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Studies on the Genera *Frullania* Raddi and *Jubula* Dum. from Meghalaya (India): Eastern Himalayas

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ABSTRACT: Genera *Frullania* Raddi and *Jubula* Dum. liverworts belonging to family Frullaniaceae have been studied from Khasi and Jaintia Hills: Meghalaya in Eastern Himalayas. Critical investigations and taxonomic studies on the plants collected by authors recently, and details based on earlier records have revealed occurrence of 31 species of *Frullania* and 1 species of *Jubula* in this bryogeographically rich dominion of Eastern Himalayas. Amongst above 31 species, *Frullania udarii* Nath *et* Singh has been recently discovered, however *Frullania rotundistipula* is an addition to Indian bryoflora. The comprehensive and consolidated account which includes taxonomic observation, diversity, distribution, ecology, habitat and discussions on more plastic and allied species of the two genera has been provided for the first time. Additionally the distributional Map and keys to the genera as well as species have also been provided.

KEY WORDS: Bryophytes, Hepaticae, *Frullania, Jubula*, Meghalaya, India, Eastern Himalayas.

INTRODUCTION

The Himalayan ramble protracts almost 3200 km from east to west, from the north of Burma in the east to Afghanistan in the west and consists of a nearly linear mountain range of territory origin (Mani, 1994). To the east the Himalayan range continues, linking up with north eastern regions of India, western China and Burma. The general climatic conditions in the east are semioceanic, becoming increasingly continental westwards (Mani, 1994). The Himalayan contingent in east (Eastern Himalayas) sustains high precipitation which ensue the tropical rain forest cover area. The Eastern Himalayas hot spot is sumptuously known for embellished flora and fauna on the globe. In India, the East Himalayan region is comprised of seven provinces of north east region which are collectively called seven sisters and are the major tropical rain forest cover of India. The Meghalaya province known for rainiest place of the world Cherrapunji and Mawsynram where in the mid of monsoon month July-August rainfall is not unusual as much as 1633 mm. This province laying 24° 58'-26° 8' N and 89° 47'-92° 50' E is comprised of Khasi, Jaintia, Garo Hills and cover an area about 22,429 sq km. The Khasi and Jaintia Hills ranges from 600-6400 ft altitude forms the central and eastern part of province which constraint plateau with gyrating grassland hills and river valley (Bor, 1936; Balakrishnan, 1981). These two hills exhibit diverse microclimatic condition and rainfall. On account of high precipitation and rainfall the climate of these regions much more favors exuberant growth of drizzle and moist loving plants particularly liverworts but the occurrence and distribution of liverworts in most part of Indian Himalayas regions are poorly known. The East Himalayan regions of India are less visited by hepaticologists, thus fingercount and scattered references are known on the liverworts (Long, 1979). However, the Eastern Himalayas are considered as an important speciation centre for leafy liverworts (Schuster, 1984). The leafy liverworts particularly *Frullania* Raddi exhibiting enormous adoptive propensity is considered to be the most advanced genus in the Jungermanniales of the family Frullaniaceae including another genus *Jubula* Dum. The genus *Frullania* is prevalently distributed in the world including about one thousand taxa (Yuzawa, 1991). In India, the history of the studies on the genus *Frullania* goes dates back since the time of Mitten (1860-61) whose study based on collections of J. D. Hooker and T. Thomson, led discovery of many species from Khasi Hills. Stephani (1910-12, 1924)

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described 69 species from Asia, including India. Verdoorn (1930), Chopra (1938, 1938a, 1943), Parihar (1961-62), Parihar et al. (1994) and Kachroo (1970) made contribution on the *Frullania* species in India. Hattori (1972, 1972 a, 1973, 1974, 1975, 1975 a, 1975 b, 1976, 1978) contributed on the Asiatic species of *Frullania* and discovered number of species from Indian subcontinent. Udar and Nath (1971, 1976, 1979, 1981), Udar and Kumar (1983) and Nath and Asthana (1992, 1998) made portentous contribution for Indian *Frullanias*. Additionally, Singh and Nath (2004) described *Frullania rotundistipula* Steph. from Khasi Hills as an addition to Indian bryoflora. In another contribution Nath and Singh (2006) discovered a new species *Frullania udarii* Nath *et* Singh from Meghalaya. However Singh and Singh (2005) described *Frullania larjiana* Singh *et* Singh from Western Himalayas. Thus, in India the genus *Frullania* is represented by approximately 61 species mainly distributed by 40 species in Eastern Himalayas, 15 species in Western Himalayas, 17 species in South India, 2 species in Central India and 1 species in Andaman Islands (Parihar *et al* 1994; Singh and Nath 2004; Nath and Singh 2006). The genus *Jubula* is represented by two species viz. *Jubula hutchinsiae* (Hook) Dum. sub sp. *javanica* (Steph) Verd. and *Jubula hattorii* Udar *et* Nath from Eastern Himalayas (Parihar et al. 1994; Udar and Nath, 1978). These species have been alluded in scattered contribution but no comprehensive and consolidated taxonomic account on these two genera has been published. Keeping above view in mind an exhaustive exploration and collection of the bryogeographically richest territory Khasi and Jaintia Hills of Eastern Himalayas has been conducted in subsequent years for preparation of taxonomic illustrated account of the genera *Frullania* and *Jubula*. Present contribution is largely based on the specimens collected by authors, loaned materials and previous publications. The present study includes taxonomic details, line drawing illustrations (Figs. 2-9) and distribution (Fig. 1) of *Frullania* (31 species) and *Jubula* (1 species) occurring in Khasi and Jaintia Hills: Meghalaya.

MATERIALS AND METHODS

The study area Khasi and Jaintia Hills: Meghalaya were selected as a natural bryogeographic region and due to probability of new species and new records of liverworts. Different pure as well as admixed populations of plant specimens were collected in the year 1965, 1998, 2000 and 2001 from various localities of Khasi and Jaintia Hills: Meghalaya. The altitude of occurrence and relative humidity were measured with the help of altimeter as well as hygrometer. The plant materials were properly processed and deposited in the Bryophytes Herbarium, National Botanical Reserach Institute (LWG). The line drawing illustrations were made with the help of Camera Lucida (Olympus, Tokyo-203954).

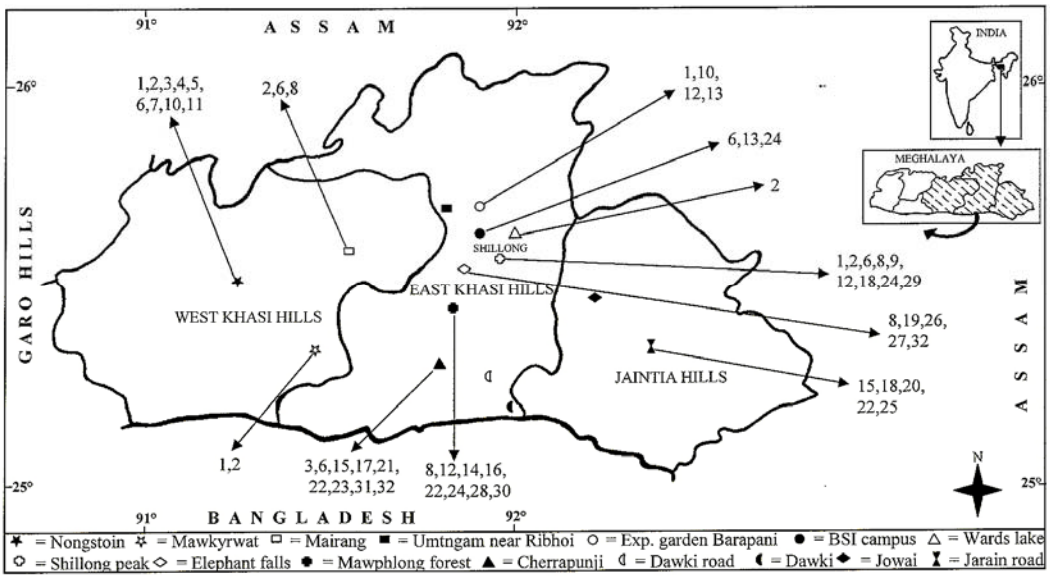
TAXONOMIC TREATMENTS

Family: Frullaniaceae Lorch.

Bebat, Fl. Muscin, 209, 230, Lyon (1874).

This family encounters species of very characteristic features, pioneering as bark habitat, excluding *Jubula* which occurs on rocks. Plants generally large, reddish brown to blackish, rarely small and greenish. Stem prostrate, pinnately branched, intraaxillary (originating from the inner base of leaves), subfloral innovation absent or one and of the *Frullania* type branching (gen. *Frullania*) or usually 2 and of the *Radula* type branching (gen. *Jubula*). Leaves incubous, very shortly and nearly transversely inserted, strongly bilobed, dorsal lobes of leaf much larger than the ventral lobes (lobules), ventral lobes generally inflated, which however is usually more or less helmet shaped, saccate or explanate or galeate and is parallel to the stem and quite distant from the latter, being connected to it only by a small stalk, stylus present or absent; small ventral lobes lying free from the stem, is absolutely characterstic of the members of the family, lobes margin entire, rarely dentate: cells thick walled: well marked trigones, oil bodies spherical-elliptical or oval, long fusiform, 2-12 or more (usually 3-6) per cell, with minute, rarely large globules. Underleaves always present, bilobed or rarely unlobed, entire. Monoecious or dioecious: androecial branching arising either by *Frullania* type (gen. *Frullania*) or *Radula* type (gen. *Jubula*) branching; antheridia axillary, globose, on uniseriate stalk; female inflorescence without innovation, terminal on main stem or on lateral branches with archegonia 2-12 rarely more, rarely one; female bracts 2-5 pairs (gen. *Frullania*) or in 1 pair (gen. *Jubula*), usually dentate or laciniate, the innermost generally adnate to each other and to the bracteoles. Perianth mostly flattened dorsally, usually with 3-5 keeled, mouth small with a beak (rostrum). Seta short, 4 celled thick, cruciate, articulate when dry (gen. *Jubula*) and 8-9 celled thick, neither cruciate in section nor articulate when dry (gen. *Frullania*). Capsule spherical, wall

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1. *Frullania wallichiana*
2. *F. neurota*
3. *F. apiculata*
4. *F. inflexa*
5. *F. tamarisci*
6. *F. ericoides*
7. *F. acutiloba*
8. *F. nepalensis*
9. *F. pseudoschensiana* var. *darjeelingensis*
10. *F. giraldiana*
11. *F. rotundistipula*
12. *F. muscicola*
13. *F. udarii*
14. *F. physantha*
15. *F. alstonii*
16. *F. duthiana*
17. *F. evelynae*
18. *F. evoluta*
19. *F. gemulosa*
20. *F. gracilis*
21. *F. inflata*
22. *F. meyeniana*
23. *F. pariharii* var. *intermedia*
24. *F. retusa*
25. *F. serrata*
26. *F. subpedicellata*
27. *F. rhytidantha*
28. *F. sphaerantha*
29. *F. pseudoschensiana*
30. *F. asperula*
31. *F. grandistipula*
32. *Jubula hattorii*

Fig. 1. Distribution of the genera *Frullania* Raddi and *Jubula* Dum.

bistratose, outer layers cells larger, variously thickened, quadrate, inner layers cells thickenings usually sheet like or with fenestrate pattern. Elaters trumpet shaped, unispiral, occasionally bi or trispiral attached to the upper part of the valves subsequent to capsule dehiscence. Spores oblong to orbicular or angular or spherical, smooth or tuberculate or papillate.

Type: *Frullania* Raddi.

Key to the genera of the family Frullaniaceae Lorch.

1. Plants usually large, rarely small, reddish brown, sometimes almost black, seldom green; androecium arising by the *Frullania* type branching; female inflorescence with out innovation or with 1 of the *Frullania* type branching; bracts in 2-5 pairs, usually dentate or laciniate, the innermost generally adnate to each other and to the bracteole; archegonia 2-4, rarely 12; seta 8 or more cells thick, neither cruciate in section nor articulate when dry; leaf cells thick walled, with well marked trigones; perianth 4-10 angled ..... *Frullania*

1. Plants rather large, dark green to olive yellow; androecium arising by *Radula* type branching; female inflorescence with two innovations, rarely one, opposite subfloral innovation of the *Radula* type branching; bracts in 1 pair; archegonia 1-2 per perianth, rarely 4; seta 4 cells thick, cruciate in cross section and articulate when dry; leaf cells usually thin walled, trigones wanting or less developed; perianth 3 angled ..... *Jubula*

1. Genus: *Frullania* Raddi

Frullania Raddi, Atti Soc. Ital. Modena, **18**: 20 (1818).

Plants large or medium, rarely small, green to dark reddish brown or black; prostrate, pinnately branched, branches axillary, replacing the lobules (i.e. *Frullania* type); cortical cells of stem small, thick walled and medullary cells large and thin walled; leaves imbricate, incubous, almost transversely inserted, complicate bilobed, dorsal lobes ovate to suborbicular, convex, apex obtuse to acute or acuminate or decurved, entire; cells thick walled and well trigonous; ocelli sometimes present, scattered or linear; ventral lobe (lobules) cucullate, galeate, occasionally evolute and then ovate-lanceolate (explanate) or campanulate, cylindrical or clavate, attached to the stem by a stalk like base and to the lobes by a keel; stylus present or absent, small; underleaves always present, large, usually smaller than the leaves; base cordate, apex bilobed or retuse, margin entire or undulate, sometimes with one or two projection teeth. Dioecious or monoecious. Male inflorescence usually terminal on short lateral branches, globose (capitate) to ellipsoid (spicate); bracts closely

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imbricate, 2-5 pairs or more; antheridia axillary, globose on uniseriate stalk; bracteoles entirely absent or limited to the base of inflorescence. Female inflorescence terminal on the main axis or on the lateral branch lacking subfloral innovations or rarely with 1 of the *Frullania* type branching; archegonia 2-4, rarely more; bracts in 2-5 pairs, usually dentate or laciniate, bracteoles free or united with 1 or both bracts, the innermost generally adnate to each other and the bracteoles. Perianth tri or pluri keeled, usually flattened dorsally, mouth small and forming a beak (rostrum). Sporophyte with anchor-shaped foot. Seta short, 8-9 cells thick, cells in cross-section not differentiated, neither cruciate nor articulate when dry; capsule walls double layered, outer layers cells large, quadrate, with variously thickened walls, inner layers cell thickenings usually sheet like or with fenestrate patterns; elaters trumpet shaped, usually large and truncate at the free end, unispiral or bi or trispiral; spores orbicular to oblong or angular, brownish, papillate or with minute tubercles.

Key to the species of genus *Frullania* Raddi

1. Plants monoecious 2
1. Plants dioecious 5
2. Lobules helmet shaped, perianth 4-5 keeled when young and 9-10 keeled when mature ..... *F. wallichiana*
2. Lobules not helmet shaped, perianth 4 keeled 3
3. Perianth 4 keeled, lobules saccate portion galeate, keels very long and wide connate with the base of lower leaf margin .... *F. neurota*
3. Perianth 4 keeled, lobules galeate-explanate, keels not much long and wide 4
4. Leaves obtuse-subacute, or acute, lobules remote from the stem, perianth ventral keels flat ..... *F. apiculata*
4. Leaves ovate, lobules vertex direted towards stem, perianth ventral keels angled ..... *F. inflexa*
5. Ocelli present on leaf lobes ..... *F. tamarisci*
5. Ocelli absent on leaf lobes 6
6. Leaves squarrose ..... *F. ericoides*
6. Leaves not squarrose 7
7. Lobules with a long piliferous beak ..... *F. acutiloba*
7. Lobules with out a long piliferous beak 8
8. Underleaves with longitudinal obtuse plicae and often with more or less incurved lateral margins ..... *F. nepalensis*
8. Underleaves with out longitudinal obtuse plicae and with out incurved lateral margins 9
9. Perianth with tuberculate outgrowth over keels with smaller ones ..... *F. pseudoschensiana* var. *darjeelingensis*
9. Perianth with out tuberculate outgrowth over keels 10
10. Leaf lobes with incurved apices, lobules beaked with rounded heads, underleaves with well developed median plicae .... *F. giraldiana*
10. Leaf lobes with out incurved apices, lobules beaked, rounded and underleaves with median plicae 11
11. Underleaves entire, lobules beaked obtusely .... *F. rotundistipula*
11. Underleaves not entire, lobules not beaked obtusely 12
12. Leaves imbricate, lobules saccate, occasionally explanate, perianth 5 keeled, ovoid and gemmae on leaf marginal cells .... *F. muscicola*
12. Leaves distant, lobules explanate throughout, perianth 3 keeled, pyriform and gemmae not present on leaf marginal cells ..... *F. udarii*

1.1. *Frullania wallichiana* Mitt., Proc. Linn. Soc. **5:** 118 (1861). Figs. 1 & 2 (1-22)

F. indica Steph., Spec. Hepat. **4:** 347 (1910);
F. hosseana Steph., Spec. Hepat. **4**: 348 (1910).

Monoecious; plants large, light yellowish green to dark brown, prostrate, 40 mm long and 2.40 mm wide including leaves. Branching irregular of *Frullania* type, primary branches 20-25 mm long and 2.10 mm wide including leaves; secondary branches upto 15 mm long and 2.38 mm wide including leaves; tertiary branches 9-10 mm long and 2.25 mm wide including leaves; quartery branches 3.50 mm long and 1.88 mm wide including leaves. Stem dark brown, cylindrical, 0.15 x 0.18 mm in diameter and 7-8 cells across; cortical cells thick walled, 12.5-25 x 10-12.5 μm, angular; medullary cells thick walled, 17.5-30 x 10-17.5 μm, angular. Leaf lobes imbricate, oval to oblong, incurved, margin entire, 1.45-1.70 mm long and 1.18-1.38 mm wide with rounded apex; leaf marginal cells thin walled, less trigonous, quadrate-semiquadrate, 17.5-20x15-17.5 μm; median cells polyhedral, angular, trigonous, 20-27.5 x 17.5-25 μm; basal cells thin walled, trigonous, 35-37.5 x 20-27.5 μm. Lobules large, helmet shaped, dorsal portion almost flat, long, arched, widely connate with the lobes, parallel to the stem or slightly truncate towards stem, 0.60-0.75 mm long and 0.29-0.48 mm wide. Underleaves loosely imbricate, 0.85-1.25 mm long and 0.88-1.28 mm wide, appressed to the stem, bifid, sinus wide, orbicular, 100-200 μm deep, base gibbous, margin wavy-entire to occasionally incurved. Female inflorescence on main axis, semiexserted, cylindrical, 1.2 mm long and 0.38 mm wide; cross section of perianth 0.45-0.58 x 0.88-1.15 mm in diameter, 4-5 keeled when young and 9-10 keeled when developed; bracts 1-2 pairs, 1.88-2.0 mm long and 1.3-1.5 mm wide, margin undulate-denticulate with apiculate-acute apex; lobules explanate, long, apiculate, acute; bracteoles oblong, bifid, 1.0-1.28 mm long and 0.75-1.0 mm wide, margin denticulate, with acute-apiculate apex. Male inflorescence lateral on main axis, capitate, 3-4 pairs bracts, medium, stalked.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong: On the way of Shillong peaks, B.S.I. Barapani; West Khasi Hills: Nongstoin, Mawaiban F.R.H., Mawkadiang, Mawkyrwat.

