

Lopholejeunea (Spruce) Schiffn. in India*

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Awasthi, U.S., Srivastava, S.C. & Sharma, D 2000. *Lopholejeunea* (Spruce) Schiffn. in India. *Geophytology* **29** (1&2) : 35-60.

An account of the Indian species of the genus *Lopholejeunea* (Spruce) Schiffn. is provided. Ten species and two varieties are recognized. Two species (*L. kashyapii* and *L. nilgiriensis*) are described as new to science. Three species (*L. abortiva*, *L. javanica* and *L. nigricans*) are new for India. Two new varieties, *L. sikkimensis* var. *dentata* and *L. abortiva* var. *doliiformis* are described. *L. gradsteinii* has been reduced as synonym of *L. abortiva*.

Key-words – Bryophyta, Hepaticae, Jungermanniales, Lejeuneaceae, Ptychanthoideae, *Lopholejeunea*.

INTRODUCTION

THE first report of the genus from India comes from Mitten (1860-61) who recorded *Lopholejeunea applanata* Nees from Sikkim and Mt. Khasia, and *L. subfusca* Nees from Mt. Khasia and Madras. Subsequently Stephani (1912) recorded *L. infuscata* (Mitt.) St. from the Himalayas and Mt. Khasia, *L. nicobarica* St. from Nicobar Is. and *L. sikkimensis* St. from Sikkim. He, however, did not record *L. applanata* (Nees) St. and *L. subfusca* (Nees) St. from India. Verdoorn (1934) described *L. sikkimensis* and treated *L. infuscata* (Mitt.) St. as *Trocholejeunea infuscata* (Mitt.) Verd. and reduced *L. nicobarica* St. under *L. eulopha* (Tayl.) Spruce. Mizutani (1976) extended the range of *L. sikkimensis* from eastern India to western India (Almora) and Central India (Amarkantak). Mizutani (1985) reinstated *L. nicobarica* considering it distinct from *L. eulopha* on the basis of marked differences in the leaf lobe, underleaf and the female bracteole of the two species.

Recently Udar *et al.* (1983) described an atypical species : *Lopholejeunea gradsteinii* from Agumbe (Karnataka), south India which mostly lacked dentitions on female inflorescence, but a recent collection from Kerala and Karnataka revealed smaller dentitions on perianth. It is, therefore, treated here as a synonym of *L. abortiva* (Mitt.) St. Udar and Awasthi (1983) further described *L. indica* from Jowai (Meghalaya) eastern India.. Here, 10 species are rec-

ognized to occur in India, *L. abortiva*, *L. applanata*, *L. indica*, *L. javanica*, *L. kashyapii*, *L. nicobarica*, *L. nigricans*, *L. nilgiriensis*, *L. sikkimensis* and *L. subfusca* (Map 1).

DESCRIPTION

Lopholejeunea (Spruce) Schiffn.

In Engler & Prantl, *Nat. Pf.-fam.* **1,3** : 129 (1895) *Lejeunea* subgen. *Lopholejeunea* Spruce, *Trans. Proc. Bot. Soc. Edinburg* **15** : 119 (1884).

Plants green or blackish, irregularly branched (*Lejeunea* – type), the stem with 10-20 rows of cortical cells which are slightly larger than the thick walled, distinctly trigonous medullary cells. Leaf-lobe margin entire, cells with radiate trigones; lobule highly inflated, often with free margin characteristically infolded, free margin of lobule with inconspicuous tooth; oil-bodies homogeneous. Underleaves with entire margin. Monoecious. Male inflorescence terminal or intercalary on main or lateral branch, bracts, hypostatic. Female inflorescence terminal on main or lateral branch, lacking subfloral innovation [present in *L. javanica* (see Mizutani, 1985), also present, though rare in *L. sikkimensis*, (see also Gradstein, 1985)]; bracts isomorphic (= lobule both of same size) or heteromorphic (= lobule differing in size), bracts and bracteole laciniate, dentate or even entire; perianth 3-5 plicate, plicae sharp, laciniate, dentate or dentate-entire. In some species viz. : *L. indica*, *L. sikkimensis* var. *dentata* and *L. nilgiriensis* sometimes dentitions

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portion, marginal cells of the valve rectangular and also mostly smaller than the cells in the central portion, cells in entire $\frac{1}{4}$ portion of the capsule at base are nearly lacking thickenings, or have uniformly developed thickenings (see also Mizutani 1979), cells of the outer valve possess sinuose (Pl. 1:5) or sinuose nodulose thickening (Pl. 1:6), cells of the inner layer are smaller than those of outer layer, subquadrate-rectangular-rhombic shape, possess yellow-brown sheet like thickening on inner tangential layer leaving few [(4-8 pitted or unthickened or less-thickened, circular, oblong regions (fenestrate) (Pl. 1:7)], sometime due to deposition of secondary thickening a complex type of deep brown plurifenestrate thickening develops (Pl. 1:8); cells of the inner layer also have nodular thickenings on radial walls which often extend, upto extreme base of the capsule though fenestrate thickening is lacking there (Pl. 1:9). In central portion of the valve 5 ridges are present due to projecting cells (Pl. 1:4). Spores with spinulate surface and rosettes; elaters with 1-2 spiral thickenings (Pl. 1:7).

All the Indian species of *Lopholejeunea* except, *L. applanata* and *L. nigricans* are remarkably similar in most of the gametophytic details including stem anatomy, leaf and underleaf structure. This evidently poses limitation in ascertaining the status of sterile plants so far as the Indian taxa are concerned. They differ, however, in the female inflorescence and have been accordingly categorised in 3 different groups :

1. Female bracts, bracteole and perianth dentate as in *L. applanata*, *L. indica*, *L. kashyapii*, *L. nicobarica* and *L. nigricans*.

2. Female bract and perianth dentate, bracteole entire as in *L. nilgiriensis*, *L. sikkimensis* and *L. subfusca*.

3. Female bracts and bracteole entire, perianth dentate as in *L. abortiva* and *L. javanica*.

L. abortiva and *L. javanica* normally have entire margin of female bracts but some populations show small dentitions as well.

Plants collected from several localities of the country were sterile and therefore, could not be identified to the species level.

Lopholejeunea is one of the large and difficult

genus of pantropical Lejeuneaceae (Schuster, 1980). Like most other binomials of Lejeuneaceae, species of *Lopholejeunea* exhibit a wide range of variation in their gametophytic characters (particularly in female inflorescence) and consequently their delimitation is often difficult. One has to depend upon the degree and the range of variability and consistency of the character in mature plants while deciding the status of a species and also a large number of populations are required for investigation.

ECOLOGY AND DISTRIBUTION

In India the majority of the taxa of the Lejeuneaceae sub-family Ptychanthoideae are confined almost exclusively to one or the other bryogeographical territories (Pande, 1958 and Srivastava, 1998). *Lopholejeunea* shows maximum differentiation by being distributed in all bryogeographical territories of India. It inhabits bark of trees (corticolous population), shrubs either solely or in association with other leafy liverworts, grows at the base of trees and also on rocks or boulders which are lying exposed or in streams and are often lashed with water currents. Epiphyllous growth although cited by Verdoorn (1934), has not been recorded for *Lopholejeunea* from India so far. Generally, leafy liverworts prefer shady and moist places but *Lopholejeunea* has the capacity to grow even under totally exposed, warm conditions where many other liverworts fail to grow. The genus is found from sea level (near the sea coast; Trivandrum) to higher altitudes of ca 2000 m (Ootacamund, Nilgiri Hills). *L. abortiva*, *L. javanica* and *L. nilgiriensis* are confined to south India, *L. applanata*, *L. kashyapii* and *L. nigricans* are restricted to eastern India. *L. nicobarica* occurs only on the Nicobar Is., *L. indica* and *L. subfusca* grow both in eastern as well as southern territory, while *L. sikkimensis* shows maximum differentiation being distributed in all bryogeographical territories of the country. This indicates that in south India particularly in Kerala the warm climate prevailing throughout the year, together with high precipitation offer most congenial conditions for the growth of *Lopholejeunea*. Map-1 provides the distribution of Indian species including the sterile plants for complete range of distribution of the genus in India.

Key to Indian species of *Lopholejeunea*

- | | | | |
|---|---|---|---------------------|
| 1. Leaves with acute apices ... | 2 | 9. Perianth 5-keeled, dentition in between keels absent ... | <i>L. kashyapii</i> |
| 1. Leaves with rounded apices ... | 3 | Species description | |
| 2. Underleaves occupying more than ½ of lobe length, almost 3-4 times wider than long ... | | 1. <i>Lopholejeunea abortiva</i> (Mitt.) St., <i>Spec. Hepat</i> 5: 70 (1912) (Figure 1: 1-23). | |
| 2. Underleaves occupying less than ½ of lobe length, almost 2 times wider than long ... | | <i>Lejeunea abortiva</i> Mitt., <i>Phil. Transact.</i> 168 : 399 (1879); Vanden Berghen, <i>Bull. Jard. Bot. Etat. Bruxelles</i> 20 : 168 (1850)
TYPE : Africa (Isle of Rodrigues), (Mitten, 1879).
<i>Lopholejeunea gradsteinii</i> Udar, Awasthi et Shaheen, <i>Lindbergia</i> 9 : 34-36 (1983) <i>syn. nov.</i> | |
| 3. Female bracteole entire ... | 4 | Plants apparently dioecious, 5-15 mm long. Stem in cross-section (0.06-0.07 x 0.08-0.09 mm) with 11-14 cortical and 12-14 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.40-0.46 mm long, 0.29-0.33 mm wide, margin entire and apex rounded, cells with inconspicuous trigones and intermediate nodular thickenings, basal cells 16-24 x 12-20 µm, median cells 12-24 x 12-16 µm, marginal cells 8-12 x 8-12 µm, lobule ovate, distinctly saccate, 0.14-0.17 mm long, 0.09-0.11 mm wide, with inconspicuous tooth. Underleaves wider than long, 0.22-0.24 mm long, 0.25-0.30 mm wide, margin entire. Male plants not seen. Female inflorescence terminal on short or elongated branch, lacking in subfloral innovation, bracts ovate, 0.67-0.77 mm long, 0.38-0.48 mm wide, margin entire and apex rounded, lobule nearly rectangular and ½ of the lobe length, 0.19-0.45 mm long, 0.08-0.16 mm wide, with margin entire and apex rounded, bracteole longer than wide, almost equal to perianth length, 0.75-0.84 mm long, 0.67-0.72 mm wide, margin entire and revolute; perianth obovate, 0.70-0.80 mm long, 0.47-0.49 mm wide, 5 keeled, keels with small dentitions; sporophyte with foot, seta and capsule, foot bulbous, seta with 16 (sometimes 13 or 17) peripheral and 4 central cells; capsule wall bistratose, cells of the outer layer with sinuate-nodular thickenings on radial walls, cells of the inner layer with fenestrate thickenings on inner tangen- | |
| 3. Female bracteole dentate ... | 8 | | |
| 4. Female bracts orbicular ... | 5 | | |
| 4. Female bracts ovate, oblong or obovate ... | 6 | | |
| 5. Female bracts isomorphic ... | | <i>L. subfusca</i> | |
| 5. Female bracts dimorphic ... | | <i>L. nilgiriensis</i> | |
| 6. Margin of female bract-lobule and bracteole usually flat, bracts and perianth with none or few small teeth ... | 7 | | |
| 6. Margin of female bract-lobule and bracteole revolute, bracts and perianth usually with several prominent teeth ... | | <i>L. sikkimensis</i> | |
| 7. Female bract-lobule small (1/3 of the lobe length) ... | | <i>L. javanica</i> | |
| 7. Female bract-lobule large (ca. ½ of the lobe length) ... | | <i>L. abortiva</i> | |
| 8. Female bracts, bracteole and perianth lacinate-dentate, perianth 4-keeled ... | | <i>L. nicobarica</i> | |
| 8. Female bracts, bracteole and perianth dentate, perianth 4 or 5-keeled, ... | 9 | | |
| 9. Perianth 4-keeled, dentition in between keels present ... | | <i>L. indica</i> | |

PLATE 1(Some sporophytic details of *Lopholejeunea*)

1. Sporophyte showing foot (bulbous), seta (non-articulate) and capsule (x 48). 2. Foot and a portion of seta (x 152). 3. Cross-section of seta (x 150). 4. Cross-section of capsule-wall showing projecting cells of inner layer (x 240). 5. Outer layer of capsule-wall showing sinuate thickening (x 244). 6. Outer layer of capsule-wall showing sinuate-nodular thickenings (x 485). 7. A valve of capsule showing cells of inner layer with fenestrate thickenings and also basal cells lacking in thickening (x 122). 8. Cells of the inner layer with complex fenestrate thickenings (x 365). 9. Basal cells of the inner layer showing nodular thickenings (x 485).

