
Systematic studies on the family Geocalycaceae (Marchantiophyta) of Kerala, India

Manjula K.M., Vidya, V., Manju C.N. and R. Prakashkumar

Department of Botany, The Zamorin's Guruvayurappan College, Calicut, Kerala, India
Malabar Botanical Garden, GA College P.O., Calicut, Kerala, India
(Corr.Auth. E-mail: manjucali@gmail.com)

Abstract: The family Geocalycaceae are one of the largest families of leafy liverworts in India consisting of 9 genera and 27 species belongs to two subfamilies. Present study reports the distribution of members of this family in Kerala state. In Kerala the family Geocalycaceae are represented by 11 species belonging to three genera viz., *Heteroscyphus* (6 species), *Chiloscyphus* (3 species) and *Lophocolea* (2 species). Among these *Chiloscyphus muricatus* and *Heteroscyphus bescherellei* are new record of occurrence for the state of Kerala.

Introduction

Geocalycaceae are one of the largest families of leafy liverworts consisting of 3 subfamilies and 23 genera. Schuster (1979) placed this family in suborder Geocalycineae under Jungermanniales. In India, it is represented by 9 genera and 27 species, which belongs to two subfamilies, Lophocoleoideae and Geocalycoideae. Srivastava and Srivastava (2002) described 27 taxa belonging to 4 genera from India, of which 7 species were new to science. In Kerala, the family is represented by the subfamily Lophocoleoideae with 11 species belonging to three genera such as *Heteroscyphus* (6 species), *Chiloscyphus* (3 species) and *Lophocolea* (2 species).

Plants included in the family Geocalycaceae are delicate, seen in prostrate patches, usually without secondary pigmentation, light or yellowish green to proper greenish, occasionally brownish or even reddish, dorso-ventral or laterally compressed. Stem rarely to frequently branched, may or may not be dorso-ventrally flattened. Leaves succubous, slightly to closely imbricate, alternate, sub-opposite to opposite, shape variable ranging from ovate, oblong, rectangulate, semicircular to triangular, apex either entire, bilobed or dentate with 1 to 10 small dentitions, cells uniformly thin walled or may be thick walled towards the outer margin mostly polygonal, with or without minute to distinct tri-radiate to nodulose bulging trigones. Oil bodies several, 2-12 (-25) per cell. Under leaves well developed, distant or slightly to closely imbricate, free or united small to large, usually shortly to deeply bilobed at apex. Rhizoids usually in tufts at underleaf bases.

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The present study reports the occurrence of 11 species of Geocalicaceae in three genera from Kerala. Taxonomic account of each species is provided with a brief description and other relevant details such as locality, habitat, altitude, collectors name, collection number, distribution of the species, etc. Detailed account is provided for for *Chiloscyphus murigatus* and *Heteroscyphus bescherellei*, being new record of occurrence for the stat of Kerala. (Abbreviations: MCN- Manju C. Nair, KPR- KP Rajesh, CALI- Calicut University Herbarium, ZGC- Herbarium of the Zamorin's Guruvayurappan College).

Key to the genera of the family Geocalycaceae in Kerala

- 1a. Leaves often entire, orbicular to oval, underleaves slightly bilobed at apex or cordate *Chiloscyphus*
- 1b. Leaves often toothed, squarrose or rectangular, underleaves deeply bilobed or lobes 2-4 2
- 2a. Leaves obliquely to subtransversely inserted on stem, non-overlapping, often 2 spines present *Lophocolea*
- 2b. Leaves arranged almost parallel to the axis, slightly to closely imbricating, spines more than 2 or absent *Heteroscyphus*

Key to the species of *Chiloscyphus*

- 1a. Leaves closely imbricate, leaf margins normally smooth to wavy 2
- 1b. Leaves usually slightly imbricate, leaf margins highly spinulose from base to apex *C. muricatus*
- 2a. Underleaves oblong-lanceolate, underleaf lobes subulate, 7 cells long, apical 5-6 cells uniseriate, margin with 1- 2 cells long tooth at each side of the outer margins near base *C. polyanthus*
- 2b. Under leaves oblong to rectangular, underleaf lobes margins usually with one small additional tooth with two series of double cells or a single row of 1-2 cells, usually 7-9 cells broad at base, under leaf bases with numerous pale rhizoids *C. chinnarensis*

Chiloscyphus chinnarensis Manju, Rajesh *et* Madhus., Acta Bot. Hung. 53(1-2): 151-157.

Plants dark greenish, yellowish brown in herbaria, prostrate, dorsiventral, in thin mats. Leaves closely imbricate. Under leaves oblong to rectangular, small, free, distantly arranged, underleaf lobes margins usually with one small additional tooth with two series of double cells or a single row of 1-2 cells, usually 7-9 cells broad at base,. Underleaf bases with numerous pale rhizoids. (Fig. 1 A-H)

Ecology and Distribution: Epiphytic leafy liverwort with prostrate thin leafy shoot. Endemic to the Western Ghats of Kerala.

Specimen/s examined: Idukki district, Chinnar wild life Sanctuary, Kariveppin Shola (1, 850 m), MCN & KPR (87425C), 19.01.2003.

Chiloscyphus muricatus (Lehm.) J.J.Engel & R.M.Schust., Nova Hedwigia 39: 419. 1984[1985]. *Jungermannia muricata* Lehm., Linnaea 4: 363. 1829. *Lophocolea muricata* (Lehm.) Nees, Syn. Hepat. 169. 1845.

