Gradstein *et al.* (2001), many species are rather xerotolerant epiphytes of trees at forest margins or in rather open vegetation. None of the species of West Java were found growing on living leaves, which are generally inhabited by tiny members of the subfamily Lejeuneoideae, and few species occur on small branches of shrubs, which are the habitat of the ramicolous bryophytes. Dendroid, feather or bracket-type mosses and liverworts, belonging to Neckeraceae, Hookeriaceae, Pterobryaceae, and Plagiochilaceae, as well as various tiny members of Lejeuneaceae are the specialists of this habitat (Gradstein and Pócs, 1989). A study of the ecology and optimum habitat conditions of the members of Lejeuneaceae subfam. Ptychanthoideae, including moisture and temperature rates, would be desirable. Such data might further improve our understanding of the distribution of the species of Ptychanthoideae in West Java.

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References

Ariyanti, N.S. and S.R. Gradstein. 2007. Wallace's line and the distribution of the liverworts of Sulawesi. *Cryptogamie*, *Bryologie* **28**: 3-14.

Gradstein, S.R. 1975. Monograph of the genus *Acrolejeunea. Bryophytorum Bibliotheca* **4**: 1-216.

Gradstein, S.R. 1991. Diversity and distribution of Asian Lejeuneaceae subfamily Ptychanthoideae. *Tropical Bryology* **4**: 1-16.

Gradstein, S.R. 1994. Verdoorn's Studien über Asiatische Jubulae. *Hikobia* **11**: 451-456.

Gradstein, S.R. 1995. Diversity of Hepaticae and Anthocerotae in montane forests of the tropical Andes, pp. 321-334. In: Churchill, S.P., J. Luteyn, E. Forero and H. Balslev (eds.), *Biodiversity and Conservation of Neotropical Montane Forests*. New York Botanical Garden, New York.

Gradstein, S.R., S.P. Churchill and N. Salazar-Allen. 2001. Guide to the bryophytes of Tropical America. *Memoirs of the New York Botanical Garden* **86**: 1-157.

Gradstein, S.R., X.-L. He, S. Piippo and M. Mizutani. 2002. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXVIII. Lejeuneaceae subfamily Ptychanthoideae (Hepaticae). *Acta Botanica Fennica* **174**: 1-88.

Gradstein, S.R. and T. Pócs. 1989. Bryophytes, pp. 311-325. In: Lieth, H. and M.J.A. Werger (eds.), *Tropical Rain Forest Ecosystems.* Elsevier Science Publishers, Amsterdam.

Gradstein, S.R. and L.Terken. 1981. Studies on Lejeuneaceae subfam. Ptychanthoideae VI. A revision of *Schiffneriolejeunea* sect. *Saccatae* from Asia. *Occasional Papers of the Farlow Herbarium of Cryptogamic Botany* **16**: 71-81.

Hasan, M. and N.S.Ariyanti. 2004. *Mengenal Bryophyta (Lumut) Taman Nasional Gunung Gede Pangrango.* Vol. 1. Balai Taman Nasional Gunung Gede Pangrango, 93 pp.

Menzel, M. 1988. Annotated Catalogue of the Hepaticae and Anthocerotae of Borneo. *Journal of the Hattori Botanical Laboratory* **65**: 145-206.

Mizutani, M. 1961. A revision of Japanese Lejeuneaceae. *Journal of the Hattori Botanical Laboratory* **24**: 116-180.

Mizutani, M. 1969. Lejeuneaceae subfamily Ptychanthoideae from Sabah (North Borneo). *Journal of the Hattori Botanical Laboratory* **32**: 129-139.

Nees von Esenbeck, C.G. 1830. Enumeratio Plantarum Cryptogamicarum Javae et Insularem Adjacentium. I. Hepaticas complectens. Breslau.

Piippo, S, T. Koponen and D.H. Norris. 1987. Endemism in the Bryophyte Flora in New Guinea. *Symposia Biologica Hungarica* **35**: 361-372.

Reinwardt, C., C. Blume and C.G. Nees von Esenbeck. 1824. Hepaticae javanicae. *Acta Physico-Medica Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum* **12**: 181-238.

Sande Lacoste, C.M. 1856. Synopsis Hepaticarum Javae. *Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen* **5**: 1-112.

Schiffner, V. 1898. *Conspectus Hepaticarum Archipelagi Indici.* Batavia Staatsdruckerei. 382 pp.

Schuster, R.M. 1980. Phylogenetic studies on Jungermanniidae II. Radulineae (Part I). *Nova Hedwigia* **32**: 637-693.

Thiers, B.M. and S.R. Gradstein. 1989. Lejeuneaceae (Hepaticae) of Australia. I. Subfamily Ptychanthoideae. *Memoirs of the New York Botanical Garden* **52**: 1-79.

Verdoorn, F. 1933. Die von V. Schiffner (1893-1894) und von Fr. Verdoorn (1930) auf den Indomalesischen Inseln gesammelten Lejeuneaceae Holostipae. De Frullaniaceis XI. *Recueil des Travaux Botaniques Néerlandais* **30**: 212-233.

Verdoorn, F. 1934. Studien über Asiatische Jubuleae. *Annales Bryologici Supplement* **4**: 1-231.

Wilson, R., J. Heinrichs, J. Hentschel, S.R. Gradstein and H. Schneider. 2007. Steady diversification of derived liverworts under steady Tertiary climatic fluctuations. *Biology Letters* **3**: 566-569.

Zanten, B.O. van, and S.R. Gradstein. 1987. Experimental dispersal geography of tropical liverworts. *Nova Hedwigia Beiheft* **90**: 41-94.

Zhu, R.-L. and S.R. Gradstein. 2005. Monograph of *Lopholejeunea* (Lejeuneaceae, Hepaticae) in Asia. *Systematic Botany Monographs* **74**: 1-98.