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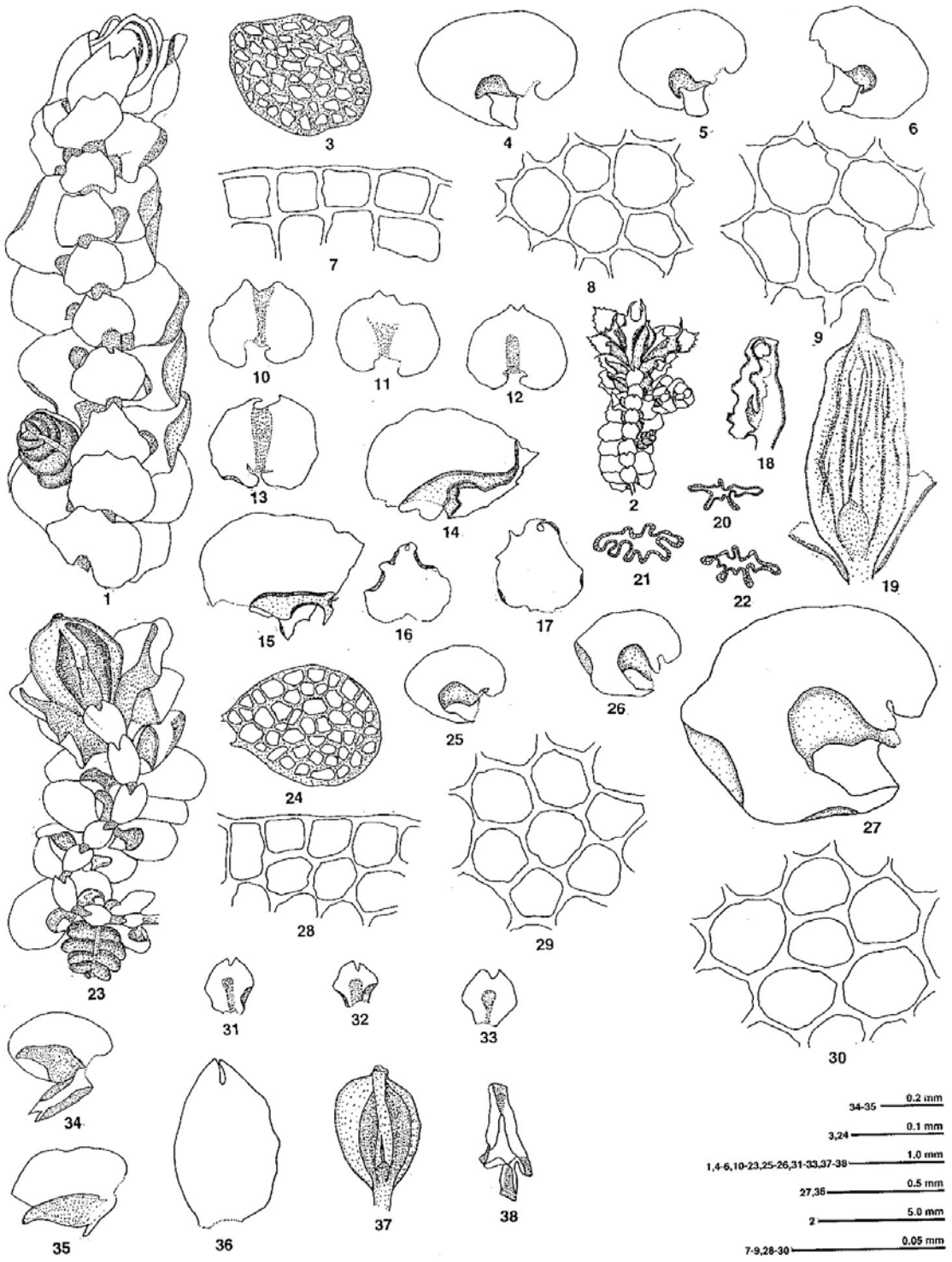


Fig. 2. *Frullania wallichiana* Mitt. 1-22. (LWG 207967-A): 1. Plant ventral view, 2. Fertile plant, 3. Cross-section of stem, 4-6. Leaves, 7. Leaf marginal cells, 8. Leaf median cells, 9. Leaf basal cells, 10-13. Underleaves, 14-15. Female bracts, 16-18. Female bracteoles, 19. Perianth, 20-22. Cross-section of perianth. *F. neurota* Tayl.,. 23-38. (LWG 205903-A): 23. Fertile plant, 24. Cross-section of stem, 25-26. Leaves, 27. Leaf magnified view, 28. Leaf marginal cells, 29. Leaf median cells, 30. Leaf basal cells, 31-33. Underleaves, 34-35. Female bracts, 36. Female bracteole, 37. Perianth, 38. Cross-section of perianth.

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Plants grow epiphytically on the bark, occasionally on rocks near stream forming a dense mat with *Mastigolejeunea* sp., *Ptychanthus striatus*, *Lopholejeunea subfusca*, *Lejeunea* sp., *Lejeunea flava*, *Lejeunea punctiformis*, *Cheilolejeunea* sp., *Frullania inflexa*, *Frullania muscicola* and *Frullania ericoides* at 2550-5600 ft altitude, 22.5-26.3 ℃ temperature and 61-70% relative humidity.

Range: Himalayas, India, Sumatra, Java and Philippines.

Specimens examined: India: Meghalaya: East Khasi Hills: On the way of Shillong peak, 11.11.1998, Leg. V. Nath and party, 207967-A, 207971-A, 207974-A, 207981-A (LWG); B.S.I. Barapani, 12.11.1998, Leg. V. Nath and party, 208038-A, 208076-B (LWG); West Khasi Hills: Nongstoin, Mawaiban, 14.09.2000, Leg. A.P. Singh, 208528-B, 208529-B, 208530-B, 208532-F (LWG); Mawkyrwat, 16.09.2000, Leg. A.P. Singh, 208639-C, 208650-B (LWG); Mawkadiang, 17.09.2000, Leg. A.P. Singh, 208657-C, 208672-A, 208676-B (LWG), Det. V. Nath & A.P. Singh.

Frullania wallichiana Mitt. was instituted and first described by Mitten (1860-61) from Khasia Hills, Nepal and Sikkim on the basis of the collections made by J.D. Hooker and T. Thomson. Chopra (1943) also listed *F. wallichiana* Mitt. from Khasia, Assam, Nepal and South India. Parihar (1961-62) listed *F. indica* Steph. as a synonym of *F. wallichiana* Mitt. with its extended range of distribution in South India, Western and Eastern Himalayas. Present study is based on the plants collected from Shillong peak road, Experimental Garden Barapani, F.R.H. Nongstoin and Mawkyrwat of Khasi Hills, Meghalaya. *Frullania wallichiana* Mitt. exhibit an interesting range of diversity in its color (light yellowish green to dark brown); size (25-50 mm long); leaf lobes oval-oblong, flat, or generally with recurved apices, size (1.45-1.70 mm long and 1.18-1.38 mm wide); underleaf size (0.85-1.25 mm both in width and length) or occasionally variable in shape, rotund-reniform, margin wavy to entire, sinus subacute-lunate to divergent lunate, and 100-200 μm deep. *F. wallichiana* approaches to *F. nepalensis* (Spreng.) Lehm. & Lindenb. in its length, elliptical to ovate with evolute-recurved apices of leaves and well developed basal appendages, but differ in sexuality, which is monoecious in former and dioecious in latter. Besides, *F. nepalensis* has only entire to rarely wavy margined underleaf with longitudinal obtuse plicae and acute-obtuse sinus, which make it more apart from the *F. wallichiana* Mitt.

1.2 *Frullania neurota* Tayl., J. Bot. **5**: 400 (1846). Figs. 1. & 2 (23-38)

F. breviuscula Mitt., Proc. Linn. Soc. **5**: 120 (1861); *F. sandvicensis* Aongstr., Kongl. Vetensk. Akad. Forh. **24**: (1872).

Monoecious; plants medium, brownish green or green, prostrate, 20-40 mm long and 2.0-2.13 mm wide including leaves, irregularly *Frullania* type branching, bi-or occasionally tripinnately branched; primary branches 7 mm long and 1.50 mm wide; secondary branches 2.0 mm long and 1.0 mm wide including leaves. Stem reddish-brown, cylindrical to prostrate, 0.14 x 0.18 mm in diameter and 7-9 cells across; cortical cells thick walled, quadrate, 15-25 x 22.5-25 μm; medullary cells larger, subquadrate, thick walled, 22.5-25 x 25-30 μm. Leaf lobes imbricate, rarely contiguous, transverse, dorsal margin convex and concave ventrally with involuted apices and recurved margin, when flattened ovate with obtuse (rounded) apices, 1.05-1.30 mm long and 0.83-1.00 mm wide with rounded appendages; marginal cells thin walled, pale-orange, triangular trigones, 15-20 x 17.5-22.5 μm; median cells thin walled, trigonous, 22.5-25 x 25-37.5 μm; basal cells 22.5-35 x 25-45 μm, thin walled with large somewhat nodulose trigones. Leaf lobules large, 0.35-0.40 x 0.60-0.65 mm, subcucullate without beak, the ventral portion about 1/2 the dorsal portion, obliquely oriented or running parallel to the stem and small stalk, 1/4 appendiculate, margin free or slightly connate to leaf lobe. Underleaves ovate, rotundate, 3 times as wide as the stem, 0.50-0.58 mm long and 0.51-0.63 mm wide, a little wider than long, about 1/8-1/9 bifid, sinus wide and obtuse, lobes wide, triangular, obtuse, base narrowed, margin incurved. Rhizoids from the centre of the underleaf. Perianth oblong, 1.75 mm long and 0.90 mm wide, strongly 4 keeled (2 lateral and 2 ventral), keels smooth; bracts 2 pair, oblong, 1.30 mm long and 0.75 mm wide, margin entire, lobules oblong, base wider, apex subacute; bracteoles oblong, 0.75 mm long and 0.45 mm wide, margin entire, apex 1/6-1/7 bifid, lobes subacute; male inflorescence on lower portion of branch (below gynoecia), short stalked with 4 pairs of bracts (without ordinary leaves).

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong: Wards lake, On the way of Shillong peak; West Khasi Hills: Nongstoin: Mawaiban F.R.H., Mawsiangdur forest; Mawkyrwat: Mawkadiang; Mairang: Children park.

Plants grow epiphytically on the bark forming a mat in association with *Ptychanthus striatus*, *Cheilolejeunea intertexta*, *Plagiochila* sp., *Lejeunea flava*, *Lejeunea punctiformis*, *Leucolejeunea xanthocarpa* and *Spruceanthus* sp. at 2550-5600 ft

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altitude, 22.5-26.3 ℃ temperature and 61-70% relative humidity.

Range: India, Nepal, Ceylon, Java, China, Mexico and Hawai.

Specimens examined: India: Meghalaya: East Khasi Hills: Shillong: Wards lake, 0.4.11.1998, Leg. V. Nath and party, 205903-A (LWG); On the way of Shillong peak, 11.11.1998, Leg. V. Nath and party, 207965-A, 207973-A, 207976-B, 207977-A, 207980-A (LWG); West Khasi Hills: Nongstoin, Mawaiban F.R.H., 14.09.2000, Leg. A.P. Singh, 208535-B, 208537-A (LWG); Mawsiangdur forest, 15.09.2000, Leg. A.P. Singh, 208608-A (LWG); Mawkyrwat, 16.09.2000, Leg. A.P. Singh, 208624-B, 208627-C (LWG); Mawkadiang, 17.09.2000, Leg. A.P. Singh, 208653-A (LWG); Mairang: Children park 19.09.2000, Leg. A.P. Singh, 208722-A (LWG). Det. V. Nath & A.P. Singh.

Frullania neurota Tayl. was first instituted by Taylor (1846) from Nepal. Moreover, Mitten (1860-61), along with this species also described *F. breviuscula* Mitt. from Khasi Hills on the basis of the collections made by J.D. Hooker and T. Thomson, but it is now found to be synonym of *F. neurota* Tayl. Parihar (1961-62), Verdoorn (1930) listed *F. breviuscula* Mitt. and *F. lauterbachii* Steph., the two earlier known species as synonyms of *F. neurota* Tayl. with its extended range of distribution to Khasi Hills, Sikkim, Kurseong and Madura. The present study is based on the plants collected from Wards lake, Shillong peak in East Khasi and F.R.H. Nongstoin region in West Khasi Hills. *Frullania neurota* collected from Wards lake exhibit wide range of diversity in its length (20-40 mm long) and pigmentation (brownish green to green). However, these characters of plants length (20 mm) and pigmentation (yellowish green) remains constant in the plants collected from Shillong peak. The specimens collected from Nongstoin show variation in plant length (30 mm), leaf length, underleaf shape and size, which is smaller than the plants of above two localities. Therefore, the study revealed that a considerable range of diversity exists in length (20-40 mm long); color (brownish green-green); leaves imbricate-contiguous, dorsal margin convex and ventrally concave with involuted apices and recurved margin, when flat ovate with rounded apex; leaf size (1.05-1.30 mm long and 0.83-1.00 mm wide) with rounded appendages; lobules larger (0.60-0.65 mm long and 0.35-0.42 mm wide), subcucullate without beak, ventral portion about 1/2 of the dorsal portion, running parallel to the stem, 1/2 appendiculate, margin slightly connate to the leaf lobes; underleaves wider than the length (0.50-0.58 mm long and 0.51-0.63 mm wide), about 1/8-1/9 bifid, base narrowed. Moreover, this species approaches in its sexuality (monoecious) to three encountered taxa i.e. *F. wallichiana* Mitt., *F. inflexa* Mitt. and *F. apiculata* (Reinw *et al.*) Dum. All these three species are more distinctive with *F. neurota* in not having subcucullate, appendiculate lobules which is without beak and slightly connate to the leaf lobe; underleaves narrower at base and perianth 4 keeled.

1.3 *Frullania apiculata* (Reinw. *et al.*) Dum. Rec. d'obs **13** (1835). Figs. 1 & 3 (1-20)

F. densifolia Steph., Hedwigia **33**: 161 (1894); Bonner, Index Hepat. **5**: 285 (1965).

Monoecious; plants brownish yellow on upper and brown on base, 20-25 mm long and 1.63 mm wide including leaves. Branching irregular, primary branches 8.0 mm long and 1.5 mm wide including leaves; secondary branches 4.13 mm long and 1.13 mm wide including leaves; tertiary branches 0.45 mm long and 0.25 mm wide including leaves. Stem yellowish brown, cylindrical, 1.0 x 1.13 mm in diameter; cortical cells smaller, thick walled, 10-12.5 x 10-17.5 μm; medullary cells slightly larger, 12.5-15 x 17.5-25 μm. Leaf lobes imbricate, very slight oblique to transverse, upper margin convex, lower slightly concave and arched at base, ovate, 0.70-0.84 mm long and 0.64-0.72 mm wide with slight rounded, obtuse to slight apiculate apex; marginal cells subquadrate, minute trigonous, 17.5-22.5 x 12.5-15.0 μm; median cells oblong, 25.0-32.5 x 15.0-22.5 μm, trigonous, thin walled; basal cells large, 45.0-47.5 x 22.5-30.5 μm, with thin walled and large triangular trigones. Leaf lobules small, obliquely to widely spreading and remote from the stem, stalked, cylindric with obtuse head and subtruncate to arched, oblique mouth, 0.20-0.21 mm long and 0.09-0.11 mm wide. Underleaves flat, 2-2.5 times (or less) as wide as the stem, ovate, quadrate, nonappendaged base, about 1/4-1/3 bilobed, sinus almost orbicular-lunate to right angled, lobes subtriangular, subacute-acute, 0.30-0.43 mm long and 0.25-0.38 mm wide, margin entire, undulate, occasionally single toothed. Perianth terminal on primary branches mostly with an innovation branching below, semiexserted, long with two lateral and 1 (or two) ventral keels, dorsally flat smooth; bracts usually in 3 pairs, 0.90-1.60 mm long and 0.70-0.95 mm wide, innermost bracts lobe oblong, elliptical with entire or occasionally spinose margin, obtuse to acute apex, lobules smaller, oblong-obcuneate, irregularly toothed; bracteoles oblong, bilobed, sinus 1/3-1/2 (or less), obtuse, acute, lobes lanceolate, margin entire, undulate. Androecia lateral near base of the primary branch, very short stalked (without ordinary leaves), capitate with 4 pairs of bracts.

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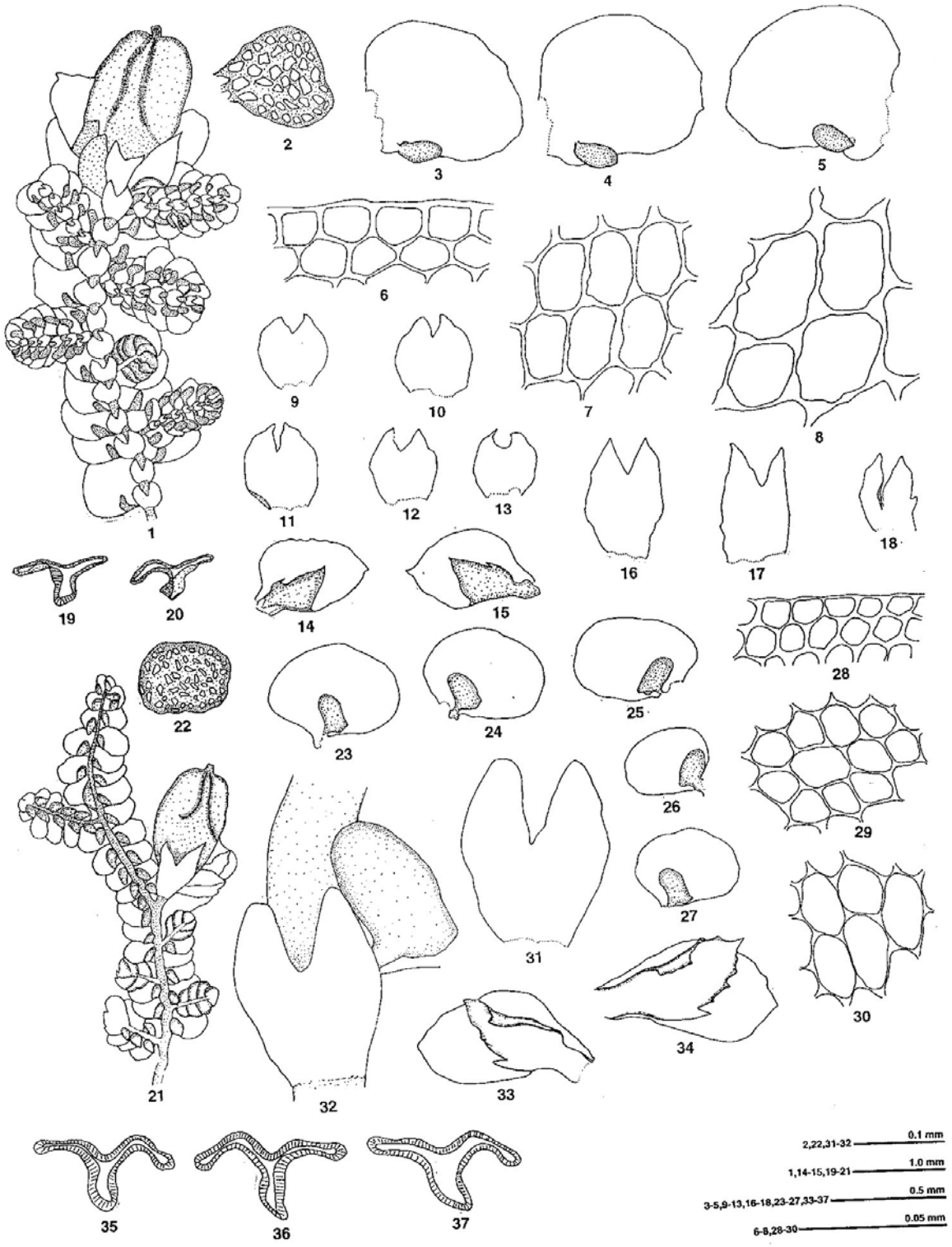


Fig. 3. *Frullania apiculata* (Reinw. *et al*) Dum. 1-20. (LWG 208542-B): 1. Fertile plant, 2. Cross-section of stem, 3-5. Leaves, 6. Leaf marginal cells, 7. Leaf median cells, 8. Leaf basal cells, 9-13. Underleaves, 14-15. Female bracts, 16-18. Female bracteoles, 19-20. Cross-section of perianth. *F. inflexa* Mitt., 21-37. (LWG 208532-D): 21. Fertile plant, 22. Cross-section of stem, 23-27. Leaves, 28. Leaf marginal cells, 29. Leaf median cells, 30. Leaf basal cells, 31-32. Underleaves, 33-34. Female bracts, 35-37. Cross-section of perianth.