Plants yellowish green, lateral, overlapping, small to medium sized, 3-5 mm x 0.5-1 mm wide including leaves, stem 0.086-0.1 mm wide; leaves alternate, longer than wide, bilobed, base broader, spinulose from base to apex, leaf size variable, top leaves 0.31-0.35 x 0.19-0.21 mm, middle leaves 0.33-0.35 x 0.31-0.34 mm, basal leaves 0.29-0.37 x 0.26-0.35 mm; cells rectangular without intercellular spaces, 11.8 - 9.44 x 14.16 - 11.8 µm at top, middle cells 14.16- 11.8 x 16.52-

11.8 μm , basal cells 11.8-9.44 x 14.16-11.8 μm ; spines numerous, 2-4 series of cells, single cells at tip; under leaves deeply bilobed, each lobe again divided into one or two small lobes; upper 2-3 single cells, 0.95-0.11 μm wide at base; rhizoids are restricted to the base of under leaves. (Fig. 2. I-J)

Ecology & Distribution: On land cuttings near stream.

In India this species known to occur from Tamil Nadu and Kerala; China, Brazil, United states.

Specimen/s examined: Malappuram, Nilambur, New Amarambalam Reserve Forest (1100 m) KPR 109008 (CALI, ZGC).

Note: Srivastava and Srivastava (2002) mentioned the occurrence of *Chiloscyphus muricatus* as *Lophocolea muricatus* from Palni hills of Tamil Nadu. The present collection is a new record of occurrence for Kerala.

Chiloscyphus polyanthus (L.) Corda in Sturm., D. Crypt. 19, p.35 in Stephani, Spec. Hepat., 3: 259 (1908).

Plants small, green-yellowish green or purplish yellow green. Leaves alternate, slightly imbricate, margin entire, smooth, apex rounded. Underleaves very small, distant, appressed. (Fig. 3 A-H)

Distribution and Ecology: Plants grow on soil, soil covered rocks, on rocks in pure population or in association with *Folioceros assamicus*, *Jungermannia* sp. and *Scapania* sp., at 1300m altitude.

Eastern Himalayas, Meghalaya, East Khasi Hills; South India (Tamil Nadu, Kerala, Karnataka).

Specimen examined: Idukki, Munnar (1300m), 24.10.2007, Gokul Das, A.K. 106424 (CALI).

Key to the species of *Heteroscyphus*

- 1a. Leaf tip dentitions absent 2
- 1b. Leaf tip dentitions present 3
- 2a. Leaves usually longer than broad, dentition absent, without hyaline papillae on the margins, cells undifferentiated, through out thick walled *H. perfoliatus*
- 2b. Leaves sub-opposite to opposite, presence of hyaline papillae, cells differentiated 4
- 3a. Leaf dentition usually 6-11 cells long, 2-4 cells wide at base; underleaves slightly imbricate, rounded with lateral teeth similar to the apical lobes *H. coalitus*
- 3b. Leaf dentitions at leaf apex relatively smaller, 3-8 cells long, 2-5 cells broad at base; underleaves distant, squarrose with lateral teeth smaller than the apical lobes
.....*H. bescherellei*
- 4a. Dentitions at apex 2-10 in number, uniseriate for most of their length, uniform in size, 1-9 cells long, 1-4 cells broad at the base 5
- 4b. Dentitions at apex 2-6 in number, biseriata to uniseriate, size variable, 2-5 cells long, 2-3 cells broad at the base *H. splendens*
- 5a. Leaves broader than long, underleaf lobes 4 to 8 cells uniseriate at apex *H. hyalinus*
- 5b. Leaves longer than broad, underleaf lobes 2-5 cells uniseriate at apex *H. argutus*

Heteroscyphus argutus (Reinw. *et al*) Schiffn., Oesterr. Bot. Zeitschr. 60: 172 (1910).

Plant delicate, medium sized, yellow brown to yellowish green, mixed with other liverworts. Leaves longer than broad, margin entire, apex almost equally broad as the base, usually pluridentate with 4-8 tooth in numbers or some times leaves even entire. Underleaves distant, free or united. Rhizoids in bunch at underleaf bases (Fig. 4 A-K)

Distribution and Ecology: Plants grow on bark, soil, soil covered rocks in pure population or in association with other liverworts.

A widely distributed species in India, Nepal, China, Japan, Java, other regions of tropical to warm temperate Asia and Australia. In India, it is reported from Eastern Himalayas Meghalaya, East Khasi Hills and Cherrapunji; Kerala (widely distributed from low to high altitude areas).

Specimen/s examined: India: Kerala: Wayanad, Chandanathode, river side (750 m) 14.09.2001, MCN 80085; Thekkadi, Mlappara (900 m), 03.02.2002, KPR 84317; Kannur, Chavachi, Aralam WLS (150 m) 05.02.2003, MCN 87521(b); Kakkayam, Raveendra estate (750 m), 10.05.2003, MCN 12011; 120146; Kakkayam, Vattakkayam (1050 m) 10.05.2003, KPR 120158 (CALI); Pannikottoor Reserve forest (60m), *Leena 901/X40, 894/X29, 900/X39* (ZGC); Kannur, Aralam WLS, Paripputhodu (150 m) 06.02.2003, MCN 87603; Ambalapara (1400) 09.10.2005, KPR 99854, 99826; Idukki, Chinnar WLS, Chambakkad (480 m) 13.01.2003, MCN, 87233(a), Chinnar, Ichampathy (1550 m), 16.01.03, MCN, 87346; Avarukutty (1500 m), 10.01.2004. SEK, 120749; Ozhuvathadam (1300 m), 12.01.2004, SEK 120580; Parambikulam WLS (800 m) 12.10.2005, MCN, 106803; Thrissur, Athirapalli (700 m), 24.11.2006, MCN, 106803 (CALI); Ernakulam, Sali Ali Bird Sanctuary (100 m), Nikesh 2429, 1119 (MBG).