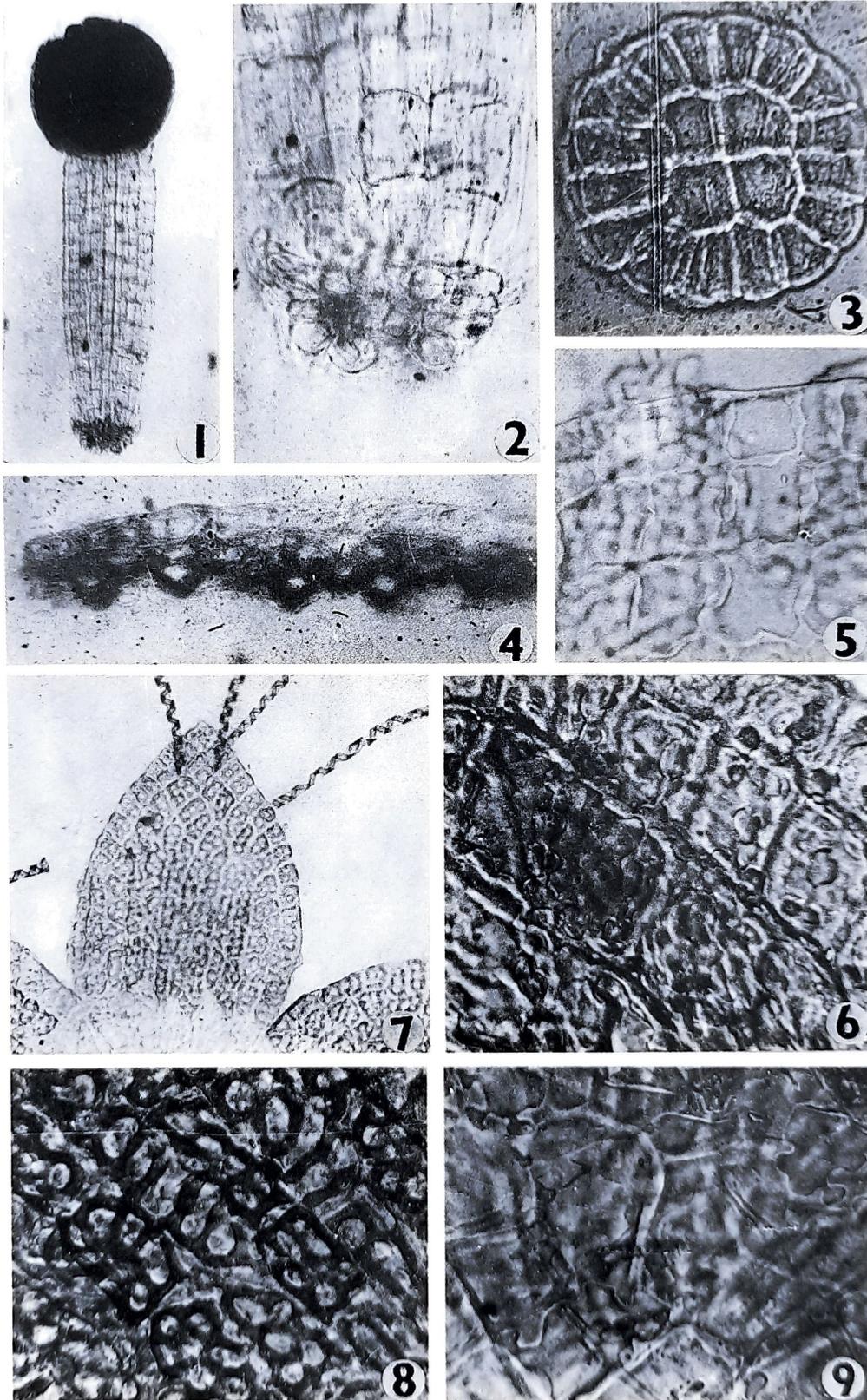


PLATE I

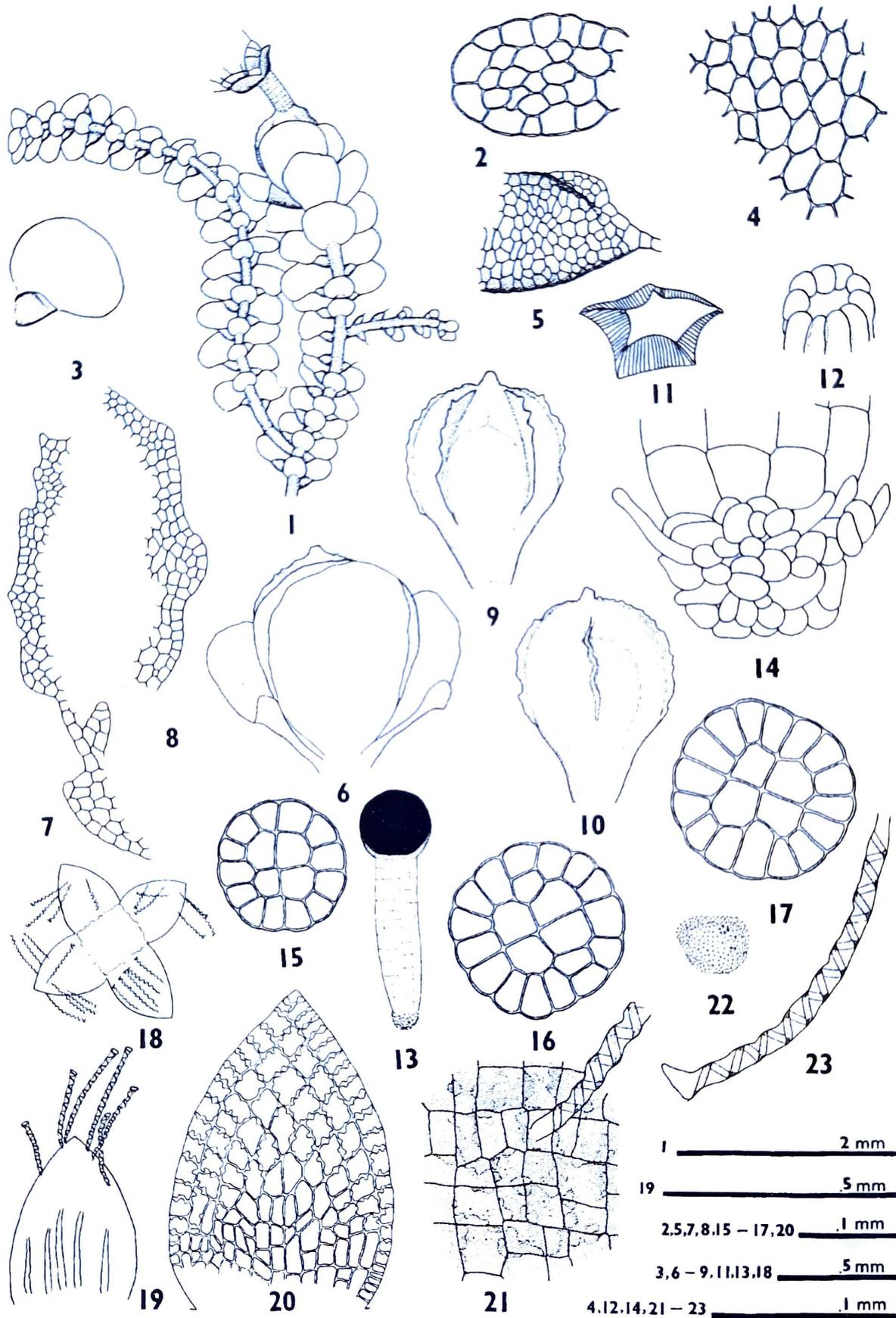


Fig. 1. *Lopholejeunea abortiva* (Mitt.) St.

1. Plants with dehiscent sporophyte. 2. Cross-section of stem. 3. Leaf. 4. Cells of the leaf. 5. Leaf-lobule. 6. Female bracts, bracteole and perianth. 7. Dentate margin of the perianth keel. 8. Wavy margin of perianth keel. 9, 10. Perianths. 11. Cross-section of perianth. 12. Ros-trum. 13. Sporophyte. 14. Portion of the seta with foot. 15-17. Cross-section of the seta. 18. Dehiscent capsule. 19. Capsule valve with elaters (vertical stripes show areas where wall is tristratose). 20. Capsule valve showing outer layer. 21. Inner layer of capsule wall. 22. Spores. 23. Elaters.

tial walls in addition to nodular thickenings on radial wall; spores variously shaped, 32-48 x 24-54 μm or 24-40 μm in diameter with small papillae and 'rosettes' of spines; elaters 180-232 x 10-12 μm , with single spiral thickening band.

Specimens examined : INDIA-Karnataka : Shimoga, Agumbe (alt. ca. 791 m) on *Croton*, Dharendra Kumar, Adarsh Kumar and U.S. Awasthi, 4704/81, 3 May 1981, LWU. (Holotype - *L. gradsteinii*). Mercara (alt. ca. 700m), D. Kumar, A. Kumar and U.S. Awasthi, 4623/81, 4687/81, 1 May, 1981, LWU. Kerala : Lakkidi (ca. 50 km. from Calicut, alt. ca. 712 m), D. Kumar, A. Kumar and U.S. Awasthi, 4527/81, 28 April, 1981, LWU. Peechi Dam, Trichur (alt. 500 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 5466/82, 20 Sept. 1982, LWU. Rubber Research Institute, Kottayam (alt. 1000m), R. Udar and S.C. Srivastava, 5554/82, 22 Sept. 1982, LWU. Palghat, Mukkali-Silent Valley (alt. 2000m), R. Udar and U.S. Awasthi, 5703A/82, 23 Sept. 1982, LWU.

Herb BR 88B, Nigeria, E.W. Jones, 21 Dec., 1947, BR 219, 220, Nigeria, J.P.M. Brenau & E.W. Jones, 6 March 1948. BR 473, Seychelles, J.L. De Sloover, 15 July 1983. BR 34208, Mt. Rungwe, N. of Tukuyu, S. and T. Pocs & students, 17 Aug. 1972. BR 34209, ajomian legume oky cote d'ivoire, E. Assel, 30 Oct. 1969. BR 34212, Cameroon, Jones BR 34214, Moubouegon (Gabon), Le Testu, 1 Aug. 1925. BR 34215 Toungou (Gabon), Dt. 10 May 1925.

Ecology and distribution : Grows on bark of trees and shrubs. INDIA - Kerala, Karnataka; South Africa.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves almost orbicular, slightly wider than long, (3) Female bract-lobe, lobule and bracteole entire, bracts isomorphic, lobe obovate with rounded or acute apex, lobule almost rectangular, $\frac{1}{2}$ of the lobe length, sometimes slightly extending beyond the keel, apex rounded, (4) Perianth 4-5 keeled, keels dentate, dentitions small.

This taxon approaches *L. javanica* in the female bracteole having an entire margin, female bracts hav-

ing an obtuse or rounded apex and perianth keels with small teeth but differs in having female bracts with comparatively larger lobule (lobe : lobule-3: 2) (Fig. 1:6).

The specimens collected from Kerala, Mukkali-Silent Valley (Fig. 1:1-23) differ slightly from those found in Karnataka, Agumbe and described earlier as *L. gradsteinii* (Udar *et al.*, 1983) in having relatively prominent teeth on 5-keeled perianth (Fig. 1:9, 11). The perianth in the latter has 4-keels which either lack teeth or possess very small teeth of 1-2 cells in height. Further, the female bracts are obovate in the former (Fig. 1:6) while they are oblong in the latter.

Further, in Indian plants of *L. abortiva* the perianth keels are nearly smooth or have smaller teeth in comparison to that in African plants. Also the bracts, bracteole and the perianth are almost of equal length in Indian specimens while in African plants perianth is relatively larger than bracts and bracteole (see also Vanden, Berghen 1973).

2. *Lopholejeunea abortiva* var. *doliiformis* var. nov. (Figure 2: 1-23).

Haec varietas a Lopholejeunea abortiva var. abortiva in perianthium doliiformis differt.

TYPE : INDIA-Kerala, Palghat, on way to Achilatti forest (alt. 2000 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 5638/82, 22 Sept. 1982, LWU.

Specimens examined : INDIA- Kerala, Palghat, on way to Achilatti forest (alt. 2000 m) R. Udar, S.C. Srivastava and U.S. Awasthi, 5638/82 (Holotype), 5648/82, 22 Sept. 1982, LWU.

Ecology and distribution : Grows on bark of trees. INDIA - Kerala.

Characteristics of the variety : (1) Female bract-lobe and bracteole entire, lobule almost rectangular, more than $\frac{1}{2}$ of the lobe length, (2) Perianth doliiform.

L. abortiva var. *doliiformis* differs from *L. abortiva* var. *abortiva* in its characteristic barrel-like perianth (Fig. 2:9) and comparatively larger lobule of the female bract (Fig. 2:8, 10).

3. *Lopholejeunea appanata* (Reinw., Blume et Nees) Schiffn. (Figure 3: 1-6).

In : Engler & Prantl. *Nat. Pfl. Fam.* 1, 3 : 129 (1893). *Jungermannia appanata* Reinw., Blume et Nees, *Nova Acta Acad. Caes. Lep. Carol.* 12 : 210 (1825).