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Distribution and ecology: Eastern Himalayas: Meghalaya: West Khasi Hills: Nongstoin: Iangmaw on the way of Rishiang; East Khasi Hills: Cherrapunji.

Plants grow on the tree bark in association with *Lejeunea* sp., and *Chandonanthus birmensis* at 4500-4600 ft altitute, 25.5 ℃ temperature and 61% relative humidity.

Range: Tropical region of Asia, Madagascar, Pacific Island, Laos, Burma.

Specimens examined: India: Meghalaya: West Khasi Hills: Nongstoin, 14.09.2000, Leg. A.P. Singh, 208542-B, 208543-A (LWG); East Khasi Hills: Cherrapunji, 07.04.1965, Leg. S. Chandra, 201098-B (LWG). Det. V. Nath & A.P. Singh; Meghalaya: Jowai, Jarain (Alt. 5000 ft), 25.04.1976, Leg. D. Kumar & D.K. Singh, L00200, Det. R. Udar & V. Nath.

Frullania apiculata (R.B.N.) Dum. was reported for the first time by Mitten (1860-61) from Khasi Hills in Eastern Himalayas. The study was made on the basis of the collections made by J.D. Hooker and T. Thomson. Chopra (1943) listed *F. apiculata* from Khasi Hills and South India. Parihar (1961-62) in his census listed *F. apiculata* from both Eastern Himalayas and South India. Hattori (1972a), in his study on a few Asiatic *Frullania* species including *F. apiculata* and other closely related taxa, stated that *F. anamensis* Steph., *F. densifolia* Steph. and *F. engleri* Steph. are conspecific with *F. apiculata*. The present study is based on the plants collected from Rishiang, Nongstoin in West Khasi Hills, Cherrapunji in East Khasi Hills and the collections made by D. Kumar and D.K. Singh from Jowai Jarain, Meghalaya (L-00200). *F. piculata* collected from Rishiang-Nongstoin and Jowai-Jarain shows similarities in its length but the leaf apices in the plants of former locality are usually obtuse-subrounded, while in the latter it is obtuse to subapiculate or apiculate. The plants of Cherrapunji region exhibit reduced length (8.0 mm long and 0.45-0.48 mm wide) than the former two localities. Thus, in *F. apiculata* diversity exists in plants color (yellowish brown in upper and brown on base); size (8.0-25 mm long); leaf lobes incubous, imbricate, apices slight rounded, obtuse to apiculate; leaf size (0.70-0.84 mm long and 0.64-0.72 mm wide); leaf lobules stalked, cylindrical with obtuse head, oblique mouth, 0.20-0.21 mm long and 0.09-0.11 mm wide; underleaves 2.0-2.5 times as wide as the stem, 1/4-1/3 bilobed, 0.30-0.43 mm long 0.25-0.38 mm wide and margin occasionally single toothed. *F. apiculata* approaches to *F. inflexa* Mitt. in the appearance of leaves, bracts and perianth but the latter is distinctive in having vertex lobules which are directed towards stem and ventral keels of the perianth are 1 angled, while in *F. apiculata* the lobules are distant from stem and ventral keels of the perianth are 1-2 angled.

1.4 *Frullania inflexa* Mitt., J. Proc. Linn. Soc. **5**: 120 (1861). Figs. 1 & 3 (21-37)

Monoecious; plants reddish brown, prostrate, 15 mm long and 0.8-0.9 mm wide including leaves. Branching irregular; primary branches 4.43 mm long and 0.5 mm wide including leaves. Stem brownish, cylindrical, 0.08-0.12 x 0.11-0.13 mm in diameter and 7-9 cells across; cortical cells thick walled, smaller, quadrate-semiquadrate, 7.5-10 x 5-7.5 µm; medullary cells slightly larger, thick walled 10-12.5 x 7.5 µm. Leaf lobes loosely imbricate, narrowly incurved, slightly bent downward to transverse, ovate, dorsal margin convex, ventral margin slightly concave at base, 0.50-0.74 mm long and 0.40-0.45 mm wide with obtuse to rounded apex; marginal cells semiquadrate, less trigonous, 12.5-15 x 10-12.5 µm, slightly thick walled; median cells thin walled, trigonous, 15-20 x 12.5-15 µm; basal cells thin walled, trigonous, 22.5-35 x 15-17.5 µm; lobules saccate, oblong with rounded vertex directed towards stem and somewhat covering the stem, connected with a short stalk, 0.19 mm long and 0.10 mm wide, mouth obliquely truncate with or without constriction. Underleaves flat, transverse, oblong, bifid, longer than wide, 0.20-0.22 mm long and 0.15-0.20 mm wide, sinus acute, 80-100 µm deep, lobes acute-subtriangular. Female inflorescence terminal on main stem or lateral branch. Perianth 0.82-0.83 mm long and 0.43-0.50 mm wide, 3 keeled, smooth; bracts 1-2 pairs, oblong, 0.82-0.83 mm long and 0.43-0.50 mm wide, margins undulate-dentate, apex apiculate, acute, lobules explanate, margin incurved, dentate, apex acute to apiculate. Male inflorescence on lateral branches, capitate (ovoid), 3-4 pairs of bracts, short stalked.

Distribution and ecology: Eastern Himalayas: Meghalaya: West Khasi Hills: Nongstoin, Mawaiban F.R.H.

Plants grow on the tree bark at 4500 ft altitude, 26.3 ℃ temperature and 61% relative humidity.

Range: India.

Specimens examined: India: Meghalaya: West Khasi Hills: Nongstoin, 14.09.2000, Leg. A.P. Singh, 208532-D (LWG), Det. V. Nath & A.P. Singh.

Frullania inflexa Mitt. was instituted by Mitten (1860-61). However, in India, this species was described by Stephani (1910) from Himalaya and Sikkim. Parihar et al. (1994) listed *F. inflexa* Mitt.

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from Nepal and Eastern Himalayas. Nath and Asthana (1998) described this species from South India: Karnataka, Agumbe at 1000-1500 mt altitude. However, the present study is based on the plants collected from Nongstoin: West Khasi Hills in Meghalaya. *F. inflexa* exhibit considerable diversity in its color (reddish brown to brownish green or brown); leaf lobes size (0.50-0.74 mm long and 0.40-0.45 mm wide), ovate-narrowly incurved; lobules saccate, oblong with rounded vertex directed towards stem and somewhat covering the stem, 0.19 mm long and 0.10 mm wide; underleaves longer than wide (0.20-0.22 mm long and 0.15-0.20 mm wide); perianth 0.82-0.83 mm long and 0.43-0.50 mm wide, 3 keeled and ventral keel angled. This species approaches and stands near to *F. apiculata* in its appearance, color and perianth length but highly differs having vertexed lobules directed towards stem, ventral keel of perianth angled, however in *F. apiculata* the lobules are distant, stalked from the stem and ventral keels of the perianth is flat.

1.5 *Frullania tamarisci* (L.) Dum. Sde. Lac. in Miquel, Ann. Mis. Lugd.-Batavi **1**: 313 (1836). Figs. 1 & 4 (1-12)

Dioecious; plants yellowish green, 30-40 mm long and 1.75 mm wide including leaves. Branching irregular; primary branches 7.0-8.0 mm long and 1.25 mm wide including leaves; secondary branches small, 1.13 mm long and 0.73 mm wide including leaves. Stem brownish, cylindrical, 0.21-0.22 x 0.22 mm in diameter and 12 cells across; cortical cells thick walled, smaller, semiquadrate to angular, 10.0-12.5 x 5.0-7.5 µm; medullary cells slightly larger, thick walled, angular to subquadrate, 17.5-25.0 x 10.0-12.5 µm. Leaf lobes imbricate, slightly oblique to transverse, widely spreading, dorsal margin convex, ventral margin slight concave with appendaged base, ovate with acute-acuminate or obtuse to apiculate apex, apex often incurved, 1.10-1.25 mm long and 0.85-1.00 mm wide; ocelli in 1-2 rows, 10-25 cells long or scattered as single or in groups of 6-7 cells, hyaline, pink, 25-30 x 20-27.5 µm. Stylus uniseriate on appendages, 6 cells long; leaf marginal cells quadrate-semiquadrate, regular, slightly trigonous, 10.0-12.5 x 10.0-12.5 µm; median cells large, polyhedral, oblong, trigonous, 20.0-27.5 x 10.0-15.0 µm; basal cells thin walled, large, trigonous, 20-35 x 10.0-15.0 µm; lobules saccate (clavate), explanate, parallel or subparallel to stem with constricted mouth, connected with a short stalk, bearing semicircular appendages. Underleaves wider than length, less than 1/3 bifid, recurved along margin, not obcuneate in out line, appendages toothed at base, lobes acute, 0.50-0.65 mm long and 0.58-0.80 mm wide. Androecia lateral on main stem, short, stalked, without ordinary leaves, capitate with 3-4 pairs of bracts.

Distribution and ecology: Eastern Himalayas: Meghalaya: West Khasi Hills: Nongstoin, Mawsiangdur forest.

Plants grow on tree bark at 5900-5950 ft altitude, 25.9 ℃ temperature and 59% relative humidity.

Range: Europe, Asia minor, Himalaya, India, Ceylon, Malaysia, China, Formosa, Korea, Temperate Siberia, Japan, Vancouver and Orcas Island.

Specimens examined: India: Meghalaya: West Khasi Hills: Nongstoin, 15.09.2000, Leg. A.P. Singh, 208600-A, 208619-A (LWG), Det. V. Nath & A.P. Singh.

The first report on *Frullania tamarisci* (L.) Dum. complex in India was made by Mitten (1860-61) on the taxon *F. moniliata* (R.B.N.) Mont. from Sikkim and Nilgiri mountains on the basis of the collections made by J.D. Hooker and Perrottet respectively. Stephani (1910) also described *F. moniliata* and *F. breviramea* Steph. from India Orientalis. Verdoorn (1930) instituted *F. moniliata* subsp. *breviramea* (Steph.) Verd. and *F. moniliata* subsp. *obscura* Verd. Chopra (1938; 1943) reported *F. moniliata* and *F. breviramea* Steph. from South India. Kamimura (1961) reduced *F. moniliata* under *F. tamarisci* subsp. *moniliata* (Reinw, Blume *et* Nees) Kamim. at the level of subspecies. Parihar (1961-62) listed *F. moniliata* and *F. moniliata* subsp. *breviramea* from South India. Hattori (1966) described *F. tamarisci* from Eastern Himalayas, India. Hattori (1972) reduced *F. moniliata* subsp. *obscura* under *F. tamarisci* as *F. tamarisci* subsp. *obscura*. He recognized two varieties under this subspecies viz. *F. tamarisci* subsp. *obscura* var. *obscura* Hatt. and *F. tamarisci* subsp. *obscura* var. *breviramea* (Steph.) Hatt. from India. Nath (1977) remarked, atleast four types of variations within the speices in India. However, the present investigation is based on the plants collected from Nongstoin: West Khasi Hills, Meghalaya. These plants were of broader leaf with incurved apices having semicircular appendages, which were attached with the stalk of the lobules and exhibit linear and scattered ocelli. Moreover, the considerable range of diversity has been noticed in *F. tamarisci*. The plants size ranges (30-40 mm long); color (yellowish green to green); leaf lobes ovate with acute-subacute or obtuse-subobtuse often incurved apices, 1.10-1.25 mm long and 0.85-1.00

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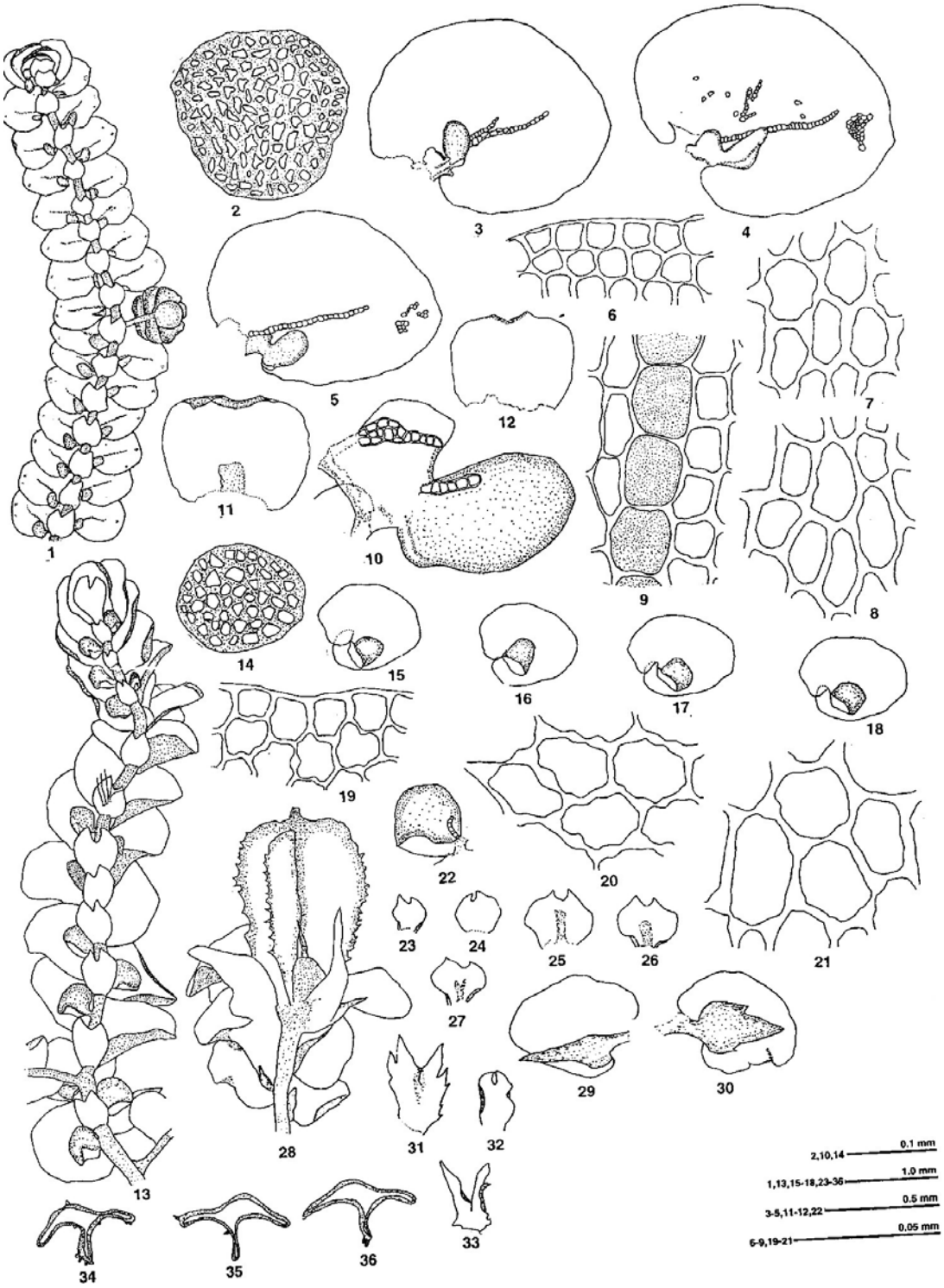


Fig. 4. *Frullania tamarisci* (L.) Dum.. 1-12. (LWG 208600-A): 1. Plant, 2. Cross-section of stem, 3-5. Leaves, 6. Leaf marginal cells, 7. Leaf median cells, 8. Leaf basal cells, 9. Ocelli, 10. Leaf lobule with stylus, 11-12. Underleaves. *F. ericoides* Nees. 13-36. (LWG 208073-B): 13. Plant, 14. Cross-section of stem, 15-18. Leaves, 19. Leaf marginal cells, 20. Leaf median cells, 21. Leaf basal cells, 22. Leaf lobule, 23-27. Underleaves, 28. Perianth, 29-30. Female bracts, 31-33. Female bracteoles, 34-36. Cross-section of perianth.

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mm wide; ocelli in 1-2 rows, 10-25 cells long or scattered as single or in groups of 6-7 hyaline, pink cells; lobules saccate, clavate, occasionally explanate, connected with a short stalk bearing semicircular appendages; underleaves wider than length, bifid, recurved along margin, appendages toothed at base. This species is entirely distinctive with other allied species in having uni-biseriate ocelli in leaf cells.

1.6 ***Frullania ericoides*** Nees., Syn. Hepat. 417 (1846). Figs. 1 & 4 (13-36)

F. squarrosa (Reinw., Blume *et N*ees) Dum., Rec. d'obs. **13**: (1835).

Dioecious; plants medium sized, light yellowish green, prostrate, 20 mm long and 1.75 mm wide including leaves. Branching irregular, bi-tripinnately branched; primary branches 5-7 mm long and 1.45 mm wide including leaves; secondary branches 1.75 mm long and 0.75 mm wide including leaves. Stem light brownish, cylindrical, 0.13-0.14 x 0.15-0.16 mm in diameter and 8-9 cells across; cortical cells slightly thick walled, 15.0-22.5 x 12.5-15 µm, semiquadrate, angular; medullary cells larger, thick walled, quadrate-semiquadrate, angular, 20-25 x 12.5-20.0 µm. Leaf lobes strongly squarrose with cordate base, loosely imbricate, oblong, ovate-oval, entire, 1.0-1.3 mm long and 0.90-0.98 mm wide with rounded apex; leaf marginal cells quadrate-semiquadrate, slightly vulged, trigonous, thick walled, 17.5 x 12.5-17.5 µm; median cells larger, thick walled, polyhedral, trigonous, 27.5-37.5 x 17.5-22.5 µm; basal cells large, polyhedral, trigonous, 35-45 x 25.0-27.5 µm. Lobules variable in shape and size, wholly saccate or frequently explanate, lobules saccate, helmet shaped with rounded vertex and obliquely truncate mouth, 0.31 mm long and 0.35 mm wide. Underleaves narrow towards base, suborbicular, 0.45-0.62 mm long and 0.50-0.67 mm wide, entire, basal margin incurved, sinus orbicular, acute, 150-220 µm deep, lobes acute. Female inflorescence terminal on the main axis or on the leading branches. Perianth exserted, cross-section of perianth 0.75-0.83 x 1.20-1.38 mm diameter, ovate to oblong, dorsally compressed, strongly 3 keeled with dentitions on the surface and the margins; bracts ovate-oblong, entire or slightly undulate, 2-3 pairs, 1.30-1.63 mm long and 1.00-1.25 mm wide, lobules explanate, margin entire, dentate, apex acute; bracteoles oblong, bifid, margin incurved, dentate to entire, 0.75-1.25 mm long and 0.45-0.73 mm wide, apex acute.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong peak, B.S.I. Campus, Cherrapunji; West Khasi Hills: Nongstoin: Mawkadiang F.R.H.; Mairang: Children park.