Heteroscyphus bescherellei (Steph.) S.Hatt., Bot. Mag. Tokyo, 58: 39 (1944). *Chiloscyphus bescherellei* Steph., Spe. Hep. 3: 214 (1906). *Chiloscyphus communis* (Steph.) Schiffn., Oesterr. Bot. Zeitschr. 60: 169-173 (1910). *Lophocolea sendaica* Steph., Spe. Hep. 6: 292 (1922); *Heteroscyphus communis* (St.) Schiffn., Oesterr. Bot. Zeitschr. 160: 169-173 (1910).

Plants yellowish green to brownish green, 2.5-3 cm long and 3 mm wide including leaves, branching simple. Stem translucent, slender, 0.22 mm in diameter and about 13 cells across; cortical cells thin walled, non-pigmented; medullary cells thin walled and non-pigmented. Leaves imbricate, sub oblique to horizontally inserted; patent, oblong ovate to oblong – quadrate, 0.59-0.63 mm long and 0.58-0.6 mm wide at apex, 1.08-1.02 mm long and 0.86-0.88 mm wide at middle, 1.43-1.5 mm and 1.5-1.7 mm wide at base; leaf dentitions at leaf apex relatively smaller, 3-8 cells long, 2-5 cells broad at base; under leaves deeply bilobed and bidentate with one large and one small lobe on both sides, underleaves distant, squarrose with lateral teeth smaller than the apical lobes, 4-6 cells in small lobes and 7-9 cells in large lobes; cells 25-26 μm at apex, 30 μm at middle and 38-40.12 μm at base. Rhizoid medium sized and numerous, hyaline. (Fig. 5 A-K.)

Distribution and Ecology: Epiphytic, on the bark of higher plants.

India (Kerala, Tamil Nadu), China.

Specimen examined: India: Kerala: Kannur, Chavachi, Aralam Wild life Santuary (180 m), 05.02.2003, MCN 87537(b) (CALI).

Note: Hattori (1966) recorded *H. bescherellei* from Palni hills of Tamil Nadu. The present collection is a new record of occurrence for Kerala.

Heteroscyphus coalitus (Hook.) Schiffn., Oesterr. Bot. Zeitschr., 60: 172. (1910).

Plants delicate, in prostrate patches. Leaves closely imbricate, opposite or subopposite, margin entire, apex much narrower than the base, truncate, usually bidentate. Under leaves slightly imbricate. Rhizoids in bunch at underleaf bases. (Fig. 6)

Distribution and Ecology: Terrestrial on moist soil or on rocks, or epiphytic (on bark), along with other mosses.

India (Eastern Himalayas, Assam, Khasia Hills; Sikkim, W. Bengal, Darjeeling); Kerala (Wayanad).

Specimen examined: Wayanad, Chandanathode (900 m), 14.09.01, MCN 80091 (CALI).

Heteroscyphus hyalinus (Steph.) Srivast. & Srivast., Indian Geocalycaceae. (Hepat.), pp.1-246 (2002).

Plants delicate, yellowish brown-brownish green, in prostrate patches, Leaves very slightly imbricate at base only, subopposite to alternate, usually dentate, 1-4 tooth in number. Under leaves distant, either free or united one side very narrowly with antical margin of leaf base. Rhizoids in bunch and restricted at underleaves bases. (Fig. 7 A-I)

Distribution and Ecology: Terrestrial, grow as epiphytic and on rocks near stream in association with *Lopholejeunea subfusca*, *Lejeunea* sp., etc.

India (Kerala, Eastern Himalaya, Meghalaya, East Khasi Hills).
Specimen examined: Kozhikode, Kakkavayal RF (100 m) Jitha 1181 (ZGC).

Heteroscyphus perfoliatus (Mont.) Schiffn., Oesterr. Bot. Zeitschr, 60: 171. (1910).

Plants small, laterally compressed, light greenish-yellow to brownish, delicate, prostrate, closely appressed with substratum. Leaves usually longer than broad, dentition absent, without hyaline papillae on the margins, succubus. Under leaves large, orbicular to reniform, wider than the stem, closely imbricate. (Fig. 8 A-D)

Distribution and Ecology: On land cuttings and as epiphytic on *Rhododendron* sp. along with *Lejeunea* sp. and *Pterobryopsis* sp.

Eastern Himalayas, Meghalaya, East Khasi Hills; Kerala (Wayanad, Idukki: Eravikulam National Park).

Specimen/s examined: India: Kerala: Idukki, Vaguvarai, Eravikulam National Park (1850 m) 19.09.2001, MCN, 80194; Bheemanoda Shola, Idukki (1950 m), 20.09.01, MCN 80169(a); Wayanad; Chembra hills (1380 m), (13.07.04) MCN 120354 (CALI).

Heteroscyphus splendens (Lehm. & Lindenb.) Grolle. Acta Bot. Fenn. 125: 68 (1984).