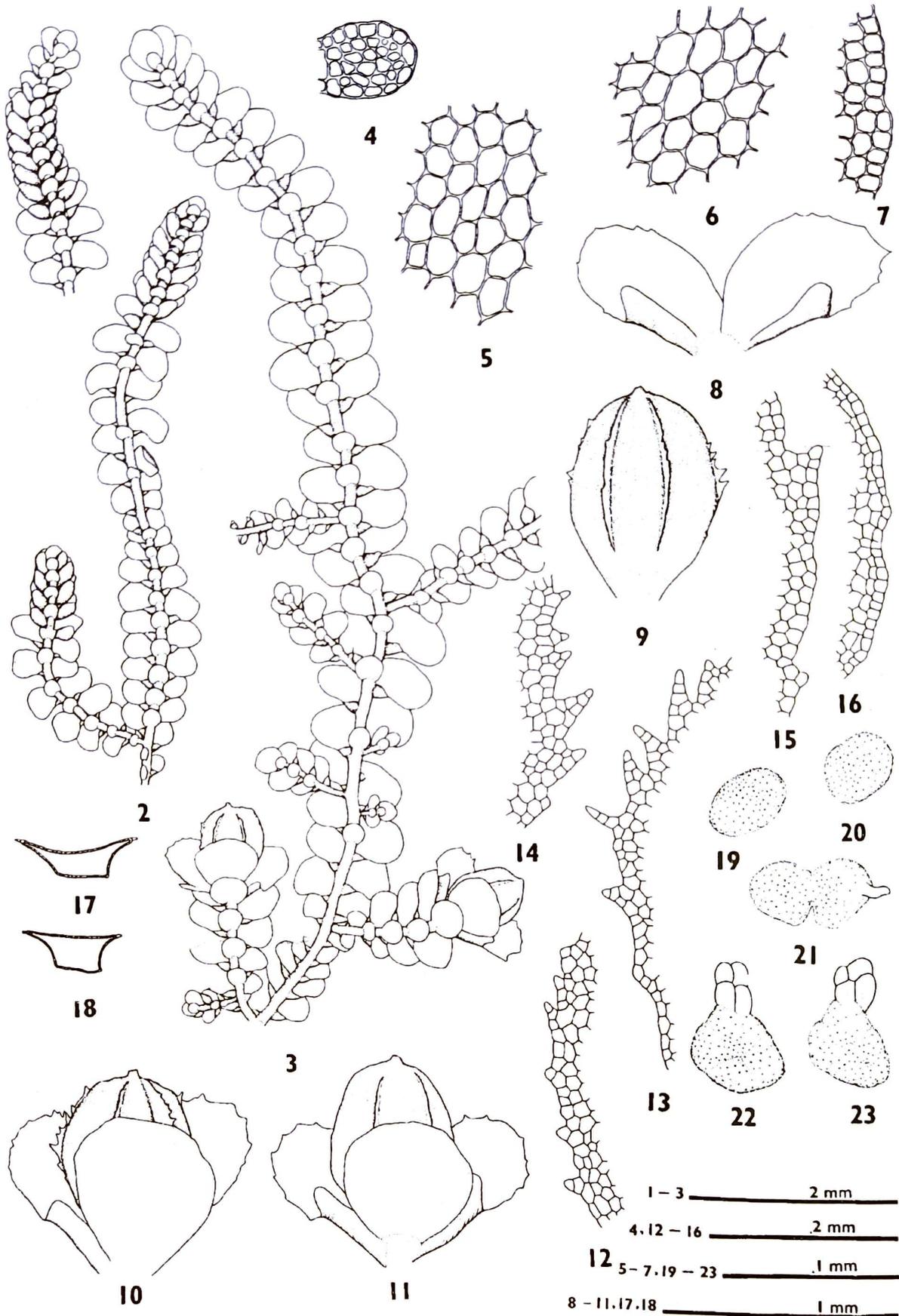


Fig. 2. *Lopholejeunea abortiva* var. *doliiformis* var. nov.

1. Portion of the plant showing intercalary male inflorescence. 2. Portion of the plant showing male inflorescence terminal in position. 3. Portion of the plant showing female inflorescences. 4. Cross-section of stem. 5. Basal cells of the leaf. 6. Median cells of the leaf. 7. Marginal cells of the leaf. 8. Female bracts. 9. Perianth. 10, 11. Female inflorescences. 12-14. Margin of female bracts. 15, 16. Lateral margin of perianth keel. 17, 18. Cross-sections of perianth. 19-23. Germinated spores.

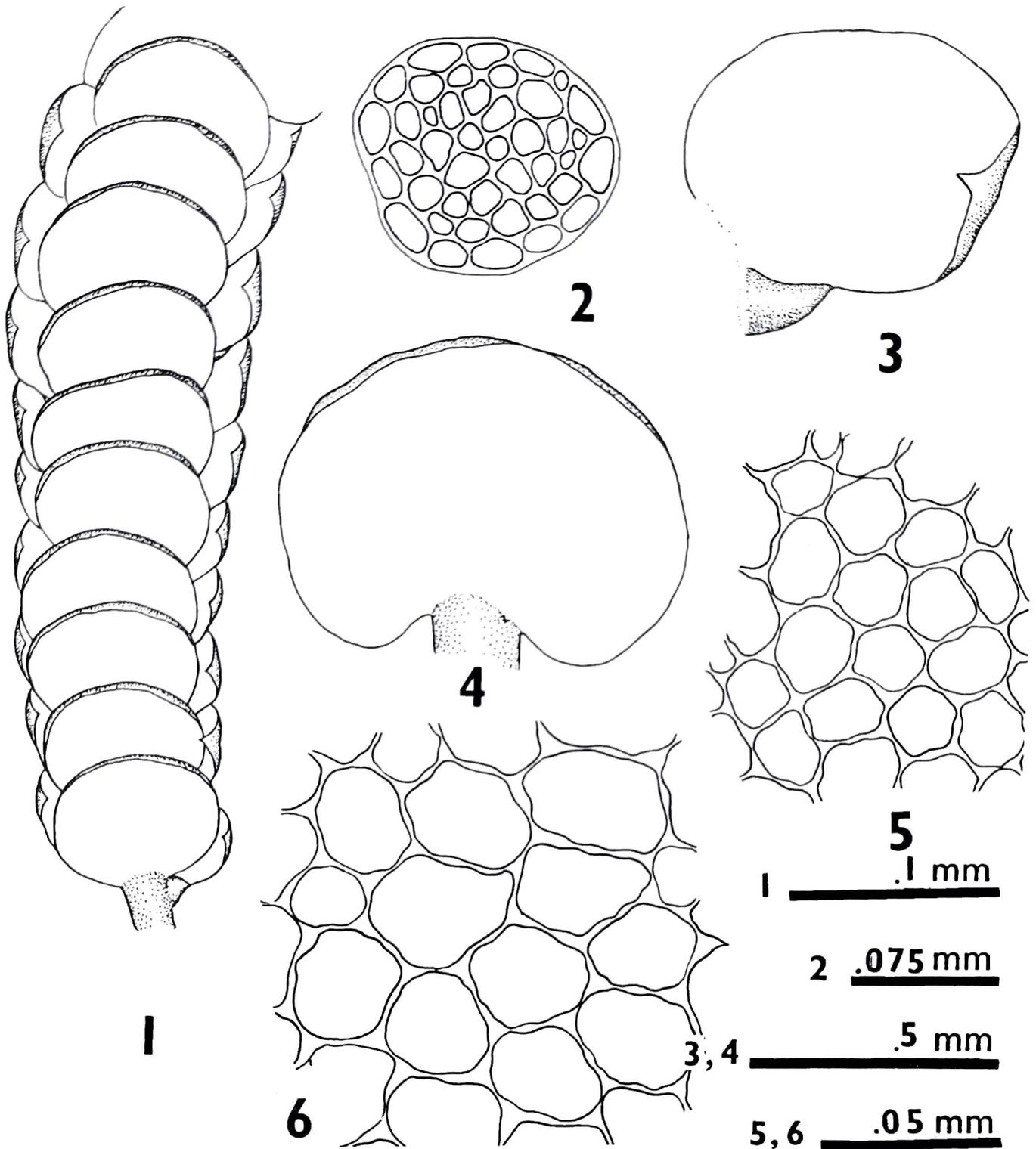


Fig. 3. *Lopholejeunea applanata* (R., Bl. et N.) Schiffn.

1. Portion of the plant. 2. Cross-section of the stem. 3. Leaf. 4. Underleaf. 5. Median cells of the leaf. 6. Basal cells of the leaf.

TYPE : Java Prov. Bentam, in montibus ad Kamayan Blume s.n. (Bonner, 1976).

Plants autoecious (according to Mizutani, 1979) 10-20 mm long, green. Stem in cross-section 0.10-0.16 mm in diameter, with 12-13 cortical and 22-23 medullary cells, cortical cells larger than medullary cells,

medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.65-0.80 mm long, 0.46-0.68 mm wide, margin entire or often 1-2 small teeth near the apex, apex acute or apiculate, incurved, leaf cells thick walled with radiate trigones and inter-

mediate nodular thickenings, basal cells 20-41 x 21-25 µm, median cells 23-30 x 17-24 µm, marginal cells 10-11 x 14-18 µm, lobule ovate 1/3 of the lobe length 0.20-0.24 mm long, 0.16-0.17 mm wide, distinctly saccate, with inconspicuous tooth. Underleaves reniform, wider than long, 6-7 times wider than stem, 0.3-0.35 mm long, 0.6-1.0 mm wide, apex subtruncate or widely rounded, narrowly or strongly recurved. Male inflorescence (according to Mizutani, 1979) terminal on short or long branches, bracts lobe oblong, 0.4 mm long, bracteole orbicular, 0.15 mm long, Female inflorescence terminal on stem or long branches, bract lobe ovate oblong, 0.15-1 mm long, 0.4-0.5 mm wide, apex acute, margin dentate, bract lobules about 1/2 as long as the lobe, sublinear, apex usually acute, keel slightly shorter than lobe, bracteoles widely oblong to orbicular, apex dentate or nearly entire, flat or slightly recurved. Perianth pyriform, about 1 mm long, 0.6-0.7 mm wide, 4-keeled, keels densely spinose.

Specimens examined : INDIA—West Bengal, Darjeeling, Llyod Botanical Garden (alt. ca. 1800 m), S.C.Srivastava, U.S. Awasthi and A. Kumar, 3476/77, 31 Dec. 1977, LWU; BM 19, Loc : West Java (Tijbodas 1420 m), Leg. : ?, Dt. : June 1930, Det. : Fr. Verdoorn (No. 241); BM 20: NICH 226162, Loc.: Western Sumatra (alt. 1520 m), Leg. : V. Schiffner, Dt. : July 1984. Det. : Fr. Verdoorn (Hep. Sel. Et. Crit. No. 240). Java, 17512, G. (Isotype).

Ecology and distribution : Grows on bark of trees and shrubs. INDIA - Darjeeling, Sikkim and Mt. Khasia : (Mitten 1860-61); Borneo, China, Java, Japan, New Guinea, Ryukyu, Sumatra.

Characteristics of the species : (1) Leaf lobe with acute or apiculate apex, (2) Underleaves reniform, 3-4 times wider than long, (3) Female bracts isomorphic, bract-lobe, lobule and bracteole dentate, lobe ovate or oblong with acute apex, lobule triangular-rectangular, 1/2 or slightly less than 1/2 of the lobe length, sometimes slightly extending beyond the keel with acute or subacute apex, (4) Perianth 4-keeled, keels dentate.

The Indian plants described here do not bear reproductive structures. Information about female inflorescence is however, based on study of specimens from

Java and Sumatra and the description of the species given by Mizutani (1961).

4. *Lopholejeunea indica* Udar et Awasthi, *Bull. bot. Surv. India* 25 : 174 (1983) (Figure 4 : 1-40).

TYPE : INDIA - Meghalaya, Jowai (alt. 1600 m), U.S. Awasthi and A. Kumar, 4014/79, 11 Nov. 1979, LWU.

Plants monoecious, 5-10 mm long, greenish brown in colour. Stem in cross-section (0.08x 1.04-1.20 mm) with 11-12 cortical and 16-18 slightly smaller, thick-walled medullary cells with small trigones. Leaves widely spreading, lobe ovate, 0.77-0.88 mm long, 0.56-0.61 mm wide, margin entire, apex rounded, cells thick-walled, with radiate trigones and intermediate nodular thickenings, lobule ovate 1/3 of the lobe length, 0.24-0.32 mm long, 0.12-0.27 mm wide, with inconspicuous tooth. Underleaves slightly wider than long, 0.10-0.27 mm long, 0.29-0.32 mm wide, margin entire, bracts hypostatic, lobe ovate, 0.32-0.42 mm long, 0.20-0.32 mm wide, margin entire, apex obtuse or rounded, lobule ovate-oblong 0.32-0.37 mm long, 0.18-0.21 mm wide, margin entire, apex obtuse, bracteole almost orbicular, 0.19-0.21 mm long, 0.21-0.22 mm wide margin entire. Female inflorescence terminal, on short lateral branch, lacking in subfloral innovation, bract-lobe obovate-oblong, 0.77-0.81 mm long, 0.48-0.50 mm wide, margin dentate or entire, apex acute, sometimes rounded, lobule almost rectangular, 1/2 or slightly more than 1/2 of the lobe length, 0.41-0.48 mm long, 0.21-0.27 mm wide, sometimes extended beyond the keel, with 1-6 teeth, bracteole orbicular, ca 3/4 of the perianth length, 0.61-0.64 mm long and wide, margin dentate, slightly revolute, perianth obovate, 0.80-1.0 mm long, 0.60-0.65 mm wide, 4-keeled, keels dentate, dentitions also present in between the keels. Sporophyte not seen.

Specimens examined : INDIA - Meghalaya, Jowai (alt. 1600 m) U.S. Awasthi and A. Kumar 4014/79 (Holotype), 11 Nov. 1979, LWU. Kerala, Lakkidi (alt. 700 m), R. Udar, S.C. Srivastava and U.S. Awasthi 6002/82, 25 Sept. 1982, LWU.