Plants grow epiphytically on bark in association with *Cheilolejeunea serpentina*, *Lopholejeunea* sp., *Ptychanthus striatus* and *Frullania wallichiana* at 3900-5700 ft altitude, 22.5-23.4 ℃ temperature and 67-70% relative humidity.

Range: Widely distributed in Asia, Pacific Island, Australia, N. & S. America and Africa (warm-temperate to tropical region).

Specimens examined: India: Meghalaya: East Khasi Hills: Cherrapunji, 07.04.1965, Leg. S. Chandra, 201107-A (LWG); On Shillong peak, 08.04.1965, Leg. S. Chandra, 201178-C (LWG); On way to Shillong peak, 11.11.1998, Leg. V. Nath and party, 207972-A (LWG); Shillong, 12.11.1998, Leg. V. Nath and party, 208073-B (LWG); B.S.I. Barapani, 12.11.1998, Leg. V. Nath and party, 207988-C (LWG); West Khasi Hills: Nongstoin: Mawkadiang F.R.H., 17.09.2000, Leg. A.P. Singh, 208652-C, 208670-B (LWG); Mairang: Children park, 19.09.2000, Leg. A.P. Singh, 208716-A, 208720-A (LWG), Det. V. Nath & A.P. Singh.

Mitten (1860-61) provided detailed account on different taxa of *Frullania ericoides* complex on the basis of the collections made by T. Thomson, J.D. Hooker and Wallich from India. Although, *F. ericoides* complex includes five Indian taxa viz. *F. ericoides* Nees, *F. aeolotis* Nees, *F. squarrosa* (Reinw., Blume *et* Nees) Dum., *F. laciniosa* Auct., and *F. rotundiloba* Steph. Mitten (1860-61) described *F. aeolotis* from Khasi Hills. Stephani (1910) described *F. squarrosa*, *F. laciniosa* as two distinct taxon and treated *F. ericoides* and *F. aeolotis* as the synonyms of *F. squarrosa* (Reinw., Blume *et* Nees) Dum. and *F. riparia* Hamp. respectively and also instituted a new species *F. rotundiloba* from Sikkim (Stephani, 1910-12). Verdoorn (1929) distinguished one form and one variety viz. *F. squarrosa* fo. *ericoides* (Nees) Verd. and *F. squarrosa* var. *planescens*. Moreover, Verdoorn (1930) synonymized *F. himalayensis* Steph. and *F. chinensis* Steph. under *F. muscicola* Steph., while describing a *Frullania* specimen from Mussoorie he says, "I think *F. squarrosa* Nees might be also a form of *F. muscicola* Steph". Kashyp (1932) remarked that the "*F. squarrosa* is common in the Western Himalayas". Chopra (1943) described four distinct species viz. *F. aeolotis*, *F. laciniosa*, *F. rotundiloba* and *F. squarrosa* from India and neighbouring regions. During critical study on *Frullania*, Kamimura (1961) described *F. squarrosa* and also instituted a variety *F. squarrosa* var. *verrucosa* Kamim. Parihar (1961-62) listed *F. squarrosa* from Eastern Himalayas, Western Himalayas and South India. Hattori (1966) also mentioned many new localities for occurrence of this species in East

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Himalayan region. However, present investigation is based on the plants collected from Shillong peak, B.S.I. Campus, Cherrapunji in East Khasi and Nongstoin, Mawkadiang and Mairang in West Khasi Hills. The plants collected from B.S.I. Campus Barapani were medium sized (20 mm long); the leaves were squarrose, ovate-rotundate, apex rotundate with cordate base; underleaves base narrowed with incurved margin, sinus obtuse-sublunate; while plants collected from other localities were similar with the former one except the underleaves basal margin which is either entire or semirecurved and sinus less deep or similar with the plants collected from former locality. Moreover, *F. ericoides* shows diversity in color (light yellowish brown to yellowish green); size (15-30 mm long); leaf size (1.0-1.3 mm long and 0.90-0.98 mm wide); leaf lobes shape (squarrose, ovate-oval with cordate base and rounded-broadly obtuse-rotundate apices); leaf lobules saccate with rounded vertex, 0.31 mm long and 0.35 mm wide; underleaves imbricate-distant, narrow towards base, suborbicular, basal margin incurved, sinus 0.15-0.22 mm deep; 3 keeled perianth with tubercles on the surface and the margin of keels. This taxon highly resembles and stand near to the *F. muscicola* Steph., but former differs with later in having squarrose leaves, large underleaves, perianth 3 keeled with tubercles on the surface and at the margins, whereas in the *F. muscicola* leaf lobes are nonsquarrose, perianth 5 keeled without tubercles on the surface as well as margins.

1.7 *Frullania acutiloba* Mitt., Proc. Linn. Soc. **5**: 120 (1861). Figs. 1 & 5 (1-16)

Dioecious; plants pale brown or deep green, growing on bark, prostrate, 25-30 mm long and 2.5 mm wide including leaves. Branching irregular; primary branches 7-8 mm long and 1.88-2.00 mm wide including leaves; secondary branches 1.50 mm long and 1.05 mm wide including leaves. Stem brown, cylindrical, 0.17 mm in diameter. Leaf lobes imbricate, slight oblique to widely spreading, upper margin convex, lower margin slightly concave, when flattened ovate, 1.13-1.50 mm long and 0.88-1.13 mm wide with rounded to obtuse apex and small rounded quadrate basal appendages; marginal cells 15.0-17.5 x 10.0-12.5 µm; median cells 17.5-25.0 x 15.0-20.0 µm; basal cells 37.5-40.0 x 12.5-25.0 µm; cell wall more or less sinuate with somewhat nodulose trigones and intermediate thickenings, except for basal, the basal cells whose walls are straight and rather thin but whose trigones are large and subtriangular; lobules widely helmet shaped, large, 0.44-0.60 mm long and 0.25-0.38 mm wide with long piliferous beak, the apical portion of rostrum of a row of 4-5 cells, curved downward far beyond the ventral margin of leaf lobes. Underleaves large, flat, ovate-rotund, 0.50-0.73 mm long and 0.45-0.70 mm wide, 1/4-1/3 bifid, sinus acute-subactue to obtuse, narrow, lobes triangular with acuminate-acute or more or less piliferous and often connivent lobes, insertion transverse to sinuate.

Distribution and ecology: Eastern Himalayas: Meghalaya: West Khasi Hills: Nongstoin: Mawsiangdur forest.

Plants grow epiphytically on bark in association with *Ptychanthus striatus* at 5900-5950 ft altitude, 25.9℃ temperature and 59% relative humidity.

Range: India, Ceylon, Java.

Specimen examined: India: Meghalaya: West Khasi Hills: Nongstoin, 15.09.2000, Leg. A.P. Singh, 208605-A (LWG). Det. V. Nath & A.P. Singh.

Frullania acutiloba Mitt. was first instituted by Mitten (1860-61) on the basis of the collections made by Perrottet from Nilgiri in South India. Robinson (1964) collected and listed *F. hampeana* Nees, an allied taxon of *F. acutiloba* from the Misanari Jungles, Assam growing on bark. However, present investigation is based on the plants collected from Nongstoin, West Khasi Hills in Meghalaya. Although the population of *F. acutiloba* collected from single locality show a remarkable range of diversity in size (25-30 mm long); color (pale brown-deep green); leaf lobes size (1.13-1.50 mm long and 0.88-1.13 mm wide) with rounded to obtuse apex and small rounded quadrate basal appendages; lobules large (0.44-0.60 mm long and 0.25-0.38 mm wide) with long piliferous beak; underleaves ovate-rotund, 0.50-0.73 mm long and 0.45-0.70 mm wide and 1/4-1/3 bifid, lobes acute-apiculate. But this species is entirely distinctive with others in having characteristic piliferous beaked lobules.

1.8 *Frullania nepalensis* (Spreng.) Lehm. & Lindenb., in Leh. Pugillus **4**: 19 (1832). Figs. 1 & 5 (17-33)

Frullania grevilleana Tayl., in Gott. et al. Syn. Hep. 421 (1845).

Dioecious; plants long, light purple red to dark brown, prostrate, 65-75 mm long and 1.75 mm wide including leaves. Branching irregular, bi-tripinnately branched; primary branches 17 mm long and 1.4-1.5 mm wide including leaves; secondary branches 5.0-6.0 mm long and 1.00-1.25 mm wide including leaves.

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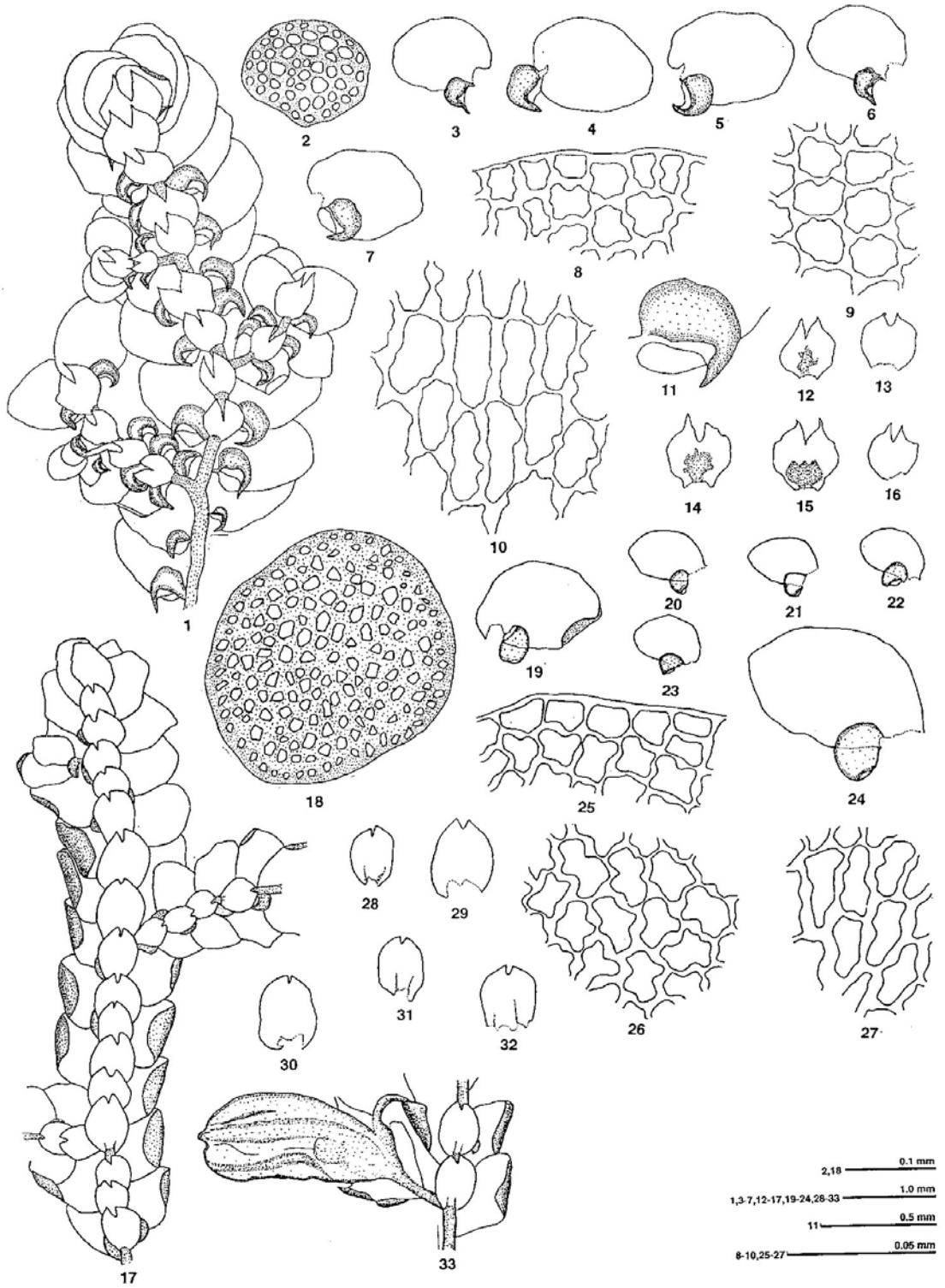


Fig. 5. *Frullania acutiloba* Mitt., 1-16. (LWG 208605-A): 1. Plant, 2. Cross-section of stem, 3-7. Leaves, 8. Leaf marginal cells, 9. Leaf median cells, 10. Leaf basal cells, 11. Leaf lobule, 12-16. Underleaves. *F. nepalensis* (Spreng.) Lehm. & Lindenb., 17-33. (LWG 205967-A): 17. Plant, 18. Cross-section of stem, 19-24. Leaves, 25. Leaf marginal cells, 26. Leaf median cells, 27. Leaf basal cells, 28-32. Underleaves, 33. A branch with perianth.

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Stem dark brown, cylindrical to prostrate, 0.27 x 0.33 mm in diameter and 13-14 cells across; cortical cells small, thick walled, 7.5-12.5 x 10-15 µm; meduallary cells slightly large, angular, thick walled, 17.5-20 x 20-22.5 µm. Leaf lobes loosely imbricate, concave with involute apices, when flat elliptical-ovate with rounded or widely obtuse apices and well developed basal appendages, 0.78-1.40 mm long and 0.53-1.00 mm wide; marginal cells subquadrate, sinuate walled, slightly stellate, 17.5-20.0 x 12.5-17.5 µm; median cells stellate, more or less sinuate walled with subnodulose trigones and intermediate thickenings, 22.5-27.5 x 15-17.5 µm; basal cells trabeculately elongate and angulate, trigonous intermediate thickenings, thin walled, 32.5-37.5 x 10-15 µm; lobules almost entirely covered by the underleaves, contiguous to the stem, asymmetric, elongate, more or less incurved beak, obtuse at the tip, mouth strongly obliquely truncate, vertex entire, rounded, convex, 0.30 mm long and 0.20 mm wide. Underleaves imbricate with longitudinal obtuse plicae and often with more or less incurved lateral margins, subquadrate-ovate, 0.75-0.88 mm long and 0.50-0.68 mm wide, cuneate, 1/5-1/6 bifid, sinus narrow, acute-subacute or rarely obtuse, lobes acute-obtuse, base gibbous and appendiculate, the appendages rounded, usually with involute free portion. Perianth lateral, intercalary on main stem, 2.5 mm long and 0.95 mm wide, 3 keeled; male inflorescence lateral, capitate, stalked with 5 pair of bracts.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong: Mawphlong forest, Elephant falls, On the way of Shillong peak; West Khasi Hills: Mairang: Mawtmian forest.

Plants grow on the leaf and tree bark or very occasionally on rocks forming a dense mat with *Lejeunea punctiformis*, *Cololejeunea* sp., *Cololejeunea lanciloba*, *Leptolejeunea* sp., *Cheilolejeunea* sp., *Spruceanthus semirepandus*, *Radula* sp., *Leucolejeunea paroica, Plagiochila* sp. at 5400-5600 ft altitude, 22.5 ℃ temperature and 70% relative humidity.

Range: India, Thai, W. China (Yunnan, Szechuan), Sumatra, Celebes, Philippines, Botjan I., Korea and Japan (excl. Hokkaido).

Specimens examined: India: Meghalaya: East Khasi Hills: Mawphlong forest, 05.11.1998, Leg. V. Nath and party, 205967-A (LWG); Elephant falls, 05.11.1998, Leg. V. Nath and party, 205972-D (LWG); On the way of Shillong peak, 11.11.1998, Leg. V. Nath and party, 207982-B (LWG); West Khasi Hills: Mairang: Mawtmian forest, 18.09.2000, Leg. A.P. Singh, 208707-A (LWG). Det. V. Nath & A. P. Singh.

Frullania nepalensis (Spreng.) Lehm. *et* Lindenb. was described by Mitten (1860-61) from Himalaya including Khasi and Sikkim on the basis of the collections made by J. D. Hooker and T. Thomson. He synonymised the *F. grevilleana* Tayl., collected by J. D. Hooker and T. Thomson from Khasi Hills, from Assam by Griffith and Shimla in Western Himalayas by T. Thomson under *F. nepalensis*. Verdoorn (1930) synonymised *F. sanguinea* Steph., *F. montana* Steph., *F. laxepinnata* Steph. under *F. nepalensis*. Kachroo (1970) listed *F. nepalensis* from Sikkim and Assam and *F. grevilleana* from India. Hattori (1973) gave a brief description of Himalayan *F. nepalensis* and does not agree with Verdoorn (1930), who reduced *F. sanguinea* Steph., *F. montana* Steph., and *F. laxepinnata* Steph. under *F. nepalensis*. He remarked: "However, *F. montana* Steph. is a different species as I have demonstrated on p. 126". Moreover, Nath (1977) remarked that *F. laxepinnata* Steph., *F. evoluta* Mitt. and *F. grevilleana* Tayl. are synonyms of *F. nepalensis*, although he showed certain variation in leaf lobes and underleaves. The present study is based on the plants collected from Mawphlong forest, Elephant falls, Shillong peak in East Khasi and Mairang in West Khasi Hills, Meghalaya. The plants collected from former three localities with epiphytic habitat showed similarities in their color, length and shape and size of leaves, except the underleaves, which are minutely bifid or truncate in the plants collected from Mawphlong forest. However, the plants encountered in Mairang are highly variable in their habitat: growing on rocks; are smaller and the underleaves are much reduced and less bifid. The study revealed that the *F. nepalensis* exhibit extreme variation in plants size (50-75 mm long); color (light purple red to dark brown); leaf lobes size (0.78-1.40 mm long and 0.53-1.00 mm wide), concave with recurved apices and when flat elliptical-ovate; underleaf size (0.75-0.88 mm long and 0.50-0.68 mm wide), cuneate, oblong, margin entire, very rarely wavy, sinus very small, acute-subacute, base gibbous, appendiculate with longitudinal obtuse plicae.