Plants brownish-green, leaves opposite rarely alternate, slightly imbricate. Leaves more or less round or ovate at apex, 2-6 dentitions at apex. Under leaves flattened, broader than the stem at tip and slightly bilobed (Fig. 9. A-M)

Distribution and Ecology: Plants epiphytic along with other mosses.

India (Kerala).

Specimen examined: Idukki, Eravikulam National Park, Kolukkumala (2250 m), 23.10.2001, MCN 80243 (CALI).

Note: Pocs *et al.* (2007) reported this species as new record for India. Endemic to the Western Ghats.

Key to the species of *Lophocolea*

- 1a. Leaves alternate; slightly imbricate to distant, quadrate to sub-rectangular *L. minor*
1b. Leaves subopposite, slightly imbricate, obliquely inserted, quadrate-oblong
..... *L. bidentata*

Lophocolea minor Nees, Naturg. Eur. Leberm. 2: 330. 1836; Singh & Nath, Hep. Khasi & Jaintia hills 71. 2007.

Thallus yellowish -green, main stem creeping, branching irregular. Rhizoids long, hyaline in small tufts from the base of under leaves. Leaves alternate; slightly imbricate to distant, quadrate to sub-rectangular. (Fig 10 A&B)

Distribution and Ecology: On land cuttings and on rocks.

India (Western & Eastern Himalaya, Central India, Kerala: Present collection), Europe, America, Asia, China, Nepal, Japan, Siberia, Korea.

Specimen/s examined: Pannikottoor Reserve Forest (Alt. 60m), *Leena* 744/Z22, 843/S7, 735/Z14 (ZGC, CALI).

Lophocolea bidentata (L.) Dum., Rec. d'Obs, 17 (1835).

Plant pale green-brownish to yellowish-green. Leaves subopposite, slightly imbricate, apex broad, shortly bilobed. Under leaves 0.40 mm long, distant as or more wide as the stem, deeply bilobed. Rhizoids hyaline. (Fig. 11 A-L)

Distribution and Ecology: Plants grow epiphytically on bark in association with *Porella* sp., *Spruceanthus* sp., *Cheilolejeune imbricata*, *Radula* sp., etc.

India (Eastern Himalayas: Meghalaya, East Khasi Hills; Kerala (Thiruvananthapuram).

Specimen examined: India: Kerala: Thiruvananthapuram, Agasthyamala, (1300 m) 15.04.2008, MCN, 106583, (CALI).

Conclusion

In Kerala the family Geocalycaceae are represented by 11 species belonging to three genera viz., *Heteroscyphus* (6 species), *Chiloscyphus* (3 species) and *Lophocolea* (2 species). Among these *Chiloscyphus muricatus* and *Heteroscyphus bescherellei* are new record of occurrence for the state of Kerala. Except for *Heteroscyphus argutus*, the members of Geocalycaceae are present in the high altitude areas of Kerala. Most members of *Chiloscyphus* are found growing in soil or soil covered rocks. The genus *Lophocolea* is found in land cuttings and on rocks. *Heteroscyphus splendens* and *H. bescherellei* prefer to grow as epiphytes only. *H. argutus* is widely distributed in all microhabitats in pure population or in association with other bryophytes and ferns, usually in the low and medium altitude areas. *Chiloscyphus chinmarensis* is an endemic species of Kerala. All these species are thickly packed and grow as bed and serve as microhabitat for higher plants.

The bryophytes are probably the least documented macro-elements of most of the ecosystem, especially in South India. The present study reveals the diversity of family Geocalycaceae, with two additions for the state of Kerala.

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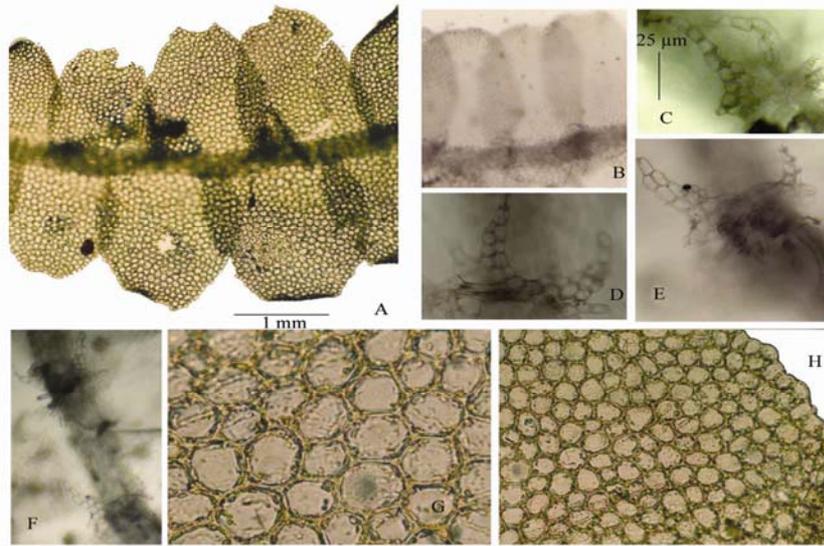


Fig.1. A-H. *Chiloscypus chinmarensis*, A. Habit, B. Leaves, C-F. Underleaves, G. Basal cells, H. Marginal cells (B-H same size)