Ecology and distribution : Grows on bark of trees. INDIA - Meghalaya & Kerala.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves almost orbicular,

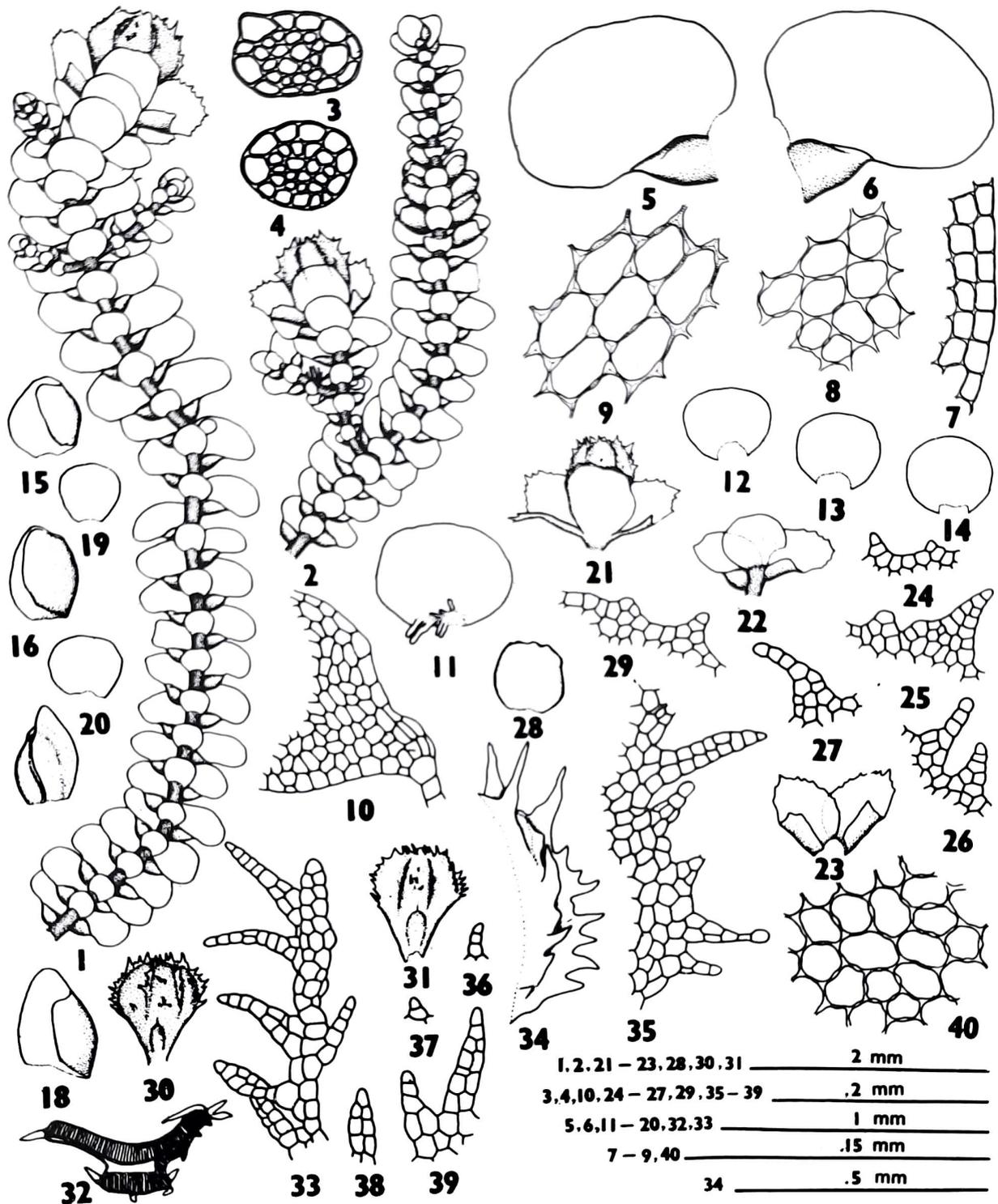


Fig. 4. *Lopholejeunea indica* Udar et Awasthi.

1. Portion of the plant showing female inflorescence. 2. Portion of the plant showing female inflorescence on short lateral branch and male inflorescence intercalary in position. 3, 4. Cross-section of stem. 5-6. Leaves. 7. Marginal cells of leaf-lobe. 8. Median cells of the leaf-lobe. 9. Basal cells of the leaf-lobe. 10. Portion of leaf-lobule showing indistinct marginal tooth. 11-14. Underleaves. 15-18. Male bracts. 19-20. Male bracteoles. 21. Female bracts, bracteole and perianth. 22. Female bracts and bracteole. 23. Female bracts. 24-27. Dentitions of female bract-lobe. 28. Female bracteole. 29. Dentitions of female bracteole. 30, 31. Perianth. 32. Cross-section of perianth. 33. Ventral plica of perianth showing dentitions. 34, 35. Lateral plicae of perianth showing dentitions. 36-39. dentitions of general surface of perianth. 40. Cells of the perianth.

slightly wider than long, (3) Female bract-lobe, - lobule and bracteole dentate, bracts isomorphic, lobe ovate with acute apex, lobule almost rectangular, $\frac{1}{2}$ or more than $\frac{1}{2}$ of the lobe length, sometimes slightly extending beyond the keel, with entire or dentate margin, apex acute or sometimes rounded, (4) Perianth 4-keeled, keels dentate, dentitions present also in between keels.

This species differs from the allied species, *L. nicobarica* and *L. kashyapii* in having female bracts, bracteole and perianth with much less developed dentitions. *L. kashyapii* occupies an intermediate position between *L. indica* and *L. nicobarica* with regard to the vigour of the plant and degree of development of dentitions and differs from both (*L. indica* and *L. nicobarica*) in having a 5-plicate perianth (Fig. 6: 14, 15). Further the bracteole has a conspicuously revolute margin (Fig. 6: 9) in *L. kashyapii* but it is flat in *L. indica* (Fig. 4:28). The dentitions often present between the keels (Fig. 4: 30-32) in *L. indica* are absent in the other two species.

5. *Lopholejeunea javanica* (Nees) Schiffn.
Nat. Pfl. Fam. 1,3 : 129 (1893) (Figure 5 : 1-22).

TYPE : JAVA (without detailed locality and collector's name (herb. Lindenberg 6161 W).

Plants monoecious, 5-20 mm long, green. Stem in cross-section (0.08-0.10 x 0.10-0.12 mm) with 11-13 cortical cells and 18-20 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.45-0.51 mm long, 0.30-0.41 mm wide, margin entire, apex rounded, cells thick-walled, with radiate trigones and intermediate nodular thickenings, basal cells 24-40 x 12-20 μm , median cells 16-32 x 12-20 μm , marginal cells 10-12 x 10-14 μm , lobule ovate, 0.16-0.19 mm long, 0.14-0.16 mm wide, distinctly saccate, with inconspicuous tooth. Underleaves wider than long, 0.22-0.27 mm long, 0.25-0.40 mm wide, margin entire. Male inflorescence terminal or intercalary, bracts hypostatic, lobe ovate, 0.37-0.49 mm long, 0.24-0.32 mm wide, margin entire and apex obtuse-rounded, lobule ovate, 0.32-0.40 mm long, 0.16-0.24 mm wide, margin entire and apex rounded, bracteole wider than long, 0.19-0.27 mm long, 0.22-

0.32 mm wide, with entire margin. Female inflorescence terminal on short or elongated branch, lobe obovate or ovate, 0.73-0.92 mm long, 0.48-0.64 mm wide, margin dentate, denticulate or almost entire, apex mostly rounded, lobule almost rectangular, $\frac{1}{2}$ or less than $\frac{1}{2}$ of the lobe length, 0.16-0.38 mm long, 0.06-0.11 mm wide, margin entire and apex rounded, bracteole wider than long, $\frac{1}{2}$ or less than $\frac{1}{2}$ of the lobe length, 0.51-0.56 mm long, 0.59-0.62 mm wide, perianth obovate, 0.65-0.75 mm long, 0.45-0.50 mm wide, 4-keeled, keels with small dentitions, spores variously shaped, 24-44 x 20-32 μm , with minute spinulae and 'rosettes' of spines, elaters 208-248 μm long, ca. 12 μm wide, with single spiral thickening band.

Specimens examined : INDIA-Kerala, Palghat, Silent Valley (alt. 2000 m), R. Udar and U.S. Awasthi 5700A/82, 5700B/82, 5732/82, 23 Aug. 1982, LWU.

NICH 269547, Loc. : Philippines. Leg. : Juan V. Pancho & B. Hernaeg. Dt. : 28 Aug. 1965.

Ecology and distribution : Grows on boulders. INDIA - Kerala; Java, Philippines.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves nearly orbicular, wider than long, (3) Female bracts isomorphic, bract-lobe obovate, mostly with rounded apex and poorly developed dentitions, bract-lobe and bracteole entire, lobule almost rectangular, small, almost $\frac{1}{3}$ of the lobe length with rounded apex, (4) Perianth 4-keeled, keels with small dentitions.

Mizutani's (1985) characterization of *L. javanica* differs from ours as follows : (1) Perianth keels without or with few teeth, (2) female bracteole usually orbicular and with entire margin, (3) small linear female bract-lobe and (4) female bract lobe entire, (5) presence of one or two subfloral innovations of the *Lejeunea*-type.

The examined specimen of *L. javanica* from Philippines agree with the Indian specimens except for the presence of subfloral innovations which were also lacking in the specimens from Philippines. Though, the Indian plants agree in lacking subfloral innovations but differ in having small dentitions on female bracts (Fig.

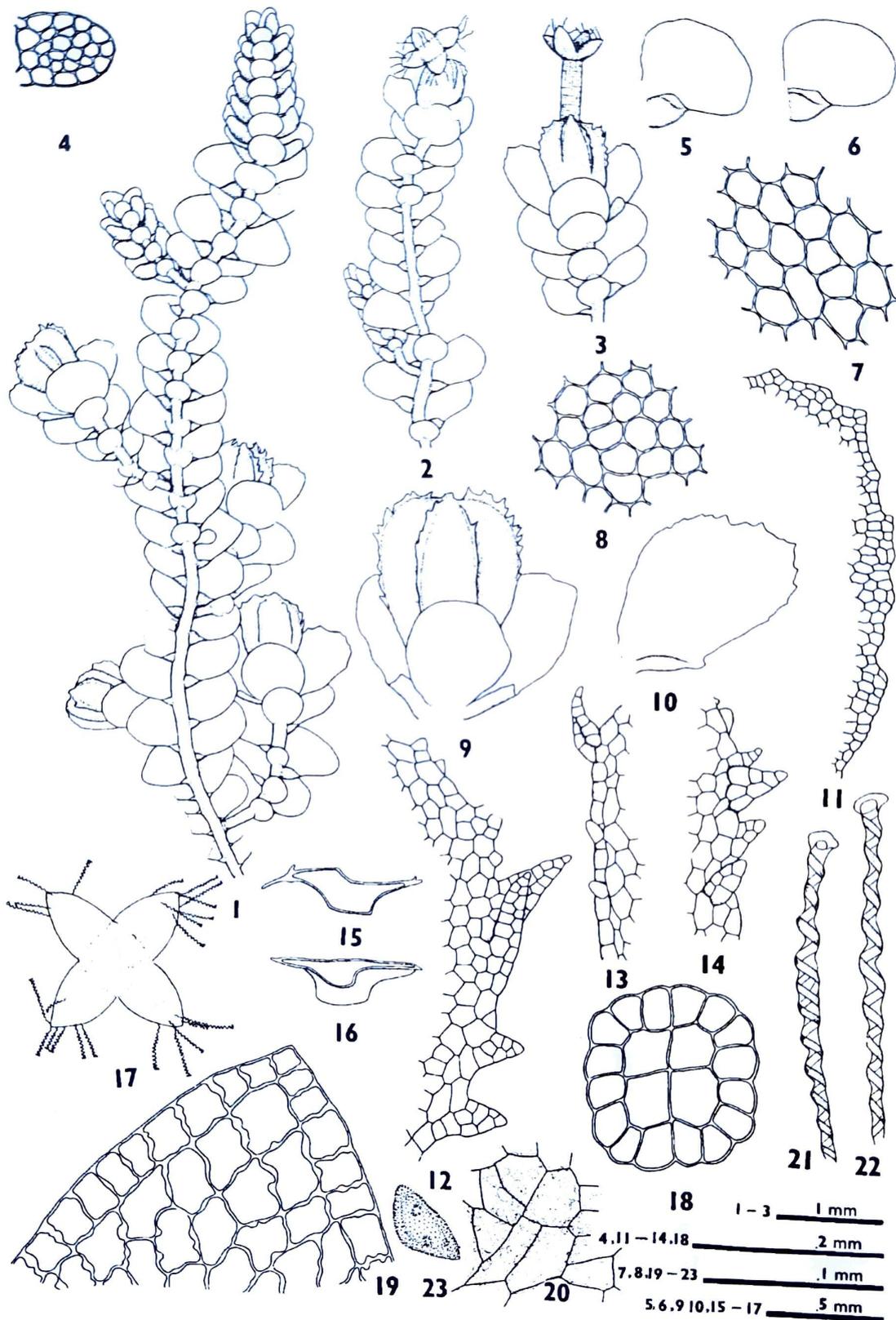


Fig. 5. *Lopholejeunea javanica* (Nees) Schiffn.

1, 2. Portion of the plant showing male and female inflorescences. 3. Portion of the plant showing female inflorescences with dehiscent sporophyte. 4. Cross-section of the stem. 5, 6. Leaves. 7. Basal cells of the leaf. 8. Median cells of the leaf. 9. Female inflorescence. 10. Female bract. 11. Margin of female bract. 12. Lateral keel of the perianth. 13, 14. Ventral keel of the perianth. 15, 16. Cross-sections of the perianth. 17. Dehiscent capsule. 18. Cross-section of seta. 19. Outer layer of capsule wall. 20. Inner layer of capsule wall. 21, 22. Elaters.

5: 10, 11). Judging the overall features and flexibility in these taxa, the Indian specimens are considered here as belonging to *L. javanica*.

6. *Lopholejeunea kashyapii* sp. nov. (Figure 6 : 1-15)

Folii apice rotundato, Bractae et bracteolae femineae et perianthium dentatis margine, bracteolae revolutus, perianthium 5- carinatum.

TYPE : INDIA - Meghalaya, Khasi-Jayantia Hills (alt. 1600 m), S.K. Pande 8074/52, Sept.-Oct. 1952, LWU.

Plants monoecious, 5-15 mm long. Stem in cross-section (0.06-0.7 x 0.07-0.08 mm) with 12-14 cortical and 14-17 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with inconspicuous trigones. Leaves widely spreading, lobe ovate, 0.81-0.91 mm long, 0.59-0.67 mm wide, margin entire and apex rounded, cells with inconspicuous trigones and intermediate nodular thickenings, lobule ovate, 0.25-0.27 mm long, 0.22-0.25 mm wide, highly saccate, free margin with single inconspicuous tooth, tooth often hidden due to involute margins. Underleaves mostly wider than long, 0.40-0.41 mm long, 0.40-0.60 mm wide, margin entire. Male inflorescence terminal or intercalary preceded or not by vegetative leaves, bracts, hypostatic, ovate-oblong, 0.48-0.56 mm long, 0.28-0.32 mm wide, margin entire and apex obtuse-rounded, lobule 0.32-0.35 mm long, 0.12-0.16 mm wide, margin entire and apex obtuse to rounded bracteole longer than wide, 0.32-0.35 mm long, 0.32-0.40 mm wide, margin entire and apex rounded. Female inflorescence on short or elongate branch lacking in subfloral innovation, bract-lobe ovate, 1.07-1.12 mm long, 0.70-0.72 mm wide, margin dentate, apex acute, lobule wider at apex, narrower towards base, $\frac{3}{4}$ of the lobe length, 0.76-0.80 mm long, 0.28-0.32 mm wide, margin dentate and apex acute, bracteole almost orbicular, equal or slightly larger than perianth length, 1.12-1.15 mm long, 0.88-0.96 mm wide, margin dentate, revolute, perianth obovate, 1.12-1.20 mm long, 0.83-0.88 mm wide, 5-keeled, keels dentate. Sporophyte not seen.