1.9 *Frullania pseudoschensiana* var. ***darjeelingensis*** Hatt., J. Hatt. Bot. Lab. No. **49**: 147-168 (1981). Figs. 1 & 6 (1-20)

Dioecious; plants pale brown, prostrate, 30 mm long and 2 mm wide including leaves. Branching irregular; primary branches upto 20 mm long and 1.75 mm wide including leaves; secondary branches up to 8 mm long and 1.05 mm wide including leaves;

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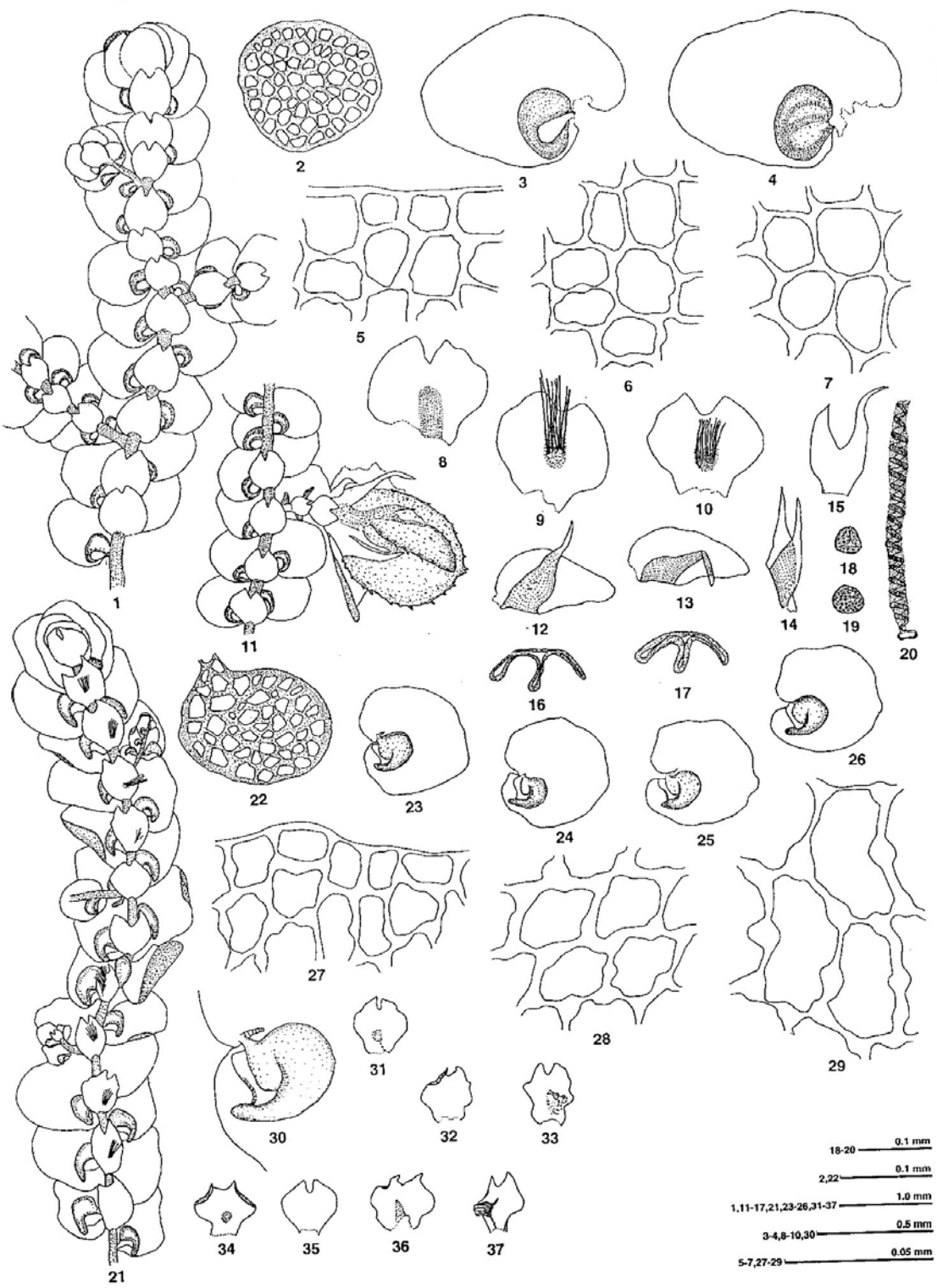


Fig. 6. *Frullania pseudoschensiana* var. *darjeelingensis* Hatt. 1-20. (LWG 201188-B): 1. Plant, 2. Cross-section of stem, 3-4. Leaves, 5. Leaf marginal cells, 6. Leaf median cells, 7. Leaf basal cells, 8-10. Underleaves, 11. Plant with perianth, 12-13. Female bracts, 14-15. Female bracteoles, 16-17. Cross-section of perianth, 18-19. Spores, 20. Elater. *F. giraldiana* Massal. 21-37. (LWG 207987-B): 21. Plant, 22. Cross-section of stem, 23-26. Leaves, 27. Leaf marginal cells, 28. Leaf median cells, 29. Leaf basal cells, 30. Leaf lobule, 31-37. Underleaves.

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tertiary branches upto 1.5 mm long and 1.0 mm wide including leaves; quartery branches occasionally. Stem dark brown, cylindrical, 0.15 x 0.15-0.18 mm diameter and about 8 cells across; cortical cells slightly thick walled, 12.5-15 x 15-20 µm; medullary cells thick walled, 15-17.5 x 17.5-20 µm. Leaf lobes loosely imbricate, ovate to oblong, entire, 1-1.25 mm long and 0.75 mm wide, base appendaged. Leaf marginal cells radiate, trigonous, thin walled, 12.5-15 x 20-22.5 µm; median cells thin walled, radiate, trigonous, 20-22.5 x 22.5-27.5 µm; basal cells thin walled, trigonous, 25-27.5 x 27.5-40 µm; lobules medium, helmet shaped, saccate, mouth oblique, transverse, 220 x 300 µm; stylus 4-5 celled long. Underleaves loosely imbricate, reniform, orbicular, cuneate, 0.53 mm long and 0.49-0.52 mm wide, entire, bifid, 1/3-1/2 of the lobe, sinus acute, obtuse, 100-110 µm deep. Female inflorescence lateral on main axis. Perianth 1.75 mm long and 1.25 mm wide and 3 keeled, tuberculate out growth over keels with smaller ones; bracts one pair, oblong, entire, 1.38-1.43 mm long and 0.65-0.75 mm wide, lobules explanate, apiculate; bracteoles large, 1.38 mm long and 0.70 mm wide, bifid, entire, sinus acute-obtuse, lobes apiculate, acute. Spores spherical, light pale-purple, triradiate, 37.5-45 x 45-55 µm in diameter. Elaters brown, 400 µm long and 30 µm wide, unispiral.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong peak.

Plants grow on the soil forming a dense mat in association with *Ptychanthus striatus*, *Plagiochila* sp., *Cheilolejeunea* sp., at 6400 ft altitude

Range: India

Specimen examined: India: Meghalaya: East Khasi Hills: Shillong peak, 08.04.1965, Leg. S. Chandra, 201188-B (LWG). Det. V. Nath & A.P. Singh.

Frullania pseudoschensiana var. *darjeelingensis* Hatt. was instituted by Hattori (1981) from Darjeeling. This plant agrees well with the *F. pseudoschensiana* Hatt. and *F. schensiana* Massal. The only distinction seems to be in the perianth. Hattori (1981) refers the perianth of var. *darjeelingensis* has almost uniform lateral and ventral keels and the tubercles out growths are uniformly dispersed over the keels with smaller ones more scattered over the surface between keels both ventrally and dorsally. Whereas in var. *pseudoschensiana* the perianth bears tubercles densely on the lower portion of the ventral surface (particularly on the keels); dorsal surface almost or entirely lack such tubercles. Whereas in *F. schensiana*, the perianth lacks tubercles. However, the present investigation is based on the plant population of *F. pseudoschensiana* var. *darjeelingensis* collected from single locality Shillong peak in East Khasi Hills of Meghalaya. This species show diversity in size (20-30 mm long); color (pale brown to greenish brown); leaf lobes (1.0-1.25 mm long and 0.75 wide); shape (ovate-oblong); underleaves size (0.53 mm long and 0.49-0.52 mm wide), reniform, orbicular, cuneate, bifid, base narrowed; lobules saccate; perianth 3 keeled and tubercles scattered on the surface and margins with smaller ones; bracts only one pair. This species resembles with *F. ericoides* Nees but highly differ in having ovate-oblong leaves, uncurved basal margin of underleaves, smaller ones tubercles on keels, occasionally on surface of the perianth where as in *F. ericoides* the leaves are squarrose, basal margin of underleaves recurved and tubercles are maximum on the keels as well as surface of the perianth.

1.10 *Frullania giraldiana* Massal., Mem. Accad. Agr. Art. Verona **73**(3): 41, tab. 11, fig. 16 (1897). Figs. 1 & 6 (21-37)

Plants large, light yellowish green, prostrate, 35-45 mm long and 1.75-1.95 mm wide including leaves. Branching irregular; primary branches 20-21 mm long and 1.55-1.87 mm wide including leaves; secondary branches 7 mm long and 1.25-1.45 mm wide including leaves; tertiary branches 2.20 mm long and 1.0 mm wide including leaves. Stem cylindrical to prostrate, olive brown to brown, 0.13-0.14 x 0.14-0.18 mm in diameter and 7-8 cells across; cortical cells semiquadrate, angular, 15-20 x 15-25 µm, thick walled; medullary cells slightly larger, thin walled, 20-22.5 x 20-37.5 µm. Leaf lobes somewhat remote, contiguous or rarely slightly imbricate, widely spreading, concave ventrally with incurved apices, when flattened widely ovate and rotund, 1.2-1.3 mm long and 1.15-1.25 mm wide with rounded apex and both dorsal as well as ventral bases with large rounded appendages, similar to each other and insertion very short upto the lobule stalk; marginal cells of leaf lobes thick walled, slightly flexuose, 12.5-15 x 17.5-27.5 µm with large trigones; median cells thick walled, more or less flexuose, 17.5-20 x 37.5-42.5 µm, large trigonous with intermediate thickenings; basal cells thin walled, large, straight, 20-27.5 x 45-55 µm with larger nodulose trigones and occasionally nodulose intermediate thickenings; lobules contiguous to the stem, helmet shaped, 0.48-0.50 mm long and 0.33-0.38 mm wide with rounded heads and obtuse beaked mouths. Underleaves 0.60-0.75 mm long and

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0.57-0.70 mm wide, not flat, obcuneate, more or less apical as well as basal margin revolute, with well developed median plicae, 1/3-1/4 bifid, sinus 150-160 µm deep, obtuse to subacute, lobes triangular, subacute. Rhizoids from the ventral centre of the underleaves.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: B.S.I. Barapani, Shillong; West Khasi Hills: Nongstoin: Mawsiangdur forest.

Plants grow on the bark forming a dense mat of *Lejeunea flava*, *Cololejeunea lanciloba* and *Ptychanthus striatus* at 2550-5900 ft altitude, 25.9°C temperature and 59% relative humidity.

Range: E. Nepal and China (Shensi and Szechuan).

Specimens examined: India: Meghalaya: East Khasi Hills: B.S.I. Barapani, Shillong, 12.11.1998, Leg. V. Nath and party, 207987-B (LWG); West Khasi Hills: Nongstoin: Mawsiangdur forest, 15.09.2000, Leg. A.P. Singh, 208605 (LWG). Det. V. Nath & A. P. Singh.

Frullania giraldiana Massal. was first described by Massalongo (1897) from China. However, detailed description on this species was made by Stephani (1910), where he remarks its distribution from China: Schensi. Verdoorn (1930) recorded *F. giraldiana* from Szechwan and Hattori (1966) showed its distribution from Eastern Nepal and China (Shensi and Szechuan). He remarked that this species is very close to, or conspecific with *F. nepalensis* (Spreng.) Lehm. *et*. Lindenb. Hattori (1972) states going thorough Verdoorn (1930) "I agree with him on the close relationship of these two species; I think *F. giraldiana* "is a small" species in the *F. grevilleana* complex widely distributed and highly variable in Southeastern Asia. Furthermore, he described *F. giraldiana* from E. Nepal and Bhutan (Hattori 1971). Hattori (1972) mentioned the important separating features of this species from *F. nepalensis* is the base of leaf lobes with similarly developed dorsal and ventral appendages and the underleaf base with large, rounded appendages. Besides, Verdoorn (1930) described a new variety *F. nepalensis* var. *handelli* under *F. nepalensis*. Hattori (1972) critically examined this variety and remarks it to be more closely approaching to *F. giraldiana* than the *F. nepalensis.* The above features of *F. giraldiana* by which *F. nepalensis* is separated are present in this variety. Moreover, underleaves of *F. giraldiana* and *F. nepalensis* var. *handelii* have clear median plica, which is weak in *F. nepalensis*. Therefore, he made clear two distinct species of *F. giraldiana* and *F. nepalensis*, and synonymized the *F. nepalensis* var. *handelii* Verd. under *F. giraldiana* var. *handelii* (Verd.) Hatt. However, present study is based on the plants collected from B.S.I. Barapani: East Khasi Hills and Mawsiangdur forest Nongstoin: West Khasi Hills. Plants from B.S.I. Barapani are light yellow brown, larger, leaves suboval-rotundate, lobules beaked, underleaves orbicular, 1/4 bifid; while the plants from Mawsiangdur forest are brownish green, smaller, leaves slightly oblong-oval, apex rotundate-obtuse and lobules beaked. Besides, *Frullania giraldiana* shows considerable range of diversity in leaf lobes arrangement and shape (contiguous-imbricate, incurved apices, when flattened widely ovate and rotund); leaf size (1.2-1.3 mm long and 1.15-1.25 mm wide), both dorsal as well as ventral base with large rounded appendages; lobules helmet shaped, 0.48-0.50 mm long and 0.33-0.38 mm wide with rounded head and beaked mouth; underleaves bifid, 0.60-0.75 mm long and 0.57-0.70 mm wide with well developed median plicae and more or less revolute margin. This species approaches to *F. nepalensis* and a little bit to *F. ericoides* Nees, but highly differ in having lobules with rounded head and beaked mouth, the underleaf basal margin recurved and both margins of leaves strongly rounded appendaged, which is uncommon in latter two species.

1.11 *Frullania rotundistipula* Steph., Hedwigia **33**: 147 (1894). Figs. 1 & 7 (1-12)

Dioecious; plants large, light yellowish green to brown, prostrate, 35-40 mm long and 2.50 mm wide including leaves. Branching irregular; primary branches 30 mm long and 2.25 mm wide including leaves; secondary branches 7 mm long and 1.88 mm wide including leaves. Stem yellowish brown, cylindrical, prostrate, 14-15 cells across; cortical cells thick walled, quadrate, 10-15 x 15-22.5 µm; medullary cells larger, thick walled, angular, 15-25 x 20-27.5 µm. Leaf lobes imbricate, widely spreading, concave with incurved apices and dorsally extending beyond the farther edge of stem, when flat ovate with obtuse apices, dorsally convex and developed appendages rounded and so closed, 1.63-1.90 mm long and 1.50-1.75 mm wide; leaf marginal cells thin walled, medium sized, trigonous with intermediate thickenings, 10-15 x 20-22.5 µm; median cells thin walled with large nodulose trigones, 20-25 x 30-32.5 µm; basal cells thin walled, with large nodulose, often more or less confluent trigones, 22.5-30 x 35-42.5 µm; lobules helmet shaped, erect, 0.42-0.45 mm long and 0.34-0.35 mm wide with rounded heads

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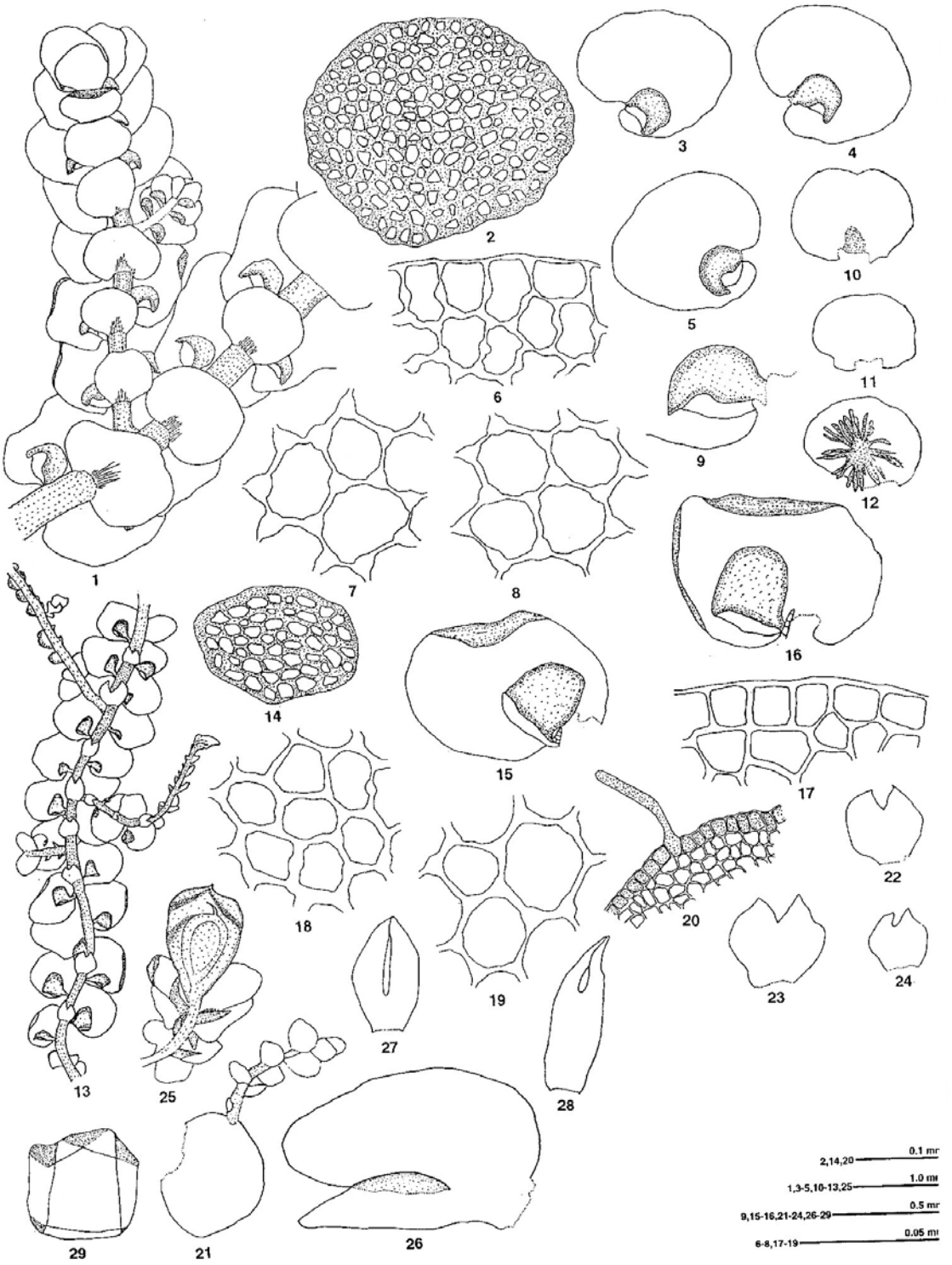


Fig. 7. *Frullania rotundistipula* Steph. 1-12 (LWG 208526-A): 1. Plant, 2. Cross-section of stem, 3-5. Leaves, 6. Leaf marginal cells, 7. Leaf median cells, 8. Leaf basal cells, 9. Leaf lobule, 10-12. Underleaves. *F. muscicola* Steph. 13-29. (LWG 207966-A): 13. Plant, 14. Cross-section of stem, 15-16. Leaves, 17. Leaf marginal cells, 18. Leaf median cells, 19. Leaf basal cells, 20. Leaf marginal gemmae cells germinating, 21. Plantlet on leaf margin, 22-24. Underleaves; (LWG 205938-G): 25. Perianth, 26. Female bract, 27-28. Female bracteoles, 29. Cross-section of perianth.

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and truncate, wide mouth, distal portion of mouth more or less acute (beaked). Underleaves loosely imbriacte to remote, large, nearly flat, rotund, 0.75-1.10 mm long and 1.18-1.63 mm wide, margin entire, base cordate, insertion sinuate. Rhizoids ventrally from the centre of the underleaf.

Distribution and ecology: Eastern Himalayas: Meghalaya: West Khasi Hills: Nongstoin: Mawaiban F.R.H.

Plants grow epiphytically on the bark at 4500 ft altitude, 26.3 ℃ temperature and 61% relative humidity.

Range: China (known only in Yunnan and Szechwan), India.

Specimen examined: India: Meghalaya: West Khasi Hills: Mawaiban F.R.H., 14.09.2000, Leg. A.P. Singh, 208526-A (LWG), Det. V. Nath & A. P. Singh.