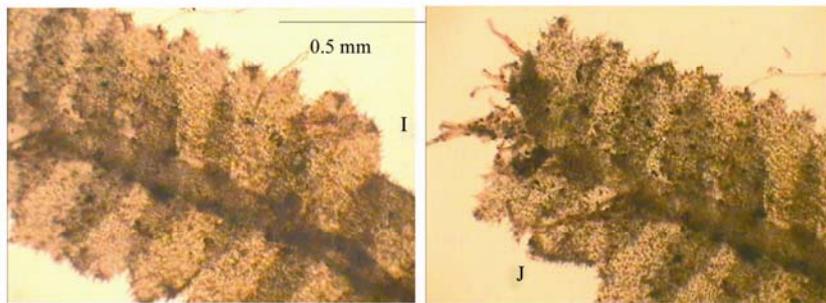


Fig. 2. I-J *Chiloscypus muricatus* branches

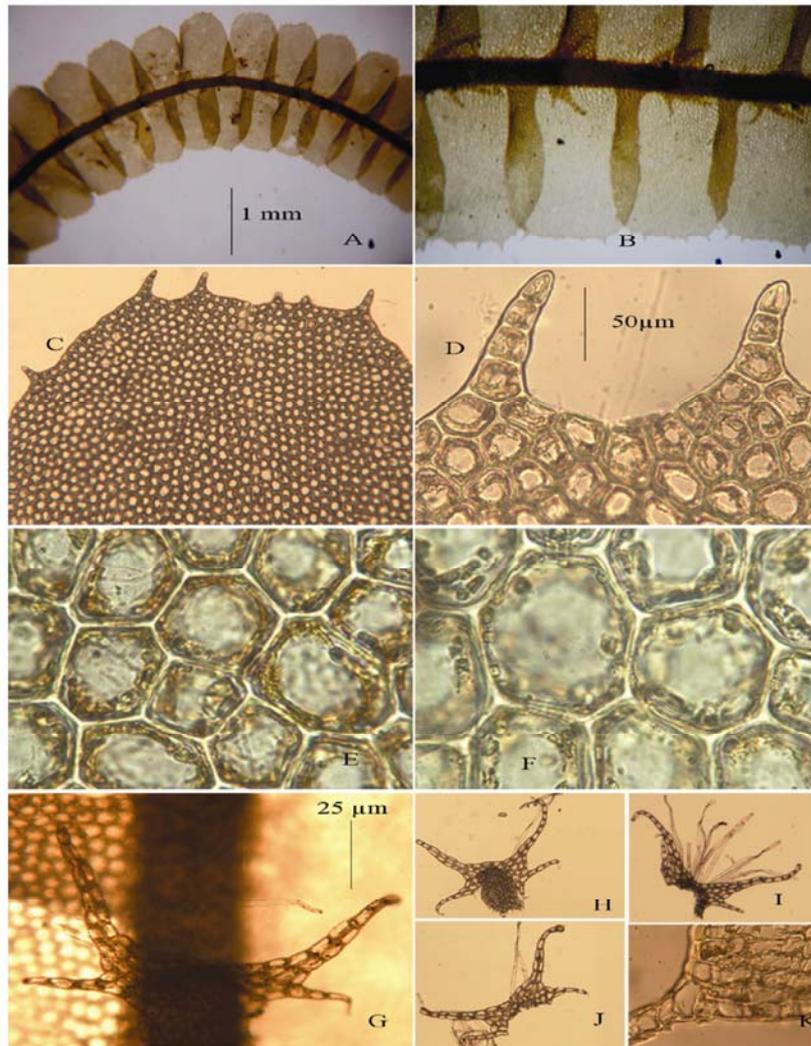


Fig. 4 A-K. *Heteroscyphus argutus*, A. Habit dorsal view, B. Ventral view, C. Leaf spine at margin, D. enlarged view, E. Marginal cells, F. Basal cells, G-J. Underleaves, K. C.S. of stem (A-B,C-F,G-K same size)