Specimens examined : INDIA-Meghalaya, Khasi-Jayantia Hills (alt. 1600 m), S.K. Pande, 8074/52 (Holotype), Sept. - Oct. 1952, LWU.

Ecology and distribution : Grows on bark of trees. INDIA - Meghalaya.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves almost orbicular, slightly wider than long, (3) Female bract-lobe, lobule and bracteole dentate, bracts isomorphic, lobe ovate with acute apex, lobule $\frac{2}{3}$ of the lobe length, wider at apex and gradually narrower towards base, apex acute, bracteole with revoluted margin, (4) Perianth 5-keeled, keels dentate.

L. kashyapii approaches *L. indica* and *L. nicobarica* in having dentate female bracts, bracteole and perianth (Fig. 6: 7-9) but differs in its 5-keeled perianth (Fig. 6: 14,15) as opposed to 4-keeled in the latter two species.

7. *Lopholejeunea nicobarica* St., *Hedwigia* 35 : 111 (1826). (Figure 7 : 1-12).

Spec. Hepat. V : 91 (1912). Mizutani 469 (1985)

TYPE : INDIA - Nicobar Is. (Stephani 1912).

Plants dioecious, 10-15 mm long, Stem in cross-section (0.1-0.15 mm in diameter) with 13-14 cortical and 28-32 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with inconspicuous trigones. Leaves widely spreading, lobe ovate-oblong, 0.6-0.8 mm long, 0.4-0.6 mm wide, margin entire and apex rounded, cells with distinct radiate trigones and intermediate nodular thickenings, basal cells 25-35 x 18-28 μ m, median cells 20-32 x 16-22 μ m, lobule ovate, ca. $\frac{1}{3}$ of the lobe length, with inconspicuous tooth at its free margin. Underleaves reniform, 0.25-0.50 mm long, 0.7-1.0 mm wide, margin entire. Male inflorescence terminal on short branches, bracts hypostatic, lobe ovate, 0.4-0.5 mm long, 0.28-0.30 mm wide, margin entire and obtuse-rounded apex, lobule ovate-oblong, 0.30-0.35 mm long, 0.10-0.15 mm wide, bracteole wider than long, 0.30-0.35 mm long, 0.35-0.40 mm wide, margin entire. Female inflorescence terminal on long branches without subfloral innovation, bract-lobe oblong, 1-1.6 mm long, 0.5-1 mm wide, margin ciliate-dentate, apex acute, lobule ca. $\frac{3}{5}$ the length of the lobe 0.75-1 mm long, 0.2-0.3 mm wide, almost rectangular, margin ciliate-dentate, apex acute, slightly extending beyond the keel, bracteole large, obovate, $+\frac{3}{4}$ of the perianth length, 0.8-1.3 mm long, 1-1.5 mm wide, margin ciliate-dentate, apex usually flat, perianth obovate, 1-1.8 mm long, 0.8-1 mm wide, 4-keeled,

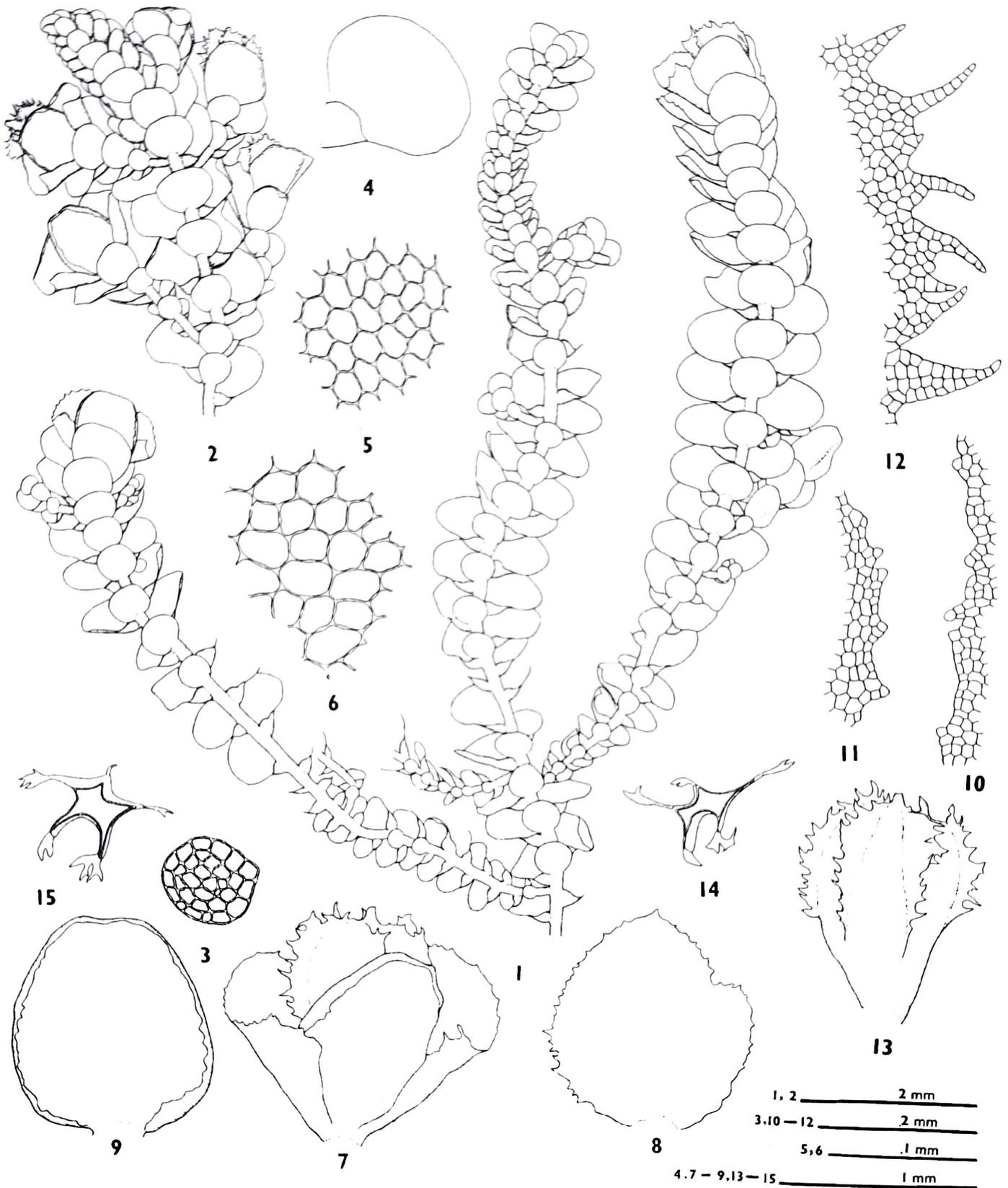


Fig. 6. *Lopholejeunea kashyapii* sp. nov.

1,2. Portions of the plants showing male and female inflorescences. 3. Cross-section of the stem. 4. Leaf. 5. Median cells of the leaf. 6. Basal cells of the leaf. 7. Female inflorescence. 8. Female bract. 9. Female bracteole. 10. Margin of the female bract-lobe. 11. Margin of the female bracteole. 12. Portion of the lateral keel of the perianth. 13. Perianth. 14,15. Cross-sections of the perianth.

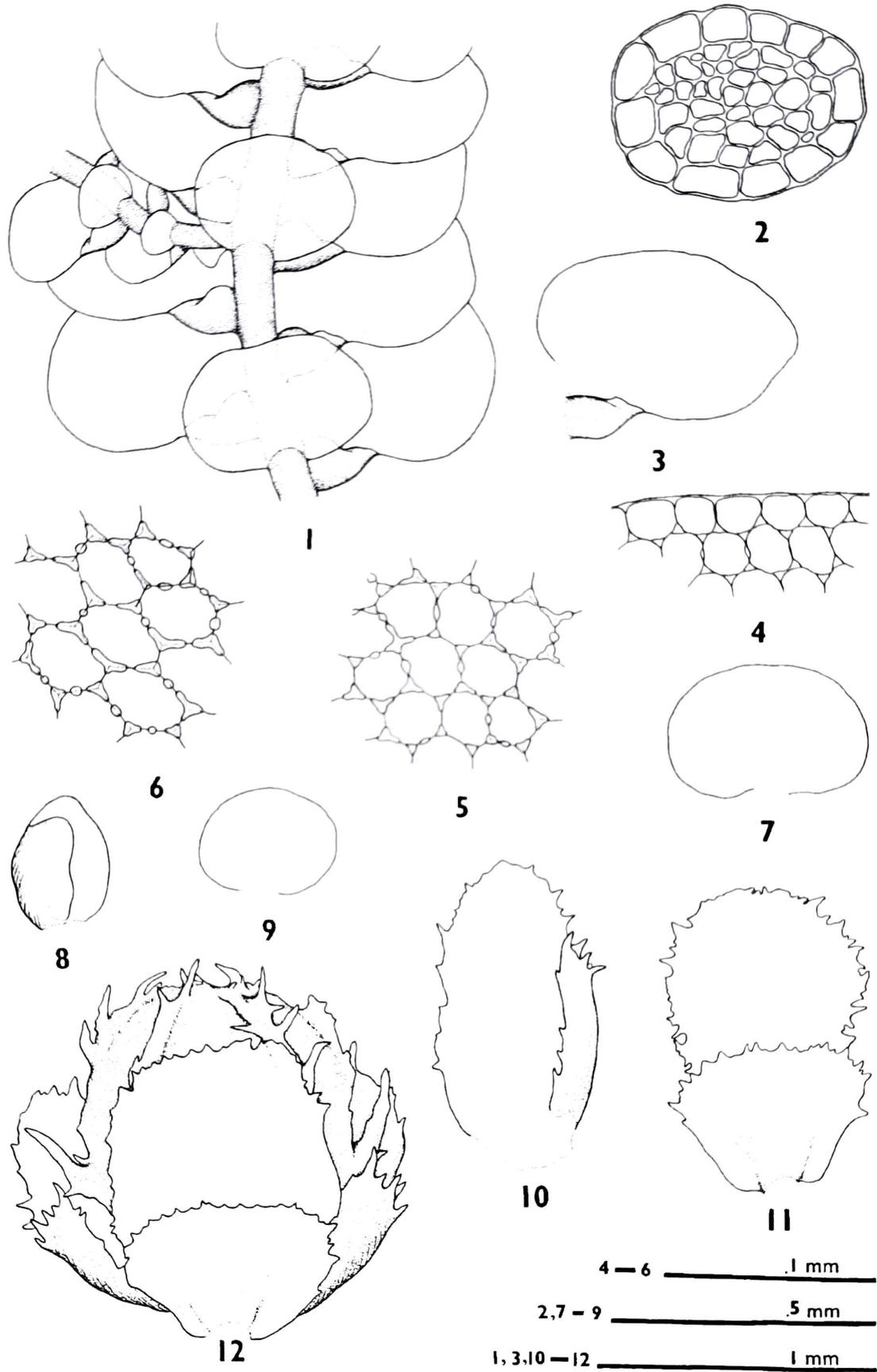


Fig. 7. *Lopholejeunea nicobarica* St.

1. Portion of the plant. 2. Cross-section of the stem. 3. Leaf. 4. Marginal cells of the leaf. 5. Median cells of the leaf. 6. Basal cells of the leaf. 7. Underleaf. 8. Male bract. 9. Male bracteole. 10. Female bract. 11. Female bracteole. 12. Female inflorescence.

keels ciliate-dentate. Sporophyte not seen.

Specimens examined : INDIA–Nicobar Is. Fatschall & S. Kurz, 751/20, G.

Ecology and distribution : Grows on bark of trees. INDIA - Nicobar Is.; Thailand, Philippines, Formosa, Ryukyu.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves reniform, 2-3 times wider than long, (3) Female bract-lobe, lobule and bracteole ciliate-dentate, bracts isomorphic, lobe ovate-oblong, with acute apex, lobule almost rectangular, 3/5 of the lobe length, slightly extending beyond the keel, with acute apex, (4) Perianth 4-keeled, keels ciliate-dentate.

This species is clearly distinguishable from its close allies, *L. kashyapii* and *L. indica* (in which all involucre parts are relatively shortly dentate) by being comparatively robust and by the ciliate-dentate margin of the bract-lobes, bract-lobules, bracteoles, and keels of the perianth (Fig. 7 : 10-12).

8. *Lopholejeunea nigricans* (Lindenb.) Schiffn.
Consp. Hepat. Archip. Indici. : 293 (1898)
(Figure 8 : 1-36).

Lejeunea nigricans Lindenb. In Gott., Lindenb. et Nees. *Synop. Hepat.* : 316 (1845).

TYPE : Java, Blume (Verdoorn, 1934).