Frullania rotundistipula Steph. was instituted for the first time by Stephani (1894) from China on the basis of the specimens collected by Delavay from Yunnan, Hokin, Yem-han (China). Later on Stephani (1910-12) provided its distribution with full description from China. Hattori (1973) made study on the same specimens drawn on loan, along with a single shoot of *F. delavayii* too, and described it as *F. rotundistipula*. Recently, Singh and Nath (2004) described this species as an addition to Indian bryoflora. However, present study in based on the plants collected from Mawaiban: West Khasi Hills Meghalaya. The *Frullania rotundistipula* is uncommon in India and has remarkable diversity among plants of same population (35-40 mm long); color (light yellowish green to brown); leaf lobes size (1.63-1.90 mm long and 1.50-1.75 mm wide), imbricate, apices incurved, when flat ovate with obtuse apices, and rounded appendaged dorsal base; lobules 0.42-0.45 mm long and 0.34-0.35 mm wide with rounded heads and truncate mouth, more or less acute (beaked); underleaves 0.75-1.10 mm long and 1.18-1.63 mm wide, entire, sinuate insertion. *F. rotundistipula* is entirely distinctive with other species in possessing unlobed underleaves, rounded headed lobules with less acute beak and leaf lobes dorsal margin appendaged.

1.12 *Frullania muscicola* Steph., Hedwigia **33**: 146 (1894). Figs. 1 & 7 (13-29)

F. gollani Steph., Spec. Hepat. **4**: 445 (1910)

Dioecious; plants medium, light pale brown to dark brown, 20-30 mm long and 1.83 mm wide including leaves. Branching irregular, bi-tripinnately branched; primary branches 6-7 mm long and 1.38 mm wide including leaves; secondary branches 5 mm long and 1.13 mm wide including leaves; tertiary branches 3 mm long and 0.46 mm wide including leaves. Stem reddish brown to dark brown, cylindrical to prostrate, 0.14 x 0.19-0.20 mm diameter, 8-9 cells across; cortical cells thick walled, subquadrate, 12.5-22.5 x 7.5-15 µm; medullary cells larger, 12.5-22.5 x 10-22.5 µm. Leaf lobes loosely imbricate, entire, ovate, incurved, 0.58-1.01 mm long and 0.5-0.9 mm wide with obtuse apex and small appendages; leaf marginal cells occasionally thick walled, distinct, transformed into gemmae and new plantlets, semiquadrate, slightly thick walled, 15-20 x 12.5-15 µm; median cells trigonous, 17.5-25 x 15-22.5 µm. Lobules strongly saccate, rarely cucullate or explanate, 0.39-0.43 mm long and 0.30-0.35 mm wide, stylus 4-5 cells long. Underleaves distant, obcuneate, reniform, entire to angulate, on one or both sides, with 1-2 teeth on lateral margin, 0.39-0.51 mm long and 0.36-0.45 mm wide, apex bifid, 1/3, occasionally 1/2 of the lobe, sinus acute, divergent, 112.5-175 µm deep. Perianth terminal on the main or lateral branches, 1.25 mm long and 0.95 mm wide, exserted, 4 keeled, smooth, apical beak small, cross section of perianth 0.51 x 0.54 mm in diameter; bracts 2-3 pair, ovate-oblong, entire, 0.68-0.75 x 1.10-1.25 mm, lobules explanate, apex obtuse; bracteoles oblong, 0.55-0.75 mm long and 0.26-0.33 mm wide, sinus deep.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Shillong: On the way of Shillong peak, Mawphlong forest, B.S.I. Barapani.

Plants grow epiphytically on bark forming a mat in association with *Ptychanthus striatus*, *Radula* sp., *Porella* sp., *Plagiochila* sp., *Frullania wallichiana*, *Leucolejeunea* sp., *Cheilolejeunea* sp., *Lejeunea* sp., at 2550-5600 ft altitute, 22.5°C temperature and 65% relative humidity.

Range: India: Himalaya, China, Manchuria, Saghalin, Japan, Korea and Formosa.

Specimens examined: India: Meghalaya: East Khasi Hills: On the way of Shillong peak, 08.04.1965, Leg. S. Chandra, 201178-C (LWG); Det. V. Nath & A.P. Singh, 11.11.1998, Leg. V. Nath and party, 207966-A, 207971-B (LWG); Mawphlong forest, 05.11.1998, Leg. V. Nath and party, 205938-G (LWG), B.S.I. Barapani, 12.11.1998, Leg. V. Nath and party, 208027-A, 208041-A (LWG); Det. V. Nath & A. P. Singh.

Frullania muscicola Steph. for the first time was established by Stephani (1894) from China (Yunnan). Although in India, *F. muscicola* complex includes atleast three related taxa viz. *F. gracillima* Steph., *F. himalayensis* Steph., and *F. gollani* Steph. Later on Stephani (1910) instituted *F. gollani* Steph.

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from Himalaya, *F. gracillima* Steph. from Indian orientalis and *F. himalayensis* Steph. from Himalaya. Verdoorn (1930) has given *F. himalayensis* Steph. as synonym of *F. muscicola* Steph. Kashyap (1932) also described *F. muscicola* Steph., *F. gracillima* Steph., *F. gollani* Steph. and *F. himalayensis* Steph. from India. Moreover, Chopra (1938a) listed *F. muscicola* from Darjeeling and later on Chopra (1943) listed *F. gollani* from Western Himalayas; *F. gracillima* from Western Himalayas, South India; *F. himalayensis* and *F. muscicola* from Western Himalayas. Besides, Kamimura (1961) described *F. muscicola* from Japan with its distribution in India. In addition, Robinson (1964) listed *F. muscicola* from Assam, while Hattori (1966) listed it from Eastern Himalayas for the first time. The present investigation is based on the plants collected from Shillong peak, Mawphlong forest, B.S.I. Barapani in East Khasi Hills. The plants collected from Shillong peak are yellow to light brown in color; underleaves comparatively larger, distant with obcuneate base and occasionally margin with 1-2 tooth like protrusions. The leaves are comparatively larger with marginal gemmae and cucullate lobules. While the plants of Mawphlong forest – are -- comparatively -- larger, blackish brown-green; underleaves remote-subcontiguous with obcuneate base and entire margin; the leaves are medium with clavate lobules. However, the plants collected from Experimental Garden B.S.I. Barapani are similar to the plants of Mawphlong forest, except the underleaves, which are minutely bifid and apex of the lobes are triangular. Besides, plants of one more population from Experimental Garden B.S.I. Barapani are varying in their length, which is reduced and approaches to the plants of Shillong peak. Thus all of the known *F. muscicola* exhibit maximum variability in almost its overall features viz. plants color (light pale brown-dark brown); size (20-30 mm long); leaf size (0.58-1.01 mm long and 0.5-0.9 mm wide), entire, ovate, incurved, apex obtuse with small appendages; lobules (0.39-0.43 mm long and 0.30-0.35 mm wide), helmet shaped, saccate-cucullate or rarely explanate, stylus 4-5 cells long; underleaves distant, reniform, obcuneate, entire-angulate, 1-2 tooth on lateral margin of each lobes, bifid and 5 keeled perianth. Possessing above features, this species also approaches to *F. ericoides*, but differs in having ovate leaves with obtuse apex; helmet shaped, saccate-explanate lobules and 5 keeled perianth, whereas in *F. ericoides* the leaves are squarrose with saccate, rounded vertex lobules and 3 keeled perianth.

1.13 *Frullania udarii* Nath *et* Singh, in Current Science, Vol. **91,** No. 6: 744-746 (2006).
Figs. 1 & 8 (1-23)

Monoecious; plants brownish light green to dark green, prostrate or strongly appressed to the substratum, delicate. Stem 20-30 mm long and 2.25 mm wide including leaves; branching irregular; primary branches 16 mm long and 1.45 mm wide including leaves; secondary branches small, 1.25 mm long and 1.18 mm wide including leaves. Stem yellowish brown, cylindrical, 0.14 x 0.16 mm in diameter and 9 cells across; cortical cells subquadrate, thick walled, 7.5-10 x 12.5 µm, one layered; medullary cells quadrate to subquadrate, thick walled, 12.5-15 x 22.5 µm. Leaf lobes remote-loosely imbricate or imbricate, widely spreading, slightly concave, with flat or recurved apices, dorsal margin arching to the farther edge of stem or once the stem width beyond it, ventral margin of leaf generally adnate the lobule margin and base becomes concave or rarely the leaf both basal margin develops appendages with slightly broader base, apex narrow; leaf lobe 1.15-1.23 mm long and 0.90-0.95 mm wide, margin entire, ovate-oblong with rounded or subobtuse apex; lobules always explanate, subparallel with stem, 1/2 of the lobe length, 0.52 mm long and 0.20 mm wide, oblong, acute, margin entire; marginal cells of leaf slightly thick to thin walled, 12.5 x 15-20 µm, trigonous; median cells thin walled, 15-20 x 17.5-25 µm, acute and nodulose trigonous; basal cells thin walled, 20-25 x 30-45 µm, acute and nodulose trigonous. Underleaves distant, flat, appressed to the stem, as wide or wider than the stem, 0.43-0.46 mm long and 0.34-0.40 mm wide with subsinuately insertion, ovate, bilobed 1/3, sinus subacute, occasionally obtuse, 145 µm deep, lobes triangular, subacute, margin entire or rarely undulate, or with one celled protrusion each side, transversely inserted. Male inflorescence on a very short lateral branch, usually capitate, bracts 3-4 pairs, closely imbricate. Female inflorescence terminal on the main stem or branches, bracts 2-3 pairs, lobes oblong-ovate, 0.67 mm long and 0.25 mm wide, apex subobtuse, dorsal margin arched, ventral margin incurved onwards the adnation of the lobules, bracts lobule oblong, 0.95 mm long and 0.35 mm wide, apex acute with one marginal 7-8 celled long tooth at base; bracteoles free or very slightly adnate one side with bracts margin at extreme base, oblong, 0.13 mm long and 0.06 mm wide, bilobed, sinus deep, 2/3 of the lobes, very narrow, acute, lobes acute, margin

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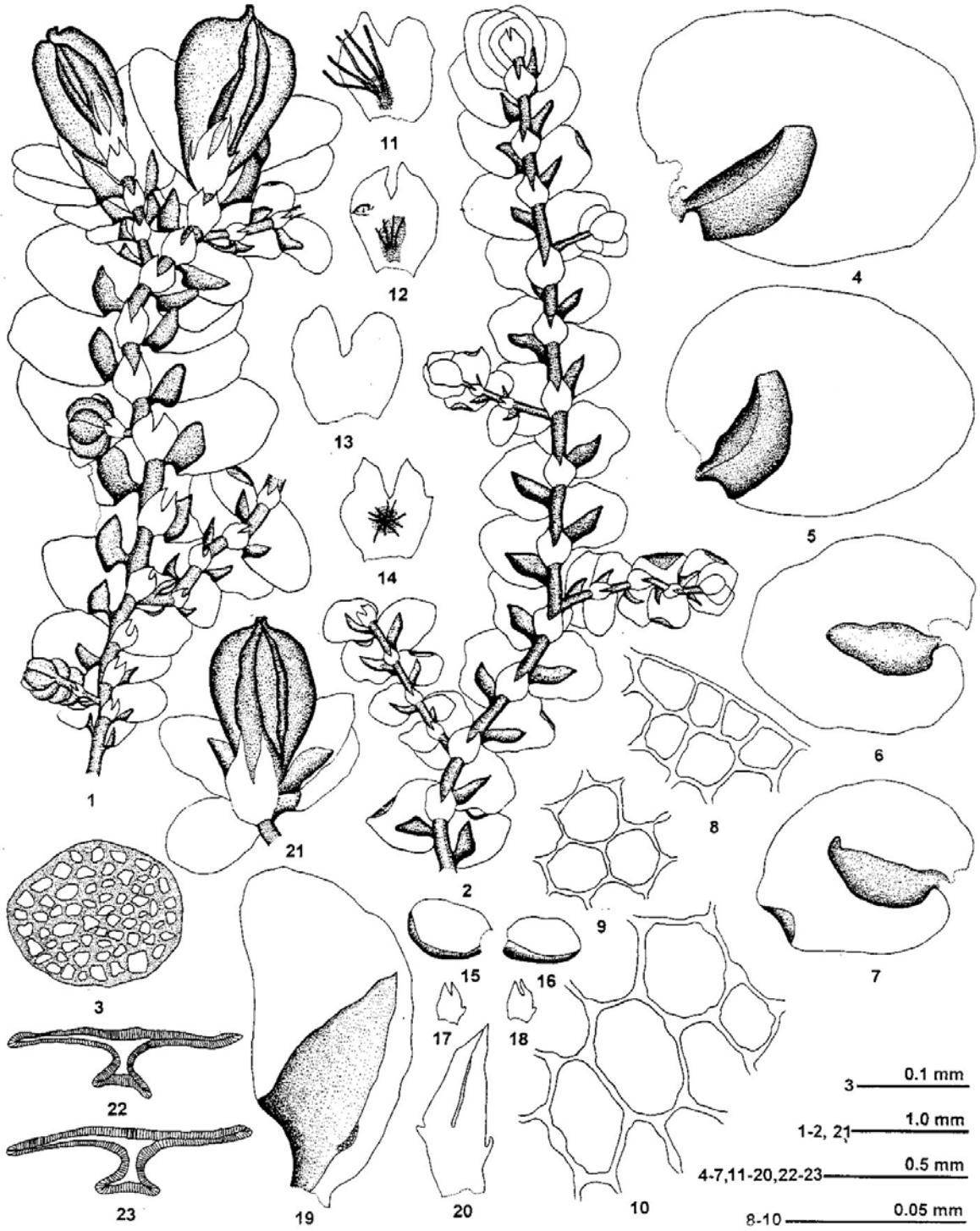


Fig. 8. *Frullania udarii* Nath *et* Singh. 1-23. (LWG 208067-A): 1. Fertile plant; (LWG 208008-A): 2. Vegetative plant; (LWG 208067-A): 3. Cross-section of the stem, 4-5. Leaves; (LWG 208008-A): 6-7. Leaves; (LWG 208067-A): 8. Leaf marginal cells, 9. Leaf median cells, 10. Leaf basal cells, 11-14. Underleaves, 15-16. Male bracts, 17-18. Male bracteoles, 19. Female bract, 20. Female bracteole, 21. Perianth, 22-23. Cross-section of perianth.

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entire-subundulate with one tooth on each side of the margin at base; perianth 1.75 mm long and 0.95 mm wide, 2/3 emergent, pyriform-obcuneate, smooth, 4-keeled (2 lateral, 2 ventral), apex beaked.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: B.S.I. Barapani, B.S.I. Campus Shillong.

Plants grow on the bark in association with *Chiloscyphus* sp., *Cheilolejeunea* sp., *Plagiochila* sp. at 2550-4700 ft altitude, 20.7°C temperature and 73% relative humidity.

Range: India.

Specimens examined: India: Meghalaya: East Khasi Hills: B.S.I. Barapani, 12.11.1998, Leg. V. Nath and party, 208008-A, 208067-A, 208070-A (LWG); B.S.I. Campus Shillong, 20.09.2000, Leg. A.P. Singh, 208724-C, 208726-C, 208727-A (LWG). Det. V. Nath & A. P. Singh.

Frullania udarii Nath *et* Singh was first discovered by Nath and Singh (2006) from Meghalaya. This taxon exhibit stable characters in all examined six populations collected from various localities of Khasi Hills Meghalaya, except the plant specimens 208008-A (LWG) of B.S.I. Barapani, (2500 ft) growing epiphytically. The plants of this single locality were varying in length 30 mm; color brown; leaves loosely imbricate-more distant, apices incurved, leaf lobes 0.88 mm long and 0.75 mm wide, apex narrowed than the base, lobules rarely subexplanate; underleaves very distant and margins of leaf lobes were ending with slightly developed appendages and sinuate insertion. While the plant populations of other five localities were similar among each other having their length 20-25 mm, color light green-green; leaves loosely imbricate-imbricate, apices rounded-subobtuse, lobules explanate; underleaves remote, leaf lobes margin ending with subtransverse insertion or with (±) variations. However, other anatomical and cellular taxanomic characters in all six populations were found similar. These variations are considered to be due to variable ecological conditions. This species shows resemblance with *F. muscicola* but *F. udarii* is light green to dark green in color, monoecious in sexuality, possesses only explanate-lanceolate or very rarely subexplanate lobules and 4 keeled perianth; whereas in *F. muscicola* the plants are pale brown-dark brown, lobules saccate, rarely explanate-cucullate and perianth usually 5 keeled. Thus this species is much apart from above new species.

On the other hand *F. udarii* closely approaches to *F. neurota* Tayl. in its sexuality (monoecious), perianth keels (4 keeled) and plants length. Additionally, the incurved apices of leaf lobes and subrotund basal appendages of *F. neurota* are more similar to *F. udarii* specimen 208008-A (LWG). However, *F. neurota* is more distinct and differs in plant color (red brown), lobules shape (saccate portion galeate without or weakly developed beak and rounded apex; laminal portion triangular, free margin entire, slightly sinuose, keels more widely and long), while *F. udarii* is yellowish green or brown-dark green and always with explanate lobules.

Kamimura (1961) described a new species *F. mayebarae* Hatt. from Japan with always explanate lobules. *F. udarii* resembles with it in monoecious sexuality, explanate lobules and plants color. *F. udarii* differs with *F. mayebarae* in perianth (4 keeled); bracts lobules margin (single teeth); bracteoles (connate one side with bract) and 1 tooth on each side of margin; whereas in *F. mayebarae* the perianth is (5 keeled); bracts lobules margin are entire and bracteoles are free as well as entire. Recently, Yuzawa (1991) described *F. tetraptera* Nees *et* Mont. from Mexico and America. This species also approaches to *F. udarii* in monoecious sexuality, 4 keeled perianth, 1 tooth on the margin of bracts lobules, leaf lobes distal margin somewhat incurved, leaf lobes ovate with semirotundate basal appendages in specimen of 208008-A (LWG). However, *F. tetraptera* is variable with *F. udarii* in shape and size of leaf lobules (saccate-galeate, very rare subexplanate); underleaf contiguous (with rounded basal appendages); bracteoles (oblong with entire margin and rounded to obtuse apex, connate with bracts lobules at both sides, shortly bifid); whereas in *F. udarii*, leaf lobules are always explanate; underleaf distant, subtransversely inserted, without basal appendages; bracteoles oblong with 1 teeth on each basal margin, apex acute-apiculate, connate with bracts one side and deeply bifid.

1.14 *Frullania physantha* Mitt., Proc. Linn. Soc. **5**: 121 (1861); J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants olive yellow to reddish brown. Stem 10-35 mm long. Leaf lobes densely imbricate, distant, ovate, apex rounded to subtruncate, margin entire; leaf lobules cucullate, vertex. Underleaves rounded, entire, broader than long, transversely inserted. Perianth large, ovate, inflated, 5 keeled, margin entire and apex with short beak.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills; Sacred forest Mawphlong, 24 km from Shillong, 6000 ft, IES 6257

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(on fallen branch), 6258 (on fallen branch with *F. ericoides*), IES 6261 (on fallen branch); Mawphlong, 22 km from Shillong, 6000 ft, IES 7500 (on tree trunk).

Range: Himalaya, China, N. Vietnam.

Frullania physantha Mitt. was instituted by Mitten (1860-61) from Khasia Hills in Eastern Himalayas on the basis of the collections made by J.D. Hooker and T. Thomson. Moreover, Stephani (1910) described this species from Sikkim and Khasia Hills. Unfortunately during our exploration, we could not collect the species from this area.

1.15 *Frullania alstonii* var. ***pfleidereri*** Hatt., *F. dusenii* Steph., Icones Hepaticarum (inedit.), non. Fig. 1

F. dusenii Steph., Arch. Mus. Rio de Janeiro **13**: 115 (1903); Spec. Hepat. **4**: 344 (1910), type from Brazil; J. Hatt. Bot. Lab. No. **44**: 177-193 (1978).