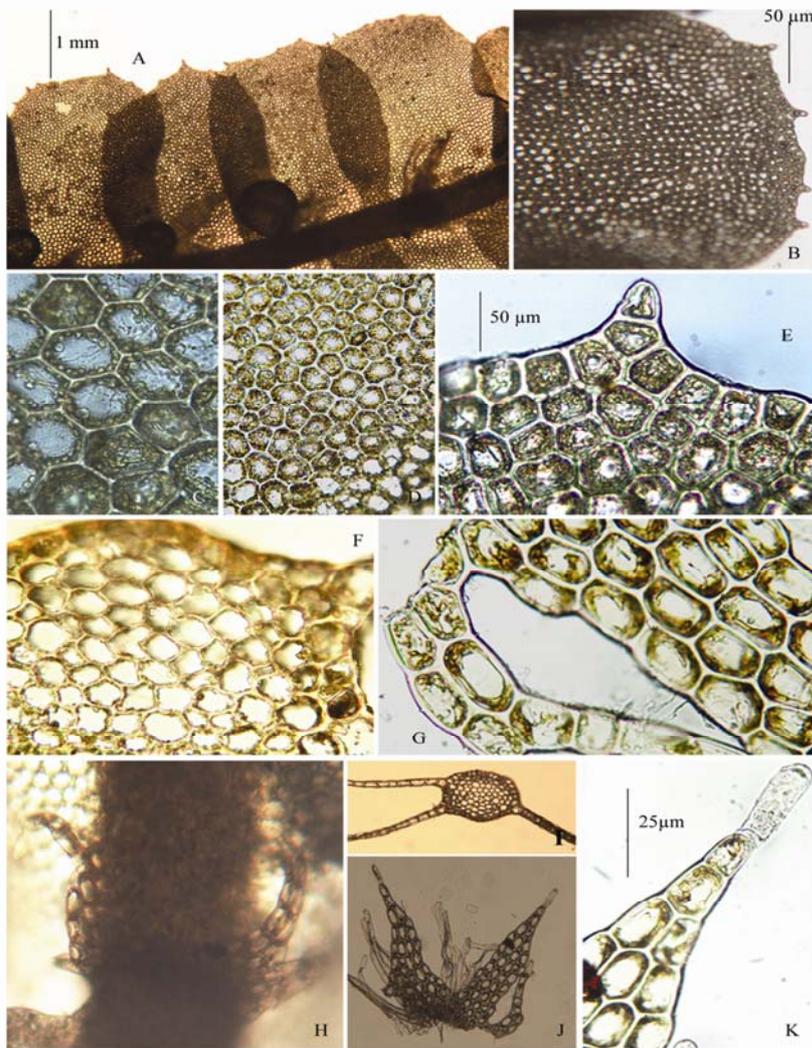


Fig. 5. A-K. *Heteroscyphus bescherelei* A. Habit, B. Leaf margin with spines, C. Basal cells, D. Middle cells, E. Marginal cells, F. C.S. of stem, G. Underleaf base, H, J. Underleaves, I. C.S. of stem, K. Underleaf spine (C,F,G,K. same size)

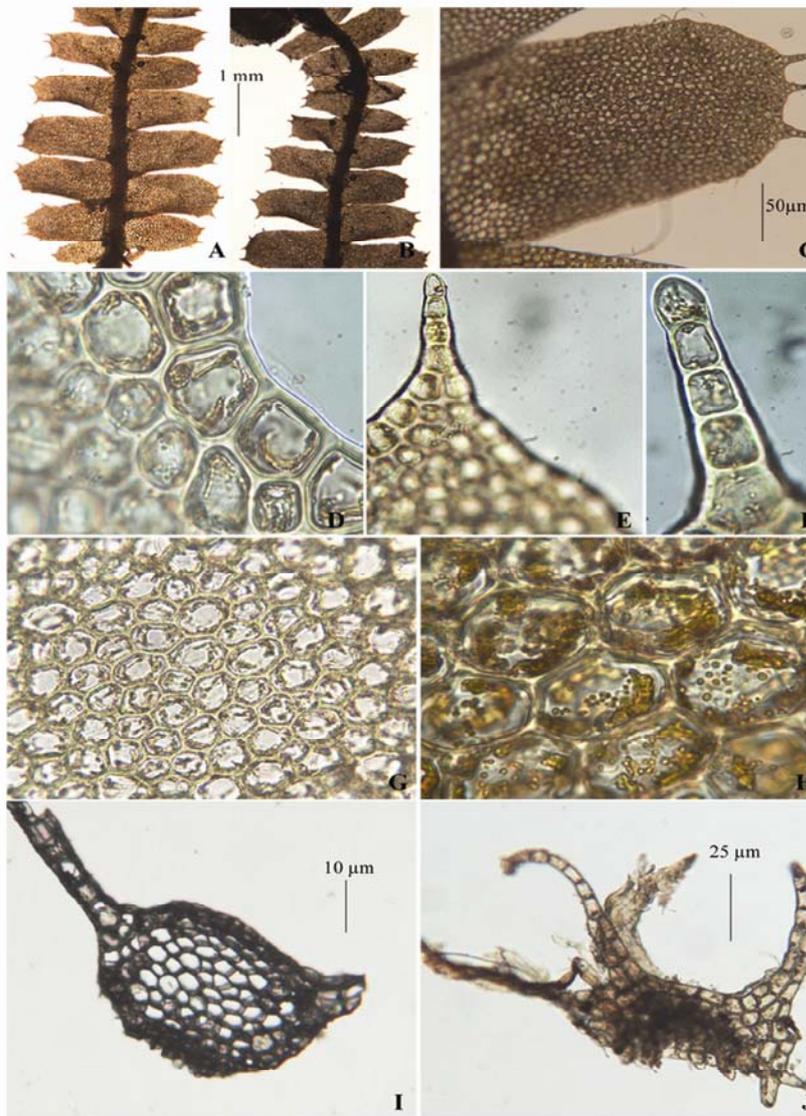


Fig. 6 A-J. *Heteroscyphus coalitus*, A-B. Habit, C. Leaf, D&G. Marginal cells, E-F. Spine, H. Basal cells, I. C.S. of stem, J. Underleaf (A-B,C-H same size)