Plants monoecious, 5-15 mm long, green. Stem in cross-section (0.14-0.16 x 0.10-0.11 mm) with 12-14 cortical and 22-24 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.77-0.80 mm long, 0.43-0.48 mm wide, margin entire, apex acute or apiculate or sometimes rounded, often incurved, cells thick-walled with radiate trigones and intermediate nodular thickenings, basal cells 20-40 x 20-24 µm, medium cells 24-32 x 16-24 µm, marginal cells 10-12 x 16-20 µm, lobule ovate, 1/3 of the lobe length, 0.21-0.25 mm long, 0.16-0.17 mm wide, distinctly saccate, with inconspicuous tooth. Underleaves wider than long, 3-4 times wider than stem, 0.37-0.30 mm long, 0.54-0.56 mm wide, margin entire, sometimes with rhizoids at base. Male inflorescence terminal or intercalary, bracts hypostatic, lobe ovate, 0.45-0.48 mm long, margin en-

tire, apex obtuse or rounded, lobule ovate-oblong, 0.35-0.37 mm long, 0.16-0.19 mm wide, margin entire and apex obtuse or rounded, bracteole usually wider than long, 0.35-0.36 mm long, 0.50-0.54 mm wide, margin entire. Female inflorescence terminal on short lateral branch, lacking in subfloral innovation, bract lobe ovate, 0.89-0.99 mm long, 0.57-0.64 mm wide, ovate or oblong, apex acute, margin dentate, lobule triangular-rectangular, 1/2 or slightly less than 1/2 the length of the lobe, 0.38-0.41 mm long, 0.08-0.10 mm wide, sometimes slightly extending beyond the keel, with 0-2 teeth and acute or subacute apex, bracteole almost orbicular, 3/4 of the perianth length, 0.72-0.75 mm long, 0.70-0.73 mm wide, with dentate margin, perianth obovate, ca. 1.0 mm long and 0.67 mm wide, 3-4-keeled, keels dentate. Sporophyte not seen.

Specimens examined : INDIA–Meghalaya, Jowai (alt. 1600 m) U.S. Awasthi and A. Kumar, 4013/79, 4013A/79, 4013B/79, 4013C/79, LWU.

NICH 219751 (243 : Hepat. Sel. Crit. Ed. Fr. Verdoorn) Loc : Sumatra, Leg. : V. Schiffner, Dt. : July 1894. BM 1. Loc Western Sumatra (alt. : 770 m.) Leg. : V. Schiffner, Dt. : July 1894.

Ecology and distribution : Grows on bark of trees and shrubs. INDIA - Meghalaya and Sikkim (Mitten, 1860-61). A widespread pantropical species.

Characteristics of the species : (1) Leaf-lobe usually with acute or apiculate apex, (2) Underleaves reniform, 2 times wider than long, (3) Female bracts isomorphic, bract-lobe, lobule and bracteole dentate, lobe-ovate, or oblong with acute apex, lobule triangular-rectangular, 1/2 or slightly less than 1/2 of the lobe length, sometimes slightly extending beyond the keel, with acute or subacute apex, (4) Perianth 3-4 keeled, keels dentate.

It differs from *L. applanata* in having comparatively less wider underleaves : 2 times wider than stem (Figs. 8 : 6.17) (6-7 times wider than stem in *L. applanata*; Fig. 3: 4)

9. *Lopholejeunea nilgiriensis* sp. nov.
(Figure 9 : 1-27)

Folii apice rotundato, Bractae feminae dentatis duo isomorphus et dimorphus, bracteole integro-marginatae, perianthium carinatum carinae dentatis.

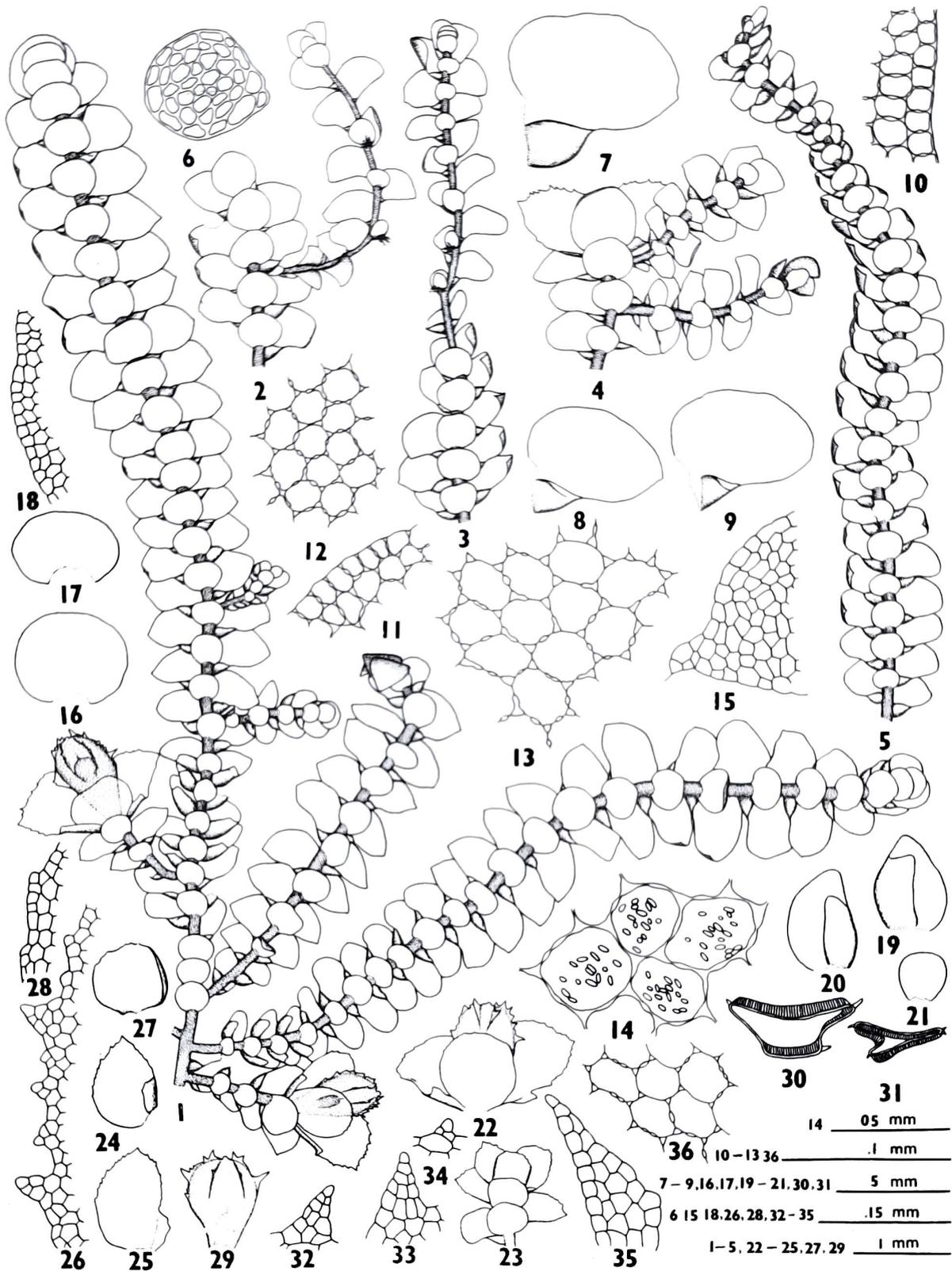


Fig. 8. *Lopholejeunea nigricans* (Lindenb.) Schiffn.

1. A plant showing male and female inflorescences. 2,3. Portions of the plant showing leaves both with acute apex and rounded apex. 4. Portion of the plant showing female inflorescence with subfloral innovation. 5. Portion of the plant showing leaves with recurved apex. 6. Cross-section of the stem. 7-9. Leaves. 10,11. Marginal cells of the leaf. 12. Median cells of the leaf. 13. Basal cells of the leaf. 14. Leaf basal cells with oil-bodies. 15. Portion of the leaf-lobule, 16,17. Underleaves, 18. Marginal cells of the underleaf. 19,20. Male bracts. 21. Male bracteole. 22. Female inflorescence. 23. Portion of plant showing recurved margins of bracteole. 24,25. Female bracts. 26. Margin of the female bract. 27. Female bracteole. 28. Margin of female bracteole. 29. Perianth. 30,31. Cross-sections of perianth. 32-35. Dentitions on perianth. 36. Perianth cells.

TYPE : INDIA - Tamil Nadu, Naduvattam (alt. 1800 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 7190/83, 27 Sept. 1983, LWU.

Plants monoecious 5-15 mm long, Stem in cross-section (0.06-0.07 x 0.07-0.08 mm) with 11-12 cortical and 16-18 medullary cells, cortical cells larger than medullary cells, medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.64-0.96 mm long, 0.59-0.64 mm wide, margin entire and apex rounded, cells with inconspicuous trigones and intermediate nodular thickenings, basal cells 32-40 x 20-28 μm , median cells 12-32 x 16-20 μm , marginal cells 12-16 x 8-12 μm , lobule ovate, distinctly saccate, 0.25-0.32 mm long, 0.12-0.25 mm wide, with inconspicuous tooth. Underleaves wider than long, 0.35-0.40 mm long, 0.36-0.41 mm wide, margins entire. Male inflorescence terminal or intercalary, bracts hypostatic, lobe ovate, 0.35-0.37 mm long, 0.25-0.45 mm wide, margins entire, apex obtuse-rounded, lobule oblong 0.30-0.34 mm long, 0.14-0.16 mm wide, margin entire and apex obtuse-rounded, bracteole orbicular, 0.22-0.25 mm long, 0.20-0.23 mm wide margin entire. Female inflorescence terminal on short or elongated branch, lacking in subfloral innovation, bract-lobe orbicular to ovate, 1.21-1.22 mm long, 0.89-1.07 mm wide, margin dentate and apex acute sometimes rounded, lobule equal or unequal of a pair of bracts (both large, both reduced or one large and one reduced), larger $\frac{1}{2}$ (or slightly more) of the lobe length, extended beyond the keel for about $\frac{1}{2}$ of its length, 0.40-0.80 mm long, 0.16-0.24 mm wide, reduced one $\frac{1}{3}$ (or less) of the lobe length, not extended beyond the keel, bracteole wider than long, 0.74-1.15 mm long and 1.08-1.36 mm wide, $\frac{2}{3}$ of the perianth length, perianth obovate, 1.08-1.20 mm long, 0.80-1.12 mm wide, 4-keeled, sometimes 5-keeled, keels dentate, dentitions also present in between the keels, lateral keels winged. Sporophyte with foot, seta and capsule, foot bulbous, seta with 16 peripheral and 4 central rows of cells, capsule wall bistratose, cells of the outer layer with sinuate-nodular thickenings on radial walls, cells of the inner layer with fenestrate thickenings on inner tangential wall in addition to nodular thickenings on radial wall, spores variously shaped, 32-50 x 24-25 μm or 25-42 μm in diameter with small papillae and 3-5 'rosettes' of

spines, elaters 180-232 x 10-12 μm with single spiral thickening bands, free and wide.

Specimens examined : INDIA—Tamil Nadu, Naduvattam (alt. 1800 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 7190/83 (Holotype), 27 Sept. 1983. LWU.

Ecology and distribution : Grows on bark of trees and shrubs. INDIA - Tamil Nadu.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves orbicular, slightly wider than long, (3) Female bract-lobe dentate, bract-lobe and bracteole entire, bracts dimorphic, lobe ovate with acute, obtuse or rounded apex, lobules of a pair of bracts equal or unequal (both reduced or one larger and other reduced), the larger one linear or clavate, extended beyond the keel for $\frac{1}{2}$ or more than $\frac{1}{2}$ of its length with rounded apex, the other reduced one ovate, $\frac{1}{3}$ of the lobe length, not-extended beyond the keel, bracteole with entire margin, (4) Perianth 4-(5) keeled, keels dentate, dentitions also present in between the keels.

L. nilgiriensis exceptionally has both isomorphic (Fig. 9: 7,9) as well as heteromorphic female bracts (Fig. 9: 10). Their lobule may be reduced (Fig. 9: 7) or large explanate in both the bracts (Fig. 9:9) or it may be reduced on one bract and large explanate on the other (Fig. 9: 10).

10. *Lopholejeunea sikkimensis* St., Spec. Hepat. V : 87 (1912) (Figure 10:1-27).

TYPE : INDIA - Sikkim (Stephani, 1912).