Dioecious; plants red brown, 10-15 mm long. Leaf lobes contiguous or remote or imbricate; elliptical, obtuse-rounded at apices, almost truncate at dorsal bases, entire, longer than broader, ocelli thin walled with a red coloured lumen in a uniseriate row of 3-5 moniliate; lobules contiguous, bent, head obtuse. Underleaves 1/2 bilobed, lobes triangular, lanceolate. Gynoecia terminal, bracts 1-2 pairs, remotely denticulate often with few teeth; bracteoles 1/2 bilobed, few toothed.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills; Jowai-Jarain 54 km and 85 km from Shillong, 5000 ft, IS 7006 (on tree trunk); fall of Jarain River 80 km from Shillong, 5000 ft, IS 8135-a (on branch with *F. meyeniana*), IS 8436 (on tree trunk with *F. gracilis* var. *zennoskei*, *F. meyeniana*); Forest around Mashwai Lime stone cave near Cherrapunji, 53 km from Shillong Khasia and Jaintia Hills, 4500 ft, IES 6048 (on trunk with *F. ericoides*).

Range: India orientalis, Malay Peninsula, South China.

Verdoorn (1930) described *Frullania alstonii* and overlooked the character of ocelli. Later on Verdoorn (1932, 1934) re-examined this species very critically and considered one more species *F. punctata* synonym to this. Moreover, Hattori (1972) described *F. alstoni* var. *pfleidereri* Hatt. based on the characteristics of underleaf, whose lobes are acute at the apex. However unfortunately we could not collect this specimen during our collection trip.

1.16 *Frullania duthiana* Steph., Spec. Hepat. **4**: 351 (1910); Kashyp, Liverw. W. Himalayas & Panjab Pl. **2**: 18 (1932); Chopra, Journ. Ind. Bot. Soc. **22**: 249 (1943); Hatt. in Hara (ed.), Fl. of Eastern Himalayas: 525 (1966); J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants brown, 15 mm long. Leaf lobes imbricate, widely spreading, concave with widely involute apices and rounded dorsal base; obovate; cells trigonous; leaf lobules helmet shaped, as broad as stem, rounded to obtuse, mouth truncate, narrow. Underleaves loosely imbricate, entire, broader than its length, more or less incurved along upper margin; Female bracts and bracteoles margins entire, apex obtuse. Perianth 3 keeled with smooth surface and margin.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills, Assam at 6000 ft on tree associated with *F. nepalensis* and *F. ericoides*.

Range: India

Frullania duthiana Steph. was instituted by Stephani (1910) from Himalaya. Kashyap (1932) reported it from Western Himalayas. Verdoorn (1933) reported this species from India. Recently, Hattori (1966) added localities of its occurrence in Eastern Himalayas. Moreover, Hattori and Thiathong (1978) states “Prof. and Mrs. A.J. Sharp and Dr. Z. Iwatsuki in 1965, made 2 collections of *F. duthiana* from Khasi and Jaintia Hills, Meghalaya at 6000 ft, on trees”. However, we could not collect this species during our exploration.

1.17. *Frullania evelynae* Hatt. *et* Thiath., J. Hatt. Bot. Lab. **44**: 177-193 (1978). Fig. 1

Dioecious; plants reddish brown, 30-40 mm long. Leaf lobes slightly to moderately imbricate; widely spreading, ovate-orbicular, apex rounded, with entire margin; leaf lobules contiguous to the stem, cucullate, apex rounded, beak obliquely truncate, stylus of 4 uniseriate cells. Underleaves remote, recurved along margin, suborbicular, apex widely rounded to subtruncate, sinuate insertion. Gynoecium terminal with innovation below, bracts 3 pairs, bracts lobe obtuse with entire margin, lobule connate, obtuse with 1-2 large teeth near base; bracteoles recurved along margin and with 1 large tooth, 1/4 bifid. Perianth pyriform, sharply 5-6 keeled, smooth keel.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills; Between circuit house and Mashwai Cave, Cherrapunji, 53 km from Shillong, 4800 ft, IES 7144, Holotype in herb. NICH; dupl. in herb. TENN (on tree branches).

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Range: Endemic to India.

Frullania evelynae Hatt. *et* Thiath. was instituted by Hattori and Thiathong (1978) from Khasi & Jaintia Hills and Darjeeling. This species approaches to *F. physantha*. In *F. evelynae*, the perianth are larger, inflated with very short 5 keels; female bracts with an acute lobes and usually acuminate-acute lobules with 1 large tooth or lacina on the ventral margin; female bracteoles with 2 apical teeth and often with minute basal teeth, but without large lateral teeth as in *F. evelynae*. However, during our exploration we could not encountered this species from the study area.

1.18. *Frullania evoluta* var. ***tagawana*** Hatt. *et* Thiath., J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Monoecious; plants reddish brown, 20-30 mm long. Leaf lobes imbricate, elliptical, apex rounded, obtuse or rarely subacute, dorsal margin widely arched towards the nonappendiculate base; margin entire; leaf lobules contiguous to the stem, subcylindrical, apex obtuse, lobules of stem leaves often explanate and canaliculate-lanceolate, of branch leaves almost always saccate; stylus 4-5 cells long. Underleaves distant, narrow, recurved along margin, oblong, 1/6 bifid, lobes triangular, acute, transverse insertion. Gynoecium terminal on short branches; bracts 2-3 pairs; inner bract and bracteoles highly connate; bract lobes oblong, lobules lanceolate; bracteoles oblong, 1/2 bifid. Perianth pyriform, 3 keeled, smooth.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Jowai-Jarain 54 km and 85 km from Shillong, 5000 ft, IES 6323 (on branch; + *F. nepalensis*); 5000 ft, IS 7036 (on fallen branch with *F. nepalensis*), IS 8439 (on tree trunk with *F. apiculata*, *F. meyeniana*); top of Shillong peak, 6000 ft, ES 6804a (on decaying branch).

Range: India and Thailand.

Frullania evoluta var. *tagawana* Hatt. *et* Thiath. is instituted by Hattori and Thiathong (1978) from Khasi Hills and Darjeeling in India. They remarks that the Indian material is somewhat more similar to the type variety (var. *evoluta*) than the Thailand material in that the lobes of stem-leaves are often obtuse or rarely subacute, and the lobules of stem leaves are often explanate as in var. *evoluta*. However, we could not collect this species from Meghalaya.

1.19. *Frullania gemmulosa* Hatt. & Thiath., J. Hatt. Bot. Lab. No. **43**: 439-457 (1977); J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants yellowish brown to reddish brown, 25-35 mm long. Leaf lobes imbricate, ovate-orbicular, apex rounded and slightly incurved, dorsal margin rounded and surface bearing several gemmae; leaf lobules partly covered by underleaves, apex widely rounded, mouth obliquely truncate, styli 4-5 cells long. Underleaves imbircate, suborbicular, apex subtruncate-retuse, margin entire, transversely inserted. Gynoecium terminal on stem and branches; innermost bract lobes elliptical-lanceolate, apex obtuse, margin entire, lobules lanceolate; bracteoles oblong, 2/5 bilobed, lobes apex acute. Perianth pyriform, tuberculate, 3 keeled, often with 1 smaller additional keel.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills; near Elephant falls, Shillong, 5000 ft, ES 6090 (on trunk).

Range: Assam (India) and Thailand.

Frullania gemmulosa Hatt. *et* Thiath. is described by Hattori and Thiathong (1978) from N. Thailand and Khasi Hills (India). This species agrees to *F. retusa* but the latter is distinct in lacking elliptical leaf lobes with obtuse and flat apex, small size of leaf lobules and absence of gemmae. However, during our exploration we could not collect the *F. gemmulosa* from Meghalaya.

1.20. *Frullania gracilis* (Reinw. *et al.*) Dum. subsp. ***zennoskei*** Hatt. *et* Thiath., J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants dark brown, 15-20 mm long. Leaves loosely to moderately imbricate or slightly remote, ovate-elliptic, gibbous base but not appendiculate; apiculate-subacute at apex; leaf lobules remote from stem, elevate-cylindric, apex obtuse and wide. Underleaves narrowly recurved along margin, subrectangular, 1/4 bifid, lobes triangular, transversely inserted. Gynoecium terminal on stem with innovation below; bracts 3 pairs, inner most bract lobe ovate with acute apex, entire margined; lobule lanceolate with spinose apex, toothed or laciniate along lateral margin; bracteoles ovate, strongly toothed along margin, 1/2 bifid, lobes lanceolate with spinose apices. Perianth 3 keeled, smooth, apex obtuse-subtruncate with large beak.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Jowai-Jarain, 54 km and 85 km from Shillong, 5000 ft, IS 7055 (on fallen branch with *F. meyeniana*), IS 8435 (on tree trunk with *F. meyeniana*), IS 8436, Holotype in NICH, dupl. in TENN (on tree trunk with *F. alstonii* var. *pfleidereri*), IS 8440 (on tree branch with *F. meyeniana*).

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Range: Endemic to India.

Frullania gracilis var. *zennoskei* Hatt. *et* Thiath. was instituted from Khasi and Jaintia Hills: Meghalaya by Hattori and Thiathong (1978). They described this subspecies to differ from the *F. gracilis* by its long perianth, entire margined innermost female bract lobes, stem leaf lobes with rounded gibbous dorsal base and its shortly bifid underleaves. However, during our exploration we could not collect this species from Meghalaya.

1.21. *Frullania inflata* Gott., Syn. Hep., p. 424; Spec. Hepat. Vol. **4**: 434 (1910); J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Autoecious; plants fusco-virens, 15 mm long. Leaf lobes concave obovate, apices rotundate.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Bidon Falls, Shillong, 5000 ft IS 7782 (on tree branch).

Range: Europe, N. America, Japan, India, China.

This species was instituted by Gottsche *et al.* (1845-47) from N. America and China. Hattori and Thiathong (1978) described it from Khasi and Jaintia Hills, Meghalaya. However, during our exploration we could not collect this species from any locality of Meghalaya.

1.22. *Frullania meyeniana* Lindenb., Hedwigia **33**: 168 (1894); Spec. Hepat. **4**: 649 (1911); J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Monoecious; plants brownish red, 10-20 mm long. Leaf lobes contiguous to rarely imbricate, elliptical, concave, widely rounded truncate at apex, entire, ventral margin more or less sinuate; leaf lobules cylindric, parallel and little remote from the stem, head obtuse. Underleaves 1/3 bilobed, small, obovate-obcuneate, lobes obtuse-subacute, transversely inserted. Perianth smooth with 2 lateral and 1 ventral keels.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Jowai-Jarain 54 km and 85 km from Shillong, 5000 ft, IS 7017 (on tree trunk), IS 7055 (on fallen branch with *F. gracilis* subsp. *zennoskei*); forest around Mashwai lime stone cave near Cherrapunji, 4500 ft IES 7258 (on branch); sacred forest Mawphlong, 6000 ft IES 7552 (on tree trunk with *F. nepalensis*); Falls of Jarain river 80 km from Shillong, 5000 ft, IS 8135a (on branch with *F. alstonii* var. *pfleiderri*), IS 8435 (on tree trunk with *F. gracilis* subsp. *zennoskei*) IS 8436 (on tree trunk with *F. alstonii* var. *pfleidereri*, *F. gracilis* subsp. *zennoskei*), IS 8439 (on tree trunk with *F. evoluta* var. *tagawana*, *F. apiculata*), IS 8440 (on branch with *F. gracilis* subsp. *zennoskei*).

Range: Tropical and subtropical Asia and Pacific Island; Japan, Formosa, Bonin Island., Thailand, Combodia, Vietnam, Jawa, Philippines, N. Borneo and Hawaii.

Hattori (1972a) studied the loan specimens of *Frullania tonkinensis* Steph. from the Stephani Herbarium and confirmed it to be identical to *F. meyeniana*. Hattori and Thiathong (1978) described this species from Khasi and Jaintia Hills. However, unfortunately during our exploration we could not collect this species from Meghalaya.

1.23. *Frullania pariharii* Hatt. *et* Thiath. fo. ***intermedia*** Hatt. *et* Thiath., J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants olive to reddish brown, 30-40 mm long. Leaf lobes loosely-moderately imbricate, widely spreading, slightly concave with narrowly incurved or involute distal margin, elliptical-ovate, orbicular with rounded apex and semirotund appendiculate base; leaf lobules galeate, symmertic, rounded, inflated and apex wide, mouth truncate, beak inflated, truncate, styli several cells long. Underleaves remote, orbicular-reniform, 1/6 bifid, lobes subtriangular. Gynoecium terminal, on stem or branches with innovations below; bracts 3 paired, bracts lobe oblong, apex obtuse, lobules canaliculate, with recurved entire lateral margin or with small spinose basal tooth; bracteoles elliptical, recurved along margin, with small basal tooth at both sides, 2/5 bifid. Perianth 3 keeled, paraphyllium like outgrowth on perianth surface particularly on keels.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills, at altitude of 3000 ft on cliff; Darjeeling area: around Dak Banglaw, Tongloo, IES 10840, Type in NICH, dupl. in TENN (on tree trunk).

Range: Endemic to India.

Frullania pariharii fo. *intermedia* Hatt. *et* Thiath. was first described by Hattori and Thiathong (1978) from Darjeeling and Khasi & Jaintia Hills. They refer this fo. *intermedia* to be more allied to Javanese *Frullania microauriculata* Verd. but in it, the perianth paraphyllium like outgrowth on the surface of perianth are much larger and dense from the base to the middle of the perianth. This new form is distinguishable from the type (fo. *pariharii*) by the much more strongly tuberculate perianth. While in fo. *pariharii* tuberculation is thin and nearly limited to the 3 keels. However during our exploration we could not encountered this taxon from Meghalaya.

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1.24. *Frullania retusa* Mitt. var. ***hirsuta*** Hatt. *et* Thiath., J. Hatt. Bot. Lab. No. **44**: 177-193 (1978). Fig. 1

Dioecious; plants greenish brown, 40-45 mm long. Leaf lobes slightly imbricate, elliptical, apex obtuse-rounded, dorsal margin arched with rounded to subtruncate basal appendages; leaf lobules apex rounded, mouth obliquely truncate, beak acute-obliquely truncate, styli 6-7 cells long. Underleaves contiguous, margin strongly recurved, obovate-orbicular, apex sub-truncate to retuse, lower lateral margin straight, transversely inserted. Gynoecium terminal or lateral on stem or branches; bracts 2-3 pairs, innermost bract falcate-oblong, apex acuminate, margin entire, lobules falcate; bracteoles elliptical with 2-3 long teeth along ventral margin, 1/2 bilobed. Perianth 3 keeled.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Top of Shillong peak, 6000 ft ES 61890, Holotype in NICH, dupl. in TENN (on boulder with *F. wallichiana*); around office bldgs. Botanical Survey of India, Shillong, E 6773 (on tree with *F. ericoides*, *F. neurota*); sacred forest Mawphlong, 24 km from Shillong, 6000 ft IES 7617a (on branch with *F. nepalensis*).

Range: Endemic to India.

Mitten (1860-61) instituted *Frullania retusa* on the basis of collection made by Strachey and Winterbottom from Western Himalayas. However, this var. *hirsuta* is instituted by Hattori and Thiathong (1978) for the first time from Khasi and Jaintia Hills, Meghalaya. During their study, Hattori and Thiathong (1978) referred this new variety that the perianth is densely covered by hairy outgrowth and the underleaves are usually strongly recurved-repand, whereas in var. *retusa*, perianth merely bears scattered, shorter tubercles and the underleaves are flat and appressed. However, during our exploration this species could not be collected from the study area.

1.25. *Frullania serrata* Gott., in Gott. et al., Synop. Hepat.: **5**: 453 (1845); Vanden Berghen, Rev. Bryol. Lichenol. **29**: 54 (1960). Fig. 1

Monoecious; plant brown or slightly reddish brown or blackish, 50-80 mm long. Leaf lobes imbricate, widely spreading, apices incurved, ovate, apex apiculate-acute, clearly appendiculate at dorsal base, appendages rounded; leaf lobules erect, cylindrical or clavate, vertex rounded. Underleaves contiguous or loosely imbricate, strongly recurved along upper margin, 1/2 bifid, lobes acuminate-acute, transversely inserted; female bracts and bracteoles erect, densely toothed along margin; bracteoles 1/2-2/3 bifid. Perianth 3 keeled, oblong, cylindric, flat dorsally and smooth.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: ravine along Jarain-Jowai road, 53 km from Shillong, 5000 ft IS 8139-A (on sand + *F. nepalensis*).

Range: India, Ceylon, Vietnam, Sumatra, Java, Celebes, Borneo, Philippines, New Caledonia, Tahiti, Fiji, Marqueses and other Islands in tropical Asia and Oceania; Africa and Madagascar.

For the first time this species was described in India by Verdoorn (1930) from South India. Recently, Hattori (1973) described *F. serrata* and *F. cordistipula*, which are difficult to separate from each other if the taxa are without perichaetial leaves. In *F. serrata* the perichaetial leaves are densely toothed along the margin; while in *F. cordistipula* the margins are entire. Although, during our exploration we could not collect *F. serrata* from Meghalaya.

1.26. *Frullania subpedicellata* Hatt., J. Hatt. Bot. Lab. No. **47**: 85-125 (1980). Fig. 1

Dioecious; plants olive in herbaria, 20-30 mm long. Leaf lobes moderately imbricate, widely spreading, distal margin narrowly incurved, widely obovate, rounded at apices; leaf lobules galeate, bending downward, depressed along wide margin, beak not well developed; stylus composed of 5 uniseriate cells. Underleaves subquadrate, outer margins minutely and irregularly 1-3 toothed, subtransversely inserted. Gynoecium terminal with innovation below which is again branched; bracts 2-3 pairs, inner bract lobe flat, elliptical, lobes widely obtuse, lobules lanceolate, free margin with long tooth; bracteoles bifid 1/2, apex pilose, with large tooth at both bases. Perianth 5 keeled.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills, Elephant falls near Shillong, 5000 ft, on tree trunk (with *F. gemmulosa*, *F. nepalensis*), April 8, 1965 collected A.J. & Evelyn Sharp 6090, all in Herb. NICH and TENN.

Range: India

Frullania subpedicellata Hatt. was instituted by Hattori (1980) from Eastern Himalayas for the first time. He showed, close relationship of this new species to a southern Japanese *Frullania pedicellata* Steph. Although, *F. pedicellata* is clearly distinguishable from *F. subpedicellata* in having perianth without very sharp plicae, female bract and bracteoles not flat but margin recurved, underleaves 1/4 bifid, lobules larger and rounded. However, this

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species could not be collected during our exploration in Meghalaya.

1.27. *Frullania rhytidantha* Hatt., J. Hatt. Bot. Lab. No. **47**: 85-125 (1980). Fig. 1

Dioecious; plants deep brownish in herbaria, 30-40 mm long. Leaf lobes densely to loosely imbricate, widely spreading, widely oval, apices rounded; leaf lobules subsymmetric-cucullate, apex rounded, beak ± developed, mouth wide, stylus of 3-4 uniseriate cells. Underleaves obovate-obcuneate, obtusely or bluntly angular, bifid, lobes acute and weakly angular repand outer margins, subtransversely inserted. Gynoecium terminal, innovating below; bracts 3 pairs, oblong, apex obtuse, lobules canaliculate-lanceolate with canaliculate teeth on outer margin; bracteoles 1/2 bifid, base with canaliculated lateral tooth. Perianth 5 keeled, semiexserted, often with a few, much smaller additional keels, keel worm like with irregular outgrowth and several smaller tubercles scattered over the whole surface, beak large, truncate.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Elephant falls near Shillong, 5000 ft, on boulders (+ *Trocholejeunea infuscata*), April 8, 1965, Coll: A.J. Sharp and E. Sharp 61316. Type in herb. NICH dupl. in TENN.