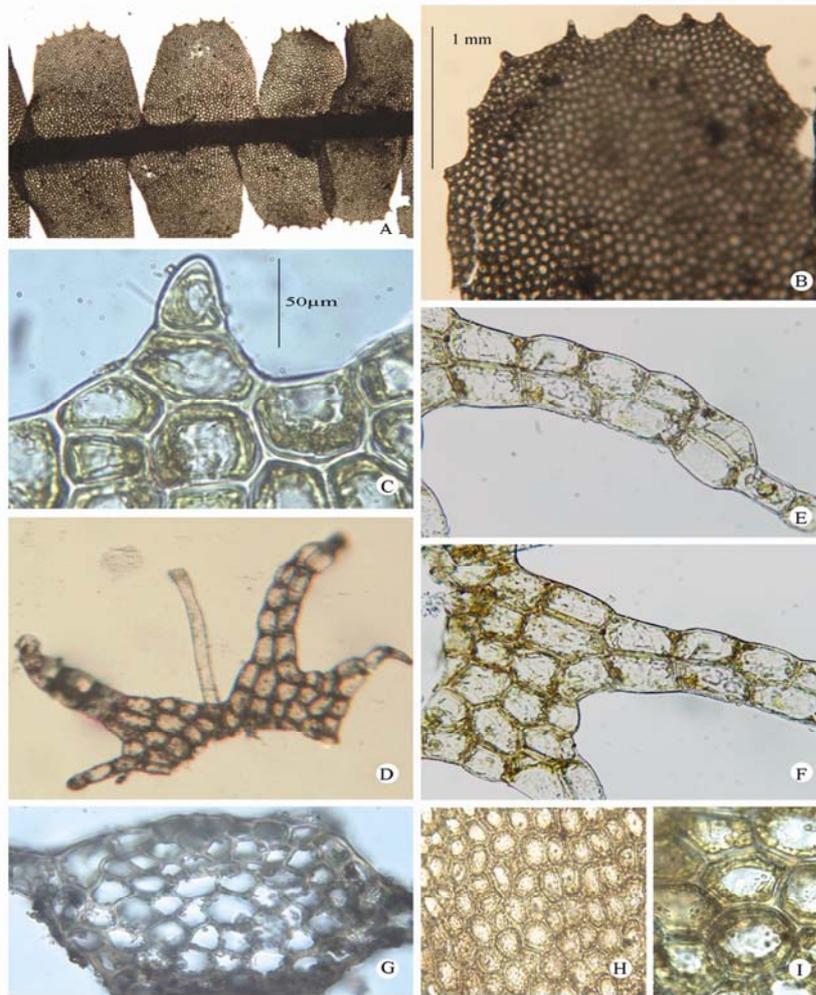


Fig. 7. A-I. *Heteroscyphus hyalinus*; A. Habit, B. Leaf margin with spines, C. Spine cells, D. Under leaf, E&F. Underleaf spine and base enlarged, G. C.S. of stem, H. Tip cells, I. Basal cells (A-B and C-I same size)

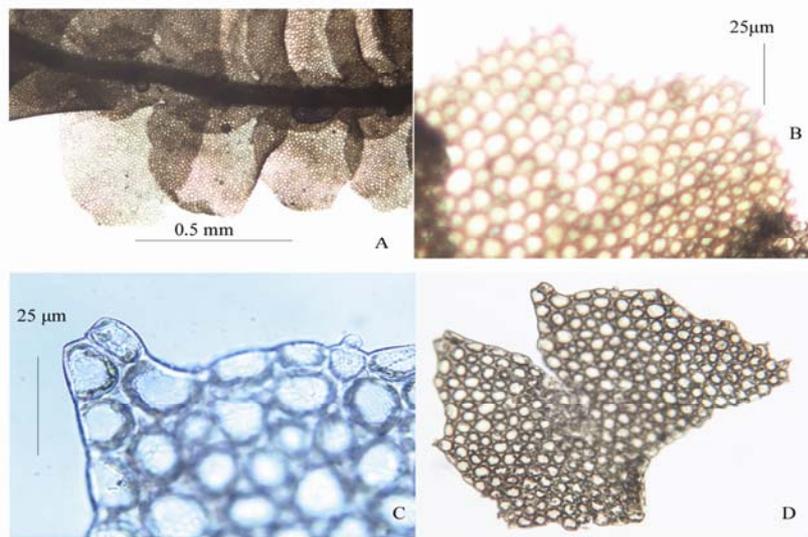


Fig. 8. *Heteroscyphus perfoliatus*, A. Habit, B. Leaf cells, C. Underleaf tip, D. Underleaf (C&D same size)