Plants monoecious, 5-10 mm long. Stem in cross-section (0.13-0.15 x 0.10-0.12 mm) with 10-12 cortical and 26-32 slightly smaller medullary cells, medullary cells thick-walled with small trigones. Leaves widely spreading, lobe ovate, 0.67-0.80 mm long, 0.51-0.64 mm wide, margin entire, apex rounded, cells with distinct radiate trigones and intermediate nodular thickenings, basal cells 24-40 x 20-32 μm , median cells 20-36 x 16-28 μm , marginal cells 12-16 x 8-16 μm , oil-bodies homogeneous or rod-shaped (3-4 x 1-4 μm), 20-35 in each cell at base, 10-20 at middle and 9-12 at margin, lobule distinctly saccate, slightly less than $\frac{1}{2}$ of the lobe length, 0.27-0.32 mm long,

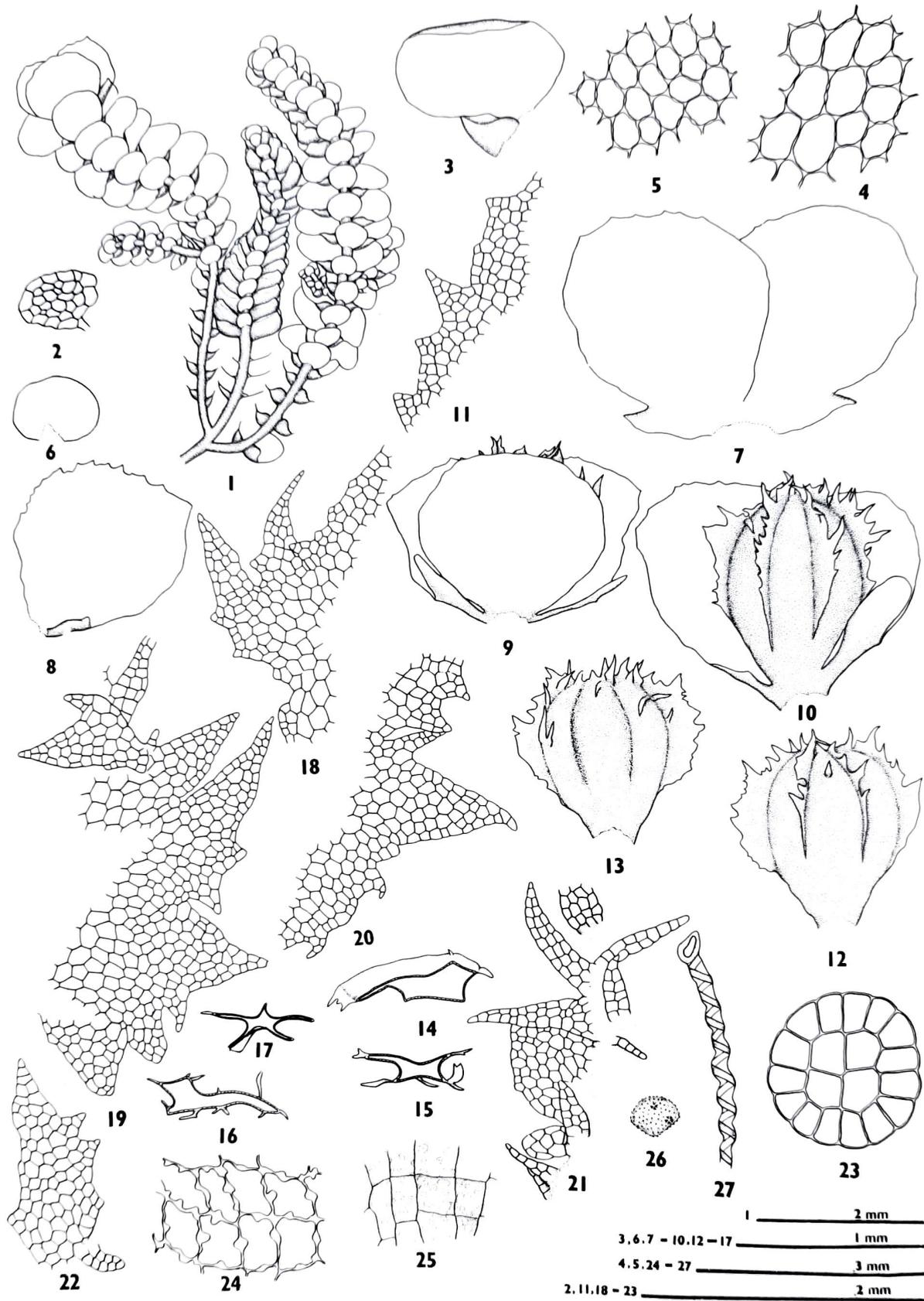


Fig. 9. *Lopholejeunea nilgiriensis* sp. nov.

1. Portion of the plant showing male and female inflorescence. 2. Cross-section of stem. 3. Leaf. 4. Basal cells of the leaf. 5. Median cells of the leaf. 6. Underleaf. 7. Female bracts showing less dentate margin. 8. Female bract with highly dentate margin. 9. Female inflorescence showing isomorphic bracts. 10. Perianth and heteromorphic bracts. 11. Margin of female bract. 12. Perianth in ventral view. 13. Perianth in dorsal view. 14-17. Cross-sections of the perianth. 18, 19. Lateral keel of the perianth. 20, 21. Ventral keel of the perianth. 22. A dentition of lateral keel showing secondary dentitions. 23. Cross-section of seta. 24. Outer layer of capsule wall. 25. Inner layer of capsule wall. 26. Spore. 27. Elaters.

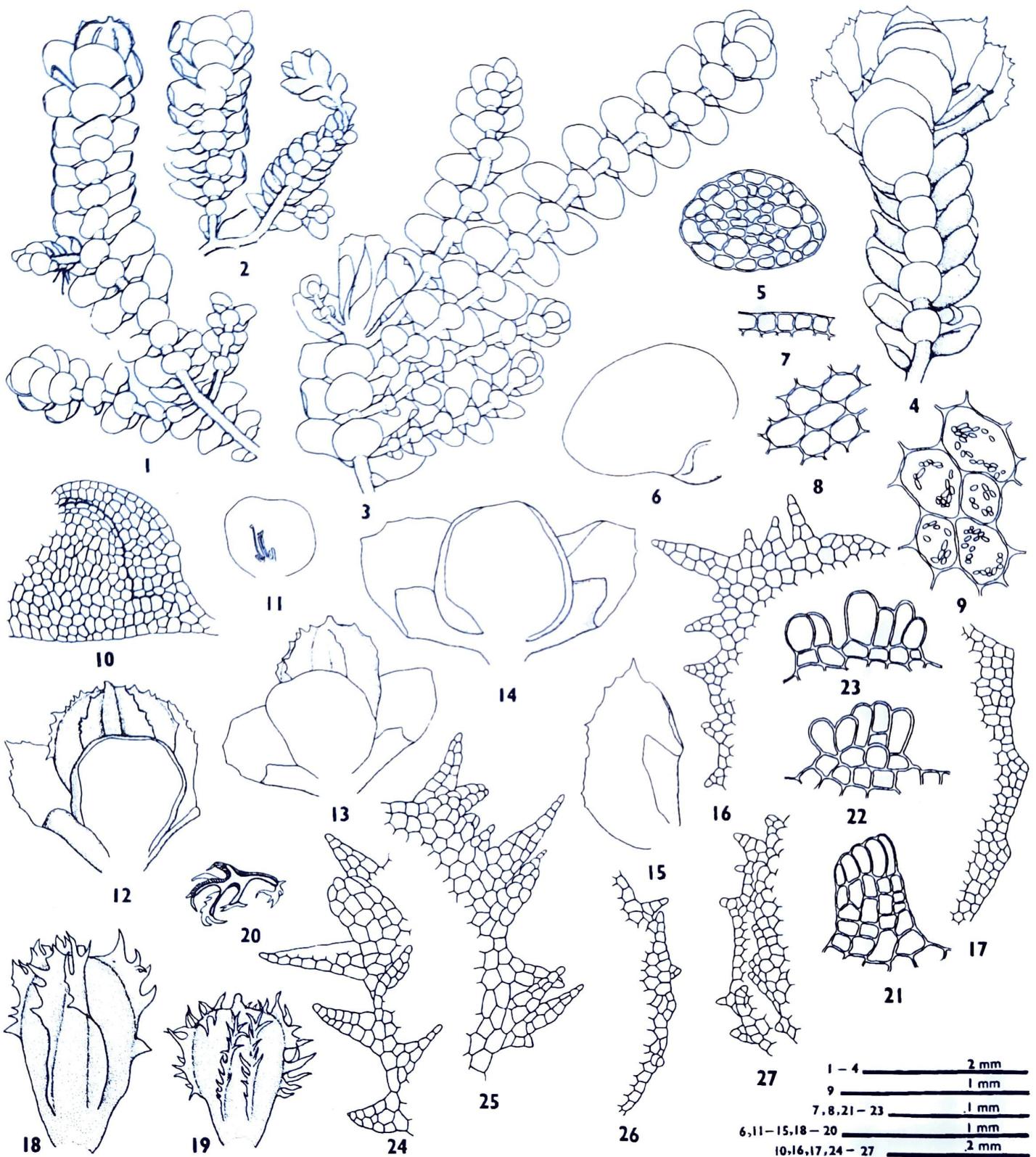


Fig. 10. *Lopholejeunea sikkimensis* St.

1. Portion of the plant showing female inflorescence. 2. Portion of the plant showing male and female inflorescences. 3. Portion of the plant showing female inflorescence with one subfloral innovation. 4. Portion of the plant showing parocious sexuality. 5. Cross-section of stem. 6. Leaf. 7. Marginal cells of the leaf. 8. Median cells of the leaf. 9. Basal cells of the leaf with oil bodies. 10. Leaf-lobule. 11. Underleaf. 12, 13. Female inflorescence. 14. Female bracts and bracteole. 15. Female bract. 16, 17. Margins of the female bracts. 18, 19. Perianths. 20. Cross-section of perianth. 21. Rostrum of the perianth. 22, 23. Portion of the rostrum with mammilated cells at apex. 24. Ventral keel of the perianth. 25. Lateral keel of the perianth. 26, 27. Lateral and ventral keel of the perianth.

0.19-0.22 mm wide, with indistinct tooth. Underleaves wider than long, 0.32-0.37 mm long, 0.45-0.51 mm wide, margin entire, apex rounded, rhizoids sometimes present at the base. Male inflorescence intercalary, bracts hypostatic, strongly saccate, lobe ovate, 0.37-0.48 mm long, 0.19-0.21 mm wide, margin entire, apex obtuse or rounded, lobule obovate, 0.27-0.37 mm long, 0.16-0.19 mm wide, margin entire, apex obtuse or rounded, bracteole as long as wide or wider than long, 0.17-0.27 mm long, 0.10-0.32 mm wide. Female inflorescence usually on short lateral branch, without subfloral innovation, bracteole ovate or obovate, 0.37-0.96 mm long, 0.56-0.70 mm wide, margin dentate, apex acute, lobule somewhat triangular or rectangular, more than 1/2 of the lobe length, 0.51-0.65 mm long, 0.14-0.30 mm wide, entirely adnate with the lobe or slightly extending beyond the keel, margins entire and revolute, apex subacute, bracteole almost orbicular, 3/4 of the perianth length, 0.67-0.85 mm long and wide, with entire but revolute margin, apex rounded, perianth obovate, 0.20-1.0 mm long, 0.64-0.72 mm wide, 5-keeled, keels sharp, dentate. Sporophyte not seen.

Specimens examined : INDIA - Tamil Nadu, Nilgiri Hills, Naduvattam (alt. ca. 1982 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 97/72, 2 Jan. 1972, LWU. Nilgiri Hills, Ootacamund (alt. ca. 2000 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 125/72, 2 Jan. 1972, LWU. Karnataka, Mercara (alt. ca. 700 m), D. Kumar, A. Kumar and U.S. Awasthi, 4658/81, 1 May 1981, LWU. Kerala, Lakkidi (alt. ca. 800 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 5994/82, 25 Sept. 1982, LWU. West Bengal, Darjeeling, Llyod Botanical Garden (alt. ca. 1800 m), S.C. Srivastava, U.S. Awasthi and A. Kumar, 3282/77, 3475/77, 31 Dec. 1977, LWU. Manipur, Imphal, Kanchipur (ca. 1000 m), U.S. Awasthi and A. Kumar, 3592/79, 28 Oct. 1979, LWU. Sikkim, Levier, 001693, 1897 G. (Holotype).

Ecology and distribution : Grows on bark of trees and shrubs. INDIA - (South India : Tamil Nadu, Karnataka, Kerala; Eastern Himalaya : West Bengal, Manipur, Meghalaya; Western Himalaya : Uttar Pradesh, Central India : Madhya Pradesh); Nepal.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves almost orbicular, slightly wider than long, (3) Female bract-lobe dentate, bract-lobule and bracteole with entire margin, bracts isomorphic, lobe ovate with acute apex, lobule almost rectangular, 1/2 of the lobe length (Mizutani, 1976) sometimes slightly extending beyond the keel, margin revolute; bracteole with entire and revolute margin, (4) perianth 5-keeled, keels dentate.

L. sikkimensis shows a great range of variation in the degree of development of teeth on bracts, bracteole and perianth keels in different populations (Fig. 10 : 12, 13, 18, 19), they were found to be less developed in plants from peninsular India (Fig. 10 : 12, 13), while those from eastern India possess well developed dentitions (Fig. 10 : 18, 19). A subfloral innovation, though lacking in this genus, has been rarely observed in this species (Fig. 10 : 3). Also parocious sexuality not known in *Lopholejeunea* has been noticed (Fig. 10 : 4) in this species. The rostrum of the perianth consists of 10 vertical rows of cells as also in other species (Fig. 12 : 21) but in *L. sikkimensis* the terminal ring of cells forming the mouth of the rostrum become mammilate in mature perianth (Fig. 10 : 22, 23).

11. *Lopholejeunea sikkimensis* var. *dentata* var. nov. (Figure 11: 1-19).

Haec variety a Lopholejeunea sikkimensis in perianthium 4-carinatum, carinae et paginae dentatis differt.

TYPE : INDIA - Meghalaya, Shillong, Elephant fall (alt. 1600 m), U.S. Awasthi and A. Kumar, 3939/79, 9 Nov. 1979, LWU.

Specimens examined : INDIA - Meghalaya, Shillong, Elephant fall (alt. 1600 m), U.S. Awasthi and A. Kumar, 3939/79 (Holotype), 9 Nov. 1979, LWU.

Ecology and distribution : Grows on bark of trees. INDIA - Meghalaya,

Characteristics of the variety : Perianth 4-keeled, keels dentate - laciniate, dentitions also present in between keels.

L. sikkimensis var. *dentata* var. nov. differs from *L. sikkimensis* St. var. *sikkimensis* in having a perianth with 4 keels (5-keeled in *L. sikkimensis*), teeth between the keels (Fig. 11 : 10, 11) (absent in *L. sikkimensis*) and the dentate margin of female bract-lobule (entire in *L. sikkimensis*).