Range: Endemic to India.

This species was instituted by Hattori (1980) from Eastern Himalayas. This species closely relates to Japanese *Frullania pedicellata* Steph., but is easily distinguishable by the perianth with often much smaller 5 additional keels which are ± worm like with irregular outgrowth and a few tubercles; the bracteoles with canaliculate lanceolate lobes and lateral teeth; underleaves with irregularly angular repand upper outer margins. However, during our exploration we could not collect this species from Meghalaya.

1.28. *Frullania sphaerantha* Hatt., J. Hatt. Bot. Lab. No. **47**: 85-125 (1980). Fig. 1

Dioecious; plants brown, 30-40 mm long. Leaf lobes slightly imbricate to contiguous, widely spreading, concave with narrowly to strongly incurved apices, elliptical with rounded apices and semirotund basal auricles; leaf lobules subsymmetrical cucullate, apex widely rounded, beak short, wide, truncate, stylus 4-5 uniseriate cells. Underleaves widely obovate-orbicular, 1/4 bifid, lobes with acute apices, subtransversely inserted. Gynoecium terminal, innovating below; bracts 2-3 pairs, bract lobes oblong-ovate, apex acute-subacute, lobules lanceolate with attenuate acute apex; bracteoles 3/5 bifid, margin substraight. Perianth poorly 2 lateral keeled.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: Mawphlong, 22 km from Shillong, 6000 ft, on tree trunk (with *F. ericoides*), April 9, 1965, Leg. Iwatsuki, A.J. and E. Sharp, 7503, Type in NICH, dupl. in TENN.

Range: Endemic to India.

This species was instituted by Hattori (1980) from Meghalaya in Eastern Himalayas. *F. sphaerantha* is clearly recognizable in having nonplicate, large and strongly inflated perianth; perianth is pyriform and with short but wide beak at apex; the bracts lobules and bracteoles without lateral teeth; 1/3 bifid, obovate-orbicular underleaves. Although, this species could not be encountered during our collection from Meghalaya.

1.29. *Frullania pseudoschensiana* Hatt., J. Hatt. Bot. Lab. No. **47**: 85-125 (1980). Fig. 1

Dioecious; plants olive brown-brown, 30-40 mm long. Leaf lobes moderately or rarely imbricate, widely spreading, oblong-ovate with rounded to widely obtuse apex and semicircular appendages at dorsal base; leaf lobules asymmetric, cucullate, turning downward, apex widely rounded, truncate at tip; stylus 4 cells long. Underleaves widely obovate-reniform, 1/5 bifid, lobes with acute apex, subsinuately inserted. Gynoecium lateral; bracts 3 pairs, bract lobe oblong to lanceolate with partially recurved margin; lobule 1/4 connate with a few minute irregular teeth below the middle; bracteoles 1/3 bifid, margin irregularly toothed. Perianth 3 keeled with spinose tubercles densely on lower portion of the ventral surface of the perianth, tubercles smaller, scattered and finally absent towards the upper portion; dorsal surface flat and entirely lacking such tubercles.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi and Jaintia Hills: at base of Shillong peak near Shillong, 5500 ft, on tree trunk (with *Ptychanthus striatus*, *Lejeunea* etc.), April 8, 1965; Coll. A.J. Sharp and E. Sharp 6162-b, Type in Herb. NICH, dupl. in Herb TENN.

Range: Endemic to India.

This species was instituted by Hattori (1980) from Eastern Himalayas. *F. pseudoschensiana* very much resembles with *F. schensiana* Massal. and *F.*

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pseudoschensiana var. *darjeelingensis*. If the perianth is overlooked, it is very difficult to differentiate this species from latter both. *F. schensiana*, whose perianth lack tubercles, while *F. pseudoschensiana* var. *darjeelingensis* possesses tubercles only over keels of perianth with smaller ones. However, *F. pseudoschensiana* possesses tubercles scattered over surface and keels of the perianth. But unfortunately, during our exploration we could not collect *F. pseudoschensiana* from the study area.

1.30. *Frullania asperula* Mitt., Proc. Linn. Soc. **5**: 119 (1861). Fig. 1

Dioecious: plants olive green-pale olive or often brownish, 50 mm long. Leaf lobes imbricate, widely spreading, elliptical with rounded apices and often with small, rounded basal appendages; lobules similar to those of *F. acutiloba*, mouth wide, long rostrate, rostrum mostly acuminate, acute-piliferous, stylus minute, filiform. Underleaves widely oblong, ovate-rotund, 1/4 bifid, lobes acuminate-acute, base narrowed, insertion less sinuate. Gynoecium terminal with 1 innovation below; bracts in 3 pairs, bract lobes oblong-ovate with entire margin; lobules shorter, lanceolate, free margin with 2-4 laciniae or long tooth; bracteoles oblong, margin recurved and irregularly toothed, 1/3 bifid. Perianth 3 keeled, spinous outgrowth throughout the surface of perianth.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi Hills, 5000-6000 ft, on *Meteorium*, Leg. J.D. Hooker and T. Thomson, No. 1440, Type in herb, NY.

Range: India.

Frullania asperula Mitt. was instituted by Mitten (1860-61). Hattori (1973) studied and described this species from Meghalaya. Although, this species resembles *Frullania acutiloba* Mitt., but in *F. acutiloba* the perianth is smooth, except on the keels which are sharp with irregular protuberances, while in *F. asperula* the perianth is with spinous outgrowth throughout the surface of the perianth. However, during our exploration we could not collect the specimens of *F. asperula* from Khasi and Jaintia Hills in Meghalaya.

1.31. *Frullania grandistipula* Ldbg., Syn., Hepat. 430 (1845). Fig. 1

Frullania subinflata Mitt., Proc. Linn. Soc. **5**: 119 (1861).

Dioecious; plants reddish brown, 20-57 mm long. Leaf lobes imbricate, suberect, widely spreading, concave, when flattened ovate-obovate, apex rotundate, appendages rotundate, margin entire; lobules contiguous to stem, cucullate, obovate, vertex rotundate, mouth obliquely truncate. Underleaves subrotundate, 1/3 bifid, lobes triangular, subacute-obtuse, entire; female inflorescence terminal; bracts and bracteoles entire, lobules entire. Perianth 3 keeled with spinose ornamentation only on keels and margins, sometimes on surface unless it is smooth.

Distribution and ecology: Eastern Himalayas: Meghalaya: Khasi mountain, 4000 ft (Mitten, 1860-61); Khasi and Assam (Chopra, 1943).

Range: Java, Ceylon, Sumatra, Borneo, New Guinea, India.

Frullania grandistipula Ldbg. was instituted by Lindenberg in Gottsche et al. (1845-47). Moreover, Nath (1977) stated that Mitten (1860-61) described *Frullania rugosa* Mitt. from Khasi Hills on the basis of the collections made by J.D. Hooker, T. Thomson and Gardner, and *Frullania subinflata* Mitt. from Madras which were later found to be synonym of *F. grandistipula*. However, during our exploration, unfortunately we could not encountered this species from the study area.

2. Genus: *Jubula* Dum.

***Jubula* Dum.**, Comm. Bot. p. 112 (1822) emend. Rec. d'obs. p, 12 (1835); Spruce, Hep. Amaz. *et* And. P. 58 (1884).

Lejeunea sp., Corda in Opiz Mat. P. 652 (1829); *Frullania* sp., Nees. Eur. Leb. III p. 240 (1838).

Plants rather large, dark green or brown green. Stem prostrate, pinnately or bipinnately branched; branching terminal and of *Frullania* type, with an antical elobulate leaf at the insertion of each, seated partly on the stem and partly on the branch; cortical cells of the stem in 30-32 longitudinal rows, thick walled and nonpigmented, slightly smaller than the medullary cells. Leaves incubous, entire to spinose, apex acute to acuminate; leaf cells usually isodiametric, walls usually thin, trigones wanting or very minute with minute intermediate nodulose thickenings in basal cells, ocelli absent; leaf lobules saccate, distant from the stem, small, rarely evolute, acuminate, stylus usually unicellular, papillose. Underleaves sharply bilobed, apex of each lobe acute to acuminate, margin entire or dentate or spinulose with the insertion on the stem strongly arching.

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Dioecious or monoecious. Male inflorescence on lateral branches (not replacing the leaf lobule) of *Radula* type, spicate; bracts 2-5 pairs or more; bracteoles bilobed. Female inflorescence with two, rarely one, opposite subfloral innovations, terminal on the main stem or lateral branches (*Radula* type); bracts in one pair, archegonia 1-2, rarely 3-4, bracts usually entire or spinose; bracteoles free from the lobes (bracts), deeply bilobed, entire or spinose. Perianth sharply 3 angled, smooth with short beak; seta slender, 4 cells thick, in cross-section cruciate and articulate when dry, cells of outer layers of capsule wall with nodular brownish trigones on the radial walls, intermediate thickenings absent; inner layers thickenings usually sheet like or with fenestrate patterns, rarely with intermediate nodular thickenings; elaters unispiral, rown; spores spherical, smooth or slightly papillate.

2.1. ***Jubula hattorii*** Udar *et* Nath, Misc. Bryol. Lichen. Nichinan **8**: 49-52 (1978).

Figs. 1 & 9 (1-17)

Dioecious; plants medium, dark green or brown green, prostrate, on rocks near water, 20 mm long and 1.50-1.63 mm wide including leaves, bi-tripinnately branched; primary branches 8-10 mm long and 1.33 mm wide including leaves; secondary branches 3 mm long and 1.25 mm wide including leaves. Stem greenish brown, cylindrical to prostrate, 0.13 x 0.19-0.20 mm in diameter, 8-9 cells across; cortical cells thick walled, smaller, semiquadrate, 12.5-17.5 x 7.5-10 µm; medullary cells slightly thick walled, larger, angular, 17.5-32.5 x 12.5-17.5 µm. Leaf lobes imbricate, minutely apiculate-acute, ovate without any basal appendages, entire, 0.95-1.10 mm long and 0.75-0.88 mm wide; lobules stalked, saccate, clavate or cylindric, parallel to the stem, distant from stem with rounded to obtuse head, crenulate mouth, slightly exerted from the lobe margin. Leaf marginal cells pale red brown, 12.5-15 x 15-17.5 µm, thick walled, quadrate; median cells red-brown, 15-20 x 25-32.5 µm with large trigones; basal cells deeply red brown, 20-27.5 x 30-37.5 µm with large nodulose trigones. Underleaves contiguous, ovate to obovate, 0.35-0.44 x 0.45-0.55 mm, bifid, sinus acute, 200-220 µm deep, lobes acute, insertion transverse sinuate. Perianth semiexerted, smooth, 3-4 keeled, perianth in cross-section 120-170 x 600-630 µm; bracts 1-2 pairs, ovate, apiculate, 50 x 92.5 µm, lobules acicular, explanate, entire; bracteoles ovate, deeply bifid, 0.8-1.13 mm, lobes acute.

Distribution and ecology: Eastern Himalayas: Meghalaya: East Khasi Hills: Elephant falls, Mawsmai falls Cherrapunji.

Plants grow on the rocks near stream forming a dense mat with *Plagiochila* sp., *Trichocolea* sp., *Chiloscyphus argutus*, *Heteroscyphus bescherellei* at 4000-5400 ft altitude.

Range: Endemic to India.

Specimens examined: India: Meghalaya: East Khasi Hills: Elephant falls, 05.11.1998, Leg. V. Nath and party, 206002-D (LWG); Mawsmai falls Cherrapunji, 09.11.1998, Leg. V. Nath and party, 206181-B (LWG). Det. V. Nath & A. P. Singh. Other specimens examined: Eastern Himalayas: Darjeeling: Tiger Hills, 04.01.1970, Leg. R. Udar, L00221; L00222, Det. R. Udar and V. Nath.

The first report on the *Jubula hattorii* Udar *et* Nath in India was provided by Udar and Nath (1978) from Tiger Hills (Darjeeling) *ca*. 9865 ft; between Sukiya and Tanglu *ca*. 10744 ft (Eastern Himalayas). However, before this, Kamimura (1961) listed only *Jubula hutchinsae* subsp. *javanica* (Steph.) Verd. from India as an extended range of distribution. Parihar et al. (1994) also listed both the taxon from Eastern Himalayas.

DISCUSSION

The East Himalayan region of India particularly Khasi and Jaintia Hills of Meghalaya had been bryologically richest territory and prone centre of bryophytes speciation due to propitious environmental factors. The critical taxonomic studies and survey of relevant literature have revealed occurrence of 31 species of *Frullania* viz. *Frullania wallichiana, F. neurota, F. apiculata, F. inflexa, F. tamarisci, F. ericoides, F. acutiloba, F. nepalensis, F. pseudoschensiana* var. *darjeelingensis, F. giraldiana, F. rotundistipula, F. muscicola, F. udarii, F. physantha, F. alstonii* var. *pfleidereri, F. duthiana, F. evelynae, F. evoluta, F. gemmulosa, F. gracilis* ssp. *zennoskei, F. inflata, F. meyeniana, F. pariharii* var. *intermedia, F. retusa, F. serrata, F. subpedicellata, F. rhytidantha, F. sphaerantha, F. pseudoschensiana, F. asperula, F. grandistipula* and 1 species of *Jubula* viz. *Jubula hattorii* in this bryogeographical rich territory. The study showed that all the species of both the genera *Frullania* as well as *Jubula* are relatively distinctive morphologically and most of them can be identified fairly readily. The most distinguishable characteristics to identify each species were found to be shape, size and arrangement of leaves and underleaves; development of cellular trigones,

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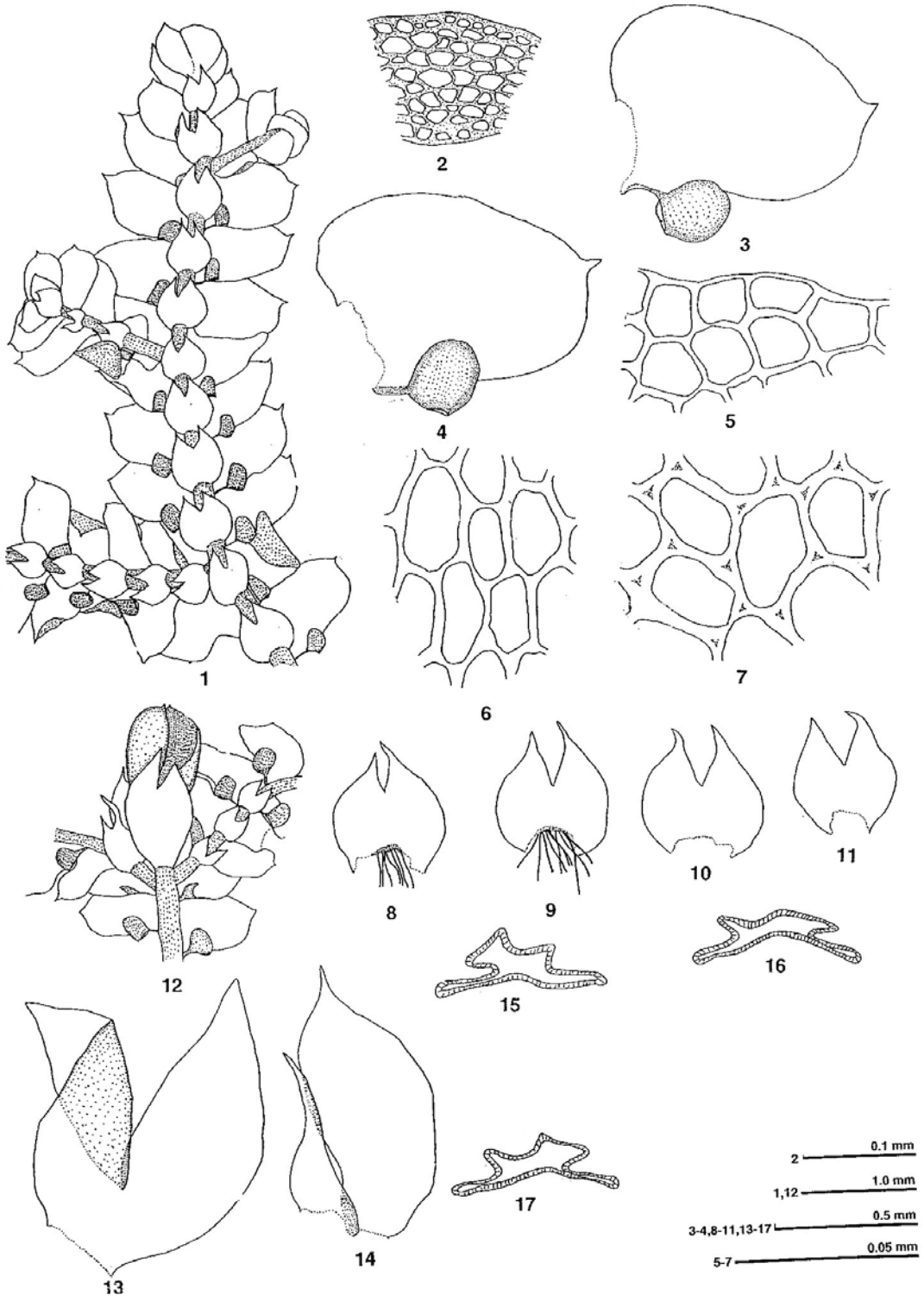


Fig. 9. *Jubula hattorii* Udar *et* Nath, 1-17. (LWG 206002-D): 1. Plant, 2. Cross-section of stem, 3-4. Leaves, 5. Leaf marginal cells, 6. Leaf median cells, 7. Leaf basal cells, 8-11. Underleaves, 12. A branch with perianth, 13. Female bracteole, 14. Female bract, 15-17. Cross-section of perianth.

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presence or absence of ocelli; lobules shape, size, arrangement, orientation, keels pattern; shape and size of bract, bracteoles; perianth keels, presence as well as absence of tubercles over wing and keels of the perianth. Studies also have provided information on the host specificity (epiphyllous, corticolous, rupicolous and saxicolous), distribution pattern and frequency of occurrence of each taxon in varied environmental condition and geographical regions. The taxonomic plasticity and interrelationships amongst more allied species of both of the genera are precisely discussed at the end of taxonomic treatment individually.

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印度梅加拉亞邦（東喜瑪拉雅山脈）蘚苔 *Frullania* 和 *Jubula* 之分類研究

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摘　　要

本文進行印度梅加拉亞邦(位於喜瑪拉雅山脈東方)伯力市及耆那山脈之地錢 *Frullania* 屬和 *Jubula* 屬之分類研究。作者進行植物標本之蒐集、調查和分類研究，部分資料則依據以前苔蘚植物地理學東喜瑪拉雅山脈之記錄，共有 31 種 *Frullania* 和 1 種 *Jubula*。上述 31 種 *Frullania* 中，*Frullania udarii* Nath *et* Singh 最近已被發現，然而 *Frullania rotundistipula* 是印度苔蘚誌的新記錄種。文中包羅廣泛的總分類表內容，包括有：分類觀察、差異性、地理分佈、生態學、產地等，和討論這二屬之間的親緣關係均為首次報導。另外地理分佈圖、屬及種間的分類檢索表也一併提供。

關鍵詞：蘚苔類植物、Hepaticae、*Frullania*、*Jubula*、梅加拉亞邦、印度、東喜瑪拉雅山脈。

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