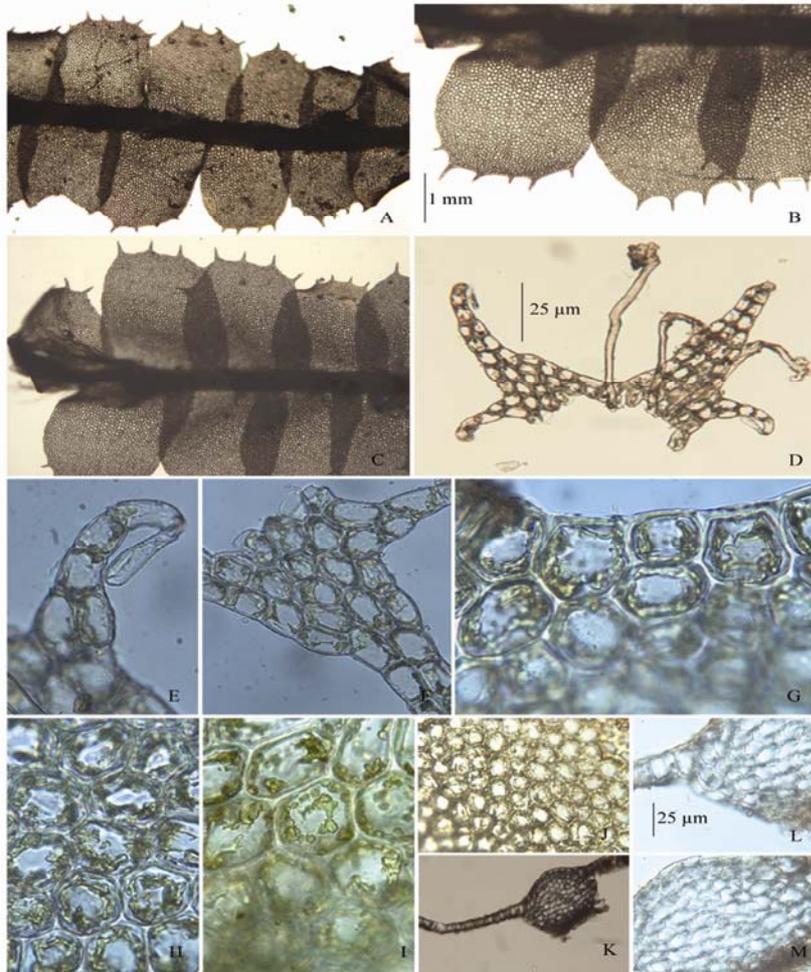


Fig. 9. A-M. *Heteroscyphus splendens*, A-C. Habit, D. Underleaf, E-F. Underleaf spine and base, G. Leaf marginal cells, H. Middle cells, I. Basal cells, J. Stem cells, K-M. C.S. of stem (A-C, D-I, J-M same size)

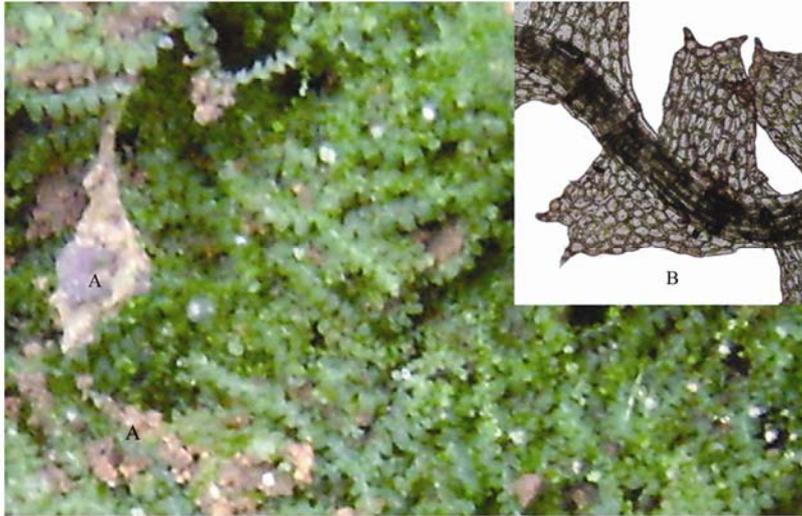


Fig. 10 A&B. *Lophocolea minor*

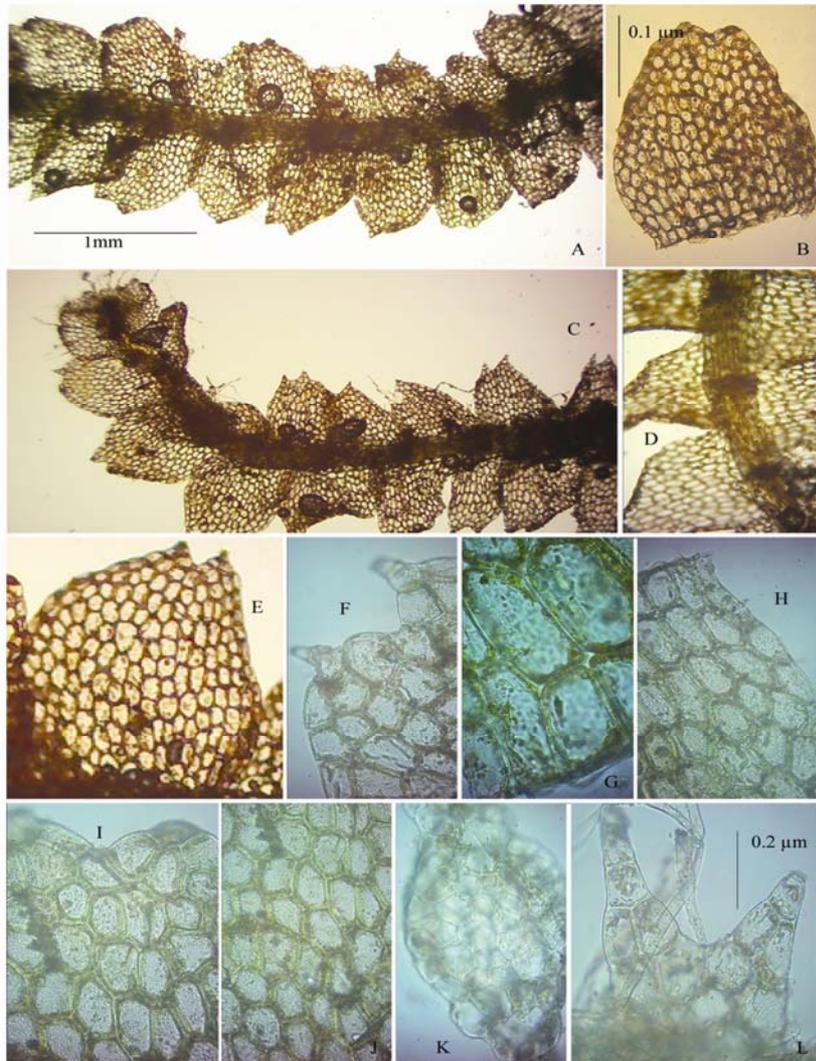


Fig 11. A-L. *Lophocolea bidentata*, A, C-D. Habit, B,E. Leaf, F. Leaf tip cells, G-K. Leaf cells, L. Underleaf (A,C,D; B&E, F-L same size)