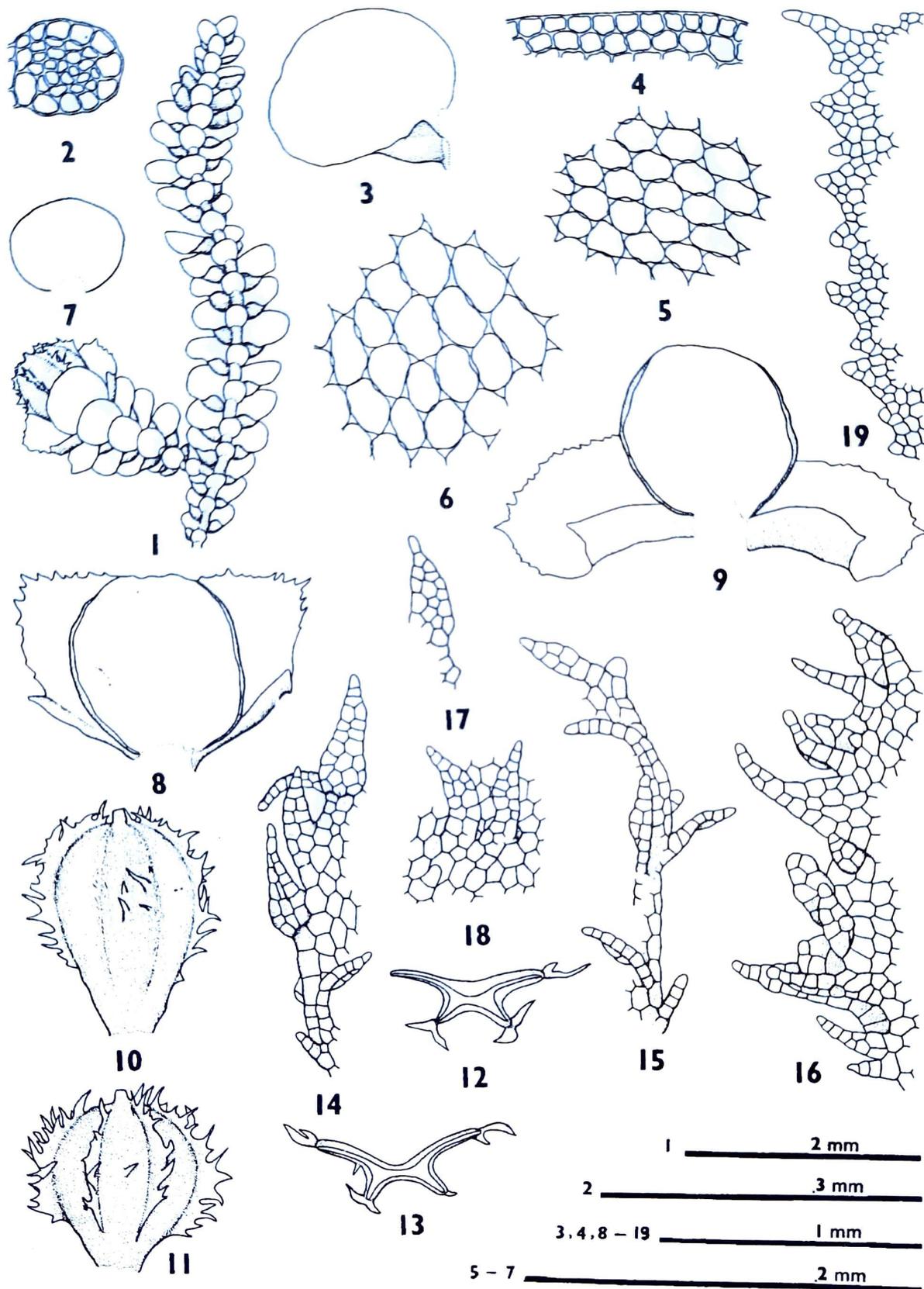


Fig. 11. *Lopholejeunea sikkimensis* var. *dentata* var. nov.

1. Portion of the plant showing male and female inflorescences. 2. Cross-section of the stem. 3. Leaf. 4. Marginal cells of the leaf. 5. Median cells of the leaf. 6. Basal cells of the leaf. 7. Underleaf. 8,9. Female bracts and bracteole. 10. Perianth in dorsal view showing surface dentitions. 11. Perianth in ventral view. 12,13. Cross-section of perianth. 14,15. Ventral keel of the perianth. 16. Lateral keel of the perianth. 17,18. Surface dentitions. 19. Margin of the female bract.

12. *Lopholejeunea subfusca* (Nees) St. Hedwigia 29 : 16 (1890) (Figure 12: 1-25).

Jungermannia subfusca Nees, *Hepat. Javan.*, 36 (1830).

TYPE : "Java Leg. : Blume S.n (L)" not seen.

Plants monoecious, 5-15 mm long. Stem in cross-section (0.76-0.12 x 0.08-0.10 mm) with 11-12 cortical and 11-17 slightly smaller medullary cells, cortical cells larger than medullary cells, cells thick-walled with small trigones. Leaves widely spreading, lobe 0.57-0.75 mm long, 0.48-0.64 mm wide, ovate or suborbicular, margin entire, apex rounded, cells thick-walled with distinct radiate trigones and intermediate nodular thickenings, basal cells 20-44 x 20-28 μm , oil-bodies homogeneous, spherical (1-4 μm in diameter) oval, elliptical or rod shaped (3-10 x 2-3 μm), 9-12 in each cell at margin, lobule ovate, distinctly saccate, slightly less than $\frac{1}{2}$ of the lobe length, 0.12-0.27 mm long, 0.10-0.21 mm wide, with inconspicuous tooth. Underleaves wider than long, 0.24-0.35 mm long, 0.30-0.51 mm wide, margin entire, apex rounded, rhizoids present at the base. Male inflorescence on short lateral branch or sometimes on main branch, bracts hypostatic, distinctly saccate, lobe ovate 0.32-0.48 mm long, 0.21-0.32 mm wide, margin entire and apex obtuse rounded, lobule 0.29-0.35 mm long, 0.16-0.19 mm wide, margin entire, apex obtuse, bracteole usually wider than long, 0.21-0.27 mm long, 0.16-0.29 mm wide, margin entire, apex obtuse. Female inflorescence terminal on short lateral branch or on main branch lacking in subfloral innovation, bract-lobe almost orbicular, 0.67-1.05 mm long, 0.64-0.91 mm wide, margin dentate, apex rounded, sometimes acute, lobule rectangular or sometimes triangular $\frac{1}{3}$ or slightly more than $\frac{1}{3}$ of the lobe length, 0.17-0.30 mm long, 0.06-0.14 mm wide, usually not extending beyond the keel, margin entire, bracteole usually $\frac{2}{3}$ of the perianth length, 0.51-0.72 mm long, 0.54-0.91 mm wide, margin entire and apex rounded, perianth slightly exserted, obovate, 0.88-0.93 mm long, 0.54-0.88 mm wide, 4-keeled, keels dentate. Sporophyte with foot, seta and capsule, seta with 16 peripheral and 4 central rows of cells, capsule wall bistratose, cells of the outer layer with sinuate-nodular thickenings on radial walls, cells of the inner layers with fenestrate thickenings on inner tangential wall in

addition to nodular thickenings on radial wall. Spores variously shaped 30-50 x 22-24 μm or 22-45 μm in diameter, with small papillae and 3-5 'rosettes' of spines, elaters 180-200 x 10-11 μm , with single spiral thickening bands, free and wide.

Specimens examined : INDIA—Nilgiri Hills, Tamil Nadu, Ootcamund (alt. ca. 2000 m), R. Udar, S.C. Srivastava and U.S. Awasthi, 2005/72, 2 Jan. 1972, LWU. Karnataka, Mercara (alt. ca. 700 m) D. Kumar, A. Kumar and U.S. Awasthi 4619/81, 1 May, 1981, LWU. Kerala, Lakkidi (alt. ca. 712 m), D. Kumar, A. Kumar and U.S. Awasthi, 4522/81, 4538/81, 4547/81, 4548/81, 28 April, 1981, LWU. Near Pookot Lake, Devicolam (alt. ca. 1000m), R. Udar and S.C. Srivastava 5973/82, 25 Sept. 1982, LWU. Vagavurrai (alt. 1907 m), R. Udar and S.C. Srivastava, 6062/82, 25 Sept. 1982, LWU. Ponmudi (alt. 1067 m), R. Udar and S.C. Srivastava, 6441/82, 6444/82, 6448/82, 2 Oct. 1982, LWU. Sikkim, Gangtok (alt. 1700 m), U.S. Awasthi, 8822/86, 27 Nov. 1986, LWU.

Ecology and distribution : Grows on bark of trees and shrubs. INDIA—South India : Kerala, Karnataka, Tamil Nadu, Eastern India : West Bengal (Chopra, 1938 and Hattori, 1966), Meghalaya, Sikkim; Africa, Borneo, Carolina Is., China, Formosa, Japan, Java, Madagascar, Malaya, Marshall, New Guinea, New Caledonia, Philippines, Ryukyu Is., Sri Lanka, Sumatra, Tahiti, Thailand.

Characteristics of the species : (1) Leaf-lobe with rounded apex, (2) Underleaves almost orbicular, slightly wider than long, (3) Female bract-lobe dentate, bract-lobule and bracteole entire, bracts isomorphic, lobe orbicular, lobule almost rectangular or sometimes triangular, $\frac{1}{3}$ or slightly more than $\frac{1}{3}$ of the lobe length, with entire margin, (4) Perianth 4-keeled, keels dentate or laciniate.

This species is distinctive in having dentate, orbicular female bracts with a small lobule (Fig. 12: 16). The capsule wall of *Lopholejeunea subfusca* (Mizutani, 1979a) has cell with an outer layer possessing nodular intermediate thickenings together with nodular trigones (Fig. 12: 25) typical of the fenestrate-type of sporophyte (Udar & Awasthi, 1981, 1982;

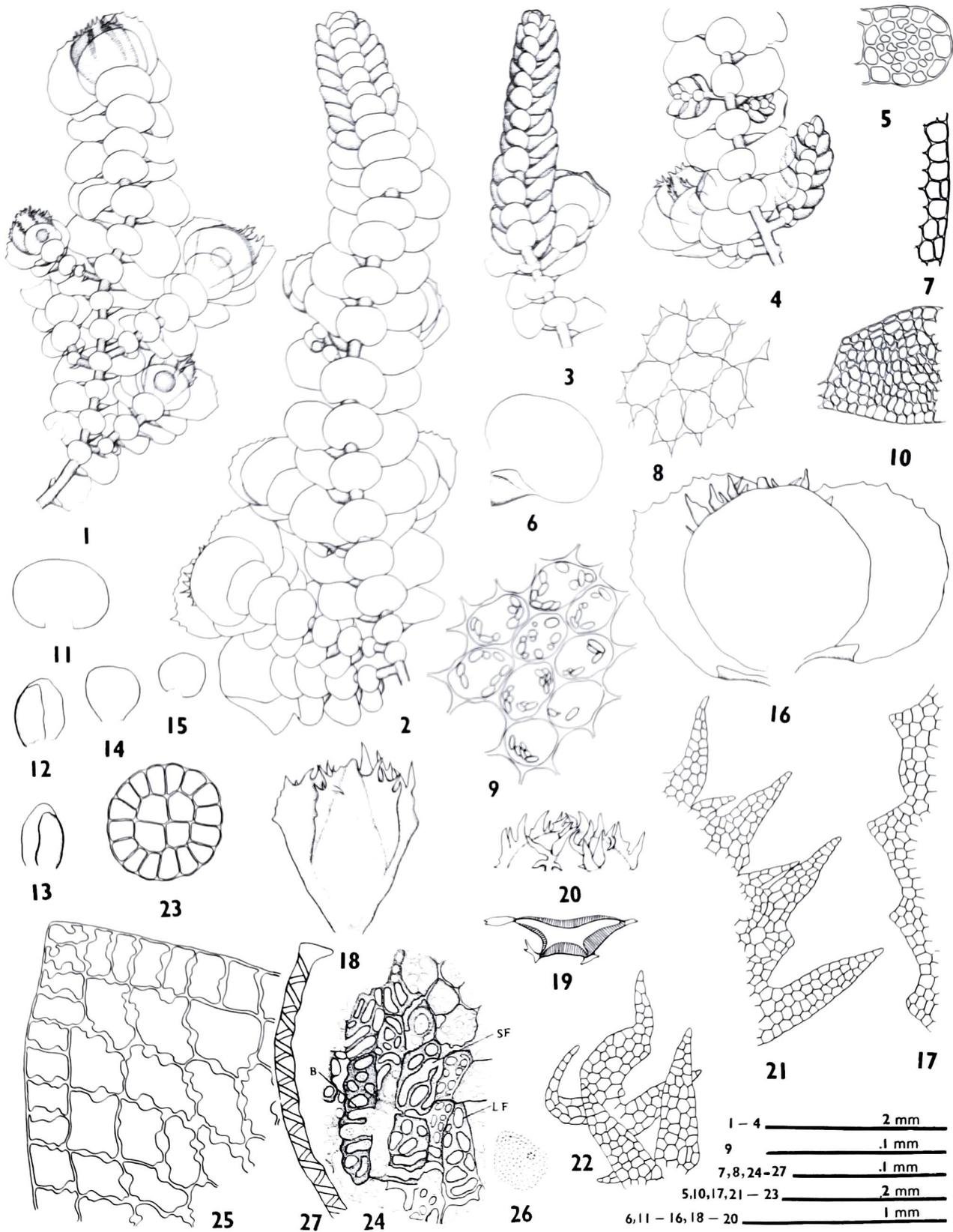


Fig. 12. *Lopholejeunea subsfusca* (Nees) St.

1. Portion of the plant showing female inflorescences. 2-4. Portions of the plant showing male and female inflorescences. 5. Cross-section of stem. 6. Leaf. 7. Marginal cells of the leaf-lobe. 8. Median cells of the leaf-lobe. 9. Basal cells of the leaf-lobe. 10. Leaf-lobule. 11. Underleaf. 12,13. Male bracts. 14,15. Male bracteoles. 16. Female inflorescence. 17. Margin of female bract. 18. Perianth. 19. cross-section of the perianth. 20. Perianth top showing laciniae. 21. Portion of the lateral keel of the perianth. 22. Portion of the ventral keel of the perianth. 23. Cross-section of seta. 24. Inner layer of capsule wall. (LF=Large fenestrae, SF=small fenestrae, B= complete transverse band). 25. Outer layer of capsule wall. 26. Spore. 27. Elater.